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WATER CHEMISTRY AND SEDIMENT CORE DATA FROM PICTOU HARBOUR AND THE EAST RIVER ESTUARY

J.A. Dalziel, P.A. Yeats and D.H. Loring

Physical and Chemical Sciences Branch
Scotia-Fundy Region
Department of Fisheries and Oceans
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia
Canada B2Y 4A2

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Marine Chemistry Division
Physical and Chemical Sciences Branch
Scotia Fundy Region
Department of Fisheries and Oceans
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia
Canada B2Y 4A2

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ABSTRACT

Dalziel, J.A., Yeats, P.A. and Loring, D.H. 1993. Water chemistry and sediment core data from Pictou Harbour and the East River estuary. Can. Tech. Rep. Fish. Aquat. Sci. 1917: iv + 78 pp.

This report presents two sets of chemical data from surveys in Pictou Harbour and the East River estuary conducted to assess the levels of heavy metals and determine the degree of contamination. In chapter one, the water chemistry data from the 1990 survey of Pictou Harbour and the 1991 East River survey are presented. These surveys determined the distributions of nutrients, dissolved metals (Zn, Cd, Pb, Ni, Cu, Fe and Mn), particulate metals (Fe, Mn, Zn, Al, Cd, Cu, and Pb) and particulate and total organic carbon. Significant contamination of these waters was not detected in either of these surveys. In chapter two, the data from the geochemical analysis of sediment cores collected during the 1990 Pictou Harbour survey are presented. These cores were analyzed for total Cd, Cr, Cu, Hg, Pb and Zn. The results show that Cd was above natural background levels in most of the core sediments and that the highest concentrations of all metals analyzed were found in the fine-grained organic-rich material.

RÉSUMÉ

Dalziel, J.A., Yeats, P.A. and Loring, D.H. 1993. Water chemistry and sediment core data from Pictou Harbour and the East River estuary. Can. Tech. Rep. Fish. Aquat. Sci. 1917: iv + 78 pp.

Le présent rapport contient deux séries de données chimiques provenant de levés réalisés dans les eaux du port de Pictou et de l'estuaire de la rivière East dans le but de déterminer la teneur en métaux lourds et le degré de contamination de ces eaux. On trouvera au premier chapire les données résultant des levés réalisés dans le port de Pictou en 1990 et dans la rivière East en 1991. Elles portent sur la distribution des nutriments, des métaux dissous (Zn, Cd, Pb, Ni, Cu, Fe et Mn), des particules de métaux (Fe, Mn, Zn, Al, Cd, Cu et Pb) ainsi que des particules de carbone organique et du carbone total. Ces données ne dénotent pas de contamination notable des eaux. Le chapitre deux contient les résultats de l'analyse géochimique de carottes de sédiments prélevées au cours du levé réalisé dans le port de Pictou en 1990. On a étudié la teneur de ces carottes en Cd, Cr, Cu, Hg, Pb et Zn. Les concentrations de Cd se sont avérées supérieures aux niveaux de référence dans la plupart des carottes de sédiments. De plus, il est apparu que les carottes à grains fins riches en matière organique contenaient les plus fortes concentrations de tous les métaux.

INTRODUCTION

The Federal Government (Environment Canada) in 1989 allocated funds for the Pictou Harbour Environmental Action Plan in response to the concerns about the health of this harbour. One of the goals of the Action Plan was to determine the environmental state of the Harbour. This study on "The Distributions of Contaminants in Pictou Harbour and The East River Estuary" was one of several projects funded by the Advisory Committee of the Pictou Harbour Environmental Action Plan. The data from this report have been used in the assessment of the environmental quality of the harbour and some of the results appear in the final report - "An Assessment of the Environmental Quality of Pictou Harbour and Surrounding Watershed" by H.G. Painter and P.L. Stewart.

CHAPTER 1

WATER CHEMISTRY SURVEY OF PICTOU HARBOUR AND THE EAST RIVER

by

J.A. Dalziel and P.A. Yeats

INTRODUCTION

The growing concern over the extent of environmental pollution in the Pictou Harbour area has lead to an extensive environmental study of Pictou Harbour. One component of this general study has been an investigation of the distributions of several, mostly inorganic, contaminants in the waters of the Pictou Harbour and the East River estuary. This investigation is based on samples collected during two surveys. During the first survey, in September 1990, samples were collected in Pictou Road, Pictou Harbour and the outer part of the East River Estuary for total (TOC) and particulate organic carbon (POC), suspended particulate matter (SPM), nutrients and dissolved trace metals. The second survey, in September 1991, focussed on trace metal and nutrient distributions in the East River Estuary.

METHODS

The cruise track and station information for the 1990 survey are shown in Figure 1 and Table 1 and that for 1991 in Figure 2 and Table 2. On the first cruise, salinity and temperature were measured at each station using a Seabird CTD (model SBE-25), and water samples were collected with a Niskin bottle at 0.5 m for salinity, nutrients, total organic carbon, particulate organic carbon, suspended particulate matter, and dissolved trace metals. On the second cruise (1991), salinity, temperature, dissolved oxygen, and pH were measured on site and water samples were collected for salinity, nutrients, dissolved and particulate metals and SPM using an all plastic peristaltic pumping system to recover samples from 0.5 to 1 m.

On the 1990 cruise, 2 liter unfiltered water samples were collected from the Niskins and filtered the following day in a clean laboratory through acid cleaned and tared 0.4 μm Nuclepore filters. The filtrate (dissolved metal sample) was preserved with 2.5 ml/L of high pure HCl (Seastar). The particulate material collected on the filter was washed of residual salt, dried and weighed to determine the concentration of suspended solids (SPM).

TOC and POC samples were collected from each station during the 1990 survey in glass containers and processed each evening at the Bedford Institute of Oceanography (BIO). The POC samples were pressure filtered through 0.8 μm silver filters and later

analyzed using a CHN analyzer (Carlo Erba Model 1106). The TOC samples were collected in duplicate, acidified with 100 µl of H_3PO_4 and stored at -4 °C. The samples were thawed and analyzed using an "in house" method of first photo-oxidizing the sample, then catalytically reducing the CO_2 to methane and detected the methane by gas chromatography.

The dissolved metal samples collected from the 1991 cruise were filtered at each station through a precleaned polypropylene 0.45µm Gelman cartridge and stored in acid cleaned 2 liter polyethylene bottles. The filtrates were preserved with 1 ml per liter of high purity (Seastar) acid (HNO_3). The filtrates from both studies(1990 and 1991) were analyzed using the methods of Danielsson et al. (1982), for Zn, Pb, Cd, Ni, Cu, Fe and Bewers et al. (1976) for Mn. Samples with a salinity ≤16 psu were digested prior to extraction.

The particulate metal samples collected from the 1991 cruise were processed in a class 100 clean room the morning after the samples were collected. The water samples collected for the separation of particulate metals and SPM were filtered through acid cleaned and tared 0.4 µm Nuclepore filters. The particulate samples were washed and processed as described above for gravimetric determination of SPM. The samples were then decomposed in LORRAN teflon-PTFE digestion bombs for 45 seconds with 1 ml of aqua regia and 1 ml of HF (Ultrex grade) in a microwave oven (Rantala and Loring, 1989; Loring and Rantala, 1990). The fluorides were dissolved using 0.5 grams of boric acid crystals and the solutions were made up gravimetrically to the equivalent of 10 ml in polypropylene bottles. The metals were determined using either flame (Fe, Mn, Zn) or graphite furnace (Al, Cd, Cu, Pb) atomic absorption spectrophotometry methods (Rantala and Loring, 1977, 1985).

The salinity samples collected during the surveys were analyzed using a Guildline Autocell Salinometer to determine practical salinity as defined by the 1980 Unesco/ICES/SCOR/IAPSO Joint Panel. The measurement errors of the salinometer are typically <0.003 practical salinity units (psu). The field measurements for salinity, conductivity and temperature were made using a portable conductivity meter during the 1991 cruise. Field measurements for dissolved oxygen and pH were collected as part of the 1991 East River survey. The dissolved oxygen concentration was measured at each station using an Orion oxygen electrode and pH was measured insitu using an Orion - Ross pH electrode.

The nutrient samples collected from the 1990 cruise were unfiltered and the samples collected from the 1991 cruise were filtered during sample collection. In both cruises, the nutrient samples were collected in duplicate from each station and preserved at -4 °C within 12 hours of collection. The samples were thawed and then analyzed with a Technicon Auto Analyzer II using modified Technicon procedures.

RESULTS

1990 Survey

The results for SPM, POC and TOC from the 1990 sampling cruise are shown in Table 3. The salinity and nutrient data are listed in Table 4. The data for gravimetric determination of SPM show rather high and scattered values. The data range from 2.1 to 8.5 mg/l with an average of 3.35 ±1.64 mg/l. For comparison, typical coastal seawater values are <1 mg/l. There is not an obvious river source for the SPM as station 18 had the lowest concentrations. Station 19 had the highest SPM concentration and the sample was visibly different - black in colour - than the other samples. This station was near the smoke plume from Scott Paper.

The POC levels in these samples were low and scattered. Station 5 had a POC level significantly higher than any of the others and also had the highest C:N ratio in the area. Even here, the level of carbon was not extremely high. The TOC result for this station was also the highest in the data set. Two other nearby stations (4 and 6) also appear to have elevated levels. Station 5 was located down wind of the Boat Harbour outfall on this sampling day, and adjacent to the Pictou Sewage Treatment Plant discharge. The only other interesting observation is that the SPM from station 19 was visibly different, but the POC numbers were not noticeably anomalous.

The nutrient data show phosphate to be high and nitrate to be low, which is not surprising considering sewage is a known source for phosphate. Silicate concentrations are perhaps slightly higher than would be expected for inshore waters in summer. Silicate concentrations decrease from highest in the East River sample (station 18) to a minimum in the outer part of the East River estuary and then increase through Pictou Harbour to Pictou Road. Nitrate concentrations follow a similar pattern to silicate, with undetectable concentrations ($\leq \approx 0.05$ μM) seen through most of the East River estuary and Pictou Harbour. Phosphate follow a somewhat different pattern, decreasing more consistently from the highest concentration at station 18 to lowest in Pictou Road.

When the phosphate concentrations are plotted against salinity (Figure 3), concentrations decrease with increasing salinity but are not described by a linear relationship. A distinct change in slope is observed at 28.2 psu (in the vicinity of stations 15, 16 and 19). If the section of the plot between 28 and 29 psu is expanded a distinctly linear P vs. salinity relationship is still evident, despite the very restricted salinity range. The only sample that deviates from this trend is the one from station 5 adjacent to the discharge from the Pictou Sewage treatment plant. This sample, which had high

concentrations of POC has low dissolved phosphate concentrations. Plots of silicate and nitrate vs. salinity (Figure 4) show a different pattern, going through a concentration minimum at 28.2 psu. For silicate, the sample from station 5 is again the only one that deviates from the trend at high salinity, but in this case the concentration is elevated compared to the trend.

The data for the dissolved metals from the 1990 cruise are listed in Table 5. The concentrations of dissolved metals versus station number are illustrated in Figures 5 to 8. Concentration peaks in these plots should indicate sources of metals or remobilization processes.

The plot of Cd vs station number (Figure 5) shows a decreasing trend in dissolved Cd from Pictou Road, through the harbour and into the estuary. The concentration decreases from a high of 0.057 μg/L at station 6, to a minimum of 0.015μg/L at station 16. The increases noted at station 17 and 18 were attributed to sources from the East River estuary. The survey show Cd has an average concentration of 0.032 μg/L and a standard deviation of ±0.010 μg/L.

The concentration of dissolved Cu, (Table 5 and Figure 5), show little variability from station 1 through to station 16 (average of 0.52 ±0.06 μg/L). The data from station 17 and 18 point to the East River as a source of Cu. The survey average was 0.61 ±0.25 μg/L with a maximum of 1.46 μg/L from station 18 off Trenton car works.

The data for dissolved Fe (Figure 6) show little variability from station 1 through to station 16. with the exception of higher level at station 14, a shallow station located off Mussel Point. Stations 17 and 18 had high levels that can be attributed to the fresh water sources of the East River. The average concentration from this survey was 6.98 ±4.32 μg/L.

Dissolved manganese shows (Figure 6) relatively uniform concentrations from the harbour through the estuary, stations 1 to 17. The higher concentrations found at station 10, 14 and 15 could be an indication of fresh water sources near these sites and the level found at station 18 will be due to the effect of East River input and estuarine mobilization processes. The data has an overall average of 2.73 ±1.72 μg/L with the highest concentration of 8.01 μg/L found at station 18.

The concentration of dissolved Ni from the survey illustrated in Figure 7 show little variability from station 1 through to station 17 and the highest concentration found at station 18 off Trenton. The survey data have an average of 0.36 μg/L and a standard deviation of ±0.06 μg/L.

The plot of the dissolved Pb data (Figure 7) from the 1990 survey exhibit a lot of variability from the station off Pictou Road through to the station off Trenton car works. The survey has an average of 0.053 μg/L and a standard deviation of ±0.021 μg/L. The consistently elevated levels found from station 7 through to

11 may indicate a local input in the Pictou Harbour area.

The Zn data from this survey (Fig.8) shows considerable scatter with the concentration from station 1 and 7 about twice the concentration of the other survey stations and the level found at station 16 only one quarter of the average. No clear trends are evident from the data. The average concentration of Zn from the survey was 0.80 μg/L and a standard deviation of ±0.29 μg/L.

1991 Survey

The 1990 survey indicated that the East River could be a potentially important source for several of the trace metals, notably copper, iron and manganese. The 1991 survey was thus designed to investigate the estuarine geochemistry of metals in the East River estuary and possibly identify sources of metals to the estuary.

The results for physical/chemical parameters measured in the field at each station during the 1991 study (time, salinity, conductivity, pH, temperature and dissolved oxygen) are shown in Table 6. The salinity and conductivity data show that only station 1 is in the freshwater regime of the East River. The stations from the rail bridge at New Glasgow (station 2) to the N.S. Power plant at Cantley Point (station 16) were brackish (7.5 to 18 psu). The observed differences between the field and bottle salinity data were characteristic of the variability seen with this type of sampling in an estuarine mixing zone. This variability was most pronounced where the mixing was most intense. The pH data show a gradual increase from 7 (neutral) in the river to a sea water pH of 8. The temperature data show a gradual decrease from the fresh water of station 1 (20.0 °C) to the saline water (27 psu) of station 20 (17.0 °C). The dissolved oxygen data from the twenty station survey average 8.0 ppm with a standard deviation of ±0.7 ppm and the lowest values measured were between stations 2 to 6. None of the oxygen data indicated extensive depletion of oxygen in the estuary at the sampling depth of 0.5-1 m, although some depletion of oxygen is seen at station 2-4.

The silicate, phosphate, and nitrate data are given in Table 7 and illustrated in plots of nutrient versus station number and salinity in Figures 9, 10 and 11. Silicate concentrations decrease from the maximum concentration in the river to the lowest concentration at station 20. The plot of Si vs station location (Figure 9) shows a secondary minimum at station 3 but the plot vs. salinity shows a linear decrease with salinity. A comparison to the 1990 data shows that very similar concentrations are observed between 20 and 28 psu although the location of the stations with 20-27 psu salinity are displaced downstream in 1991. The situation for nitrate (Figure 10) looks very similar to that for silicate except the maximum concentration occurs at station 2 rather than station 1. The concentrations of nitrate seen in the 1990 survey were slightly

lower than those seen at similar salinities in 1991. The picture for phosphate is quite different with the lowest concentration seen at station 1 and maxima at station 3 and stations 16-18 (Figure 11). The plot of phosphate vs. salinity shows a broad maximum centered around a salinity of 20. The phosphate concentrations measured in 1990 were considerably higher but the trend between 20 and 28 psu was for decreasing phosphate with increasing salinity in both cases. These observations indicate a major input of phosphate to the water in region where the East River estuary broadens out downstream from Trenton.

The data for the dissolved metals are given in Table 8 and plots of metal concentration versus station number and salinity are illustrated in Figures 12 to 17. A linear relationship between the concentration of dissolved metals and salinity indicates that freshwater influxes of these metals are not modified significantly in the river-estuary system. Concentration peaks within the estuary could indicate internal remobilization processes or additional sources.

Cadmium data illustrated in Figure 12 show that the concentration was lowest at station 1 and relatively uniform (0.042 ±0.007 μg/L) from station 2 through to station 20. The concentrations appear to be highest at stations 3-4 and 13-14 and all the estuarine concentrations are considerably higher than in the river. The plot of Cd vs. salinity shows a broad maximum centered at 16 psu and a general trend to lower concentrations between 20 and 28 psu. The concentrations are very similar to those found in 1990 in the region of salinity overlap.

The copper data (Figure 13) show that the Cu concentration was also lowest at station 1 and uniform (0.80 ±0.14 μg/L) from station 2 to station 17. The fresh water sample from station 1 and the estuarine sample at station 20 were about half the concentration found in station 2 to 17. A linear relationship between Cu and salinity was evident from ≈18 psu outward. In 1990 concentrations also decreased with increasing salinity in this salinity range but the concentration at 20 psu was almost twice that found in 1991.

Figure 14 shows iron to be highest at the first two stations and lowest in the most saline stations in the outer estuary (stations 19 and 20). The concentrations between stations 3 and 15 were fairly uniform at 21.5 ±3.3 μg/l. The plot of salinity versus Fe showed a clear linear relationship for all samples from the survey. In 1990, the concentration at 20 psu was 13 μg/l, i.e. almost perfectly coincident with the 1991 data. The highly significant linear regression, however, is somewhat misleading as it would extrapolate through zero μg/l at ≈28 psu. This clearly does not happen, as indicated by the residual Fe concentration of ≈4 ug/l throughout Pictou Harbour on the 1990 survey.

The survey data for Ni (Figure 15) show that the fresh water sample from station 1 has the lowest concentration. There was not a great deal of variability in the data from station 2 to 15 with an average of 0.51 μg/L and a standard deviation of ±0.02 μg/L.

A linear relationship between Ni and salinity was evident for the data from station 3 to 20. The 1990 data gave a similar picture of the Ni distribution in the estuary.

The plots of Pb versus salinity and station number in Figure 16 show the highest concentration at station 1 and decreasing concentrations through the estuary. The lowest levels were found in the outer part of the estuary at station 19 and 20 with station 3 through to 18 having an average of 0.035 ±0.006 μg/L. The lead vs salinity relationship is similar to that of iron, except that there may be some curvature in the Pb vs salinity relationship. Extrapolation to higher salinity would indicate that some curvature must exist. The concentrations observed in 1990 were somewhat higher and showed no indication of a negative correlation with salinity.

The plot of dissolved Zn versus station number illustrated in Figure 17 shows an average concentration from station 2 through to 15 of 1.79 ±0.17 μg/L. The lowest levels were found in the outer estuary at station 18 to 20 with a concentration of 0.50 μg/L which was about a third the level found at mid salinity. The plot of Zn versus salinity shows a negative relationship for stations 3 to 20. There is very little similarity between this picture of the Zn distribution and that seen in the 1990 survey.

The SPM and particulate metal data are given in Table 9 and the data plots of concentration against station location and salinity are illustrated in Figures 18 to 24. High concentration of Ni and Cd were found in the reagents used to analyze the particulate samples resulting in high blanks and limited usable data for these elements.

The data for the gravimetric determination of suspended solids (SPM) is given in Table 9 and plots of SPM versus station number and salinity are illustrated in Figure 18. The concentration of SPM throughout the estuary was relatively uniform with an average of 2.12 mg/L and a standard deviation of ±0.58 mg/L. The data from stations 8 and 13 seem anomalous. The low levels could represent real features or analytical errors in sample processing. Particulate Al and Fe results for station 8 are anomalously high so it would appear that there has been a weighing error and this sample should be ignored. Station 13 does not show up as anomalous for Al or Fe so it would appear that this sample could be real. The SPM concentration at station 1 is also rather low, only one half that at station 2. There is no indication from any of the other measurements, however, that this sample was incorrectly collected.

The Al data from Table 9 and the plots of concentration versus station location and salinity (Figure 19) show that the concentrations of particulate Al decrease from 7.4% in the river water sample to 3.4% at 27 psu with considerable scatter in the mid-salinity range. The elevated concentration at station 8 is probably related to the suspect SPM data from this station and should be ignored. The salinity vs Fe plot (Figure 20) was

similar to that for Al, showing a decrease in concentration from fresh to salt water. The Al and Fe content of the river water sample (station 1) are typical of inorganic material, while the reduced Al and Fe content of the estuarine samples could indicate an increased organic content.

The concentration of Cu versus station location and salinity that are illustrated in Figure 21 show a freshwater source for particulate Cu and also sources from along the river near stations 12 through 17. Dissolved Cu concentrations were also highest in this area (station 15). The concentration of particulate Cu range from 32 to 106 ug/g with an average of 67 ug/g and a standard deviation of ±20 ug/g.

The particulate Mn data from Table 9 and the illustrated plots of concentration versus station number and salinity (Figure 22) show an interesting relationship to salinity. The illustrations show that particulate Mn increases in concentration through the estuary. The obvious explanation for this trend is the chemical oxidation of Mn^{+2} to Mn^{+4} which shifts Mn from the dissolved to particulate phase. The particulate Mn concentrations on the survey are all rather high averaging 5208 ug/g with a range of 2728 to 8971 ug/g and a standard deviation of ±1575 ug/g. Dissolved Mn results for this survey, that are not yet available, may help in developing an understanding of the particulate Mn results.

The concentration of particulate Pb versus salinity and station number are illustrated in Figure 23. The plot of concentration versus salinity did not show an obvious relationship between these two parameters. Higher levels of Pb were noted from station 1, 8, 13 and 20. Station 8 and 13 have low SPM concentrations which could account for the Pb anomalies. Station 20 is a puzzle, as there is no obvious reason for a higher concentration at this location and it may be due to contamination of the sample. The overall data average was 115 ug/g, with a range of 72 to 200 ug/g and a standard deviation from the survey data of ±33 ug/g.

The Zn versus salinity plot (Figure 24) was similar to Pb in that a clear relationship was not obvious. The high levels observed from station 10 and 15 could be the result of the industrial activity in this portion of the river, however, a trend of Zn concentration with station location on the river and estuary was not clearly evident. The data have a range of 157 to 881 ug/g with an average of 427 ug/g and a standard deviation of ±160 ug/g.

The particulate Cd data (Table 9) should be treated with caution because many of the samples were at or near the detection limit. It is clear, however, that there is a very significant decrease from a rather high concentration in the river water to low concentrations in the estuary. This decrease is paralleled by an increase in the concentration of dissolved Cd with the apparent loss of particulate Cd almost exactly matching the gain in dissolved Cd.

CONCLUSIONS

The first survey was conducted from the waters of the Pictou Road, through Pictou harbour and into the estuary of the East River in order to determine the extent of environmental pollution in this area. The SPM data was high and scattered with no clear indication of a river source. An anomalously high concentration of SPM was found at a station off Indian Cross Point (station 19) but no other chemical anomaly was noted here. No high SPM concentrations were observed in this area in the 1991 survey. The concentrations of TOC and POC from the survey do not show any reason for concern. The high phosphate concentrations reflect the effect of sewage input to the survey area.

The concentrations of dissolved cadmium, copper, manganese, iron and nickel show little variability from Pictou Road through most of the stations sampled. The average concentration for most metals was about 1 to 1.5 times the levels found in near shore coastal waters. For iron, the average concentration from the survey was 3 to 4 times coastal values, but not unlike concentrations found in other harbour/estuary systems. The higher concentrations noted at stations 17 and 18 for metals Cd, Cu, Mn, Fe and Ni were indications that the East River estuary was a source for these metals. The data for lead and zinc was more scattered but the levels were still only 1 to 2 times those found in near shore coastal waters. Indications of significant sources of dissolved lead or zinc in this survey area were not apparent.

The indications that the East River was a potentially important source of several trace metals lead to a 1991 study investigating the geochemistry of metals in the East River estuary and sources of metals in this system. The chemical/physical parameters measured in the field showed that only station 1 near Stellarton was fresh water, and stations 3-16 had a rather narrow range of salinities between 11 and 18 psu. The pH data show an increase from 7 in the river to a sea water pH of 8. The dissolved oxygen data shows only a small decrease in oxygen levels to ≈85% saturation on stations 2-4.

The nutrient data for silicate and nitrate show a negative correlation with salinity, while phosphate shows high levels at station 3 and major inputs to the water in the region where the river estuary broadens out downstream from Trenton.

The concentrations of dissolved cadmium, copper, nickel and zinc show an increase from the fresh water station near Stellarton to the first station in the estuary (station 2). Parallel decreases in particulate metals are seen for Cd and Cu but only for Cd is the decrease large enough to account for the increase in the dissolved phase. The levels of these four dissolved metals through the estuary out as far as station 17 show little variability or indication of significant input sources. A negative relationship to salinity was evident for most of the nickel, zinc and copper data. Of these metals, only zinc was shown to have a much higher concentration in the river

estuary compared to outer estuary stations 18 to 20. The data for dissolved lead and iron have a pattern of high concentrations in the first two stations with a gradual decrease through the rest of the estuary and little indication of any large input sources. Both Pb and Fe show indications of geochemical removal of the dissolved metals within the estuary. The levels of dissolved metals found in this estuarine survey were generally within a factor of two compared to near shore coastal waters.

The SPM data from the 1991 survey were relatively uniform. The higher concentrations found at station 2 and 3 may have been due to estuarine resuspension of surface sediment or flocculation processes. The decrease in particulate aluminum and iron concentrations through the estuary was an indication increasing organic content of the SPM. The particulate copper data showed a fresh water source and additional sources around stations 12 to 17. This same area had elevated levels of dissolved copper. A few high concentrations of particulate lead and zinc were observed but no clear patterns or indications of an important source were evident. Generally the concentrations of particulate copper, zinc and lead in the inner part of the estuary were within a factor of two of the levels in the outer estuary.

The metal distributions measured in these two surveys do not indicate severe contamination of the waters of the East River, the East River estuary or Pictou Harbour. Dissolved metal levels found in the East River and estuary during the 1991 survey are all within the range of concentrations normally seen in uncontaminated estuaries. The 1990 survey, however, indicated a higher dissolved Cu concentration for the East River estuary. Particulate copper and zinc concentrations are somewhat elevated compared to what might be expected for uncontaminated estuaries, based on the limited data available for estuarine particulates, but lower than levels seen in Halifax Harbour, for example (Dalziel et al., 1989). The particulate Cd concentration measured for the one sample in the East River is quite high but the estuarine concentrations of particulate Cd are relatively low.

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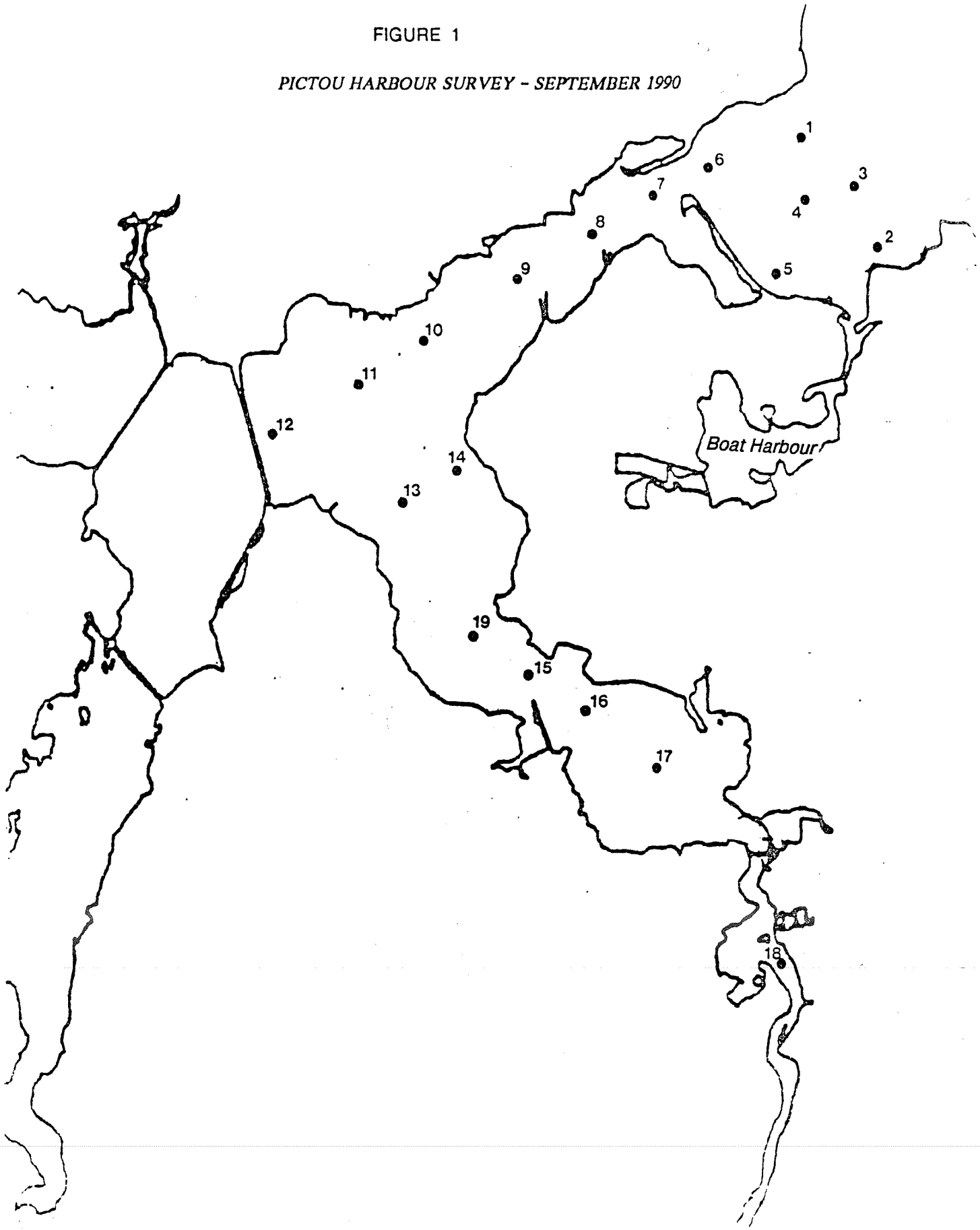
FIGURE 1

PICTOU HARBOUR SURVEY - SEPTEMBER 1990



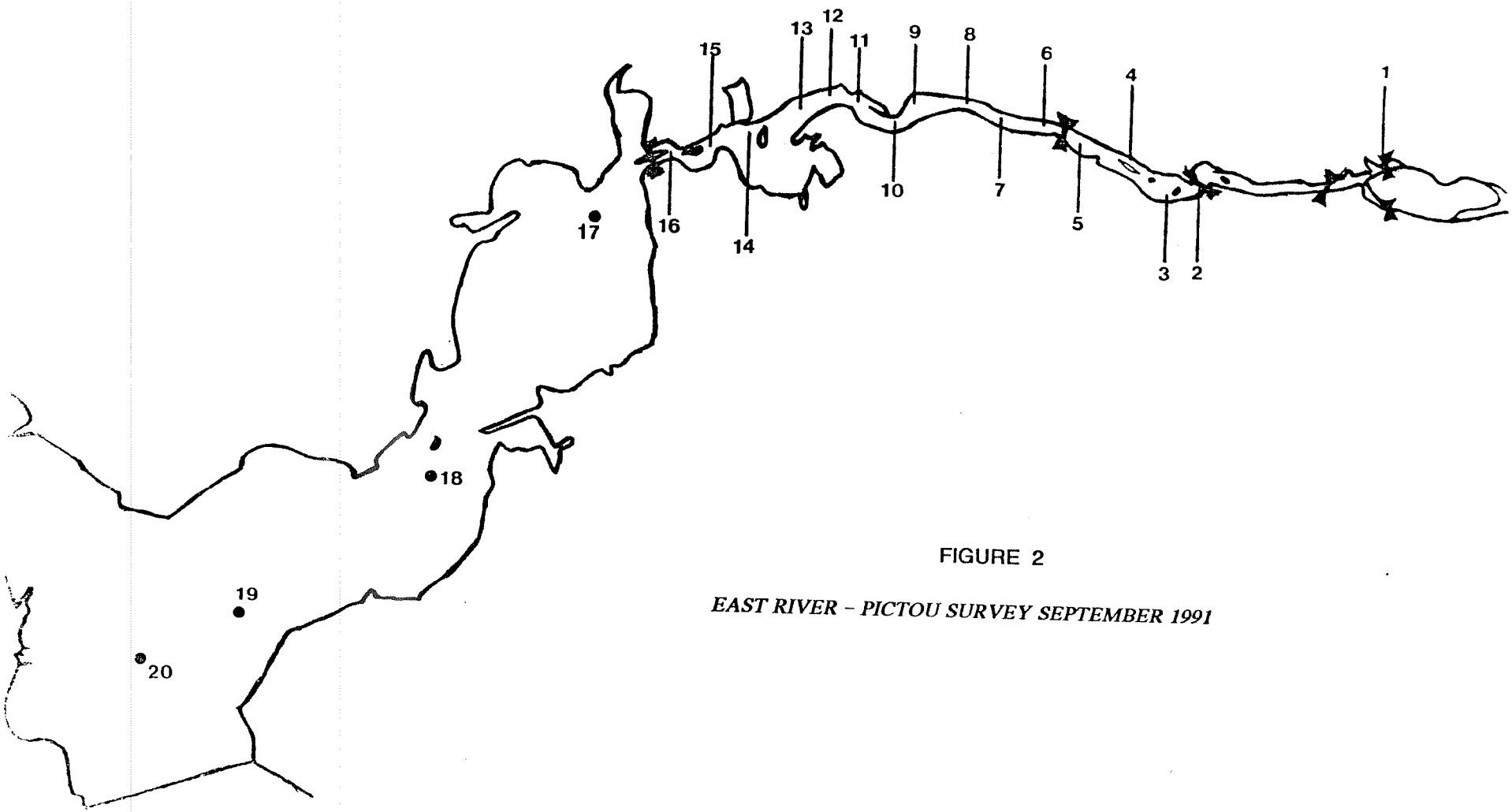
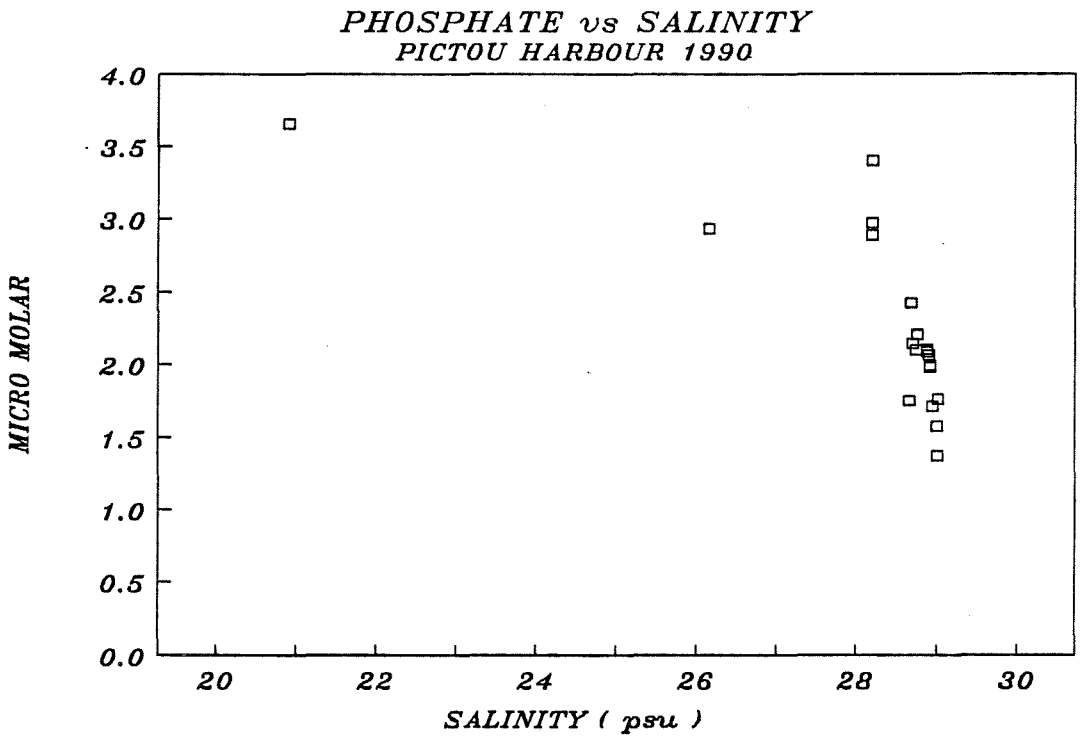


FIGURE 2

EAST RIVER – PICTOU SURVEY SEPTEMBER 1991

FIGURE 3


PHOSPHATE vs SALINITY
PICTOU HARBOUR 1990
MICRO MOLAR
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
20
22
24
26
28
30
SALINITY (psu)

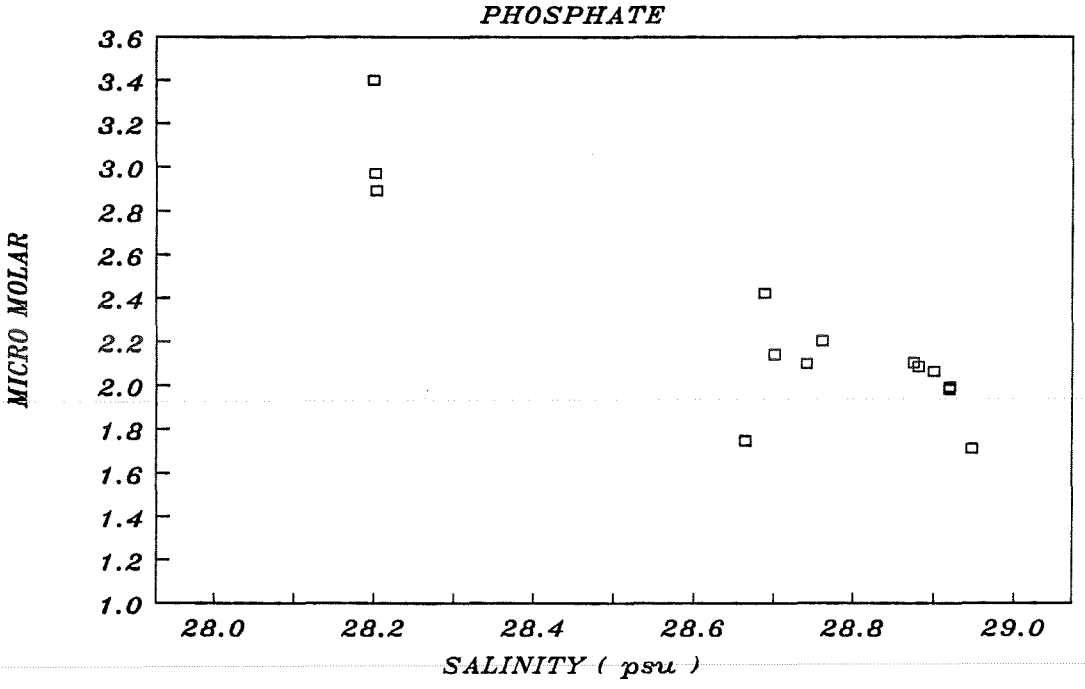
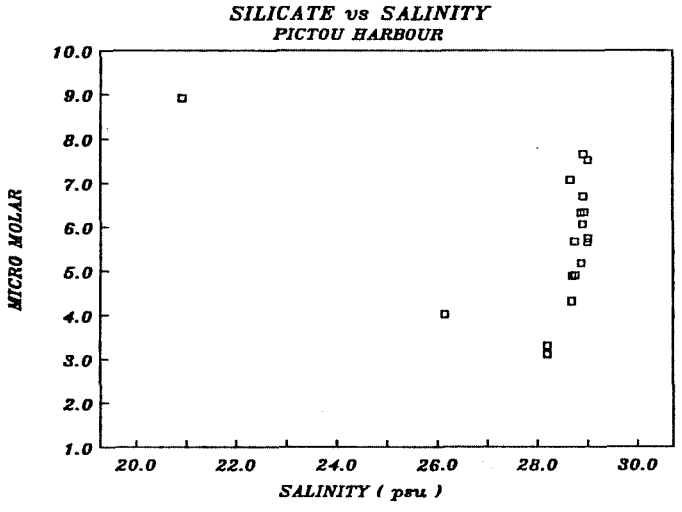
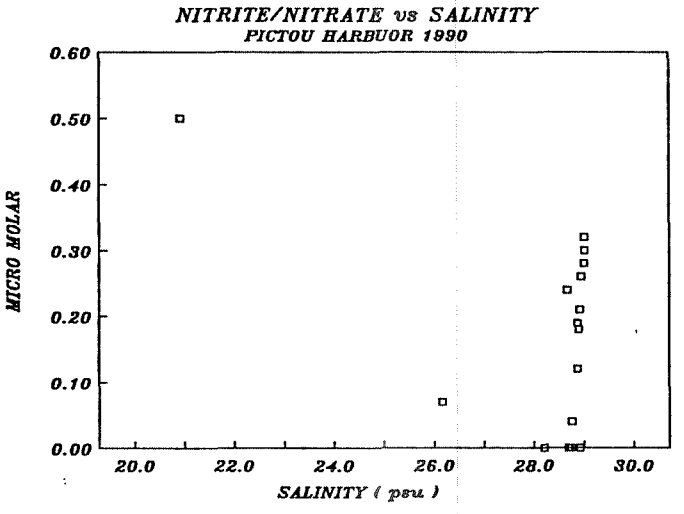
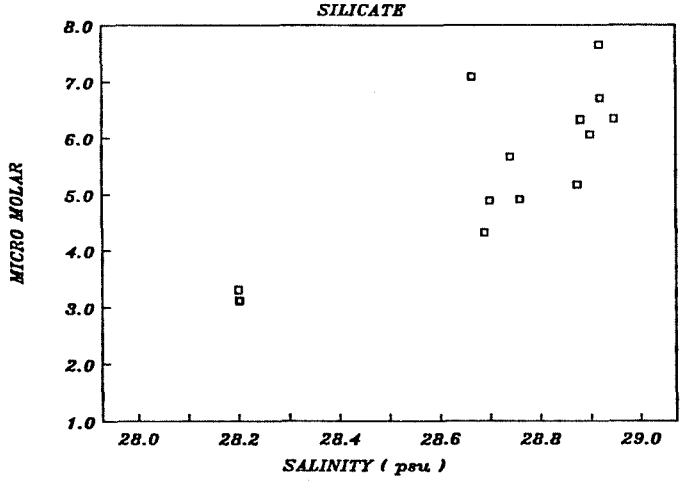

PHOSPHATE
MICRO MOLAR
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
28.0
28.2
28.4
28.6
28.8
29.0
SALINITY (psu)

FIGURE 4


SILICATE vs SALINITY
PICTOU HARBOUR
MICRO MOLAR
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
20.0
22.0
24.0
26.0
28.0
30.0
SALINITY (psu)


NITRITE/NITRATE vs SALINITY
PICTOU HARBUOR 1990
MICRO MOLAR
0.60
0.50
0.40
0.30
0.20
0.10
0.00
20.0
22.0
24.0
26.0
28.0
30.0
SALINITY (psu)


SILICATE
MICRO MOLAR
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
28.0
28.2
28.4
28.6
28.8
29.0
SALINITY (psu)

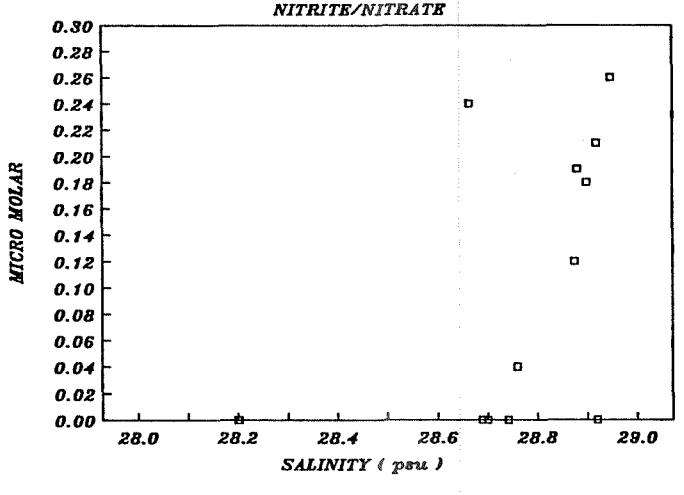
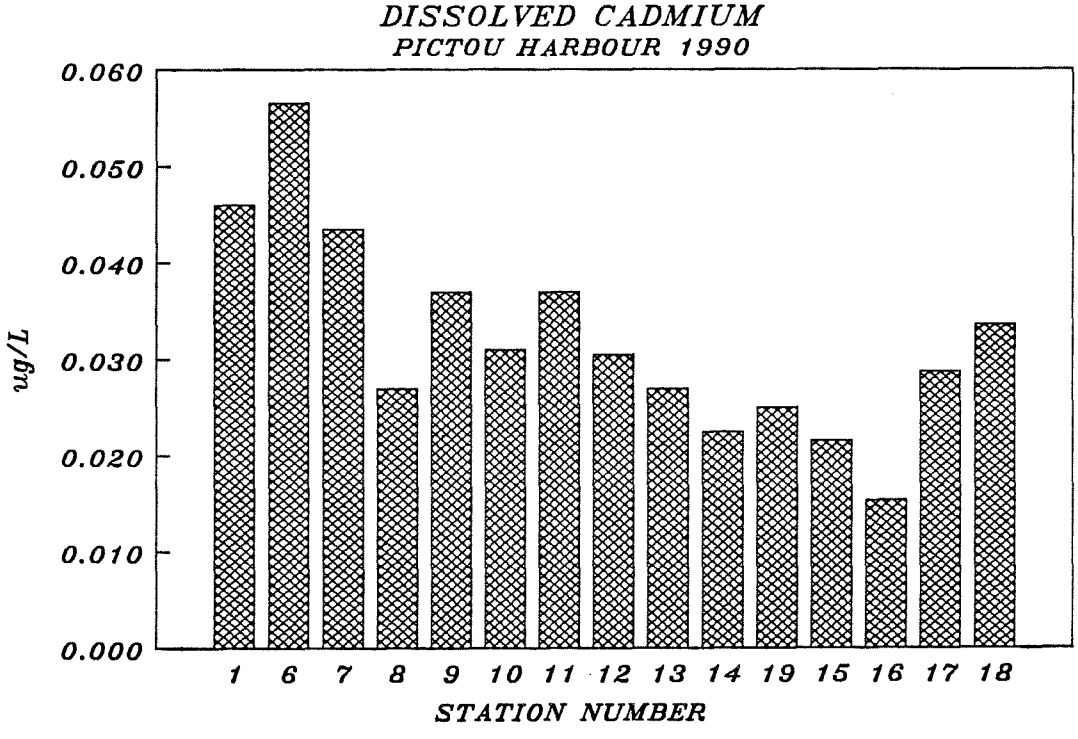

NITRITE/NITRATE
MICRO MOLAR
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
28.0
28.2
28.4
28.6
28.8
29.0
SALINITY (psu)

FIGURE 5


DISSOLVED CADMIUM
PICTOU HARBOUR 1990
0.060
0.050
0.040
0.030
0.020
0.010
0.000
ug/L
1 6 7 8 9 10 11 12 13 14 19 15 16 17 18
STATION NUMBER

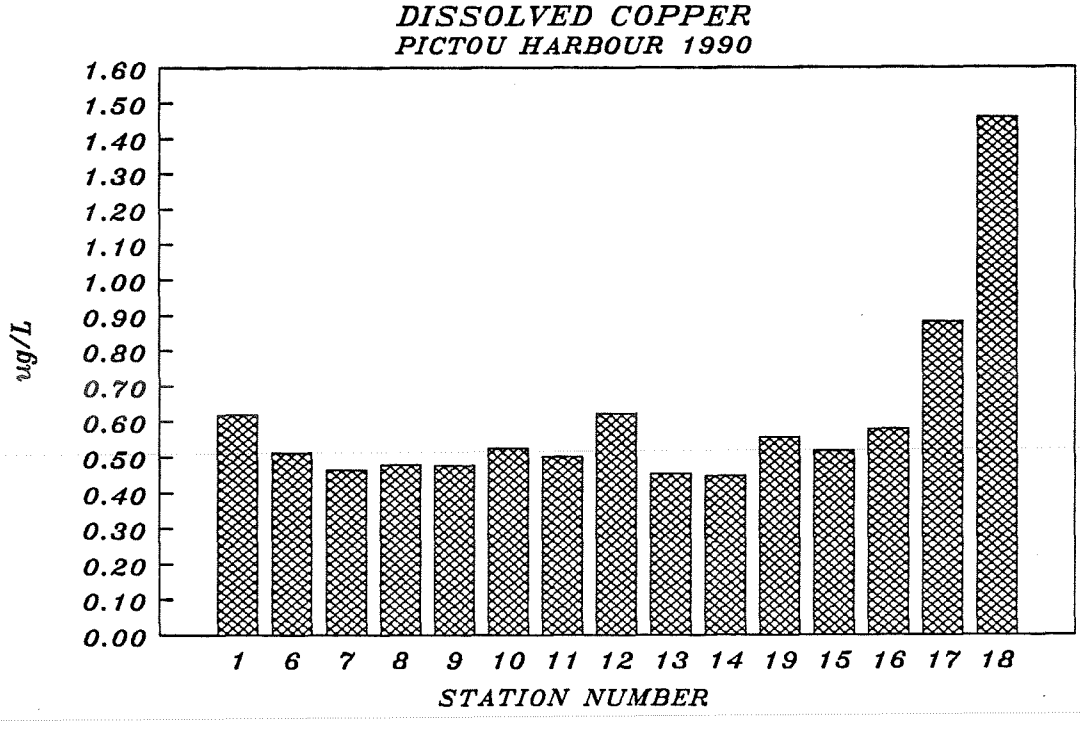
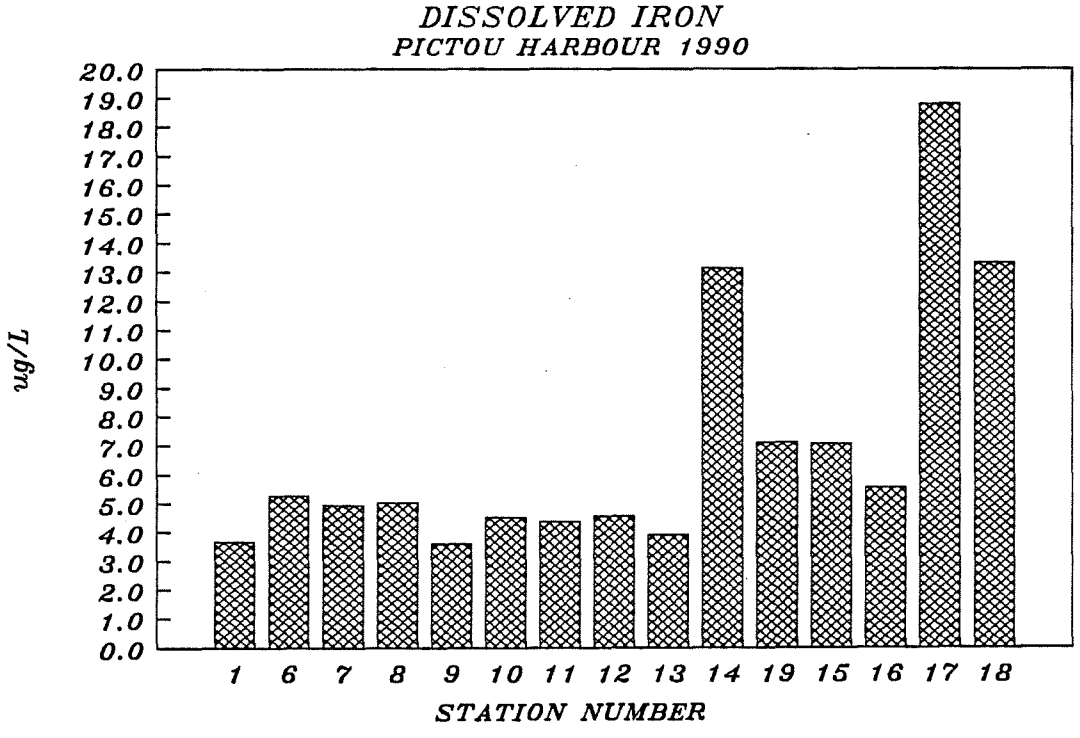

DISSOLVED COPPER
PICTOU HARBOUR 1990
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
ug/L
1 6 7 8 9 10 11 12 13 14 19 15 16 17 18
STATION NUMBER

FIGURE 6


DISSOLVED IRON
PICTOU HARBOUR 1990
ug/L
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1 6 7 8 9 10 11 12 13 14 19 15 16 17 18
STATION NUMBER

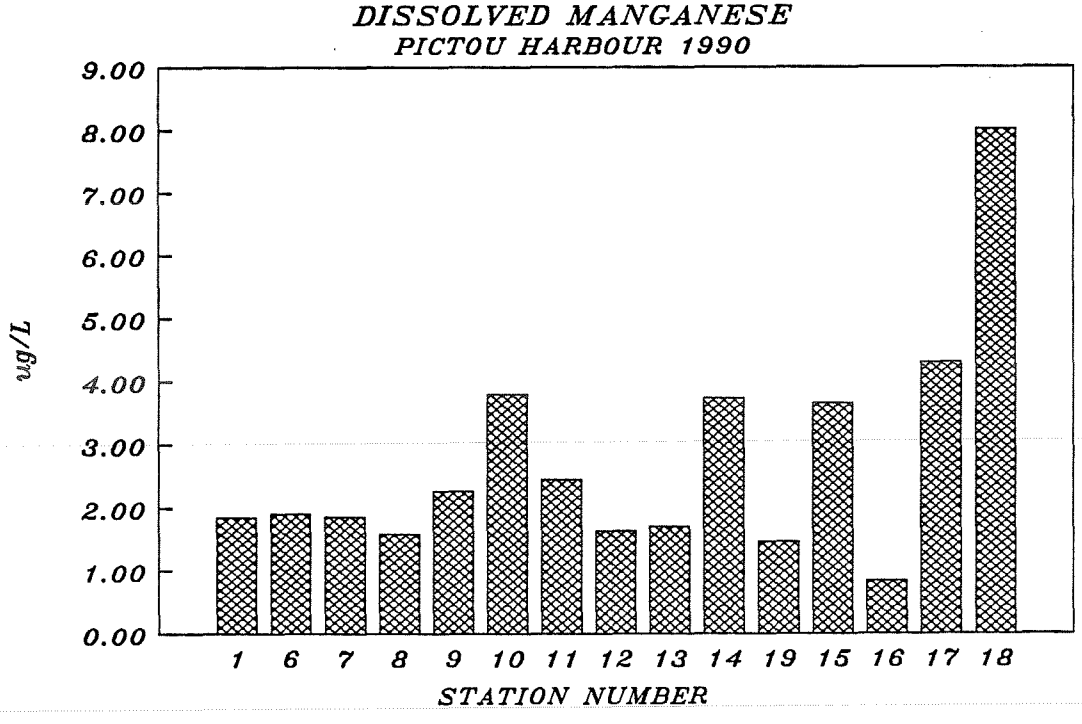
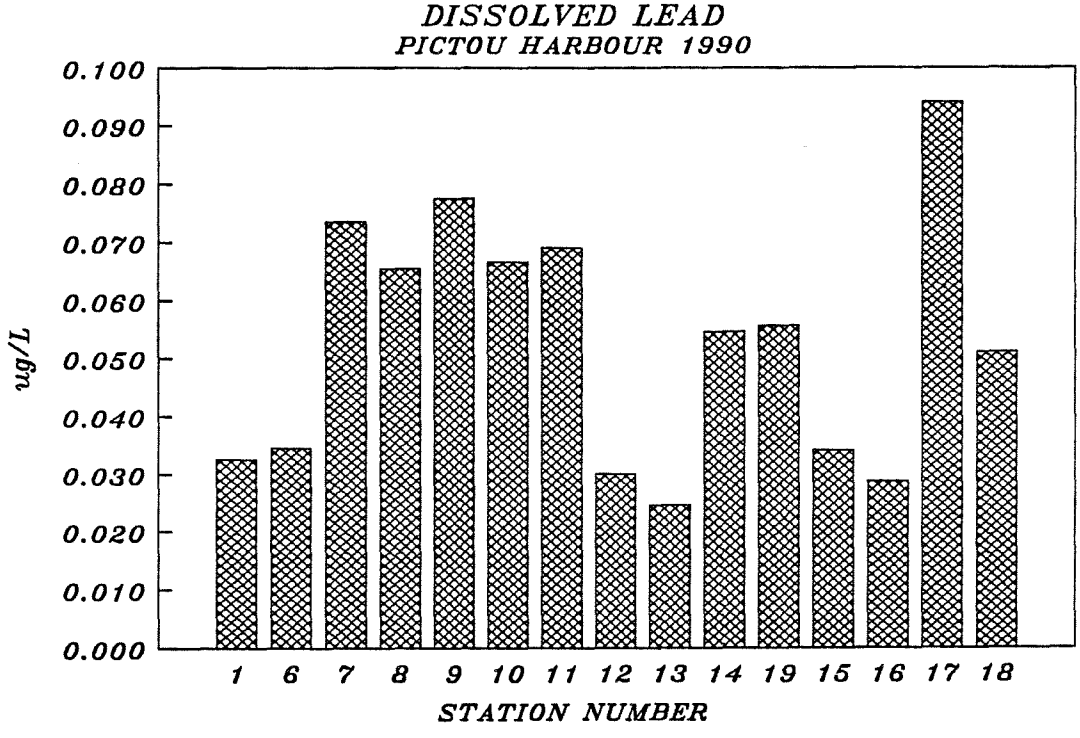

DISSOLVED MANGANESE
PICTOU HARBOUR 1990
ug/L
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
1 6 7 8 9 10 11 12 13 14 19 15 16 17 18
STATION NUMBER

FIGURE 7


DISSOLVED LEAD
PICTOU HARBOUR 1990
0.100
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
ug/L
1 6 7 8 9 10 11 12 13 14 19 15 16 17 18
STATION NUMBER

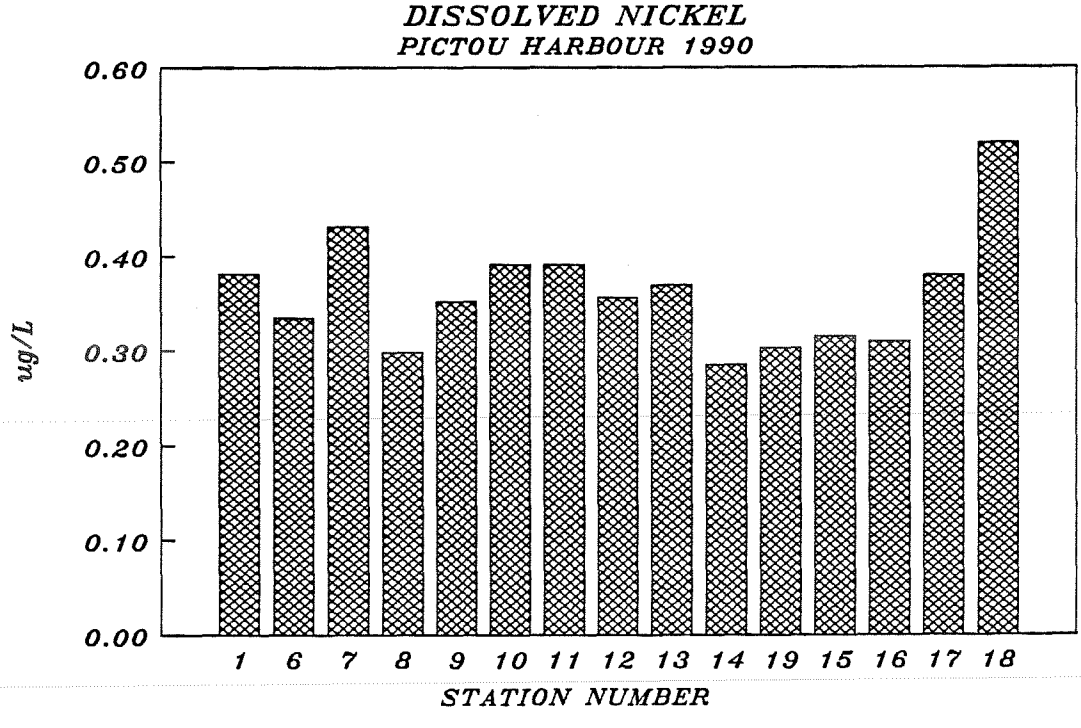

DISSOLVED NICKEL
PICTOU HARBOUR 1990
0.60
0.50
0.40
0.30
0.20
0.10
0.00
ug/L
1 6 7 8 9 10 11 12 13 14 19 15 16 17 18
STATION NUMBER

FIGURE 8

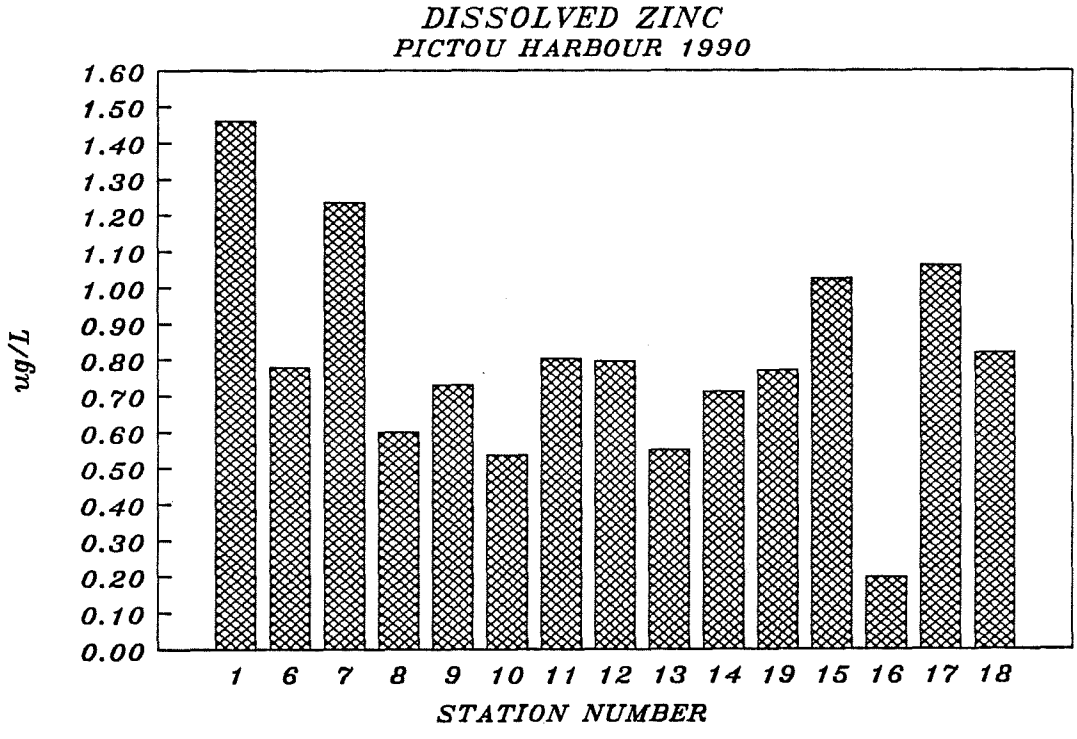
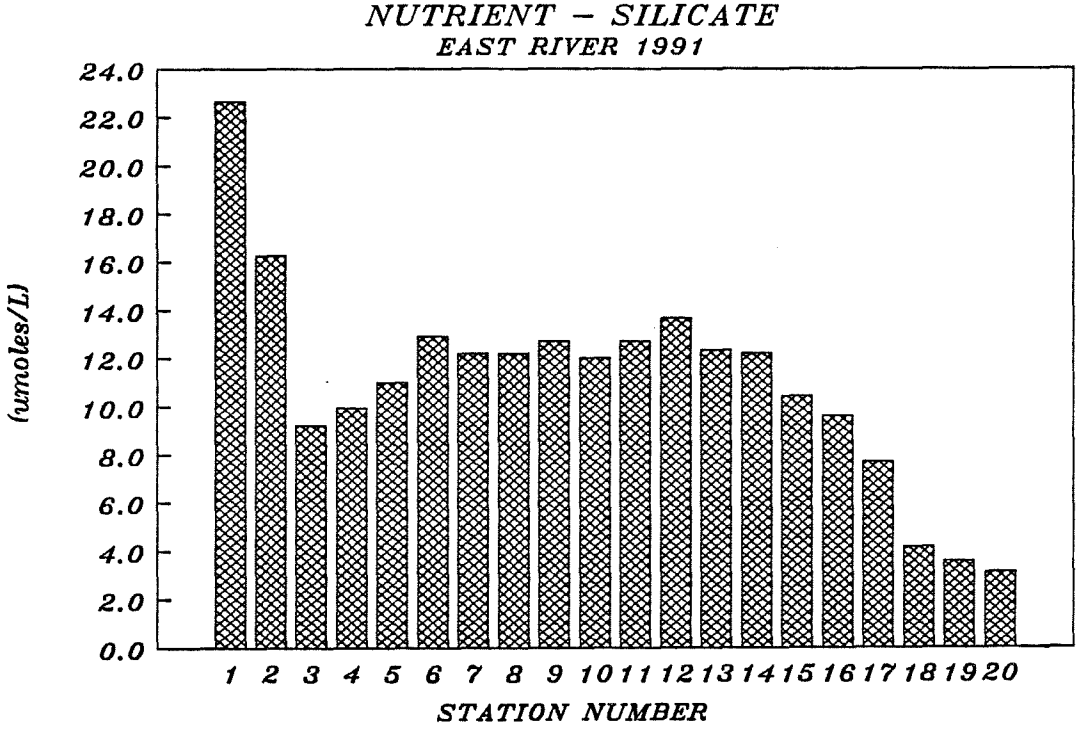

DISSOLVED ZINC
PICTOU HARBOUR 1990
ug/L
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1 6 7 8 9 10 11 12 13 14 19 15 16 17 18
STATION NUMBER

FIGURE 9


NUTRIENT – SILICATE
EAST RIVER 1991
(umoles/L)
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
STATION NUMBER

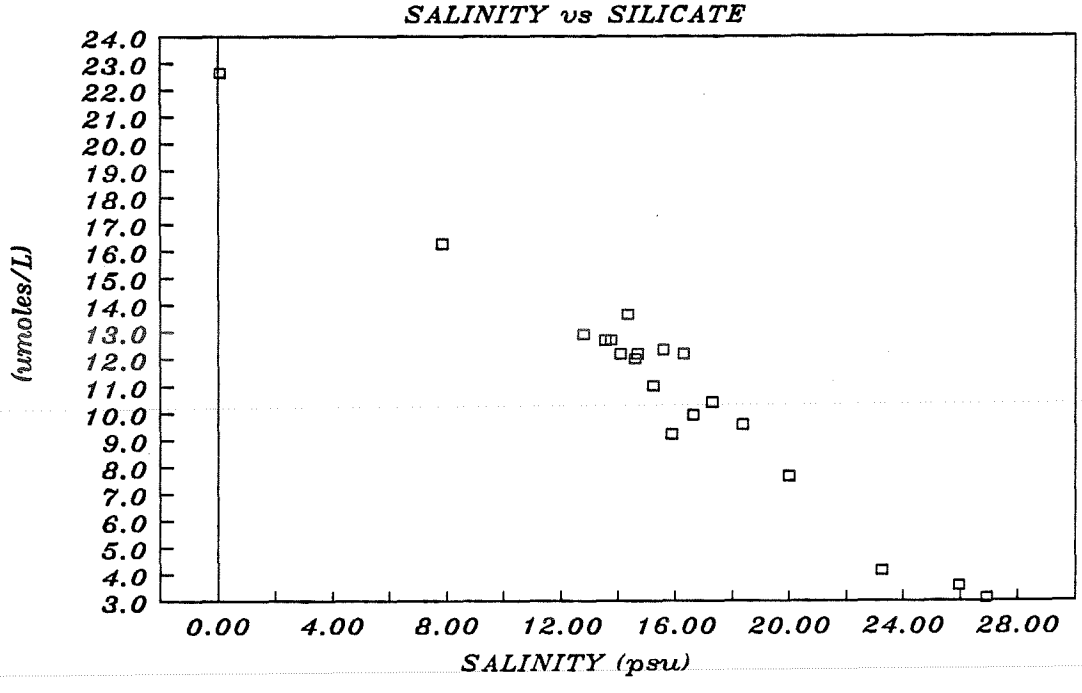
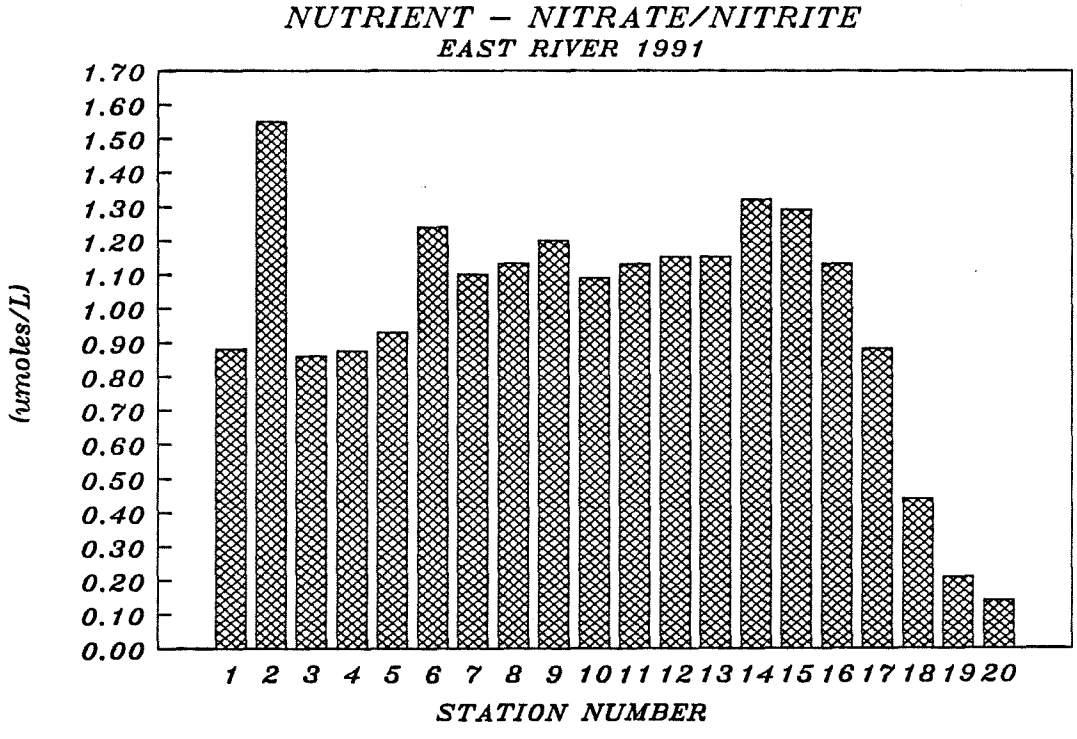

SALINITY vs SILICATE
(umoles/L)
24.0
23.0
22.0
21.0
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00
SALINITY (psu)

FIGURE 10


NUTRIENT – NITRATE/NITRITE
EAST RIVER 1991
(umoles/L)
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
STATION NUMBER

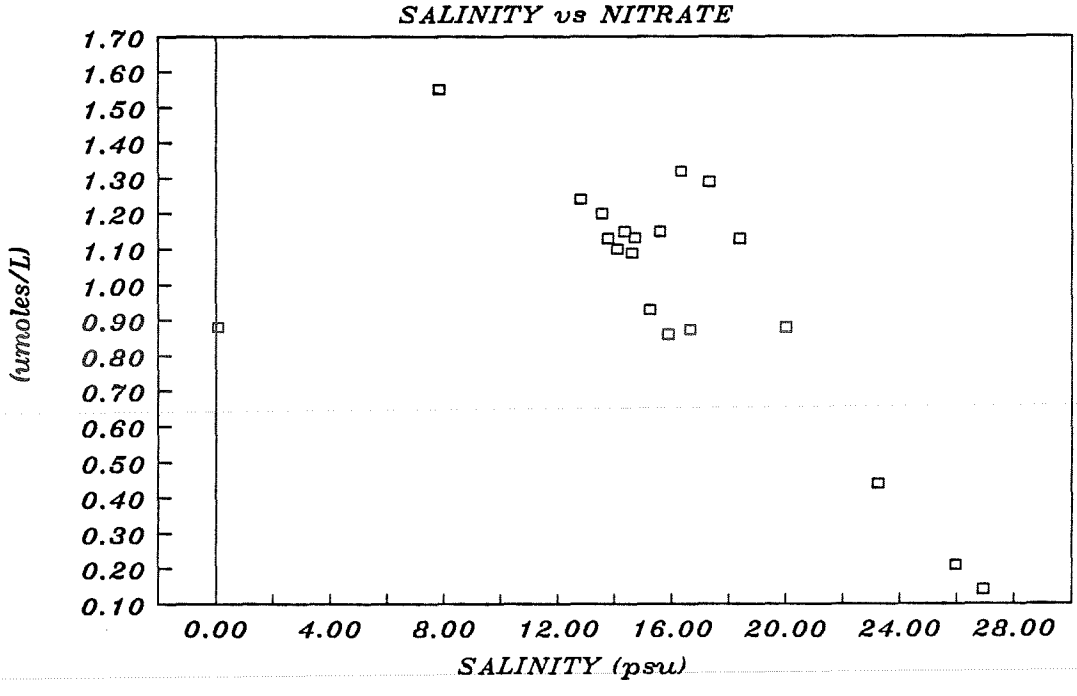
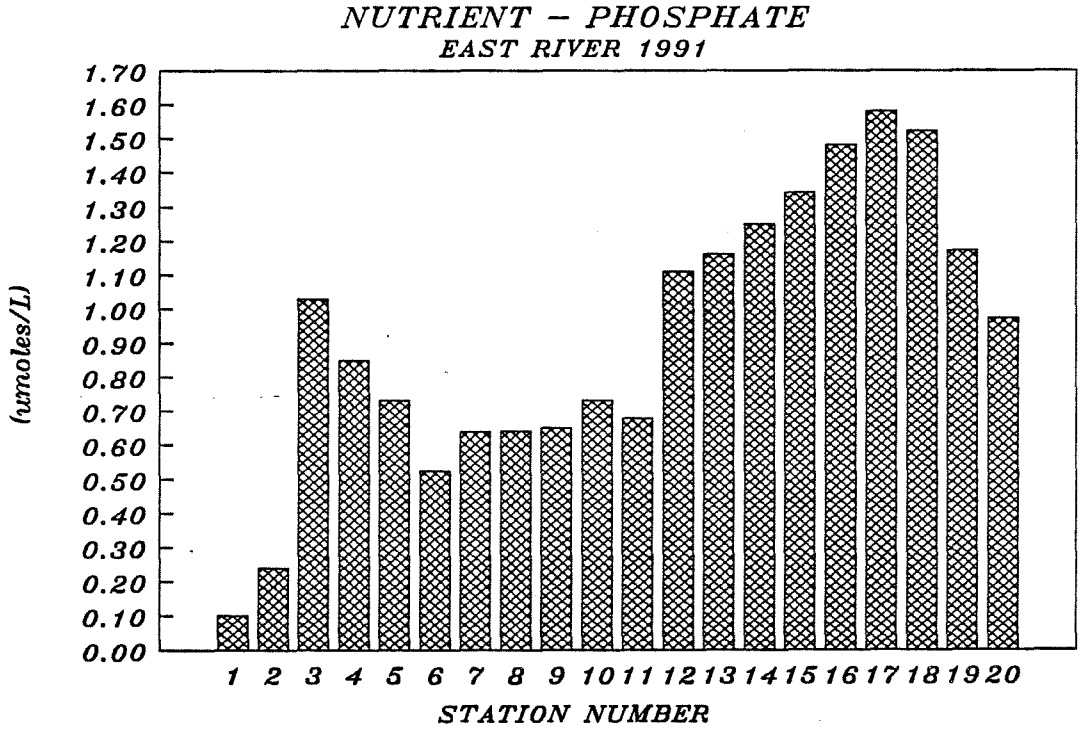

SALINITY vs NITRATE
(umoles/L)
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
SALINITY (psu)

FIGURE 11


NUTRIENT – PHOSPHATE
EAST RIVER 1991
(umoles/L)
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
STATION NUMBER

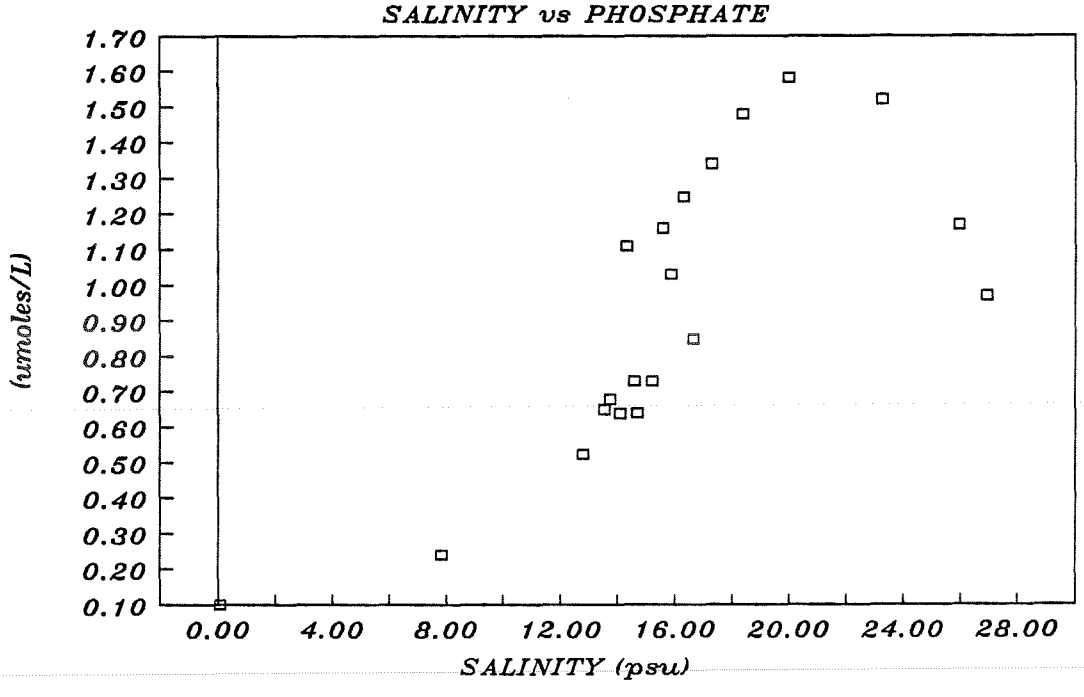
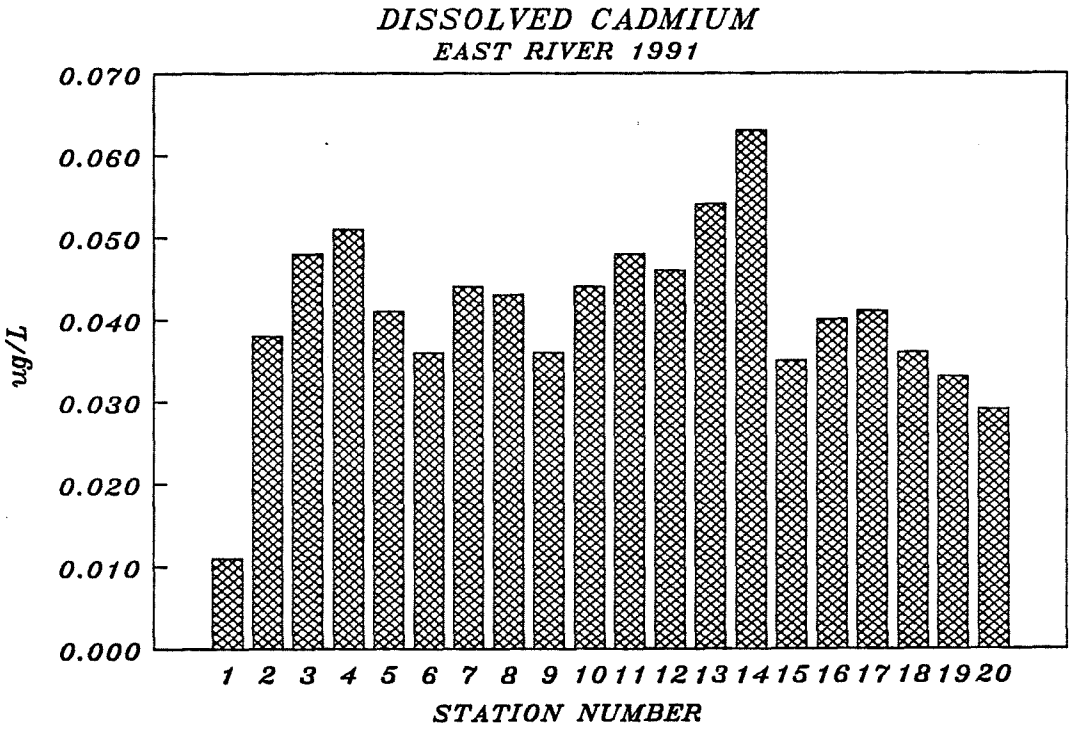

SALINITY vs PHOSPHATE
(umoles/L)
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
SALINITY (psu)

FIGURE 12


DISSOLVED CADMIUM
EAST RIVER 1991
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
ug/L
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
STATION NUMBER

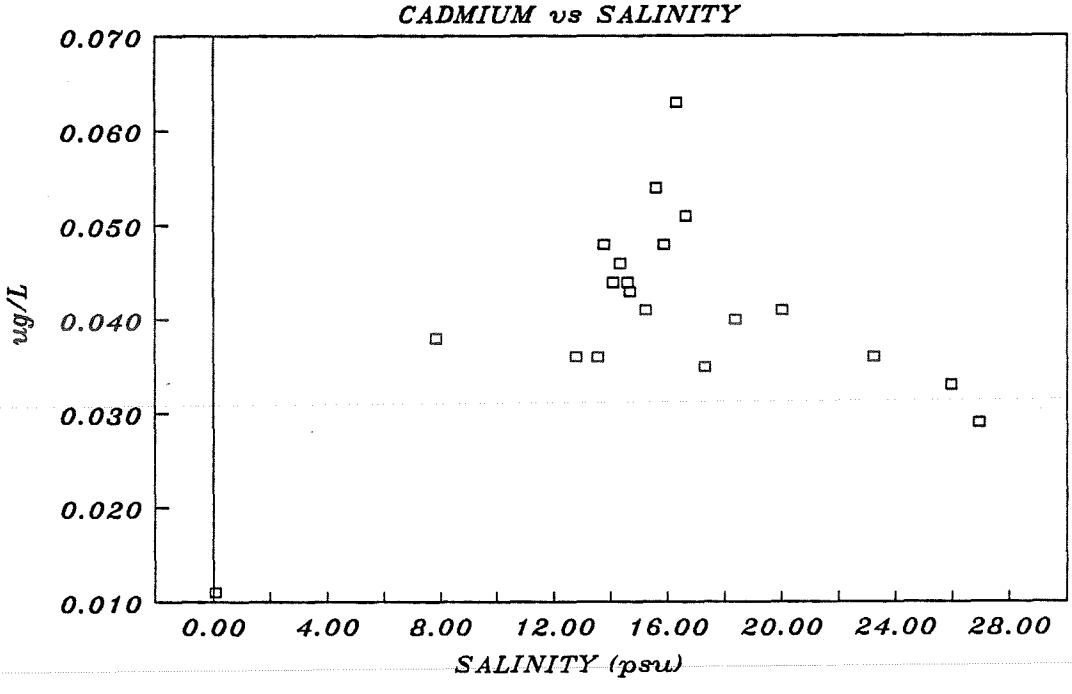
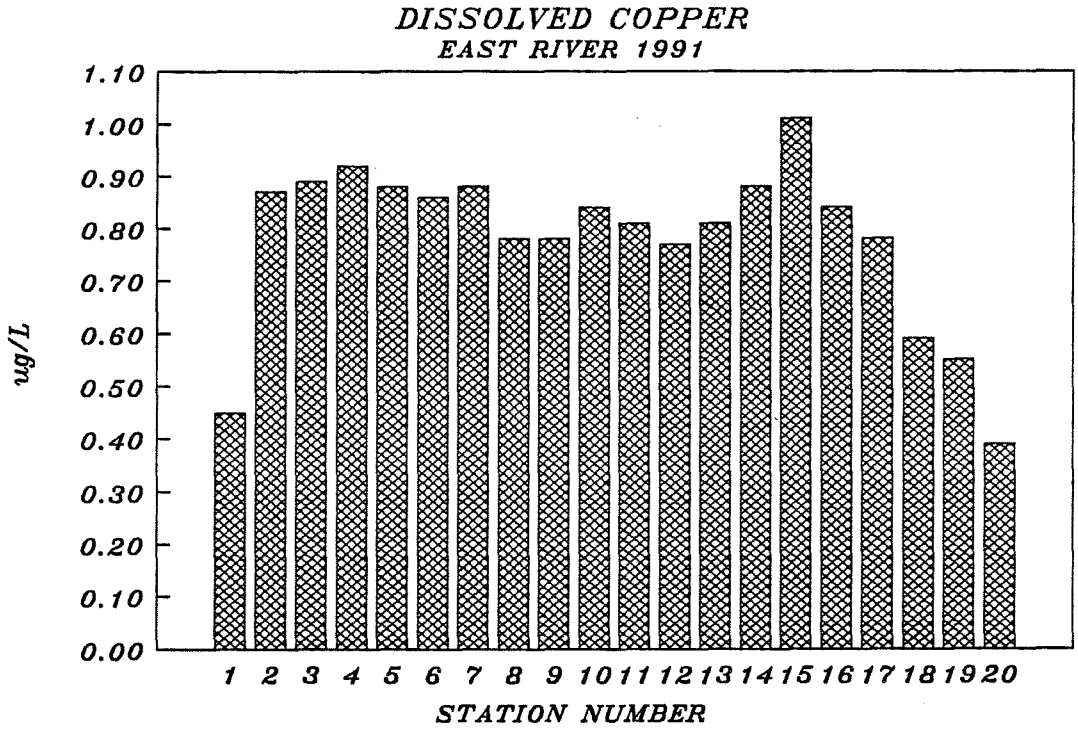

CADMIUM vs SALINITY
0.070
0.060
0.050
0.040
0.030
0.020
0.010
ug/L
0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00
SALINITY (psu)

FIGURE 13


DISSOLVED COPPER
EAST RIVER 1991
ug/L
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
STATION NUMBER

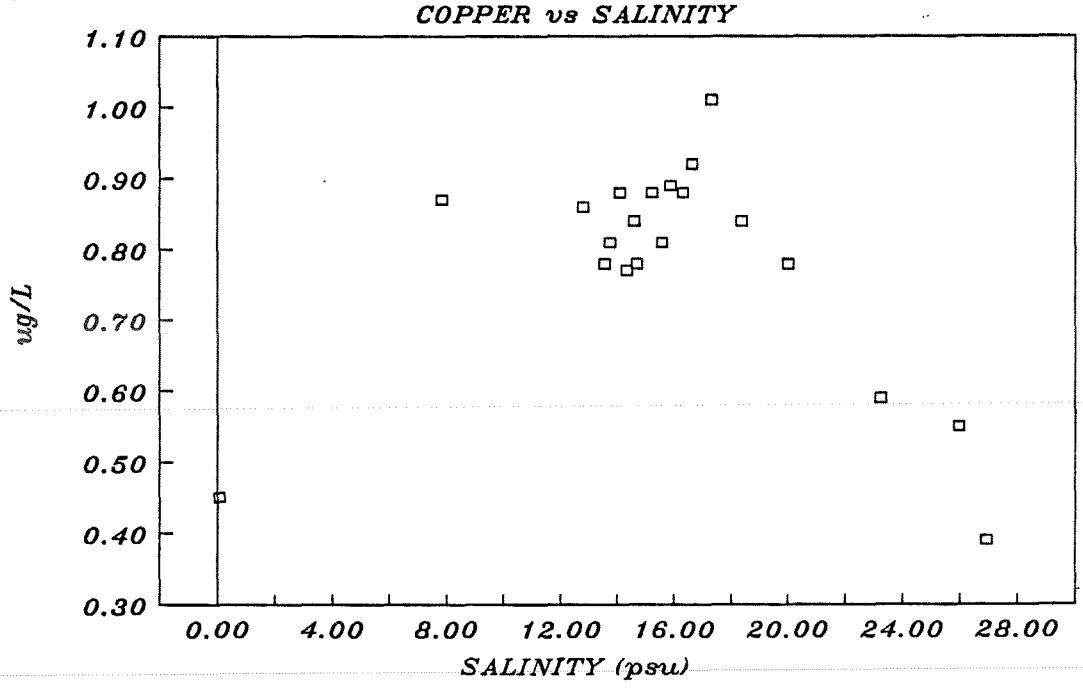
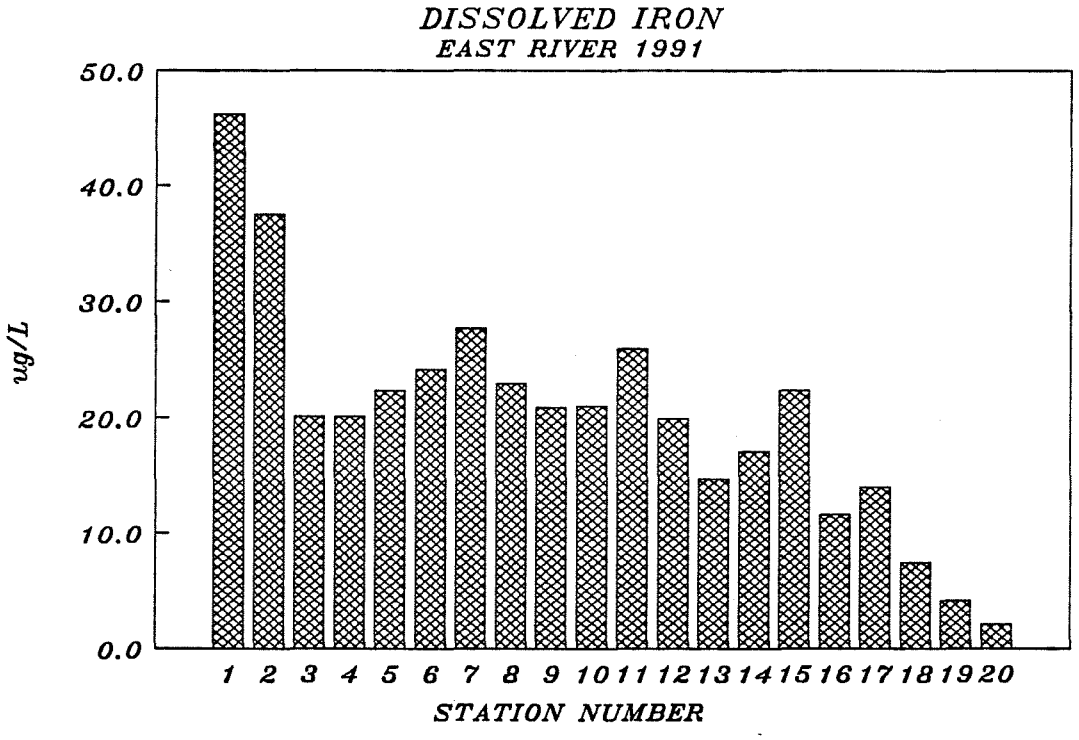

COPPER vs SALINITY
ug/L
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00
SALINITY (psu)

FIGURE 14


DISSOLVED IRON
EAST RIVER 1991
50.0
40.0
30.0
20.0
10.0
0.0
ug/L
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
STATION NUMBER

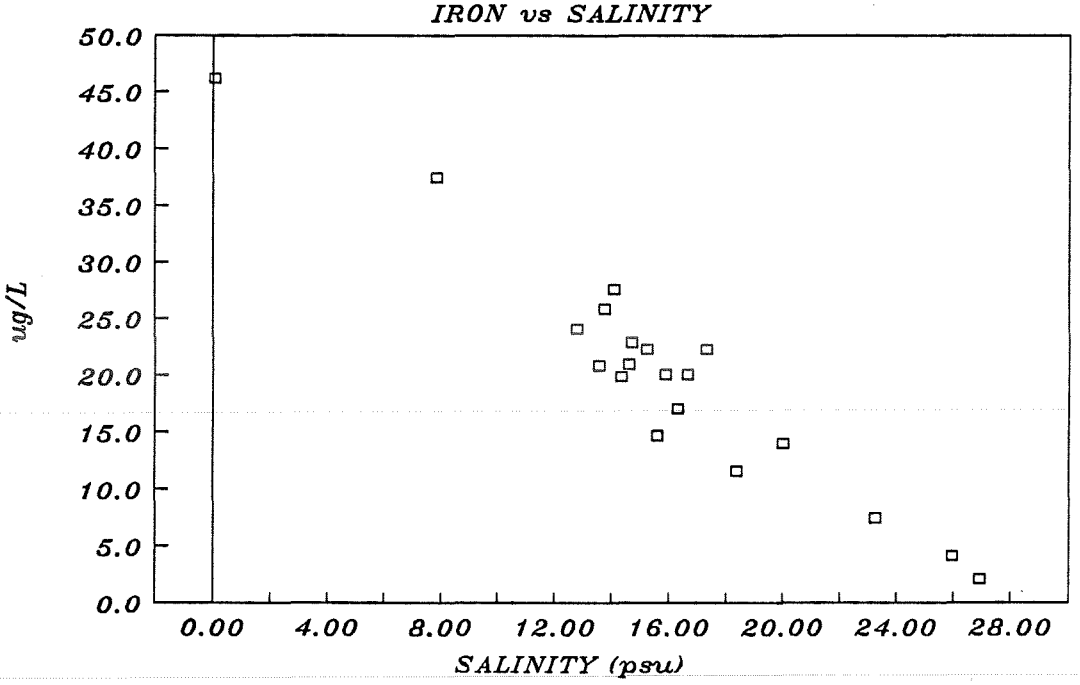
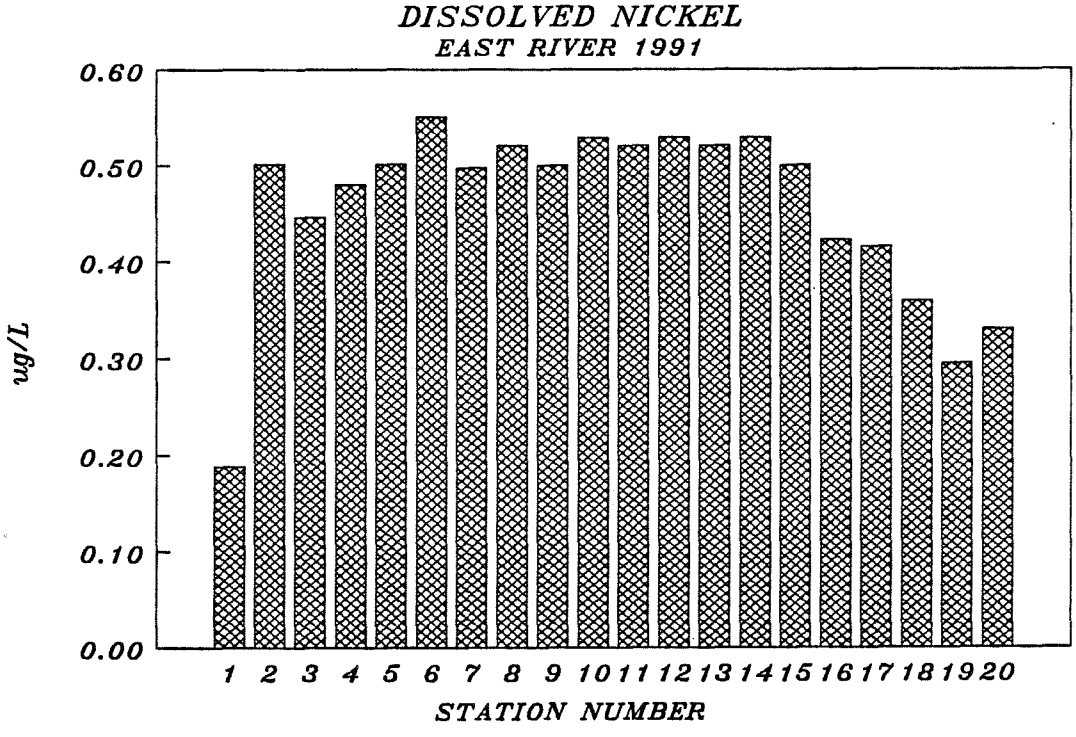

IRON vs SALINITY
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
ug/L
0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00
SALINITY (psu)

FIGURE 15


DISSOLVED NICKEL
EAST RIVER 1991
0.60
0.50
0.40
0.30
0.20
0.10
0.00
ug/L
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
STATION NUMBER

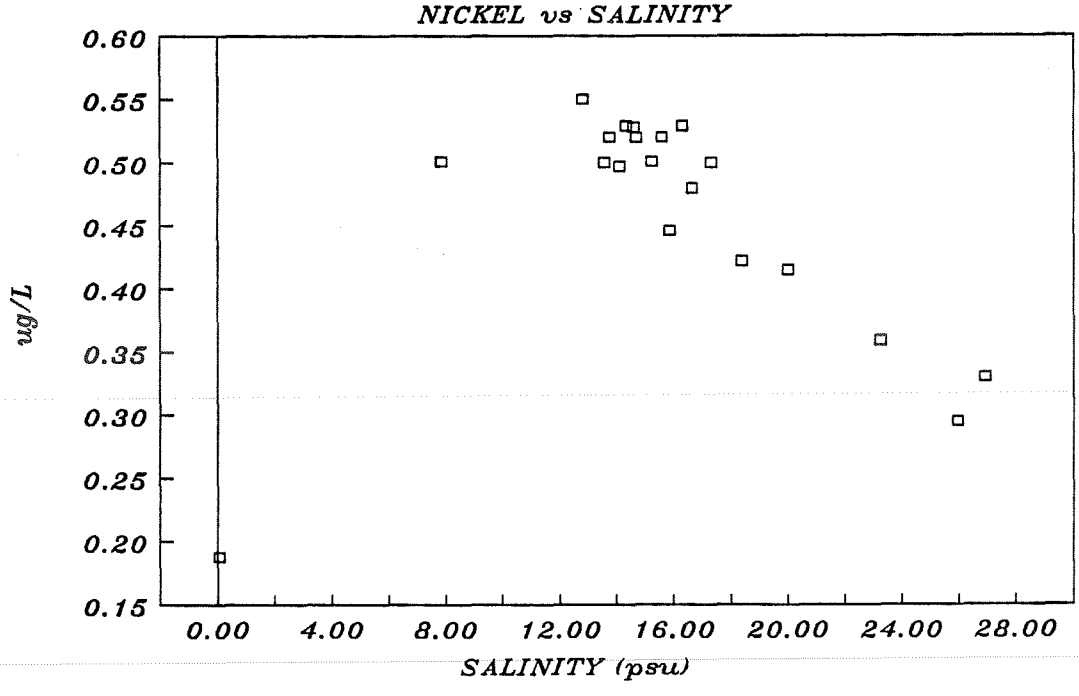
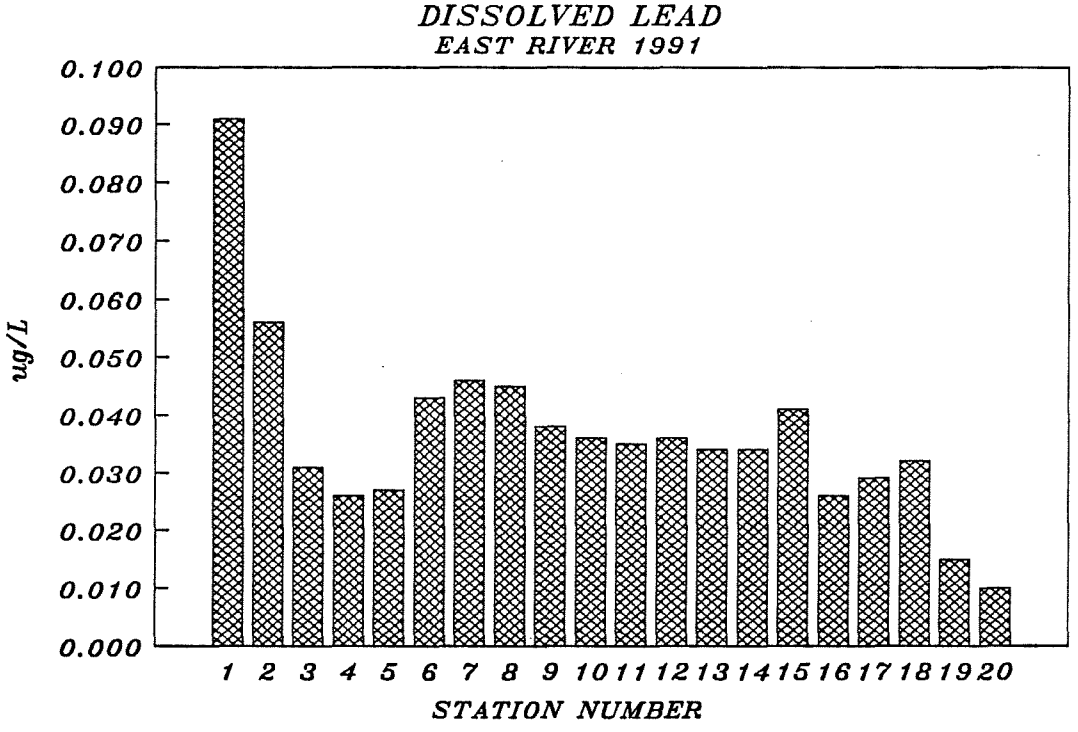

NICKEL vs SALINITY
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
ug/L
0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00
SALINITY (psu)

FIGURE 16


DISSOLVED LEAD
EAST RIVER 1991
0.100
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
ug/L
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
STATION NUMBER

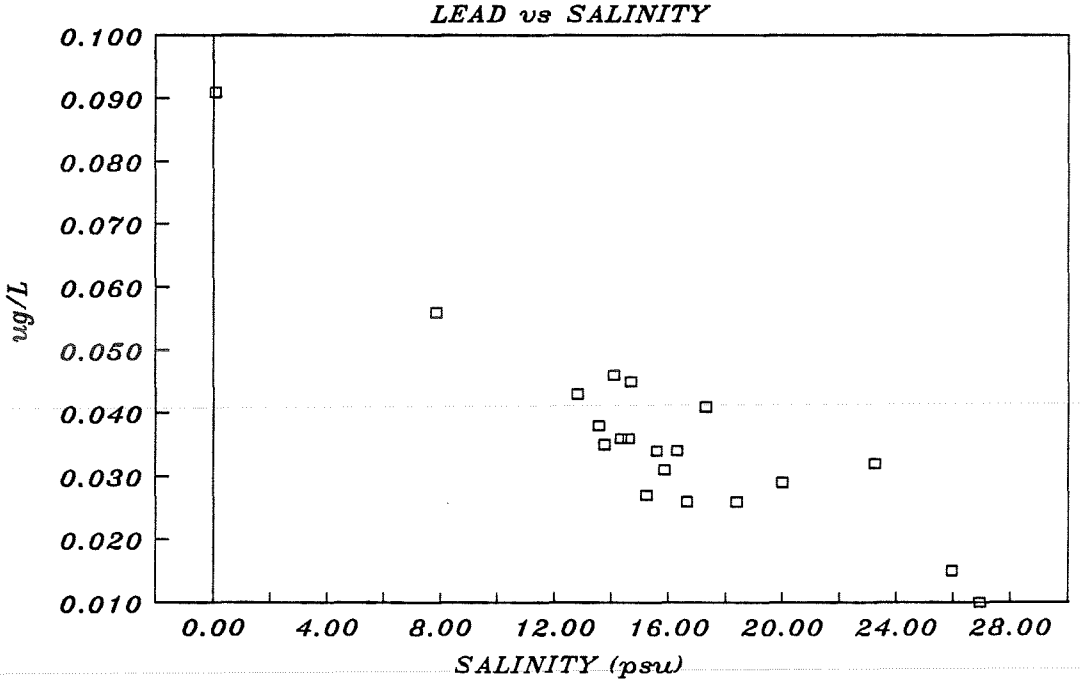
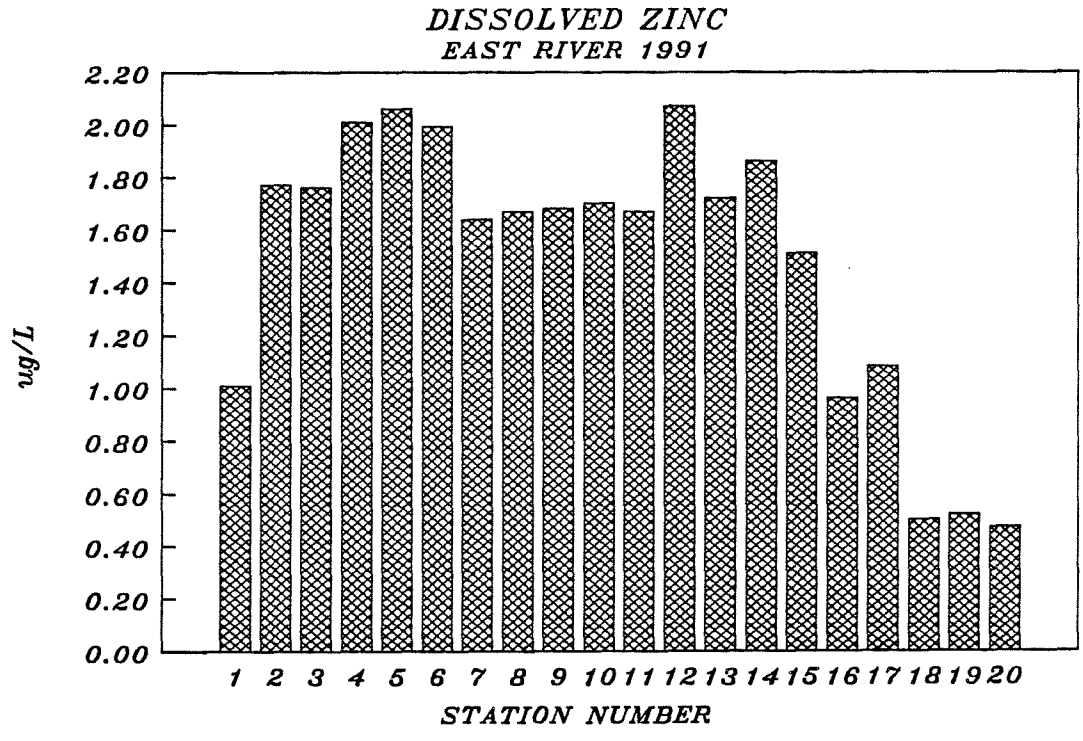

LEAD vs SALINITY
0.100
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
ug/L
0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00
SALINITY (psu)

FIGURE 17


DISSOLVED ZINC
EAST RIVER 1991
ug/L
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
STATION NUMBER

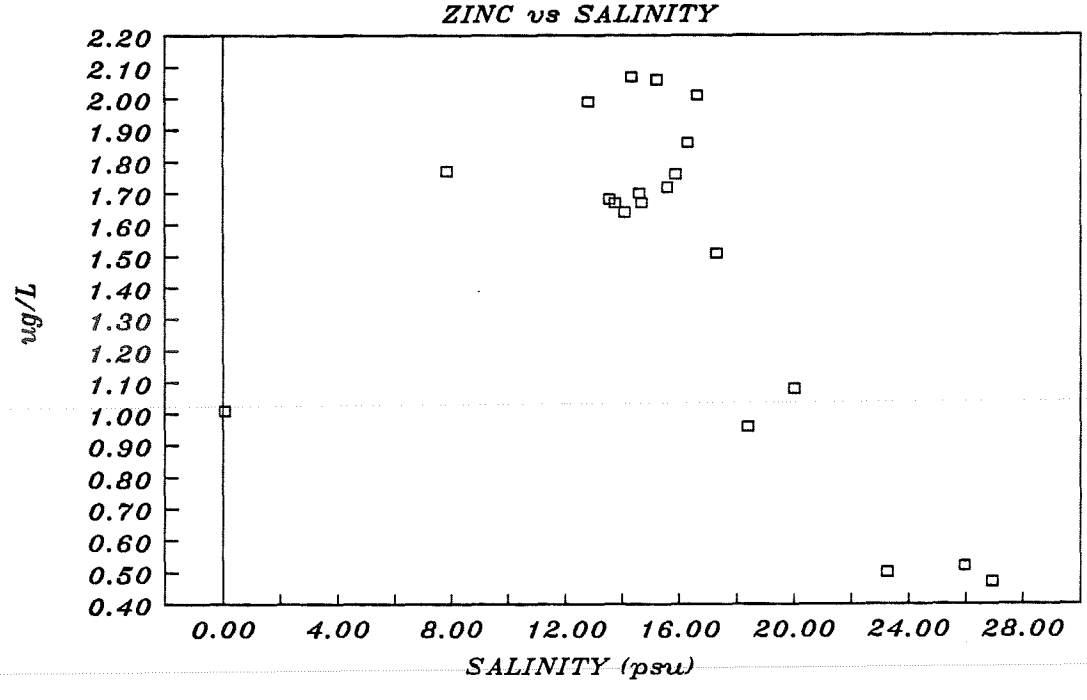
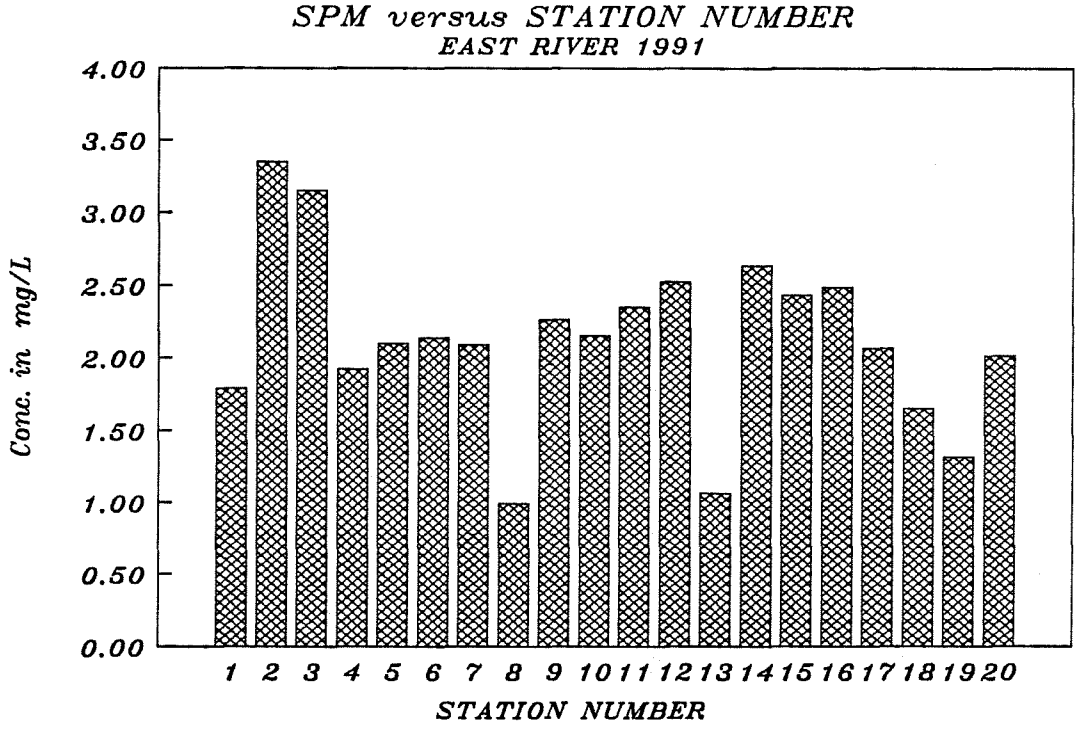

ZINC vs SALINITY
ug/L
2.20
2.10
2.00
1.90
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00
SALINITY (psu)

FIGURE 18


SPM versus STATION NUMBER
EAST RIVER 1991
Conc. in mg/L
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
STATION NUMBER

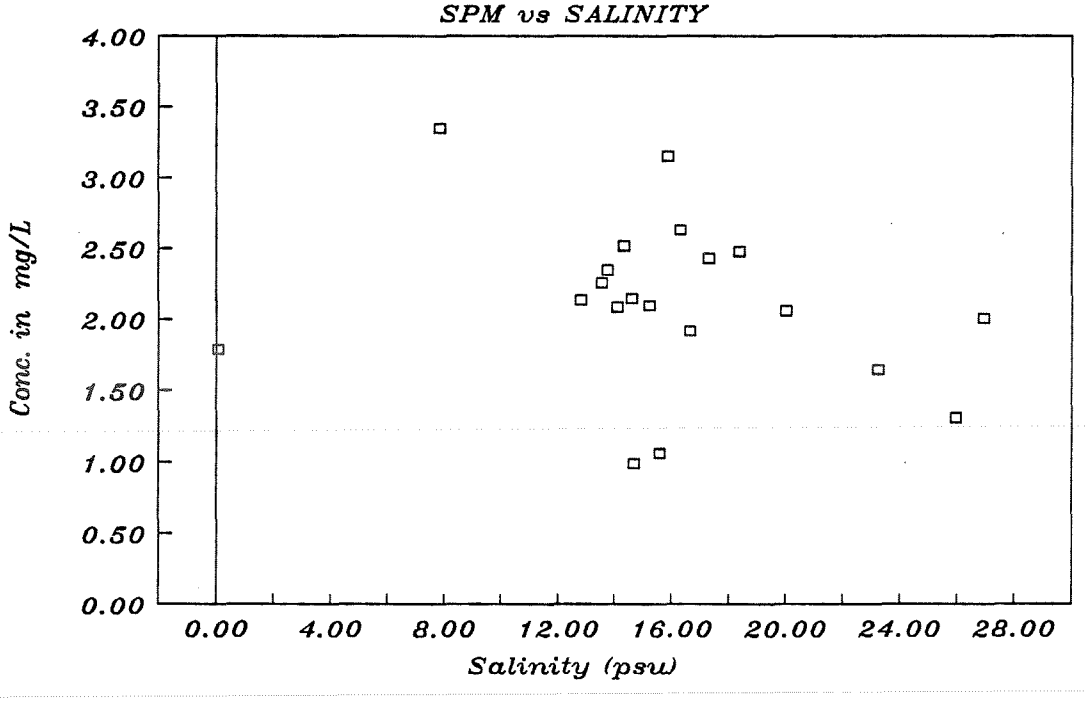
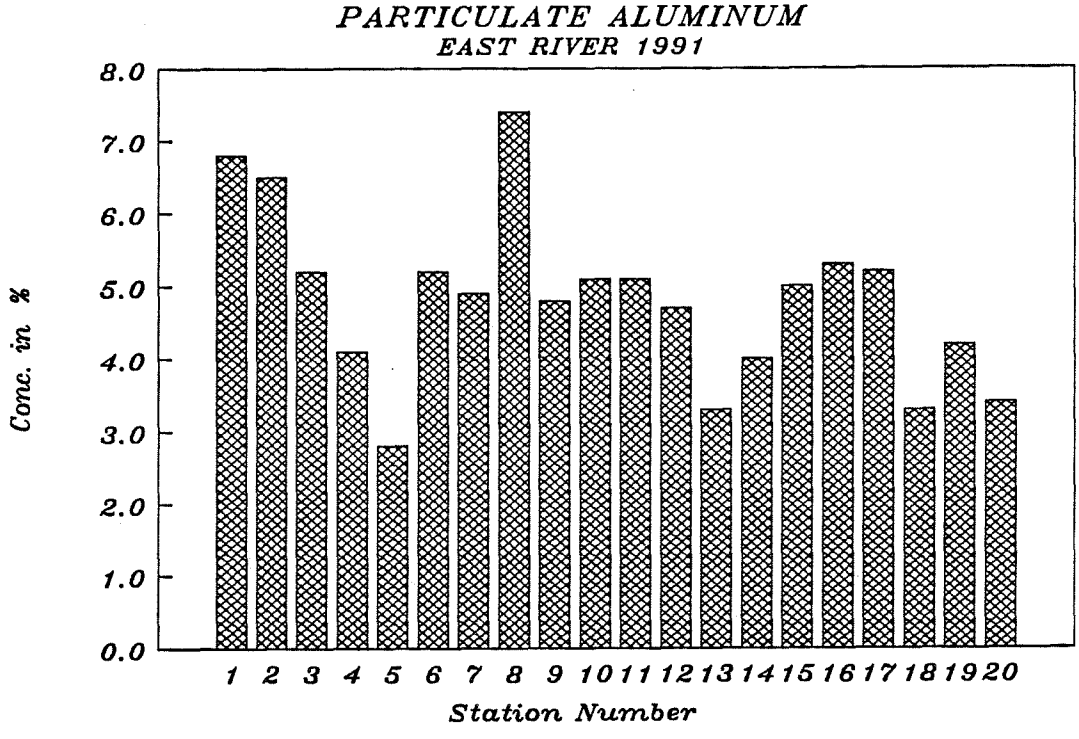

SPM vs SALINITY
Conc. in mg/L
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00
Salinity (psu)

FIGURE 19


PARTICULATE ALUMINUM
EAST RIVER 1991
Conc. in %
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Station Number

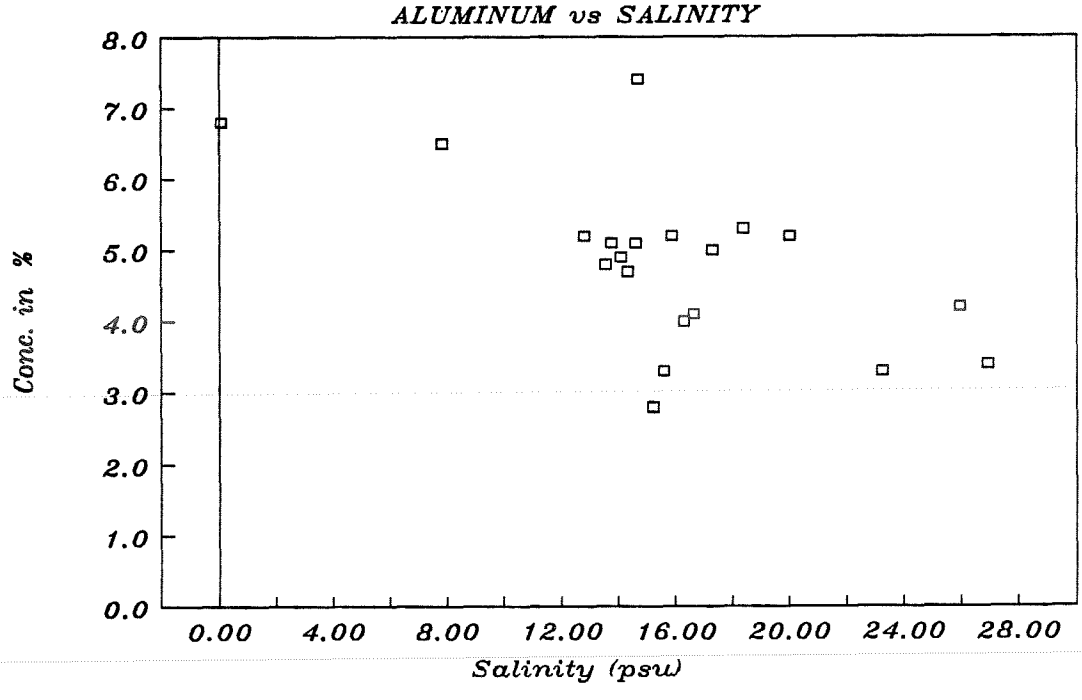
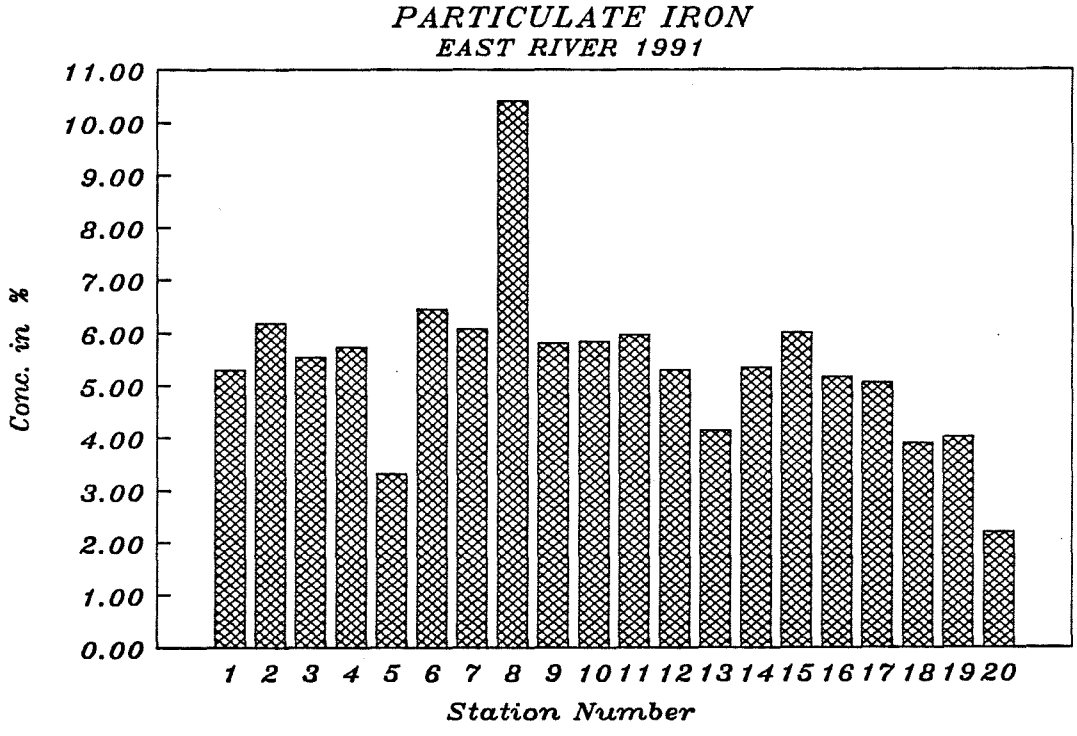

ALUMINUM vs SALINITY
Conc. in %
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00
Salinity (psw)

FIGURE 20


PARTICULATE IRON
EAST RIVER 1991
Conc. in %
11.00
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Station Number

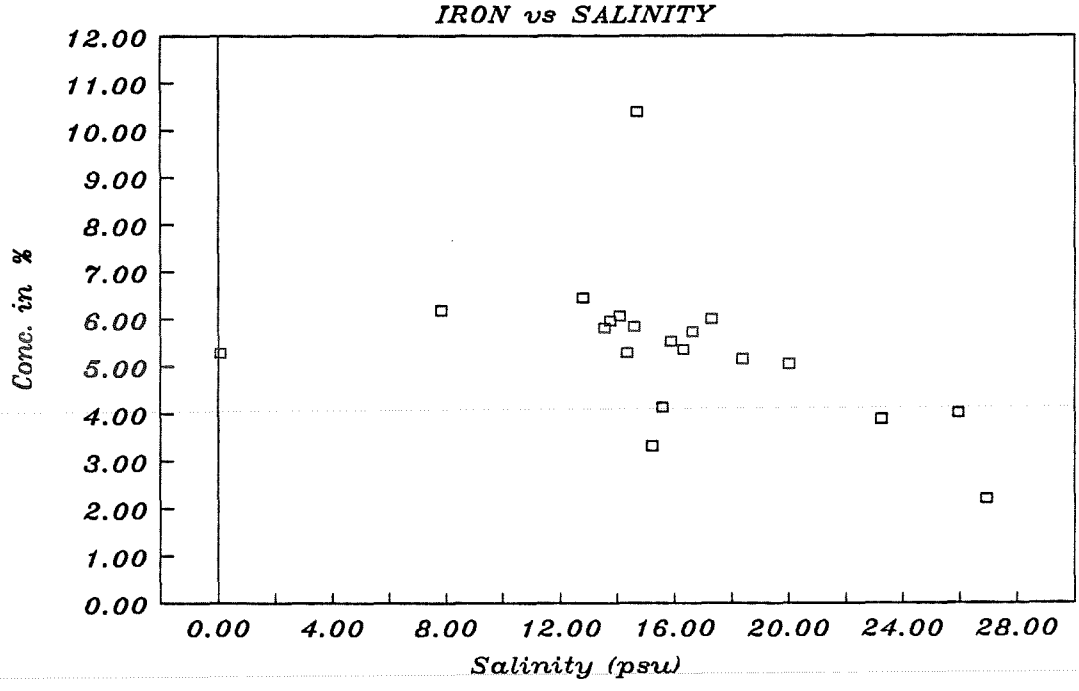
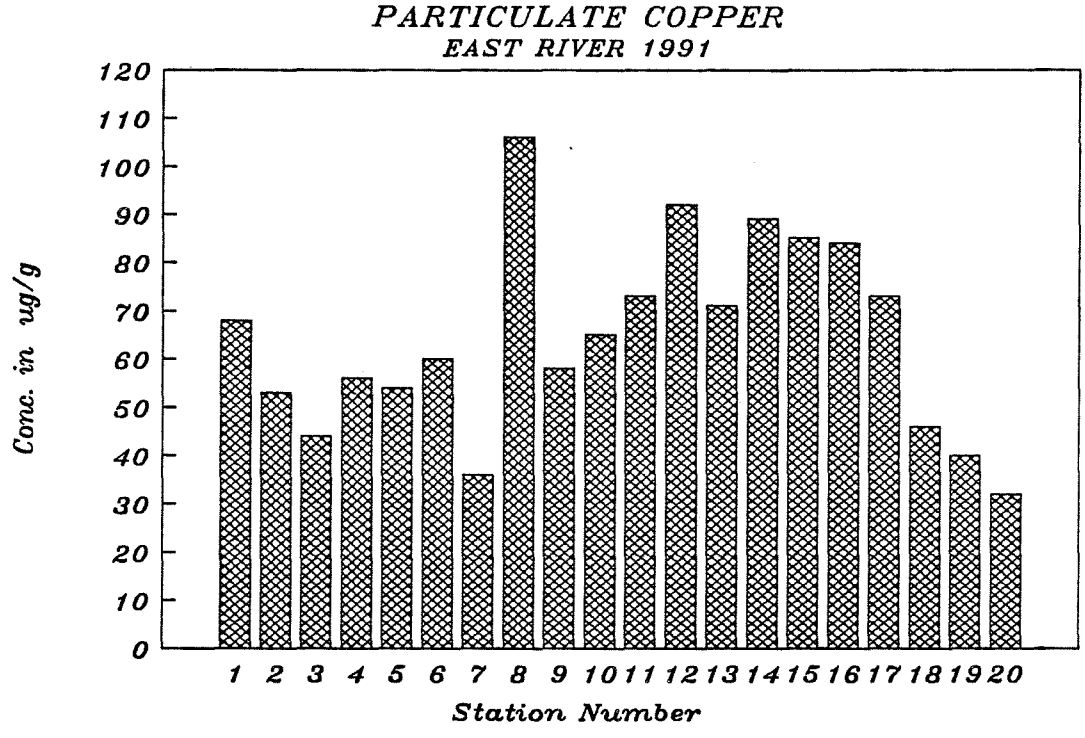

IRON vs SALINITY
Conc. in %
12.00
11.00
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00
Salinity (psu)

FIGURE 21


PARTICULATE COPPER
EAST RIVER 1991
Conc. in ug/g
120
110
100
90
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Station Number

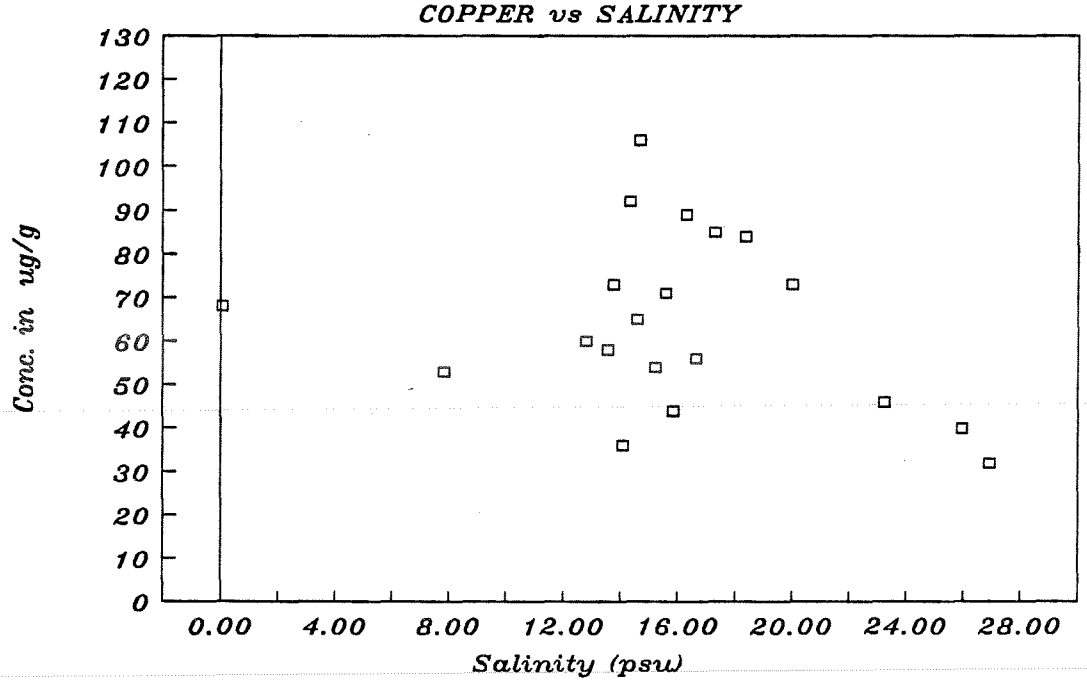
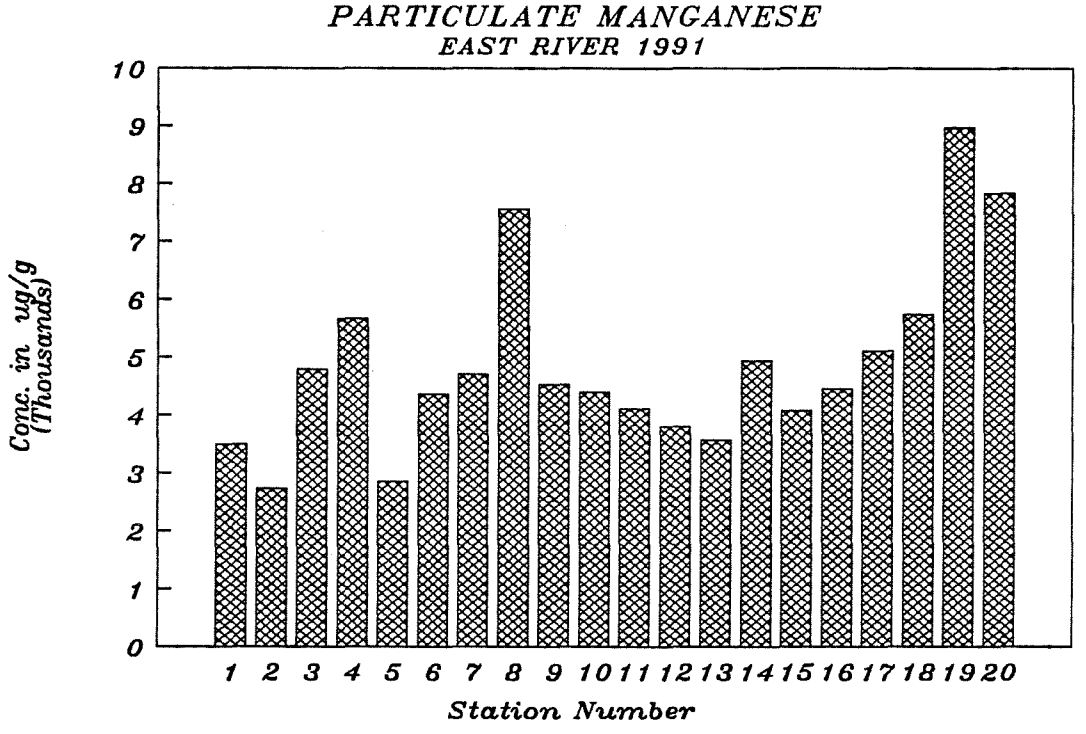

COPPER vs SALINITY
Conc. in ug/g
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00
Salinity (psu)

FIGURE 22


PARTICULATE MANGANESE
EAST RIVER 1991
Conc. in ug/g (Thousands)
0 1 2 3 4 5 6 7 8 9 10
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Station Number

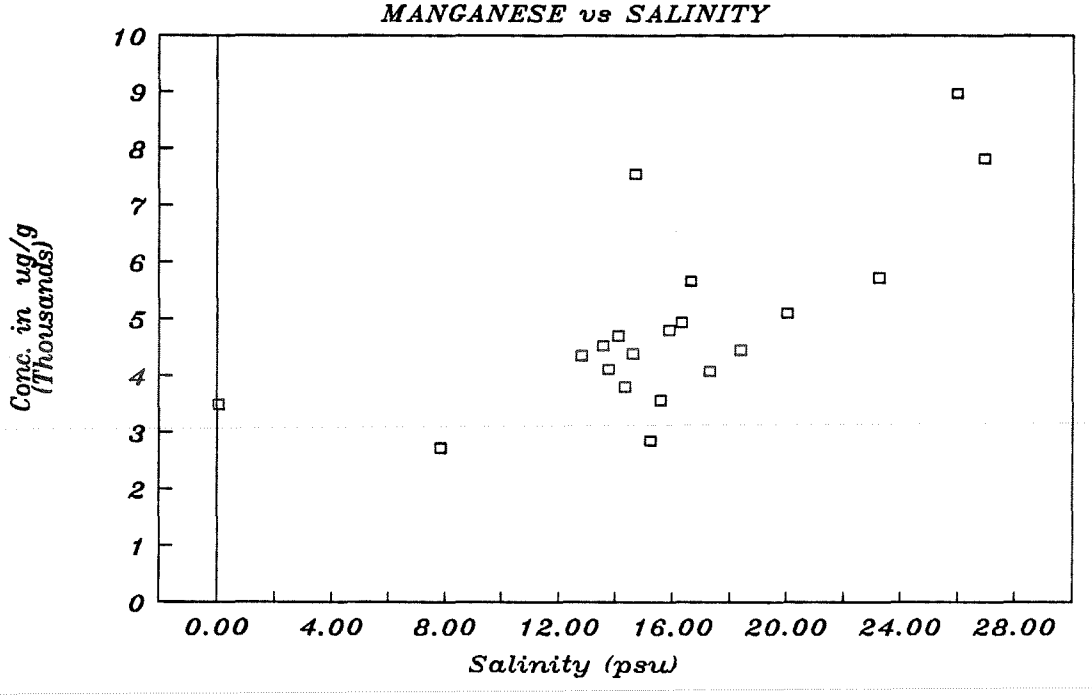
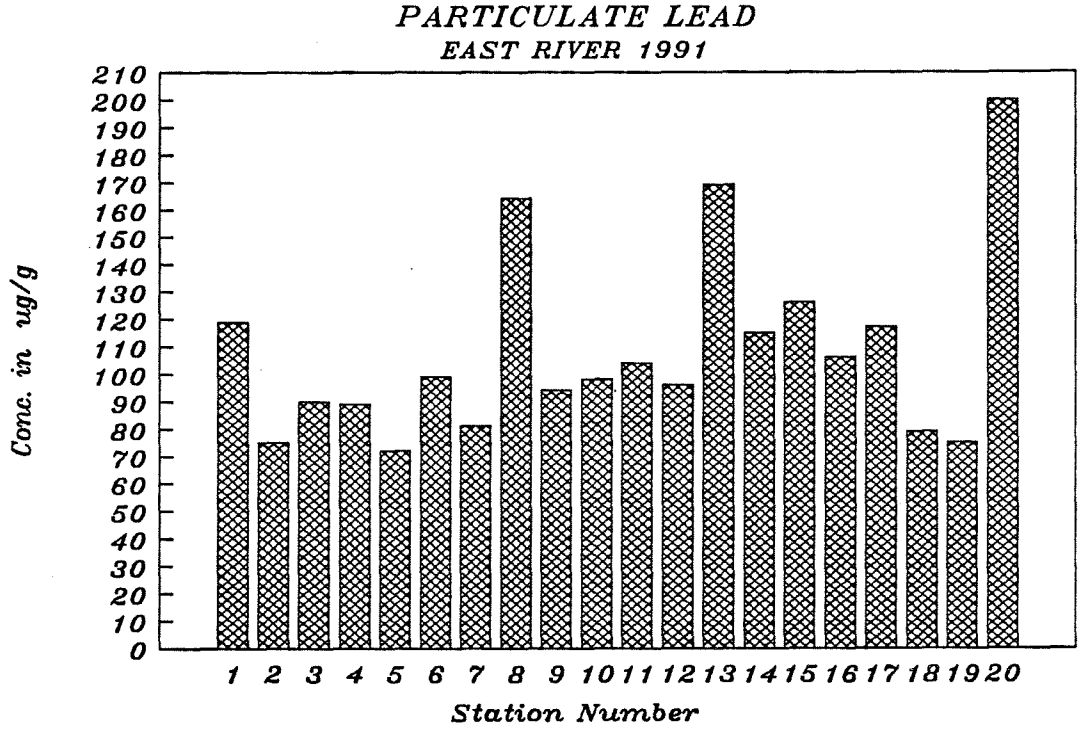

MANGANESE vs SALINITY
Conc. in ug/g (Thousands)
0 1 2 3 4 5 6 7 8 9 10
0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00
Salinity (psw)

FIGURE 23


PARTICULATE LEAD
EAST RIVER 1991
Conc. in ug/g
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Station Number

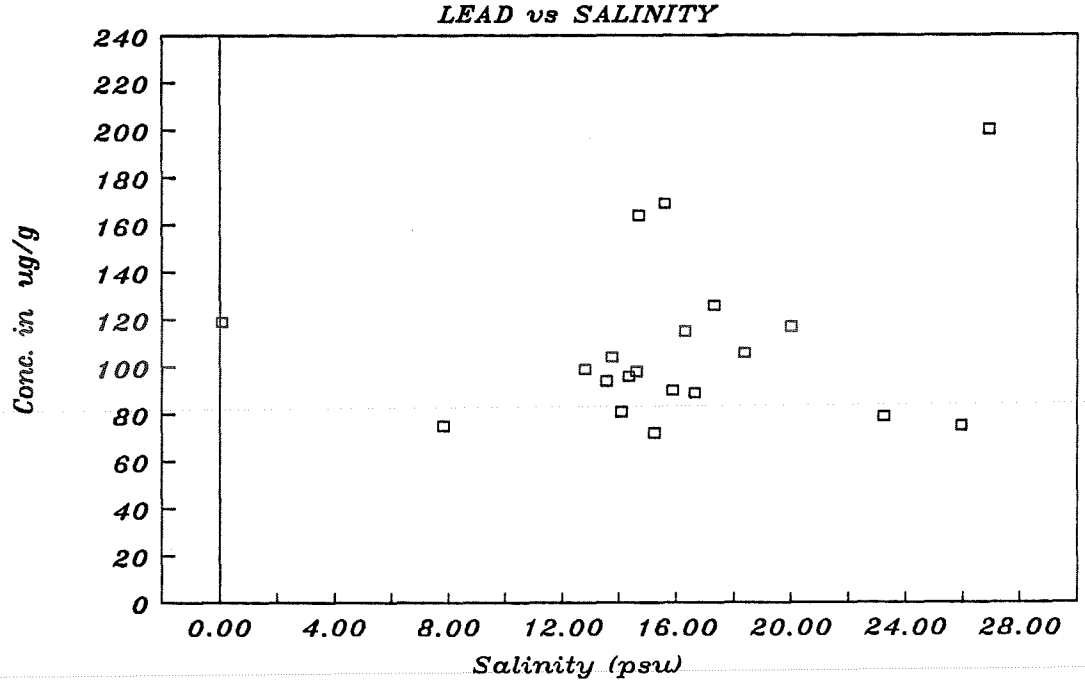
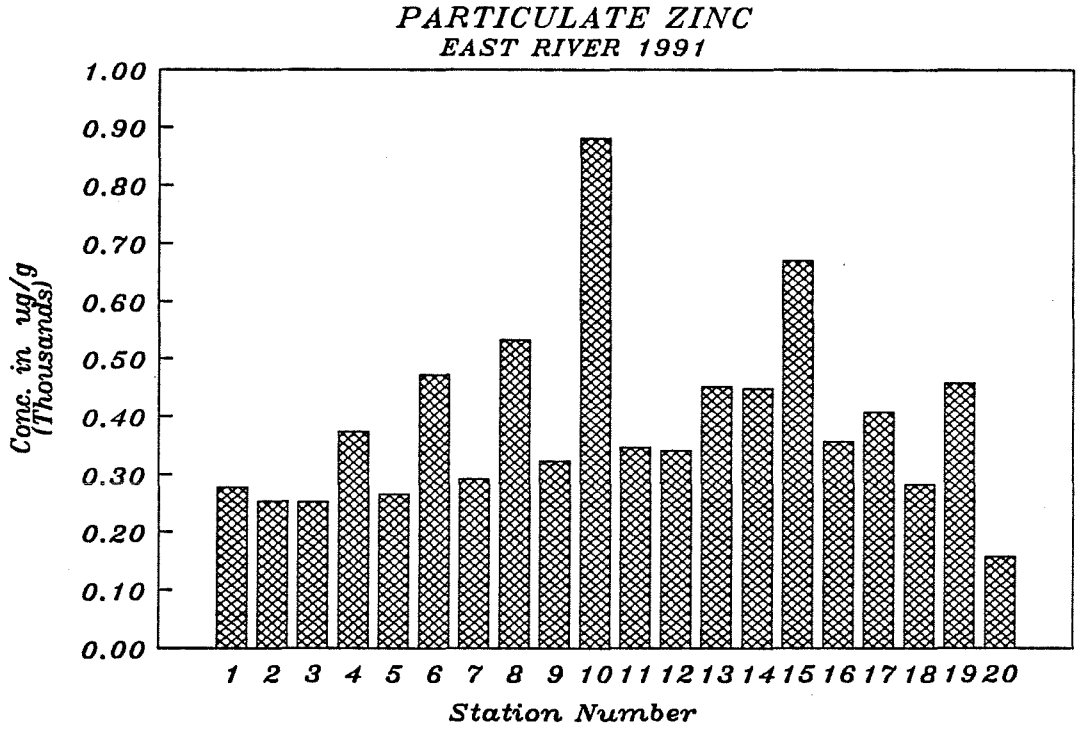

LEAD vs SALINITY
Conc. in ug/g
240
220
200
180
160
140
120
100
80
60
40
20
0
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
Salinity (psu)

FIGURE 24


PARTICULATE ZINC
EAST RIVER 1991
Conc. in ug/g (Thousands)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Station Number

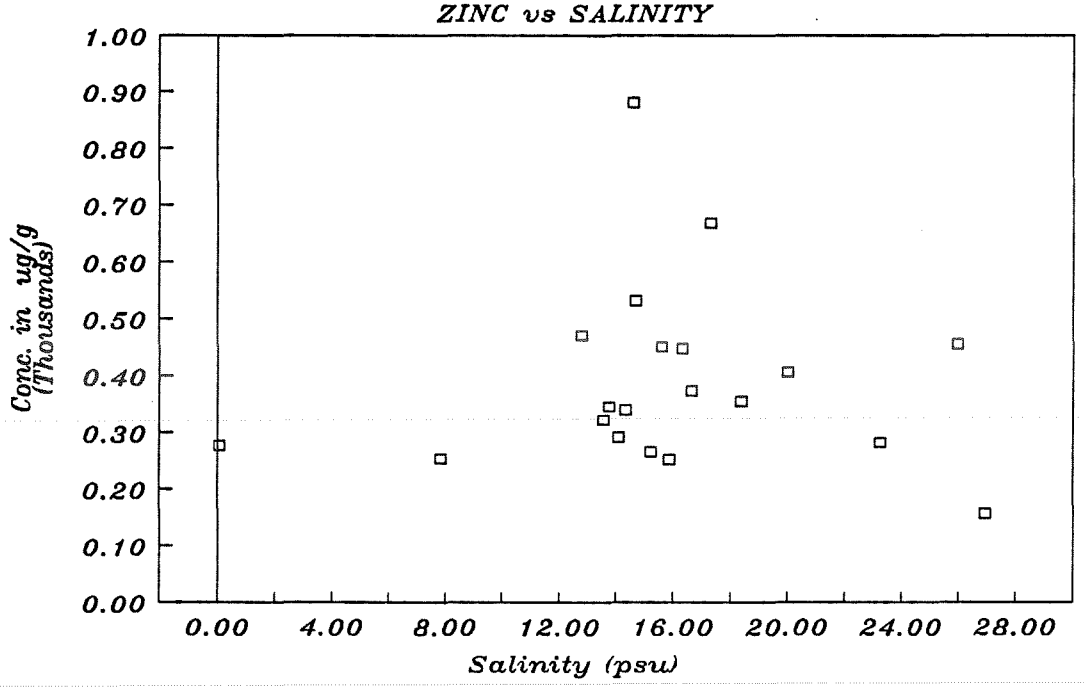

ZINC vs SALINITY
Conc. in ug/g (Thousands)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00
Salinity (psu)

TABLE 1

STATION DESCRIPTION FROM PICTOU HARBOUR SURVEY
SEPTEMBER 1990

Station Number	Sampling Day–Time	Station Location Lat. 45	Long. 62	Station Description
1	4–15:30	41'.55	38'.78	Pictou Road – near marker SJ4
2	4–15:54	41'.02	38'.33	Pictou Road – off Powells Hd.
3	4–16:10	41'.36	38'.46	Pictou Road area
4	4–16:16	41'.37	38'.78	Pictou Road area
5	4–16:30	41'.00	39'.08	Pictou Road area – nearshore
6	4–16:35	41'.43	39'.65	near channel marker SJ7
7	4–16:50	41'.23	40'.27	off Moodie Point
8	4–17:05	40'.92	40'.83	off Seaview Point
9	4–17:20	40'.60	41'.38	off Campbell Point
10	4–17:30	40'.27	42'.17	off Pictou
11	4–17:45	40'.00	42'.87	off Pictou
12	5–12:50	39'.65	43'.45	off the Causeway
13	5–13:10	39'.32	42'.30	near channel marker SJ22
14	5–13:25	39'.55	41'.77	off Mussel Point
15	5–13:48	38'.32	41'.10	between Ballast I. and Albion Pt.
16	5–14:00	38'.20	40'.83	near channel marker SJ30
17	5–14:20	37'.82	39'.87	near channel marker SJ34
18	5–14:40	36'.62	38'.67	near Trenton Car Works
19	5–15:10	38'.78	41'.87	off Indian Cross Pt.

TABLE 2

STATION DESCRIPTION FROM EAST RIVER SURVEY
SEPTEMBER 1991

Sta. #	Time	Lat. 45	Long. 62	Sampling Location
1	18:20	34.70	39.10	near first bridge to Stellarton off route 348
2	10:55	34.70	39.30	under unused rail bridge near TC highway
3	11:21	34.80	39.45	near first island down stream from stat. 1
4	11:35	35.24	38.86	off Martime Steel
5	11:59	35.34	38.94	off Rotary Park in New Glasgow
6	12:50	35.42	38.78	off Gov. Wharf in New Glasgow
7	13:05	35.67	38.72	off Kelderman Concrete Plant
8	13:32	35.83	38.64	off Matheson St. grave yard
9	13:54	36.07	38.58	in the river bend opposite Terrace Heights
10	14:10	36.18	38.77	past the transmission line down from Stat.8
11	14:20	36.40	38.64	approx. 150m upstream from the Irving Wharf
12	14:36	36.52	38.58	adjacent channel marker SJ-52
13	14:51	36.70	38.67	adjacent channel marker SJ-50
14	15:10	36.90	38.85	off Shipyard Pt.
15	15:25	37.14	38.97	adjacent channel marker SJ-44
16	15:40	37.29	39.05	under transmission lines and adjacent SJ-42
17	16:00	37.68	39.49	adjacent estuary channel marker SJ-36
18	16:25	38.48	41.47	off Indian Cross Pt., near marker SJ-25
19	16:44	39.32	42.42	off Scott Paper, near channel marker SJ-22
20	17:00	39.82	42.86	near causeway, between markers SJ-20, SJ-19

TABLE 3

TOC AND POC DATA FROM PICTOU HARBOUR SURVEY
SEPTEMBER 1990

Station Number	SPM (mg/L)	TOC mg carbon/L	Particulate Carbon(ug/L)	Particulate Nitrogen(ug/L)	C:N atomic
1	4.50	2.71	800	101	9.2
2		2.26	711	86.7	9.6
3		2.63	640	78.9	9.5
4		2.99	840	96.9	10.1
5		4.87	1451	148	11.5
6	2.57	2.98	918	105	10.3
7	2.21	2.30	450	68	7.4
8	2.21	2.31			
9	2.80	2.29	414	44	9.4
10	3.89	2.15			
11		2.00	315	48	7.7
12	3.03	2.34			
13	2.43	2.14	550	79	8.2
14	3.67	1.77	570	89	8.8
15	3.00	1.67	394	59	7.7
16	2.56	2.85	336	52	7.4
17	3.44	2.64	557	90	7.2
18	2.09	3.76	709	114	7.3
19	8.50	3.48	431	53	9.5

TABLE 4

NUTRIENT DATA FROM THE PICTOU HARBOUR SURVEY
SEPTEMBER 1990
(conc. in micro molar)

Station Number	Salinity (psu)	Silicate	Phosphate	Nitrate / Nitrite
1	29.0171	7.53	1.76	0.30
2	29.0151	5.74	1.38	0.32
3	29.0066	5.66	1.58	0.28
4	28.9477	6.34	1.71	0.26
5	28.6641	7.08	1.75	0.24
6	28.9188	7.65	1.98	0.21
7	28.8808	6.32	2.09	0.19
8	28.9001	6.06	2.07	0.18
9	28.9198	6.71	2.00	d.l.
10	28.6885	4.32	2.42	d.l.
11	28.7596	4.91	2.20	0.04
12	28.8744	5.17	2.11	0.12
13	28.7405	5.67	2.10	d.l.
14	28.6998	4.89	2.14	d.l.
15	28.1994	3.31	3.40	d.l.
16	28.2023	3.11	2.89	d.l.
17	26.1616	4.02	2.93	0.07
18	20.9159	8.92	3.66	0.50
19	28.2009	3.12	2.97	d.l.

TABLE 5

PICTOU HARBOUR SURVEY SEPT./90
DISSOLVED METALS
(conc. in ug/L)

Station Number	Cd	Cu	Fe	Mn	Ni	Pb	Zn
1	0.046	0.62	3.65	1.85	0.38	0.033	1.46
6	0.057	0.51	5.27	1.90	0.34	0.035	0.78
7	0.044	0.46	4.93	1.86	0.43	0.074	1.24
8	0.027	0.48	5.03	1.58	0.30	0.066	0.60
9	0.037	0.48	3.60	2.26	0.35	0.078	0.73
10	0.031	0.53	4.52	3.80	0.39	0.067	0.54
11	0.037	0.50	4.38	2.44	0.39	0.069	0.80
12	0.031	0.62	4.57	1.64	0.36	0.030	0.80
13	0.027	0.45	3.89	1.71	0.37	0.025	0.55
14	0.023	0.45	13.1	3.73	0.29	0.055	0.71
15	0.022	0.52	7.04	3.65	0.32	0.034	1.02
16	0.015	0.58	5.53	0.84	0.31	0.029	0.20
17	0.029	0.88	18.8	4.30	0.38	0.094	1.06
18	0.034	1.46	13.3	8.01	0.52	0.051	0.82
19	0.025	0.56	7.09	1.46	0.30	0.056	0.77

TABLE 6

EAST RIVER FIELD DATA – SEPTEMBER 1991
(low tide at 3:05)

Station Number	Salinity (insitu)	(autocell)	Conduct. (umohs)	pH	Temp (C)	Oxygen (ppm)	Oxygen Saturation
1	0.0	0.077	160	7.0	20.0	9.5	105
2	7.5	7.833	12500	6.9	20.0	7.2	83
3	11.0	15.876	17000	6.9	20.0	7.1	84
4	14.5	16.656	22000	7.0	20.0	7.2	87
5	14.0	15.241	21000	7.2	20.0	7.4	89
6	13.0	12.800	19000	7.1	20.0	7.5	89
7	13.5	14.092	20000	7.3	20.5	7.7	93
8	13.8	14.702	20500	7.3	20.0	7.7	92
9	13.7	13.552	20000	7.5	20.0	7.7	92
10	14.5	14.617	20500	7.5	19.0	7.5	88
11	14.0	13.753	20100	7.5	19.7	7.7	92
12	14.1	14.337	20500	7.6	19.0	7.9	93
13	16.5	15.602	23000	7.6	19.5	8.1	97
14	15.5	16.315	22500	7.6	19.5	8.2	98
15	17.5	17.298	25000	7.8	19.5	8.2	99
16	18.0	18.389	26800	7.8	19.0	7.8	94
17	20.0	20.015	29000	7.9	20.0	8.1	100
18	23.0	23.247	32200	8.1	19.0	9.7	120
19	25.2	25.968	34500	8.0	17.8	8.2	101
20	27.2	26.942	35200	8.0	17.0	8.8	107

TABLE 7

NUTRIENT DATA
EAST RIVER – 1991

Station Number	Salinity (psu)	Silicate	Phosphate (conc. in umoles/L)	Nitrate / Nitrite
1	0.077	22.64	0.10	0.88
2	7.833	16.28	0.24	1.55
3	15.876	9.22	1.03	o.86
4	16.656	9.93	0.85	0.87
5	15.241	11.01	0.73	0.93
6	12.800	12.92	0.52	1.24
7	14.092	12.18	0.64	1.10
8	14.702	12.19	0.64	1.13
9	13.552	12.69	0.65	1.20
10	14.617	12.01	0.73	1.09
11	13.753	12.70	0.68	1.13
12	14.337	13.66	1.11	1.15
13	15.602	12.33	1.16	1.15
14	16.315	12.18	1.25	1.32
15	17.298	10.40	1.34	1.29
16	18.389	9.58	1.48	1.13
17	20.015	7.67	1.58	0.88
18	23.247	4.14	1.52	0.44
19	25.968	3.57	1.17	0.21
20	26.942	3.11	0.97	0.14

TABLE 8

EAST RIVER PICTOU 1991
DISSOLVED METALS
(ug/L)

Station Number	Salinity (psu)	Cd	Cu	Fe	Mn	Ni	Pb	Zn
1	0.077	0.011	0.45	46.2	72.4	0.19	0.091	1.01
2	7.833	0.038	0.87	37.5	274.7	0.50	0.056	1.77
3	15.876	0.048	0.89	20.1	194.0	0.45	0.031	1.76
4	16.656	0.051	0.92	20.1	179.6	0.48	0.026	2.01
5	15.241	0.041	0.88	22.3	190.7	0.50	0.027	2.06
6	12.800	0.036	0.86	24.1	235.0	0.55	0.043	1.99
7	14.092	0.044	0.88	27.7	209.6	0.50	0.046	1.64
8	14.702	0.043	0.78	22.9	215.1	0.52	0.045	1.67
9	13.552	0.036	0.78	20.9	212.9	0.50	0.038	1.68
10	14.617	0.044	0.84	21.0	175.2	0.53	0.036	1.70
11	13.753	0.048	0.81	25.9	191.8	0.52	0.035	1.67
12	14.337	0.046	0.77	19.9	160.8	0.53	0.036	2.07
13	15.602	0.054	0.81	14.7	138.7	0.52	0.034	1.72
14	16.315	0.063	0.88	17.1	124.4	0.53	0.034	1.86
15	17.298	0.035	1.01	22.3	123.3	0.50	0.041	1.51
16	18.389	0.040	0.84	11.6	98.9	0.42	0.026	0.96
17	20.015	0.041	0.78	14.0	82.4	0.42	0.029	1.08
18	23.247	0.036	0.59	7.5	43.7	0.36	0.032	0.50
19	25.968	0.033	0.55	4.1	30.4	0.30	0.015	0.52
20	26.942	0.029	0.39	2.1	17.2	0.33	0.010	0.47

TABLE 9

EAST RIVER PICTOU – 1991
PARTICULATE METALS

Station Number	Salinity (psu)	SPM mg/L	Al %	Fe %	Cd	Cu	Mn	Ni	Pb	Zn
					(conc. in ug/L)					
1	0.077	1.79	6.8	5.29	16	68	3489	<64	119	277
2	7.833	3.35	6.5	6.18	0.5	53	2728	<59	75	254
3	15.876	3.15	5.2	5.53	<0.3	44	4791	<39	90	252
4	16.656	1.92	4.1	5.73	0.8	56	5667	<61	89	374
5	15.241	2.10	2.8	3.32	2.6	54	2851	<57	72	266
6	12.800	2.14	5.2	6.45	0.9	60	4356	<58	99	471
7	14.092	2.09	4.9	6.07	<0.4	36	4708	<57	81	292
8	14.702	0.99	7.4	10.40	1.5	106	7553	<128	164	532
9	13.552	2.26	4.8	5.81	0.4	58	4531	<53	94	323
10	14.617	2.15	5.1	5.84	<0.4	65	4390	<55	98	881
11	13.753	2.35	5.1	5.96	<0.4	73	4114	<53	104	346
12	14.337	2.52	4.7	5.29	0.9	92	3802	<57	96	340
13	15.602	1.06	3.3	4.14	1.9	71	3569	118	169	451
14	16.315	2.63	4.0	5.35	1.5	89	4940	<45	115	448
15	17.298	2.43	5.0	6.00	0.8	85	4079	<47	126	669
16	18.389	2.48	5.3	5.16	2.7	84	4458	<51	106	356
17	20.015	2.06	5.2	5.05	2.1	73	5102	<56	117	407
18	23.247	1.65	3.3	3.89	<0.5	46	5730	<71	79	282
19	25.968	1.31	4.2	4.01	7.9	40	8971	<88	75	456
20	26.942	2.01	3.4	2.20	0.4	32	7824	<59	200	157

CHAPTER 2

Geochemical Analysis of Sediment Cores from Pictou Harbour, N.S.

by

D.H. Loring

SUMMARY

Total Cd, Cr, Cu, Hg, Pb, and Zn concentrations were determined in 156 samples from thirteen short (14-20cm) sediment cores from Pictou Harbour. Total metal concentrations measured in the core sediments were: Cd 0.02-0.93 mg/kg; Cr 4-95 mg/kg, Cu 1-56 mg/kg; Hg 0.01-0.85mg/kg; Pb 5-57mg/kg, and Zn 7-231 mg/kg. The concentrations of Cr, Cu, Hg, Pb, and Zn are at or near natural levels with only a few exceptions in the cases of Cu, Hg, Pb, and Zn. Fine grained organic core sediments, however, appear to be contaminated with Cd. Most of the core sediments (67%) contain Cd concentrations above natural background levels, and fourteen samples have concentrations in excess of the Ocean Dumping Guidelines (>0.60 mgCd/kg). Geochemical normalization of the data indicates that abundance and distribution of heavy metals in the Pictou Harbour core sediments is mainly controlled by the texture of the sediments with the highest concentrations occurring in fine-grained organic-rich material.

INTRODUCTION

At the request of EPS, a series of core samples were obtained in September 1990 to assess the levels of heavy metals and degree of contamination in Pictou Harbour, N.S.

METHODS and MATERIALS

Nine sediment cores were obtained at selected intervals along a longitudinal section of the Harbour commencing inside the reservoir behind the breakwater and extending seaward for 10 km. Four additional cores were obtained in estuary of the East river. The locations of the cores are shown in Fig.1.

The cores were taken by divers inserting 30 cm plastic core liners (7 cm in diameter) into the sea floor. Core samples, 14 to 20 cm in length, were obtained by this method. The core tubes were capped after their removal from the sea floor. They were kept cool, transported in a vertical position to the laboratory and frozen immediately.

In the laboratory, the cores were thawed and split. One half of the core was sampled and the other half was archived. Most cores were sampled at 0-0.5 cm and from 0.5 to 1 cm and thereafter at 1 cm intervals down to 10 cm. For cores from stations 5,8, A2 and A4, it was only possible to obtain 0-1 cm samples and 0-3 cm samples (station 4) from the top part of the cores because of the nature of the core material. Below 10 cm, the cores were sampled in 5 cm sections or shorter ones depending on the length of the core.

The core samples (a total of 156) were initially stored in plastic vials, homogenized, and oven dried at 60°C. A portion of the dried sample was removed for Hg analysis and the rest redried at 110°C for chemical and sedimentological analysis. One portion of the oven dried material was used for total metal analysis. Another portion of the preweighed oven dried sample was wet-sieved to determine the amount of sand (2000-63 μm) and mud (<63μm) size material in each sediment sample.

Total Al, Cd, Cr, Cu, Li, Pb, and Zn concentrations were determined from a dried sample (0.2g) by the atomic absorption (AAS) techniques described by Loring and Rantala (1977) after digestion with a combination of HF and aqua regia in a microwave oven (Rantala and Loring, 1989). The analytical precision was determined by triplicate analysis of the 5-6 cm section from each core and is shown in Table 1. The relative accuracies for Al, Cd, Cu, Cr, Pb, and Zn were within the standard deviations for the NRCC certified sediment reference material MESS-1.

Mercury (Hg) was determined using a cold vapor atomic absorption technique (Hatch and Ott, 1968) described in detail by Loring and Rantala (1991).

Easily oxidizable organic carbon was determined for each sample using the wet oxidation method (cold H_2SO_4 and chromic acid) described by Walkey (1947). The results (organic carbon) were converted to organic matter by multiplying by a factor of 1.72.

RESULTS

Core Sediments

The texture of the Pictou Harbour core material varies from fine grained reddish brown and black organic rich muds to medium to fine grained brownish gray sands depending on the amounts (by weight) of sand (material > 63μm in diameter) and mud(material <63μm in diameter) size material, and organic matter they contain. The upper sections of the fine grained cores are characterized by a reddish brown oxidized layer from 0.5 to 7 cm in thickness. Beneath which are black reduced sediments. The relative amounts of sand and mud in each of the cores and sediment types are shown in Table 2. The sediment classification is that used by Loring and Nota (1973). It is based on the

amounts of sand and mud size material. Material containing >95% by weight of mud size particles is classified as mud, sediment with >95% by weight of sand size material is classified as sand. Sediments containing 5-30 % by weight of sand and >70% mud are classified as sandy muds. Sediments containing 5-30 % by weight of mud and >70% sand are classified as muddy sands. Sediments containing >30 of each component are classified as very sandy muds.

Table 2 indicates that fine grained muds occur throughout cores S1-S4 with only a few horizons containing sufficient sand to be classified as sandy muds. The upper 9 cm of core S5 consists of sandy mud. Below 9 cm, very sandy mud and muddy sand make up the bottom part of the core. A seaward increase in the sand component results in muddy sands and sands with low organic contents making up most of the sedimentary material in cores S6, S7, S8, and S9. Core A1 consists of fine grained mud. In contrast, cores A2, A3, and A4 comprise mainly of very sandy mud (A2 and A4) and sandy muds (A3). Core A2 is also rich in organic material (4-7.3%).

Organic Matter

Easily oxidizable organic carbon content varies from 0.06% in the sandy sediments to 7.26% in fine grained core sediments (Table 3). The highest amounts of organic matter (4-7%) occur in the cores S1 to S4 and cores A1 and A2, and lowest in the sandy sediments of cores S5-S9.

Abundance and Distribution of Heavy metals

Total metal concentrations measured in the core sediments are: Cd 0.02-0.93 mg/kg; Cr 4-95 mg/kg, Cu 1-56 mg/kg; Hg 0.01-0.85mg/kg; Pb 5-57mg/kg, and Zn 7-231 mg/kg (Table 3). Heavy metal concentrations vary with sediment texture and location of the cores. Variation of metals with depth in individual cores is usually less than that between cores (Table 4). Figure 2 shows the seaward longitudinal distribution of Cd, Cr, Cu, Li, Hg, Pb, and Zn concentrations in the near surface samples (3-4cm) of cores S1-S9. Figure 2 indicates that the metal concentrations are highest in the fine grained sediments of core S1 (in reservoir). Thereafter concentrations decline slightly seaward in the fine grained sediments of cores S2-S5, followed by a sharper drop in concentrations in the coarser grained sandy sediments of cores S6-S8 and finally followed by a small rise in the muddy sands of core S9. The covarience of the metals with Li, a proxy for grain size variation, illustrates in Fig. 2 the dependence of the metal concentrations on the granular variability of the core sediments.

INDIVIDUAL METALS

Cadmium

Cadmium concentrations vary from 0.02 to 0.93 mg/kg in the core samples. The highest concentrations (>0.4mg/kg) occur in the fine grained organic rich core material (84 samples) from stations S1,S2,S3, S4, A1, A2, A3, and A4. Lower concentrations occur in sandy cores from stations S5, S6, S7, S8, and S9 located in the outer part of the Harbour. Most of the fine grained core sediments are contaminated with Cd to a greater or lesser extent. Compared (Table 5) to natural values (0.15-0.3 mg Cd/kg), Cd is enriched by factors of 1.3 to 3 in all of the fine grained organic rich core material. A total of 102 core samples exceed the 0.30 mgCd/kg normal background level.

Inspection of the data indicate that some of the core material (14 samples) contains Cd concentrations that exceed the Ocean Dumping Guidelines (> 0.60mg/kg). Cadmium concentrations of 0.6 mg/kg and greater occur in parts of cores S1 (10-15cm); S2 (0-05cm); A1 15-20cm), and A3 (1-2cm). In addition, core A2 located at the mouth of the East River contains high concentrations of Cd at all levels from the surface to 10cm with the highest concentration (0.93 mgCd/kg) occurring at the 3-4cm level. Such values are higher than that of the Cd contaminated CRM MESS-1 from the Miramichi estuary, N.B (Table 5).

Chromium

Chromium (Cr) concentrations vary from 4-95 mg/kg with the highest concentrations occurring in the fine grained core material. Chromium does not appear to be enriched in the core samples as the concentrations determined are at or near the natural levels of texturally equivalent sediments (Table 5).

Copper

Copper (Cu) concentrations vary from 1 to 50 mg/kg. Copper does not appear to be greatly enriched in the core samples as the concentrations determined are at or near the natural levels of texturally equivalent sediments (Table 5). An exception is the slightly elevated level of Cu (38-50 mg/kg) in the top 4 cm of core A2.

Mercury

Mercury (Hg) concentrations vary from 0.1 to 0.85 mg/kg in the core samples. Mercury concentrations are at or near the natural levels of texturally equivalent sediments (Table 5) in all of the cores with the exception of core A1. In core A1, Hg concentrations (0.18-0.39 mgHg/kg)) from the top of the core to 10cm are within natural levels. Beneath 10 cm, high Hg concentrations (0.74 and 0.85 mgHg/kg) occur in the fine-grained

organic rich 10-15 and 15-20 cm sections of the core. Such values are near to, or exceed, the Ocean Dumping Guidelines of 0.75 mgHg/kg.

Lead

Lead (Pb) concentrations vary from 5 to 57 mg/kg with the higher concentrations occurring in the fine-grained core material. The highest concentrations (> 45mg/kg) occur in cores S1, S4, A1, and A3. Compared to natural levels of Pb (20- 30 mg/kg) found in the Gulf of St. Lawrence and Bay of Fundy, the fine grained core material is only slightly contaminated with lead.

Zinc

Zinc concentrations vary from 7 to 231 mg/kg in sediments. The higher concentrations are found in the fine grained organic rich material and the lower concentrations in the coarse grained sandy material from cores S6, S7, S8, and S9. The highest concentrations of Zn (>200 mg/kg) occur in fine grained organic rich material of core A2. Compared (Table 5) to natural levels of Zn (83-119 mg/kg) found in the fine grained sediments of the Gulf of St. Lawrence, Zn concentrations in the fine grained core material are slightly elevated (by less than a factor of 2).

NORMALIZATION of METAL DATA

Since metals from natural and anthropogenic sources accumulate together, it can be difficult to determine what proportion of the sedimentary metal load is natural and what proportion is anthropogenic. As a result, it is necessary to compensate for the grain size effects (Table 2) on metal variability in different samples so that anthropogenic metal contributions may be quantified.

Granulometric normalization shows that linear correlations occur consistently between increasing natural trace metal concentrations and decreasing grain size, expressed in changes in the amounts of material <63μm in diameter (Table. 6).

In order to reduce the trace metal variability caused by grain size as well as by mineralogy , and to identify anomalous metal contributions, geochemical normalization of trace metal data to an elemental proxy for grain size can be used.

In this approach, it is a requirement that the relationship between the normalizing element and another metal be linear i.e. should the concentration of the normalizing element vary because of changing mineralogy and particle size, the concentration of the other metal will adjust proportionally. The normalizing element must, therefore, constitute an important constituent of one or more of the major trace metal carriers

and reflect their granular variability in the sediments.

Lithium (Li) has been found to be an ideal normalizing element for eastern Canadian estuarine and coastal sediments (Loring, 1990).

To establish the relationship between Li and grain size, the concentrations of the metal are plotted against the percentage of the fine size fraction. If the relationship is significant ($p<=0.05$), a regression line is calculated and graphed along with a 95% prediction band so that the geochemical population of that metal in relation to grain size changes can be defined.

For example, Fig.3 shows a linear plot whose regression line equation takes the form of $y= 0.59X + 18.5$ for Li concentrations in relation to the mud (material <63μm in diameter) content (percentage by weight) in the core sediments. It shows Li varies significantly ($n=156$; $r=0.98$, $p<0.001$) with the mud content of the sediments (Table 6). The proportional changes in Li concentrations with changes in mud content within a narrow confidence band indicate that the data meet the criteria for mathematical metal- grain size normalization. Such a relationship allows for the compensation of the grain size effect on the natural Li population and the use of Li as a normalizing element in lieu of grain size measurements i.e most of the natural variance of Li is explained by the grain size variability of the sediment samples.

Aluminum is another metal that has found to useful as a normalizer for the granular variability of metals in sediments. Figure 4 shows a linear plot whose regression line equation takes the form of $y= 0.056X + 2.34$ for Al contents in relation to the mud (material <63μm in diameter) content (percentage by weight) in the core sediments. It also shows that Al varies significantly ($r=0.98$, $p<0.001$) with the mud content of the sediments (Table 6). Aluminum also covaries (Fig.5) significantly ($p<0.001$) with Li ($r=0.98$) indicating that both metals may be used for compensating for the granular variability of the metals in the core sediments. Since the correlations of Li with the other metals are similar to, or stronger, than those of Al, Li is the preferred normalizer for the metal data in the core sediments.

The interrelationships between the metals and Li can be established from correlation matrices (Table 6). Metal/lithium graphical solutions for the granular variability of metals in sediments can then be developed as linear plots of metal versus lithium concentrations.

For example, Fig. 6 illustrates the use of Li for normalization of Cr data from the core samples The scatterplot of Cr versus Li ($r=0.99$, $P<=0.001$) was constructed and a regression line with the 95% confidence band graphed to define the geochemical population of Cr in relation to the normalizer element Li in the sediments. It shows that the Cr population is contained within a narrow 95% confidence band. Data points

falling inside the confidence band are considered to be part of the natural population i.e the variance of Cr in the core samples is explained by the grain size variability of the sediment samples. Data points that fall significantly outside the confidence band would be considered to be anomalous values. Such samples with anomalous metal:Li ratios do not always indicate anthropogenic inputs as they might be the result of plotting errors, analytical errors, or anomalous concentrations of detrital heavy minerals containing the metal, such as chromium bearing magnetite or chromite. Such possibilities should be considered before anomalous values be interpreted as being due to anthropogenic causes.

The strong positive covariance of Cd (r=0.88), Cr (r=0.99), Cu (r=0.93), Hg (r=0.66), Pb(r=0.94), and Zn (r=0.95) with Li (Table 6) shows that Li normalizes for most of the granular variability of these metals except Hg in the Pictou Harbour core material. The proportion of the metal variability explained by the granular variability decreases in the order of Cr>Zn>Pb>Cu>Cd>>Hg.

Analytic X-Y graphics with regression lines and prediction limits for the variability of Cd, Cu, Hg, Pb, and Zn in respect to Li are presented in Figures 7- 13.

Although the correlations of Cd with Li are significant ($p<0.01$), the wide confidence band for Cd (Fig. 7) indicates that factors other than natural granular variability (about 77% of the total variance) such as organic matter are involved in Cd distribution in the core samples. The Cd:Li graph shows that four obvious data points plot well outside the confidence limits and may are thus be considered as anomalous. Fig. 8 shows a plot of Cd versus organic carbon matter. It shows Cd varies significantly ($r=0.94$, $p <= 0.01$) with organic matter and appears to have a narrower confidence band than that with Li. Since distribution of organic matter is also related to textural changes in the core sediments, it is difficult without further investigation to differentiate between the two factors as to the most important factor controlling the abundance and distribution of Cd. The sedimentary source material is not likely to be a contributing factor to the relatively high Cd concentrations because most of the sediments in Pictou Harbour result from the reworking of glacial till derived from gray and brown Carboniferous sandstones and shales that occupy the underlying watershed and harbour of Pictou.

About 87% of the variability of Cu can be explained by its granular variability in the core sediments. Inspection of the Cu graph (Fig.9) shows that four of the data points plot outside the confidence limits and are thus considered to be anomalous.

The Hg:Li graph (Fig. 10) shows that two obvious data points fall well outside the confidence limits and can thus be considered as very anomalous. The correlations of Hg with Li ($r= 0.66$) are significant($p<0.01$), but the wide confidence band for Hg (Fig. 10), indicates that factors other than natural granular

variability (about 44% of the total variance) are involved in Hg distribution in the core samples. Organic matter normally is an important factor that controls the distribution of mercury in sediments (Loring, 1975). Although the correlations of Hg with organic matter ($r = 0.65$) are significant($p<0.01$), the wide confidence band for Hg (Fig. 11), indicates that organic matter (44% of the total variance) is of equal importance to grain size in accounting for the variability of Hg in the core sediments. Since the distribution of organic matter is also related to textural changes in the core sediments, it is difficult without further investigation to differentiate between the two factors as to the most predominant factor controlling the abundance and distribution of Hg.

Figure 12 shows that most of the variance of Pb (89%) can be explained by its granular variability in the core sediments. The graph shows that two data points plot well outside the confidence limits and are thus considered to be anomalous.

Most of the variance of Zn (91%) can be explained by its granular variability in the core sediments (Fig.13). Five data points plot well outside the confidence limits and can thus considered to be part of an anomalous population.

CONCLUSIONS

Natural and anthropogenic metal populations occur in the sediments of Pictou Harbour.

The data show that the granular variability of the trace metals can be described graphically by metal/Li regressions and their prediction limits calculated. The diagram can then be used to determine if the variability of the metal concentrations are due to granular variability and/or to anomalous metal enrichment.

Geochemical normalization of the data indicate that the abundance and distribution of heavy metals in the Pictou Harbour core sediments is mainly controlled by the texture of the sediments with the highest concentrations occurring in fine -grained organic-rich material. The concentrations of Cr, Cu, Hg, Pb, and Zn are at or near natural levels with only a few exceptions in the cases of Cu, Hg, Pb, and Zn. The fine-grained sediments, however, appear to be contaminated with Cd. It is difficult to quantify additional anthropogenic Cd contributions other than identify the obviously anomalous values from the regression analysis. Most Cd concentrations in the fine grained sediments exceed natural background levels and in some cores, exceed the Ocean Dumping Guidelines. The highest Cd concentrations occur at the mouth of the East river and in the inner part of the Harbour. Most of the Cd appears to been supplied to its site of deposition along with fine grained organic matter most likely from urban and industrial discharges. The occurrence of anomalous Cd values not related to grain size suggests that other factors such the deposition of solid metallic debris may contribute Cd to the sediments. Additional core

samples from within the East river are required to determine if this system is the source of the anthropogenic Cd.

ACKNOWLEDGEMENTS

Sedimentological and chemical analysis were capably performed by R.T.T. Rantala and his review of this chapter is gratefully acknowledged.

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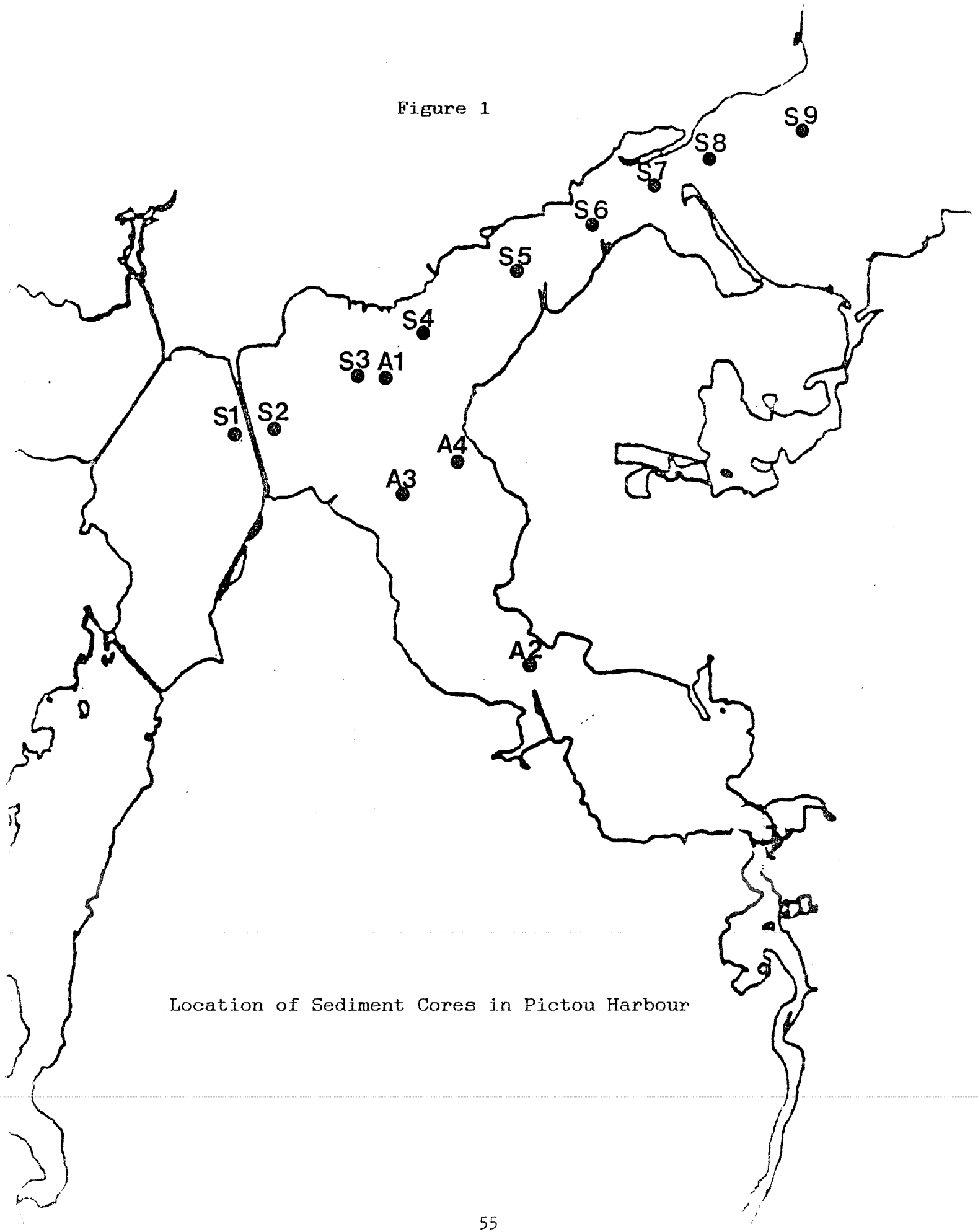
Figure 1



Location of Sediment Cores in Pictou Harbour

Figure 2

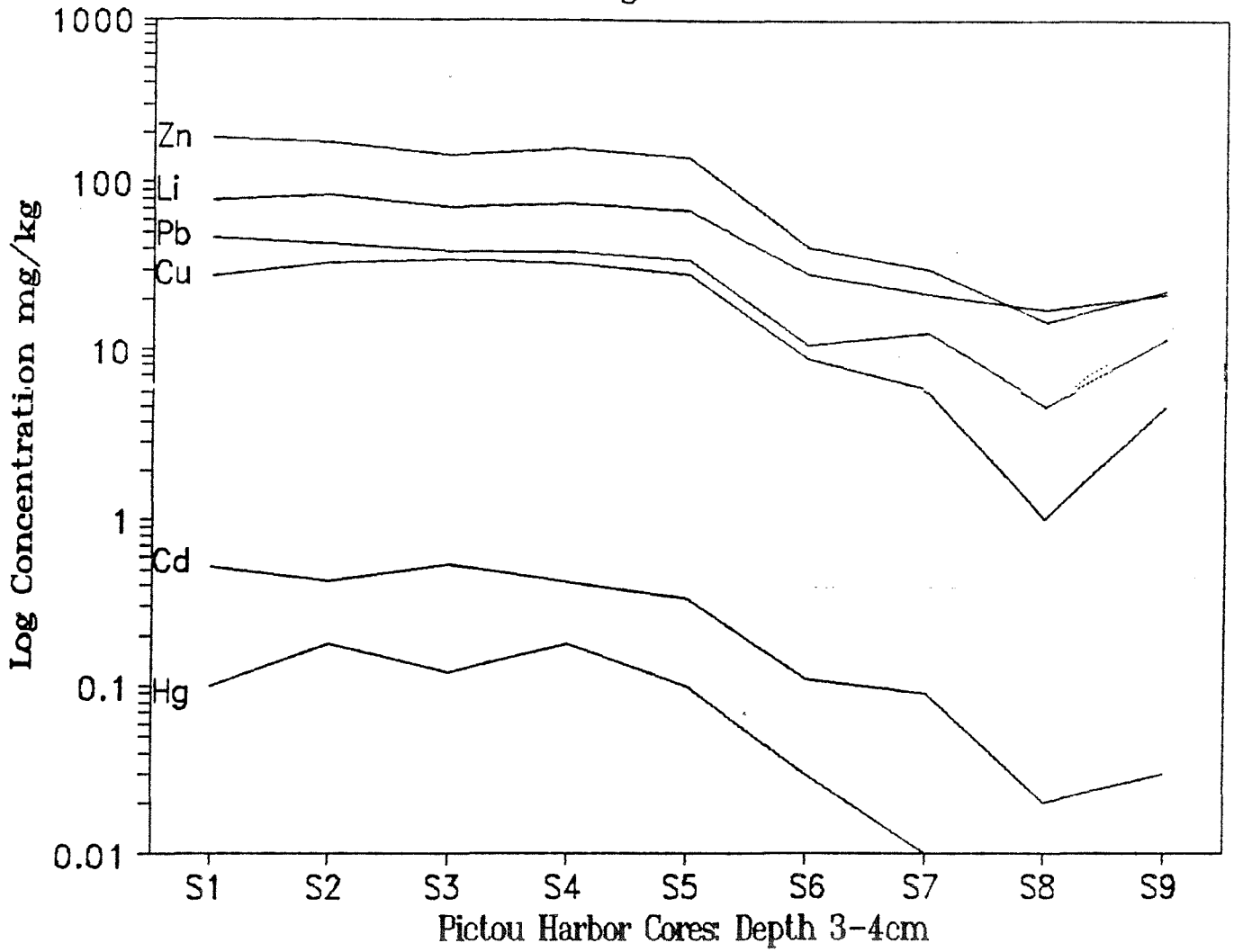

1000
100
10
1
0.1
0.01
Log Concentration mg/kg
Zn
Li
Pb
Cu
Cd
Hg
S1
S2
S3
S4
S5
S6
S7
S8
S9
Pictou Harbor Cores: Depth 3-4cm

Figure 3

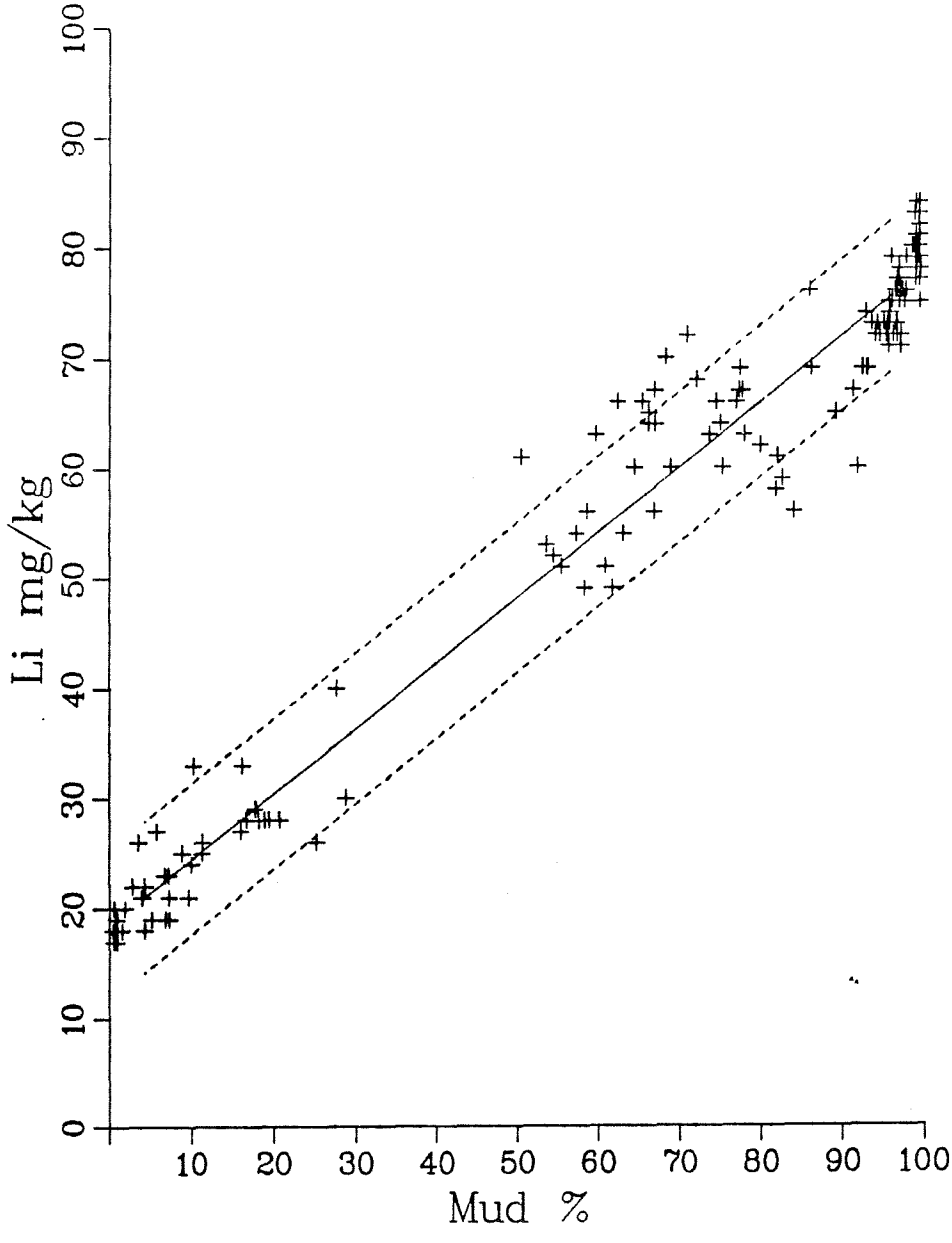

Li mg/kg
0
10
20
30
40
50
60
70
80
90
100
Mud %
10
20
30
40
50
60
70
80
90
100

Figure 4

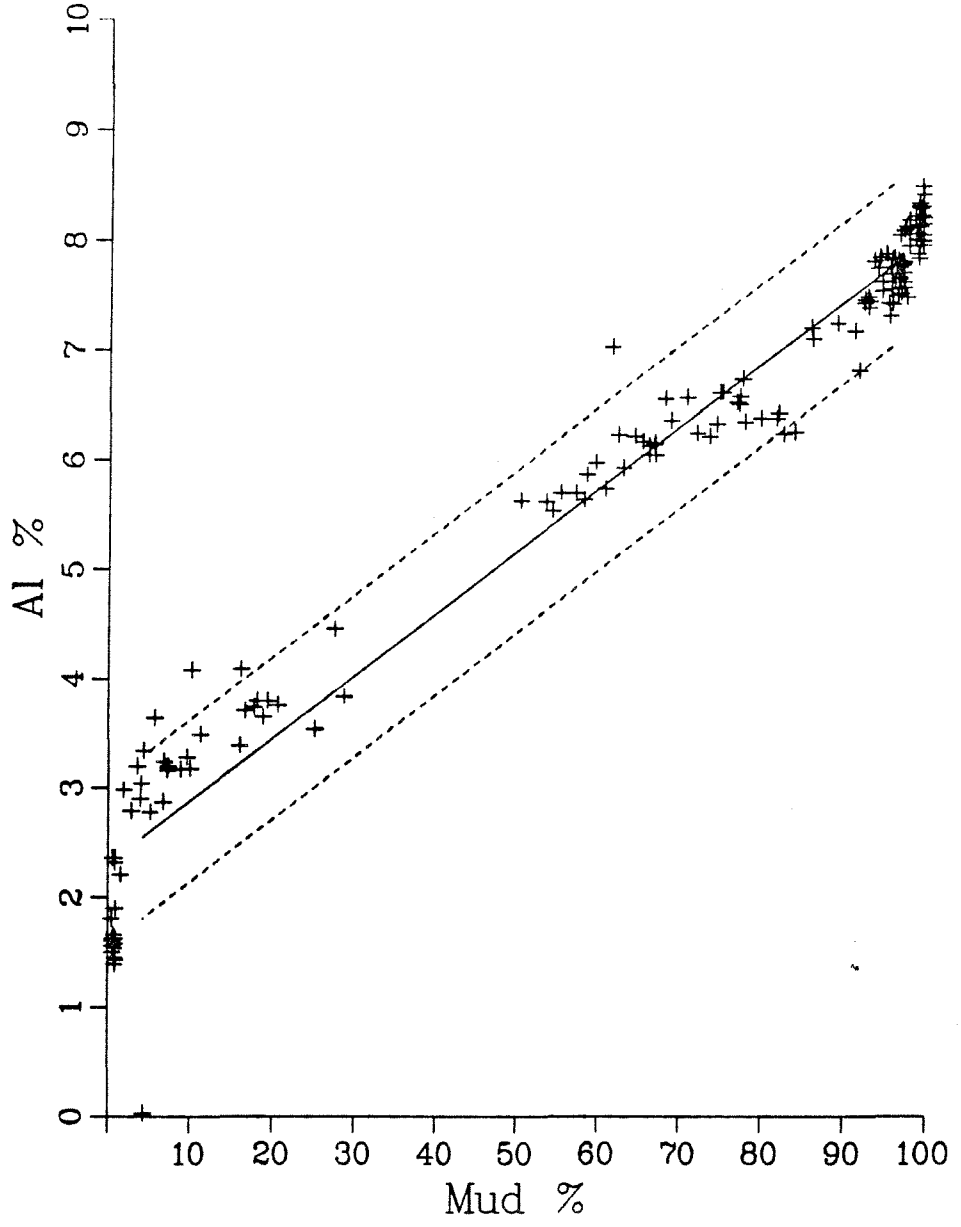
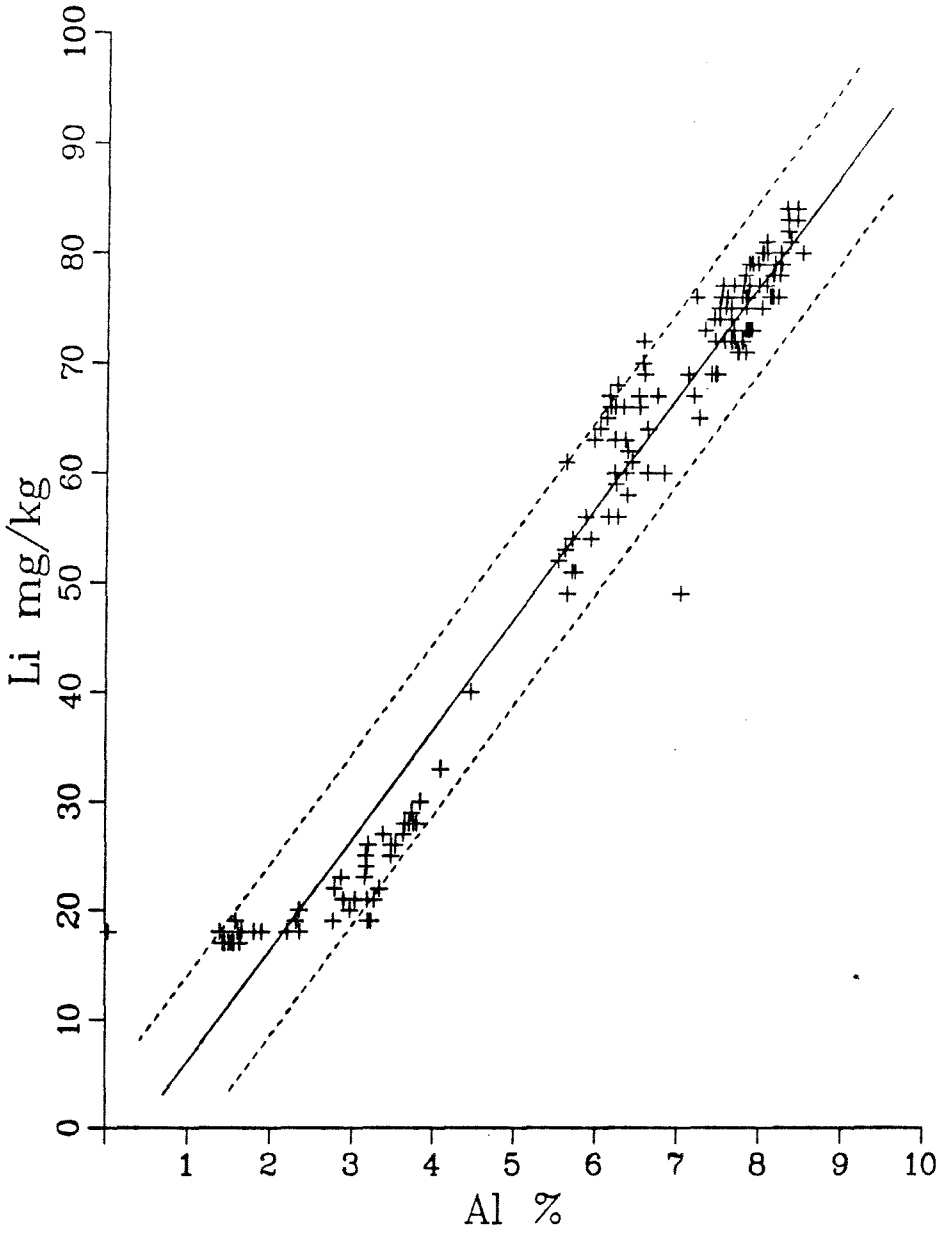


Figure 5



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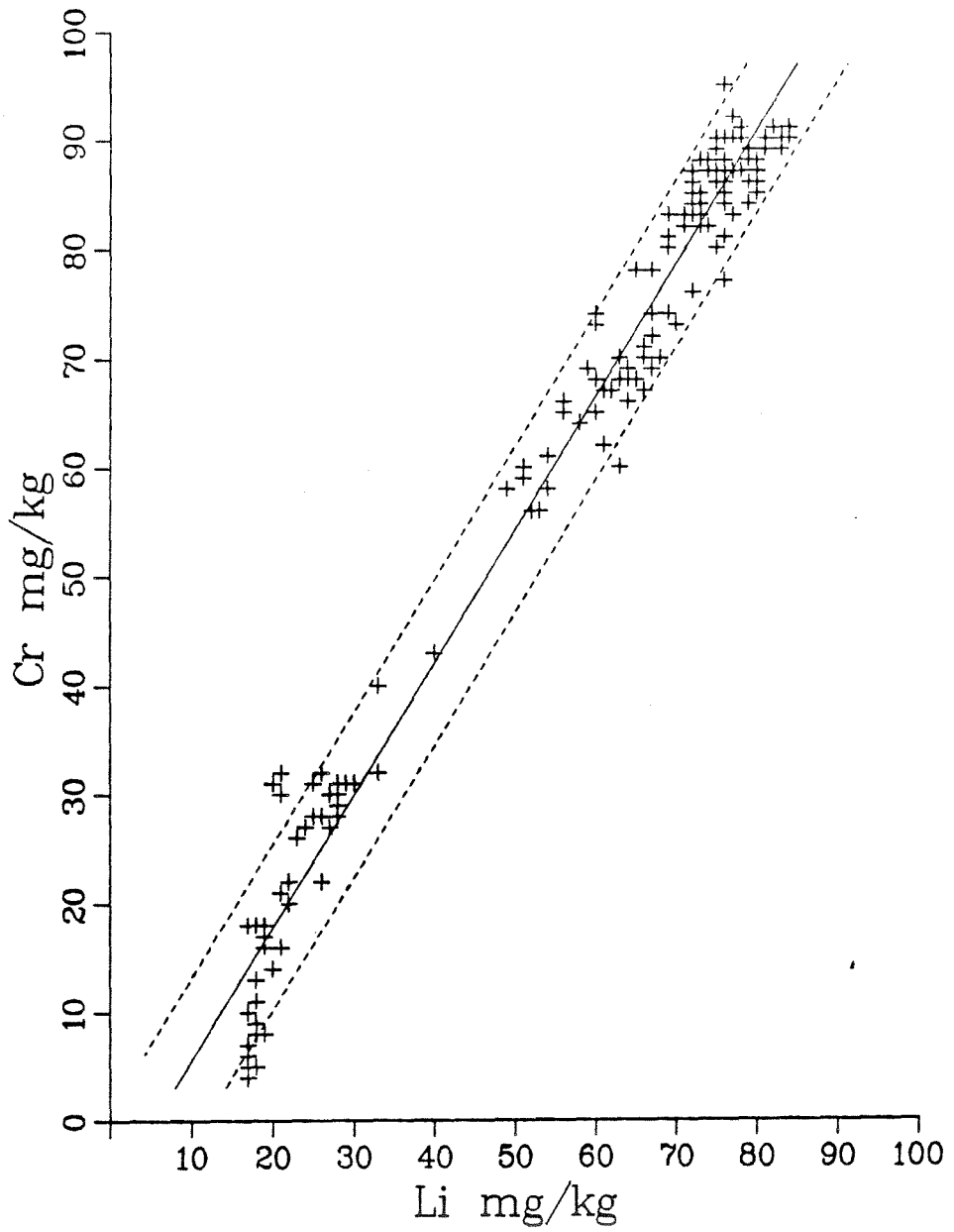

Cr mg/kg
0
10
20
30
40
50
60
70
80
90
100
Li mg/kg
10
20
30
40
50
60
70
80
90
100

Figure 7

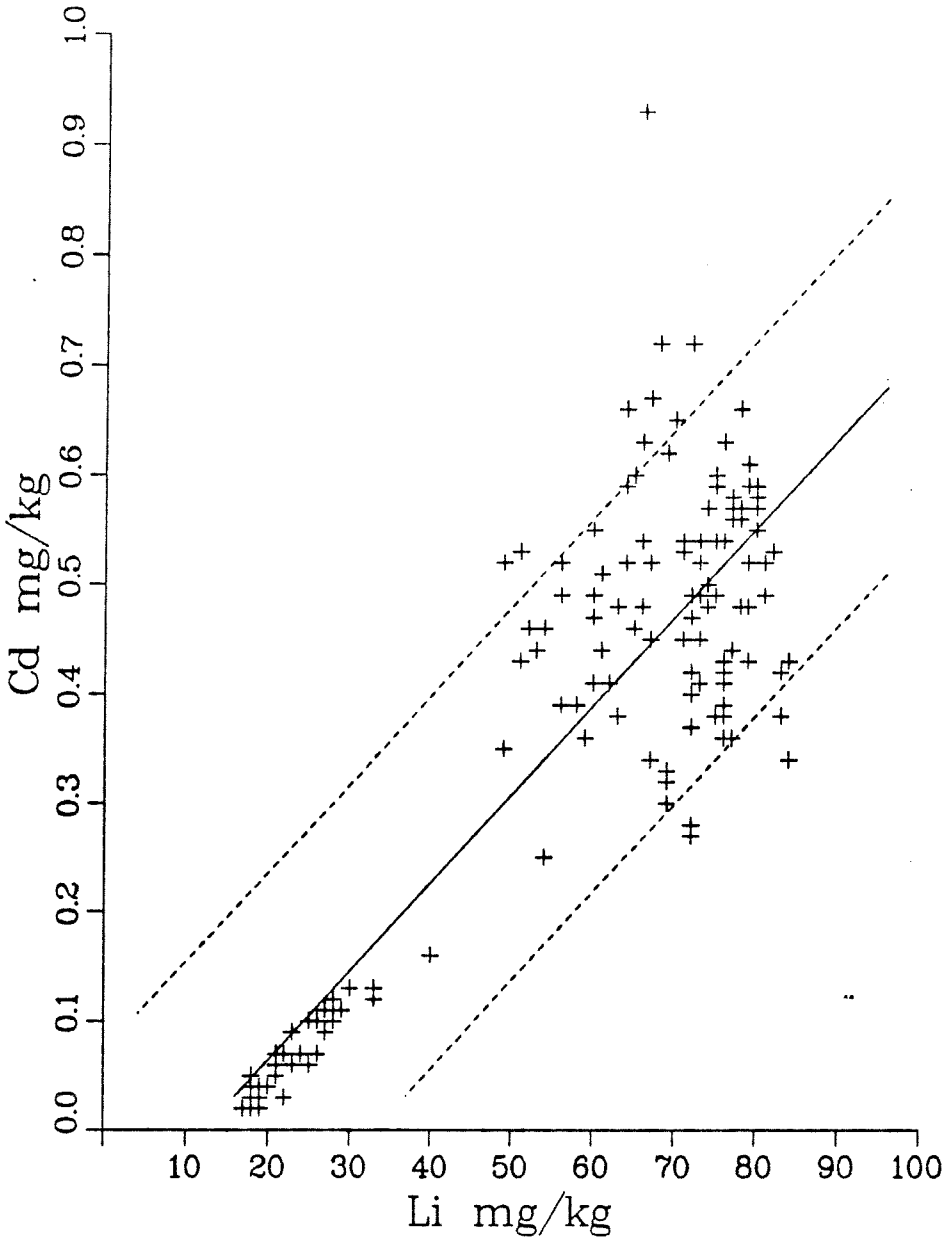

Cd mg/kg
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
10
20
30
40
50
60
70
80
90
100
Li mg/kg

Figure 8

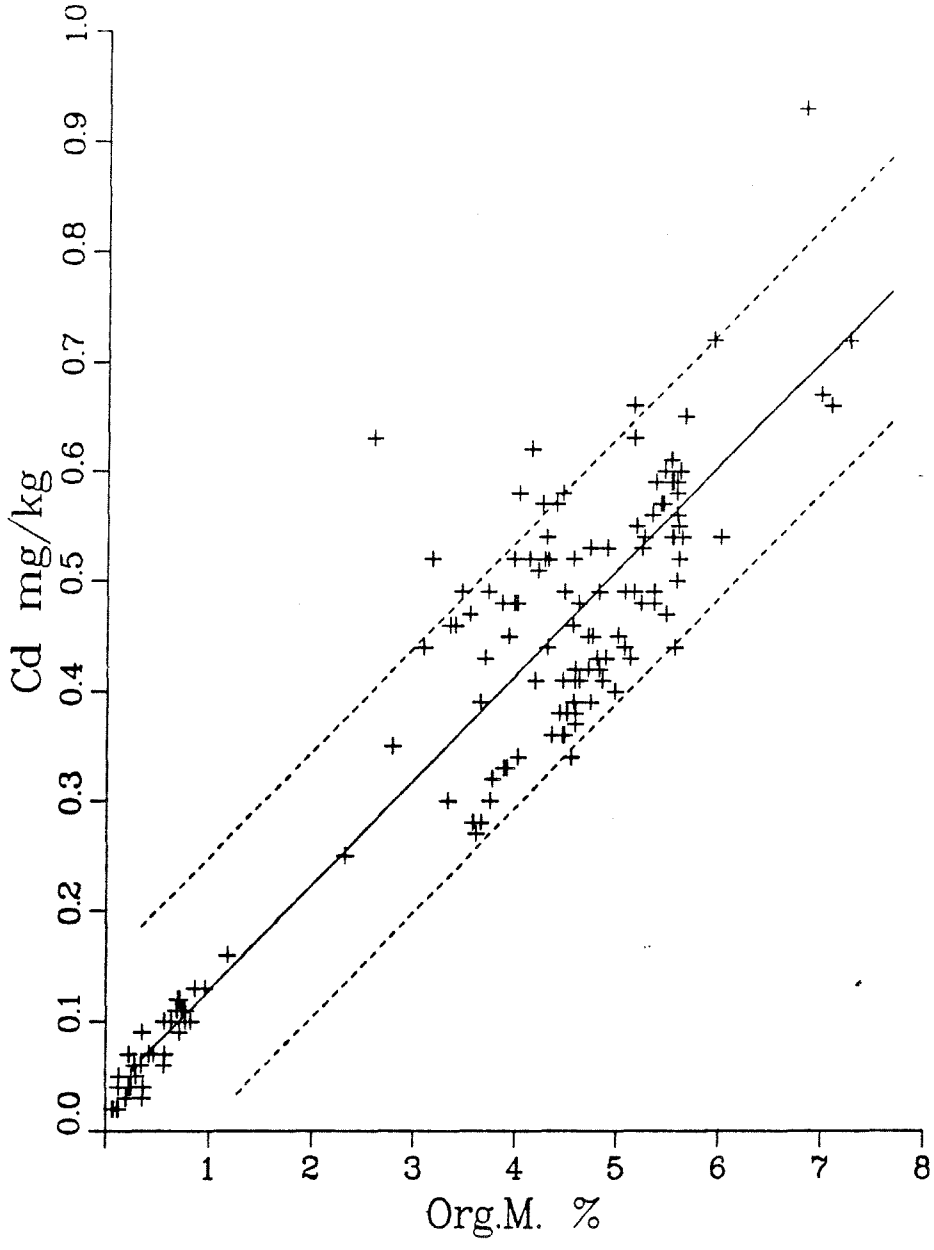


Figure 9

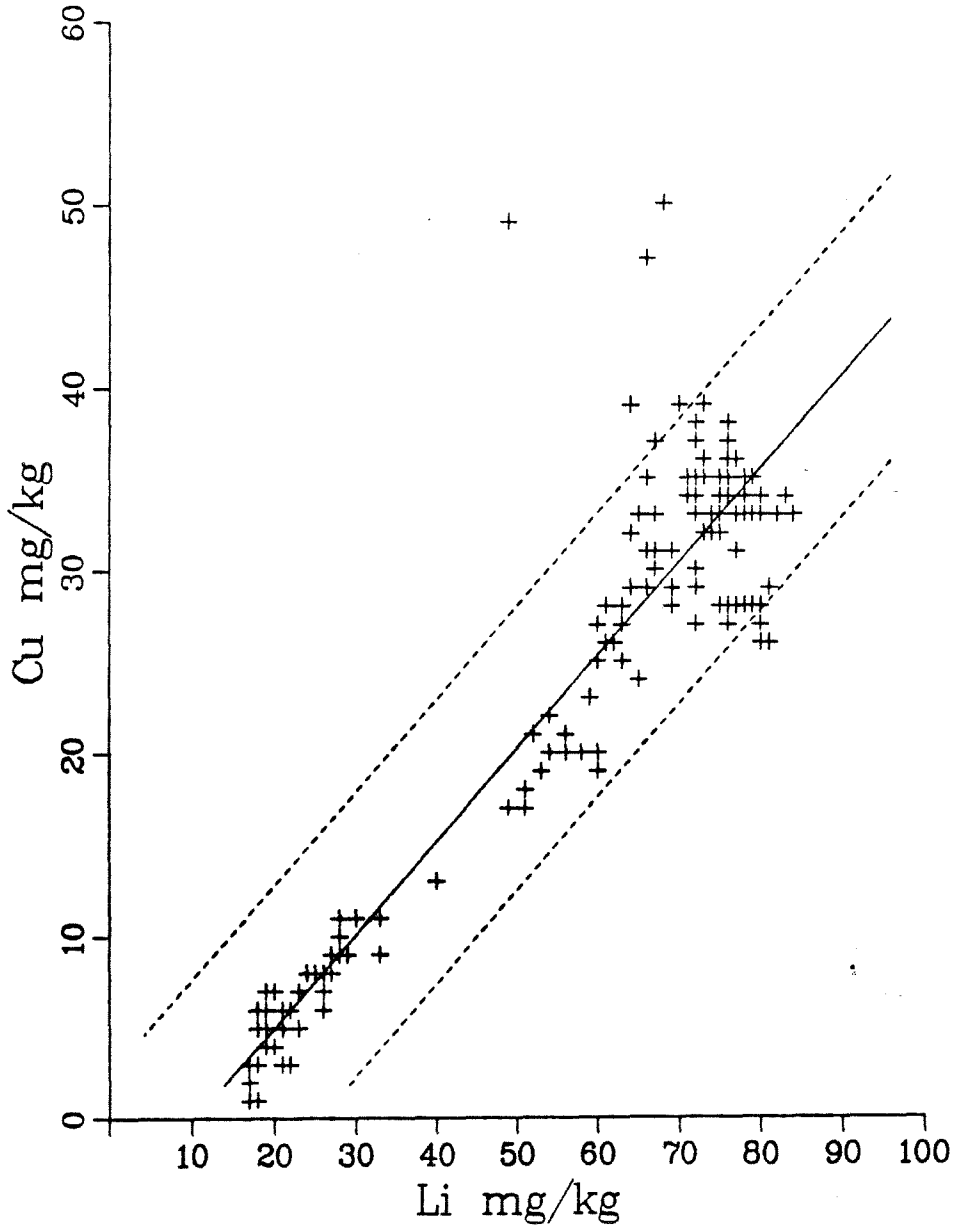


Figure 10

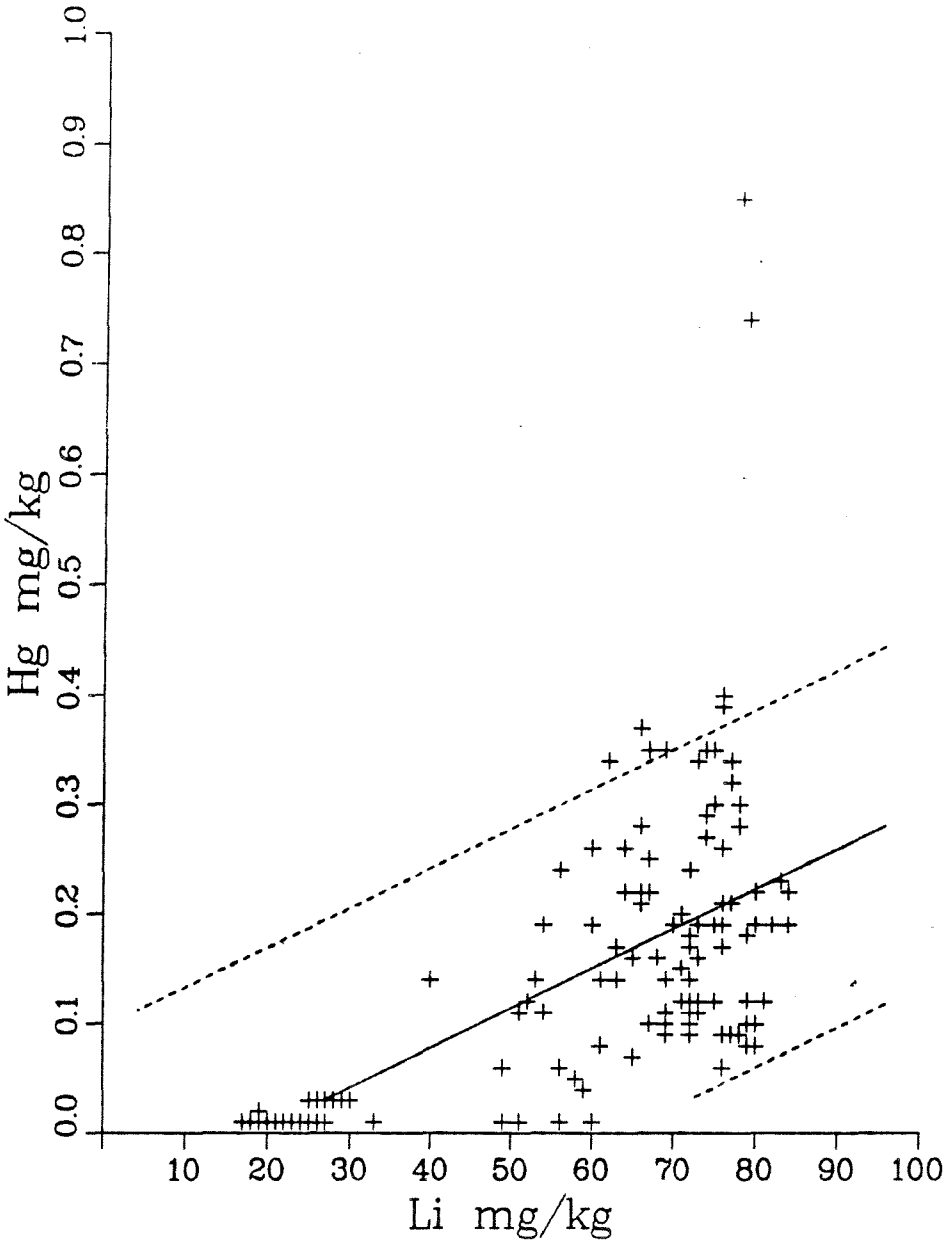
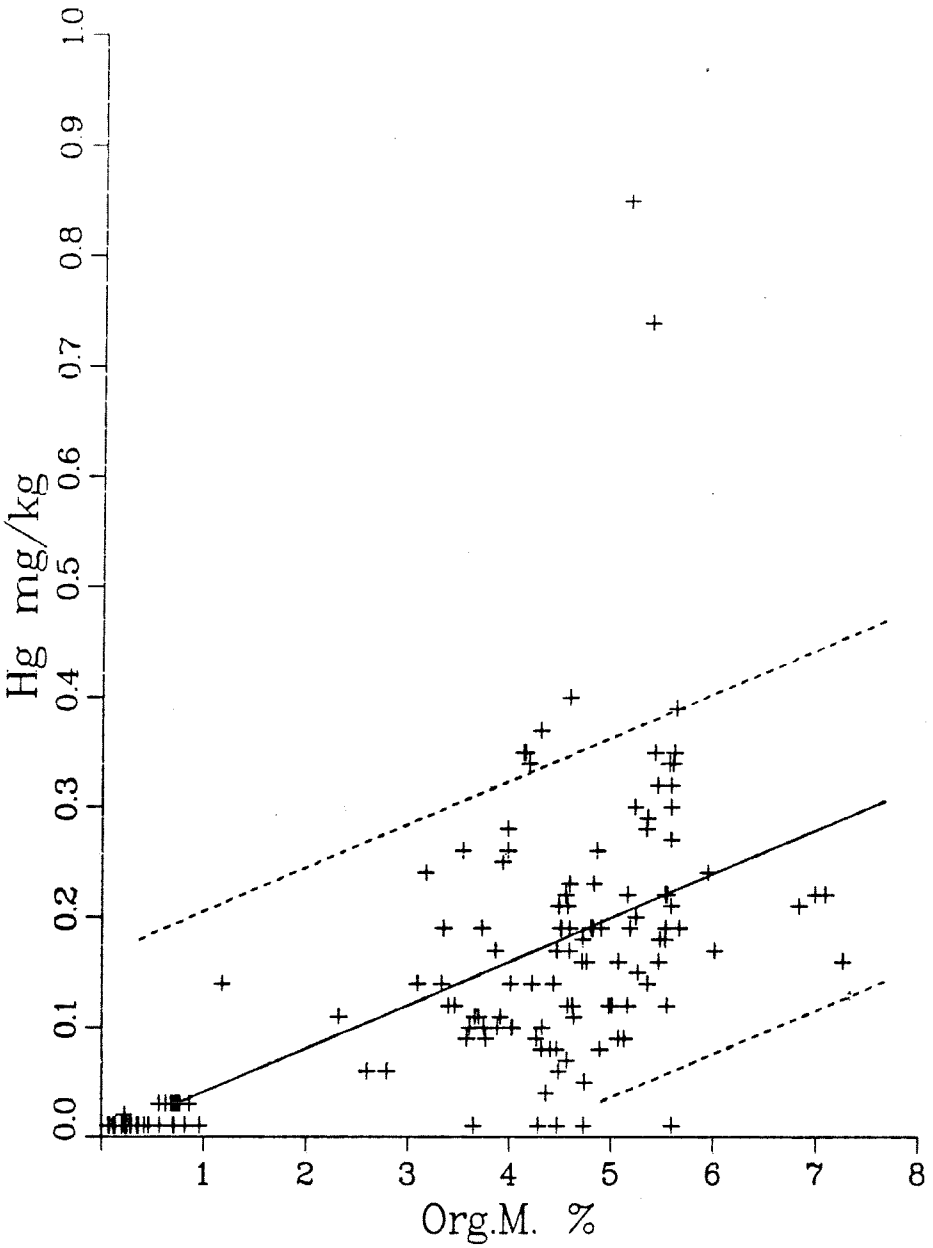

Hg mg/kg
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
10
20
30
40
50
60
70
80
90
100
Li mg/kg

Figure 11



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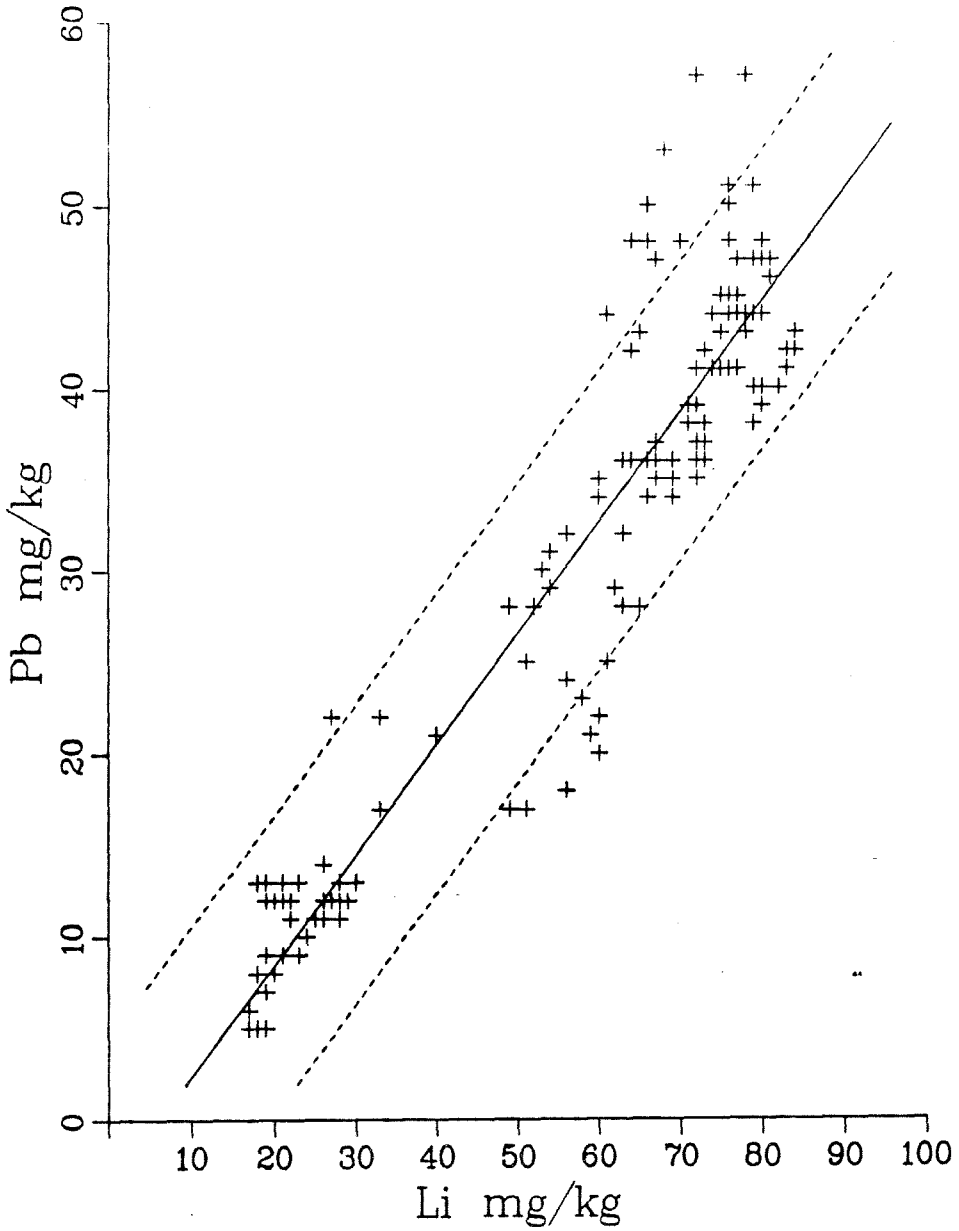

Figure 13

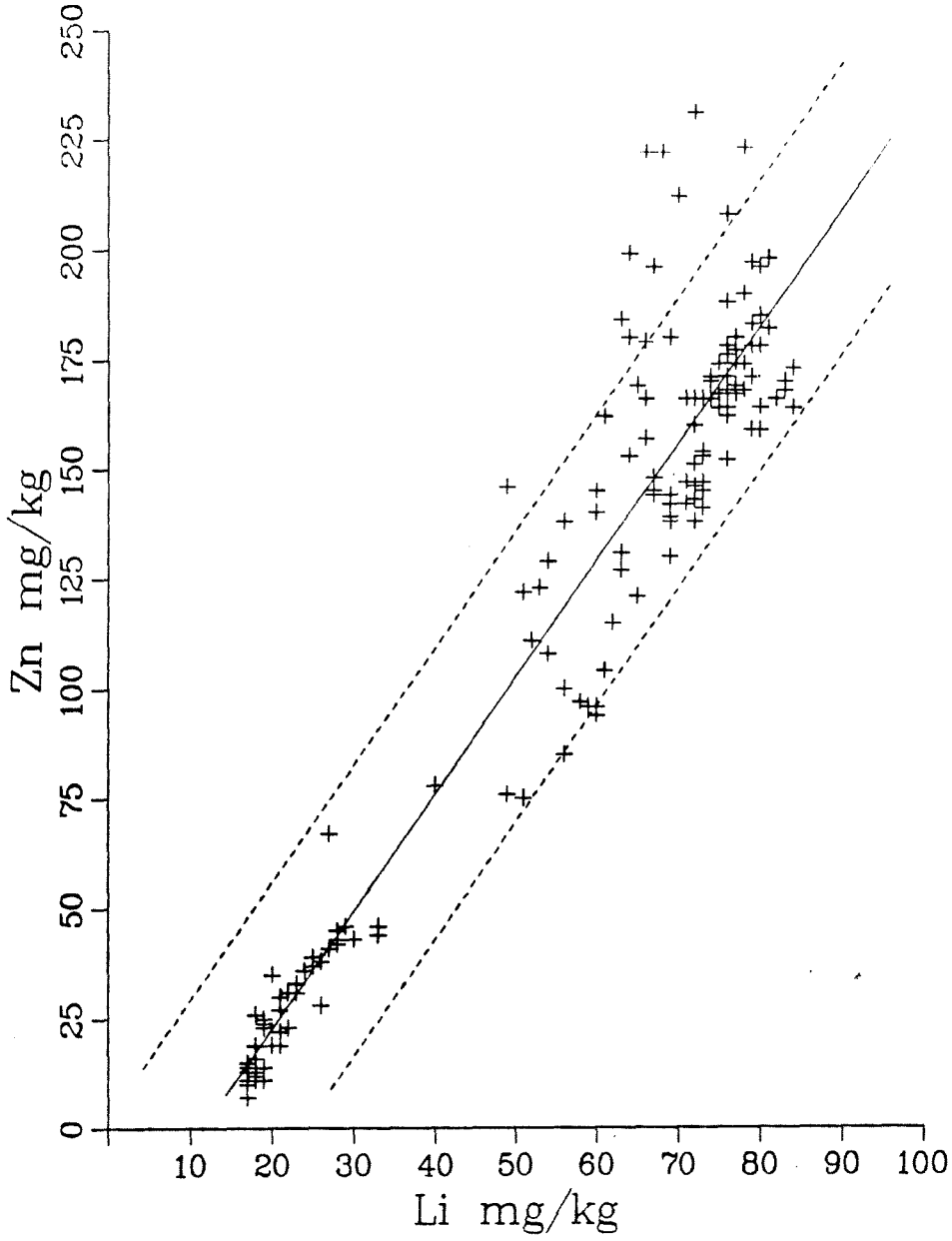
Zn mg/kg
0
25
50
75
100
125
150
175
200
225
250
10
20
30
40
50
60
70
80
90
100
Li mg/kg

Table 1

Precision Data (n=3) for Metals in Pictou Harbour Cores (5-6cm)

Core		Al %	Cd	Cu	Cr	Li	Pb	Zn
					(conc. in mg/kg)			
S1	mean	8.01	0.58	28	86	80	48	196
	sd	0.06	0.02	0.0	1.7	0.6	0.0	3.1
S2	mean	8.32	0.38	34	90	83	42	170
	sd	0.03	0.02	0.0	1.2	0.6	0.6	3.2
S3	mean	7.81	0.49	35	84	73	38	153
	sd	0.02	0.01	0.6	0.6	1.2	0.0	3.5
S4	mean	7.76	0.36	35	84	76	41	162
	sd	0.02	0.01	0.6	1.2	0.6	0.6	3.1
S5	mean	7.55	0.28	30	84	72	35	138
	sd	0.07	0.01	1.0	1.5	1.0	0.0	8.7
S6	mean	3.76	0.10	10	29	28	13	45
	sd	0.01	0.01	0.6	1.2	0.6	0.0	3.2
S7	mean	2.21	0.04	3	11	18	8	16
	sd	0.01	0.01	0.6	0.0	0.0	0.0	1.2
S8	mean	1.45	<.02	1	4	17	5	7
	sd	0.02	****	0.0	0.0	0.6	0.0	1.5
S9	mean	2.90	0.05	3	16	21	12	19
	sd	0.02	0.01	0.6	1.0	0.0	0.0	0.6
A1	mean	7.57	0.6	32	87	75	45	174
	sd	0.03	0.02	0.6	0.6	0.6	0.0	0.6
A2	mean	6.05	0.66	39	69	64	48	199
	sd	0.04	0.0	0.6	1.0	1.2	1.2	1.7
A3	mean	6.35	0.48	27	68	63	28	184
	sd	0.06	0.02	2.3	1.5	0.0	0.0	3.1
A4	mean	5.62	0.44	19	56	53	30	123
	sd	0.04	0.02	0.0	0.0	1.0	0.6	4.0

Table 2

Grain Size Distribution and Sediment Types in Pictou Harbor Cores

Stn. 1 Depth	Mud	Sand%	Type*
0-0.5	97.6	2.4	Mud
0.5-1	97.3	2.7	Mud
1-2	99.0	1.0	Mud
2-3	98.9	1.1	Mud
3-4	99.5	0.5	Mud
4-5	99.1	0.9	Mud
5-6	99.2	0.8	Mud
6-7	99.5	0.5	Mud
7-8	98.8	1.2	Mud
8-9	98.5	1.5	Mud
9-10	99.0	1.0	Mud
10-15	97.2	2.8	Mud
15-19	89.2	10.8	Sandy Mud

Stn. 2 Depth	Mud%	Sand%	Type
0-0.5	99.3	0.7	Mud
0.5-1	98.6	1.4	Mud
1-2	97.8	2.2	Mud
2-3	99.5	0.5	Mud
3-4	99.5	0.5	Mud
4-5	99.1	0.9	Mud
5-6	98.9	1.1	Mud
6-7	99.4	0.6	Mud
7-8	99.4	0.6	Mud
8-9	99.5	0.5	Mud
9-10	99.5	0.5	Mud
10-15	99.6	0.4	Mud
15-17	99.0	1.0	Mud

Stn. 3			
0-0.5	96.6	3.4	Mud
0.5-1	96.3	3.7	Mud
1-2	95.6	4.4	Mud
2-3	97.1	2.9	Mud
3-4	95.7	4.3	Mud
4-5	97.2	2.8	Mud
5-6	96.7	3.3	Mud
6-7	93.6	6.4	Sandy Mud
7-8	95.1	4.9	Mud
8-9	95.8	4.2	Mud
9-10	94.3	5.7	Sandy Mud
10-14	61.7	38.3	v. Sandy Mud

Stn. 4			
0-3	97.2	2.8	Mud
3-4	96.7	3.3	Mud
4-5	97.0	3.0	Mud
5-6	96.7	3.3	Mud
6-7	97.1	2.9	Mud
7-8	96.5	3.5	Mud
8-9	96.7	3.3	Mud
9-10	97.8	2.2	Mud
10-15	97.8	2.2	Mud
10-20	97.4	2.6	Mud

Stn. 5			
0-1	91.3	8.7	Sandy Mud
1-2	92.5	7.5	Sandy Mud
2-3	93.0	7.0	Sandy Mud
3-4	92.4	7.6	Sandy Mud
4-5	93.1	6.9	Sandy Mud
5-6	94.6	5.4	Sandy Mud
6-7	94.1	5.9	Sandy Mud
7-8	94.6	5.4	Sandy Mud
8-9	86.2	13.8	Sandy Mud
9-10	63.1	36.9	v. Sandy Mud
10-13	27.6	72.4	Muddy Sand

Stn. 6			
0-0.5	11.3	88.7	Muddy Sand
0.5-1	11.3	88.7	Muddy Sand
1-2	16.7	83.3	Muddy Sand
2-3	19.5	80.5	Muddy Sand
3-4	18.2	81.8	Muddy Sand
4-5	17.8	82.2	Muddy Sand
5-6	20.7	79.3	Muddy Sand
6-7	25.2	74.8	Muddy Sand
7-8	28.8	71.2	Muddy Sand
8-9	18.9	81.1	Muddy Sand
9-10	16.0	84.0	Muddy Sand
10-14	5.1	94.9	Muddy Sand

* Mud = >95% by weight <63μm in diameter
Sandy Mud = 5-30% by weight >63μm in diameter and >70% by weight <63μm
Sand = >95% by weight >63μm in diameter
Muddy Sand = 5-30% by weight <63μm in diameter and >70% by weight >63μm
v. sandy Mud = >30% by weight >63μm and > 30% by weight <63μm

Table 2 (continued)

Grain Size Distribution and Sediment Types in Pictou Harbor Cores

Stn. 7				
Depth	Mud%	Sand%		Type*
0-0.5	4.0	96.0		Sand
0.5-1	7.2	92.8	Muddy	Sand
1-2	10.0	90.0	Muddy	Sand
2-3	8.8	91.2	Muddy	Sand
3-4	6.7	93.3	Muddy	Sand
4-5	2.8	97.2		Sand
5-6	1.5	98.5		Sand
6-7	0.8	99.2		Sand
7-8	0.5	99.5		Sand
8-9	0.8	99.2		Sand
9-10	0.9	99.1		Sand
10-13	0.7	99.3		Sand

Stn. 8			
Depth	Mud%	Sand%	Type
0-1	0.5	99.5	Sand
1-2	0.8	99.2	Sand
2-3	0.5	99.5	Sand
3-4	0.9	99.1	Sand
4-5	0.5	99.5	Sand
5-6	0.8	99.2	Sand
6-7	0.9	99.1	Sand
7-8	0.9	99.1	Sand
8-9	0.6	99.4	Sand
9-10	0.8	99.2	Sand
10-15	0.4	99.6	Sand

Stn. 9				
0-0.5	9.6	90.4	Muddy	Sand
0.5-1	4.3	95.7		Sand
1-2	6.8	93.2	Muddy	Sand
2-3	7.3	92.7	Muddy	Sand
3-4	4.3	95.7		Sand
4-5	7.2	92.8	Muddy	Sand
5-6	3.9	96.1		Sand
6-7	5.7	94.3	Muddy	Sand
7-8	10.2	89.8	Muddy	Sand
8-9	16.2	85.8	Muddy	Sand
9-10	3.5	96.5		Sand
10-15	1.9	98.1		Sand

Stn. A1				
0-0.5	95.9	4.1		Mud
0.5-1	95.6	4.4		Mud
1-2	95.4	4.6		Mud
2-3	95.7	4.3		Mud
3-4	97.0	3.0		Mud
4-5	96.7	3.3		Mud
5-6	95.7	4.3		Mud
6-7	92.9	7.1	Sandy	Mud
7-8	96.1	3.9		Mud
8-9	96.5	3.5		Mud
9-10	96.9	3.1		Mud
10-15	96.0	4.0		Mud
15-19	97.0	3.0		Mud

Stn A2				
0-1	86.0	14.0		Sandy Mud
1-2	68.2	31.8	v.	Sandy Mud
2-3	72.1	27.9		Sandy Mud
3-4	62.4	37.6	v.	Sandy Mud
4-5	66.9	33.1	v.	Sandy Mud
5-6	67.0	33.0	v.	Sandy Mud
6-7	66.2	33.8	v.	Sandy Mud
7-8	66.2	33.8	v.	Sandy Mud
8-9	65.4	34.6	v.	Sandy Mud
9-10	70.9	29.1		Sandy Mud
10-15	50.5	49.5	v.	Sandy Mud
15-18	59.7	40.3	v.	Sandy Mud

Stn. A3				
0-0.5	77.0	23.0	Sandy	Mud
0.5-1	74.5	25.5	Sandy	Mud
1-2	77.4	22.6	Sandy	Mud
2-3	77.3	22.7	Sandy	Mud
3-4	77.7	22.3	Sandy	Mud
4-5	73.6	26.4	Sandy	Mud
5-6	77.9	2218	Sandy	Mud
6-7	79.9	20.1	Sandy	Mud
7-8	82.0	18.0	Sandy	Mud
8-9	82.6	17.4	Sandy	Mud
9-10	81.8	18.2	Sandy	Mud
10-15	84.0	16.0	Sandy	Mud
15-20	91.9	8.1	Sandy	Mud

Table 2 (continued)

Grain Size Distribution and Sediment Types in Pictou Harbor Cores

Stn. A4

Depth	Mud%	Sand%	Type
0-1	75.0	25.0	Sandy Mud
1-2	68.9	31.1	v.Sandy Mud
2-3	64.5	35.5	v.Sandy Mud
3-4	58.6	41.4	v.Sandy Mud
4-5	57.3	42.7	v.Sandy Mud
5-6	53.6	46.4	v.Sandy Mud
6-7	54.4	44.6	v.Sandy Mud
7-8	55.4	45.6	v.Sandy Mud
8-9	66.8	33.2	v.Sandy Mud
9-10	75.3	24.7	Sandy Mud
10-15	58.3	41.7	v.Sandy Mud
15-18	60.9	39.1	v.Sandy Mud

Table 3

Average concentrations of Metals and Organic Matter in Pictou Harbour Core Sediments

Metal	n	Mean	std	Range
		%		
Al%	156	5.89	2.21	1.39-7.11
OM%	156	3.4	2.1	0.06-7.26
		mg/kg		
Cd	156	0.35	0.21	0.02-0.93
Cr	156	61	29	4-95
Cu	156	23	12.8	1-50
Li	156	56	23.4	17-84
Hg	156	0.13	0.13	0.01-0.85
Pb	156	30	15	5-57
Zn	156	118	65.4	7-231

Values are expressed in mg/kg except for Al and Organic Matter which are reported in percent (%) dry weight

Table 4

Distribution of Metals, Mud, and Organic Matter with Core Depth

Metal concentrations are in mg/kg except in percent (%) for Al, Mud, and Organic carbon matter. Depth is in cm.

Stn.1 Depth	Cd	Cr	Cu	Hg	Li	Pb	Zn	Al%	Mud %	OM%
0-0.5	.49	80	28	.12	75	43	167	7.49	97.6	5.16
0.5-1	.43	81	28	.09	76	41	168	7.58	97.3	5.13
1-2	.44	83	28	.09	77	44	177	7.85	99.0	5.07
2-3	.48	86	28	.12	79	44	178	7.89	98.9	4.62
3-4	.52	84	28	.10	79	47	183	8.16	99.5	4.32
4-5	.57	87	28	.09	78	44	190	8.13	99.1	4.26
5-6	.58	86	28	.08	80	48	196	8.01	99.2	4.46
6-7	.52	89	26	.12	81	47	198	8.06	99.5	4.57
7-8	.57	86	27	.08	80	47	178	8.07	98.8	4.40
8-9	.58	87	26	.10	80	44	185	8.23	98.5	4.03
9-10	.49	90	29	.12	81	46	182	8.35	99.0	3.46
10-15	.63	85	27	.06	76	41	176	8.10	97.2	2.60
15-19	.46	78	24	.07	65	28	121	7.25	89.2	4.56
Stn 2										
0-0.5	.61	86	35	.18	79	40	171	8.24	99.3	5.52
0.5-1	.59	85	33	.22	80	39	159	8.02	98.6	5.52
1-2	.43	88	33	.08	79	38	159	7.96	97.8	4.89
2-3	.42	89	34	.23	83	41	168	8.43	99.5	4.83
3-4	.43	91	33	.19	84	43	173	8.43	99.5	4.8
4-5	.34	90	33	.22	84	42	164	8.30	99.1	4.55
5-6	.38	90	34	.23	83	42	170	8.32	98.9	4.59
6-7	.53	91	33	.19	82	40	166	8.32	99.4	4.9
7-8	.55	88	34	.19	80	40	164	8.50	99.4	5.18
8-9	.58	90	31	.21	77	41	169	7.97	99.5	5.58
9-10	.54	90	33	.19	75	41	164	8.01	99.5	5.53
10-15	.48	91	33	.30	78	44	168	8.22	99.6	5.23
15-17	.56	91	34	.28	78	43	174	8.15	99.0	5.34
Stn 3										
0-0.5	.54	83	35	.12	73	36	147	7.67	96.6	5.50
0.5-1	.49	83	37	.14	72	36	146	7.78	96.3	5.35
1-2	.40	84	33	.12	72	36	143	7.77	95.6	4.98
2-3	.45	83	34	.12	71	38	142	7.72	97.1	5.01
3-4	.54	82	34	.15	71	39	147	7.71	95.7	5.26
4-5	.53	82	35	.20	71	39	166	7.81	97.2	5.24
5-6	.49	84	35	.16	73	38	153	7.81	96.7	5.07
6-7	.45	83	35	.16	73	38	145	7.83	93.6	4.71
7-8	.41	84	36	.11	73	38	141	7.89	95.1	4.63
8-9	.49	85	39	.19	73	38	154	7.84	95.8	4.82
9-10	.45	82	36	.16	73	37	147	7.56	94.3	4.76
10-14	.35	58	49	.06	49	28	146	7.03	61.7	2.79

Table 4 (continued)

Depth	Cd	Cr	Cu	Hg	Li	Pb	Zn	Al%	Mud %	OM %
Stn. 4										
0-3	.37	85	35	.17	72	39	151	7.65	97.2	4.59
3-4	.42	86	34	.18	72	39	160	7.68	96.7	4.72
4-5	.38	86	35	.19	75	41	164	7.82	97.0	4.50
5-6	.36	84	35	.17	76	41	162	7.76	96.7	4.46
6-7	.38	86	36	.19	76	41	152	7.81	97.1	4.51
7-8	.42	87	36	.19	76	44	168	7.85	96.5	4.59
8-9	.36	92	36	.21	77	47	167	8.06	96.7	4.48
9-10	.39	90	37	.21	76	45	164	8.20	97.8	4.57
10-15	.41	88	34	.26	76	48	171	8.12	97.8	4.86
10-20	.41	95	36	.40	76	51	188	8.14	97.4	4.59
Stn. 5										
0-1	.34	78	30	.10	67	35	145	7.18	91.3	4.02
1-2	.32	81	29	.09	69	35	144	7.47	92.5	3.77
2-3	.30	80	28	.10	69	34	138	7.40	93.0	3.75
3-4	.33	83	29	.10	69	35	142	7.44	92.4	3.88
4-5	.33	80	29	.11	69	36	139	7.46	93.1	3.91
5-6	.28	84	30	.09	72	35	138	7.55	94.6	3.58
6-7	.27	86	27	.10	72	37	138	7.76	94.1	3.61
7-8	.28	86	29	.11	72	35	138	7.64	94.6	3.66
8-9	.30	81	28	.14	69	35	130	7.11	86.2	3.33
9-10	.25	61	22	.11	54	29	108	5.93	63.1	2.32
10-13	.16	43	13	.14	40	21	78	4.46	27.6	1.18
Stn.6										
0-0.5	.06	28	8	.03	25	11	39	3.49	11.3	.56
0.5-1	.1	28	8	.03	26	11	39	3.49	11.3	.63
1-2	.11	28	9	.03	28	11	45	3.71	16.7	.73
2-3	.12	31	11	.03	28	12	43	3.80	19.5	.72
3-4	.11	30	10	.03	28	11	42	3.80	18.2	.69
4-5	.11	31	9	.03	29	12	46	3.74	17.8	.75
5-6	.10	29	10	.03	28	13	45	3.76	20.7	.77
6-7	.10	32	7	.03	26	12	38	3.54	25.2	.56
7-8	.13	31	11	.03	30	13	43	3.84	28.8	.86
8-9	.11	28	11	.03	28	13	45	3.65	18.9	.77
9-10	.11	27	8	.03	27	12	41	3.39	16.0	.68
10-14	.04	17	7	.02	19	9	23	2.78	5.1	.22
Stn. 7										
0-0.5	.06	21	6	.01	21	9	30	3.04	4.0	.28
0.5-1	.06	26	7	.01	23	9	33	3.16	7.2	.34
1-2	.07	27	8	.01	24	10	36	3.18	10.0	.57
2-3	.10	31	8	.01	25	11	37	3.17	8.8	.82
3-4	.09	26	5	.01	23	13	31	2.87	6.7	.71
4-5	.07	20	6	.01	22	11	31	2.79	2.8	.46
5-6	.04	11	3	.01	18	8	16	2.21	1.5	.36
6-7	.05	13	6	.01	18	8	19	2.36	.8	.13
7-8	.04	14	4	.01	20	8	19	2.36	.5	.12
8-9	.02	16	24	.01	19	7	14	2.32	.8	.12
9-10	.02	8	5	.01	18	5	12	1.90	.9	.11
10-13	.02	8	3	.01	18	5	12	1.66	.7	.12

Table 4 (continued)

Depth	Cd	Cr	Cu	Hg	Li	Pb	Zn	Al%	Mud %	OM %
Stn. 8										
0-1	.02	10	3	.01	17	5	10	1.56	.5	.07
1-2	.02	9	1	.01	18	5	11	1.39	.8	.07
2-3	.02	18	2	.01	17	5	14	1.50	.5	.07
3-4	.02	6	1	.01	17	5	15	1.43	.9	.07
4-5	.02	8	1	.01	18	5	13	1.61	.5	.06
5-6	.02	4	1	.01	17	5	7	1.45	.8	.07
6-7	.02	8	4	.01	19	5	11	1.58	.9	.07
7-8	.02	6	2	.01	17	5	13	1.63	.9	.07
8-9	.02	7	1	.01	17	6	14	1.63	.6	.06
9-10	.02	5	1	.01	17	5	11	1.54	.8	.07
10-15	.02	5	1	.01	18	13	11	1.81	.4	.06
Stn.9										
0-0.5	.07	30	5	.01	21	13	7	3.28	9.6	.42
0.5-1	.03	18	3	.01	18	12	26	3.00	4.3	.35
1-2	.04	18	6	.01	19	13	24	3.24	6.8	.24
2-3	.03	18	5	.01	19	12	25	3.20	7.3	.20
3-4	.03	22	3	.01	22	13	23	3.34	4.3	.19
4-5	.05	32	5	.01	21	12	22	3.19	7.2	.25
5-6	.05	16	3	.01	21	22	19	2.90	3.9	.29
6-7	.09	30	9	.01	27	17	67	3.64	5.7	.35
7-8	.12	40	9	.01	33	22	46	4.08	10.2	.70
8-9	.13	32	11	.01	33	14	44	4.09	16.2	.96
9-10	.07	22	6	.01	26	12	28	3.20	3.50	.22
10-15	.04	31	7	.01	20	41	35	2.98	1.90	.12
Stn. A1										
0-0.5	.5	82	33	.27	74	42	166	7.43	95.9	5.58
0.5-1	.52	88	32	.34	73	41	166	7.32	95.6	5.60
1-2	.47	87	33	.18	72	44	166	7.44	95.4	5.47
2-3	.48	87	32	.29	74	44	170	7.63	95.7	5.35
3-4	.44	87	31	.34	77	45	169	7.78	97.0	5.56
4-5	.57	87	33	.32	77	45	174	7.66	96.7	5.45
5-6	.60	87	32	.35	75	44	174	7.57	95.7	5.61
6-7	.57	88	33	.35	74	45	171	7.50	92.9	5.42
7-8	.59	89	34	.3	75	45	174	7.63	96.1	5.58
8-9	.54	88	35	.39	76	47	178	7.51	96.5	5.63
9-10	.56	90	33	.32	77	51	180	7.53	96.9	5.58
10-15	.59	89	35	.74	79	57	197	7.85	96.0	5.37
15-19	.66	90	35	.85	78	50	223	7.80	97.0	5.16
Stn. A2										
0-1	.54	77	38	.17	76	48	208	7.21	86.0	6.01
1-2	.65	73	39	.19	70	53	212	6.56	68.2	5.66
2-3	.72	70	50	.16	68	50	222	6.25	72.1	7.26
3-4	.93	67	47	.21	66	47	222	6.23	62.4	6.83
4-5	.67	69	37	.22	67	48	196	6.16	66.9	6.99
5-6	.66	69	39	.22	64	43	199	6.05	67.0	7.09
6-7	.60	68	33	.16	65	42	169	6.13	66.2	5.46
7-8	.59	66	32	.22	64	48	180	6.05	66.2	5.54
8-9	.63	71	35	.22	66	57	179	6.17	65.4	5.16
9-10	.72	76	38	.24	72	44	231	6.57	70.9	5.94
10-15	.51	62	28	.14	61	36	162	5.63	50.5	4.22
15-18	.38	60	25	.14	63	36	127	5.98	59.7	4.43

Table 4 (continued)

Depth	Cd	Cr	Cu	Hg	Li	Pb	Zn	Al%	Mud	% OM%
Stn. A3										
0-0.5	.54	70	29	.37	66	34	166	6.53	77.0	4.30
0.5-1	.48	70	31	.28	66	36	157	6.33	74.5	3.98
1-2	.62	74	31	.35	69	37	180	6.58	77.4	4.15
2-3	.52	72	31	.35	67	36	148	6.51	77.3	4.13
3-4	.45	74	33	.25	67	32	144	6.74	77.7	3.93
4-5	.48	70	28	.17	63	28	131	6.22	73.6	3.86
5-6	.48	68	27	.14	63	29	184	6.35	77.9	4.01
6-7	.41	67	26	.34	62	25	115	6.38	79.9	4.19
7-8	.44	67	26	.08	61	21	104	6.43	82.0	4.31
8-9	.36	69	23	.04	59	23	96	6.24	82.6	4.36
9-10	.39	64	20	.05	58	18	97	6.38	81.8	4.74
10-15	.39	66	20	.01	56	20	85	6.26	84.0	3.65
15-20	.41	73	19	.01	60	36	96	6.82	91.9	4.47
Stn. A4										
0-1	.52	68	29	.26	64	34	153	6.62	75.0	3.98
1-2	.49	68	27	.19	60	35	140	6.36	68.9	3.73
2-3	.47	65	25	.26	60	32	145	6.22	64.5	3.54
3-4	.52	65	20	.24	56	31	138	5.87	58.6	3.17
4-5	.46	58	20	.19	54	30	129	5.70	57.3	3.35
5-6	.44	56	19	.14	53	28	123	5.62	53.6	3.09
6-7	.46	56	21	.12	52	25	111	5.54	54.4	3.40
7-8	.43	59	18	.11	51	24	122	5.70	55.4	3.70
8-9	.49	66	21	.06	56	22	100	6.14	66.8	4.48
9-10	.55	74	20	.01	60	17	94	6.62	75.3	5.59
10-15	.52	58	17	.01	49	17	76	5.64	58.3	4.28
15-18	.53	60	17	.01	51	17	75	5.74	60.9	4.73

TABLE 5

Textural distribution of the mean metal concentrations (mg/kg) in Pictou Harbour sediments compared to other sediments

Location	n	Li	sd	Cr	sd	Cu	sd	Hg	sd	Pb	sd	Zn	sd	Cd	sd
Pictou Harbour															
Sands	48	23	5.3	21	10	6	3.3	0.02	0.02	10	4.2	29	15.8	0.06	0.04
Muds	56	75	4.5	86	3.7	32	3.6	0.16	0.06	41	4.4	160	17.2	0.45	0.09
Mouth of East River (A Cores)															
V.S.Muds	19	59	6.4	64	5.2	27	8.9	0.16	0.07	36	10.6	147	43.2	0.55	0.12
Muds	29	69	7.1	78	17.2	30	5.1	0.27	0.19	37	10.3	154	36.7	0.51	0.08
St. Lawrence[1]															
Open Gulf:															
Sands	23	12	4.2	44	20.4	9	3.0	0.13	0.08	18	6.3	29	8.8	-	
Muds	57	33	7.8	87	17.2	24	6.5	0.22	0.13	21	5.4	83	20.6	-	
Miramichi River Estuary [2]															
Mud	1	45	0.6	71	11	25	3.8	0.17	0.01	34	6.1	191	17	0.59	0.10
Baie de Chaleurs [2]															
Mud	1	47	0.5	123	14	19	2.7	0.12	0.01	23	3.4	119	12	0.25	0.04
Baffin Bay[3]															
Sands	6	10	3.9	55	48	8	4.7	0.04	0.01	22	6.4	27	9.7	0.07	.01
Muds	20	53	15	77	19	43	21	0.07	0.03	19	7.2	1 75	20	0.15	.07
Bay of Fundy[4]															
Sands	38	23	5.0	50	46.0	13	4.3	0.03	0.01	19	5.3	41	10.0	-	
Muds	13	53	10.4	73	13.9	19	2.7	0.06	0.02	30	6.6	77	15.2	-	

[1]Loring, 1978, 1979; Berman, 1982 [2], [3] Loring, 1984;[4] Loring, 1982.
n = number of samples.
sd = standard deviation
Sands= sediments containing >70% material >63um by weight.
Muds= sediments containing >70% material <63um by weight.
V.S.Muds = sediments containing >30% of each component.

Table 6

Correlation Matrix, Pictou Harbour Core Samples

	Al	Cd	Cr	Cu	Hg	Li	Pb	Zn
Mud	0.98	0.84	0.99	0.91	0.61	0.98	0.89	0.91
OM%	0.89	0.94	0.91	0.93	0.65	0.93	0.91	0.93
Al%	-	0.84	0.99	0.91	0.60	0.98	0.91	0.91
Cd	0.84	-	0.85	0.88	0.66	0.88	0.89	0.93
Cr	0.99	0.85	-	0.92	0.64	0.99	0.92	0.93
Hg	0.60	0.66	0.64	0.67	-	0.65	0.72	0.71
Li	0.98	0.88	0.99	0.93	0.65	-	0.94	0.95
Pb	0.91	0.89	0.85	0.93	0.72	0.94	-	0.98
Zn	0.91	0.93	0.93	0.95	0.71	0.95	0.92	-

N=156; $p<0.01$