Organic Enrichment of Sediments in Bedford Basin and Halifax Harbour

N. J. Prouse and B. T. Hargrave

Biological Sciences Branch
Scotia-Fundy Region
Department of Fisheries and Oceans

Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia
B2Y 4A2

October 1987

Canadian Technical Report of Fisheries and Aquatic Sciences No. 1571

Fisheries and Oceans Pêches et Océans

Canada

Canadian Technical Report of Fisheries and Aquatic Sciences

Technical reports contain scientific and technical information that contributes to existing knowledge but which is not normally appropriate for primary literature. Technical reports are directed primarily toward a worldwide audience and have an international distribution. No restriction is placed on subject matter and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Technical reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1–456 in this series were issued as Technical Reports of the Fisheries Research Board of Canada. Numbers 457–714 were issued as Department of the Environment, Fisheries and Marine Service, Research and Development Directorate Technical Reports. Numbers 715–924 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Technical Reports. The current series name was changed with report number 925.

Technical reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport technique canadien des sciences halieutiques et aquatiques

Les rapports techniques contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui ne sont pas normalement appropriés pour la publication dans un journal scientifique. Les rapports techniques sont destinés essentiellement à un public international et ils sont distribués à cet échelon. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports techniques peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports techniques sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annual des publications scientifiques et techniques du Ministère.

Les numéros 1 à 456 de cette série ont été publiés à titre de rapports techniques de l'Office des recherches sur les pêcheries du Canada. Les numéros 457 à 714 sont parus à titre de rapports techniques de la Direction générale de la recherche et du développement, Service des pêches et de la mer, ministère de l'Environnement. Les numéros 715 à 924 ont été publiés à titre de rapports techniques du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 925.

Les rapports techniques sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Technical Report of
Fisheries and Aquatic Sciences No. 1571

September 1987

ORGANIC ENRICHMENT OF SEDIMENTS IN BEDFORD BASIN AND HALIFAX HARBOUR

by

N.J. Prouse and B.T. Hargrave

Biological Sciences Branch
Department of Fisheries and Oceans

Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia
Canada B2Y 4A2

Minister of Supply and Services Canada 1987
Cat. No. Fs 97-6/1571E ISSN 0706-6457

Correct citation for this publication:

Prouse, N.J. and Hargrave, B.T. 1987. Organic enrichment of sediments in Bedford Basin and Halifax Harbour. Can. Tech. Rep. Fish. Aquat. Sci. No. 1571: v + 36 p.

ABSTRACT

Prouse, N.J. and Hargrave, B.T. 1987. Organic enrichment of sediments in Bedford Basin and Halifax Harbour. Can. Tech. Rep. Fish. Aquat. Sci. No. 1571: v + 36 p.

Surface sediment samples from 102 stations distributed uniformly throughout Bedford Basin and Halifax Harbour were collected during 1986 to map the distribution of organic content and oxygen uptake in relation to known sources of sewage discharge. Measurements of sediment porosity, oxidation-reduction potential, organic matter content, organic carbon and nitrogen content and oxygen uptake by a sediment slurry incubated in the laboratory are presented for each station in tabular and graphical form. Interpretation of results will follow in a separate report.

RÉSUMÉ

Prouse, N.J. and Hargrave, B.T. 1987. Organic enrichment of sediments in Bedford Basin and Halifax Harbour. Can. Tech. Rep. Fish. Aquat. Sci. No. 1571: v + 36 p.

On a prélevé en 1986 des échantillons de sédiments superficiels dans 102 stations réparties uniformément dans le basin de Bedford et dans le port d'Halifax, en vue de dresser une carte montrant la distribution de la teneur en matières organiques et de la consommation d'oxygène par rapport à des sources connues de déchets. Pour chaque station, on présente sous forme de tableau et de graphique des données sur la porosité des sédiments, le potentiel d'oxydo-réduction, la teneur en matières organiques, la teneur en carbone et en azote organiques et la consommation d'oxygène par une suspension de sédiments incubée en laboratoire. L'interprétation des résultats fera l'objet d'un rapport séparé.

ACKNOWLEDGEMENTS

We thank Mr. Peter Cranford, Mr. Paul Keizer, Ms. Carol Simmons and Ms. Georgina Phillips for assistance with sample collection, some chemical analyses and preliminary statistical treatment of the data. We are grateful to Brian Smith and Stephen Hurlbut for providing information on sewage input to Halifax Inlet.

TABLE OF CONTENTS

Introduction

Considerable controversy and interest surrounds the discharge of untreated sewage into Bedford Basin and Halifax Harbour. Organic and inorganic enrichment through sewage discharge and urban runoff from Halifax and Dartmouth has fouled the central part of Halifax Harbour and there is the possibility of limitations to future recreational use of Bedford Basin, the Northwest Arm and the outer parts of Halifax Harbour. The impact of sewage discharge into these coastal waters has been visible enough to stimulate the Halifax Inlet Water Quality Study (ASA Consulting, 1986; CBCL Ltd., 1987) by the Metropolitan Planning Committee. A numerical box model of the upper mixed layer (20 m depth) was developed to predict the distribution of coliform bacteria, dissolved oxygen and oxygen demand to evaluate contamination effects due to sanitary sewage discharge. The study indicated that for seasonal variations, expected population increases over the next decade and storm events, that the oxygen demand created by sewage loading was insufficient to cause large scale oxygen depression in the upper 20 m of Halifax Harbour.

There have been numerous studies in Bedford Basin in recent years that provide a data base for evaluating the eutrophic nature of this coastal bay. Observations between 1968 and 1978 included seasonal studies of hydrography, dissolved nutrient and oxygen concentrations, phytoplankton pigments and production (Krauel 1969; Platt and Irwin 1971, 1972; Platt et al 1973; Irwin et al 1975; Taguchi et al 1975; Irwin and Platt 1978 a,b; Taguchi and Platt 1977, 1978a,b). Seasonal cycles of micro and macrozooplankton biomass have been described by Sameoto (1971) and Conover and Mayzaud (1975). Short-term temporal and spatial differences in phytoplankton biomass distribution and production have been quantified in a 24-hr chlorophyll budget (Platt and Conover 1971), the spatial distribution of production: biomass ratios (Platt and Filion 1973), and effects of wind forcing on flusing rates (Platt et al 1972; Platt 1975). The effects of sewage discharge and nutrient enrichment in Bedford Basin were discussed in a general way by Platt et al. (1970) and more directly observed in a spatial and seasonal study of coliform bacteria (Freeman 1972) and petroleum hydrocarbons in Halifax Harbour during summer (Michalik and

Gordon 1971).

All of the these earlier investigations focussed on variables in the water column in Bedford Basin or Halifax Harbour. Other observations of bottom sediments and settling particle collected in sediment traps also show the eutrophic nature of the Basin. Hargrave et al. (1976) reported seasonal changes in sedimentation rates of particles which were related to phytoplankton production (Hargrave 1978), the nature and concentration of suspended particulate matter (Taguchi and Hargrave 1978), mixed-layer depth (Hargrave 1975a) and plankton biomass and size distribution (Hargrave 1980). Organic content in sediments in Bedford Basin was observed to be inversely correlated with the gradient of the bottom slope (Hargrave and Kamp Nielson 1977) with rates of sediment oxygen uptake that vary seasonally in response to organic matter supply (Hargrave 1978) and accumulation of unoxidized reduced compounds (Hargrave 1975b). Rates of chemical oxygen uptake by sediments in Bedford Basin are high when compared to other areas and values are inversely correlated with macrofauna biomass (Hargrave 1974).

None of these earlier studies has compared distributional gradients of variables in Bedford Basin with similar measurements in adjacent areas of Halifax Harbour. Since depositional basins may be a sink for settled particular matter, evidence for enrichment due to sewage discharge into Bedford Basin and Halifax Harbour might be provided by measurements of organic matter accumulated in sediments. A survey of metals and chlorinated hydrocarbon in surface (0-15 cm) sediment collected in fifteen studies over eight years has been compiled for Halifax Harbour (Ocean Chem Group, 1986). In order to provide a more extensive spatial data base for evaluating the potential impact of sewage discharge into Bedford Basin and Halifax Harbour, we carried out a sampling program from winter to summer of 1986. A 0.1 m^2 Van Veen grab was used to collect samples of the upper few centimeters of sediment from 102 stations. Data are summarized here in tabular and graphic form. A full interpretation will follow in a separate report.

Methods

Sampling

Single bottom grab samples were taken with a 0.1 m^2 Van Veen grab at stations arranged on a grid from the head of Bedford Basin to the mouth of Halifax Harbour (Fig. 1). A total of 102 stations were sampled during the period January 22 to July 17, 1986 (Table 1). In addition, four stations (24, 47, 60, 88) were chosen for replicate grabs to determine sampling variability; two stations were samples in Bedford Basin on July 14 and two in Halifax Harbour on July 17, 1986. Ten grabs were taken at each station for separate samples and one grab was subsampled ten times.

Only grabs with an intact surface sediment layer were used for analyses. This was assessed by the presence of a distinct light brown-beige surface layer overlying a dark grey, brown or black subsurface layer. For each grab, temperature was recorded and sediment from the top 1 cm was scooped into whirl-pac bags and frozen for further analyses. An additional sample surface sediment was drawn into a 5 ml open-ended syringe and placed into a scintillation vial. A 1 mm platinum electrode with a reference electrode was used to measure the redox potential (Eh) as mv of this sediment. The platinum electrode was constructed by joining a 2 mm piece of 0.2 mm diameter platinum wire to the end of a 0.2 mm diameter silver wire. The platinum tip was sealed by epoxy cement into the end of a piece of teflon tubing (0.3 mm inside diameter) so that it protruded 1 mm. The teflon tubing was rigid enough to form a probe for penetration of silty and sandy sediments. The silver wire was attached to a Radiometer pH meter (M29) by an insulated extension wire. A calomel reference electrode (+256 mv at 5°C) (Radiometer K401) was used to complete the circuit when the tip was placed in the wet sediment next to the platinum electrode. Eh was measured at ambient sediment temperatures (4°C to 7°C) which did not change during the brief time required to record the mv output from the pH meter. Electrodes were standardized in a quinhydrone solution (+275 mv, pH 7°, 20°C). Variation between replicate measurements within one sediment sample as the standard error (SE) of the mean was

±10 mv provided that the platinum tip was cleaned before each determination. The tip was cleaned by gentle rotation in fine abrasive powder (Ajax) on damp filter paper after each measurement.

Grain size analyses of sediments will be subject of another report.

Chemical Analyses

In the laboratory, samples held frozen (-20°C) were thawed immediately prior to analysis. Subsamples of dry sediment, pulverized with a mortar and pestel, were placed in precombusted and preweighed aluminum foil boats. Percent organic matter was determined by weight loss after baking at 550°C for 4 hours. Percent water in the sediment (porosity) was calculated from weight change in wet sediment placed on preweighed glass fiber filters and dried at 60°C for 24 hours. Nitrogen and organic carbon was measured on a Perkin Elmer 240B elemental analyzer. Sediment was acid treated (3 ml 1N HCL to 1 g dried sediment) to remove carbonate. Acid was removed by drying (60°C) under vacuum for 48 h. A weight correction derived from blanks was applied to account for increases due to chloride salts added by acidification.

Measurements of total oxygen consumption by stirred sediment slurries were carried out in glass-stoppered flasks (30 ml). Flasks were filled with 0.45 μm Millipore filtered seawater at 10°C. A small amount of thawed sediment was added to flasks avoiding air spaces. Controls without sediment were also incubated. Flasks were rotated to keep particles in suspension (30 rpm) for 4-24 hours at 10°C. Initial and final dissolved oxygen concentrations ($\pm$ 0.05 mg l^{-1}) were measured with a Radiometer Blood Gas Analyzer with a thermostated injection system. Contents of flasks were allowed to settle briefly (10 min.) before withdrawal of 2 ml of sample. Particulate matter in flasks was filtered onto preweighed glass fibre filters and weight of sediment incubated was determined after drying overnight (60°C). Oxygen uptake was calculated as $\mu g\ O_2\ g^{-1}$ dry weight h^{-1}.

RESULTS AND DISCUSSION

Measurements to compare variability between samples taken in different grabs with that occuring between samples taken within one grab (Tables 2-8) showed large differences in variability for different measures at the four stations chosen for replicate sampling. Within and between grab sample variation was normalized by calculation of the coefficient of variation (C.V.) {(Standard deviation/mean). 100} for each set of replicated measurements. In general, porosity varied the least with similar variability (C.V.'s 7.3 to 14.6%) between and within grabs (Table 2). Greatest variation occurred for measures of sediment oxygen uptake with C.V. values ranging from 33 to 100% (Table 8).

In general, the least variation was observed for all measures at station 47 (Fairview Cove) (9 out of 14 comparisons) (Table 9). The shallow depth (26 m) and frequency of ship movements at the site with resulting resuspension of bottom sediments, could contribute to the more uniform distribution of variables measured between and within replicate grabs. Station 88, on the other hand, demonstrated the highest variation in 8 out of 14 comparisons. This is also a shallow station (20 m) and in an area of the outer part of Halifax Harbour subject to strong tidal currents. Bottom sediments are heterogeneous with areas of mud intermixed with sand and gravel. The distribution of sediment type and size classification will be reported separately.

The data for measures of porosity, percent organic matter, redox potential, organic carbon and nitrogen content, carbon: nitrogen ratios and oxygen uptake by slurries of sediment stirred in seawater at various sites in Bedford Basin and Halifax Harbour are tabulated in Tables 10-17. The distributions of values are shown in Figs. 1-4. Shaded areas in each figure correspond to locations of stations where values exceed maximum limits as specified in the figure captions. The distribution of values can be compared with the location of outfalls, shown in Fig. 1, which discharge a total of 66 x 10^6 m^3/year of untreated sewage (CBCL Ltd., 1987). The secondary treatment plant at Mill Cove, Bedford Basin, and the primary treatment plant at Eastern Passage contribute a total of 18 x 10^6 m^3 of treated sewage per year to Halifax Inlet

(Hurlburt, pers. comm.). Several smaller outfalls and storm overflows in the region are not illustrated. During periods of high rainfall, some of these storm sewers may flood and combine their discharge with untreated sewage.

Linear correlations were carried out to provide a preliminary indication of relationships between variables (Table 18). Since stations were arranged on the grid to increase in number from the head of Bedford Basin to the mouth of Halifax Harbour, station number was used to indicate significant effects of station location on measurements. All variables were negatively correlated with station number. Highest values for all variables tended to occur within Bedford Basin. The deep water (40-70 m) in the central part of the Basin and the sill (20 m) in the Narrows leading to Halifax Harbour, serve to trap sediments within Bedford Basin. The silt and clay sediments in Bedford Basin contrast the mixtures of sand and silt encountered at stations at the seaward end of Halifax Harbour.

Areas of lowest redox potentials (Eh $<$ 100 mv) in the deep central area of Bedford Basin reflect a depositional environment at these stations (Fig. 2). However, even lower values (-140 to -180 mv) indicating strongly reducing sediments occur in the central part of Halifax Harbour offshore from oil refineries in Dartmouth. The impact of sewage discharge in lowering sediment redox potentials is evident off Mill Cove in Bedford Basin and in the Northwest Arm and off Herring Cove.

The locations of strongly reduced sediments correspond to sites of high organic carbon and nitrogen content in surface sediments (Fig. 3). Locations of sewage discharge (Mill Cove, Halifax Harbour, Northwest Arm) all have organic carbon levels $>$ 5% of sediment dry weight. Nitrogen levels are $>$ 0.04% at these stations so that the resulting C:N ratios are $>$ 10(Fig. 4). In contrast, C:N ratios in surface sediment in the outermost stations of Halifax Harbour ranged from 3 to 9.

Areas proximate to sewage discharge also were sites with the highest levels of sediment oxygen uptake (Fig. 4). Maximum values for all

stations sampled occurred off oil refineries in Dartmouth. Rates of oxygen uptake were positively correlated with sediment porosity and organic content, but negatively related (not significant at $p < 0.01$) to station location and redox potential (Table 18). Although the negative correlation between oxygen consumption and Eh was weak, the relationship indicates that strongly reduced sediments (lower Eh values) tended to have increased rates of oxygen uptake. This is indicative of the oxygen demand created by reduced inorganic compounds such as sulphides which accumulate in an unoxidized reducing environment. There is a large chemical oxygen demand in these sediments when reduced compounds are exposed to oxygenated water.

REFERENCES

ASA Consulting Ltd., 1986. The Halifax Inlet Water Quality Study: Phase 2. Vol I and Vol II report for the Metropolitan Area Planning Commission of Halifax, Dartmouth, Bedford and Halifax County, Nova Scotia.

CBCL Ltd., 1987. The Halifax Inlet Water Quality Study: Phase 3. report for the Metropolitan Area Planning Commission of Halifax, Dartmouth, Bedford and Halifax County, Nova Scotia.

Conover, R.J. and P. Mayzaud. 1975. Respiration and nitrogen excretion of neretic zooplankton in relation to potential food supply, pp. 151-163. In G. Persoone and E. Jaspers (Eds.) Proc. 10th Eur. Symp. Mar. Biol. Ostend, Belgium, Universa Press, Wetteren. Vol. 2.

Freeman, K. 1972. The spatial and seasonal distribution of coliforms in Bedford Basin. Fish. Res. Board Can. Tech. Rep. No. 352, 27 pp.

Hargrave, B.T. 1974. Comparison of benthic invertebrate biomass and oxygen consumption by marine sediments. ICES Contribution C.M. 1974/E, 10 pp.

Hargrave, B.T. 1975a. The importance of total and mixed-layer depth in the supply of organic material to bottom communities. Symp. Biol. Hung. 15: 157-165.

Hargrave, B.T. 1975b. Stability in structure and function of the mud-water interface. Verh. Internat. Verein. Limnol. 19: 1073-1079.

Hargrave, B.T. 1978. Seasonal changes in oxygen uptake by settled particulate matter and sediments in a marine bay. J. Fish. Res. Board Can. 35: 1621-1628.

Hargrave, B.T. 1980. Factors affecting the flux of organic matter to sediments in a marine bay, p. 243-263. In. B.C. Coull and K.R. Tenore (Eds.) Marine Benthic Dynamics, Univ. S. Carolina Press.

Hargrave, B.T., G.A. Phillips, and S. Taguchi. 1976. Sedimentation measurements in Bedford Basin, 1973-1974. Fish. Mar. Ser. Tech. Rep. No. 68, 129 pp.

Hargrave, B.T. and L. Kamp Nielsen. 1977. Accumulation of sedimentary organic matter at the base of steep bottom gradients, pp. 168-173. In. H.L. Golterman (Ed.) Interactions between sediments and water. Pudoc Publ., Amsterdam.

Hargrave, B.T. and S. Taguchi. 1978. Origin of deposited material sedimented in a marine bay. J. Fish. Res. Board Can. 35: 1604-1613.

Irwin, B., T. Platt, A.D. Jassby and D.V. Subba Rao. 1975. The relationship between light intensity and photosynthesis by phytoplankton. Results of experiments at three stations in the coastal waters of Nova Scotia. Fish. Mar. Ser. Tech. Rep. No. 595, 205 pp.

Irwin, B. and T. Platt. 1978a. Phytoplankton productivity experiments and nutrient measurements in Bedford Basin, Nova Scotia, from Sept. 1975

to Dec. 1976. Fish. Mar. Ser. Tech. Rep. No. 762, 128 pp.

Irwin, B. and T. Platt. 1978b. Phytoplankton productivity experiments and nutrient measurements in Bedford Basin, Nova Scotia, from January 1977 to July 1977. Fish. Mar. Ser. Data Rep. No. 93, 26 pp.

Krauel, D.P. 1969. Bedford Basin data report - 1967. Fish. Mar. Ser. Tech. Rep. No. 120, 84 pp.

Michalik, P.A. and D.C. Gordon, Jr. 1971. Concentrations and distribution of oil pollutants in Halifax Harbour, 10 June to 20 August, 1971. Fish. Res. Board Can. Tech. Rep. No. 284, 26 pp.

Ocean Chem Group. 1986. Environmental Data on Atlantic Harbours. Rep. TP8351E, Vols. 1 and 2 prepared for Waterways Development, Canadian Coast Guard, Transport Canada, Ottawa.

Platt. T. 1975. Analysis of the importance of spatial and temporal heterogeneity in the estimation of annual production by phytoplankton in a small, enriched, marine basin. J. Exp. Mar. Biol. Ecol. 18: 99-109.

Platt, T., R.J. Conover, R. Loucks, K.H. Mann, D.L. Peer, A. Prakash and D.D. Sameoto. 1970. A study of a eutrophicated marine basin. Contribution to the FAO technical conference on marine pollution and its effects on living resources and fishing. Rome, Italy, 10 pp.

Platt, T. and B. Irwin. 1971. Phytoplankton production and nutrients in Bedford Basin, 1969-70. Fish. Mar. Ser. Tech. Rep. No. 247, 172 pp.

Platt, T. and B. Irwin. 1972. Mapping the chlorophyll concentration in Bedford Basin, Nova Scotia. Fish. Mar. Ser. Tech. Rep. No. 299, 43 pp.

Platt. T., A. Prakash and B. Irwin. 1972. Phytoplankton nutrients and flushing of inlets on the coast of Nova Scotia. Naturaliste Can. 99: 253-261.

Platt, T. and C. Filion. 1973. Spatial variability of the productivity: biomass ratio for phytoplankton in a small marine basin. Limnol. Oceanogr. 18: 743-749.

Platt, T., B. Irwin, and D.V. Subba Rao. 1973. Primary productivity and nutrient measurements on the spring phytoplankton bloom in Bedford Basin, 1971. Fish. Res. Board Can. Tech. Rep. No. 423, 42 pp.

Sameoto, D.D. 1971. Macrozooplankton biomass measurements in Bedford Basin, 1969-1971. Fish. Res. Board Can. Tech. Rep. No. 282, 238 pp.

Taguchi, S., M. Hodgson and T. Platt. 1975. Phytoplankton production and nutrients in Bedford Basin 1973 and 1974. Fish. Mar. Ser. Tech. Rep. No. 587, 42 pp.

Taguchi, S. and T. Platt. 1977. Assimilation of $^{14}CO_2$ in the dark compared to phytoplankton production in a small coastal inlet. Est. Coast Mar. Sci. 5: 679-684.

Taguchi, S. and B.T. Hargrave. 1978. Loss rates of suspended material settled in a marine bay. J. Fish. Res. Board. Can. 35: 1614-1620.

Taguchi, S. and T. Platt. 1978a. Phytoplankton biomass in Bedford Basin: volume, surface area, carbon content and size distribution. Fish. Mar. Ser. Data Rep. No. 55, 404 pp.

Taguchi, S. and T.Platt. 1978b. Size distribution and chemical composition of particulate matter in Bedford Basin, 1973 and 1974. Fish. Mar. Ser. Tech. Rep. 56, 370 pp.

Table 1: Sampling dates for collection of surface sediment samples in Bedford Basin and Halifax Harbour during 1986. Station locations identified by number are shown in Fig. 1.

Sampling Date	Station Numbers
January 22	1-32
January 29	33-58
February 5	59-69
April 30	70-87
June 6	88-102
July 7	24,47
July 17	60,88

Table 2: Multiple surface sediment samples collected at four stations (Fig. 1) in Bedford Basin and Halifax Harbour July 14 and 17, 1987, to assess between and within grab differences in porosity (percent water content). * indicates a significant difference between the two means ($p < 0.05$).

Station Number	24	47	60	88
Separate Grab Samples	62.2	63.6	48.1	66.3
	65.4	58.9	40.6	52.8
	62.2	65.5	40.3	56.2
	74.9	49.7	36.1	53.4
	67.6	71.6	45.4	48.9
	71.6	69.5	39.8	47.2
	77.1	65.4	43.6	47.9
	70.3	67.8	47.8	50.1
	66.3	66.8	46.6	46.6
	70.9	55.8	44.9	56.1
Mean (sd)	68.9 (5.0)	63.5 (6.7)	43.3 (4.0)	52.6(6.0)
SE	1.6	2.1	1.3	1.9
C.V. (%)	7.3	10.6	9.2	11.3
Within Grab Samples	68.8	71.4	45.7	50.7
	64.3	52.7	46.3	49.8
	48.8	65.4	44.8	56.2
	68.2	49.8	50.3	54.7
	63.4	69.2	41.3	56.5
	63.7	51.3	48.0	53.9
	70.0	53.5	45.2	57.9
	69.7	59.5	46.0	60.1
	77.9	69.4	47.3	54.4
	67.6	71.6	45.3	48.9
Mean (sd)	66.2 (7.4)	61.4 (9.0)	46.0 (2.3)	54.3(3.6)
SE	2.3	2.8	0.7	1.1
C.V. (%)	11.2	14.6	5.1	6.7
F ratio for comparison of means	0.85	0.34	3.44*	0.64

Table 3: Multiple surface sediment samples collected at four stations (Fig. 1) in Bedford Basin and Halfax Harbour July 14 and 17, 1986 to assess between and within grab differences in redox potentials (Eh) (mv). * indicates a significant differences between the two means ($p < 0.05$).

Station Number	24	47	60	88
Separate Grab Samples	202	-7	189	74
	34	53	251	89
	109	142	122	88
	77	136	108	127
	120	144	200	151
	78	64	191	72
	100	154	121	51
	114	113	162	71
	88	51	190	4
	104	127	138	101
Mean (sd)	103 (43)	98 (54)	167 (45)	88 (40)
SE	13	17	14	13
C.V. (%)	42	55	27	49
Within Grab Samples	120	152	126	137
	139	195	137	99
	115	147	136	100
	127	119	147	90
	51	148	150	91
	114	127	130	101
	48	136	111	98
	113	138	149	112
	116	173	147	125
	154	144	200	151
Mean (sd)	110 (34)	148 (22)	143 (23)	110 (21)
SE	11	7	7	7
C.V (%)	31	15	16	19
F ratio for comparison of means	0.17	7.43*	2.22*	3.73*

Table 4: Multiple surface sediment samples collected at four stations (Fig. 1) in Bedford Basin and Halifax Harbour July 14 and 17, 1986 to assess between and within grab differences in percent organic matter (percent weight loss on ashing). Dashes indicate no data available, * indicates a significant differences between the two means ($p < 0.05$).

Station Number	24	47	60	88
Separate Grab Samples	13.2	14.0	8.6	10.4
	12.6	14.6	5.3	8.6
	12.2	13.8	9.7	5.9
	13.6	-	5.0	8.0
	12.6	12.9	4.5	7.8
	12.5	13.5	4.4	6.9
	12.3	12.4	4.5	8.0
	21.1	12.3	4.3	6.7
	16.1	13.2	4.6	8.7
	21.5	-	4.8	7.2
Mean (sd)	14.8 (3.6)	13.3 (0.8)	5.6 (1.9)	7.8 (1.3)
SE	1.1	0.3	0.6	0.4
C.V. (%)	24.5	6.0	34.6	16.1
Within Grab Samples	12.6	12.9	4.6	7.5
	20.9	11.6	5.0	8.2
	25.5	20.9	4.4	6.1
	33.2	11.6	4.5	5.7
	11.6	-	4.4	7.5
	11.4	11.8	4.2	6.7
	11.7	15.5	3.9	6.9
	9.8	17.5	4.2	6.3
	15.9	11.8	4.0	7.5
	14.9	11.8	4.5	7.8
Mean (sd)	16.8 (7.6)	13.9 (3.3)	4.4 (0.3)	7.0 (0.8)
SE	2.4	1.1	0.1	0.3
C.V (%)	45.1	24.0	7.2	11.5
F ratio for comparison of means	0.56	0.24	3.78*	2.85*

Table 5: Multiple surface sediment samples collected at four stations (Fig. 1) in Bedford Basin and Halifax Harbour July 14 and 17, 1986 to assess between and within grab differences in percent organic carbon. Dashes indicate no data available, * indicates a significant difference between the two means ($p_{<}0.05$).

Station Number	24	47	60	88
Separate Grab Samples	5.63	5.14	-	4.24
	4.41	5.18	1.41	4.31
	5.31	4.82	-	3.83
	5.70	4.89	1.38	2.50
	5.69	4.96	1.60	1.58
	5.25	4.78	1.34	4.79
	5.50	5.08	1.31	0.57
	-	5.10	2.26	3.82
	5.34	-	0.99	4.62
	5.12	5.19	0.90	-
Mean (sd)	5.33 (0.40)	5.02 (0.16)	1.40 (0.42)	3.36(1.48)
SE	0.13	0.05	0.15	0.49
C.V. (%)	7.5	3.1	29.7	43.9
Within Grab Samples	5.69	4.89	1.60	4.83
	-	5.53	1.33	5.18
	-	-	2.83	4.55
	5.46	5.05	1.81	6.60
	5.52	5.03	2.72	5.61
	5.60	-	2.25	4.48
	6.09	4.60	1.33	4.68
	7.12	4.90	2.17	3.92
	5.87	5.18	1.60	3.44
Mean (sd)	5.91 (0.58)	5.03 (0.29)	1.96 (0.56)	4.81(0.92)
SE	0.22	0.11	0.19	0.31
C.V. (%)	9.8	5.7	28.7	19.2
F ratio for comparison of means	5.64*	0.008	5.34*	6.22*

Table 6: Multiple surface sediment samples collected at four stations (Fig. 1) in Bedford Basin and Halifax Harbour July 14 and 17, 1986 to assess between and within grab differences in percent nitrogen. Dashes indicate no data available, * indicates a significant differences between the two means ($p<0.05$).

Station Number	24	47	60	88
Separate Grab Samples	0.31	0.14	-	-
	0.39	0.45	0.27	0.48
	0.51	0.43	-	0.47
	0.54	0.37	0.17	0.41
	0.53	0.39	0.16	0.28
	0.70	0.42	0.15	0.27
	0.20	0.36	0.17	0.50
	-	0.41	0.26	0.10
	0.51	0.43	0.16	0.38
	0.46	0.49	0.16	0.49
Mean (sd)	0.44 (0.16)	0.39 (0.10)	0.19 (0.05)	0.38(0.14)
SE	0.06	0.03	0.02	0.05
C.V. (%)	36.6	24.5	25.8	35.9
Within Grab Samples	0.53	0.39	0.16	0.28
	-	0.51	0.24	0.40
	-	-	0.31	0.45
	-	0.50	0.38	0.41
	0.50	-	0.23	0.45
	0.46	0.52	0.35	0.40
	0.47	-	0.28	0.42
	0.42	0.50	0.19	0.48
	0.42	0.52	0.17	0.43
	0.39	0.55	0.14	0.36
Mean (sd)	0.46 (0.05)	0.50 (0.05)	0.25 (0.08)	0.41(0.06)
SE	0.02	0.19	0.03	0.02
C.V. (%)	10.8	10.2	33.8	13.7
F ratio for comparison of means	0.04	7.62*	3.01*	0.49

Table 7: Multiple surface sediment samples collected at four stations (Fig. 1) in Bedford Basin and Halifax Harbour July 14 and 17, 1986 to assess between and within grab differences in carbon:nitrogen ratios (by weight). Dashes indicates no data available, * indicates a significant difference between the two means ($p < 0.05$).

Station Number	24	47	60	88
Separate Grab Samples	18.2	12.5	-	-
	11.3	11.5	5.2	8.8
	10.4	11.7	-	9.2
	10.6	13.0	8.1	9.3
	10.7	12.5	10.0	8.9
	7.5	11.8	8.9	5.9
	27.5	13.3	7.7	9.6
	-	12.4	8.7	5.7
	10.5	11.9	6.2	10.1
	11.1	10.6	5.6	9.4
Mean (sd)	13.1 (6.1)	12.1 (0.8)	7.6 (1.7)	8.5 (1.6)
SE	2.0	0.2	0.6	0.5
C.V. (%)	46.6	6.5	22.7	18.8
Within Grab Samples	10.7	12.5	6.7	12.1
	-	10.8	4.3	11.5
	-	-	7.4	11.1
	10.9	10.1	7.9	14.7
	12.0	9.7	7.8	14.0
	11.9	-	8.0	10.7
	14.5	9.2	7.0	9.8
	17.0	9.4	12.8	9.1
	15.1	9.4	-	8.9
Mean (sd)	13.2 (2.4)	10.2 (1.2)	7.7 (2.4)	11.2(2.07)
SE	0.9	0.4	0.8	0.6
C.V. (%)	18.2	11.5	30.6	17.8
F ratio for comparison of means	0.0007	17.3*	0.033	9.76*

Table 8: Multiple surface sediment samples collected at four stations (Fig. 1) in Bedford Basin and Halifax Harbour July 14 and 17, 1987 to assess between and within grab differences in oxygen uptake ($\mu g\ O_2\ g^{-1}\ h^{-1}$) by sediment particles stirred in seawater. Dashes indicate no data available, * indicates a significant difference between the two means ($p < 0.05$).

Station Number	24	47	60	88
Separate Grab Samples	58.5	71.1	6.2	98.8
	244.4	92.8	1.8	30.0
	136.9	43.3	7.9	37.8
	266.7	70.0	10.8	40.4
	93.4	65.8	13.9	44.7
	120.4	59.0	2.8	36.5
	126.6	69.8	2.6	11.2
	117.8	61.0	11.5	45.2
	93.1	33.0	16.2	46.2
	115.5	28.7	13.5	39.1
Mean (sd)	137.3 (66.3)	59.5 (19.5)	8.7 (5.2)	43.0(22.1)
SE	21.0	6.2	1.7	7.0
C.V. (%)	48.3	32.8	59.8	51.5
Within Grab Samples	93.4	65.8	-	68.1
	117.7	86.3	5.3	15.4
	62.5	85.2	10.5	31.8
	135.8	42.3	3.6	37.7
	63.4	30.3	6.5	44.7
	107.0	197.7	5.7	43.2
	63.2	190.0	5.7	39.1
	183.9	418.5	8.1	41.1
	288.8	41.8	7.7	18.5
	183.1	47.2	13.9	44.7
Mean (sd)	129.9 (71.8)	120.5 (120.6)	7.4 (3.1)	38.4(14.8)
SE	22.7	38.1	1.0	4.7
C.V. (%)	55.3	100.0	41.9	38.4
F ratio for comparison of means	0.058	2.50*	0.406	0.294

Table 9: Comparison of rank of coefficients of variation determined for samples from four stations with variables measured between and within ten replicate grab samples. Data summarized from Tables 2-7.

Variable	Separate Grabs n = 10	Within One Grab n = 10
Porosity	88> 47> 60> 24	47> 24> 88> 60
Eh	47> 88> 24> 60	24> 88> 60> 47
Organic Matter 24> 47> 88> 60	60> 24> 88> 47	
Organic Carbon 60> 88> 24> 47	88> 60> 24> 47	
Nitrogen	24> 88> 60> 47	60> 88> 24> 47
C:N	24> 60> 88> 47	60> 24> 88> 47
Oxygen Uptake	60> 88> 24> 47	47> 24> 60> 88

Table 10Percent porosity, organic matter and redox potential in sediment samples from stations 1-25 in Bedford Basin (see Fig. 1 for station locations).

Station Number	Depth (m)	Porosity (%)	Percent Organic Matter	Redox Potential (mv)
1	10	54.8	4.9	171.1
2	10	62.3	9.5	123.8
3	13	62.3	19.6	-68.0
4	13	62.3	21.8	-9.4
5	16	62.3	18.0	85.6
6	20	69.8	16.2	162.6
7	20	47.3	5.0	89.6
8	20	49.6	7.9	140.2
9	11	67.6	14.1	146.3
10	18	77.1	15.2	146.2
11	38	74.4	15.6	111.2
12	38	79.1	15.3	144.6
13	38	73.0	15.5	130.0
14	52	88.2	18.2	132.2
15	65	78.3	17.0	136.3
16	56	79.8	16.1	17.1
17	54	75.8	16.5	102.2
18	38	75.4	15.2	150.7
19	13	82.2	16.9	188.8
20	56	75.4	15.3	226.9
21	15	75.5	6.7	316.7
22	50	75.5	15.0	110.2
23	62	75.6	16.1	71.3
24	68	72.6	15.3	69.0
25	62	72.2	14.8	172.2

Table 11: Percent organic carbon and nitrogen, the carbon nitrogen ratio and oxygen uptake by a sediment slurry stirred in seawater for surface sediment samples from stations 1-25 in Bedford Basin (see Fig. 1 for station locations).

Station Number	Percent Organic Carbon	Percent Nitrogen	C:N	Sediment Oxygen Uptake ($\mu g O_2 (g^{-1} h^{-1})$)
1	1.71	0.18	9.5	11
2	2.62	0.24	10.9	75
3	6.05	0.56	10.8	43
4	7.55	0.64	11.8	144
5	5.41	0.40	13.5	24
6	7.13	0.61	11.7	44
7	1.78	0.16	11.1	22
8	2.14	0.19	11.3	343
9	5.66	0.67	8.5	35
10	6.35	0.52	12.2	47
11	4.71	0.51	9.2	625
12	6.03	0.67	9.0	21
13	4.90	0.56	8.8	54
14	5.50	0.65	8.5	67
15	5.19	0.56	9.3	943
16	4.62	0.42	11.0	247
17	7.66	0.40	19.2	102
18	5.03	0.47	10.7	244
19	5.94	0.51	11.6	107
20	4.73	0.53	8.9	81
21	1.60	0.23	7.0	40
22	4.32	0.45	9.6	155
23	5.18	0.60	8.6	140
24	5.51	0.42	13.1	198
25	5.14	0.51	10.1	49

Table 12: Porosity, organic matter and redox potential in surface sediment samples from stations 26-50 in Bedford Basin and Halifax Harbour (see Fig. 1 for station locations)

Station Number	Depth (m)	Porosity (%)	Percent Organic Matter	Redox Potential (mv)
26	20	50.0	13.9	154.8
27	42	76.6	17.4	134.9
28	40	74.8	16.5	97.8
29	67	47.7	8.2	88.9
30	60	63.3	13.9	123.7
31	48	78.8	15.7	51.4
32	10	48.1	7.2	104.1
33	30	70.1	17.3	214.7
34	45	54.5	10.2	120.0
35	62	48.3	6.3	98.4
36	52	65.5	14.6	-16.5
37	42	78.7	15.8	134.8
38	28	75.1	14.8	84.8
39	26	73.5	12.4	129.5
40	33	71.9	14.3	136.3
41	32	22.5	10.9	123.0
42	28	69.6	13.8	110.2
43	28	64.9	13.2	160.1
44	20	44.0	6.0	128.6
45	27	53.9	9.4	168.1
46	23	67.2	11.9	140.3
47	26	67.2	13.6	128.9
48	20	71.2	12.2	58.7
49	20	67.2	16.4	139.8
50	20	67.2	4.3	152.2

Table 13: Percent organic carbon and nitrogen, carbon: nitrogen ratio and oxygen uptake by a sediment slurry stirred in seawater for surface sediment samples from stations 26-50 in Bedford Basin and Halifax Harbour (see Fig. 1 for station locations)

Station Number	Percent Organic Carbon	Percent Nitrogen	C:N	Sediment Oxygen Uptake ($\mu g O_2$ g^{-1} h^{-1})
26	5.49	0.34	16.2	50
27	5.04	0.47	10.7	60
28	5.50	0.44	12.5	108
29	3.21	0.49	6.6	109
30	4.42	0.30	14.7	267
31	5.35	0.63	8.5	209
32	4.31	0.55	7.8	60
33	7.18	0.63	11.4	109
34	2.70	0.37	7.3	84
35	2.22	0.21	10.6	47
36	5.36	0.45	11.9	211
37	6.08	0.35	17.4	170
38	5.48	0.40	13.7	196
39	5.13	0.78	6.6	51
40	5.92	0.61	9.7	98
41	6.12	1.41	4.3	37
42	4.69	0.44	10.7	153
43	3.76	0.38	9.9	95
44	2.62	0.58	4.5	71
45	2.81	0.28	10.0	65
46	5.06	0.39	13.0	94
47	4.47	0.50	8.9	91
48	5.15	0.51	10.1	79
49	5.14	0.50	10.3	144
50	1.73	0.55	3.2	184

Table 14: Porosity, organic matter and redox potential in surface sediment samples from stations 51-75 in Halifax Harbour (See Fig. 1 for station locations).

Station Number	Depth (m)	Porosity (%)	Percent Organic Matter	Redox Potential (mv)
51	18	39.6	10.5	159.8
52	17	57.2	12.6	84.4
53	17	68.0	9.8	125.8
54	22	64.8	12.2	-35.6
55	26	65.1	11.3	71.0
56	25	65.4	11.5	57.3
57	20	70.7	11.1	-49.7
58	15	63.5	9.0	-75.2
59	16	63.7	10.2	-50.5
60	18	59.7	9.1	109.7
61	26	68.9	9.2	76.6
63	20	62.6	9.6	78.4
64	23	64.9	7.9	35.4
65	25	54.5	7.7	-38.6
66	23	64.0	9.0	-5.0
67	22	63.5	8.2	0
68	22	63.4	8.9	-5.0
69	23	68.5	6.7	0
70	16	60.9	5.9	-4.0
71	23	65.3	6.8	-181.0
72	25	57.5	4.9	-146.6
73	25	65.4	8.3	152.5
74	27	72.4	9.3	111.2
75	25	54.6	5.3	-154.0

Table 15: Percent organic carbon and nitrogen, carbon: nitrogen ratio and oxygen uptake by a sediment slurry stirred in seawater for surface sediment samples from stations 51-75 in Halifax Harbour (See Fig. 1 for station locations).

Station Number	Percent Organic Carbon	Percent Nitrogen	C:N	Sediment Oxygen Uptake ($\mu g O_2 g^{-1} h^{-1}$)
51	4.10	0.41	10.0	47
52	3.73	0.41	9.1	108
53	3.77	0.45	8.4	98
54	5.91	0.52	11.4	83
55	4.29	0.52	8.3	85
56	4.69	0.55	8.5	112
57	4.16	0.48	8.7	173
58	3.80	0.46	8.3	123
59	3.83	0.44	8.7	123
60	3.73	0.37	10.1	148
61	3.81	0.33	11.6	275
62	4.34	0.49	0.89	181
63	4.34	0.48	9.0	137
64	3.64	0.49	7.4	130
65	3.52	0.43	8.2	301
66	4.07	0.90	4.5	128
67	2.58	0.23	11.2	168
68	3.86	0.41	9.4	123
69	3.08	0.35	8.8	169
70	2.84	0.26	10.9	214
71	3.47	0.32	10.8	8
72	2.71	0.36	7.5	113
73	3.03	0.36	8.4	141
74	3.08	0.73	4.2	349
75	1.92	0.25	7.5	176

Table 16: Porosity, organic matter and redox potentials in surface sediment samples from stations 76-102 in Halifax Harbour and the Northwest Arm (see Fig. 1 for station locations).

Station Number	Depth (m)	Porosity (%)	Percent Organic Matter	Redox Potential (mv)
76	20	58.2	5.9	-148.9
77	23	70.5	9.0	-103.3
78	20	63.5	6.6	-37.8
79	23	39.8	3.0	-166.9
80	20	65.0	5.4	-52.0
81	10	56.1	4.7	163.5
82	8	61.6	0.8	-71.1
83	25	67.1	7.1	132.2
84	23	71.6	8.0	-127.6
85	23	74.5	10.6	6.0
86	35	66.9	6.5	143.6
87	22	64.1	6.0	118.4
88	20	56.1	5.0	67.9
89	18	54.8	3.9	104.5
90	20	53.8	4.5	168.4
91	15	66.5	7.5	-112.0
92	12	71.5	11.2	-103.6
93	10	71.7	11.9	-73.6
94	8	75.6	12.4	-92.6
95	18	59.9	6.3	-59.6
96	23	55.0	6.7	102-4
97	23	59.1	5.1	-68.6
98	20	28.2	0.5	383.4
99	18	61.6	1.9	241.6
100	26	62.8	5.6	15.2
101	30	49.8	1.5	273.3
102	25	36.8	1.7	209.7

Table 17: Percent organic carbon and nitrogen, carbon: nitrogen ratio and oxygen uptake by a sediment slurry stirred in seawater for surface sediment samples from stations 76-102 in Halifax Harbour and the Northwest Arm (see Fig. 1 for station locations).

Station Number	Percent Organic Carbon	Percent Nitrogen	C:N	Sediment Oxygen Uptake ($\mu g O_2\ g^{-1}\ h^{-1}$)
76	2.07	0.19	10.9	41
77	2.71	0.29	9.3	319
78	2.75	0.34	8.1	276
79	1.11	0.16	6.9	41
80	1.80	0.27	6.7	132
81	2.37	0.49	4.8	34
82	0.27	0.08	3.9	45
83	1.88	0.17	11.1	176
84	2.92	0.18	16.2	283
85	3.19	0.27	11.8	227
86	2.70	0.20	12.3	65
87	2.10	0.29	7.2	35
88	2.60	0.37	7.0	9
89	1.62	0.23	7.0	48
90	1.84	0.30	6.1	63
91	4.96	0.46	10.8	62
92	5.64	0.59	9.6	244
93	5.90	0.62	9.5	257
94	5.27	0.63	8.4	300
95	3.15	0.35	9.0	59
96	3.71	0.38	9.8	119
97	1.93	0.27	7.2	78
98	0.49	0.05	9.8	63
99	1.85	0.34	5.4	8
100	1.92	0.31	6.2	51
101	0.44	0.14	3.1	2
102	.044	0.10	4.4	12

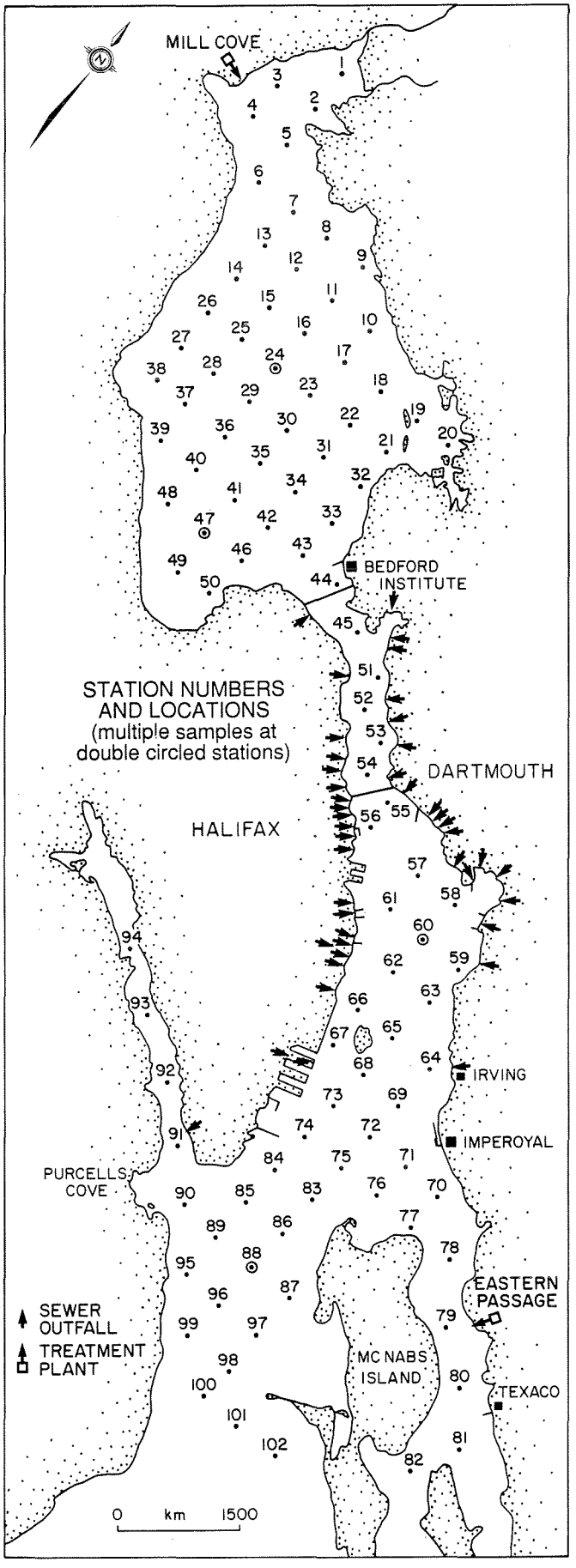
Table 18: Correlation matrix for linear regression analyses between variables measured in Bedford Basin and Halifax Harbour.
Stn - Station Number
Eh - redox potential (mv)
PCTW - porosity (percent water)
PCTORG - Percent organic matter
PCTCBN - Percent organic carbon
PCTN - Percent nitrogen
OXUPT - Oxygen uptake ($\mu g\ O_2\ g^{-1}\ h^{-1}$)
Underlined coefficients indicate a significant correlation between variables ($p < 0.05$).

Variables	Stn	Eh	PCTW	PCTORG	PCTCBN	PCTN
Eh	-0.344					
PCTW	-0.318	-.156				
PCTORG	-0.703	.133	.752			
PCTCBN	-0.487	-.01	.624	.828		
PCTN	-0.411	.086	.550	.673	.641	
OXUPT	-0.102	-.154	.334	.277	.196	.190

* $p < 0.01$

Fig. 1 Station locations for collection of surface sediment samples in Bedford Basin and Halifax Harbour during the period January 22 to July 17, 1986. Sewage outfalls and treatment plants are illustrated by arrows. Sampling dates for specific station numbers given in Table 1. Stations 24, 47, 60 and 88 were locations where 10 replicate samples were collected for assessment of between and within sample variablility (see Tables 2-8).

Porosity (percent water content) measured in surface sediments from various stations in Bedford Basin and Halifax Harbour. Shaded areas indicate sediments with porosity values $>$ 70%.


MILL COVE
BEDFORD INSTITUTE
STATION NUMBERS AND LOCATIONS
(multiple samples at double circled stations)
DARTMOUTH
HALIFAX
IRVING
IMPEROYAL
PURCELLS COVE
EASTERN PASSAGE
MC NABS ISLAND
TEXACO
SEWER OUTFALL
TREATMENT PLANT
0 km 1500

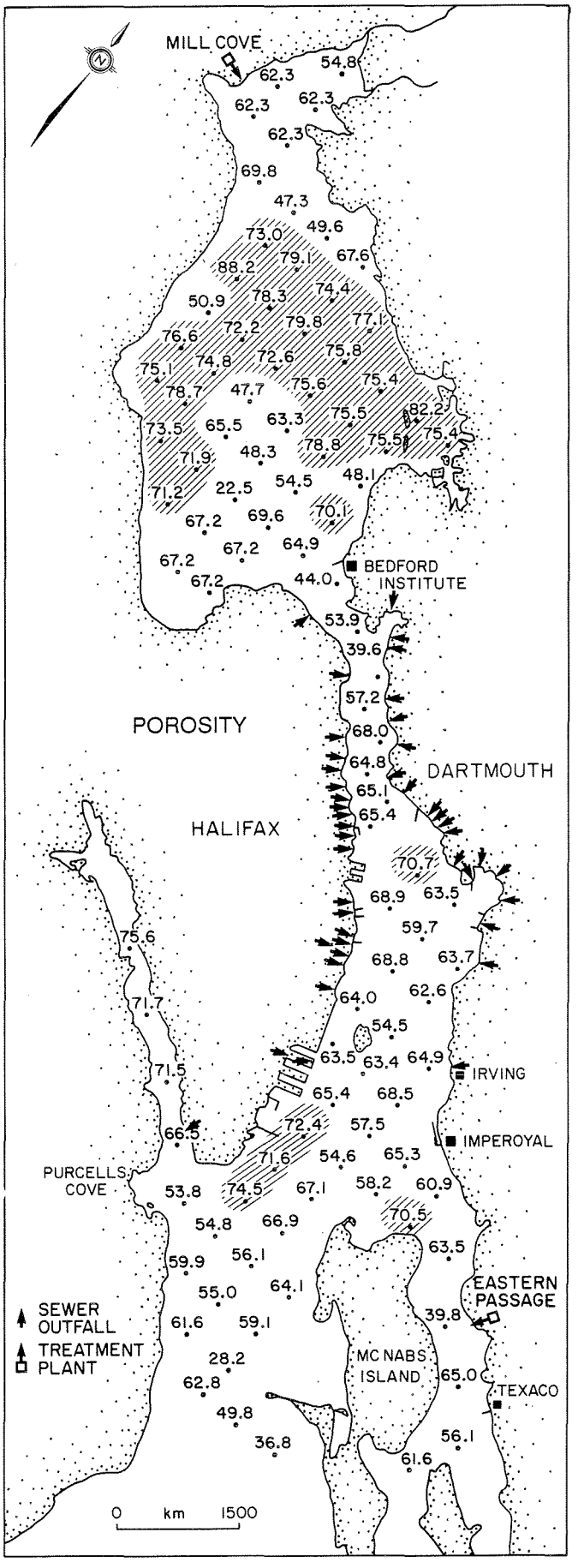
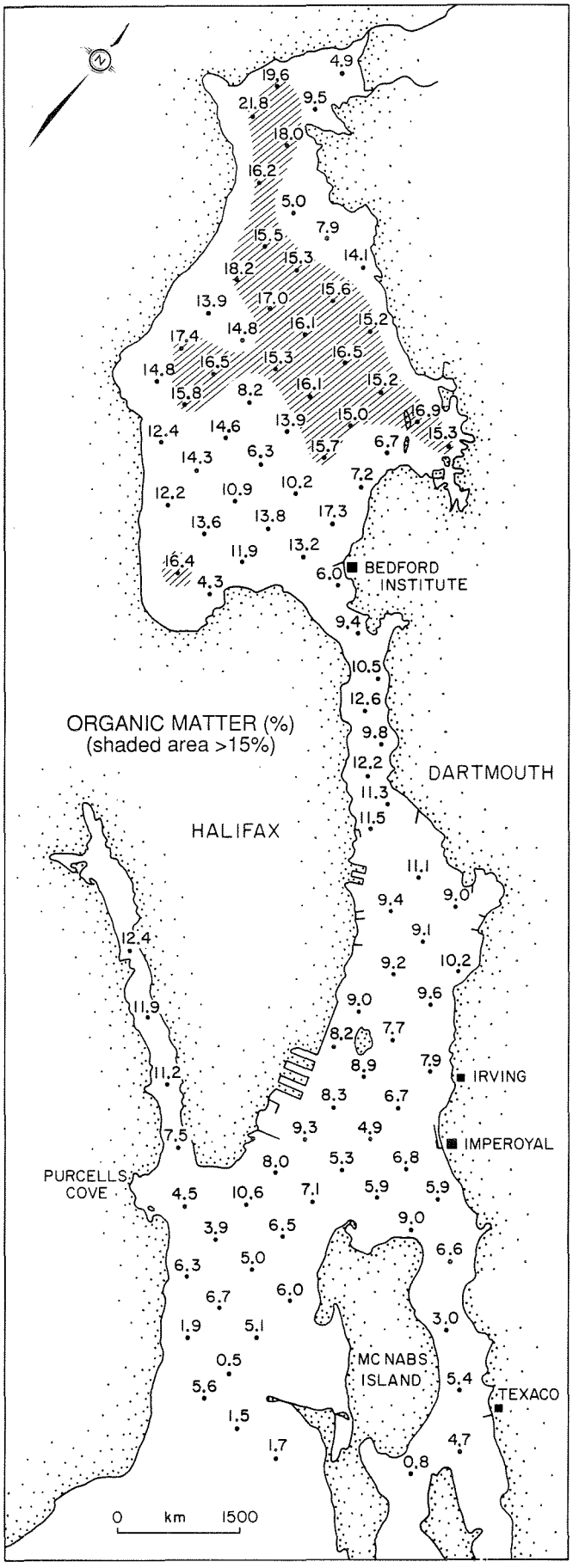

MILL COVE
BEDFORD INSTITUTE
POROSITY
DARTMOUTH
HALIFAX
IRVING
IMPEROYAL
PURCELLS COVE
EASTERN PASSAGE
MC NABS ISLAND
TEXACO
SEWER OUTFALL
TREATMENT PLANT
0 km 1500

Fig. 2 Percent organic matter in surface sediments from various stations in Bedford Basin and Halifax Harbour. Shaded areas indicate sediments with organic matter content > 15%.

Redox potentials (Eh) as mv potential against a calomel reference electrode in surface sediments from various stations in Bedford Basin and Halifax Harbour. Shaded areas indicate sediments with Eh values <+100 mv.


ORGANIC MATTER (%)
(shaded area >15%)
HALIFAX
DARTMOUTH
BEDFORD INSTITUTE
IRVING
IMPEROYAL
PURCELLS COVE
MC NABS ISLAND
TEXACO
0 km 1500

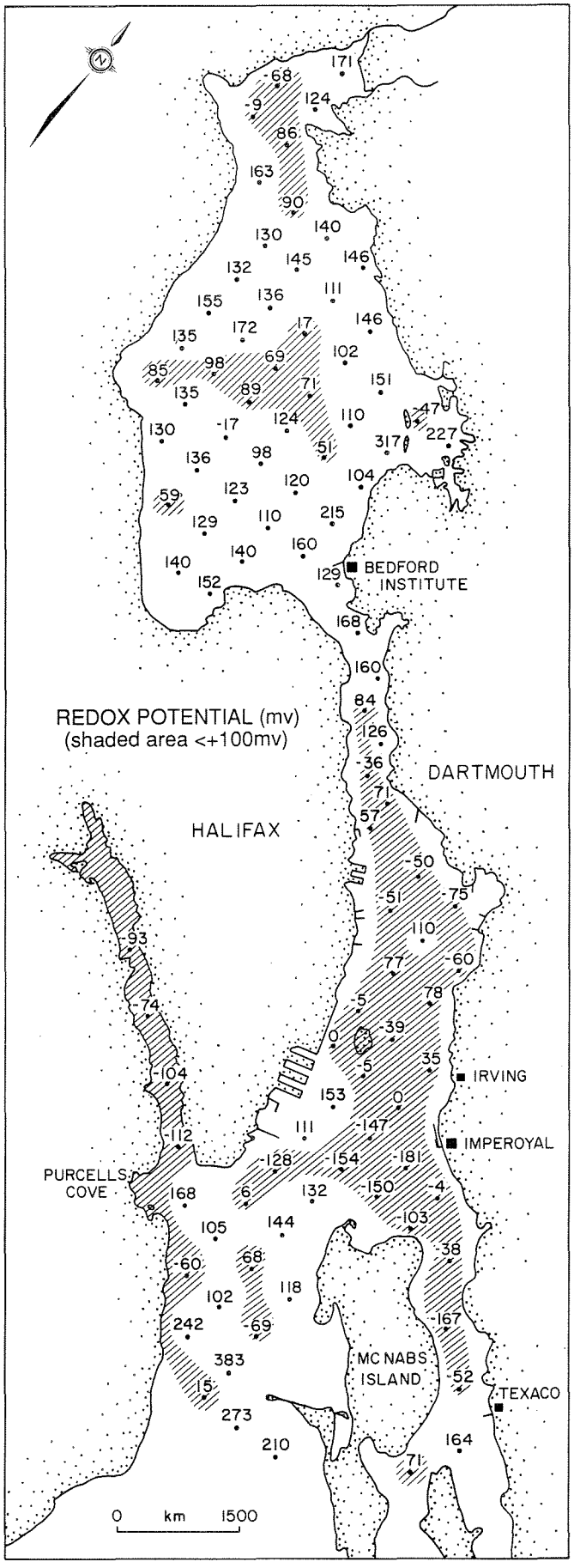
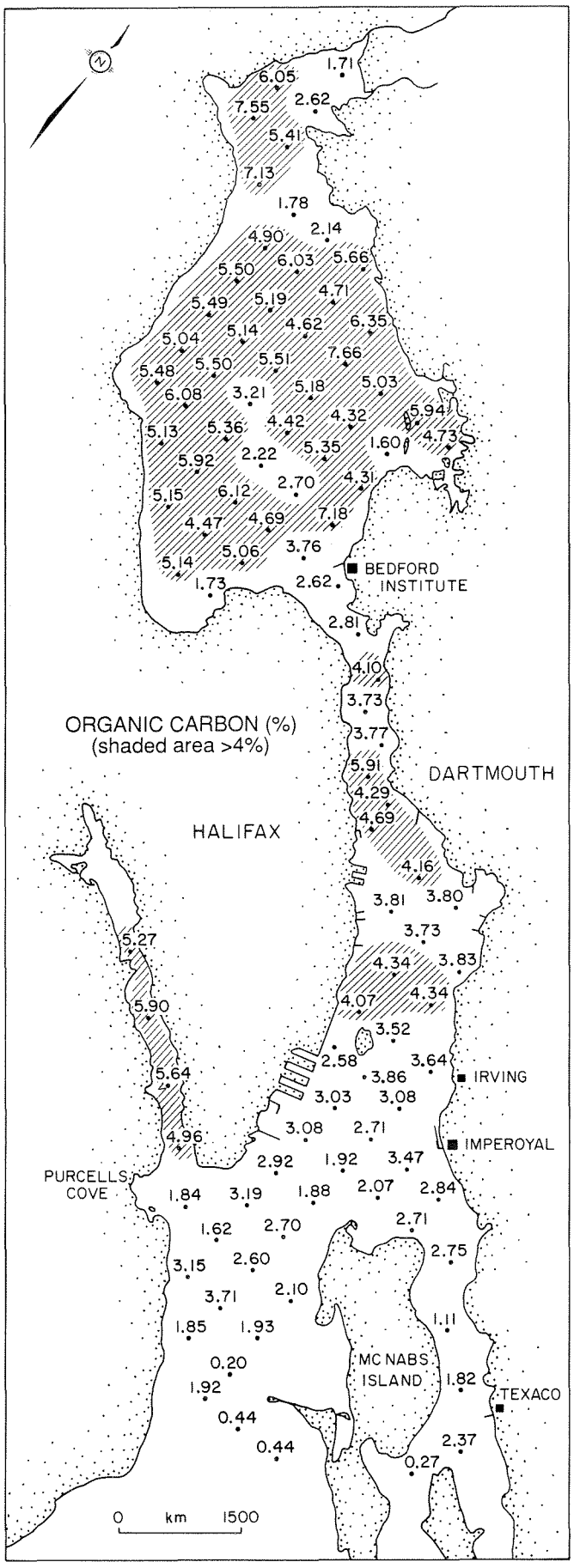

REDOX POTENTIAL (mv)
(shaded area <+100mv)
HALIFAX
DARTMOUTH
BEDFORD INSTITUTE
IRVING
IMPEROYAL
PURCELLS COVE
MC NABS ISLAND
TEXACO
0 km 1500

Fig. 3 Percent organic carbon in surface sediments from various stations in Bedford Basin and Halifax Harbour. Shaded areas indicate sediments with organic carbon content > 4%.

Percent nitrogen ($x10^{-2}$) in surface sediments from various stations in Bedford Basin and Halifax Harbour. Shaded areas indicate sediments with nitrogen content >0.04%.


ORGANIC CARBON (%)
(shaded area >4%)
BEDFORD INSTITUTE
DARTMOUTH
HALIFAX
IRVING
IMPEROYAL
PURCELLS COVE
MC NABS ISLAND
TEXACO
0 km 1500

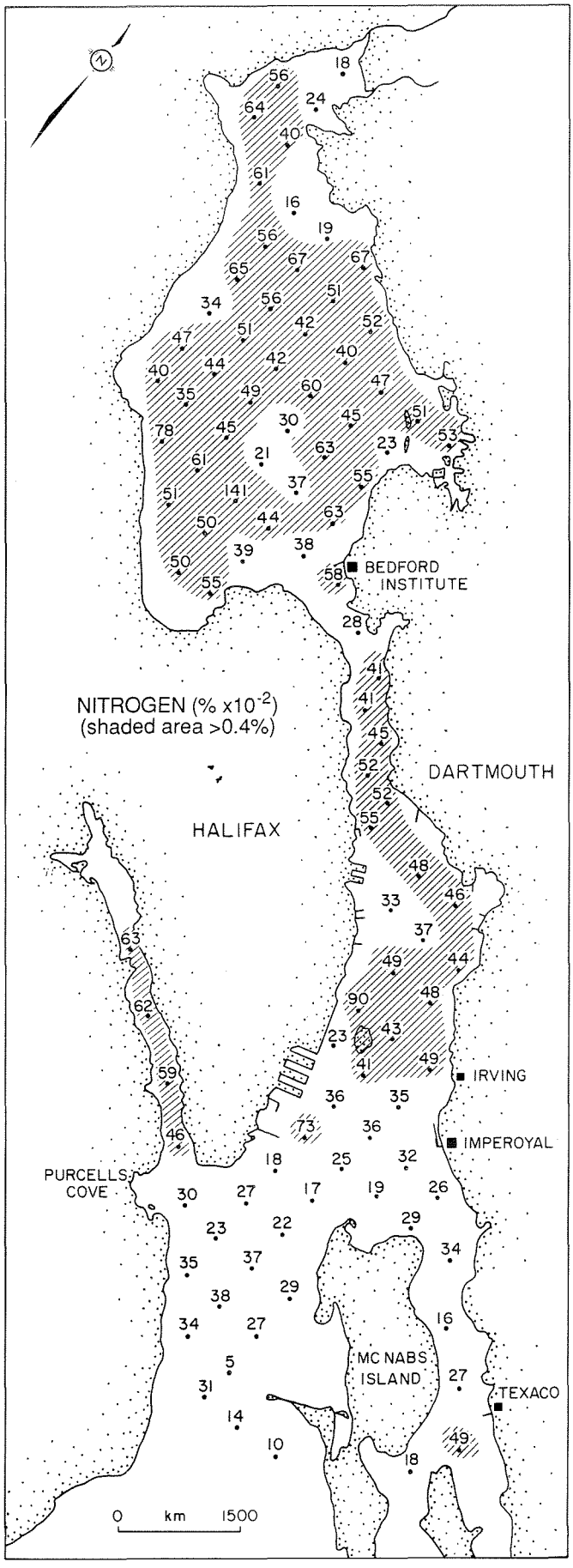
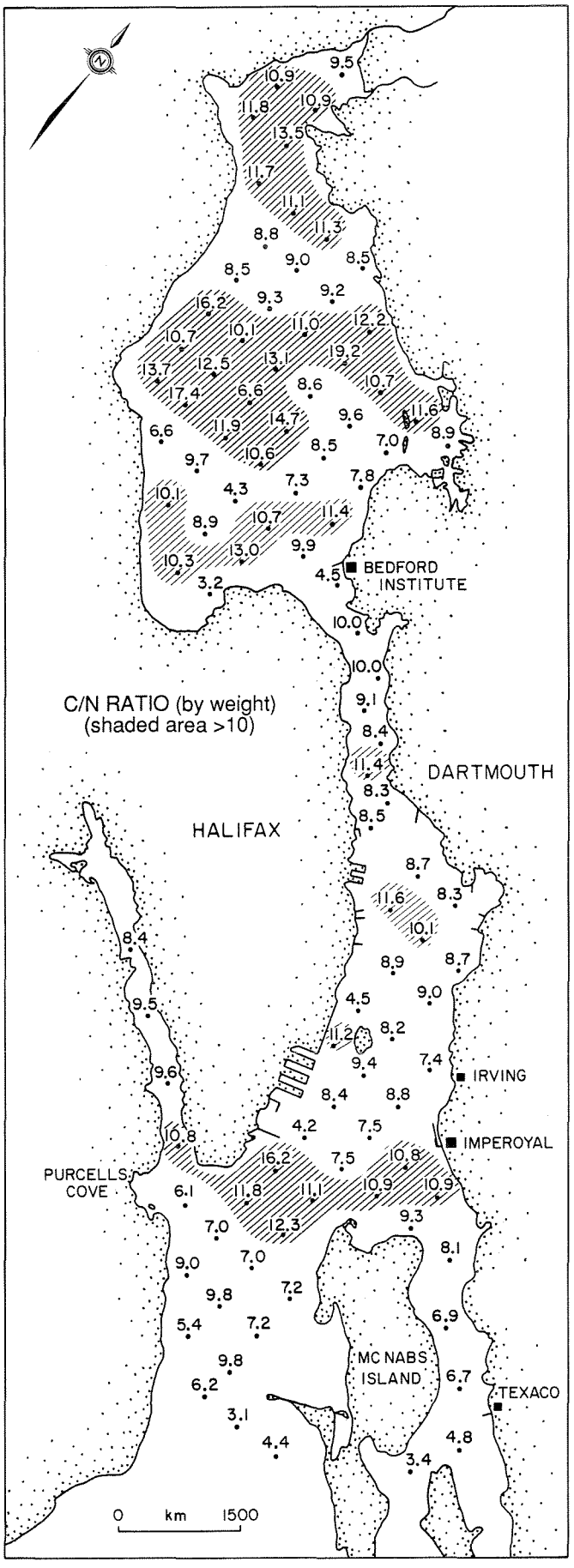
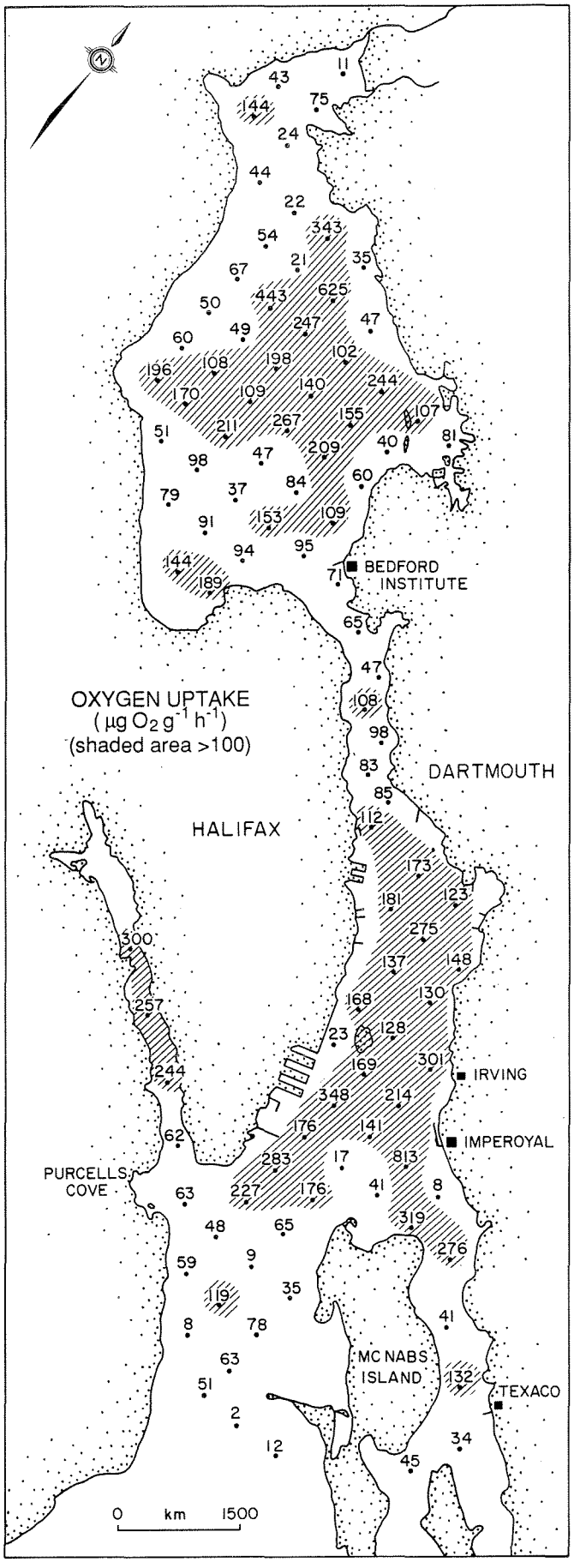

NITROGEN (% x10-2)
(shaded area >0.4%)
BEDFORD INSTITUTE
DARTMOUTH
HALIFAX
IRVING
IMPEROYAL
PURCELLS COVE
MC NABS ISLAND
TEXACO
0 km 1500

Fig. 4 Carbon: nitrogen (by weight) in surface sediments from various stations in Bedford Basin and Halifax Harbour. Shaded areas indicate sediments with a C:N ratio >10. Ratios are derived from data presented in Figs. 5 and 6.

Oxygen uptake ($\mu g\ O_2\ g^{-1}\ h^{-1}$) of surface sediment stirred as a slurry in aerated seawater. Sediment was collected from various stations in Bedford Basin and Halifax Harbour. Shaded areas indicate sediments with oxygen consumption rates >100 $\mu g\ O_2\ g^{-1}\ h^{-1}$.


C/N RATIO (by weight)
(shaded area >10)
HALIFAX
DARTMOUTH
BEDFORD INSTITUTE
IRVING
IMPEROYAL
TEXACO
PURCELLS COVE
MC NABS ISLAND
0 km 1500


OXYGEN UPTAKE
(μg O2 g-1 h-1)
(shaded area >100)
HALIFAX
DARTMOUTH
BEDFORD INSTITUTE
IRVING
IMPEROYAL
TEXACO
PURCELLS COVE
MC NABS ISLAND
0 km 1500