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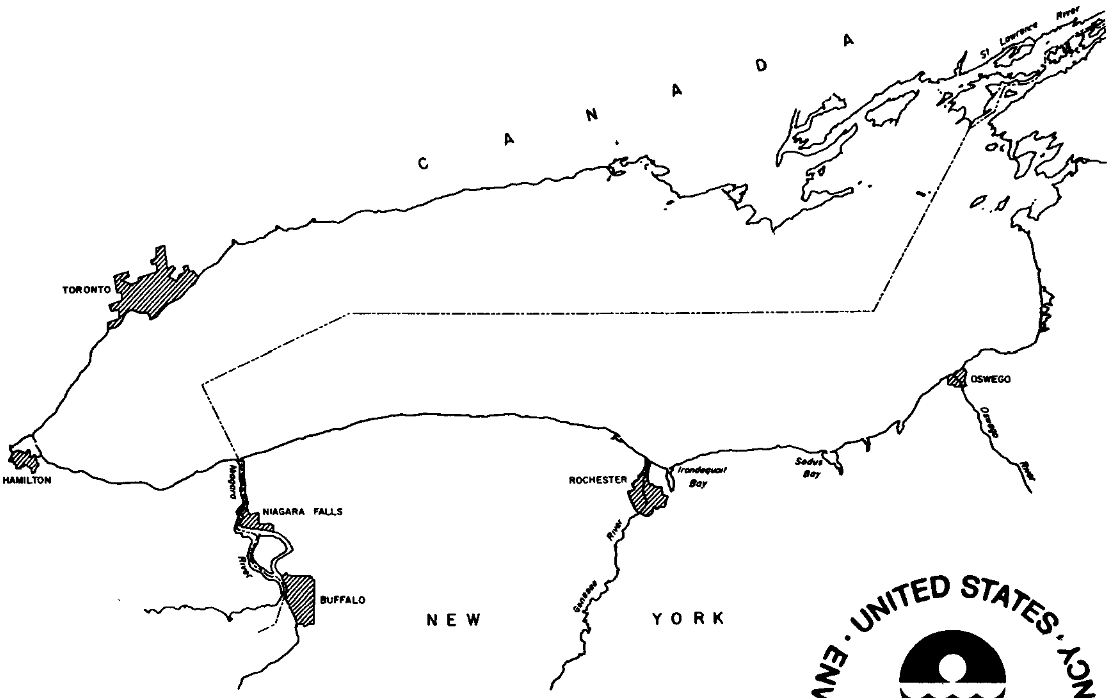
COMPREHENSIVE IFYGL MATERIALS BALANCE STUDY FOR LAKE ONTARIO BASIN

PART I



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COMPREHENSIVE IFYGL MATERIALS BALANCE STUDY FOR LAKE ONTARIO PART I

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IFYGL Comprehensive Materials
Balance Study of Lake Ontario

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Chapter 1

1.1 Program Objectives

A major objective of the International Field Year for the Great Lakes (IFYGL) study of Lake Ontario was to provide an accurate and detailed description of the trophic status of the lake, see Fig. 1.1. To this end an extensive materials balance study was conducted as a joint United States and Canadian effort. In the U.S. the study was under the auspices of the U.S. Environmental Protection Agency with the cooperation of the National Oceanic and Atmospheric Administration. The Canadian Centre for Inland Waters was responsible for the work on the Canadian side. This study included the determination of the chemical loadings of the major streams tributary to Lake Ontario (preliminary summary - Casey and Salbach, 1975) and the chemical concentration determinations at a number of positions and depths in Lake Ontario throughout the field year.

Chapter 2 describes the sampling procedures on the lake and at stream mouths. The loadings are calculated and discussed in Chapter 3. Variations in the lake chemical concentrations, both vertical and horizontal as well as seasonal, are described in Chapter 4. Based on the tributary loadings and the chemical mass determinations in the lake, the rates of retention of various chemical substances as functions of time have been calculated in Chapter 5. Appendix A tabulates the U.S. stream mouth concentrations while all of the lake measurements are presented and described in Appendix C.

1.2 Previous Lake Ontario studies

Comprehensive studies of Lake Ontario chemistry are a fairly recent phenomenon which began in the 1960's. A review of these early studies was reported by Chalwa (1971). The U.S. Federal Water Pollution Control Administration (FWPCA) 1965 study of Lake Ontario, as reported by Casey, Fisher and Kleveno (1973), included 3 cruises (May, late July - early August and late September - early October) which sampled 42 stations. The chemical paramenters sampled were total phosphate, total filterable phosphate, nitrate, ammonia, total Kjeldahl nitrogen, chloride, silica, potassium, dissolved oxygen, pH, biochemical oxygen demand and dissolved solids. In 1967, the Canadian Department of National Health and Welfare (NHW) conducted bi-monthly cruises of Lake Ontario from June through August. Surveyed in the study were total phosphate, dissolved orthophosphate, nitrite-nitrate, ammonia, sulfate, silica, sodium, iron, manganese, copper, lead, nickel, zinc, dissolved oxygen and alkalinity. Shiomi and Chawla (1970) presented an analysis of the first year-round lake-wide study which reported nutrient data collected at monthly intervals from 60 stations in Lake Ontario during the period April 1969 through March 1970. Their investigation included total phosphate, dissolved orthophosphate, nitrate, ammonia and silica. The IFYGL study reported here spanned the period May 1972 though June 1973 and included not only year-round lake wide chemical sampling of nutrients, major ions and metals, but also tributary and precipitation loadings for the same period. Table 1.1 summarizes the mean concentration measurements of these studies. More detailed comparisons will be made in Chapter 4.

Table 1.1 Summary of Previous Studies
Lake Ontario Chemistry
(milligrams per liter)

	FWPCA 1965 (1)	NHW 1967 (2)	CCIW 1970 (3)
TP (as P)	.018	.015	.023
TFP (as P)	.015	-	.008
DOP (as P)	-	.002	-
NO2-NO3 (as N)	.35 (4)	.167	.149
NH3 (as N)	.06	.03	.027
TKN (as N)	.29	.295	-
TOC	-	-	-
SO4	30.5	27.5	-
SiO2	1.20	.1-.4	.258-.415
F	-	-	-
Na	-	12.2	-
K	-	>2	-
Ca	45	-	-
Mg	9.2	-	-
Fe	-	.015	-
Mn	-	.004	-
Cu	-	.012	-
Pb	-	.004	-
Ni	-	.002	-
Zn	-	.008	-
Cd	-	.000	-
DO	12.4	12.5	-
Alka. (as CaCO3)	97	90	-
Conduct. (μmhos)	318	-	-
pH	8.5	-	-

(1) 3 cruises (May, July-August, September-October 1965) Casey et al., 1973.
(2) Bi-monthly cruises (June thru October 1967) I.J.C. (1970).
(3) 12 monthly cruises (April 1969 - March 1970) Shiomi and Chawla (1970).
(4) Nitrate only.

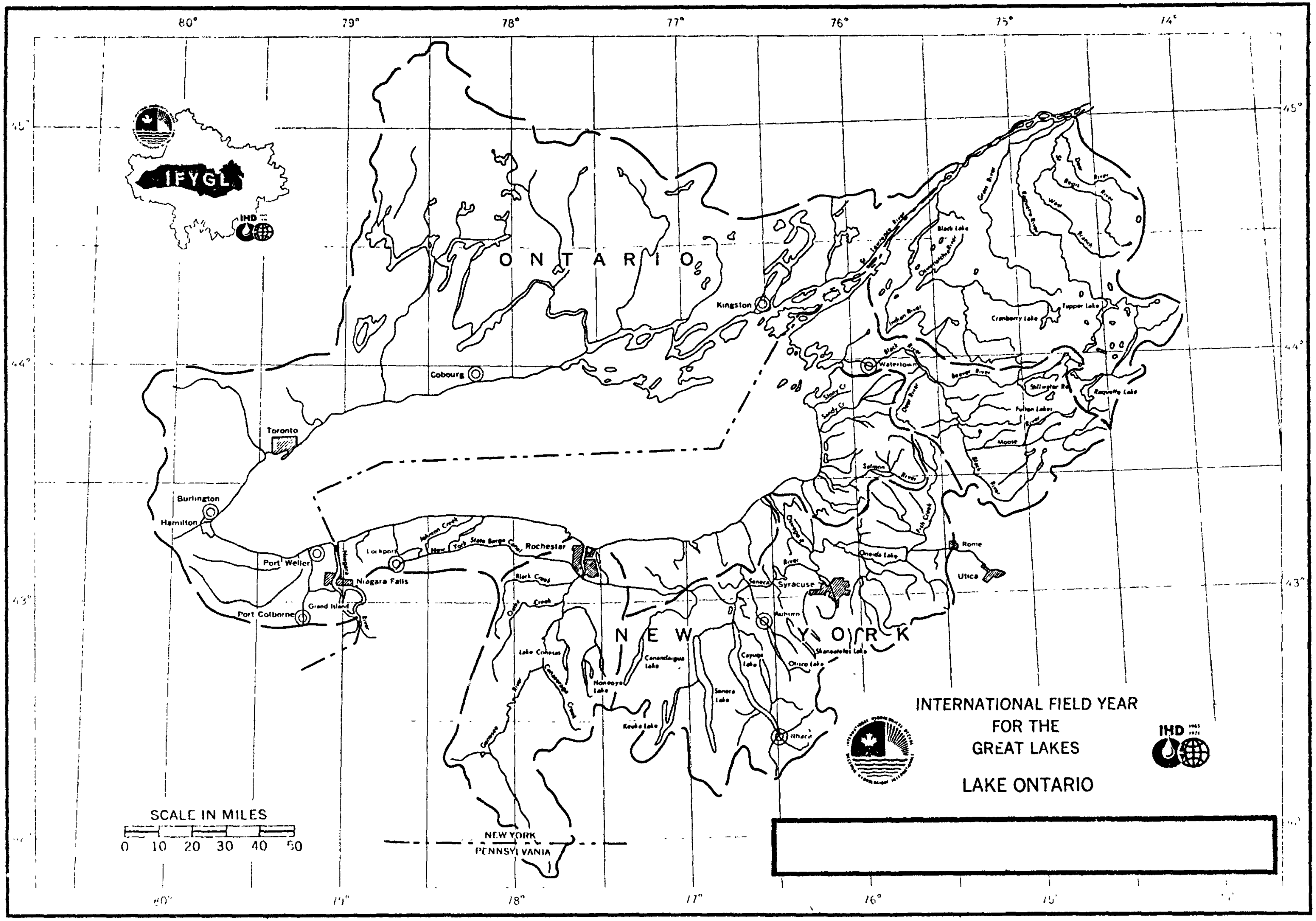

Figure 1 Map of Lake Ontario basin with tributary basins indicated

Chapter 2

2.1 Discharge measurements for U.S. tributaries

The Water Resources Division of the U.S. Geological Survey has maintained discharge gauging stations on the Niagara, Genesee, Oswego, Black and St. Lawrence Rivers for a number of years. These discharge measurements are reported in an annual series of reports entitled "Water Resources Data for New York, Part 1. Surface Water Records". Monthly discharges of each of the tributaries are illustrated in Figure 2.1a-e. In each case the field year was characterized by high discharges.

The Niagara River discharge measurements were made at the head of the Niagara River at Buffalo (latitude 42°51'40", longitude 78°53'25"). The discharge is determined from several power plants at Niagara Falls plus the discharge over the falls. Discharge measurements on the Niagara River have been made since 1860 and have averaged 5731 cubic meters per second (202,000 cfs).

For the Genesee River, the discharge measurements were made from the right bank 12.2 meters (40 ft.) downstream from plant 5 of the Rochester Gas and Electric Corporation, 30.5 meters (100 ft.) upstream from Driving Park Avenue Bridge at Rochester and 9.8 kilometers (6.1 mi.) upstream from the mouth (latitude 43° 10'50", longitude 77°37'40"). Downstream from this location, the Eastman Kodak Waste Disposal Plant and the Irondequoit - St. Paul Municipal Waste Disposal Plant contribute discharges which average 1.1 cubic meters per second (39.1 cfs) and 1.3 cubic meters per second (45.3 cfs), respectively. These discharges are less than 1.6% and .07% of the average Genesee discharge and will be neglected in the loading calculations. Discharge measurements at Rochester have been compiled since 1904 and have averaged 76.5 cubic meters per second (2696 cfs).

Discharge measurements for the Oswego River were collected from the right bank of the river at lock 7 in Oswego, 1.3 kilometers (.8 mi.) upstream from the river mouth (latitude 43° 27′06" and longitude 76°30′20"). Reliable discharges have been recorded since 1933 and have averaged 180.9 cubic meters per second (6374 cfs).

The Black River discharges have been obtained on the downstream side of the right abutment of the Vanduzee Street Bridge at Watertown, 5.6 kilometers (3.5 mi.) upstream from Philomel Creek. Discharge determinations on the Black were first recorded in 1920. Over this period, the discharge averaged 109.1 cubic meters per second (3845 cfs).

St. Lawrence River discharges have been determined since 1860 and have averaged 6798.1 cubic meters per second (239,600 cfs). These measurements are made at the Robert Moses - Robert H. Sanders power dam on Lake St. Lawrence on the International Boundary at Cornwall, Ontario, 4.67 kilometers (2.9 mi.) upstream from the Grass River, 10 kilometers (6.2 mi.) upstream from the Raquette River and 9.5 kilometers (5.9 mi.) northeast of Massena, New York (latitude 45°00′22", longitude 74°47′43").

2.2 Stream Sampling

2.2.1 Location

Water samples from each of the tributary streams were gathered at 2 to 3 day intervals thoughout the field year. The locations of the sampling sites are indicated in Fig. 2.2. Table 2.1 lists the average frequency of measurement for each of the U.S. streams together with the period during which the samples were gathered. On each occasion 4 1-liter grab samples were obtained from a depth of 1 meter using a non-metallic PCV-type sampler. A schematic of the sample handling procedure is provided in Figure 2.3.

The Niagara River samples were obtained near the Coast Guard Station just below Fort Niagara. Genesee River samples were taken at a point near the Naval Militia Station at the mouth of the river. For the Oswego River, the sampling location was near the Delaware, Lackawanna and Western Railroad bridge which is 3 blocks upstream from the Bridge Street bridge and 2 blocks downstream from lock 7 in Oswego. On the Black River the samples came from adjacent to the bridge on U.S. Route 179 at Dexter, New York. St. Lawrence River samples were taken adjacent to the concrete dock at the New York Department of Environmental Conservation at Cape Vincent. In the winter, sample water was pumped inside the NYSDEC office.

2.2.2 Field analysis

One of the 4 1-liter grab samples was analyzed in situ to determine water temperature, dissolved oxygen, alkalinity and pH.

A mercury thermometer was used to determine the water temperature which was reported in degrees Celcius. The concentration of dissolved oxygen, measured in milligrams per liter, was ascertained by means of a Winkler titration; this procedure is described on p. 474 of "Standard Methods for the Examination of Water and Waste Water". The alkalinity of the sample was determined by a titration with .02 Normal H_2SO_4 to a pH of 4.5 as described on p. 55 of the same reference; the alkalinity is reported as milligrams per liter of calcium carbonate. A Leeds and Northrup field meter was used for the pH determination. Field chemistry is tabulated in Appendix A, Tables A-N9, A-G9, A-O9 and A-S9. Field measurements for the Black River are not available.

2.2.3 Laboratory analysis

Laboratory analysis for nutrient, major ion and metals concentrations was performed on the remaining 3 1-liter grab samples at the laboratory of U.S. Environmental Protection Agency, Rochester (N.Y.) Field Office. One of these samples was frozen after collection and later thawed and used for the determination of total Kjeldahl nitrogen, total phosphate and chloride concentrations. The second sample was filtered through a Millipore filter (0.45 micron poresize) and also frozen at the sampling site. In the laboratory this sample was thawed and analyzed for concentrations of sulfate, silica, fluoride, nitrite-nitrate, ammonia, dissolved orthophosphate and total filterable phosphate. The third sample was preserved by acidification with 2 milliliters of concentrated nitric acid and later used to determine total organic carbon, magnesium, manganese, iron, potassium, sodium, calcium, zinc, nickel, copper, cadmium, lead and mercury concentrations.

Appendix C gives detailed information on the laboratory techniques used for the chemical analyses. The concentrations are tabulated in Appendix A, Tables A-N1 through A-N8 for the Niagara River, A-G1 through A-G8 for the Genesee River, A-O1 though A-O8 for the Oswego River, A-B1 through A-B8 for the Black River and A-S1 through A-S8 for the St. Lawrence River. In Chapter 3, the loadings associated with each of the chemical concentrations are calculated and discussed.

2.3 Lake sampling

2.3.1 Locations

Figure 2.2 is a map of Lake Ontario which shows the locations of each of the sampling stations and the planned route of the sampling vessel. Listed in Table 2.2 are the latitude and longitude coordinates of the station locations together with the depth of the lake at each of these locations. At each of the stations, water samples were drawn from the surface to the maximum depth of the station at intervals of approximately 5, 10, 15, 20, 25, 30, 40, 50, 100, 150 and 200 meters. Samples were obtained on a total of 11 cruises which occurred between May 1, 1972 and June 15, 1973 (see Table 2.3).

2.3.2 Procedures

The sampling procedures required a General Oceanics rosette multibottle sampling array which sequentially gathered samples below each station. Each of the 5-liter samples was split upon retrieval, with 3 1-liter samples destined for laboratory analysis and 2 samples for immediate field analysis. Fig. 2.3 is a schematic indicating the processing procedure for the materials balance samples. One of the 3 laboratory samples was immediately frozen and later thawed for the determination of total Kjeldahl nitrogen and total phosphate. A second laboratory sample was first filtered through a Millipore filter (0.45 micron pore size) and then frozen. In the laboratory this sample was thawed and analyzed for the concentrations of sulfate, silica, fluoride, nitrite-nitrate, ammonia, dissolved orthophosphate and total filterable phosphate. The third laboratory sample was acidified with 2 milliliters of concentrated nitric acid and used to determine total organic carbon, magnesium, manganese, iron, potassium, sodium, calcium, zinc, nickel and cadmium concentrations. Field measurements were carried out as described in Section 2.2.2. Table 2.4 shows the number of measurements of each substance taken on each cruise. Table 2.5 supplies a weather summary for each of the cruises.

Appendix C provides a description of the laboratory techniques used for the chemical analyses. The concentrations are tabulated in Appendix B, B-II through B-XI7. Chapter 4 provides a discussion of the lake chemical content and comparisons with previous studies.

Table 2.1 List of Periods and Frequency of Stream Sampling

River	Sampling Started	Sampling Ended	Frequency of Sampling (days)
Niagara	April 3, 1972	May 23, 1973	3
Genesee	April 10, 1972	May 28, 1973	3
Oswego	April 8, 1972	May 31, 1973	2
Black	April 4, 1972	May 1, 1973	2
St. Lawrence	May 16, 1972	March 28, 1973	3

Table 2.2 Materials Balance Sampling Stations

Station Number	Latitude XX° XX′ XX″	Longitude XX° XX′ XX″	Depth at Station (meters)	Type of Station*
1	43 22 48	79 40 48	33	X
2	43 15 36	79 38 24	16	X
3	43 13 12	79 25 12	15	X
4	43 16 48	79 26 24	66	S
5	43 21 36	79 28 48	95	X
6	43 26 24	79 30 00	82	S
7	43 32 24	79 33 00	16	X
8	43 36 00	79 21 00	15	X
10	43 25 12	79 16 48	119	XX,S
11	43 19 12	79 14 24	90	S
12	43 15 36	79 13 12	55	X,S
13	43 19 12	79 04 12	10	S
14	43 17 24	79 00 00	10	X,S
15	43 24 00	79 00 36	102	X,S
17	43 33 00	79 03 36	130	X
19	43 45 36	79 07 12	14	X
20	43 49 48	78 51 00	18	X,S
23	43 43 48	78 49 12	82	S
24	43 39 00	78 48 00	114	XX,S
26	43 30 36	78 46 12	146	X,S
27	43 26 24	78 44 24	128	S
30	43 21 36	78 43 48	20	X,S
31	43 23 24	78 30 00	28	X
32	43 32 24	78 30 00	171	X
34	43 45 00	78 30 00	85	X
35	43 52 48	78 30 00	18	X
36	43 55 12	78 14 24	14	X
38	43 45 36	78 13 48	99	X
40	43 31 48	78 12 36	175	X
41	43 23 24	78 12 00	9	X
42	43 23 24	77 59 24	15	X,S
43	43 27 00	78 00 00	120	S
44	43 31 12	78 00 00	174	X
45	43 35 24	78 00 36	183	XX,S
46	43 43 48	78 01 12	120	X,S
47	43 49 12	78 02 24	72	S
48	43 55 48	78 03 00	26	X,S
49	43 56 24	77 40 48	20	X
52	43 49 48	77 41 24	65	X

Table 2.2 (continued)

Station Number	Latitude XX°XX′XX″	Longitude XX°XX′XX″	Depth at Station (meters)	Type of Station*
54	43 39 36	77 43 12	139	X
56	43 27 00	77 44 24	134	X
59	43 21 36	77 45 00	26	X
60	43 15 36	77 30 00	12	X
62	43 28 48	77 30 00	169	X
64	43 41 24	77 30 00	85	X
66	43 54 36	77 30 00	12	X
67	43 49 12	77 15 00	20	X
69	43 35 24	77 15 00	152	X
71	43 23 24	77 15 00	186	X
72	43 18 00	77 15 00	24	X
73	43 18 00	76 24 24	17	X,S
74	43 25 12	76 36 36	157	S
75	43 29 24	76 48 48	233	XX,S
77	43 40 12	77 36 36	114	X,S
78	43 48 00	77 24 24	53	X,S
79	43 53 24	76 54 00	20	X
83	43 44 24	76 47 24	99	X
85	43 36 00	76 40 48	188	X
89	43 25 12	76 45 00	76	X
90	43 28 12	76 34 12	13	X
92	43 40 12	76 22 48	67	X,S
93	43 43 12	76 30 00	84	S
94	43 50 24	76 30 36	35	X,S
95	43 54 00	76 42 36	18	X
96	43 58 48	76 40 48	35	XX,S
97	44 00 36	76 48 00	29	X,S
98	44 04 48	76 36 00	22	X,S
99	44 00 00	76 28 48	40	X
103	43 45 00	76 15 00	27	X
105	43 33 00	76 18 00	25	X,S

* Types of stations: X - Water Quality,
XX- Master Water Quality
S - Spring bloom.

Table 2.3 Materials Balance Cruises

Number	Dates	Vessel
1	May 1-5, 1972	Researcher
2	May 15-19, 1972	Researcher
3	Jun 12-16, 1972	Researcher
4	Jul 10-14, 1972	Researcher
5	Aug 21-25, 1972	Researcher
6	Oct 30-Nov 3, 1972	Researcher
7	Nov 27-Dec 2, 1972	Researcher
8	Feb 5-9, 1973	Limnos
9	Mar 18-23, 1973	Limnos
10	Apr 24-30, 1973	Martin Karlsen
11	June 11-15, 1973	Limnos

Table 2.4 Number of Measurements of Each Substance on Each Cruise

Substance	Cr. 1	Cr. 2	Cr. 3	Cr. 4	Cr. 5	Cr. 6	Cr. 7	Cr. 8	Cr. 9	Cr. 10	Cr. 11
D.O.	21	98	465	461	439	471	282	162	66	57	324
pH	136	174	460	451	465	484	422	---	129	237	323
T. Alka.	166	179	460	616	466	483	422	---	---	---	74
Ammonia	198	193	443	331	391	290	226	60	66	243	203
TKN	---	257	453	352	376	379	278	80	84	154	248
NO2-NO3	197	190	442	331	420	408	399	96	104	244	286
T. Phos.	208	180	391	356	429	439	210	128	128	247	341
TFP	177	232	421	438	329	440	385	100	15	244	278
DOP	185	95	445	193	340	324	288	98	97	231	197
TOC	55	268	174	145	155	102	---	115	117	92	129
Calcium	38	186	92	111	128	130	104	111	117	---	130
Magnesium	38	187	93	111	127	129	104	111	117	---	130
Sodium	38	186	93	111	127	129	104	111	117	---	130
Potassium	38	186	93	111	127	129	104	111	117	---	130
Sulfate	195	191	349	131	377	425	383	97	104	241	283
Fluoride	188	150	443	329	434	426	395	---	106	246	285
Silica	190	192	441	329	357	324	186	98	85	218	282
Cadmium	---	---	64	---	---	---	---	---	---	---	---
Chromium	---	---	64	---	---	---	---	---	---	---	---
Copper	---	---	64	---	78	---	91	31	110	92	130
Iron	---	---	53	---	78	---	91	31	85	92	130
Manganese	---	---	53	---	78	---	91	31	110	92	130
Nickel	---	---	64	---	78	---	91	31	110	92	130
Zinc	---	---	64	---	78	---	91	31	110	92	130

Table 2.5 Weather Summary
Materials Balance Cruises 1972

Number	Dates	Max. Wind Speed (kts.)	Max. Wave Height (ft.)	Lowest Visibility	Length of Cruise (hrs.)
1	May 1-5	25	3	50m	86
2	May 15-19	20	0	50m	99
3	Jun 12-16	32	5	50m	99
4	Jul 10-14	25	3	4km	96
5	Aug 21-25	16	2	200m	97
6	Oct 30-Nov 3	22	5	500m	93
7	Nov 27-Dec 2	30	7	2km	--

Number	Dates	Weather - % of Observations with:				
		Fog	Drizzle	Rain	Snow	Thunderstorms
1	May 1-5	29	13	8	0	1
2	May 15-19	96	0	1	0	0
3	Jun 12-16	20	0	0	0	0
4	Jul 10-14	26	1	2	0	0
5	Aug 21-25	36	0	1	0	0
6	Oct 30-Nov 3	11	4	3	0	0
7	Nov 27-Dec 2	0	0	2	2	0

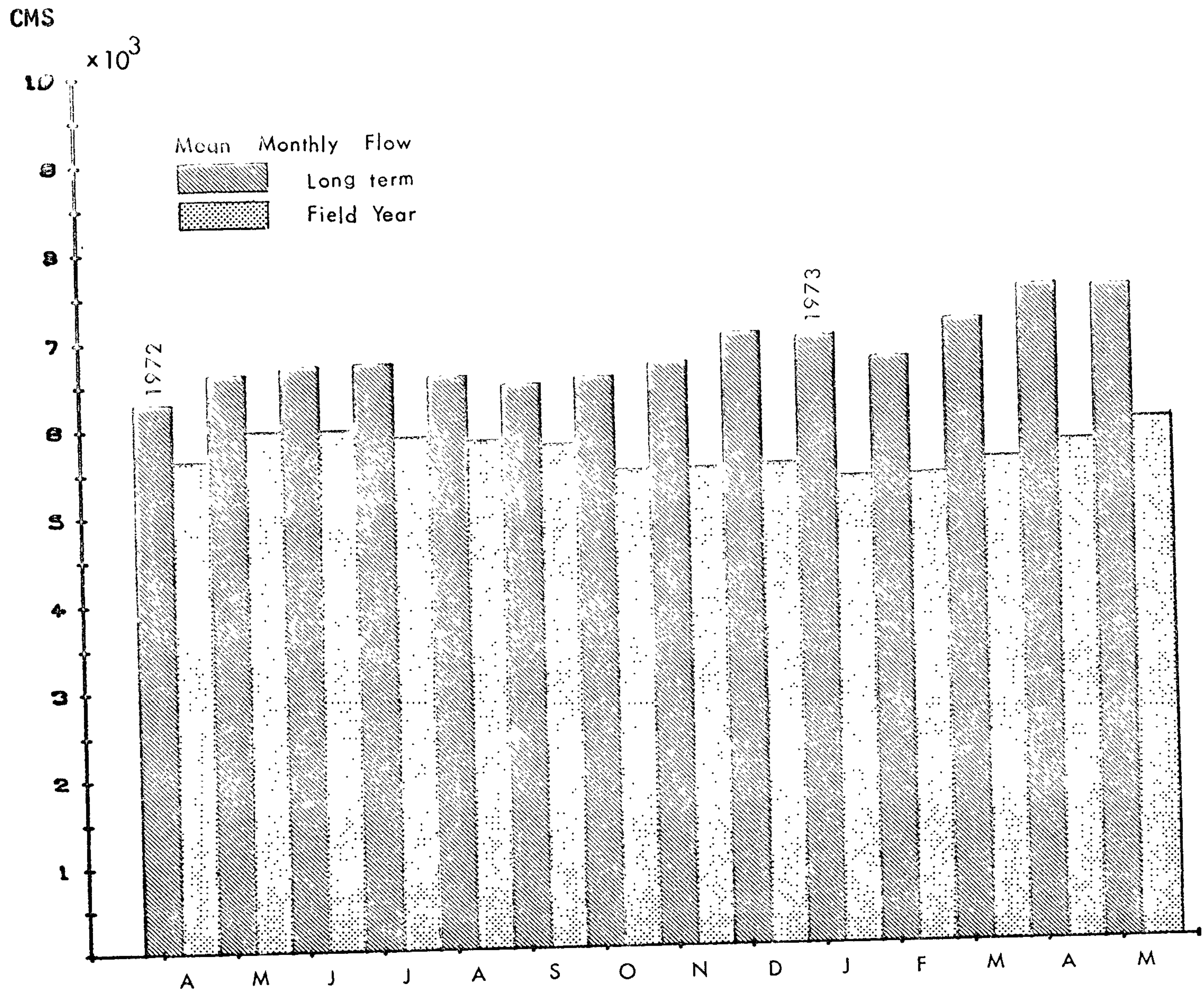

Figure 2.1a Niagara River Monthly Discharges - Comparison of Field Year and Long Term Means

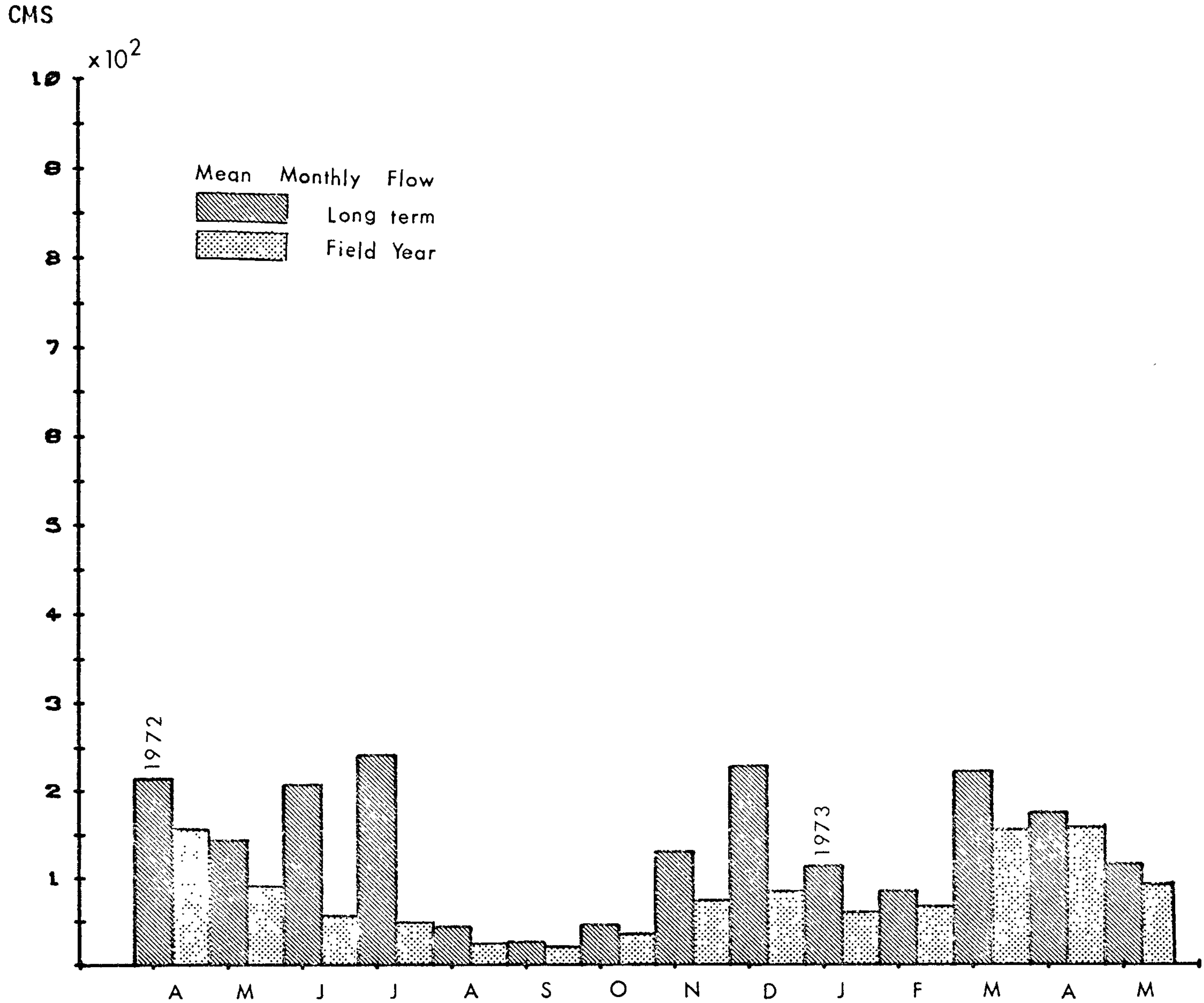

Figure 2.1b Genesee River Monthly Discharges - Comparison of Field Year and Long Term Means

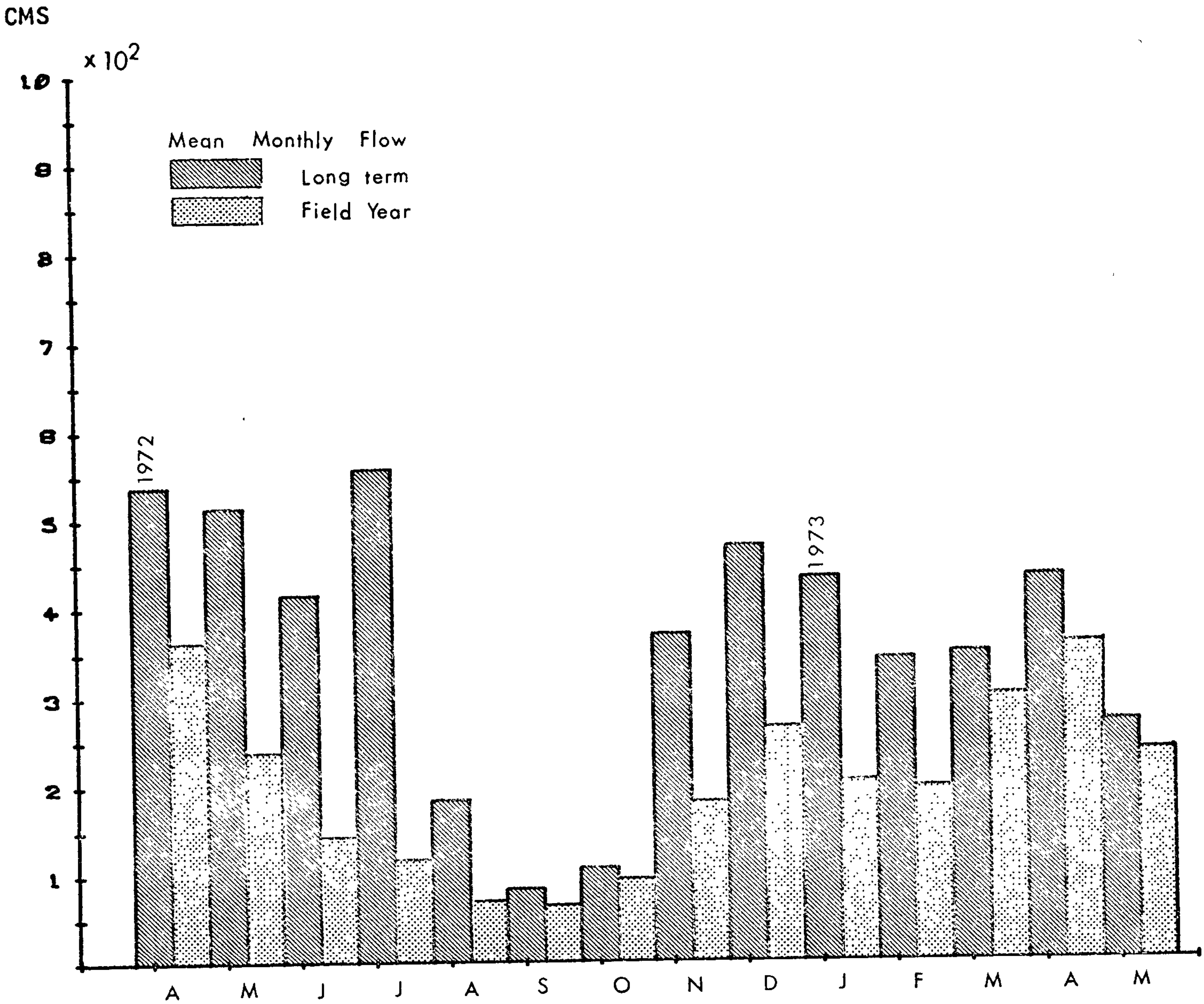

Figure 2.1c Oswego River Monthly Discharges - Comparison of Field Year and Long Term Means

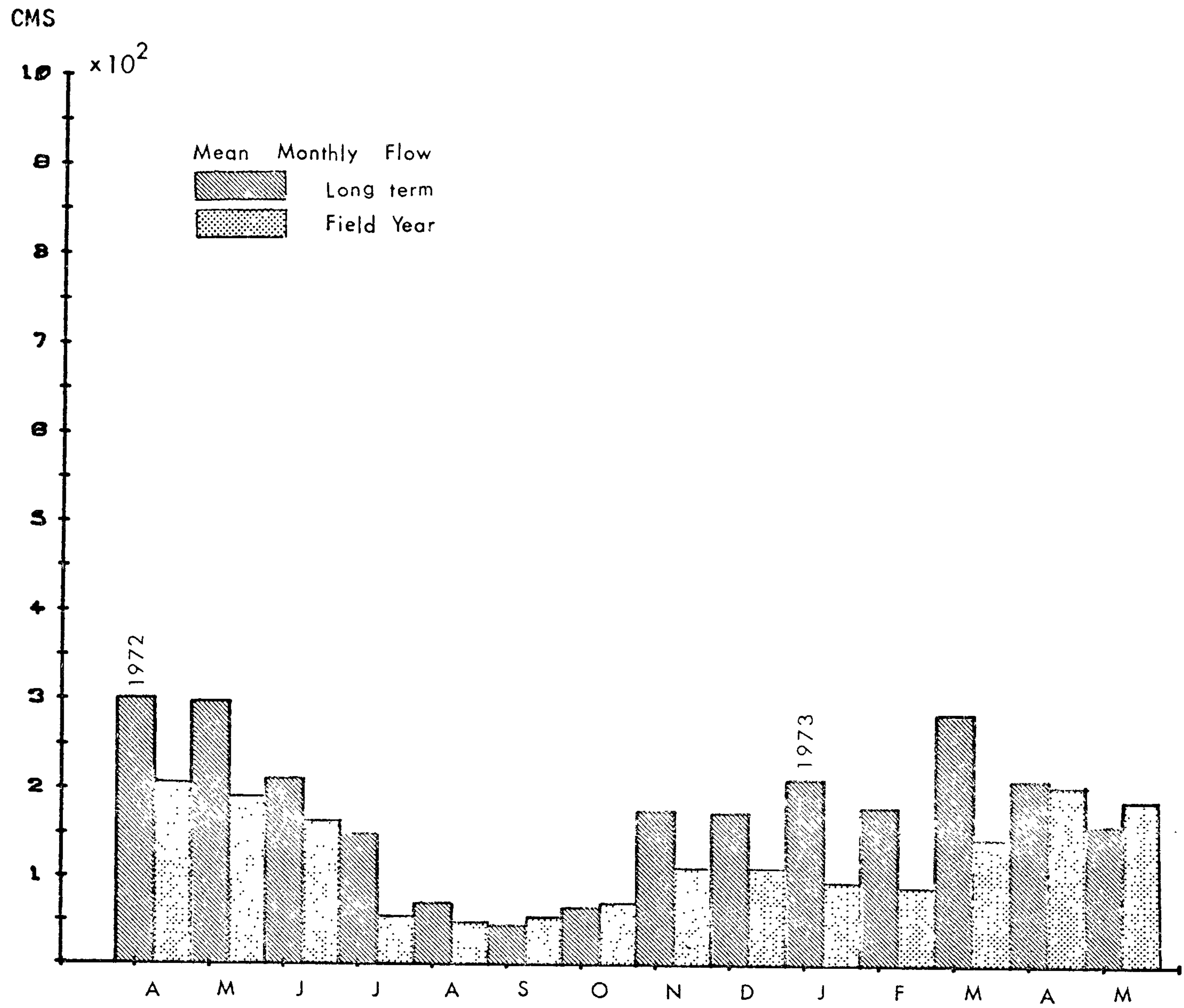

Figure 2.1d Black River Monthly Discharges - Comparison of Field Year and Long Term Means

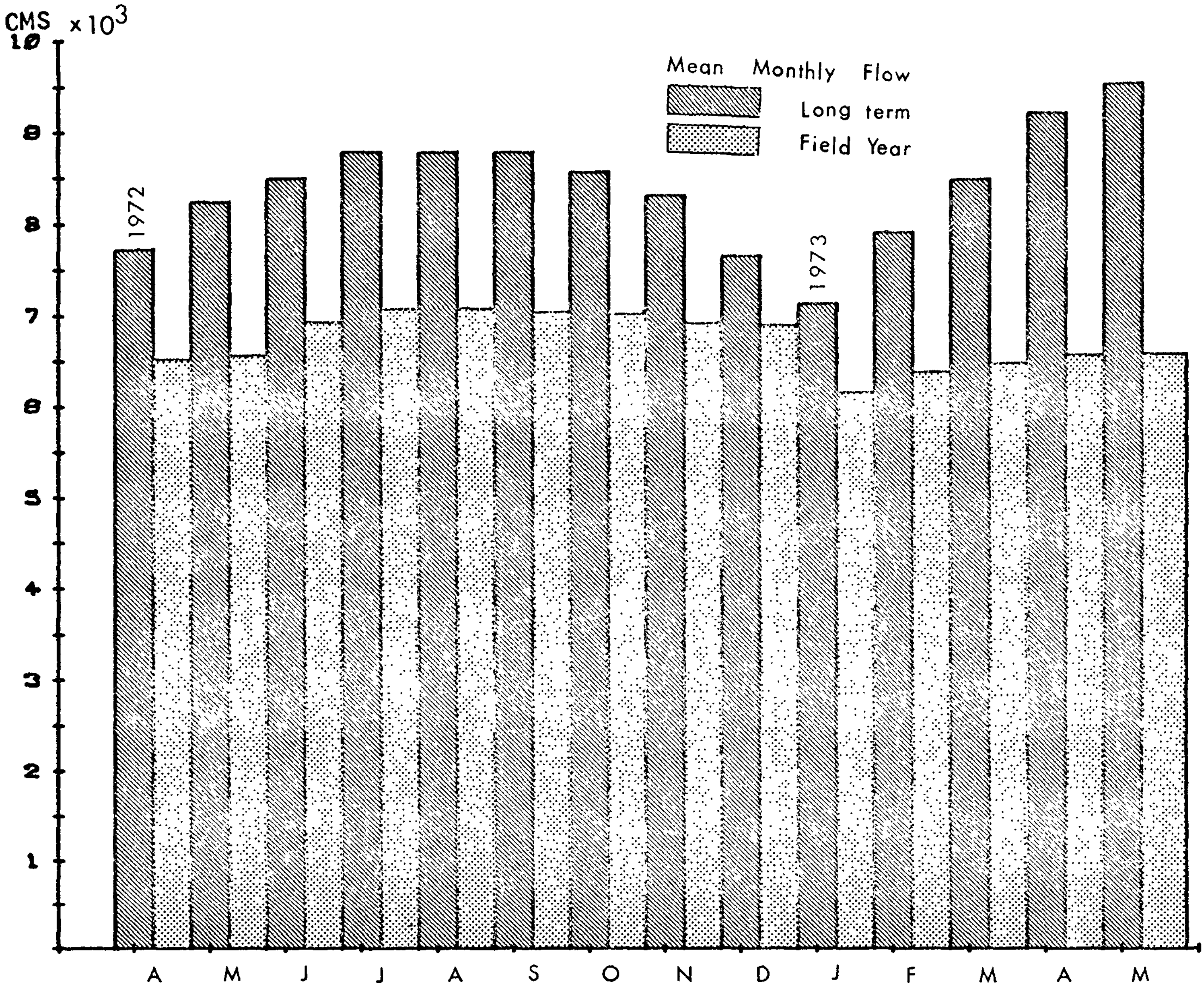

Figure 2.1e St. Lawrence River Monthly Discharges - Comparison of Field Year and Long Term Means

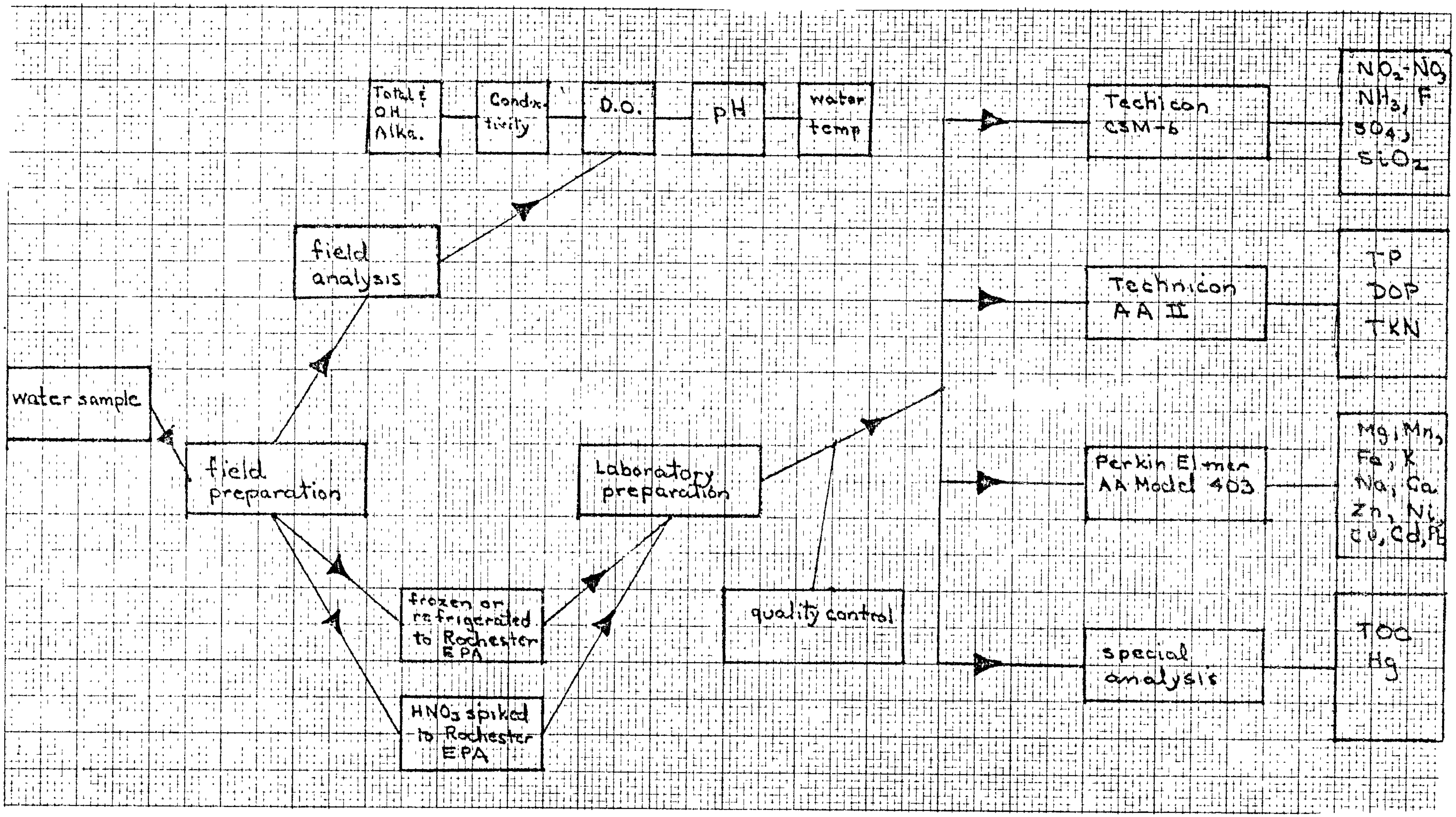

Figure 2.2 Schematic of sample handling

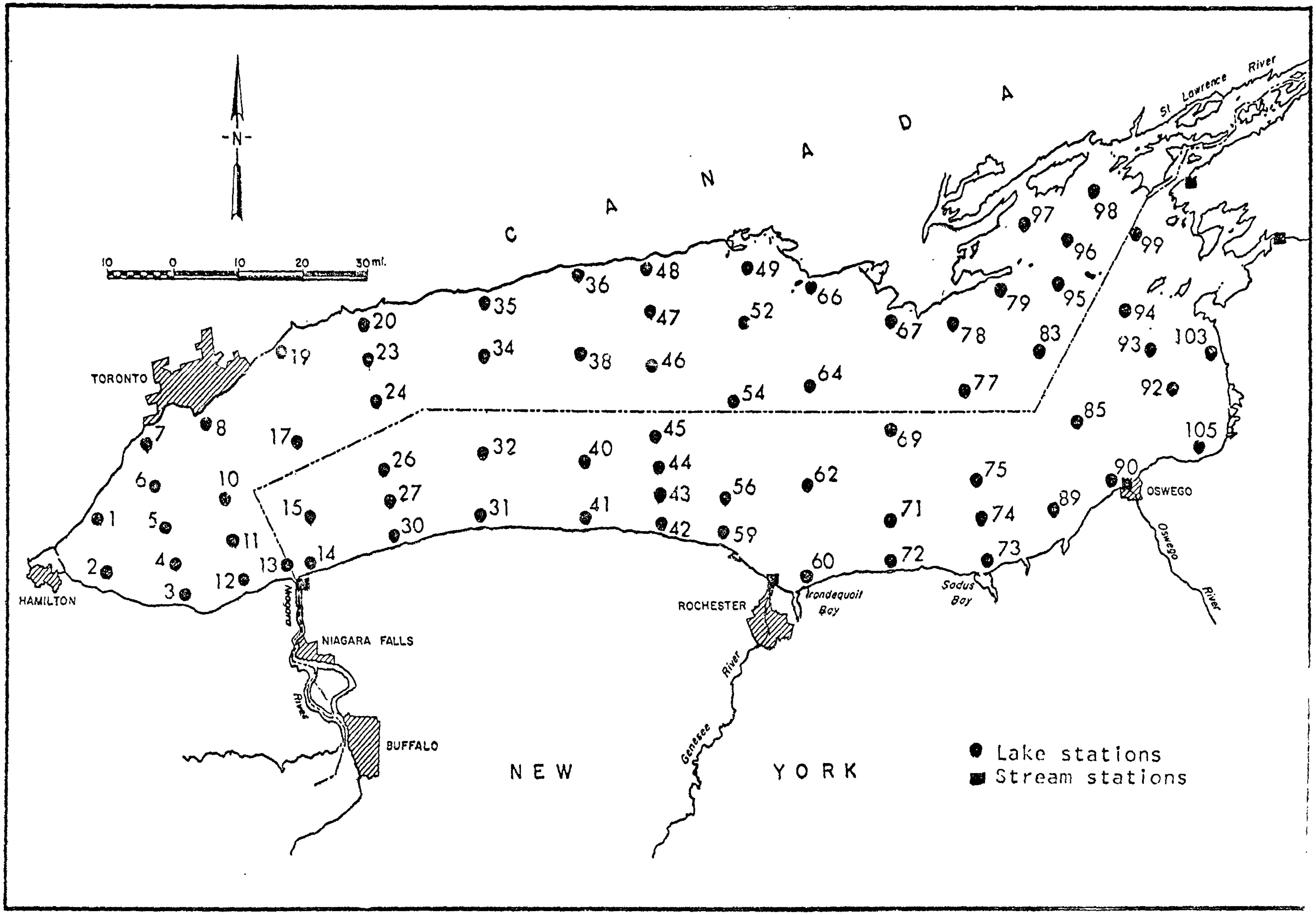

Figure 2.3 Map of Lake Ontario with locations of lake and stream sampling stations indicated

Chapter 3

3.1 Description of Loading Analysis

Provided in chapter 3 is a monthly breakdown of the loading contributions to Lake Ontario which includes the tributary streams, direct municipal, direct industrial and on-lake precipitation.

The tributary, direct municipal and direct industrial loadings were measured on the Canadian side of the lake by the Canadian Center for Inland Waters and reported by Casey and Salbach (1975). Results are summarized in Tables 3.1-3.25 for each of the various chemicals measured.

There are no direct industrial loading contributions to Lake Ontario from the U.S. side. The U.S. direct municipal loading rates were obtained directly from the Wilson, Rochester, Irondequoit, Webster and Oswego sanitary treatment plants. Summed for each chemical substance measured, these loading rates are included in Tables 3.1-3.16.

Loadings for thd Niagara, Genesee, Oswego, Black and St. Lawrence Rivers, are calculated as described in Casey and Salbach (1974). This involved finding an average daily mass contribution, measured in metric tons/day. The average daily mass was calculated to be the sum of each daily product of concentration, times the flow rate, times the constant .00247, divided by the number of days. Daily chemical concentrations (U.S. Environmental Protection Agency) were interpolated linearly from measured concentrations. Daily flows were obtained from the U.S.

Geological Survey. WRD.

For the U.S. minor tributaries and municipal sources, estimates of the loading rates were made on the basis of measured discharges and a few isolated concentration measurements. These must be considered to be considerably more uncertain than the major tributary loadings.

For the Canadian tributaries, the data used is from Casey and Salbach (1974). In this case the mean daily mass was calculated as the average flow times the average concentration, times the constant .002447. Both major and minor tributary loadings are listed in Tables 3.1-3.25.

The direct on-lake loading rates are estimated from the measured number of inches of rainfall each month during the field year as reported by Bolsenga and Hagman (1975) and the average of the U.S. Casey et al (1976) and Canadian (Shiomi and Kuntz (1973) Lake Ontario basin precipitation chemistry studies. Calculated estimates of these loading rates are also listed in Table 3.1-3.25.

3.2 Description of U. S. River Basins

NIAGARA RIVER BASIN

The Niagara River (Fig. 1.1), which drains an area of 686,400 sq. km. (264,000 sq. mi.), has a mean annual inflow to Lake Ontario of 5,720 cumecs (202,000 cfs) and is by far the greatest hydrologic factor influencing the chemical budget of the lake. The distribution of this flow is quite even because of the damping influences caused by the upstream lakes and the regulation of Lake Superior. The result is that an essentially steady-state flow is constantly imposed on Lake Ontario. A 5%

error in measuring the flow of the Niagara River, based on the long-term yearly mean, would amount to approximately 285 cumecs (10,000 cfs); while, for comparison, the sum of the long-term mean flows for the Genesee, Oswego and Black Rivers is equal to 395 cumecs (14,000 cfs).

Although the Niagara River receives a lot of municipal and industrial waste, the chemistry of the river is mainly a reflection of the chemistry of the upper water levels of Lake Erie. The industrial wastes entering the river in the Buffalo-Niagara Falls area include wastes from chemical, steel, paper and oil refineries.

During the field year the flow of the Niagara River was greater than the long-term average (Fig. 2.1a).

GENESEE RIVER BASIN

The Genesee River basin (Fig. 1.1) is located in western New York State. The basin extends southward from Lake Ontario, at Rochester, New York, on into Pennsylvania, a distance of about 160 km. (100 mi.). It is about 65 km. wide and covers an area of 6200 sq. km. (2400 sq. mi.). From its mouth to its origin in Pennsylvania, the Genesee River cuts through a 685 m. (2250 ft.) section of sedimentary rocks of Paleozoic age. These rocks gently dip southward and strike east-west and are generally made up of alternating beds of shales, limestones, sandstones, salts, gypsum and mixtures of those rock types.

The ground water of the Genesee basin is, for the most part, enriched in dissolved solids. The average annual precipitation is 86.4 cm. (34 in.). With respect to rainfall, the field year was atypical because of tropical storm Agnes, which struck the upstate New York area between June 21 and 26, 1972. Of the streams draining into Lake Ontario, the Genesee River was most affected by the storm. The annual runoff ranges from 25.4 cm. (10 in.) to 50.8 cm. (20 in.). The long-term average runoff is about 35.5 cm. (14 in.). The Genesee River is regulated by a series of dams on the main stem and several tributaries. The principal dam, which is 66 m. (218 ft.) high, is located 50 km. (30 mi.) above Rochester.

The population in the Genesee basin is concentrated in the Rochester area and was about 800,000 in 1970. Economic productivity is heavily influenced by the Rochester metropolitan area, with both manufacturing and non-manufacturing industry. About 70% of the land in the basin is devoted to agriculture. Concentrated in the central portion of the basin is a small mineral industry, the major products of which include salt, gypsum, stone, and gravel. Near the New York - Pennsylvania border, there are several small and generally depleted oil fields.

The major pollution problems in the Genesee River are in the lower and central portion of the main stem and in its triburaries. The most serious problem area is that part of the river that is below both the Eastman Kodak Co. and the storm-water overflows of the Rochester City sewer system.

OSWEGO RIVER BASIN

The Oswego River basin is situated in west-central New York and is bounded by basins of small streams tributary to Lake Ontario, the Genesee River basin, the Mohawk River basin and the Black River basin. The area of the basin is 13,200 sq. km. (5,100 sq. mi.).

The hydrological and chemical characteristics of the basin are dominated by extensive storage in the Finger Lakes, Oneida Lake and Onondaga Lake. The Oswego River originates 37 km. (23 mi.) south of Lake Ontario, at the junction of the Seneca and Oneida Rivers, and flows northward, reaching Lake Ontario at Oswego, N. Y. In addition, the New York State Barge Canal cuts across the basin and in some areas the Oswego and other rivers in the basin are used as part of the canal.

The bedrock of the Oswego River basin is entirely composed of sedimentary rocks like those of the Genesee River basin. The surface is covered with glacial till composed of silt, sand and gravel, with numerous cobbles and boulders.

There is considerable variation in the total annual precipitation of the basin, ranging from a mean of 81 cm. (24.6 in.) in the west-central part to 165 cm. (50.2 in.) in the eastern part. Precipitation during the field year was about 1.5 times higher than the long-term averages. Tropical storm Agnes caused heavy rainfall in the basin from June 21-26, 1972 with precipitation basin. In addition, November 1972 showed high precipitation levels, due to heavy snows. April 1973 also had very high precipitation. The basin-wide average annual runoff is about

43.7 cm (17.2 in); during the field year the runoff was 86.4 cm. (34 in.).

In 1970, the population of the Oswego River basin was about 970,000, about half of which was largely concentrated in the Syracuse metropolitan area. Manufacturing is a very substantial activity in the Syracuse and Oswego areas. Major products include machinery, primary metals, metal products, chemicals and transportation equipment. Agriculture is quite extensive, with dairying and vegetable and grape growing being the principal activities.

The principle pollution problems in the basin are discharges from inadequate municipal treatment plants and from industrial plants that discharge chemical, steel, paper and cannery wastes.

BLACK RIVER BASIN

The Black River (Fig. 1.1) drains an area of 4962 sq. km. (1916 sq. mi.) in the north-central area of New York State. It is bounded by the St. Lawrence River basin on the north, the Hudson and Mohawk River basins on the east, and the Oswego basin on the southwest. The Black River basin is approximately 121 km. (75 mi.) long, with a maximum width of 64 km. (40 mi.).

The main stem of the Black River flows north, in general, following a contact zone between pre-Cambrian metamorphosed rocks, making up the Adirondack highlands, and sedimentary rocks, principally limestone, of Silurian age. The eastern part of the watershed drains the wooded Adirondacks, with elevations up to 910 m. (3000 ft.) and with many lakes and ponds due to glacial damming. Streamflows from this area are characteristically low in dissolved solids. The rest of the basin is mixed forest and agricultural land, and the streamflows are relatively high in dissolved solids.

The Black River has a large annual runoff, ranking among the highest per unit area in New York State. The average annual runoff is 69 cm. (27 in.). During the field year the annual runoff reached 89 cm. (35 in.). Average annual precipitation ranges from about 76 cm. (30 in.) near the mouth to 140 cm. (55 in.) in parts of the Adirondack highlands. The basin precipitation for the field year was atypical due to heavy rains in the early summer of 1972 and spring of 1973 and heavy snows in November and December 1972. Although part of the high precipitation during the early summer of 1972 was the result of tropical storm Agnes, the effects of the storm were less dramatic than those experienced in the Genesee and Oswego basins, which lay more directly along the track of the storm center.

The population, 75,000, of the Black River basin is concentrated in the lower part of the basin. The woodpulp and paper industry is the largest commercial enterprise and dairying is the principal agricultural activity. Presently, limestone is the only mineral product produced in significant quantities, although deposits of iron ore, lead and zinc were mined in the past.

The major pollution problems in the Black River basin occur in the central and lower sections of the river and are caused by the woodpulp and paper industry.

ST. LAWRENCE RIVER BASIN

The St. Lawrence River (Fig. 1.1) is the stream by which Lake Ontario is drained. The long-term mean annual flow of the river is 68,025 cumecs (240,200 cfs). During the field year the flow of the St. Lawrence River was greater than the long-term average (Fig. 2.1a). The outflow of the St. Lawrence River is regulated, as needed, by one of two dams: one at Iroquois, Ontario, and the other, the Robert Moses Dam, somewhat further downstream. This regulation of flow in turn affects the level of Lake Ontario. Before and during the early part of the Field Year, the incoming flows plus precipitation on the lake exceeded the outflow of the St. Lawrence River, causing the volume of Lake Ontario to increase by about 1% or nearly 1 meter (3 ft.).

3.3 Nutrients

TOTAL PHOSPHATE

Figure 3.1 shows the monthly mean loadings of total phosphate (TP), reported as phosphorus, to Lake Ontario from the principal streams. While the mean monthly loadings, in a broad sense, follow the pattern of the mean monthly streamflows (Fig. 2.1a through 2.1e), percentage changes observed in the loadings are usually significantly greater than corresponding percentage changes in streamflow, indicating significant changes in stream chemistry. This is what one would expect for an ion which is involved in biogeochemical processes. The TP loading pattern of the Niagara River, which reflects the biogeochemical characteristics of Lake Erie, is more varied than that of the St. Lawrence River which is smooth.

Histograms of the TP concentrations are shown in Figure 3.2, as are also the mean, standard deviation, median and number of samples. The histograms of the Niagara, Black and St. Lawrence Rivers are narrow in range and negatively skewed, the histogram of the Oswego River is broad and negatively skewed, and the Genesee River histogram has the broadest range of concentrations. The mean TP concentrations were as follows: Niagara .034 mg/l, Genesee .143 mg/l, Oswego .090 mg/l, Black .033 mg/l and St. Lawrence .030 mg/l. For a more complete listing of the statistics see Tables A-N10, A-G10, A-O10, A-B10 and A-S10 in the appendix. Tables A-N1, A-G1, A-O1, A-B1 and A-S1 in the appendix give a complete listing of TP concentration measurements for the principal U.S. rivers.

The concentration of TP was weakly correlated to streamflow in the Oswego River and Genesee Rivers, as shown on Table 3.27. Little if any correlation exists between TP concentration and streamflow in the Black River. No attempt was made at correlating TP concentrations with streamflow for the Niagara and St. Lawrence Rivers because of their regulated streamflows. The log-log correlation coefficients were as follows: Genesee .144, Oswego -.257 and Black -.062. The regression relationship was C=kQ , where C=concentration, Q=streamflow and k and n are constants.

Table 3.1 lists the monthly average and field year average loads, expressed as metric tons per day, carried to and from the lake by streams, municipal and industrial discharges, and precipitation. The table also lists the calculated average and field year average net load (see Chapter 5) to the lake. The average field year net load to the lake was 27.6 metric tons/day (30.4 tons/day). The monthly average net load ranged from 7.2 metric tons/day (7.9 tons/day) in August to 55.4 metric tons/day (61 tons/day) in December. The mean input during the field year was 49.5 metric tons/day (55 tons/day). Of the total mean input to Lake Ontario, 42% was contributed by the Niagara River, 16% by Canadian municipal and industrial discharges, 12% by U.S. minor tributaries, 12% by precipitation, 7% by Canadian tributaries, 5% by the Oswego, 4% by the Genesee, 1% by the Black and <1% by U.S. municipal discharges. These percentages were within expectations, based on information from a previous study (IJC 1969), except for the amount of TP contributed to Lake Ontario by rainfall, which was higher than expected.

DISSOLVED ORTHOPHOSPHATE

Figure 3.5 shows the monthly mean loadings of dissolved orthophosphate (DOP), reported as phosphorus, to Lake Ontario from the principal streams. The mean monthly DOP loadings of the Niagara and St. Lawrence Rivers have a somewhat similar pattern in the summer months but are significantly different in the winter months when Niagara River DOP loads were observed to decrease, starting in December 1972, at the same time that St. Lawrence DOP loads were increasing. The mean monthly DOP loadings of the other streams tend to follow the pattern of the mean monthly streamflows. The Genesee River has the most varied mean monthly DOP loadings.

Histograms of the DOP concentrations observed for the principal streams are shown on Figure 3.6, as are the mean, standard deviation, median and number of samples. The histograms of the Niagara, Black, Oswego and St. Lawrence Rivers are negatively skewed. The histogram of DOP concentrations of the Genesee River suggests that the distribution is bimodal. This bimodal distribution may have been the result of the Agnes storm and therefore is probably not what might be expected year to year. The mean DOP concentrations were as follows: Niagara .004 mg/l, Genesee .033 mg/l, Oswego .026 mg/l, Black .004 mg/l and the St. Lawrence .006 mg/l. For a more complete listing of the statistics see Tables A-N10, A-G10, A-O10, A-B10 and A-S10 in the appendix. Tables A-N1, A-G1, A-O1, A-B1 and A-S1 in the appendix give a complete listing of the DOP concentration measurements for the principal U.S. rivers.

The concentration of DOP was moderately related to streamflow in the Genesee River, as may be seen in Table 3.27. No significant relationship between DOP concentrations and streamflow was established for the Oswego and Black Rivers. The correlation coefficients were as follows: Genesee -.500, Oswego .021, and Black .000. The regression relationship was C=kQ , where C=concentration, Q=streamflow and k and n are constants.

Table 3.3 lists the monthly average and field year average

DOP loads, expressed as metric tons of phosphorus per day, carried to and from Lake Ontario by streams, municipal and industrial discharges, and precipitation. The table also lists the calculated average monthly and field year net load (see Chapter 5) for Lake Ontario. The average net load to the lake during the field year was 10 metric tons/day (11 tons/day). The peak monthly net load, which occurred in December 1972, was 17.2 metric tons/day (19 tons/day). The total mean field year input to Lake Ontario was 14.6 metric tons/day (16 tons/day). Of the total mean field year input to Lake Ontario, 37% was contributed by Canadian municipal and industrial discharges, 17% by U.S. minor tributaries, 16% by precipitation, 15% by the Niagara River, 6% by Canadian tributaries, 5% by the Oswego River, 2% by the Genesee, 1% by the Black River and 1% by U. S. municipal discharges. Approximately 68% of the DOP load to Lake Ontario was retained or was transported from the lake as another form of phosphorus.

NITRITE-NITRATE

The monthly mean loadings of nitrite-nitrate, reported as nitrogen, to Lake Ontario from the principal streams are shown on Figure 3.7. While in the overall sense these monthly loadings tend to follow the mean monthly streamflows (Figures 2.1a through 2.1e), there are distinct differences. The most significant of these differences is the increase in nitrite-nitrate loadings observed in the St. Lawrence River from a low in September 1972 to a high in March 1973. This upward trend in loadings was not affected by the decrease in streamflow which occurred in October, November and December. In addition, the low which was observed in September 1972 occurred during a period of near maximum flow. In the Niagara River also, a nitrite-nitrate minimum load was observed in September. The Genesee, Oswego and Black Rivers also show a September minimum followed by a gradual rise into the winter months and a tendency to decrease during the spring months.

Histograms of the nitrite-nitrate concentrations observed for the principal streams are shown in Figure 3.8, as are also the mean, standard deviation, median and number of samples. The histograms of the Niagara and St. Lawrence Rivers are negatively skewed and have a relatively narrow range. The histograms of the Genesee, Oswego and Black are near normal with a broader range of concentrations. The Genesee River displayed the broadest range of all. The mean concentrations observed were as follows: Niagara .191 mg/l, Genesee .768 mg/l, Oswego .503 mg/l, Black .335 mg/l and the St. Lawrence .187 mg/l. For a more complete listing of the statistics see Tables A-N10, A-G10, A-O10, A-B10 and A-S10 in the appendix. Tables A-N2, A-G2, A-O2, A-B2 and A-S2 in the appendix give a complete listing of the nitrite-nitrate concentration measurements for the principal rivers.

The concentration of nitrite-nitrate was related to streamflow in the Genesee, Black and Oswego, as shown on Table 3.27. This relationship was weak for the Genesee and moderate for both the Oswego and Black. The log-log correlation coefficients were as follows: Genesee .231, Oswego .533 and Black .572. The regression relationship was $C=kQ$, where C=concentration, Q=streamflow and k and n are constants.

Table 3.4 lists the monthly average and field year average loads of nitrite-nitrate, expressed as metric tons of nitrogen per day, carried to and from Lake Ontario by streams, municipal and industrial discharges, and precipitation. The table also lists the calculated average monthly and average field year net load (see Chapter 5) for Lake Ontario. The average Field Year net load was 110.4 metric tons/day (122 tons/day). The maximum average monthly net load of 262.5 metric tons/day (290 tons/day) occured in June 1972, while the minimum net load, 10.9 metric tons/day (12 tons/day), occurred in August 1972. The total mean input to Lake Ontario during the field year was 254.9 metric tons/day (281 tons/day). Of this amount, 49% was carried by the Niagara River,23% by precipitation, 8% by U.S. minor tributaries, 6% by the Oswego, 5% by Canadian tributaries, 4% by the Genesee, 3% by the Black, 1% by Canadian municipal and industrial discharges and <1% by U. S. municipal discharge. Of the total mean nitrite-nitrate input, approximately 43% is retained in Lake Ontario or is removed in another form. It can be seen from the above percentages that almost one-quarter of the nitrite-nitrate input to Lake Ontario is from direct rainfall.

AMMONIA

Figure 3.9 shows the monthly mean loadings of ammonia, reported as metric tons of nitrogen per day, to Lake Ontario from the principal streams. The ammonia loadings of the Niagara River are varied and are quite different from the smooth loading patterns observed for the St. Lawrence River. The loadings of the St. Lawrence, Black, Oswego and Genesee do, in a broad sense, follow the monthly mean streamflow patterns (Figures 2.1a through 2.1e); however, in April and May, while streamflows increased, the ammonia load of the St. Lawrence decreased.

Histograms of the ammonia concentrations observed for the principal streams are shown in Figure 3.10, as are also the mean, standard deviation, median and number of samples. The histograms of the Niagara, Black and St. Lawrence Rivers are negatively skewed, with the range of values for the Niagara and St. Lawrence being relatively narrow. The histograms for the Genesee and Oswego Rivers show a wide range of values and the distribution is nearly uniform. The mean ammonia concentrations were as follows: Niagara .040 mg/l, Genesee .221 mg/l, Oswego .185 mg/l, Black .083 mg/l and St. Lawrence .026 mg/l. For a more complete listing of the statistics see Tables A-N10, A-G10, A-O10, A-B10 and A-S10 in the appendix. Tables A-N2, A-G2, A-O2, A-B2 and A-S2 in the appendix give a complete listing of the ammonia concentration values for the principal U.S. rivers.

The concentration of ammonia was weakly related to streamflow in the Genesee, Oswego and Black Rivers, as indicated on Table 3.27. The log-log correlation coefficients were as follows: Genesee -.377, Oswego .253, and Black .226. The regression relationship was $C=kQ$, where C=concentration, Q=streamflow and k and n are constants.

Table 3.5 lists the monthly average and field year average loads, expressed as metric tons of nitrogen per day, carried to and from Lake Ontario by streams, municipal and industrial discharges, and precipitation. The table also lists the calculated average monthly and average field year net load (see Chapter 5) for Lake Ontario. The average net load during the field year was 91.4 metric tons/day (101 tons/day). The maximum monthly net load of ammonia occurred in November and was 159.5 metric tons/day (176 tons/day). The total mean input of ammonia to Lake Ontario during the field year was 109.6 metric tons/day (121 tons/day). Of this total, 35% was contributed by rainfall, 25% by Canadian municipal and industrial discharges, 23% by the Niagara River, 5% by the Oswego River, 4% by Canadian tributaries, 3% by U. S. minor tributaries, 3% by U. S. municipal discharges, 2% by the Genesee River and 1% by the Black River. Approximately 83% of the ammonia is either retained in the lake or leaves it in another form. The amount of ammonia contributed to Lake Ontario by rainfall is indeed significant, particularly in view of the fact that it can be considered a "shock" loading.

TOTAL KJELDAHL NITROGEN

Figure 3.11 shows the monthly mean loadings of total Kjeldahl nitrogen (TKN), reported as metric tons per day of nitrogen, to Lake Ontario from the principal streams. The TKN loadings of all the streams follow the mean monthly streamflow patterns (Figures 2.1a through 2.1e); however, the St. Lawrence displays a greater change in the magnitude of loadings relative to a change in streamflow than do the other streams.

Histograms of the TKN concentrations observed for the principal streams are shown in Figure 3.12, as are also the mean, standard deviation, median and number of samples. The histograms of the Niagara, Oswego and Black are near normal, whereas the Black is negatively skewed and the Genesee is broad and nearly uniform. The mean TKN concentrations observed were as follows: Niagara .180 mg/l, Genesee .409 mg/l, Oswego .411 mg/l, Black .181 mg/l and the St. Lawrence .200 mg/l. For a more complete listing of the statistics see Tables A-N10, A-G10, A-O10, A-B10, and A-S10 in the appendix. Tables A-N2, A-G2, A-O2, A-B2 and A-S2 in the appendix give a complete listing of the TKN measurements for the principal U.S. rivers.

The relation of TKN concentration to streamflow was moderate in the Genesee River and weak in the Black and Oswego Rivers, as shown on Table 3.26. The log-log correlation coefficients were as follows: Genesee -.533, Oswego -.287 and Black -.388. The regression relationship was $C=kQ$, where C=concentration, Q=streamflow and k and n are constants.

The monthly average and field year average TKN loads, expressed as metric tons of nitrogen per day, carried to and from Lake Ontario by streams, municipal and industrial discharges, and precipitation are shown on Table 3.6. The table also lists the calculated average monthly and average field year net load for Lake Ontario. The average field year net load was 152 metric tons/day (168 tons/day). The minimum net load occurred in October 1972 and was 13.9 metric tons/day (15 tons/day) and the maximum net load occurred in October 1972 and was 227 metric tons/day (250 tons/day). The total mean input of TKN to the lake was 282 metric tons/day (311 tons/day), of which 38% was contributed by the Niagara River, 21% by precipitation, 13% by Canadian municipal and industrial discharges, 11% by Canadian tributaries, 8% by U. S. minor tributaries, 4% by the Oswego River, 2% by the Genesee River, 2% by U. S. municipal discharges and 1% by the Black River. Of the mean net load, approximately 54% of the TKN was either retained in the lake or transported out as some other form of nitrogen.

ORGANIC NITROGEN

The concentration of organic nitrogen was not measured directly, but was calculated by subtracting the concentration of ammonia from the corresponding concentration of total Kjeldahl nitrogen.

Figure 3.13 shows the monthly mean loadings of organic nitrogen to Lake Ontario from the principal streams. These data show seasonal changes in the stream chemistry, which can be seen in the tendency of the organic nitrogen loads to have an inverse relationship to the monthly mean streamflows at certain times (Figures 2.1a through 2.1e). The higher organic nitrogen loadings for the months of June and July for the Genesee River resulted from the tropical storm "Agnes", so therefore these months can not be considered normal early summer months. If one assumes that the higher organic nitrogen loadings of the Niagara (in August) and the St. Lawrence (in September) represent seasonal biochemical change in Lakes Erie and Ontario, then it might further be assumed that this change occurred about a month earlier in Erie than in Ontario.

Histograms of the calculated organic nitrogen are shown on Figure 3.14, as well as the mean, standard deviation, median and number of samples. The histogram of the Niagara River organic nitrogen data is normal, while the others tend to be negatively skewed. The mean concentrations of organic nitrogen were as follows: Niagara .158 mg/l, Genesee .172 mg/l, Oswego .219 mg/l, Black .117 mg/l and St. Lawrence .172 mg/l.

Table 3.7 is a tabulation of the Lake Ontario organic nitrogen data for the field year. It lists the mean monthly and mean field year loads, expressed as metric tons of nitrogen per day, carried to Lake Ontario. The table also lists the calculated mean monthly and mean net load (see Chapter 5) for Lake Ontario. The mean net load to the lake was 56.8 metric tons/day (63 tons/day). The monthly organic nitrogen budget showed a deficit in September and October 1972 of -46.7 and -61.7 metric tons/day (-51 and -68 tons/day). The highest mean monthly net load occurred in April 1973 and was 130.7 metric tons/day (144 tons/day). The total mean input to the lake was 172.2 metric tons/day (190 tons/day), of which 48% was contributed by the Niagara, 16% by the Canadian tributaries, 12% by the U. S. minor tributaries, 12% by precipitation, 5% by Canadian municipal discharges, 3% by the Oswego, 2% by the Genesee, and 1% by U. S. municipal discharges. Approximately 33% of the organic nitrogen entering Lake Ontario either remains in the lake or is transported out of the lake in another form; this figure is based on a comparison of the total mean input to the mean net load.

TOTAL NITROGEN

Total nitrogen (TN) concentrations were not measured directly in the laboratory but were calculated by adding concentrations of nitrite-nitrate to corresponding concentrations of total Kjeldahl nitrogen. Figure 3.15 shows the monthly mean loadings of total nitrogen to Lake Ontario from the principal streams. In general the patterns of total nitrogen tend to follow the mean monthly streamflow patterns, as shown on Figure 2.1a through 2.1e. The relative magnitude of the loading changes, however, appears to be greater than corresponding changes in the mean monthly flows suggest that they should be. The 1972 data for April and May cannot be compared directly with 1973 data for those months because there was a significant climatic difference between the two spring seasons.

Histograms of the total nitrogen concentrations are shown in Figure 3.15, as are also the mean, standard deviation, median and number of samples. The histograms of the streams all display normal distributions. The GEnesee River exhibits a wider range of total nitrogen concentrations than do the other streams.

Table 3.8 is a tabulation of the Lake Ontario total nitrogen budget (input and output) for the field year. It lists the mean monthly and mean field year loads, expressed in metric tons of nitrogen per day. The table also lists the calculated mean monthly and mean net load (see Chapter 5). The mean net load was 256.4 metric tons (283 tons/day) per day. The highest mean monthly net load occurred in June 1972 and was 406.3 metric tons/day (447 tons/day). The second highest net load, which was almost as great, occurred in December 1972. The lowest net load was 70.9 metric tons/day (78 tons/day) and occurred in October 1972. The total mean input to Lake Ontario during the field year was 531.1 metric tons/day (585 tons/day), of which 44% was contributed by the Niagara River, 21% by precipitation, 9% by U.S. minor tributaries, 9% by Canadian tributaries, 7% by Canadian municipal and industrial discharges, 5% by the Oswego, 3% by the Genesee, 2% by the Black and 1% by U. S. municipal discharges. Approximately 48% of the measured input of total nitrogen was retained in the lake.

TOTAL ORGANIC CARBON

The monthly mean loadings of total organic carbon (TOC) to Lake Ontario from the principal streams is shown on Figure 3.17. The loadings of the Genesee and Black Rivers follow the monthly mean streamflow patterns (Figures 2.1b and 2.1d), whereas the Oswego River (Figure 2.1c) does not. This difference in the TOC loading pattern of the Oswego versus the Black and Genesee Rivers is most likely due to the biochemical characteristics of the

Finger Lakes and other lakes which are drained by the Oswego River. The Niagara River TOC loadings are a reflection of the biochemical characteristics of eastern Lake Erie. The TOC loadings of the St. Lawrence are representative of the biochemical characteristics of Lake Ontario. There is a notable difference, however, between the pattern of TOC loadings of the Niagara and St. Lawrence Rivers: the St. Lawrence River monthly mean TOC loadings are much more varied than those of the Niagara River.

Histograms of the TOC concentrations observed for the principal streams are shown in Figure 3.18, as are also the mean, standard deviation, median and number of samples. The histograms for each of the streams are fairly close to normal, with the exception of the St. Lawrence River, which is positively skewed. The peak on the right upper side of the histogram for the Niagara River is due in part to the selection of class sizes. The mean TOC concentrations were as follows: Niagara 3.27 mg/l, Genesee 4.25 mg/l, Oswego 4.74 mg/l, Black 4.55 mg/l and St. Lawrence 2.63 mg/l. For a more complete listing of the statistics see Tables A-N10, A-G10, A-O10, A-B10 and A-S10 in the appendix. Tables A-N3, A-G3, A-O3, A-B3, and A-S3 in the appendix give a complete listing of the TOC concentration measurements for the principal U.S. rivers.

The concentration of TOC was weakly related to streamflow in the Genesee, Oswego and Black Rivers, as shown on Table 3.27. Because of the regulated streamflow of the Niagara and St.

Lawrence Rivers, no attempt at correlating TOC concentrations with streamflow was made. The log-log correlation coefficients were as follows: Genesee .295, Oswego .378 and Black .444. The regression relationship was $C=kQ^n$, where C is concentration, Q is streamflow, and k and n are constants.

Table 3.9 lists the monthly average and field year average loads, expressed as metric tons per day, carried to and from Lake Ontario by streams, municipal and industrial discharges, and precipitation. The table also lists the calculated average monthly and average net load (see Chapter 5) for Lake Ontario. The average net load to the lake during the field year was 1671 metric tons/day (1842 tons/day). In September and October the net budget of TOC to Lake Ontario showed a deficit of -102 and -316 metric tons/day (-113 and -348 tons/day), respectively. The mean total input to Lake Ontario during the field year was 3505 metric tons/day (3863 tons/day). The largest monthly mean TOC load to Lake Ontario occurred in December 1972 and was 3283 metric tons/day (3618 tons/day). In March 1973, the net TOC load was nearly as great at 3218 metric tons/day (3546 tons/day). Of the total mean TOC input to Lake Ontario, 55% was contributed by the Niagara River, 15% by the Canadian tributaries, 15% by precipitation, 6% by the Oswego River, 2% by municipal and industrial discharges directly to the lake, 2% by the Black River, 1% by the Genesee and 3% by the U. S. minor tributaries. Most of these percentages were within expectation except for the effect of precipitation, which is indeed worth noting.

SILICA

Figure 3.19 shows the monthly mean loadings of silica to Lake Ontario from the principal streams. The loadings of the Genesee, Black and Oswego Rivers tend to follow the mean monthly streamflow patterns (Figures 2.1b, 2.1c and 2.1d). Although the Niagara and St. Lawrence also generally tend to follow the patterns of the mean monthly streamflow, Figures 2.1a and 2.1e show what appears to be a significant drop in the silica load during August and September. In addition, the relative changes in silica load are greater for the St. Lawrence than for the Niagara.

Histograms of the silica concentrations observed for the principal streams are shown on Figure 3.20, as are also the mean, standard deviation, median and number of samples. The silica histograms are quite varied; the Niagara and St. Lawrence Rivers are negatively skewed and have a narrow range, the Genesee has a relatively uniform and broad distribution, the Oswego appears to be bimodal, and the Black shows a broad, near normal distribution. The mean concentrations of silica are as follows: Niagara .449 mg/l, Genesee 2.942 mg/l, Oswego 1.762 mg/l, Black 3.982 mg/l and the St. Lawrence .601 mg/l. The statistics are listed on Tables A-N10, A-G10, A-O10, A-B10 and A-S10 in the appendix. Tables A-N3, A-G3, A-O3, A-B3 and A-S3 in the appendix list the silica concentration measurements for the principal rivers.

Silica concentration was related to streamflow in the

Genesee, Oswego and Black Rivers (Table 3.27). In the Genesee and Oswego Rivers, this relationship was weak, while in the Black it was moderately strong. The log-log correlation coefficients were as follows: Genesee .266, Oswego .235 and Black -.717. The regression relationship was $C=kQ$, where C is concentration, Q is streamflow and k and n are constants.

Table 3.10 lists the monthly average and field year average loads, expressed as metric tons of silica per day, carried to and from Lake Ontario by the principal streams and U. S. minor tributaries; corresponding data from other sources of silica in the Lake Ontario basin are not available. The table also lists the calculated average monthly net load and average field year net load to Lake Ontario. The average field year net load was 21.9 metric tons/day (24 tons/day) and, in this case, represents a minimum (because of the unavailable data mentioned above). Negative monthly net loads occurred in June, July and August 1972 and in February and March 1973. These months correspond to a period when the level of Lake Ontario was being lowered. The total mean load was 495.6 metric tons/day (546 tons/day), of which 53% was contributed by the Niagara, 15% by U. S. minor tributaries, 14% by the Black, 13% by the Oswego and 5% by the Genesee. The total mean input includes only the sources of silica listed on Table 3.10.

3.4 Major Ions

SODIUM

Figure 3.21 shows the monthly mean loadings of sodium to Lake Ontario from the principal streams. The sodium loadings of the principal U.S. rivers follow the mean monthly streamflow patterns (Figures 2.1a through 2.1e). The Oswego, because of higher sodium concentrations, has greater relative changes in its load than do the other rivers.

Histograms of the sodium concentrations observed for the principal streams are shown on Figure 3.22, as are also the mean, standard deviation, median and number of samples. All of the histograms are normally distributed, with the Niagara, Black and St. Lawrence having a narrow range of concentrations and the Genesee and Oswego Rivers having a greater range of concentrations. The mean sodium concentrations were as follows: Niagara 13.1 mg/l, Genesee 27.3 mg/l, Oswego 48.0 mg/l, Black 2.6 mg/l and St. Lawrence 13.5 mg/l. For a more complete listing of the statistics, see Tables A-N10, A-G10, A-O10, A-B10 and A-S10 in the appendix. Tables A-N5, A-G5, A-O5, A-B5 and A-S5 in the appendix give a complete listing of the sodium concentration measurements for the principal U.S. rivers.

The concentration of sodium was related to streamflow in the Genesee and Black Rivers but not in the Oswego River. In the Genesee, the relation was moderately strong and in the Black it was moderate (see Table 3.27). The correlation coefficients were as follows: Genesee -.620, Oswego -.088 and Black -.559. The regression relationship was $C=kQ$, where C=concentration, Q=streamflow, and k and n are constants. It is interesting to note that although the geology of the Oswego and Genesee River basins is quite similar, sodium concentrations are not related to streamflow in the Oswego River but they are in the Genesee River. This divergence may be due to the high degree of flow regulation and storage on the Oswego River.

Table 3.11 lists the monthly average and field year average loads, expressed as metric tons of sodium per day, carried to and from Lake Ontario by the principal streams and by precipitation. The table also lists the calculated average monthly and average field year net load for Lake Ontario. The average annual net load to the lake was -81.1 metric tons/day (89tons/day) which owing to the fact that sodium input data from other sources in the basin are not available, represents the minimum amount contributed by those unavailable sources. The total mean input of sodium from the principal tributaries and from precipitation during the field year was 9735.4 metric tons/day, of which 79% was contributed by the Niagara, 16% by the Oswego, 3% by the Genesee, 1% by precipitation and <1% by the Black River.

POTASSIUM

The mean monthly loadings of potassium to Lake Ontario from the principal streams are shown on Figure 3.24. The potassium loadings follow the patterns of the mean monthly streamflows (Figures 2.1a through 2.1e).

Histograms of the potassium concentrations observed are shown on Figure 3.25, as are also the mean, standard deviation, median and number of samples. The histograms are all fairly close to normal. The Genesee River has the widest range of concentrations. The mean potassium concentrations were as follows: Niagara 1.56 mg/l, Genesee 3.14 mg/l, Oswego 2.65 mg/l, Black 0.77 mg/l and St. Lawrence 1.51 mg/l. For a more complete listing of the statistics, see Tables A-N10, A-G10, A-O10, A-B10 and A-S10 in the appendix. Tables A-N5, A-G5, A-O5, A-B5 and A-S5 in the appendix give a complete listing of the potassium concentration measurements for the principal U.S. rivers.

The concentration of potassium was weakly related to streamflow in the Oswego River, and very weakly related to streamflow in the Black River (Table 3.27). There was little if any relationship between potassium concentration and streamflow in the Genesee River. The log-log correlation coefficients were as follows: Oswego .280, Black .156 and Genesee -.070. The regression relationship was C=kQ , where C=concentration, Q=streamflow and k and n are constants.

Table 3.12 lists the monthly average and field year average loads, expressed as metric tons of potassium per day, carried to and from Lake Ontario by the principal streams and by precipitation; potassium input to Lake Ontario from other sources is not available. The table also lists the calculated average monthly and average field year net load for Lake Ontario. The average field year net load of potassium was -16.4 metric tons/day (18 tons/day), which in this case indicates the minimum amount of potassium contributed to Lake Ontario from sources other than principal streams and precipitation. The total mean input of potassium during the field year (excluding Canadian sources) was 1062.9 metric tons/day, of which 84% was contributed by the Niagara, 8% by the Oswego, 4% by the Genesee, 3% by rainfall and 1% by the Black River.

CALCIUM

Figure 3.26 shows the monthly mean loadings of calcium to Lake Ontario from the principal streams. These loadings follow the pattern of mean monthly streamflow, as shown on Figure 2.1a through 2.1e.

Histograms of the calcium concentrations observed for the principal streams are shown on Figure 3.27, as are also the mean, standard deviation, median and number of samples. The histograms of the Niagara and St. Lawrence calcium data are positively skewed, whereas the histograms for the Black, Oswego and Genesee Rivers are near normal. The mean calcium concentrations were as follows: Niagara 32.3 mg/l, Genesee 43.7 mg/l, Oswego 65.7 mg/l, Black 10.5 mg/l and St. Lawrence 32.5 mg/l. For a more complete listing of the statistics, see Tables A-N10, A-G10, A-O10, A-B10 and A-S10 in the appendix. Tables A-N5, A-G5, A-O5, A-B5 and A-S5 in the appendix give a complete listing of the calcium concentration measurements for the principal U.S. rivers.

The concentration of calcium was weakly related to streamflow in the Genesee and Oswego Rivers (Table 3.27). In the Black River, little or no relation between calcium concentration and streamflow existed. The correlation coefficients were as follows: Genesee -.409, Oswego .235 and Black -.087. The regression relationship was $C=kQ$, where C=concentration, Q=streamflow and k and n are constants.

Table 3.13 lists the monthly average and field year average loads, expressed as metric tons of calcium per day, carried to and from Lake Ontario by principal streams and precipitation. The table also lists the calculated average monthly and average field year net load to Lake Ontario. Calcium data from other sources are not available. During the field year, the average net load to Lake Ontario was -1057.6 metric tons/day. Inasmuch as the annual net load is negative and budgetary data is incomplete, this figure represents the minimum amount of calcium being contributed from other sources. The change from negative loadings in 1972 to positive loadings in 1973 is attributed to the regulation of the St. Lawrence flow. During the period from May to December 1972, the outflow from Lake Ontario via the St. Lawrence River was maximized in order to lower the level of the lake. In December the outflow was cutback, and the inflow began to equal or exceed the outflow. The mean total calcium input to Lake Ontario during the field year (excluding Canadian sources) was 22,464 metric tons/day (24,755 tons/day), of which 87% was contributed by the Niagara, 9% by the Oswego, 2% by the Genesee, 1% by the Black and 1% by precipitation.

MAGNESIUM

Figure 3.28 shows the monthly mean loadings of magnesium to Lake Ontario from principal streams. The magnesium loadings, in an overall sense, follow the mean monthly streamflow patterns, (Figures 2.1a through 2.1e).

Histograms of the magnesium concentrations observed for the principal streams are shown on Figure 3.29, as are also the mean, standard deviation, median, and number of samples. The histograms of the Niagara, Genesee, Black and St. Lawrence Rivers are normal. The histogram of the magnesium concentrations of the Oswego River is irregular. The mean magnesium concentrations were as follows: Niagara 7.95 mg/l, Genesee 12.36 mg/l, Oswego 12.39 mg/l, Black 1.25 mg/l and the St. Lawrence 7.68 mg/l. For a more complete listing of the statistics, see Tables A-N10, A-G10, A-O10, A-B10 and A-S10 in the appendix. Tables A-N6, A-G6, A-O6, A-B6, and A-S6 in the appendix give a complete listing of the magnesium measurements for the principal U.S. rivers.

The concentration of magnesium was weakly related to streamflow in the Genesee River (Table 3.27); in the Oswego and Black Rivers, this relationship was even weaker. The log-log correlation coefficients were as follows: Genesee -.267, Oswego .121, and Black .115. The regression relationship was C=kQ , where C is concentration, Q is streamflow, and k and n are constants.

Table 3.14 lists the monthly average and field year average loads, expressed as metric tons of magnesium per day, carried to and from Lake Ontario by principal streams and precipitation; data from other sources of magnesium input to the lake are unavailable. The table also lists the calculated average monthly and average field year net load. During the field year the average net load to the lake was -94.8 metric tons/day. This figure, owing to the fact that the magnesium budgetary data was incomplete and the load was negative, represents the minimum amount coming into the lake from other sources. The total mean input of magnesium (excluding Canadian sources) to the lake was 5338.7 metric tons/day, of which 89% was contributed by the Niagara, 7% by the Oswego, 3% by the Genesee, 1% by precipitation and <1% by the Black.

SULFATE

Figure 3.30 shows the monthly mean loadings of sulfate to Lake Ontario from the principal streams. The sulfate data collected and analyzed in the early months of the field year was questionable and, therefore, was not included. The stream loadings closely follow the mean monthly streamflow patterns (Figures 2.1a through 2.1e).

Histograms of the sulfate concentrations observed for the principal streams are shown in Figure 3.31, as are also the mean, standard deviation, median and number of samples. The histograms are all normal, with the Niagara, Black and St. Lawrence Rivers having rather narrow distributions and the Genesee and Oswego Rivers having relatively broad distributions. The apparent skewedness of the Niagara and Black River histograms is caused by the class size which was used. The mean concentrations were as follows: Niagara 25.1 mg/l, Genesee 47.9 mg/l, Oswego 52.4 mg/l, Black 9.6 mg/l, and St. Lawrence 27.4 mg/l. For a listing of the statistics, see Tables A-N10, A-G10, A-O10, A-B10 and A-S10 in the appendix. Tables A-N3, A-G3, A-O3, A-B3 and A-S3 in the appendix give a complete listing of the sulfate concentration measurements for the principal U.S. rivers.

The concentration of sulfate was moderately related to streamflow in the Genesee River (Table 3.27), but in the Black and Oswego Rivers, little if any such relation existed. The log-log correlation coefficients were as follows: Genesee -.545, Oswego -.091 and Black .024. The regression relationship was $C=kQ^n$, where C=concentration, Q=streamflow, and k and n are constants. Although one would normally expect sulfate to be related to streamflow in the Oswego River because of the basin's geology, the fact that it does not appear to be so may be due to the effect of streamflow regulation and storage.

Table 3.15 lists the monthly average and field year average loads, expressed as metric tons of sulfate per day, carried to and from Lake Ontario by streams, municipal and industrial discharges, and precipitation. The table also lists the calculated average monthly and average field year net load (see Chapter 5) to Lake Ontario. The average net load was 622 metric tons/day (685 tons/day). In October and November of 1972 and May 1973, the net budget of sulfate to Lake Ontario showed a deficit of -7536, -229 and -289 metric tons/day (8305, 252, and 318 tons/day), respectively. This deficit, however, was most likely due to changes in the hydrologic budget, which resulted in a lowering of the lake level (sulfate being removed from storage), rather than to any changes in basin sulfate chemistry. The total mean input to Lake Ontario during the field year was 19,472 metric tons/day (21,458 tons/day), of which 75% was contributed by the Niagara River, 7% by the Oswego River, 7% by Canadian tributaries, 4% by U. S. minor tributaries, 3% by precipitation, 2% by the Genesee River, 1% by the Black River, 1% by Canadian municipal and industrial discharges, and <1% by U. S. municipal discharges. This sulfate budget for Lake Ontario balanced to approximately 3%.

CHLORIDE

Figure 3.32 shows the monthly mean chloride loadings to Lake Ontario from the principal streams. As one would expect from a conservative ion such as chloride, the loadings parallel the monthly mean streamflows of the principal tributaries (Figures 2.1a through 2.1e). Of the three principal U.S. rivers, the Oswego is by far the largest contributor of chloride ion to Lake Ontario, reflecting the natural sources of salt as well as the industrial uses of salt in the upper part of the basin. The chloride load of the Black River is minimal, which is to be expected where no significant geologic sources of chloride exist. Deposits of salt are mined in the mid-basin area of the Genesee, and the principal source of chloride is probably mine drainage; however, in winter a significant source of chloride is large amounts of salt that are used to clear roads (Casey et al. 1976).

Figure 3.33 shows histograms of the chloride concentrations observed in the principal streams. Shown also are the mean, standard deviation, median and number of samples. The histogram of the Black River is negatively skewed. The rest of the principal U.S. rivers all have normal distributions (the apparent skewedness of the Niagara and St. Lawrence Rivers is due to the size class which was selected). The histogram of the Oswego is quite broad, whereas the other rivers are narrow. The mean chloride concentrations were as follows: Niagara 25.3 mg/l, Genesee 40.0 mg/l, Oswego 123.4 mg/l, Black 1.9 mg/l and the St. Lawrence 28.7 mg/l. For a more complete listing of the statistics, see Tables A-N10, A-G10, A-O10, A-B10 and A-S10 in the appendix. Tables A-N4, A-G4, A-O4, A-B4 and A-S4 in the appendix give a complete listing of the chloride concentration measurements for the principal U.S. rivers.

The concentration of chloride was strongly negatively related to streamflow in the Genesee River and moderately negatively related in the Oswego River (Table 3.27). No valid relationship was observed for the Black River. The log-log correlation coefficients were as follows: Genesee -.702, Oswego -.344 and Black .098. The lesser correlation coefficient of the Oswego as compared to the Genesee reflects the large amount of water storage in the Oswego basin. The regression relationship was $C=kQ$, where C=concentration, Q=streamflow and k and n are constants.

Table 3.16 lists the monthly average and field year average loads, expressed as metric tons per day, transported to and from Lake Ontario by streams, municipal and industrial discharges and precipitation. The table also lists the calculated average monthly and average field year net load for Lake Ontario. The average net load to the lake during the Field Year was -604 metric tons/day (-666 tons/day). This apparent deficit resulted from the fact that during the summer months the flow out of Lake Ontario via the St. Lawrence River exceeded inflow, and, therefore, the chloride was, in effect, coming out of storage as the lake level was lowered. Conversely, the largest net load occurred in December, when the Niagara flow was up and the St. Lawrence flow was decreasing. The mean input during the field year was 20,663 metric tons/day (22,770 tons/day). Of the total mean chloride load to Lake Ontario, 71% was contributed by the Niagara River, 17% by the Oswego, 4% by Canadian tributaries, 3% by U. S. minor tributaries, 2% by the Genesee, 2% by municipal and industrial discharges, <1% by the Black and <1% by precipitation. The apparent deficit of -604 metric tons/day caused by the lowering of Lake Ontario water levels amounts to 3% of the total mean field year input. If the lake level had not been changing during the field year the chloride budget would have balanced to less than 3%. The accuracy of the chloride budget is quite important inasmuch as the chloride ion in the lake environment is conservative and thus indicates the relative accuracy of the other chemical budgets presented in this report.

FLUORIDE

Figure 3.34 shows the monthly mean loadings of fluoride to Lake Ontario from the principal streams. In general the loading patterns follow the patterns of monthly mean streamflow, as shown on Figures 2.1a through 2.1e.

Histograms of the fluoride concentrations observed for the principal streams are shown on Figure 3.35, as are the mean, standard deviation, median and number of samples. The histograms for all of the streams are near normal and are relatively broad. The mean concentrations were as follows: Niagara .115 mg/l, Genesee .118 mg/l, Oswego .117 mg/l, Black .094 mg/l and the St. Lawrence .115 mg/l. For a listing of the statistics, see Tables A-N10, A-G10, A-O10, A-B10 and A-S10 in the appendix. Tables A-N4, A-G4, A-O4, A-B4 and A-S4 in the appendix give a complete listing of the fluoride concentrations.

The concentration of fluoride was weakly related to streamflow in the Oswego and Black Rivers and not related at all in the Genesee River (Table 3.27). The correlation coefficients were as follows: Genesee -.024, Oswego .254 and Black -.318. The regression relationship was $C=kQ$, where C=concentration, Q=streamflow, and k and n are constants.

Table 3.17 lists the monthly average and average field year loads, expressed as metric tons of fluoride per day, carried to and from Lake Ontario by the principal streams; fluoride data is not available from other sources. The table also lists the calculated average monthly and average field year net load to Lake Ontario. The average net load to the lake was 1.59 metric tons/day (1.75 tons/day). In this case, because data from other fluoride sources within the basin are not available, the average net load represents a minimum net load.

During the months of July, September and December the net budget for the measured sources showed a deficit of -12.6, -22.5 and -34.3 metric tons/day (-13.9, -24.8 and -37.8 tons/day), respectively. The total mean input to Lake Ontario from the principal streams (excluding Canadian sources) was 76.9 metric tons/day (84.7 tons/day), of which 91% was contributed by the Niagara, 4% by the Oswego, 3% by the Black and 2% by the Genesee. Approximately, 2% of the fluoride contributed by the principal streams was retained.

3.5 Heavy Metals

MANGANESE

Figure 3.36 shows the mean loadings of manganese to Lake Ontario from the principal streams. The loadings for the Genesee, Oswego, Black and St. Lawrence Rivers, for the most part, follow the mean monthly streamflow patterns (Figures 2.1b, c, d and e). The Niagara River, on the other hand, shows several large variations even though the streamflow was relatively constant. If these data for the Niagara are valid, then one would suspect that the cause of the higher manganese values is local and not due to changes in Lake Erie water chemistry.

Histograms of the manganese concentrations observed for the principal streams are shown in Figure 3.37, as are also the mean, standard deviation, median and number of samples. The histograms of the Niagara and St. Lawrence Rivers are negatively skewed, while those of the Black and Oswego are near normal. The histogram of the Genesee data shows a central normal distribution with a suggestion of additional modes on either side of the major mode. The mean manganese concentrations were as follows: Niagara .013 mg/l, Genesee .088 mg/l, Oswego .052 mg/l, Black .041 mg/l and St. Lawrence .005 mg/l. For a more complete listing of the statistics see Tables A-N10, A-G10, A-O10 and A-S10 in the appendix. Tables A-N6, A-G6, A-O6, A-B6 and A-S6 in the appendix give a complete listing of the manganese concentration measurements for the principal rivers.

The concentration of manganese was related to streamflow in the Genesee, Oswego and Black Rivers (Table 3.27) although the relationship in the Oswego and Black was weak and in the Genesee it was very weak. The log-log correlation coefficients were -.183, -.237 and .235, respectively. The regression relationship was C=kQ , where C is concentration, = is streamflow and k and n are constants.

Table 3.18 lists the monthly average and field year average loads, expressed as metric tons per day, carried to and from Lake Ontario by principal streams and precipitation. The table also lists calculated average monthly and average field year net load to Lake Ontario. Manganese data from Canadian sources and U. S. minor tributaries are not available. The average net load to the lake was 10.4 metric tons/day (11.5 tons/day). The maximum monthly net load occurred in December and was 24.6 metric tons/day (27.1 tons/day). The total mean input to the lake was 14.2 metric tons/day (15.6 tons/day). Of the total mean input of manganese, 63% was contributed by the Niagara, 13% by precipitation, 11% by the Oswego, 8% by the Genesee, 5% by the Black. The total mean input includes only the sources listed in Table 3.18. Approximately 73% of the measured manganese input to the lake was retained.

IRON

Figure 3.37 shows the monthly mean loadings of iron from the principal streams flowing into Lake Ontario. The loading patterns of all of the principal streams closely resemble the mean monthly streamflow patterns (Figures 2.1a through 2.1e). A peak load of 902 metric tons/day (994 tons/day) was transported by the Niagara River in December 1972; a peak load of 1116 metric tons/day (1230 tons/day) was observed for the St. Lawrence River in October 1972. This difference in time of occurrence of peak loads in the two rivers is due to changes in streamflow and not to biogeochemical differences between Lakes Erie and Ontario.

Histograms of the iron concentrations observed are shown in Figure 3.39, as are also the mean, standard deviation, median and number of samples. The histograms are all negatively skewed and, with the exception of the Genesee River, have a relatively narrow range of size classes. The reason for the wider range of iron concentrations observed for the Genesee is the high sediment load transported by the river. The mean iron concentrations were as follows: Niagara .320 mg/l, Genesee 4.34 mg/l, Oswego .446 mg/l, Black .770 mg/l and St. Lawrence .317 mg/l. For a more complete listing of the statistics see TAbles A-N10, A-G10, A-O10, A-B10 and A-S10 in the appendix. Tables A-N6, A-G6, A-O6, A-B6 and A-S6 in the appendix give a complete listing of the iron concentrations measured at the mouths of the principal rivers.

The relationship of iron concentration to streamflow was moderate in the Genesee, moderate to weak in the Oswego and weak in the Black River (Table 3.27). The log-log correlation coefficients were as follows: Genesee .614, Oswego .406 and Black -.220. The regression relationship was C=kQ , where C=concentration, Q=streamflow and k and n are constants. In the Genesee River, during January and February 1973, it was found by using the cross-correlation function that the concentrations of iron lagged streamflow by about twelve days. Using paired data, having a twelve day lag, it was found that the concentrations of iron were strongly related to streamflow and also to chloride concentration. The conclusion was that the iron content of the river during this time period was strongly influenced by the spreading of common salt to clear roads of snow and ice (Casey et al, 1976).

The monthly average and field year average loads, shown on Table 3.19, are expressed in metric tons per day carried into and out of Lake Ontario by streams, municipal and industrial discharges and precipitation. The table also lists the calculated average monthly and field year net load (see Chapter 5) for Lake Ontario. The average net load to the lake during the field year was 148 metric tons/day (163 tons/day). The months of July, August, September and October showed deficits of -111,

-126, -273 and -757 metric tons/day (-122, -139, -301 and -834 tons/day), respectively. The mean total input to Lake Ontario during the field year was 433 metric tons/day (477 tons/day). The largest net load, 1015 metric tons/day (1118 tons/day), occurred in December 1972 as a result of increasing inflow and decreasing outflow. Of the total mean load of iron to Lake Ontario, 65% was contributed by the Niagara River, 15% by the Genesee, 7% by Canadian tributaries, 3% by the Black, 3% from Canadian municipal and industrial sources, 2% by U. S. minor tributaries and 1% by precipitation. Data for U. S. municipal discharges were not available and, during the study period, there were no direct discharges to Lake Ontario by U. S. industries. Of the total mean input of iron to Lake Ontario, about 34% was retained.

NICKEL

Figure 3.40 shows the monthly mean loadings of nickel to Lake Ontario from the principal streams. The nickel load carried by the Niagara River follows the mean monthly streamflow pattern (Figure 21a) very closely; loading patterns of the Genesee, Black and St. Lawrence Rivers also follow the mean monthly streamflow patterns (Figures 2.1b, d and e) though not so closely as the Niagara. The nickel loadings of the Oswego, starting in July, show a continuous increase in spite of low August, September and October flows (Figure 2.1c) and reach a maximum in January 1973.

Histograms of the nickel concentrations observed for the principal streams are shown in Figure 3.41, as are also the mean, standard deviation, median and number of samples. The histograms of the Niagara, Black and St. Lawrence Rivers are negatively skewed, that of the Genesee is close to a normal distribution, and the Oswego histogram shows a distinct bimodal distribution. The upper mode on the Oswego histogram may be an indication of pollution by some metal processing industry. The mean nickel concentrations were as follows: Niagara .010 mg/l, Genesee .015 mg/l, Oswego .025 mg/l, Black .004 mg/l and St. Lawrence .007 mg/l. For a more complete listing of the statistics, see Tables A-N10, A-G10, A-O10, A-B10 and A-S10 in the appendix. Tables A-N7, A-G7, A-O7, A-B7 and A-S7 give a complete listing of the nickel concentration measurements for the principal rivers.

The concentration of nickel was weakly related to streamflow in the Oswego River (Table 3.27). The relation of nickel concentration to streamflow was weak in the Genesee River and almost non-existant for the Black River. The log-log correlation coefficients were as follows: Oswego -.354, Genesee .266 and Black -.146. The regression relationship was $C=kQ$, where C=concentration, Q=streamflow and k and n are constants. It is worth noting that the concentrations are related positively in the Genesee, while in the Black and Oswego Rivers the relation is negative. The reason for this may be the large sedimentary load transported by the Genesee River. Table 3.20 lists the monthly average and field year average loads, expressed as metric tons per day, carried to and from Lake Ontario by the principal streams and precipitation. The table also lists the calculated average monthly net load and the average field year net load. The average annual net load to the lake was 0.68 metric tons/day (0.69 tons/day). During July and August, a period when the St. Lawrence River flow was high, the nickel budget showed a deficit of -3.16 and -2.61 metric tons/day (-3.5 and -2.9 tons/day). A deficit of -0.42 metric tons/day (-0.42 tons/day) also occurred in March. The yearly mean total input to Lake Ontario from the tributaries plus precipitation was 6.51 metric tons/day (6.6 tons/day). The largest net load occurred in December and was 4.4 metric tons/day (4.9 tons/day). Of the total mean monthly load to Lake Ontario, 79% was carried by the Niagara River, 13% by the Oswego, 3% by the Genesee, 3% by precipitation and 1% by the Black. Approximately 10% of the mean net load was retained in the lake. The nickel load figures, however, do not take into account the other sources of input, for which data are not available.

COPPER

Figure 3.42 shows the monthly mean loadings of copper to Lake Ontario from the principal streams. The copper loading patterns for the principal streams, with the exception of the Oswego River, all tend to follow the pattern of the mean monthly streamflows, Figures 2.1a through 2.1e. In the Oswego River, during August, September and October, a period of relatively low streamflow, the loadings are rather high.

Histograms of the copper concentrations observed in the principal streams are shown in Figure 3.43, as are also the mean, standard deviation, median and number of samples. The histograms are all somewhat negatively skewed with broad distributions, except for the Niagara River, which, when compared to the other streams, has a relatively narrow distribution. The mean concentrations of copper were as follows: Niagara .008 mg/l, Genesee .017 mg/l, Oswego .019 mg/l, Black .010 mg/l and St. Lawrence .016 mg/l. For a listing of the statistics see Tables A-N10, A-G10, A-O10, A-B10 and A-S10 in the appendix. Tables A-N7, A-G7, A-O7, A-B7, and A-S7 in the appendix give a complete listing of the copper concentration measurements for the principal rivers.

The concentration of copper was very weakly related to streamflow in the Genesee, Oswego and Black Rivers (Table 3.27). The log-log correlation coefficients were as follows: Genesee .202, Oswego -.156 and Black .308. The regression relationship was C=kQ , where C=concentration, Q=streamflow, and k and n are constants.

Table 3.21 lists the monthly average and field year average loads, expressed as metric tons of copper per day, carried to and from Lake Ontario by the principal streams and by precipitation; data from Canadian municipal and industrial discharges and Canadian tributaries as well as U. S. municipal discharges and minor tributaries are not available. The table also lists the calculated average monthly and average field year net load to Lake Ontario. The average net load was -5.59 metric tons/day (6.2 tons/day). This figure, because much of the budgetary data is not available, represents the minimum amount of copper which may come from those unavailable sources. The net monthly loadings for copper showed a deficit throughout the study year except during December, January and February, when the relative flow of the St. Lawrence was reduced and the level of Lake Ontario was increasing. The total average input from the listed sources was 7.31 metric tons/day (8 tons/day), of which 67% was contributed by the Niagara, 11% by precipitation, 11% by the Oswego, 9% by the Genesee and 3% by the Black.

ZINC

The mean monthly loadings of zinc to Lake Ontario from the principal streams are shown on Figure 3.44. The loadings of the Genesee and Black Rivers tend to follow the monthly mean streamflow patterns (Figures 2.1b and 2.1d), whereas the other streams do not; for example, during the period of low flows of August, September and October, the copper load carried by the Oswego River (Figure 2.1c) is quite high. The Niagara and St. Lawrence Rivers exhibit large changes in the relative magnitude of the load when compared to the monthly streamflow (Figures 2.1a and 2.1e).

Histograms of the zinc concentrations observed for the principal streams are shown in Figure 3.45, as are also the mean, standard deviation, median and number of samples. The histograms are all negatively skewed. The Genesee River histogram shows the broadest range of values. The mean zinc concentrations were as follows: Niagara .021 mg/l, Genesee .072 mg/l, Oswego .030 mg/l, Black .022 mg/l, and St. Lawrence .032 mg/l. For a listing of the statistics, see Tables A-N10, A-G10, A-O10, A-B10 and A-S10 in the appendix. Tables A-N7, A-G7, A-O7, A-B7 and A-S7 give a complete listing of the observed copper concentrations for the principal rivers.

The concentration of zinc was related to streamflow in the Genesee, Oswego and Black Rivers (Table 3.27) although the relationship was weak for the Black and very weak for the Genesee and Oswego Rivers. The log-log correlation coefficients were as follows: Black .308, Genesee .202 and Oswego -.156. The regression relationship was C=kQ , where C=concentration, Q=streamflow, and k and n are constants.

Table 3.22 lists the monthly average and field year average loads, expressed as metric tons of zinc per day, carried to and from Lake Ontario by the principal streams and by precipitation. The table also lists the calculated average monthly and average field year net load to Lake Ontario. Zinc concentration data are not available for sources other than those listed. The average net load was 2.5 metric tons/day (2.8 tons/day) which, because of the lack of data from other sources of zinc, represents a minimum load. In the months of June, July, September and October, the monthly net load showed a deficit. The minimum net load was -19.96 metric tons/day (22 tons/day), and the maximum was 26.25 metric tons/day (29 tons/day); these occurred in October and December, respectively. The total mean input during the field year was 26.23 metric tons/day (19 tons/day), of which 71% was contributed by the Niagara, 20% by precipitation, 5% by the Oswego, 3% by the Genesee and 1% by the Black. Approximately 10% of the measured amount of zinc contributed to the lake was retained.

LEAD

Figure 3.46 shows the monthly mean loadings of lead to Lake Ontario from the principal streams. When the loading patterns are compared to the monthly mean streamflow patterns, as shown in Figures 2.1a through 2.1e, the Black River shows the closest agreement and the Oswego River the least. The St. Lawrence River exhibits the greatest relative change in loadings in comparison to corresponding changes in streamflow. There is a notable difference between the loading patterns of the Niagara and St. Lawrence Rivers. Histograms of the lead concentrations observed for the principal streams are shown in Figure 3.47, as is also the mean, standard deviation, median and number of samples. The histograms are all negatively skewed; in addition, the Oswego River data displays two modes. The mean concentrations of lead are as follows: Niagara .017 mg/l, Genesee .029 mg/l, Oswego .054 mg/l, Black .012 mg/l, and the St. Lawrence .030 mg/l.

The concentration of lead was weakly related to streamflow in the Oswego and very weakly related in the Genesee (Table 3.27). The log-log correlation coefficients were as follows Genesee .135, Oswego -.345 and Black .061. The regression relationship was $C=kQ$, where C=concentration, Q=streamflow, and k and n are constants.

Table 3.3 lists the monthly average and field year average loads and the calculated average monthly and average field year net loads, expressed as metric tons of lead per day, carried to and from Lake Ontario by principal streams and precipitation. Lead concentration data are not available from Canadian industrial and municipal discharges, U.S. municipal and U.S. minor tributary sources. The average net load was -7.86 metric tons/day (-8.7 tons/day) which, because all the sources of lead were not measured, represents the amount which may come from those unmeasured sources. The monthly average net load data indicates that there was a deficit in each month except January and March. The total mean input from the listed sources was 15.5 metric tons/day (17 tons/day), of which 71% was contributed by the Niagara, 14% by precipitation, 10% by the Oswego, 3% by the Genesee and 1% by the Black. When the average net load is compared to the total average input, it can be seen that the output of lead exceeds the input by approximately 51% which, although impossible, does indicate that there must be some other significant source of lead in the Lake Ontario basin besides principal streams and precipitation.

CADMIUM

The monthly mean loadings of cadmium to Lake Ontario from the principal streams is shown on Figure 3.48. The loadings of the Niagara, Genesee, Black and St. Lawrence Rivers follow the monthly mean streamflow patterns, (Figures 2.1a, b, d, and e). The distinct increase in the June loadings for the Genesee River resulted from the Agnes storm. The loading pattern displayed by the Oswego River is interesting in that the loadings are relatively high in the months of August, September and October, which was a period of low monthly mean flow (Figure 2.1c).

Figure 3.49, shows the histograms of chemical concentrations of the principle streams as well as the mean, standard deviation, median and number of samples. All of the histograms are negatively skewed. The mean cadmium concentrations were as follows: Niagara .001 mg/l, Genesee .003 mg/l, Oswego .002 mg/l Black .002 mg/l and the St. Lawrence .003 mg/l. For a more complete listing of the statistics, see Tables A-N10, A-G10, A-O10, A-B10, and A-S10 in the appendix. Tables A-N8, A-G8, A-O8, A-B8 and A-S8 in the appendix give a complete listing of the cadmium concentrations measured at the mouths of the principal rivers.

The concentration of cadmium was weakly related to streamflow in the Genesee and Black Rivers (Table 3.27). Due to the regulated streamflows of the Niagara and St. Lawrence Rivers, no attempt was made to correlate concentrations with streamflow. The log-log correlation coefficients were as follows: Genesee .210, Oswego -.058 and Black -.288. The regression relationship was $C=kQ$, where C is concentration, Q is streamflow, and k and n are constants. The positive relationships of cadmium to streamflow in the Genesee suggest an industrial source. The mean and median cadmium concentrations of the Genesee River are about 50% higher (Figure 3.49) than those of the Oswego and Black Rivers.

Table 3.47 lists the monthly average and field year average cadmium loads, expressed as metric tons per day, transported into and out of Lake Ontario by the principal streams and by precipitation; data of cadmium loadings to the lake from other sources are not available. The table also lists the average monthly and field year average net loads. Inasmuch as the chemical budget data for cadmium is incomplete, the calculated net loadings presented are from principal tributaries plus precipitation. The average net load to the lake was -1.22 metric tons/day (1.3 tons/day). For each month, the net load showed a significant and consistant deficit, indicating that a substantial source or sources of cadmium exist in the basin besides those listed on Table 3.3. The mean input from the principal tributaries and precipitation during the field year was 1.00 metric tons/day (1.0 tons/day). Of this, 79% was contributed by the Niagara, 3% by the Genesee, 9% by the Oswego, 3% by the Black and 6% by precipitation.

MERCURY

Figure 3.5 shows the montnly mean loadings of mercury to Lake Ontario from the principle streams, compiled from measurable mercury concentrations (no "less than" concentration values were used). Thus, these data should be viewed as representing maximum loads and are presented here only to show the relative loads and patterns between the streams. For a listing of the observed mercury concentrations, see Tables A-N8, A-G8, A-O8, A-B8 and A-S8 in the appendix. For a listing of the maximum observed concentrations, see Tables A-N10, A-G10, A-O10, A-B10, and A-S10.

It is estimated that, based on measurable samples, 85% of the mercury transported into Lake Ontario comes from the Niagara River, 12% from the Oswego, 2% from the Genesee and 2% from the Black River. Due to the huge streamflows in the Niagara and St. Lawrence Rivers and the low concentrations of mercury, significant loading calculations were not practical with these data.

3.6 Field Measurements

HYDROGEN ION CONCENTRATION (pH)

Figure 3.52 shows the histograms of pH for the Niagara, Genesee, Oswego and St. Lawrence Rivers. The histograms are near normal except for the Niagara River, which has two distinct peaks.

The mean pH was as follows: Niagara 7.58 units, Genesee 7.06 units, Oswego 7.97 units and St. Lawrence 7.72 units. For a more complete listing of the statistics, see Tables A-N10, A-G10, A-O10, and A-S10 in the appendix. Tables A-N9, A-G9, A-O9, and A-S9 in the appendix give a complete listing of the pH values for all the principal rivers, except the Black.

DISSOLVED OXYGEN

Histograms of dissolved oxygen are shown in Figure 3.53, as are also the mean, standard deviation, median and number of samples for the principal streams. The mean concentrations of dissolved oxygen were as follows: Niagara 12.5 mg/l, Genesee

12.4 mg/l, Oswego 11.5 mg/l, and St. Lawrence 12.4 mg/l. No dissolved oxygen data are available for the Black River. For a listing of the statistics, see Tables A-N10, A-G10, A-O10, A-B10, and A-S10 in the appendix. Tables A-N9, A-G9, A-O9, and A-S9 in the appendix give a complete listing of the dissolved oxygen data for the Niagara, Genesee, Oswego and St. Lawrence Rivers.

The concentration of dissolved oxygen was very strongly related to streamflow in the Genesee and moderately related in the Oswego River. The log-log correlation coefficients were -.815 and .481, respectively (Table 3.27). The regression relationship was C=kQ , where C=concentration, Q=streamflow and k and n are constants. One should view this relationship of dissolved oxygen to streamflow with some caution because of the strong seasonal effects.

WATER TEMPERATURE

Histograms of temperature data from the principal streams are shown in Figure 3.56, as are also the mean, standard deviation, median and number of samples.

The mean temperatures were as follows: Niagara 12.1 C., Genesee 10.8 C., Oswego 11.3 C. and St. Lawrence 9.3 C. The actual mean temperature for the Niagara River is undoubtedly lower than indicated here, owing to the fact that little or no data were collected for the Niagara in January, February and March due to ice conditions. Thus, a significant amount of temperature data in the 0-4 C. range was not included. There was no temperature data available from the Black River. Tables

A-N10, A-G10, A-O10, and A-S10 in the appendix give a more complete listing of the statistics. Tables A-N9, A-G9, A-O9, and A-S9 in the appendix give a complete listing of the temperature data collected.

TOTAL ALKALINITY

Figure 3.54 shows the mean monthly loadings of total alkalinity to Lake Ontario from the principal streams, reported as metric tons of calcium carbonate per day. The loadings of the Niagara, Genesee, Oswego and St. Lawrence Rivers follow the monthly mean streamflow patterns (Figures 2.1a through 2.1e). No data is available from the Black River.

Histograms of total alkalinity are shown in Figure 3.55, as are also the mean, standard deviation, median and number of samples. The histograms for each of the streams are fairly close to normal. The mean total alkalinity concentrations were as follows: Niagara 83.6 mg/l, Genesee 79.0 mg/l, Oswego 113.6 mg/l and the St. Lawrence 72.5 mg/l. For a more complete listing of the statistics, see Tables A-N10, A-G10, A-O10 and A-S10 in the appendix. Tables A-N9, A-G9, A-O9, and A-S9 in the appendix give a complete listing of the total alkalinity for the Niagara, Genesee, Oswego and St. Lawrence Rivers.

The concentration of total alkalinity was related to streamflow in the Genesee and Oswego Rivers (Table 3.27); the relationship was moderately strong in the Genesee River and very weak in the Oswego River. The log-log correlation coefficients were as follows: Genesee -.619 and Oswego -.135. The regression relationship was $C=kQ$, where C=concentration, Q=streamflow and k and n are constants.

Table 3.3 lists the monthly average and field year average loads, expressed as metric tons per day of calcium carbonate, carried to and from Lake Ontario by principal streams and U.S. minor tributaries. In May, July, August, September and November the net loadings showed a deficit. The mean net load was 2878.7 metric tons/day (3172 tons/day). The maximum net load occurred in January 1973 and was 18764.8 metric tons/day (20679 tons/day). The total mean input during the field year was 54611.2 metric tons/day (60182 tons/day), of which 88% was contributed by the Niagara, 6% by the Oswego, 4% by U.S. minor tributaries and 2% by the Genesee. About 5% of the total mean input was retained in the lake. This figure represents a minimum due to the fact that several sources of total alkalinity were not included in these data; if all sources had been included, the mean net load would have been higher.

Table 3.1 Mean Monthly Loadings to Lake Ontario for Total Phosphate
(mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Canadian Trib.	Canadian Municipal & Indus.	U.S. Municipal	U.S. Minor Trib.	Precip.	Loading
Apr 1972	18.9	1.6	4.4	1.2	20.7	6.5	8.3	0.2	11.2	4.9	36.5
May	12.2	1.6	2.9	1.0	19.8	3.9	7.2	0.1	7.0	6.0	22.3
Jun	24.0	2.1	2.6	0.5	21.7	3.5	7.1	0.1	5.9	7.9	32.1
Jul	20.4	2.9	4.7	0.5	27.1	2.4	7.7	0.1	4.5	4.8	21.0
Aug	22.1	0.4	2.0	0.2	33.6	1.0	6.7	0.1	1.9	6.4	7.2
Sep	17.8	0.5	1.2	0.1	22.3	0.5	8.2	0.2	1.1	5.3	11.5
Oct	15.4	0.7	1.8	0.3	16.9	1.0	7.3	0.1	2.0	5.7	17.6
Nov	19.3	1.0	1.4	0.7	15.8	3.5	7.3	0.1	5.7	7.9	31.2
Dec	31.4	4.3	1.9	0.5	13.3	4.9	9.1	0.2	8.2	8.2	55.5
Jan 1973	18.6	1.8	3.1	0.4	12.9	4.4	9.6	0.2	7.3	2.8	35.2
Feb	23.5	0.7	2.3	0.6	20.4	3.2	9.9	0.2	5.3	4.0	29.3
Mar	28.9	3.1	3.0	1.9	25.4	6.3	9.0	0.2	10.7	7.5	45.3
Apr	17.8	2.3	1.8	1.4	27.0	5.0	8.3	0.2	8.7	7.7	26.2
May	19.5	1.6	2.0	0.5	28.0	2.4	7.9	0.1	4.0	5.7	15.8
Mean	20.7	1.7	2.5	0.7	21.8	3.5	8.1	0.2	6.0	6.1	27.6
Percent of Total Input	42	4	5	1		7	16	<1	12	12	+56

Total Mean Input = 49.5 metric tons/day

Table 3.2 Mean Monthly Loadings to Lake Ontario for Total Filterable Phosphate (mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Precip.	Loading
Apr 1972	12.2	1.4	---	---	---	4.0	---
May	13.5	1.1	---	---	13.9	4.9	---
Jun	22.9	0.7	0.9	---	12.4	6.4	---
Jul	13.0	0.8	1.8	0.2	21.9	3.9	-2.1
Aug	16.5	0.2	1.0	0.2	15.9	5.2	7.1
Sep	7.9	0.1	0.5	0.3	14.7	4.2	-1.7
Oct	11.4	0.5	1.4	0.3	16.1	4.7	2.2
Nov	9.2	0.3	2.6	0.3	13.0	5.3	4.7
Dec	22.8	0.6	3.3	0.3	17.3	6.7	16.5
Jan 1973	35.7	0.2	3.3	0.5	10.3	2.3	31.7
Feb	23.7	0.2	2.4	0.5	14.9	3.3	15.2
Mar	16.5	0.4	4.7	---	25.8	6.2	---
Apr	10.3	0.3	1.4	---	---	6.3	---
May	11.4	0.4	1.2	---	---	4.7	---
Mean	16.2	0.5	2.0	0.3	16.0	4.9	9.2
Percent of Total Input	68	2	9	1		20	+38

Total Mean Input = 23.9 metric tons/day

Table 3.3 Mean Monthly Loadings to Lake Ontario for Dissolved Orthophosphate
(mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Canadian Trib.	Canadian Municipal & Indus.	U.S. Municipal	U.S. Minor Trib.	Precip.	Loading
Apr 1972	---	0.1	---	0.1	---	1.7	5.5	0.1	4.6	1.9	---
May	1.2	0.2	0.3	0.1	2.4	1.0	4.8	0.1	2.9	2.3	10.5
Jun	1.5	0.5	0.7	0.1	3.5	0.9	4.8	0.1	2.5	3.0	10.6
Jul	2.0	0.5	0.7	0.1	8.1	0.6	5.1	0.1	1.8	1.8	4.6
Aug	2.2	0.1	0.3	<0.1	4.5	0.3	4.5	0.1	0.8	2.4	6.4
Sep	1.6	0.1	0.2	<0.1	1.9	0.1	5.5	0.1	0.6	2.0	8.4
Oct	2.6	0.2	0.4	<0.1	1.8	0.3	4.9	0.1	1.0	2.2	9.9
Nov	2.2	0.4	1.2	0.1	2.1	0.9	4.8	0.1	2.4	3.0	11.2
Dec	5.2	0.5	1.6	<0.1	4.1	1.3	6.1	0.1	3.4	3.1	17.2
Jan 1973	3.6	0.2	1.1	0.1	4.1	1.2	6.4	0.1	2.9	1.1	12.5
Feb	2.3	0.2	0.9	0.2	6.5	0.9	6.6	0.1	2.2	1.5	8.4
Mar	2.1	0.5	1.1	0.6	9.3	1.7	6.0	0.1	4.3	2.9	9.9
Apr	1.2	0.3	0.5	0.3	---	1.3	5.5	0.1	3.6	2.9	---
May	0.9	0.3	0.3	---	---	0.6	5.3	0.1	1.6	2.2	---
Mean	2.2	0.3	0.7	0.1	4.4	0.9	5.4	0.1	2.5	2.3	10.0
Percent of Total Input	15	2	5	1		6	37	1	17	16	+68

Total Mean Input = 14.6 metric tons/day

Table 3.4 Mean Monthly Loadings to Lake Ontario for Nitrite-Nitrate
(mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Canadian Trib.	Canadian Municipal & Indus.	U.S. Municipal	U.S. Minor Trib.	Precip.	Loading
Apr 1972	116.2	4.1	26.4	14.7	100.0	19.8	2.3	0.5	40.4	49.2	173.6
May	112.7	3.8	18.1	10.0	158.5	13.6	2.2	0.4	25.3	60.7	88.3
Jun	182.9	15.2	22.4	3.8	82.6	17.7	2.1	0.4	21.2	79.4	262.5
Jul	122.1	16.5	27.4	3.6	222.5	20.2	1.9	0.4	16.4	48.5	34.5
Aug	93.8	2.1	5.2	1.6	169.7	4.0	1.7	0.4	7.0	64.8	10.9
Sep	25.4	0.9	2.9	0.4	30.0	1.8	1.8	0.3	4.1	53.5	61.1
Oct	41.2	1.6	3.8	0.6	60.3	2.5	1.9	0.4	7.3	58.0	57.0
Nov	93.6	8.8	12.7	4.4	90.9	11.1	2.0	0.4	20.6	80.1	142.8
Dec	130.5	15.1	21.1	7.4	108.2	18.4	2.7	0.5	29.6	58.0	175.1
Jan 1973	175.4	8.9	20.8	8.8	136.2	16.3	2.4	0.5	26.2	28.6	151.7
Feb	133.8	8.3	19.0	11.5	181.7	16.6	2.6	0.5	19.0	40.2	69.8
Mar	153.3	23.7	18.6	17.3	258.4	25.3	2.7	0.5	38.4	75.9	97.3
Apr	141.8	20.9	14.4	10.7	198.9	19.6	2.7	0.5	31.4	78.1	121.2
May	218.7	7.2	10.7	4.3	226.5	9.4	2.4	0.5	14.4	58.0	99.1
Mean	124.4	9.8	16.0	7.1	144.6	14.0	2.2	0.4	21.5	59.5	110.4
Percent of Total Input	49	4	6	3		5	1	<1	8		+43

Total Mean Input = 254.9 metric tons/day

Table 3.5 Mean Monthly Loadings to Lake Ontario for Ammonia
(mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Canadian Trib.	Canadian Municipal & Indus.	U.S. Municipal	U.S. Minor Trib.	Precip.	Loading
Apr 1972	27.8	0.5	6.8	2.5	3.3	4.5	31.4	3.5	6.3	31.0	111.1
May	16.1	0.1	3.1	2.7	4.4	2.7	25.9	2.9	4.0	38.3	9.1
Jun	47.5	2.8	5.8	1.7	12.5	4.7	25.9	3.0	3.3	50.0	132.3
Jul	33.3	1.0	5.1	1.4	29.2	3.4	23.7	2.6	2.6	30.6	74.5
Aug	27.6	0.9	1.2	0.7	32.8	1.3	22.6	2.5	1.1	40.9	66.0
Sep	17.7	0.9	0.9	0.2	13.0	0.8	20.7	2.4	0.6	33.7	65.0
Oct	17.2	1.3	3.1	0.2	11.3	2.2	22.6	2.5	1.2	36.6	75.9
Nov	60.7	2.6	10.5	1.3	11.1	6.5	3.8	3.5	3.2	50.5	159.5
Dec	14.4	2.4	11.3	0.7	13.0	6.5	31.1	3.5	4.6	52.2	113.7
Jan 1973	30.5	2.2	8.1	0.9	19.2	5.1	25.6	2.8	4.1	18.1	78.3
Feb	9.5	2.1	7.3	1.1	26.5	4.7	27.1	3.0	3.0	25.4	56.7
Mar	20.8	2.9	7.5	2.2	36.4	5.7	30.0	3.3	6.0	47.9	89.9
Apr	15.4	2.0	3.8	3.8	27.8	4.3	30.6	3.4	4.9	49.2	89.7
May	12.0	2.7	4.1	0.7	16.5	3.4	27.0	3.0	2.3	36.6	75.3
Mean	25.0	1.7	5.6	1.4	18.4	4.0	26.9	3.0	3.4	38.6	91.4
Percent of Total Input	23	2	5	1		4	25	3	3	35	+83

Total Mean Input = 109.6 metric tons/day

Table 3.6 Mean Monthly Loadings to Lake Ontario for Total Kjeldahl Nitrogen
(mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Canadian Trib.	Canadian Municipal & Indus.	U.S. Municipal	U.S. Minor Trib.	Precip.	Loading
Apr 1972	117.3	2.7	13.3	3.1	98.4	36.0	41.8	5.2	44.5	47.4	212.9
May	89.8	3.7	13.3	3.1	95.2	36.6	35.0	4.4	27.9	58.5	177.1
Jun	105.5	10.5	10.7	2.2	88.6	42.9	35.6	4.5	23.4	76.5	223.2
Jul	110.0	9.5	12.3	2.8	198.0	45.0	31.5	3.9	18.0	46.8	81.8
Aug	138.0	2.1	6.9	1.2	153.2	18.5	29.6	3.7	7.7	62.5	117.0
Sep	124.5	1.5	3.5	0.9	211.3	10.5	29.0	3.6	4.5	51.5	18.2
Oct	85.9	2.5	5.8	1.7	197.9	18.1	30.1	3.7	8.1	55.9	13.9
Nov	92.9	3.3	14.3	2.0	117.5	36.0	42.3	5.3	22.7	77.2	178.5
Dec	109.2	4.5	17.4	1.3	106.3	42.4	41.9	5.2	32.6	79.7	227.9
Jan 1973	93.9	3.6	13.1	6.2	99.1	41.9	34.5	4.3	28.9	27.6	154.9
Feb	106.5	3.4	11.1	3.7	130.1	33.2	36.6	4.5	21.0	38.8	128.7
Mar	107.6	5.0	12.4	6.0	132.4	33.5	40.4	5.1	42.3	73.2	193.1
Apr	115.8	4.2	8.6	7.7	98.7	26.5	41.2	5.1	34.6	75.3	220.3
May	113.5	3.7	9.6	3.8	89.7	28.2	36.0	4.5	15.8	55.9	181.3
Mean	107.9	4.3	10.9	3.3	129.7	32.1	36.1	4.5	23.7	59.1	152.1
Percent of Total Input	38	2	4	1		11	13	2	8	21	+54

Total Mean Input = 281.9

Table 3.7 Mean Monthly Loadings to Lake Ontario for Organic Nitrogen
(mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Canadian Trib.	Canadian Municipal & Indus.	U.S. Municipal	U.S. Minor Trib.	Precip.	Loading
Apr 1972	89.5	2.2	6.5	0.6	95.1	31.5	10.4	1.7	38.2	16.4	101.9
May	73.7	3.6	10.2	0.4	90.8	33.9	9.1	1.5	23.9	20.2	85.7
Jun	58.0	7.7	4.9	0.5	76.1	38.2	9.7	1.5	20.1	26.5	91.0
Jul	76.7	8.5	7.2	1.4	168.8	41.6	7.8	1.3	15.4	1612	7.3
Aug	1.10.4	1.2	5.7	0.5	120.4	17.2	7.0	1.2	6.6	21.6	51.0
Sep	106.8	0.6	2.6	0.7	198.3	9.7	8.3	1.2	3.9	17.8	-46.7
Oct	68.7	1.2	2.7	1.5	186.6	15.9	7.5	1.2	6.9	19.3	-61.7
Nov	32.2	0.7	3.8	0.7	106.4	29.5	10.5	1.8	19.5	26.7	19.0
Dec	94.8	2.1	6.1	0.6	93.3	35.9	10.8	1.7	28.0	27.5	114.2
Jan 1973	63.4	1.4	5.0	5.3	79.9	36.8	8.9	1.5	24.8	9.5	76.7
Feb	97.0	1.3	3.8	2.6	103.6	28.5	9.5	.1.5	18.0	13.4	72.0
Mar	86.8	2.1	4.9	3.8	96.0	27.8	10.4	1.8	36.3	25.3	47.6
Apr	100.4	2.2	4.8	3.9	70.9	22.2	10.6	1.7	29.7	26.1	130.7
May	101.5	1.0	5.5	3.1	73.2	24.8	9.0	1.5	13.5	19.3	106.0
Mean	82.9	2.6	5.3	1.8	111.4	28.1	9.3	1.5	20.3	20.4	56.8
Percent of Total Input	48	2	3	1		16	5	1	12	12	+33

Total Mean Input = 172.2 metric tons/day

Table 3.8 Mean Monthly Loadings to Lake Ontario for Total Nitrogen
(mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Canadian Trib.	Canadian Municipal & Indus.	U.S. Municipal	U.S. Minor Trib.	Precip.	Loading
Apr 1972	133.5	6.8	39.7	17.8	198.4	55.8	44.1	5.7	84.9	96.6	386.5
May	202.5	7.5	31.4	13.1	253.7	50.2	37.2	4.8	53.2	119.2	265.4
Jun	288.4	25.7	33.1	6.0	171.2	60.6	37.7	4.9	44.6	76.5	406.3
Jul	232.1	26.0	39.7	6.4	420.5	65.2	33.4	4.3	34.4	95.3	116.3
Aug	231.8	4.2	12.1	2.8	322.9	22.5	31.3	4.1	14.7	127.3	127.9
Sep	149.9	2.4	6.4	1.3	241.3	12.3	30.8	3.9	8.6	105.0	79.3
Oct	127.1	4.1	9.6	2.3	258.2	20.6	32.0	4.1	15.4	113.9	70.9
Nov	186.5	12.1	27.0	6.4	208.4	47.1	44.3	5.7	43.3	157.3	321.3
Dec	239.7	19.6	38.5	8.7	214.5	60.8	44.6	5.7	62.2	137.7	403.0
Jan 1973	269.3	12.5	33.9	15.0	235.3	58.2	37.9	4.8	55.1	56.2	307.6
Feb	240.3	11.7	30.1	15.2	311.8	49.8	39.2	5.0	40.0	79.0	198.5
Mar	260.9	28.7	31.0	23.3	390.8	58.8	43.1	5.6	80.7	149.1	290.4
Apr	257.6	25.9	23.0	18.4	297.6	46.1	43.9	5.6	66.0	153.4	342.3
May	332.2	10.9	20.3	8.1	316.2	37.6	38.4	5.0	30.2	113.9	280.4
Mean	232.3	14.2	26.8	10.3	274.3	46.1	38.4	4.9	45.2	112.9	256.9
Percent of Total Input	44	3	5	2		9	7	1	9	21	+48

Total Mean Input = 531.1 metric tons/day

Table 3.9 Mean Monthly Loadings to Lake Ontario for Total Organic Carbon
(mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Canadian Trib.	Canadian Municipal & Indus.	U.S. Municipal	U.S. Minor Trib.	Precip.	Loading
Apr 1972	1478.1	95.6	246.3	203.8	1666.8	930.3	54.2	49.1	168.4	447.7	2006.7
May	2075.3	65.9	207.7	147.2	1921.0	715.8	44.2	40.3	105.4	552.2	2033.0
Jun	1272.3	31.7	217.2	32.2	2603.9	480.4	45.7	41.7	88.5	722.1	327.9
Jul	1682.6	65.4	221.2	24.3	1894.4	531.3	40.5	36.6	68.2	441.5	1217.2
Aug	2302.3	46.9	229.6	19.4	2232.8	501.8	37.9	34.5	29.0	589.7	1558.3
Sep	1929.8	14.0	237.9	12.0	3319.9	449.9	37.2	33.5	16.9	486.5	-102.2
Oct	1872.0	11.7	246.2	29.0	3562.1	487.2	37.9	34.6	30.5	527.8	-285.2
Nov	1566.9	68.5	254.4	98.8	1935.0	717.1	54.2	49.1	86.0	728.8	1688.8
Dec	2050.5	79.4	246.4	70.1	813.2	672.1	53.7	48.5	123.3	752.6	3283.4
Jan 1973	1889.3	30.5	155.6	81.2	651.3	457.9	43.6	39.5	109.3	260.6	2416.2
Feb	1837.6	32.7	109.6	33.2	1001.9	301.5	46.2	41.9	79.3	366.1	1846.2
Mar	2101.8	69.4	131.1	99.7	641.8	509.1	51.8	46.7	159.7	690.7	3218.2
Apr	2382.2	43.6	79.4	110.2	1590.8	396.9	51.6	46.9	131.0	710.3	2361.3
May	2399.5	41.4	122.2	56.1	1812.3	376.2	45.5	41.5	59.9	527.8	1857.8
Mean	1917.2	49.8	193.2	72.7	1831.9	537.7	46.0	41.7	89.7	557.5	1673.4
Percent of Total Input	55	1	6	2		15	1	1	3	16	+48

Mean Total Input= 3505.5

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Table 3.10 Mean Monthly Loadings to Lake Ontario for Silica
(mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	U.S. Minor Trib.	Loading
Apr 1972	---	5.6	69.5	83.6	---	139.2	---
May	137.7	27.7	138.4	62.0	313.1	87.1	139.9
Jun	194.2	15.1	53.5	60.1	408.6	73.1	- 12.6
Jul	387.0	94.8	60.7	52.7	835.1	56.4	-183.5
Aug	203.0	9.8	9.9	28.5	564.4	2.4	-310.8
Sep	333.7	5.2	18.9	21.3	230.6	14.0	162.6
Oct	336.7	8.4	21.9	37.3	334.1	25.2	95.4
Nov	195.3	51.2	104.6	55.3	413.3	71.1	64.3
Dec	490.3	81.8	142.7	88.0	496.0	101.9	408.8
Jan 1973	259.6	30.6	155.4	101.3	284.9	90.4	352.4
Feb	157.7	9.1	84.1	131.3	389.1	65.5	- 58.8
Mar	265.2	7.1	17.7	103.0	664.6	132.0	-139.6
Apr	185.2	10.0	8.6	89.5	---	108.3	---
May	---	12.5	13.4	---	---	49.5	---
Mean	262.1	26.4	64.2	70.3	448.5	72.6	57.8
Percent of Total Input	53	5	13	14		15	12

Total Mean Input = 495.6 metric tons/day

Table 3.11 Mean Monthly Loadings to Lake Ontario for Sodium
(mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Precip.	Loading
Apr 1972	8628	413	2002	69	---	81	---
May	6726	484	2018	47	10795	100	-1422
Jun	7458	358	1296	45	11257	130	-1971
Jul	8116	266	2663	34	11003	80	151
Aug	7872	99	1458	20	10728	106	-1174
Sep	7253	73	828	11	11354	88	-3100
Oct	7120	134	1060	25	11286	95	-2852
Nov	7577	307	1635	46	9131	131	564
Dec	8298	496	2161	35	7299	136	3826
Jan 1973	7296	261	2089	34	7070	47	2657
Feb	6558	206	1582	33	7431	66	1014
Mar	8027	312	1317	44	8422	138	1415
Apr	8313	277	986	50	---	128	---
May	8791	243	1291	--	---	95	---
Mean	7717	281	1599	38	9617	101	-81
Percent of Total Input	79	3	16	<1		1	-8

Total Mean Input = 9735 metric tons/day

Table 3.12 Mean Monthly Loadings to Lake Ontario for Potassium (mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Precip.	Loading
Apr 1972	834.6	47.6	129.8	35.3	---	29.7	---
May	951.9	45.8	115.3	19.6	940.5	36.4	228.3
Jun	820.4	83.8	107.7	16.3	1212.2	47.9	-136.1
Jul	827.7	79.6	151.6	10.5	1373.0	29.3	-274.3
Aug	791.7	10.8	47.9	4.2	1400.6	39.1	-506.9
Sep	941.3	8.2	33.1	2.8	1287.1	32.3	-269.4
Oct	886.9	15.2	43.4	6.4	1246.0	35.0	-259.2
Nov	898.0	42.1	70.8	13.9	1153.7	48.4	- 80.5
Dec	1000.6	70.9	111.0	11.3	819.7	49.9	424.0
Jan 1973	927.3	25.1	94.1	10.8	724.4	17.3	333.2
Feb	799.4	16.2	73.1	13.1	753.1	24.3	173.0
Mar	940.0	47.5	68.9	20.7	935.3	45.8	187.6
Apr	965.0	32.7	45.9	12.7	---	47.1	---
May	---	23.1	54.1	---	---	35.0	---
Mean	891.1	39.2	81.9	13.7	1078.4	37.0	-16.4
Percent of Total Input	84	4	8	1		3	-2

Total Mean Input = 1062.9 metric tons/day

Table 3.13 Mean Monthly Loadings to Lake Ontario for Calcium (mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Precip.	Loading
Apr 1972	18087	707	2742	319	---	159	---
May	20642	608	2599	164	24220	196	- 11
Jun	17936	641	2231	173	25670	256	-4433
Jul	17089	549	3636	153	22871	156	-1287
Aug	16720	138	1362	65	19809	209	-1314
Sep	16612	107	878	34	21909	172	-4105
Oct	18339	153	1334	72	23534	187	-3449
Nov	17134	540	2276	168	24356	258	-6029
Dec	19173	763	2878	192	23964	267	- 691
Jan 1973	22517	403	2541	238	21619	92	4173
Feb	21588	379	1912	221	23709	130	522
Mar	21454	771	1941	280	19701	245	4990
Apr	22297	557	1396	261	---	252	---
May	23352	495	1727	---	---	187	---
Mean	19496	487	2104	180	22851	198	-1058
Percent of Total Input	87	2	9	1		1	-5

Total Mean Input = 22464 metric tons/day

Table 3.14 Mean Monthly Loadings to Lake Ontario for Magnesium
(mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Precip.	Loading
Apr 1972	4076	188	643	45	---	36	---
May	4475	153	629	24	4755	45	570
Jun	4471	279	465	23	5606	59	- 309
Jul	4486	222	688	22	5796	36	- 343
Aug	4831	50	271	8	5998	48	- 790
Sep	4410	29	120	4	6029	40	-1427
Oct	5001	49	203	8	5979	43	- 676
Nov	4698	155	395	20	5800	59	- 474
Dec	4770	247	462	18	5098	61	461
Jan 1973	5324	112	409	24	4560	21	1240
Feb	5233	92	310	18	5186	30	496
Mar	4686	234	318	28	5113	56	209
Apr	4996	149	226	25	---	58	---
May	4876	116	277	—	---	43	---
Mean	4738	148	387	21	5447	45	- 95
Percent of Total Mean	89	3	7	<1		1	-1.8

Total Mean Input = 5339 metric tons/day

Table 3.15 Mean Monthly Loadings to Lake Ontario for Sulfate (mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Canadian Trib.	Canadian Municipal & Indus.	U.S. Municipal	U.S. Minor Trib.	Precip.	Loading
Apr 1972	---	---	---	---	---	---	---	--	---	---	---
May	---	---	---	---	---	---	---	--	---	---	---
Jun	---	---	---	---	---	---	---	--	---	---	---
Jul	---	---	---	---	---	---	---	--	---	---	---
Aug	---	---	---	---	---	---	---	--	---	---	---
Sep	---	156	379	31	20110	188	132	27	165	491	---
Oct	11507	154	433	63	21043	364	128	27	298	533	-7536
Nov	16120	503	1313	157	21446	1318	190	39	841	736	- 229
Dec	15822	768	1954	152	17529	1822	184	39	1206	760	5178
Jan 1973	14163	492	1904	140	16340	1640	156	32	1069	263	3519
Feb	14259	362	1549	168	17795	1210	173	32	775	370	1103
Mar	14732	662	1905	244	19521	2369	170	37	1562	698	2858
Apr	14961	497	1227	255	20680	1883	190	38	1281	717	369
May	15149	594	1315	205	19771	911	156	33	586	533	- 289
Mean	14589	465	1330	157	19359	1301	164	34	865	567	622
Percent of Total Input	75	2	7	1		7	1	<1	4	3	+3

Total Mean Input = 19472 metric tons/day

Table 3.16 Mean Monthly Loadings to Lake Ontario for Chloride
(mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Canadian Trib.	Canadian & U.S. Municipal & Indus.	U.S. Minor Trib.	Precip.	Loading
Apr 1972	13525	579	4827	64	---	1318	354	1263	58	---
May	14504	509	4149	36	---	1160	354	790	71	---
Jun	14444	433	4396	27	25116	1079	354	663	92	-3628
Jul	14796	360	4419	25	23829	1160	354	511	56	-2148
Aug	14706	149	2542	7	23008	348	354	218	75	-4609
Sep	14134	115	1354	7	21898	240	354	127	62	-5505
Oct	14057	188	1787	13	22228	232	354	229	67	-5300
Nov	16845	429	4789	30	20202	839	354	645	93	3820
Dec	15803	727	5554	37	17993	1044	354	925	96	6548
Jan 1973	13892	449	3932	45	16604	928	354	820	33	3849
Feb	13891	326	3209	42	18966	770	354	595	47	269
Mar	14497	599	2648	50	19816	1044	354	1198	88	662
Apr	15346	477	2701	26	---	1079	354	982	91	---
May	16292	399	2763	--	---	696	354	449	67	---
Mean	14767	410	3505	32	20966	853	354	672	71	-604
Percent of Total Mean	71	2	17	<1		4	2	3	<1	3

Total Mean Input = 20663 metric tons/day

Table 3.17 Mean Monthly Loadings to Lake Ontario for Fluoride
(mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Loading
Apr 1972	---	2.33	---	1.50	---	---
May	36.05	1.22	---	1.60	91.16	---
Jun	57.51	2.05	---	1.44	90.16	---
Jul	50.52	2.62	4.57	1.37	71.64	-12.54
Aug	69.06	0.53	1.86	0.86	64.87	7.43
Sep	48.79	0.33	1.05	0.38	73.03	-22.48
Oct	56.53	0.36	1.12	0.62	42.31	16.31
Nov	84.90	1.36	4.88	1.32	91.63	0.82
Dec	86.53	3.47	6.61	1.47	132.35	-34.28
Jan 1973	81.65	1.37	4.37	1.77	87.83	1.32
Feb	80.64	0.83	3.17	2.28	85.02	1.90
Mar	80.83	1.98	3.31	6.83	37.10	55.84
Apr	89.89	0.63	3.03	5.96	---	---
May	88.37	0.85	2.63	---	---	---
Mean	70.10	1.42	3.33	2.08	78.87	1.59
Percent of Total Input	91	2	4	3		+2

Total Mean Input = 76.93 metric tons/day

Table 3.18 Mean Monthly Loadings to Lake Ontario for Manganese
(metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Precip.	Loading
Apr 1972	4.6	1.8	2.0	1.6	---	1.3	---
May	3.4	1.3	2.7	0.9	5.0	1.6	4.9
Jun	5.4	1.5	1.9	1.0	5.8	2.2	6.1
Jul	17.6	0.6	2.3	0.7	5.6	1.3	16.9
Aug	8.0	0.3	0.7	0.2	5.3	1.8	5.6
Sep	7.0	0.2	0.4	0.1	4.7	1.5	4.6
Oct	6.5	0.4	0.6	0.2	4.7	1.6	4.5
Nov	9.0	1.1	0.8	0.5	4.3	2.2	9.3
Dec	21.7	2.3	1.8	0.6	3.9	2.2	24.6
Jan 1973	11.9	1.1	2.2	0.8	2.4	2.6	16.1
Feb	5.1	0.8	2.7	0.7	1.4	1.1	8.9
Mar	7.5	2.7	1.7	0.8	1.8	2.1	13.0
Apr	4.2	0.5	1.6	1.3	---	2.1	---
May	13.9	0.7	1.1	---	---	1.6	---
Mean	9.0	1.1	1.6	0.7	---	1.8	10.4
Percent of Total Input	63	8	11	5		13	+73

Total Mean Input = 14.2 metric tons/day

Table 3.19 Mean Monthly Loadings to Lake Ontario for Iron
(mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Canadian Trib.	Canadian & U.S. Municipal & Indus.	U.S. Minor Trib.	Precip.	Loading
Apr 1972	194.2	112.5	---	42.1	---	49.1	13.5	13.4	4.4	---
May	147.5	54.8	35.9	14.9	39.0	43.2	13.5	7.0	5.5	283.3
Jun	81.2	76.3	35.4	22.3	147.9	40.2	13.5	6.4	7.2	134.5
Jul	98.6	94.5	25.3	10.8	407.0	43.2	13.5	5.7	4.4	-111.1
Aug	115.2	4.9	7.2	7.9	295.2	12.9	13.5	1.9	5.8	-125.9
Sep	270.5	6.7	3.4	5.1	580.6	8.9	13.5	0.6	4.8	-273.1
Oct	308.1	9.5	4.9	8.4	1115.9	8.7	13.5	0.6	5.2	-757.0
Nov	339.5	52.1	11.1	19.3	359.4	31.3	13.5	7.7	7.2	122.4
Dec	901.6	144.1	14.3	5.7	120.2	38.9	13.5	9.6	7.5	1015.1
Jan 1973	607.1	54.4	11.4	8.8	166.2	34.6	13.5	2.3	2.6	575.4
Feb	265.9	42.9	9.1	11.4	39.2	28.7	13.5	7.0	3.6	363.0
Mar	208.7	165.6	14.0	9.9	65.3	38.9	13.5	10.2	6.8	402.4
Apr	192.3	44.8	8.4	11.5	---	40.2	13.5	11.2	7.0	---
May	158.8	---	9.9	---	---	25.9	13.5	6.4	5.2	---
Mean	279.2	66.6	15.2	14.1	304.0	31.8	13.5	6.9	5.5	148.1
Percent of Total Input	65	15	4	3		7	3	2	1	+34

Total Mean Input = 432.8 metric tons/day

Table 3.20 Mean Monthly Loadings to Lake Ontario for Nickel
(mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Precip.	Loading
Apr 1972	---	0.34	0.31	0.18	---	0.18	---
May	---	0.15	0.31	0.16	---	0.22	---
Jun	3.2	0.17	0.28	0.05	---	0.29	---
Jul	3.3	0.44	0.53	0.05	7.9	0.18	-3.4
Aug	3.8	0.04	0.63	0.03	7.4	0.23	-2.7
Sep	5.2	0.03	0.60	0.02	5.9	0.19	0.3
Oct	5.8	0.07	0.96	0.03	5.7	0.21	1.4
Nov	6.1	0.29	1.1	0.06	5.8	0.29	2.0
Dec	4.7	0.34	1.5	0.05	2.5	0.30	4.4
Jan 1973	5.4	0.13	1.5	0.02	3.3	0.10	3.8
Feb	6.0	0.07	1.0	0.02	7.7	0.15	- .5
Mar	6.9	0.25	1.2	0.12	8.3	0.27	0.4
Apr	6.5	0.23	0.90	0.13	---	0.28	---
May	---	---	0.82	---	---	0.21	---
Mean	5.2	0.19	0.85	0.08	5.27	0.22	0.8
Percent of Total Input	79	3	13	1		3	12

Total Mean Input = 6.51 metric tons/day

Table 3.21 Mean Monthly Loadings to Lake Ontario for Copper
(mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Precip.	Loading
Apr 1972	4.62	0.27	0.69	0.56	10.32	0.58	---
May	3.75	0.15	0.39	0.39	14.06	0.71	- 3.60
Jun	4.91	0.15	0.37	0.10	12.48	0.93	- 8.67
Jul	7.47	0.41	1.06	0.13	24.36	0.57	- 6.02
Aug	7.08	0.06	1.04	0.06	18.78	1.79	-14.72
Sep	2.78	0.03	0.95	0.03	20.66	0.63	- 8.75
Oct	3.57	0.06	0.87	0.06	12.33	0.68	-16.24
Nov	6.74	0.13	0.79	0.12	3.74	0.94	- 7.09
Dec	4.18	0.28	0.89	0.14	5.18	0.97	4.98
Jan 1973	4.83	0.14	0.90	0.17	5.90	0.34	1.28
Feb	4.59	0.19	0.66	0.20	9.87	0.47	0.48
Mar	4.48	0.57	0.89	0.35	---	0.89	- 3.76
Apr	4.08	0.28	0.77	0.35	---	0.91	---
May	5.68	0.16	0.68	---	---	0.68	---
Mean	4.91	0.63	0.78	0.20	12.51	0.79	- 5.65
Percent of Total Input	67	9	11	3		11	-77

Total Mean Input = 7.31 metric tons/day

Table 3.22 Mean Monthly Loadings to Lake Ontario for Zinc
(metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Precip.	Loading
Apr 1972	7.53	0.66	0.89	---	---	4.21	---
May	8.59	0.56	0.75	---	17.52	5.19	---
Jun	13.26	1.30	0.79	0.39	18.15	6.79	- 5.61
Jul	8.85	1.86	2.09	0.33	36.63	4.15	-19.34
Aug	8.34	0.27	2.08	0.16	13.98	5.55	2.42
Sep	17.07	0.21	1.91	0.09	30.81	4.58	- 6.95
Oct	31.35	0.50	1.74	0.20	58.72	4.96	-19.96
Nov	24.85	0.88	1.57	0.54	25.91	6.86	8.79
Dec	26.54	1.35	2.14	0.39	11.25	7.08	26.25
Jan 1973	47.05	0.50	2.22	0.28	31.86	2.45	20.65
Feb	31.95	0.48	0.69	0.26	20.52	3.44	16.31
Mar	12.93	1.26	0.89	0.24	19.32	6.50	2.51
Apr	10.15	0.69	0.50	0.34	---	6.68	---
May	11.04	0.73	0.58	---	---	4.96	---
Mean	18.54	0.81	1.35	0.29	26.79	5.24	2.51
Percent of Total Input	71	3	5	1		20	+10

Total Mean Input = 26.73 metric tons/day

Table 3.23 Mean Monthly Loadings to Lake Ontario for Lead
(mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Precip.	Loading
Apr 1972	---	---	1.01	0.55	---	1.77	---
May	---	0.50	0.83	0.44	---	2.19	---
Jun	9.63	1.81	0.72	0.13	20.22	2.86	-5.07
Jul	4.03	0.59	1.23	0.12	21.30	1.75	-13.57
Aug	6.93	0.08	1.25	0.10	35.96	2.34	-25.26
Sep	7.41	0.05	1.23	0.04	29.71	1.93	-19.04
Oct	10.63	0.10	1.21	0.05	22.37	2.09	- 8.28
Nov	8.57	0.25	1.18	0.11	19.43	2.89	- 6.42
Dec	8.76	0.34	2.54	0.24	18.71	2.98	- 3.85
Jan 1973	15.12	0.15	3.10	0.42	19.03	1.03	0.79
Feb	14.07	0.18	2.18	0.51	21.63	1.45	- 3.23
Mar	15.02	0.75	2.54	0.09	15.83	2.74	5.32
Apr	15.30	0.46	1.85	0.15	---	2.81	---
May	17.02	0.41	1.67	---	---	2.09	---
Mean	11.04	0.44	1.61	0.23	22.42	2.21	- 7.86
Percent of Total Input	71	3	10	1		14	-51

Total Mean Input = 15.53 metric tons/day

Table 3.24 Mean Monthly Loadings to Lake Ontario for Cadmium
(mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	Precip.	Loading
Apr 1972	---	---	0.08	0.08	---	0.04	
May	---	0.02	0.07	0.05	1.43	0.05	---
Jun	0.08	0.10	0.08	0.01	1.89	0.07	-0.80
Jul	0.85	0.04	0.16	0.02	1.19	0.04	-0.09
Aug	0.76	0.01	0.14	0.01	4.54	0.06	-3.56
Sep	0.85	0.01	0.12	0.01	4.13	0.05	-3.09
Oct	1.04	0.01	0.11	0.01	1.75	0.05	-0.53
Nov	0.96	0.03	0.09	0.02	1.63	0.07	-0.46
Dec	0.80	0.04	0.11	0.02	1.56	0.08	-0.51
Jan 1973	0.74	0.03	0.10	0.04	1.78	0.03	-0.84
Feb	0.60	0.03	0.08	0.04	1.84	0.04	-1.06
Mar	0.60	0.06	0.08	---	---	0.07	---
Apr	0.71	0.04	0.06	---	---	0.70	---
May	---	0.04	0.05	---	---	0.05	---
Mean	0.79	0.03	0.09	0.03	2.17	0.06	---
Percent of Total Input	.79	3	9	3		6	-1.22

Total Mean Input = 1.00 metric tons/day

Table 3.25 Mean Monthly Loadings to Lake Ontario for Mercury (mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence
Apr 1972	0.895	0.038	0.069	---	---
May	0.716	0.006	0.023	0.011	---
Jun	0.290	0.011	0.044	0.008	---
Jul	0.728	0.010	0.211	0.010	---
Aug	0.766	0.002	0.171	0.013	---
Sep	0.312	0.001	0.130	0.004	2.828
Oct	0.181	0.001	0.090	0.002	2.183
Nov	0.145	0.002	0.049	0.003	1.309
Dec	---	0.003	0.035	0.003	0.435
Jan 1973	---	0.004	0.041	0.004	3.073
Feb	---	0.004	0.039	0.004	2.390
Mar	---	0.005	0.044	0.010	---
Apr	---	0.007	0.013	---	---
May	---	---	0.027	---	---
Mean	0.504	0.007	0.070	0.007	2.036
Percent of Total Input	85	2	12	2	

Total Mean Input = 0.596

Table 3.26 Mean Monthly Loadings to Lake Ontario for Total Alkalinity (mean metric tons/day)

Month	Niagara	Genesee	Oswego	Black	St. Lawrence	U.S. Minor Trib.	Loading
Apr 1972	39029.8	1160.4	3878.1	---	---	3630.0	---
May	40913.8	964.2	4200.3	---	46438.0	2271.7	1932.0
Jun	46633.9	1356.3	3818.0	---	50666.4	1906.9	5048.8
Jul	45752.6	1366.7	5521.2	---	55760.4	1469.9	-1670.0
Aug	49517.1	341.4	1844.1	---	57860.0	625.8	-5531.6
Sep	47990.6	197.8	796.9	---	58071.6	364.2	-8722.1
Oct	50028.4	338.5	1204.2	---	51046.0	657.1	1182.2
Nov	48830.7	942.9	4463.3	---	57839.6	1853.1	-1729.5
Dec	47991.0	1395.2	5320.5	---	48945.2	2658.2	8419.6
Jan 1973	54043.2	708.5	4689.4	---	43032.1	2355.8	18764.8
Feb	48823.3	580.9	3590.9	---	47546.4	1709.0	7157.7
Mar	49992.5	1499.8	3548.9	---	51069.7	3442.7	6814.2
Apr	53761.1	1046.1	2974.1	---	---	2823.1	---
May	50653.8	675.2	3071.2	---	---	1291.2	---
Mean	46283.0	899.6	3495.8	---	51717.8	1932.8	2878.7
Percent of Total Input	88	2	6			4	5

Total Mean Input = 54611.2 metric tons/day

Table 3.27 Relation of Chemical Concentrations to Streamflow and Correlation Coefficients for Genesee, Oswego and Black Rivers

	Genesee (1)			Oswego (2)			Black (3)		
	k	n	r	k	n	r	k	n	r
TP	.218	-.071	.144	3.532	-.424	-.257	.043	-.052	-.062
TFP	.414	-.278	-.361	---	---	---	---	---	---
DOP	1.507	-.499	-.500	.018	.024	.021	---	---	---
NO2-NO3	.129	.196	.231	.028	.304	.533	.003	.513	.572
NH3	12.13	-.545	-.377	.604	.386	.253	.067	.251	.226
TKN	5.38	-.329	-.533	1.03	-.100	-.287	3.698	-.396	-.388
TOC	1.36	.137	.295	.10	.401	.378	.367	.285	.444
SO4	322.1	-.236	-.545	67.9	-.355	-.091	5.636	.024	.024
SiO2	.82	.119	.266	.012	.481	.235	79.62	-.365	-.717
F	.122	-.014	-.024	.386	-.131	.254	.583	-.230	-.318
Cl	452.9	-.304	-.702	2032.0	-.310	-.344	1.242	.044	.098
Na	305.5	.304	-.620	90.57	-.070	-.088	15.205	-.213	-.559
K	.005	.122	-.070	1.052	.085	.280	.455	.059	.156
Ca	122.5	-.132	-.409	132.7	.074	-.235	12.647	-.030	-.087
Mg	19.77	-.058	-.267	7.11	.058	.121	.893	.038	.115
Fe	.005	.512	.614	.002	.564	.406	4.266	-.213	-.220
Zn	.256	-.172	-.236	.006	.138	.078	.007	.142	.143
Ni	.005	.122	.266	60.8	-.848	-.354	.011	-.142	-.146
Cu	.005	.129	.202	.455	.058	-.156	.001	.119	.308
Cd	.007	-.124	.210	1.052	.085	-.058	.006	-.127	-.288
Pb	.014	.074	.135	1.498	.205	-.345	.007	.048	.061
Mn	.313	-.179	-.183	1.98	.386	-.237	.013	.127	.235
DO	17.86	-.212	-.815	1.58	.210	.481	---	---	---
pH	8.32	-.020	-.248	7.73	.003	.031	---	---	---
Tot. Alka.	200.0	-.115	-.619	162.6	-.039	-.135	---	---	---

Note: Relationship expressed as C = kQ , where;
C = concentration (mg/l)
Q = streamflow (cubic feet/sec; CFS)
r = correlation coefficient

1. Casey, Clark 1976
2. Casey, Clark 1976
3. Casey, Clark 1976

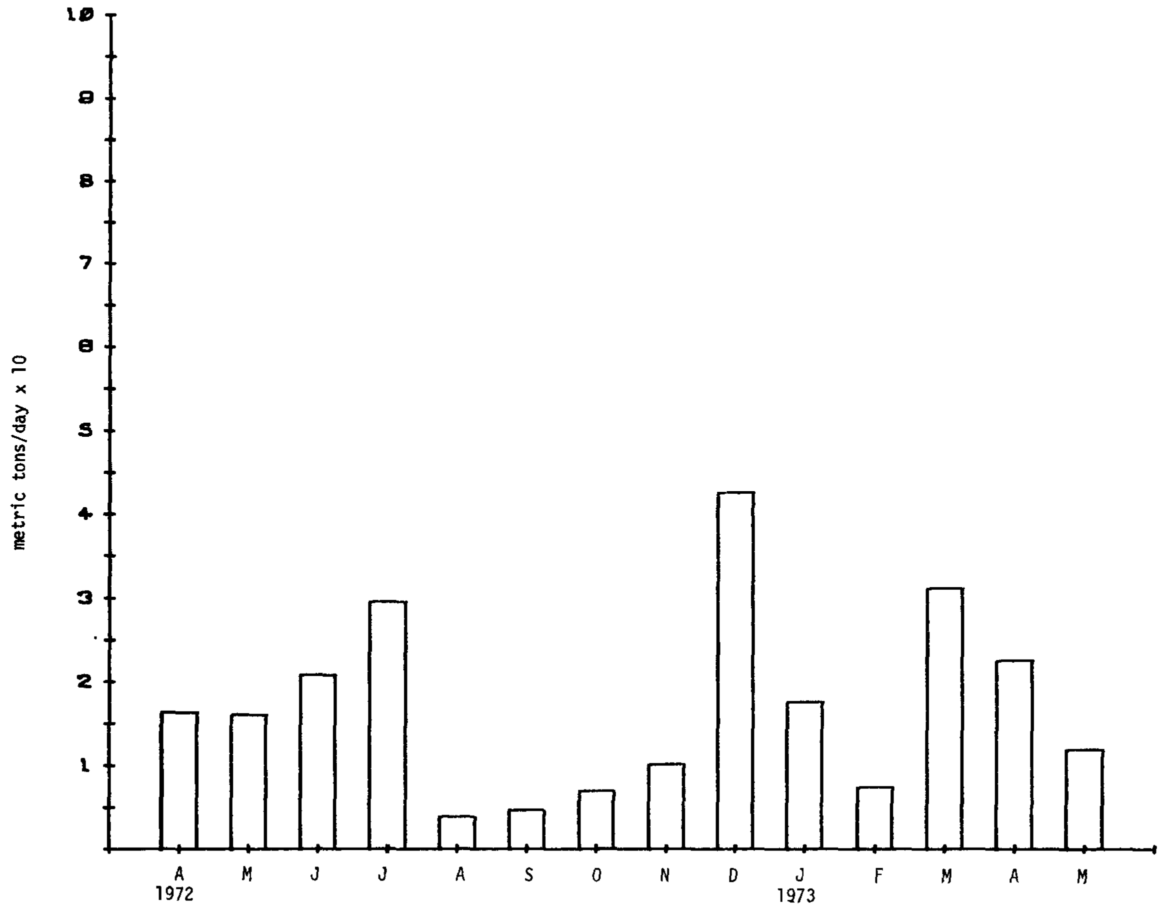


Figure 3.1 Genesee River Monthly Mean Stream Loadings - Total Phosphate

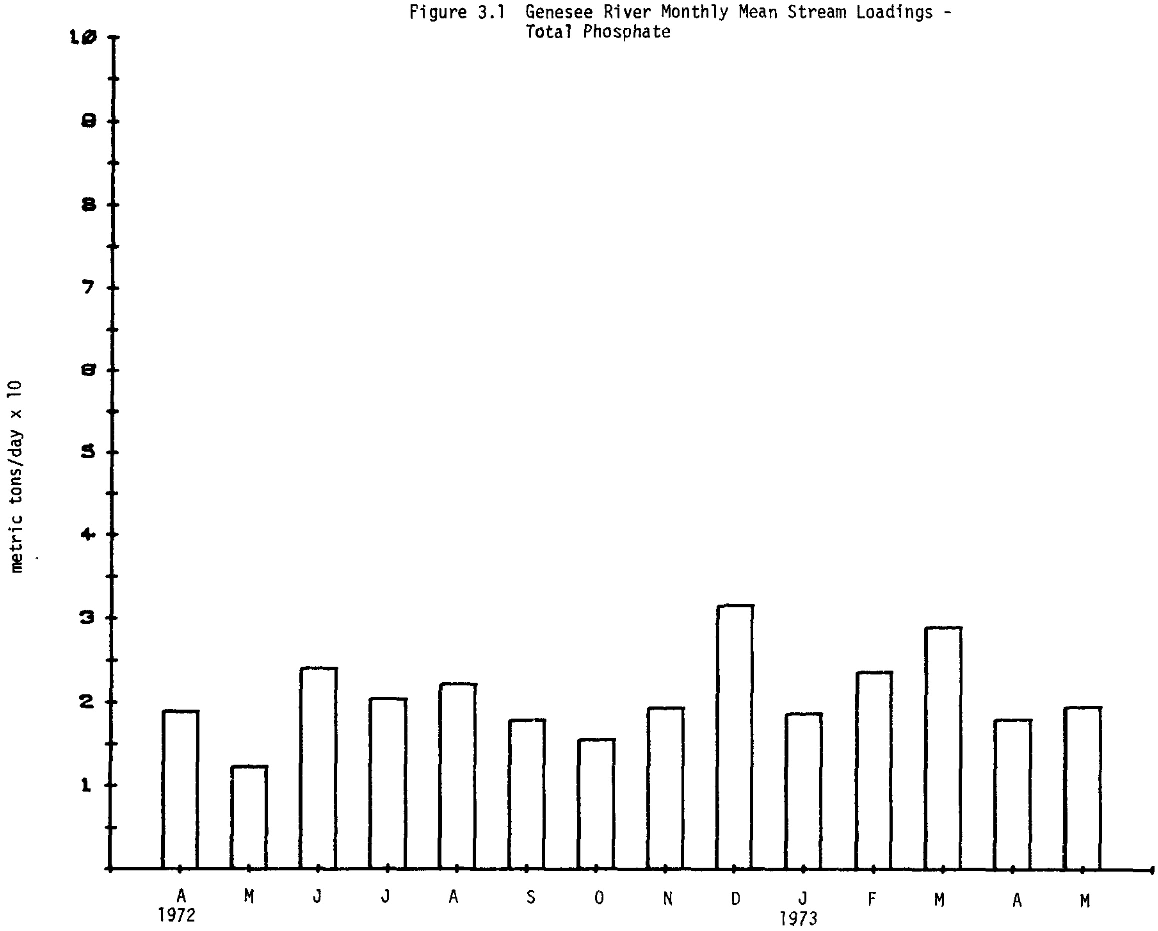


Figure 3.1 Niagara River Monthly Mean Stream Loadings - Total Phosphate

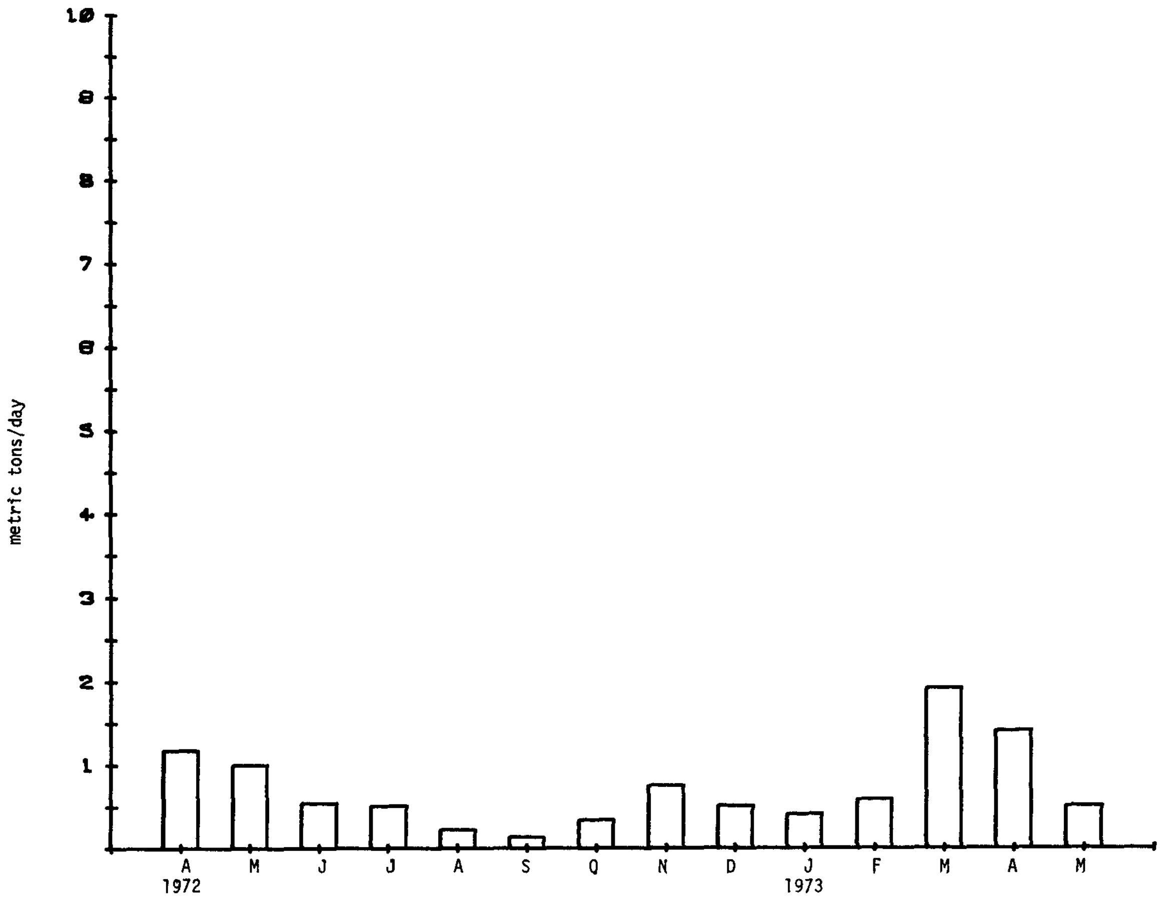


Figure 3.1 Black River Monthly Mean Stream Loadings - Total Phosphate

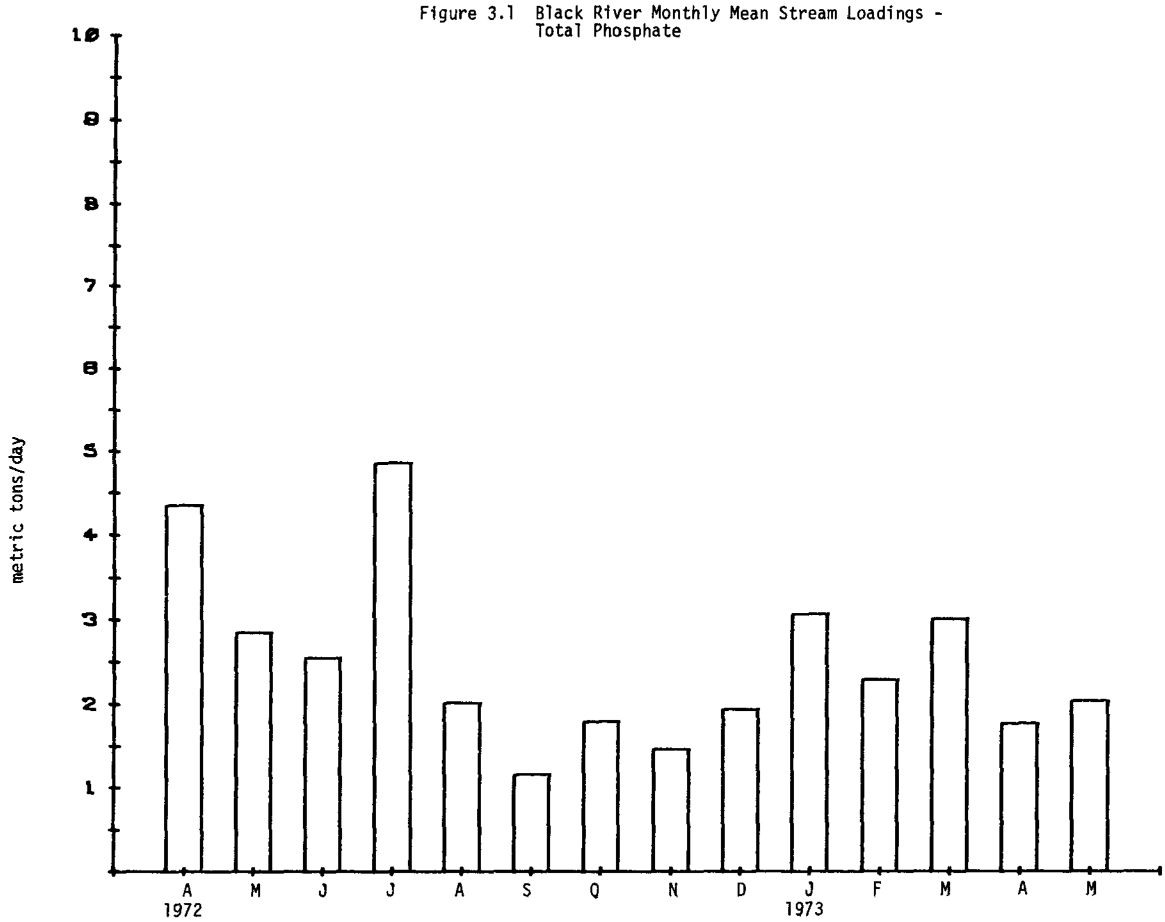


Figure 3.1 Oswego River Monthly Mean Stream Loadings - Total Phosphate

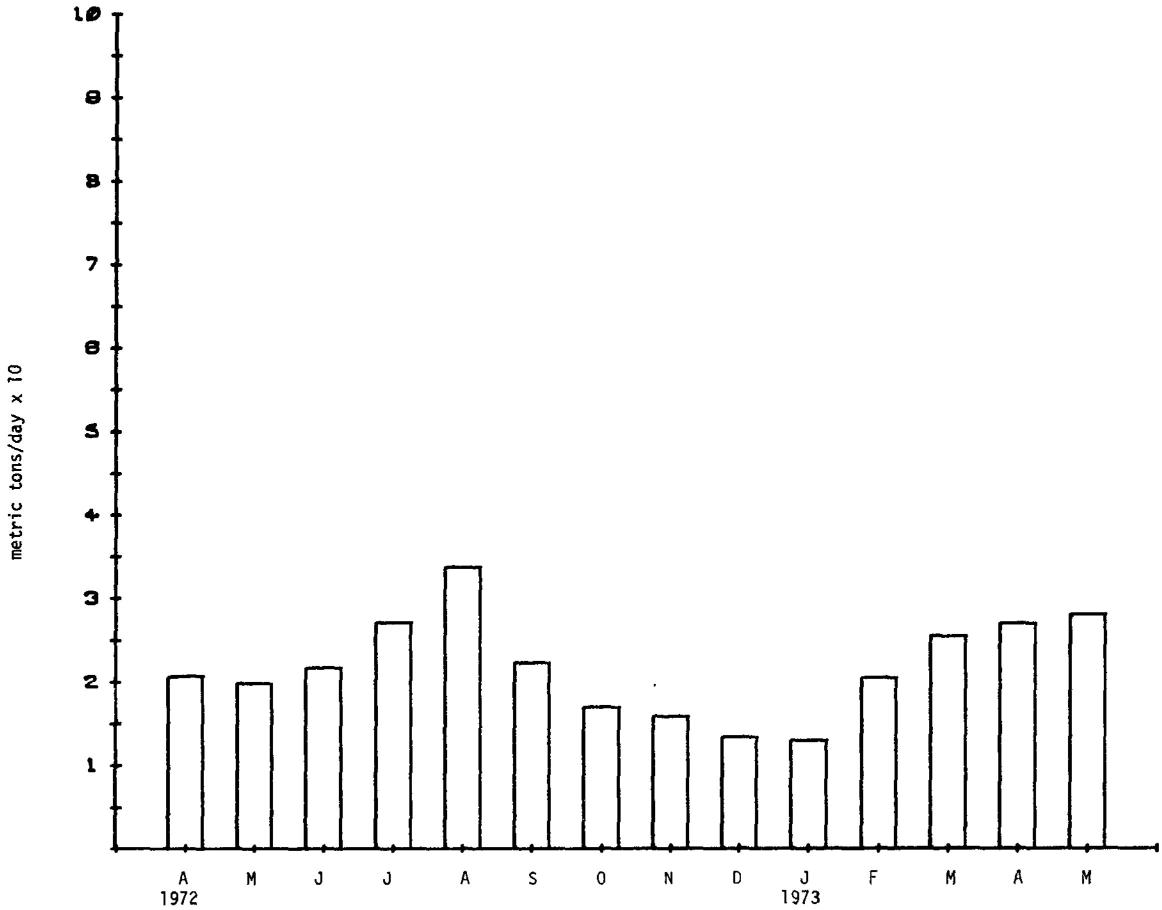


Figure 3.1 St. Lawrence River Monthly Mean Stream Loadings - Total Phosphate

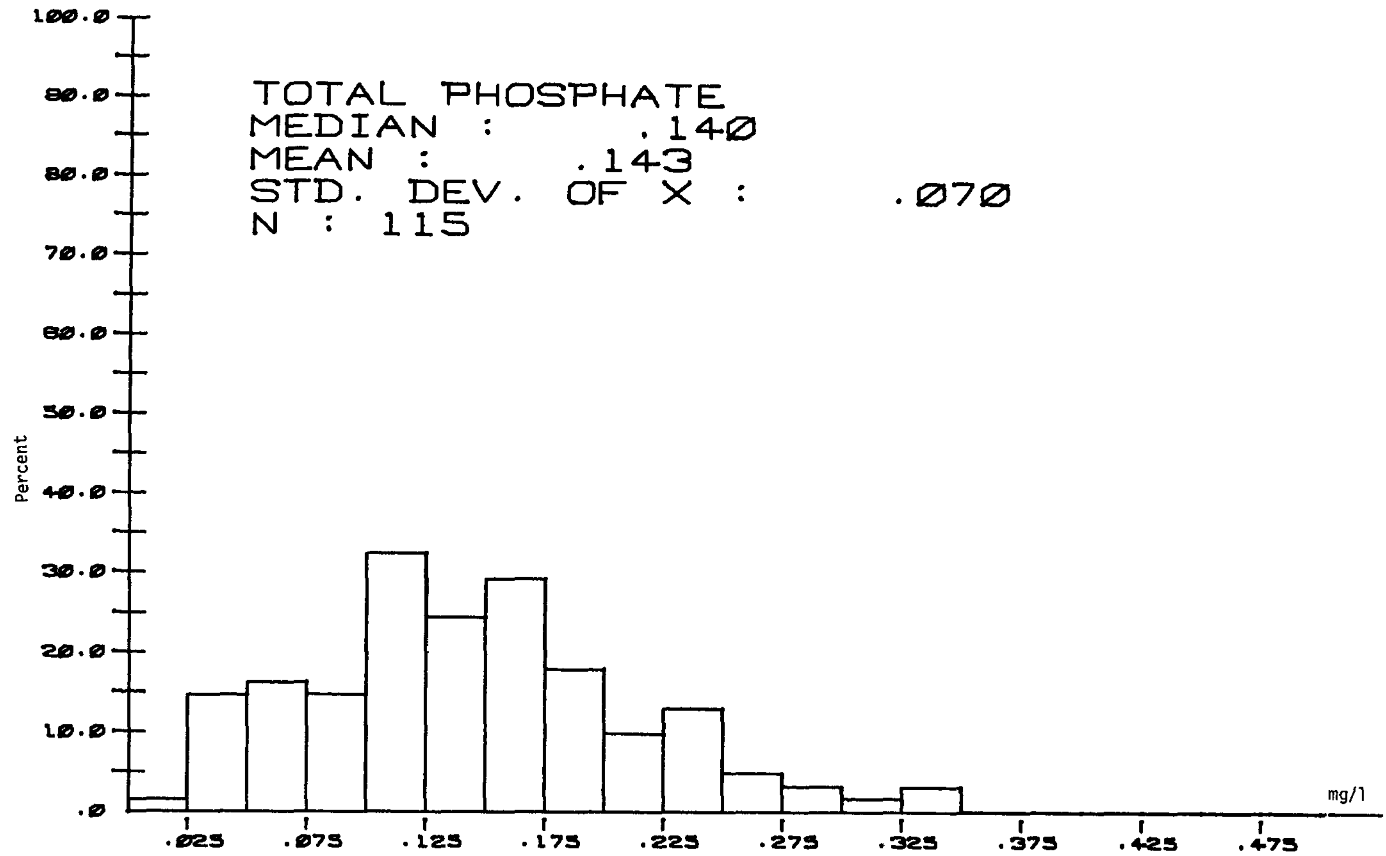


Figure 3.2 Genesee River Histograms for Total Phosphate

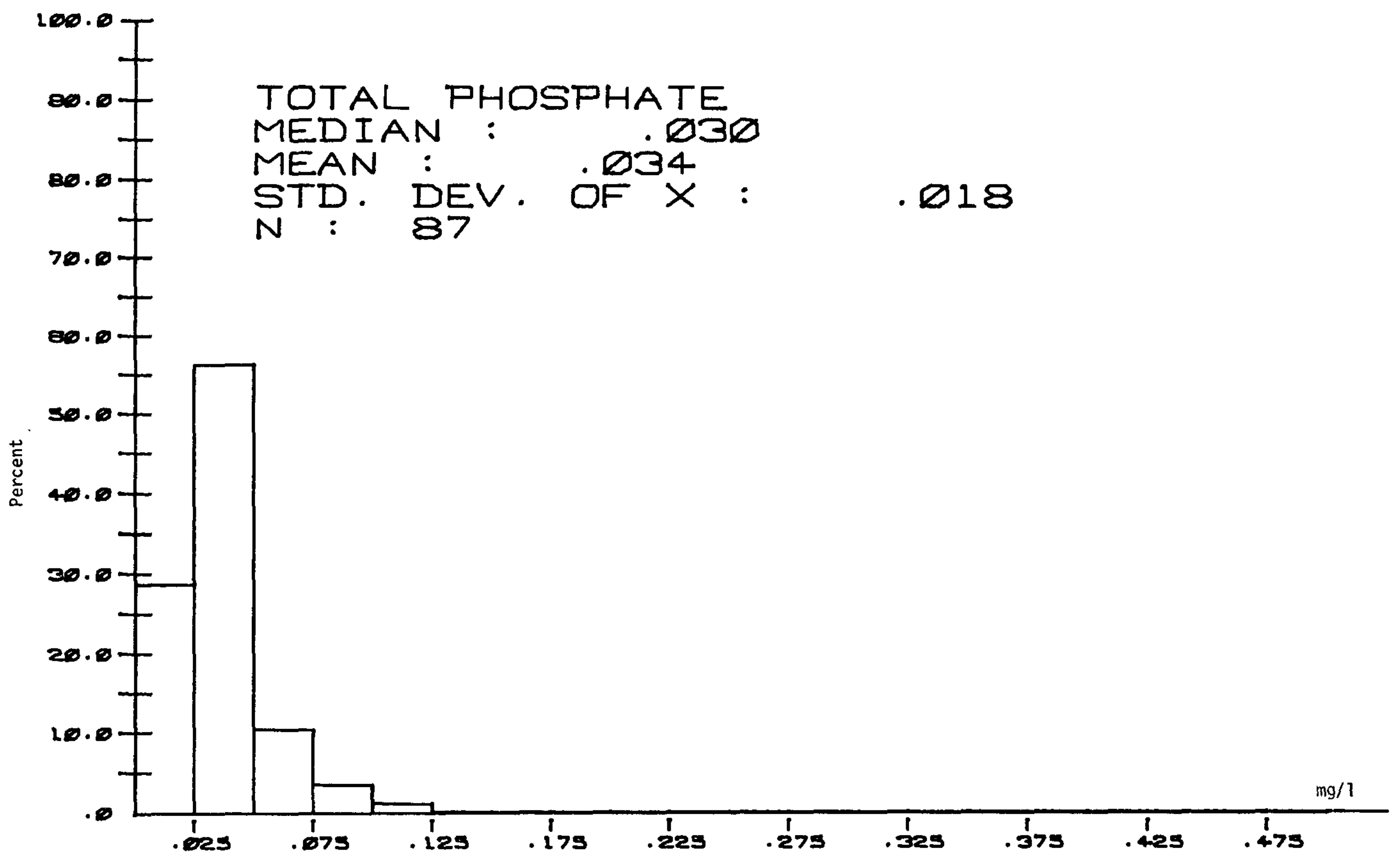


Figure 3.2 Niagara River Histograms for Total Phosphate

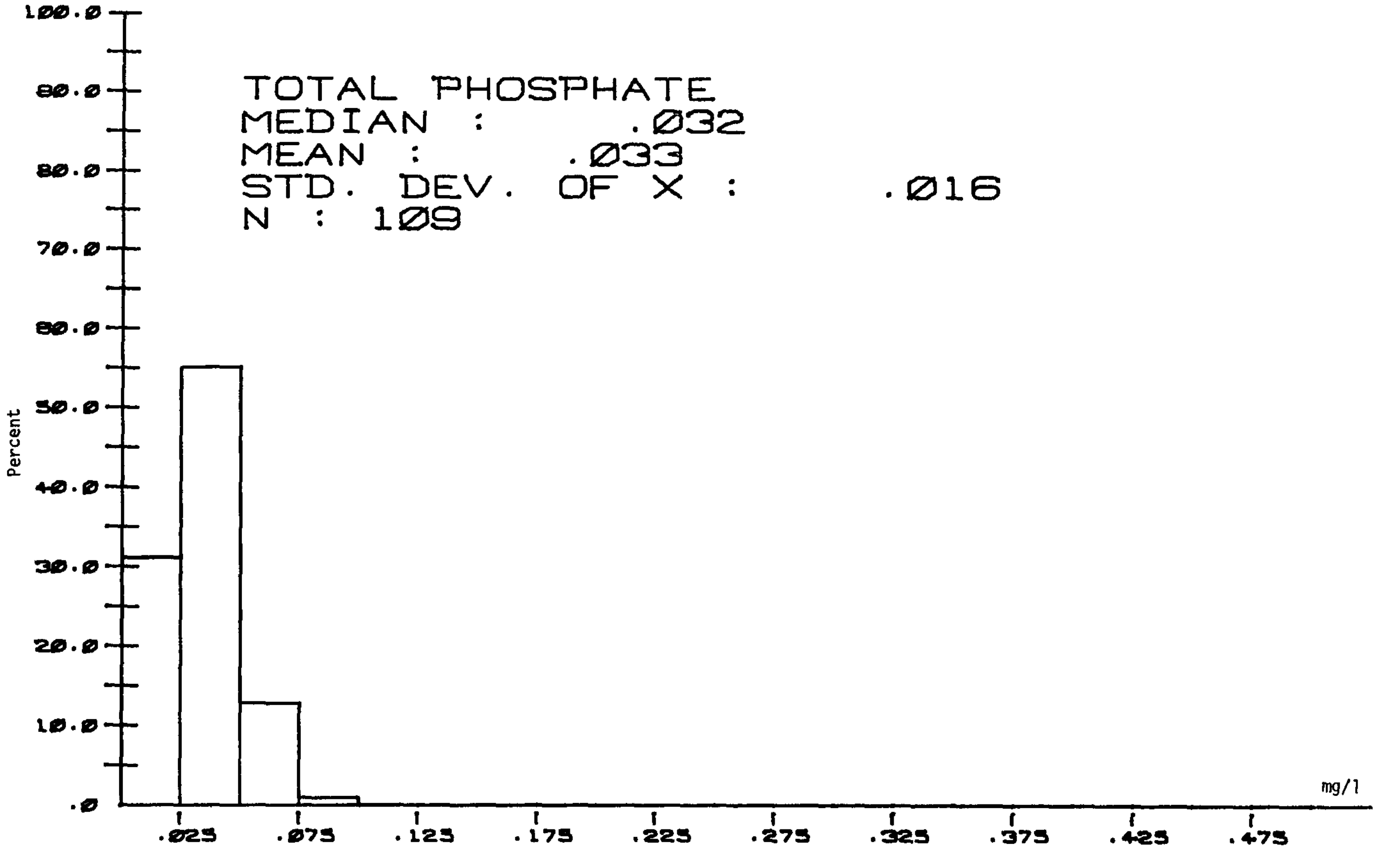


Figure 3.2 Black River Histograms for Total Phosphate

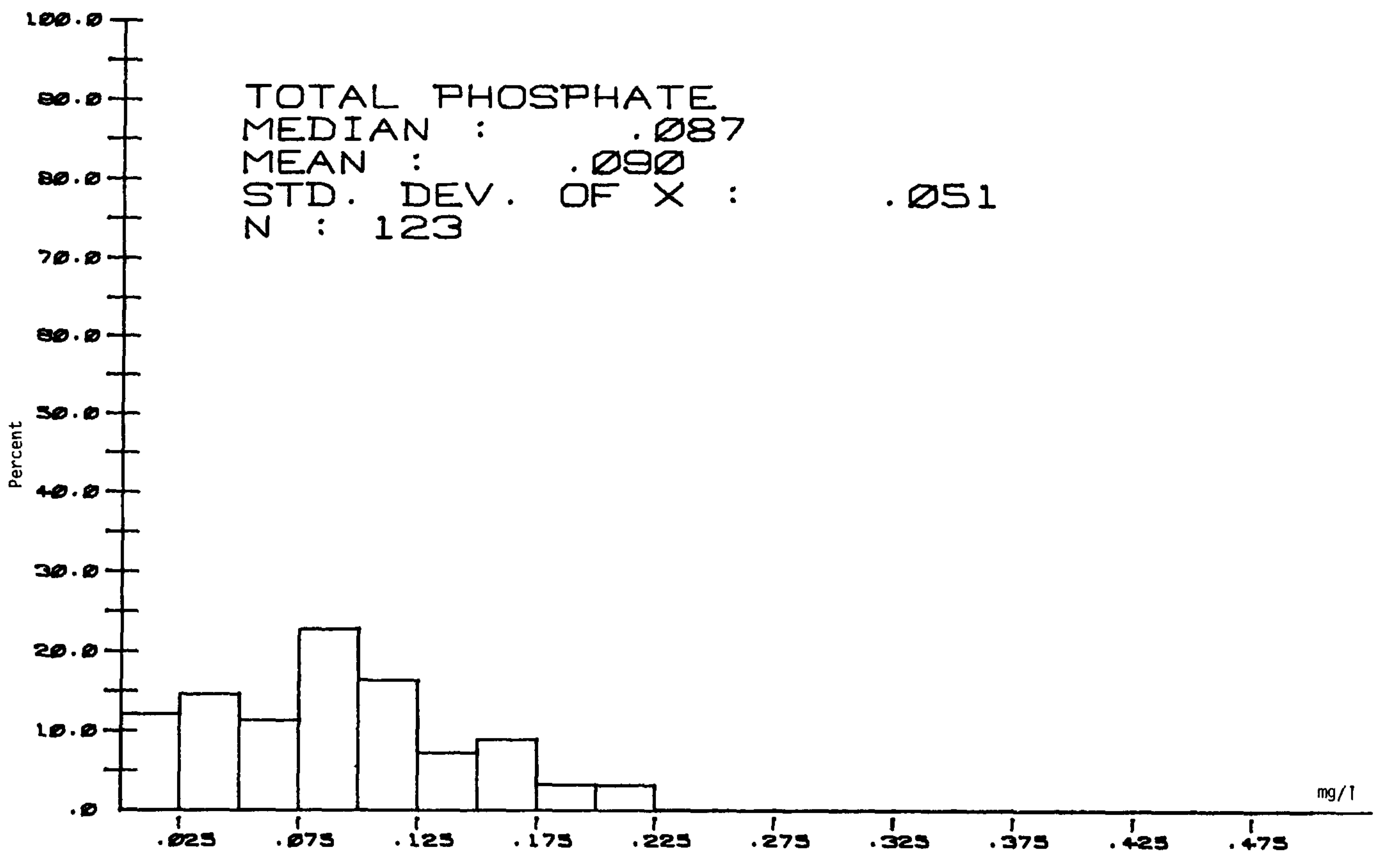
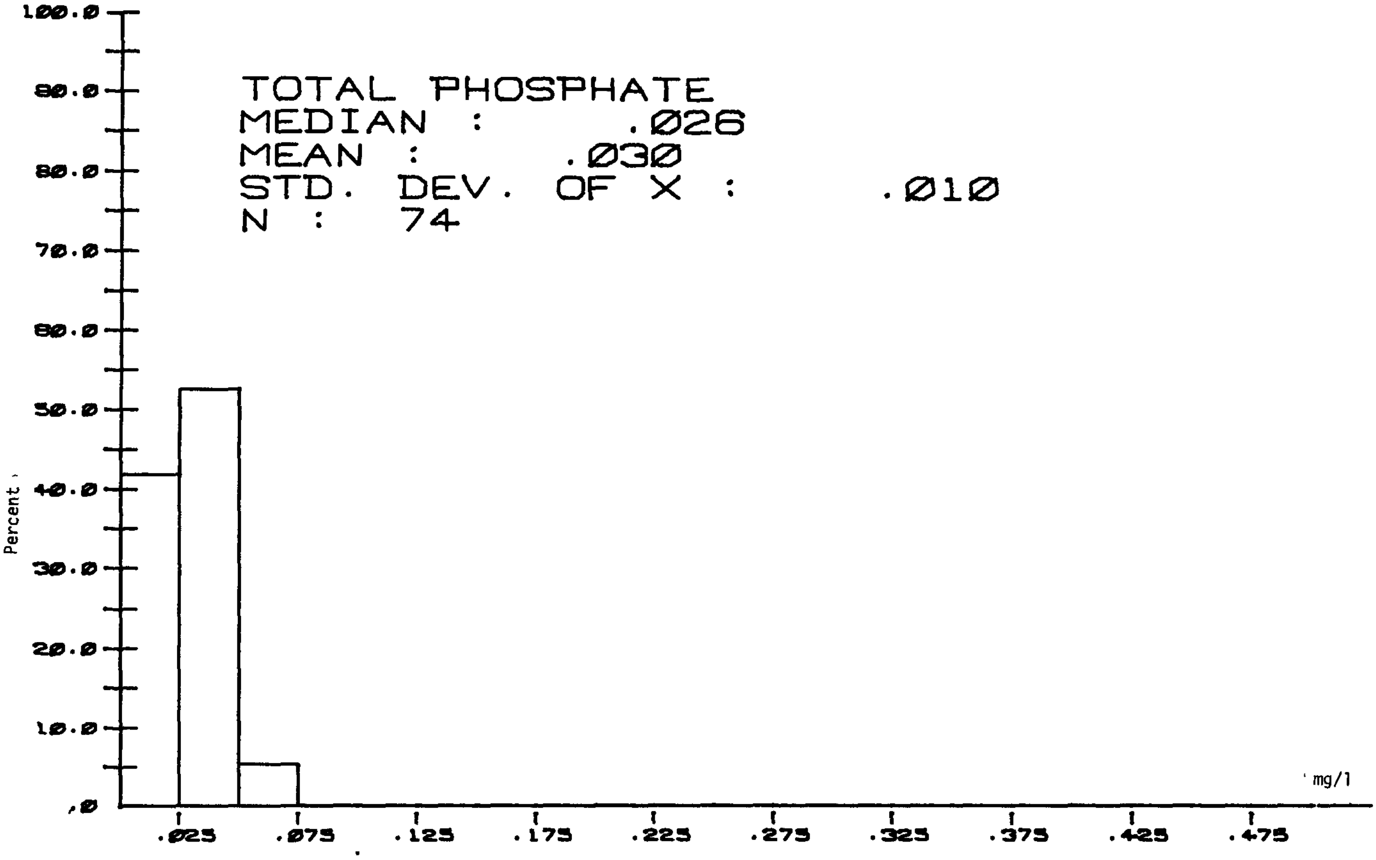


Figure 3.2 Oswego River Histograms for Total Phosphate


TOTAL PHOSPHATE
MEDIAN : .026
MEAN : .030
STD. DEV. OF X : .010
N : 74
Percent
mg/l
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
.0
.025
.075
.125
.175
.225
.275
.325
.375
.425
.475

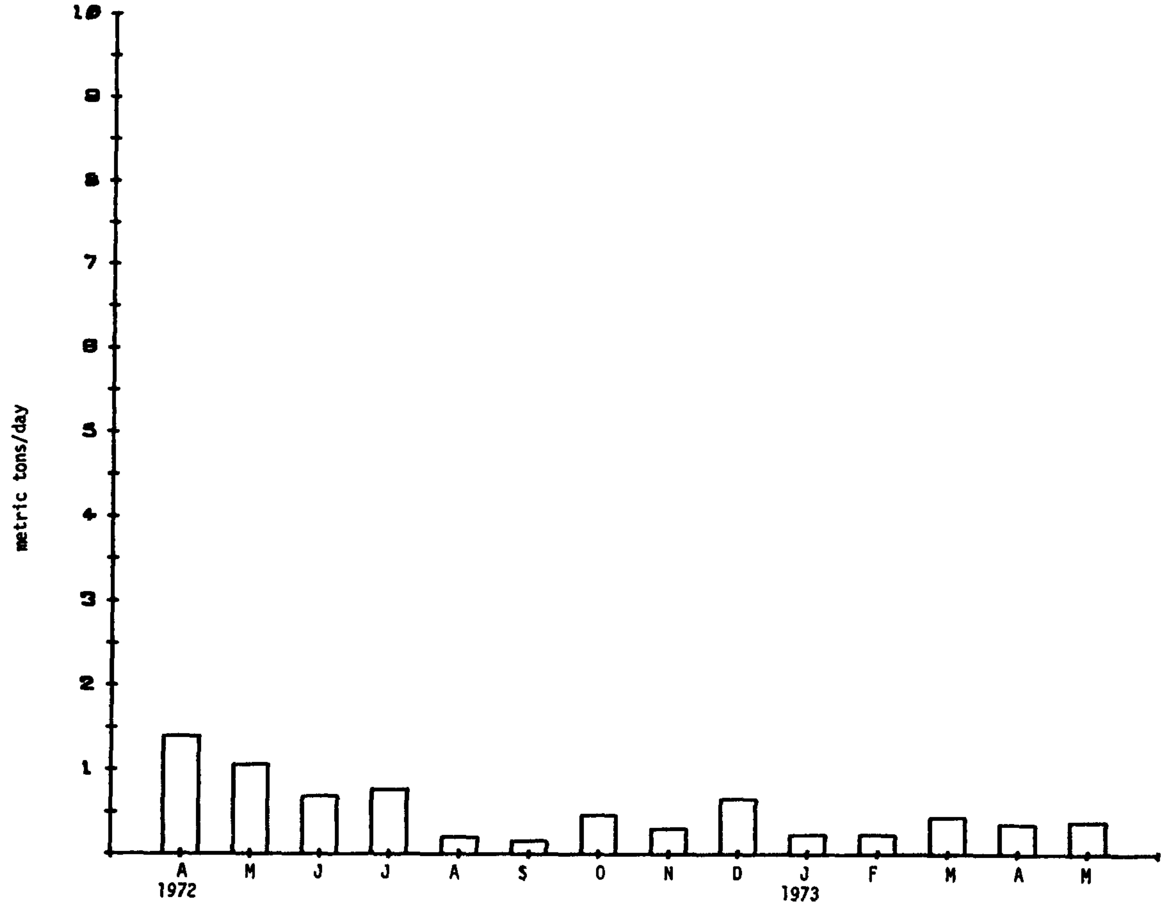


Figure 3.3 Genesee River Monthly Mean Stream Loadings - Total Filterable Phosphate

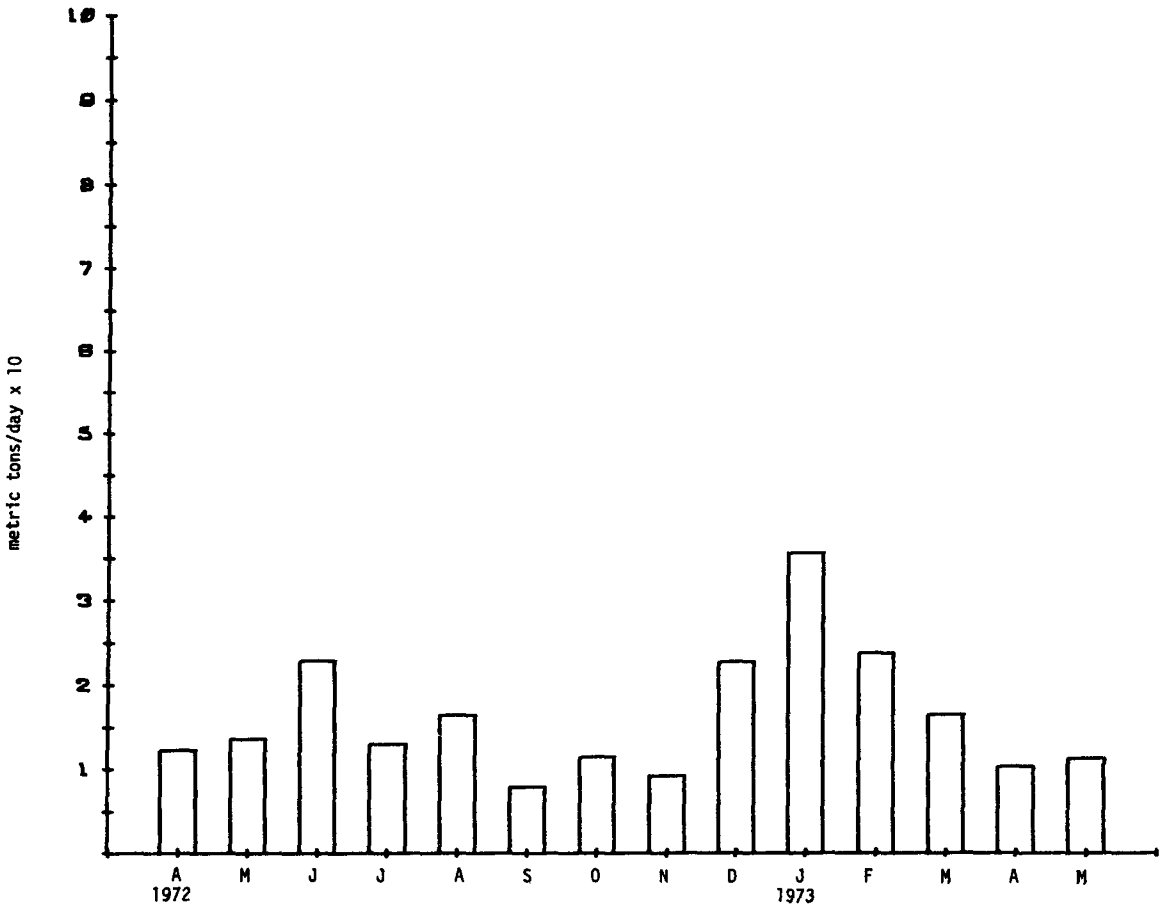


Figure 3.3 Niagara River Monthly Mean Stream Loadings - Total Filterable Phosphate

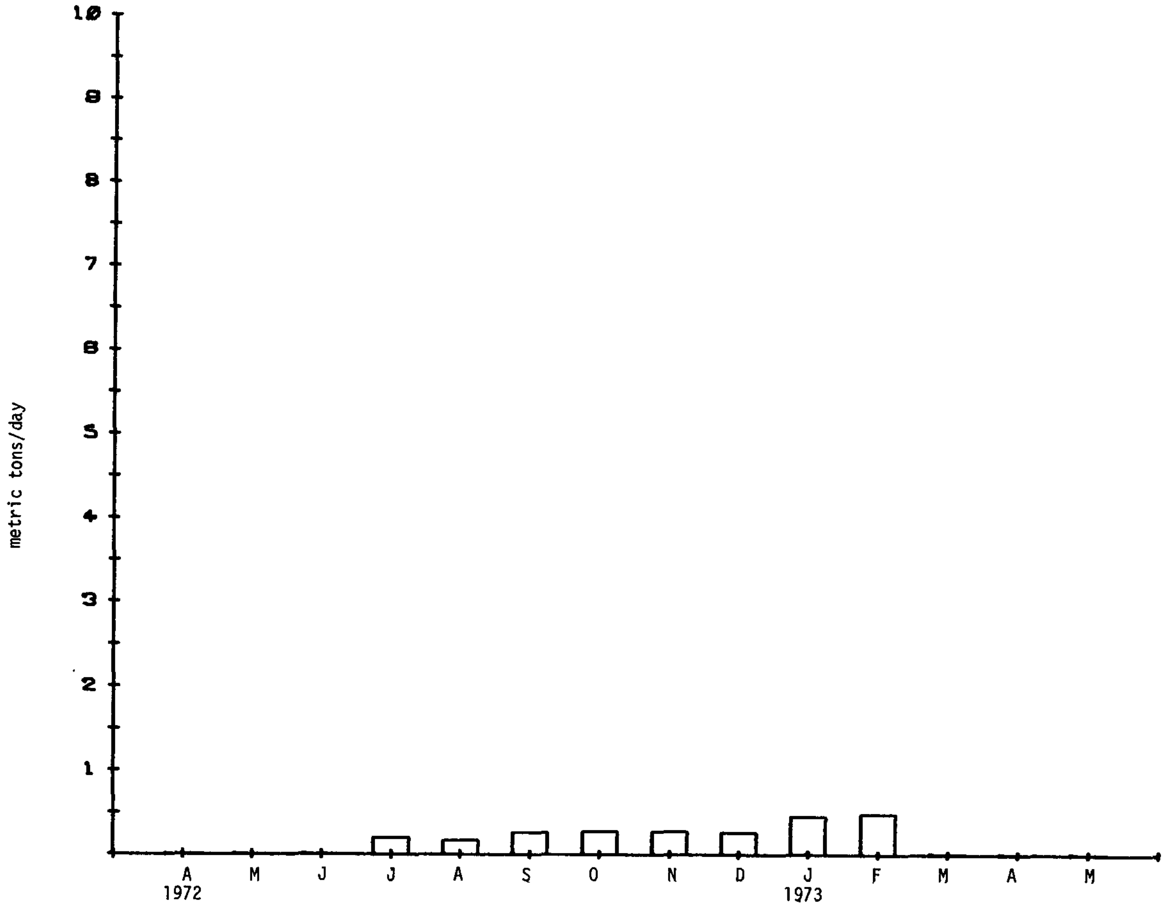


Figure 3.3 Black River Monthly Mean Stream Loadings -
Total Filterable Phosphate

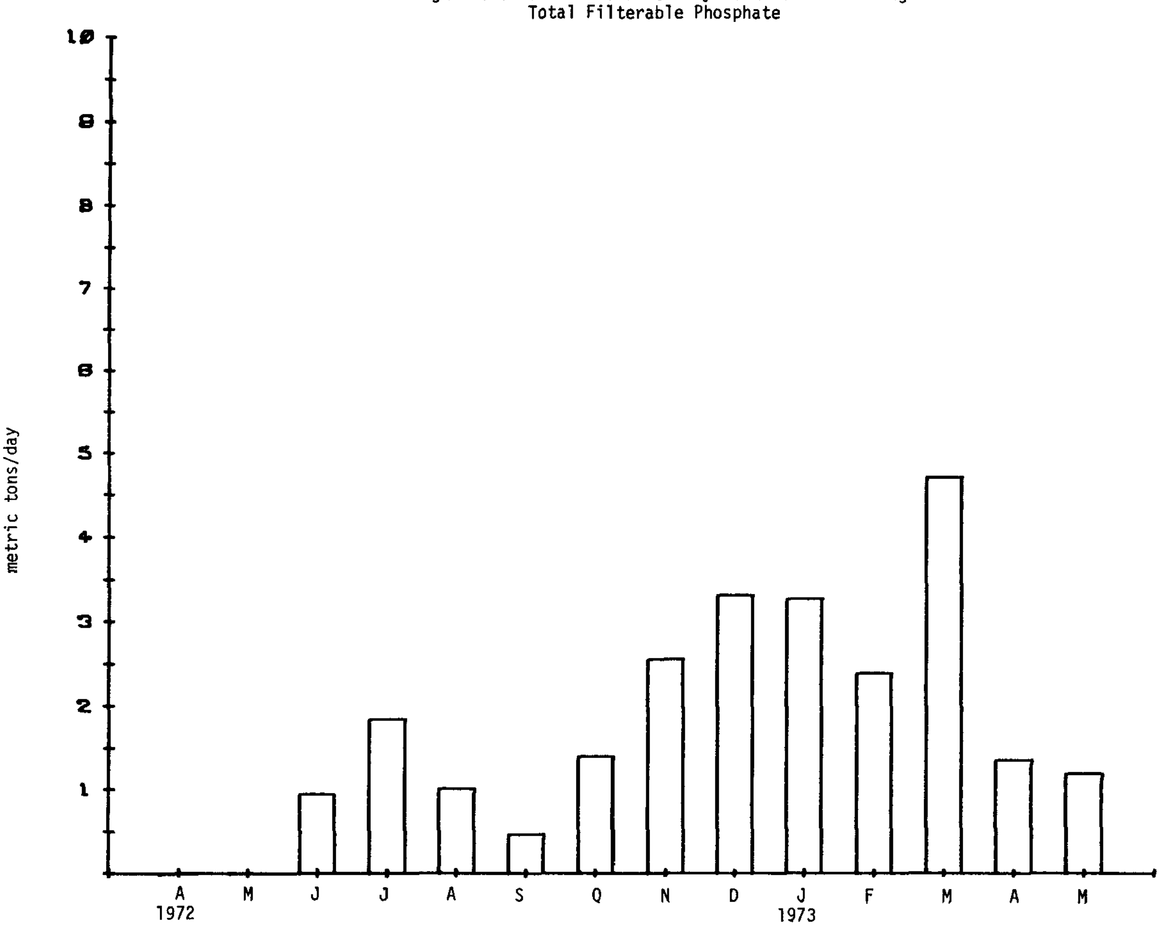


Figure 3.3 Oswego River Monthly Mean Stream Loadings -
Total Filterable Phosphate

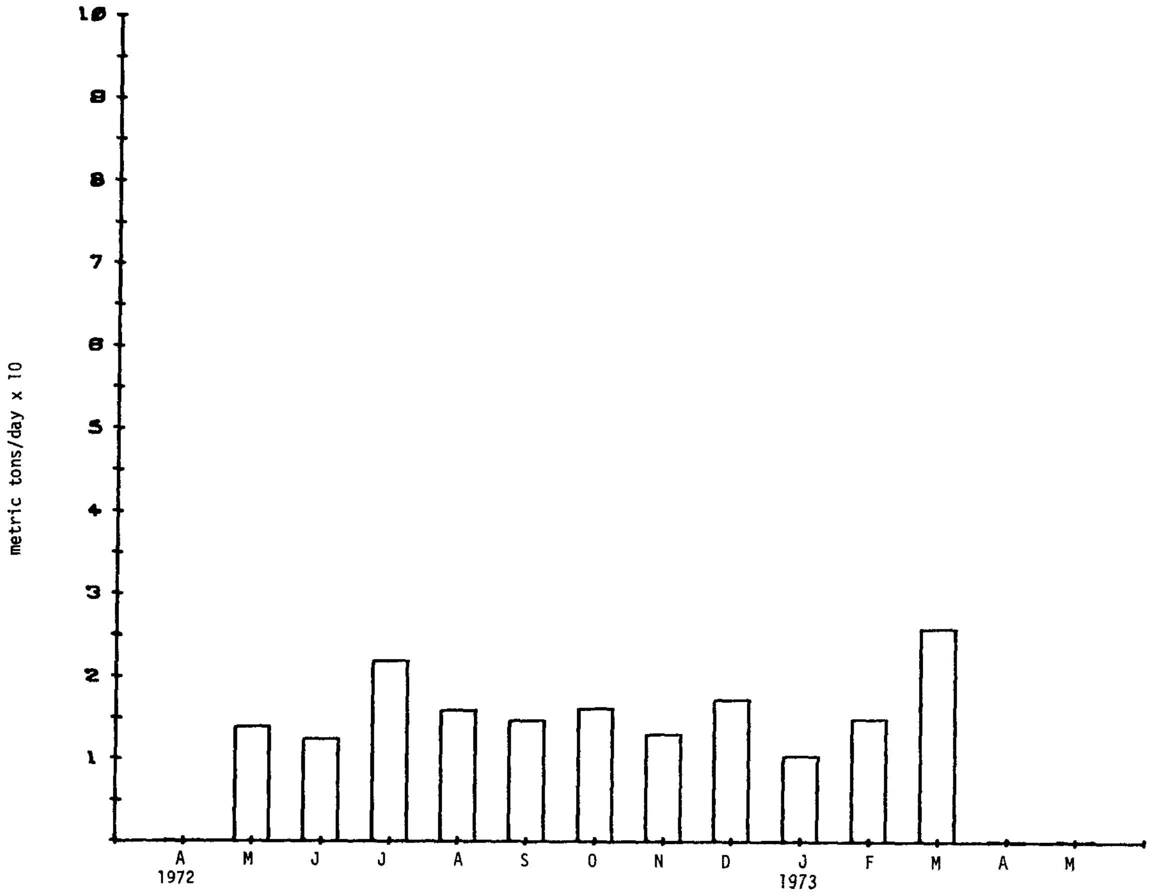


Figure 3.3 St. Lawrence River Mean Monthly Loadings - Total Filterable Phosphate

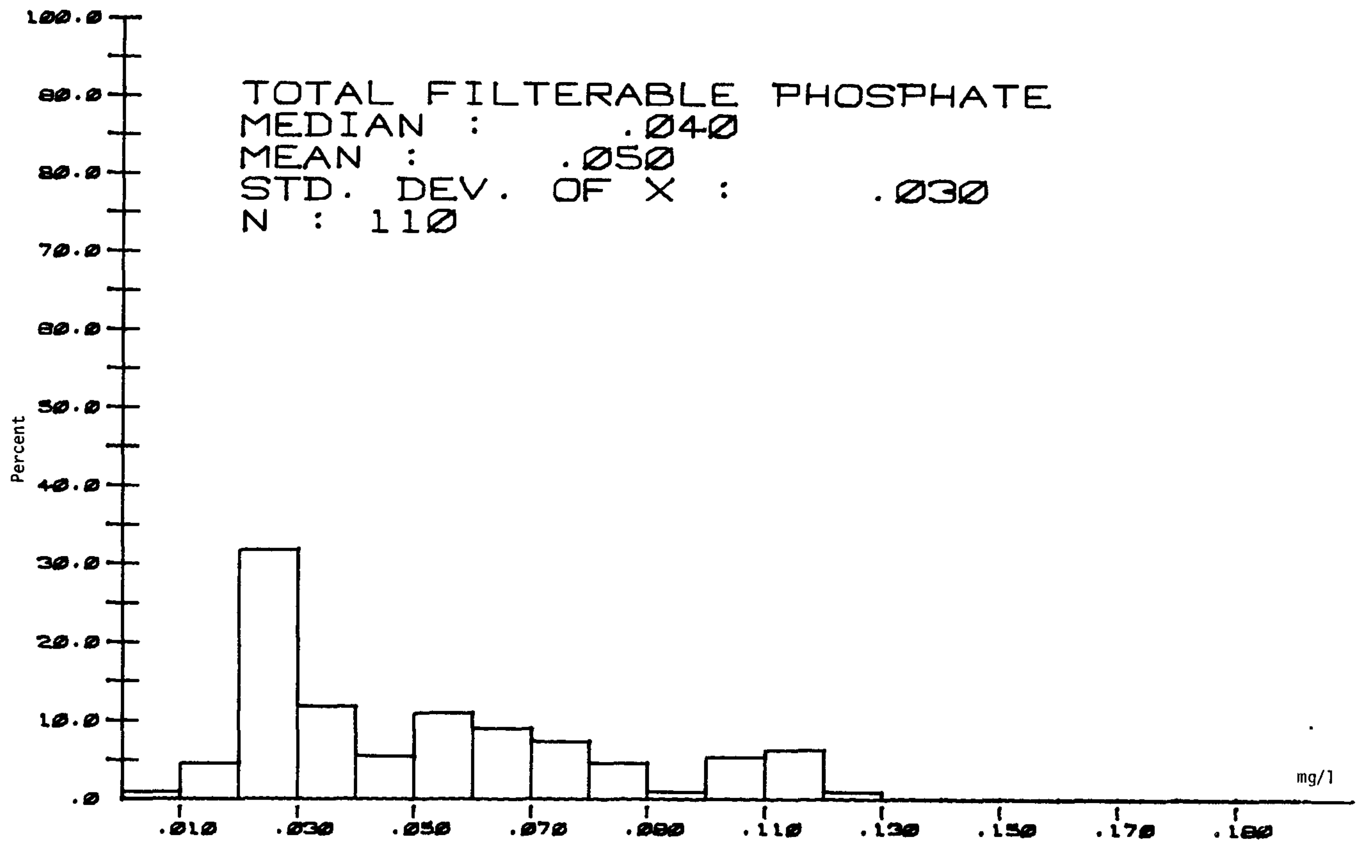


Figure 3.4 Genesee River Histograms for Total Filterable Phosphate

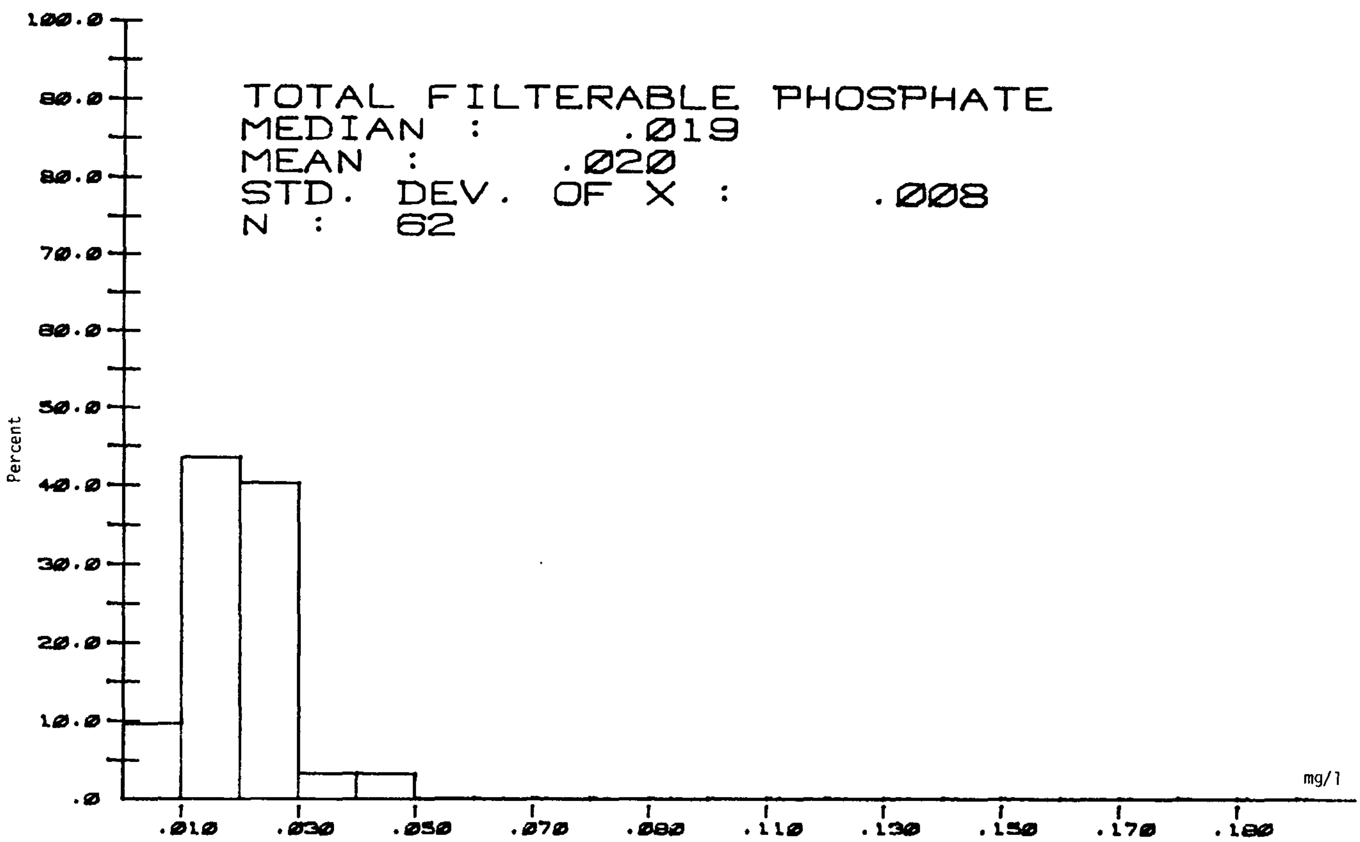


Figure 3.4 Niagara River Histograms for Total Filterable Phosphate

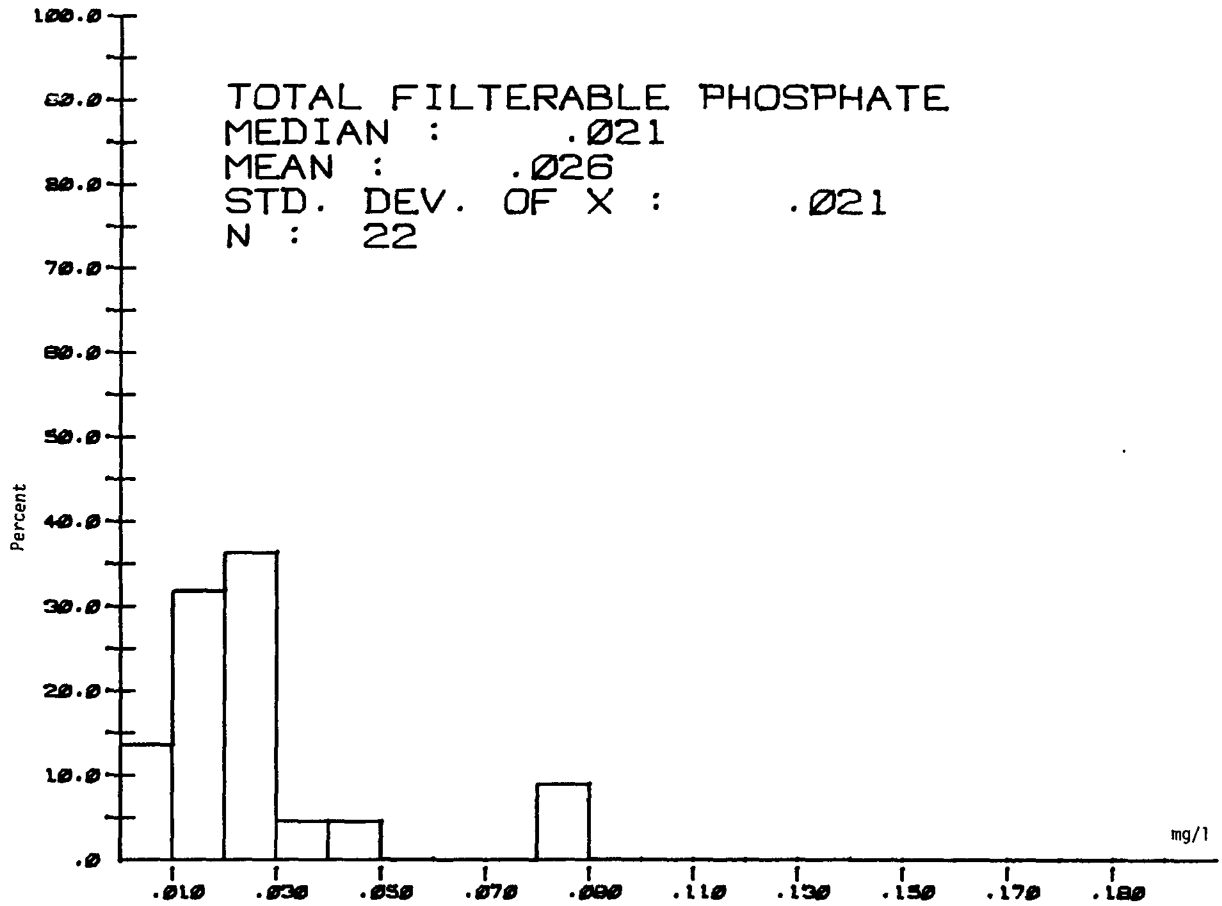


Figure 3.4 Black River Histograms for Total Filterable Phosphate

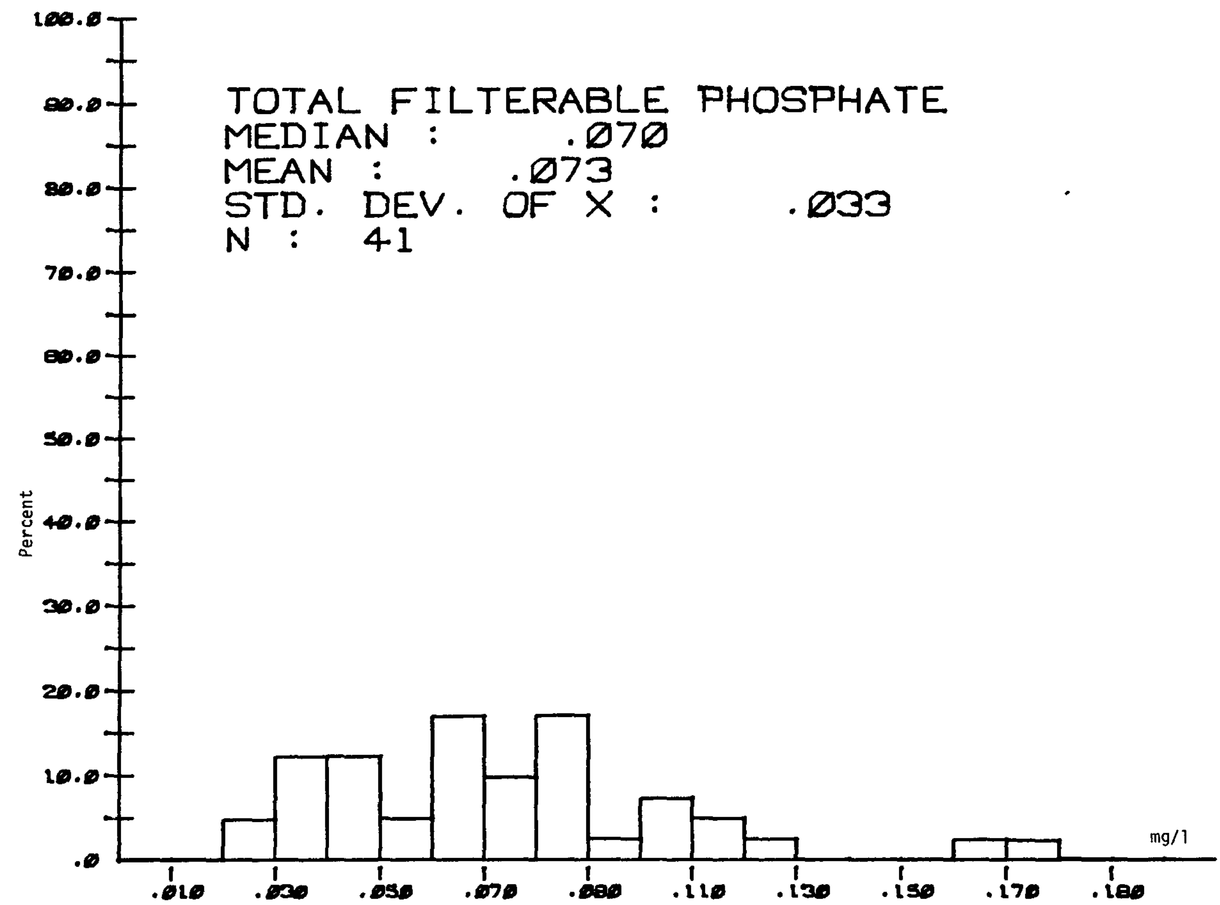


Figure 3.4 Oswego River Histograms for Total Filterable Phosphate

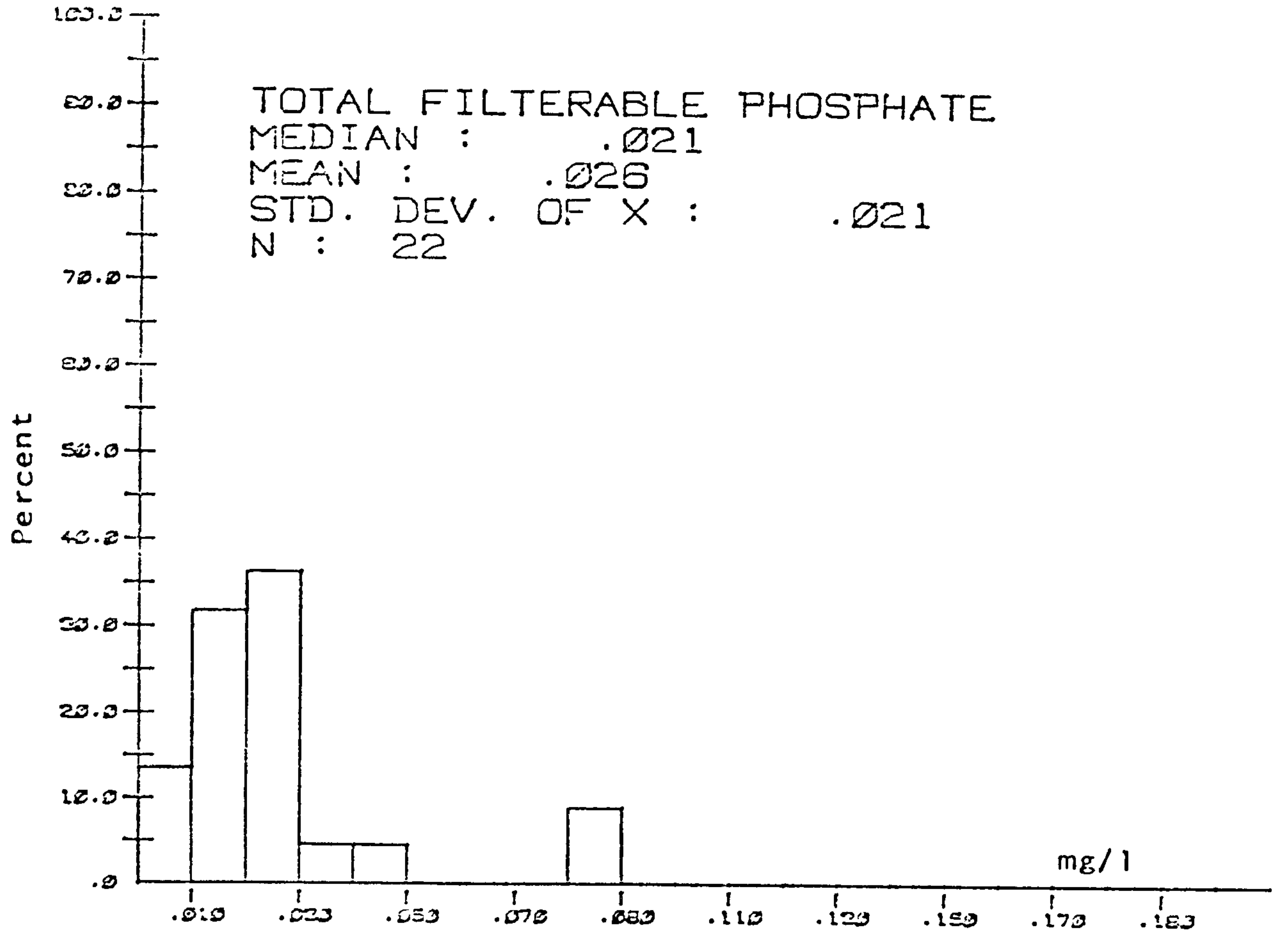


Figure 3.4 Black River Histograms for Total Filterable Phosphate

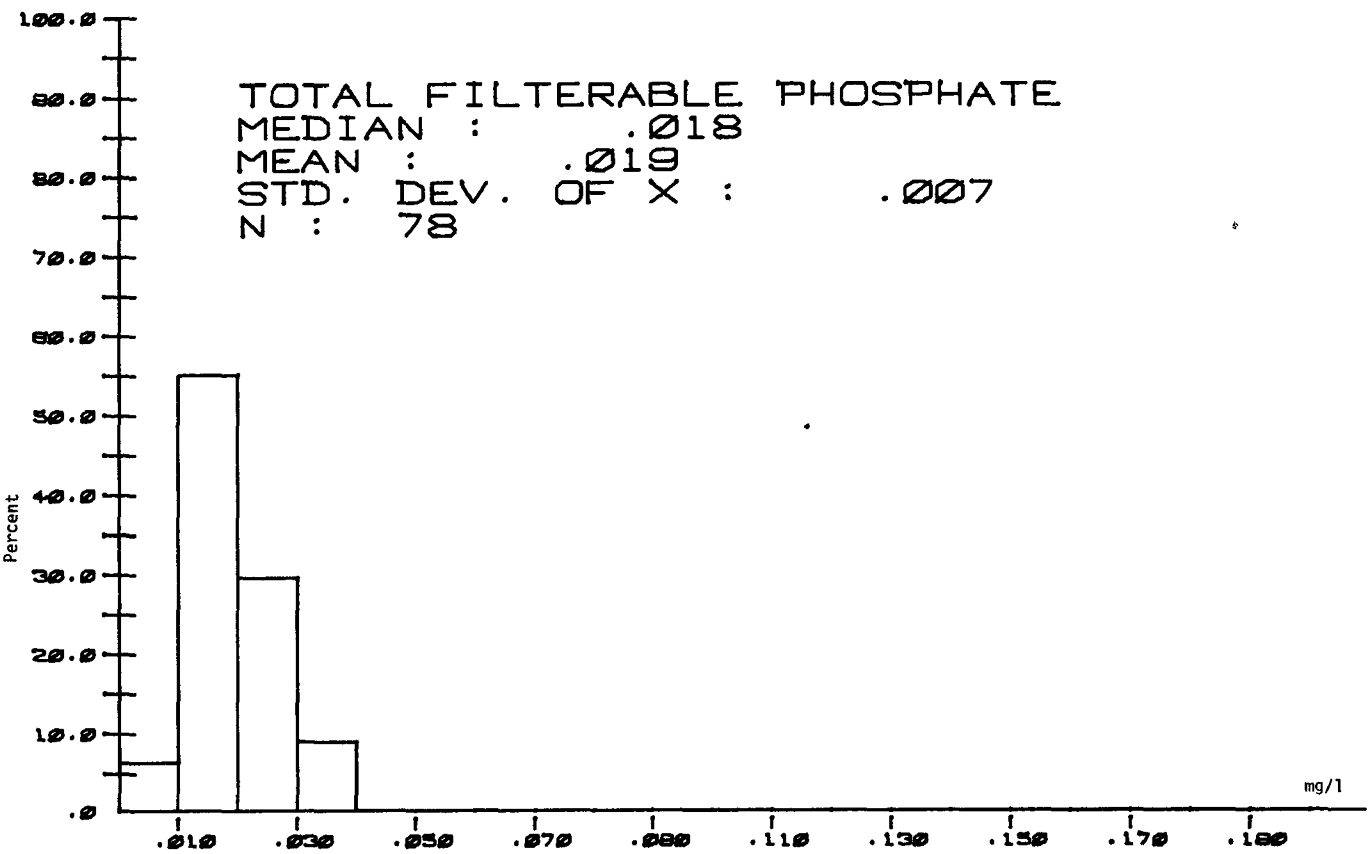


Figure 3.4 St. Lawrence River Histograms for Total Filterable Phosphate

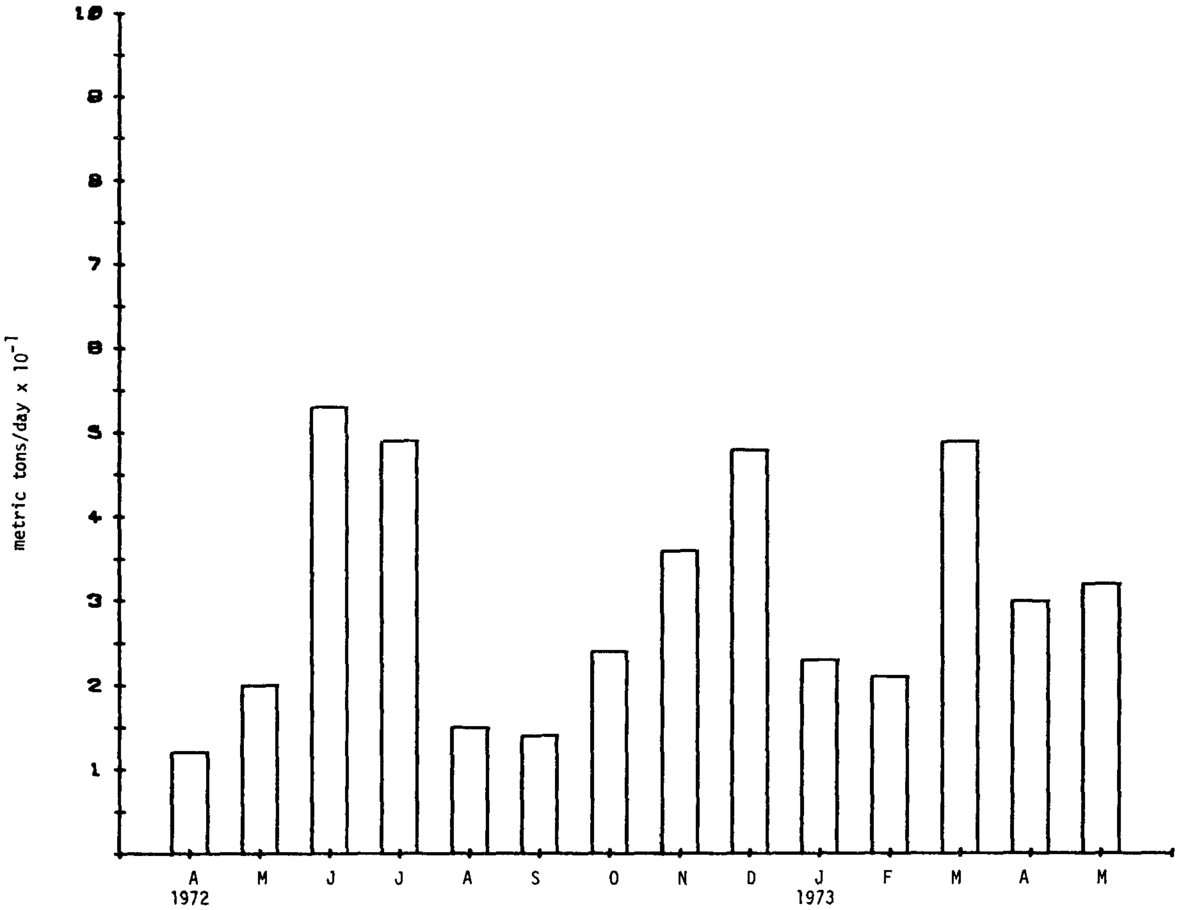


Figure 3.5 Genesee River Monthly Mean Stream Loadings - Dissolved Orthophosphate

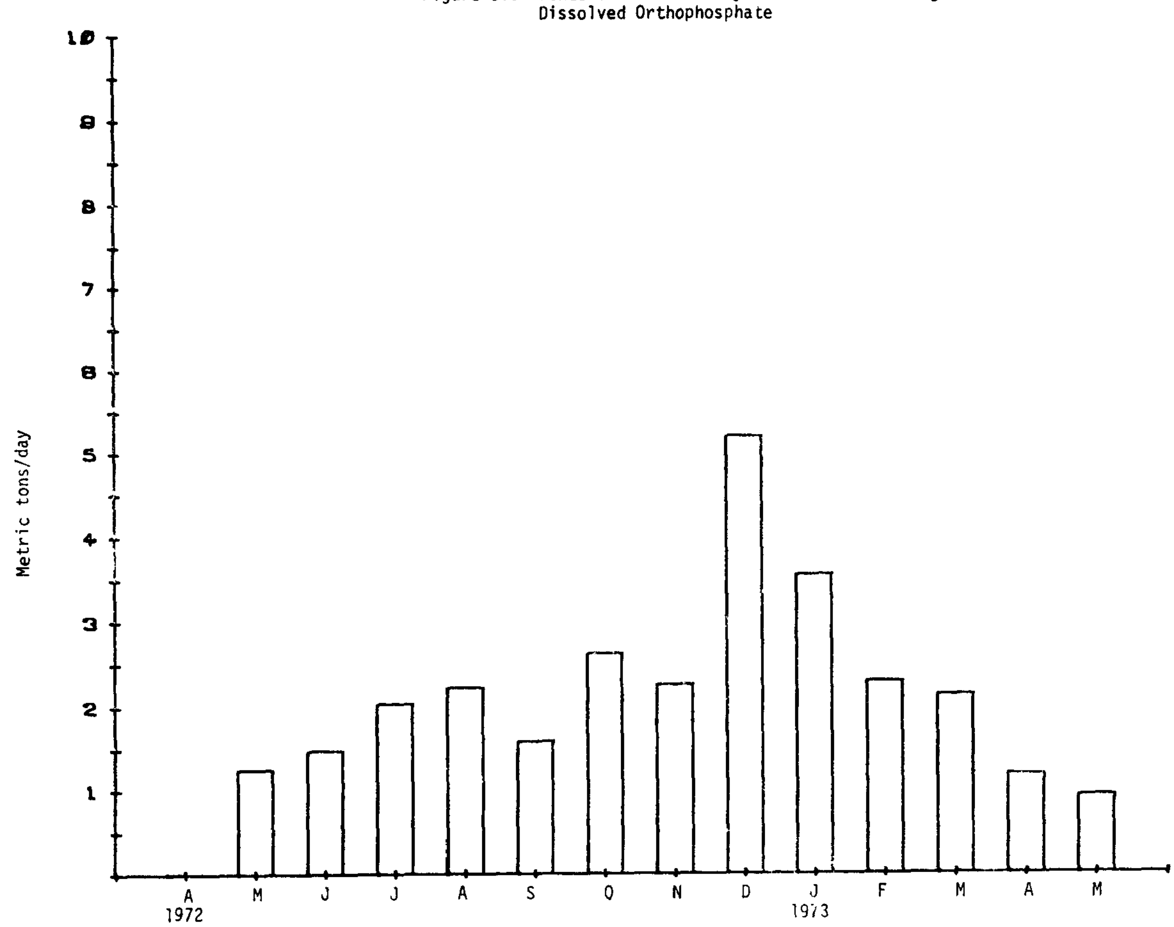


Figure 3.5 Niagara River Monthly Mean Stream Loadings - Dissolved Orthophosphate

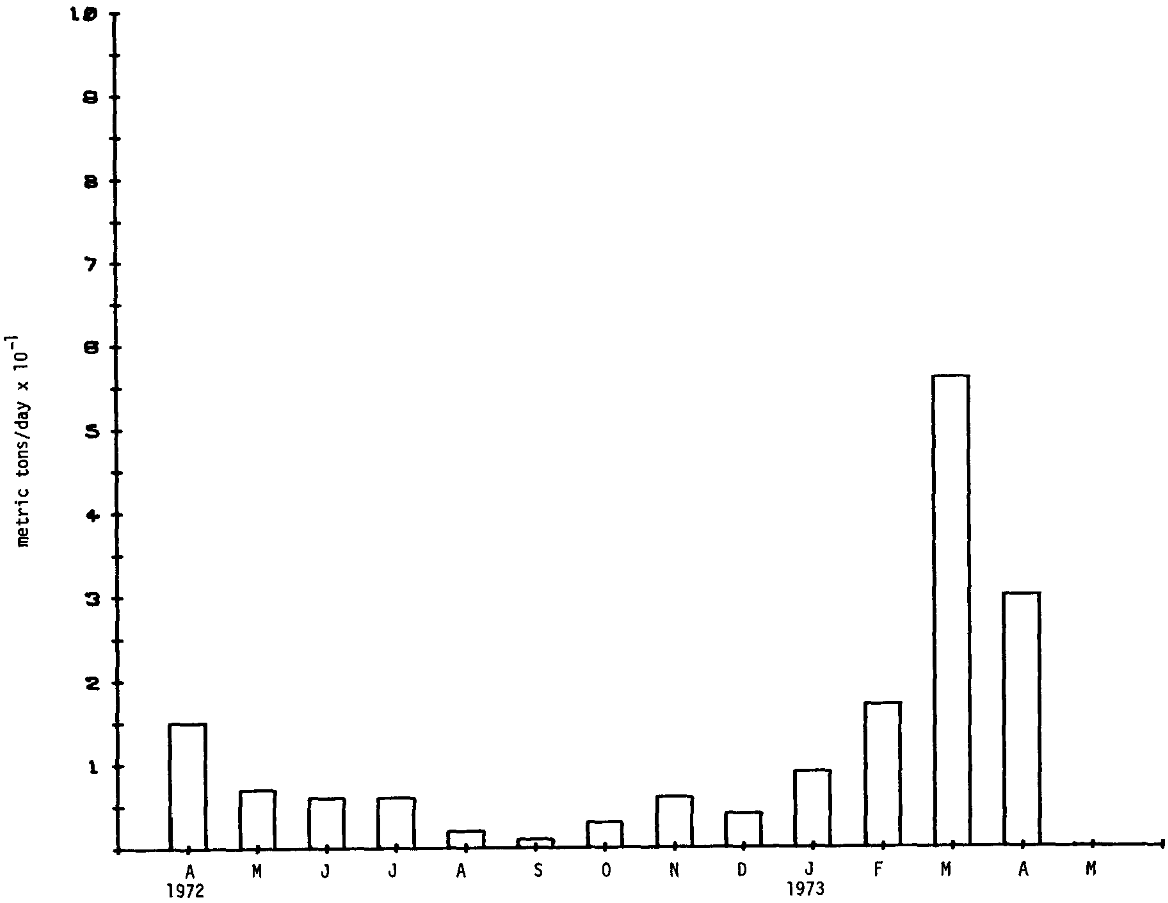


Figure 3.5 Black River Monthly Mean Stream Loadings - Dissolved Orthophosphate

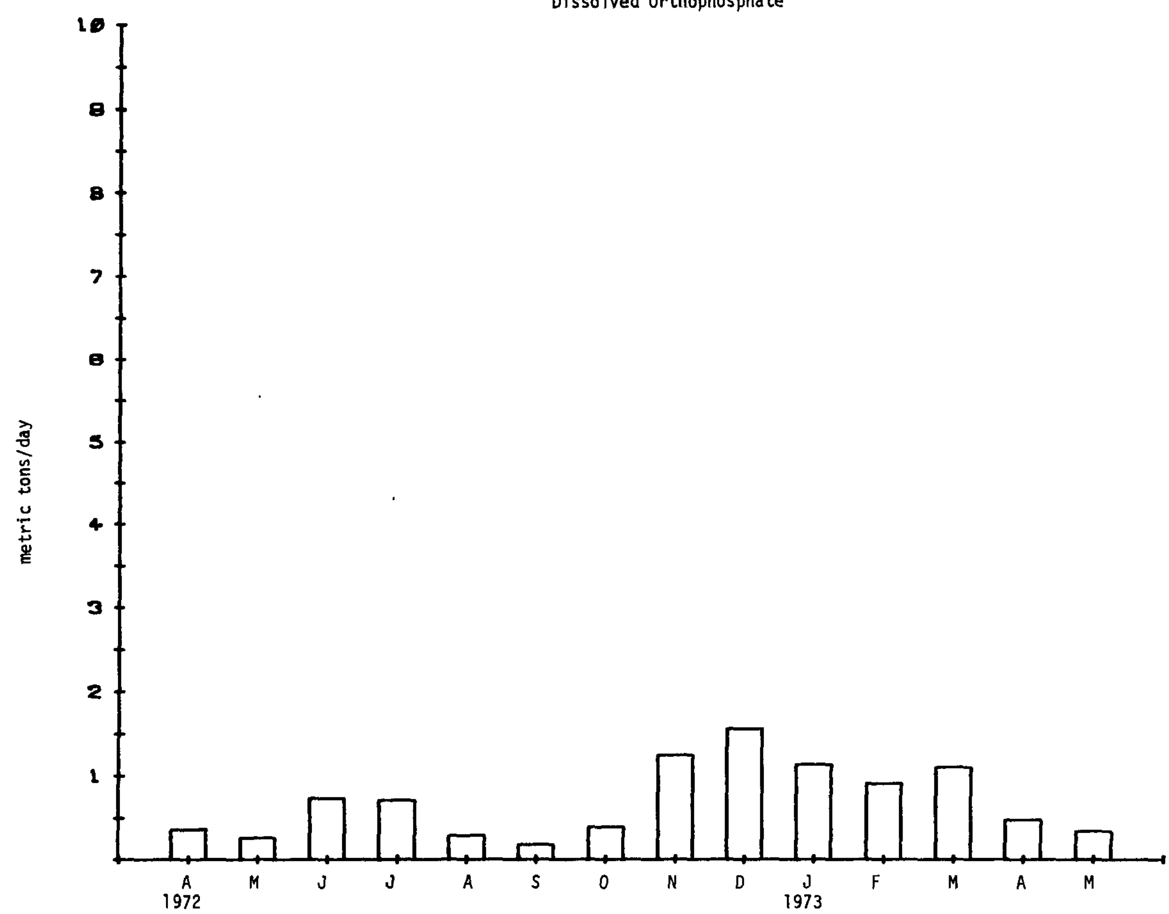


Figure 3.5 Oswego River Monthly Mean Stream Loadings - Dissolved

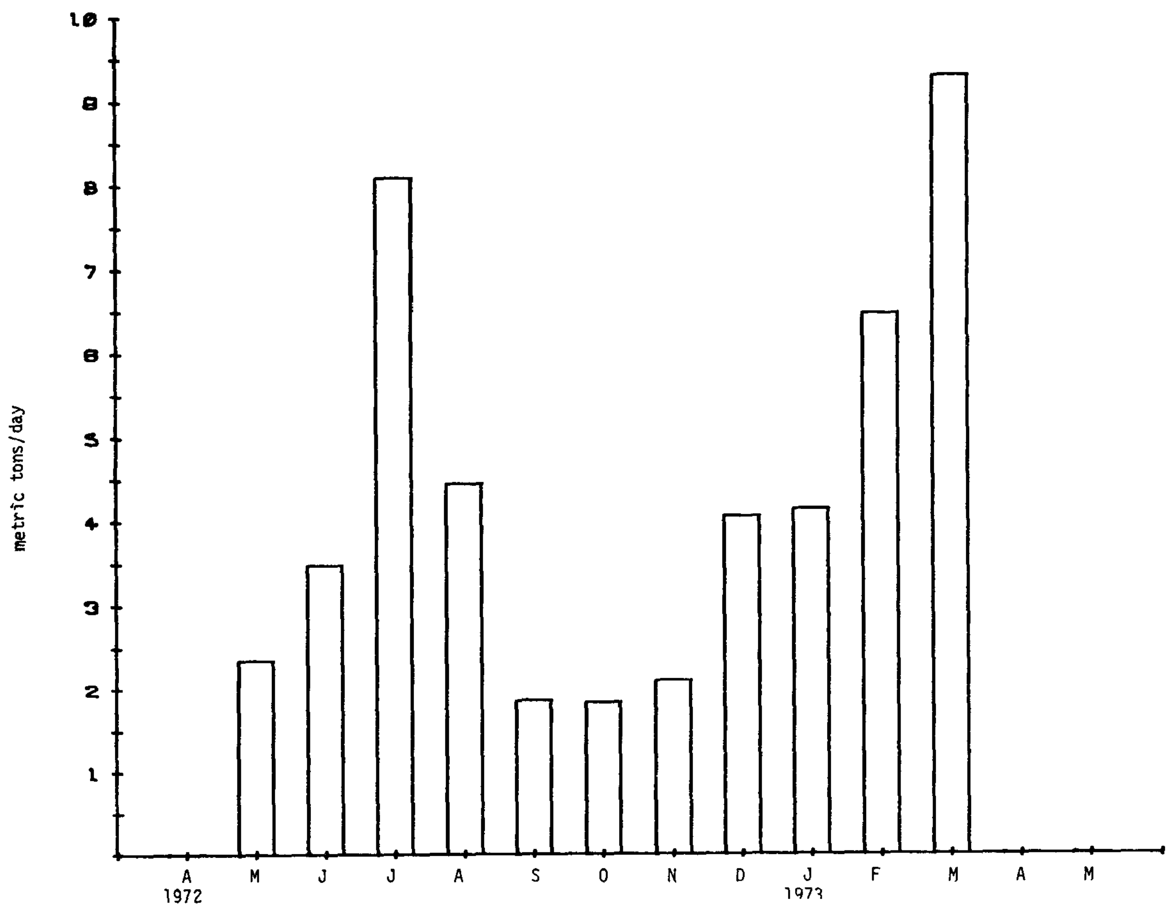


Figure 3.5 St. Lawrence River Monthly Mean Stream Loadings -
Dissolved Orthophosphate

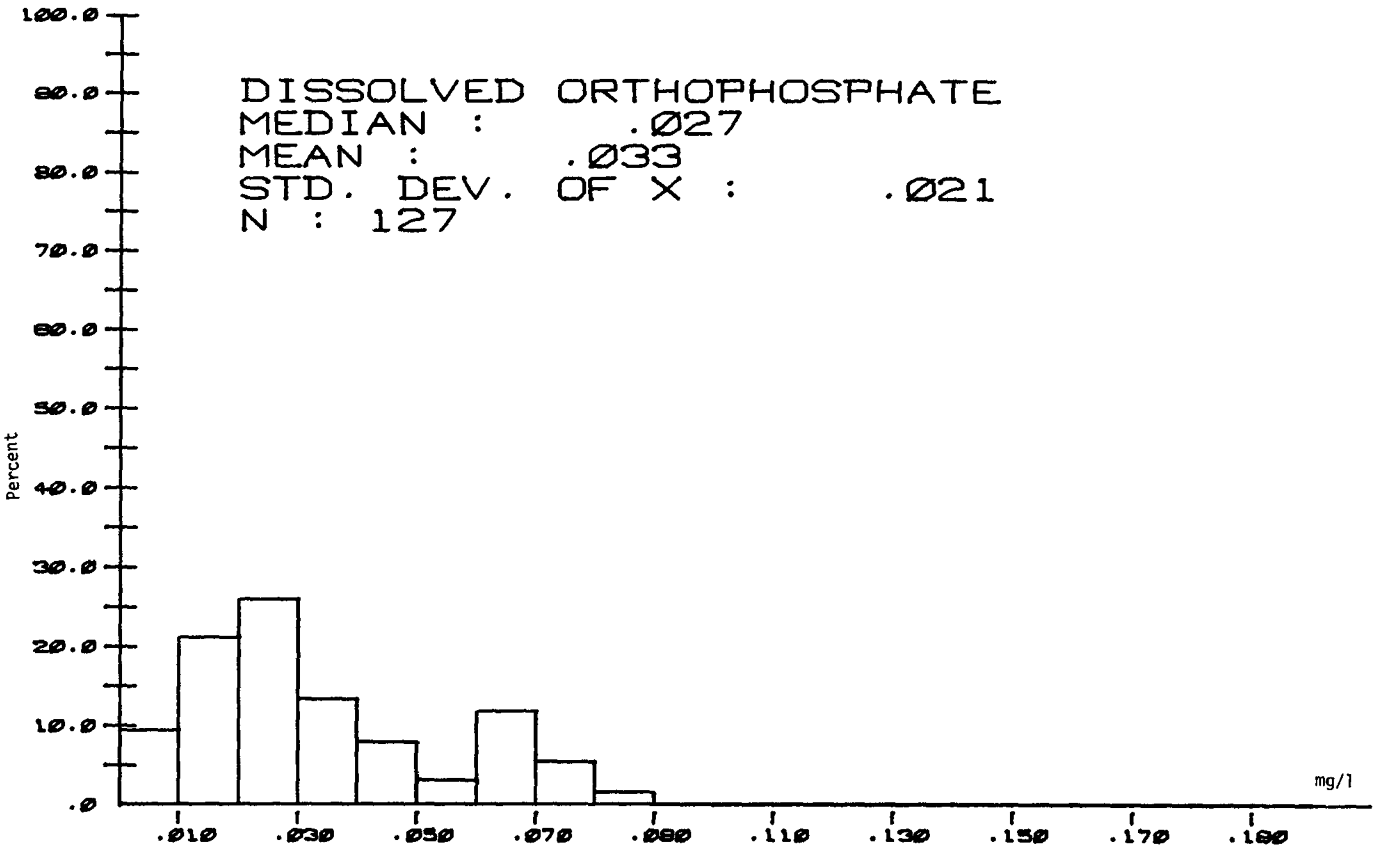


Figure 3.6 Genesee River Histograms for Dissolved Orthophosphate

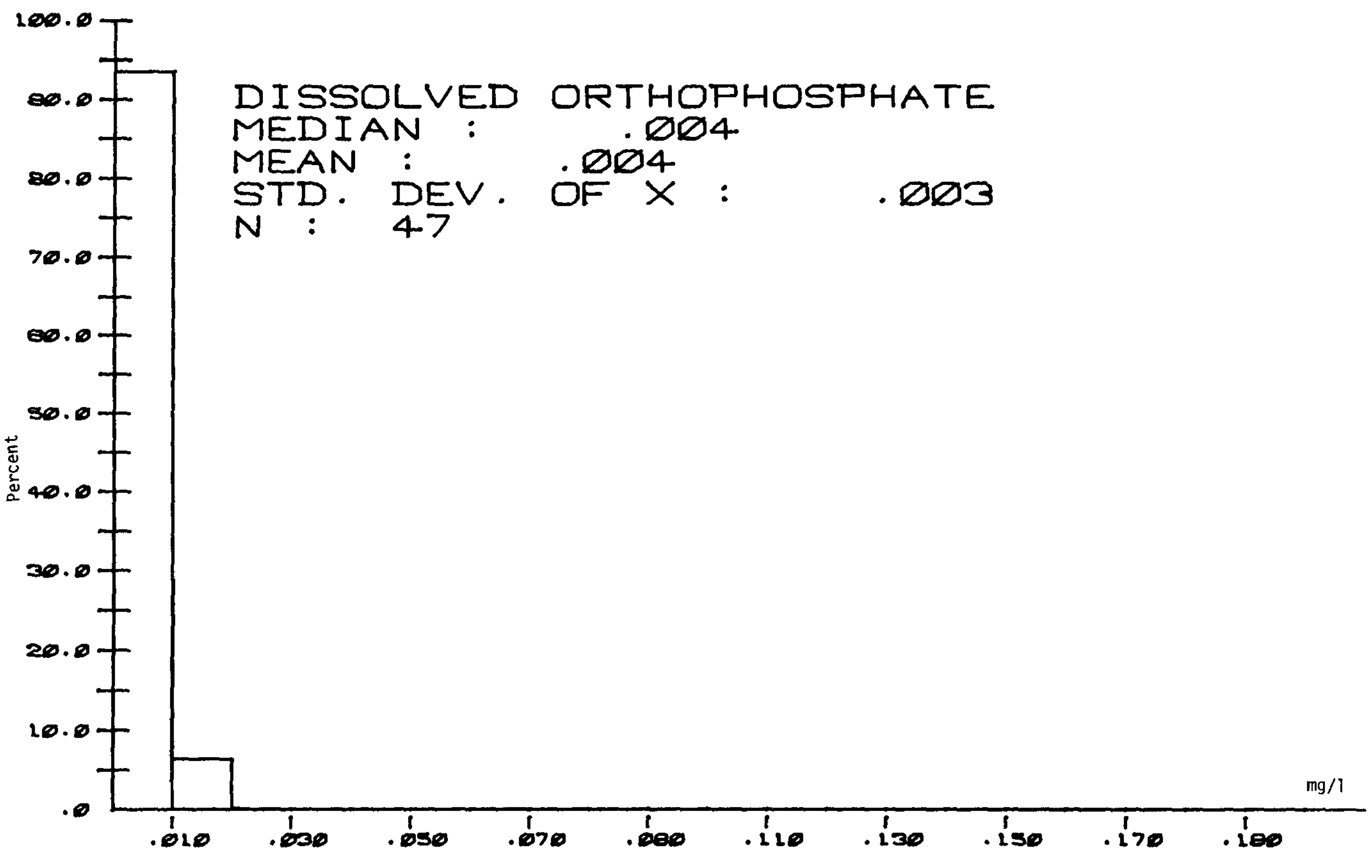


Figure 3.6 Niagara River Histograms for Dissolved Orthophosphate

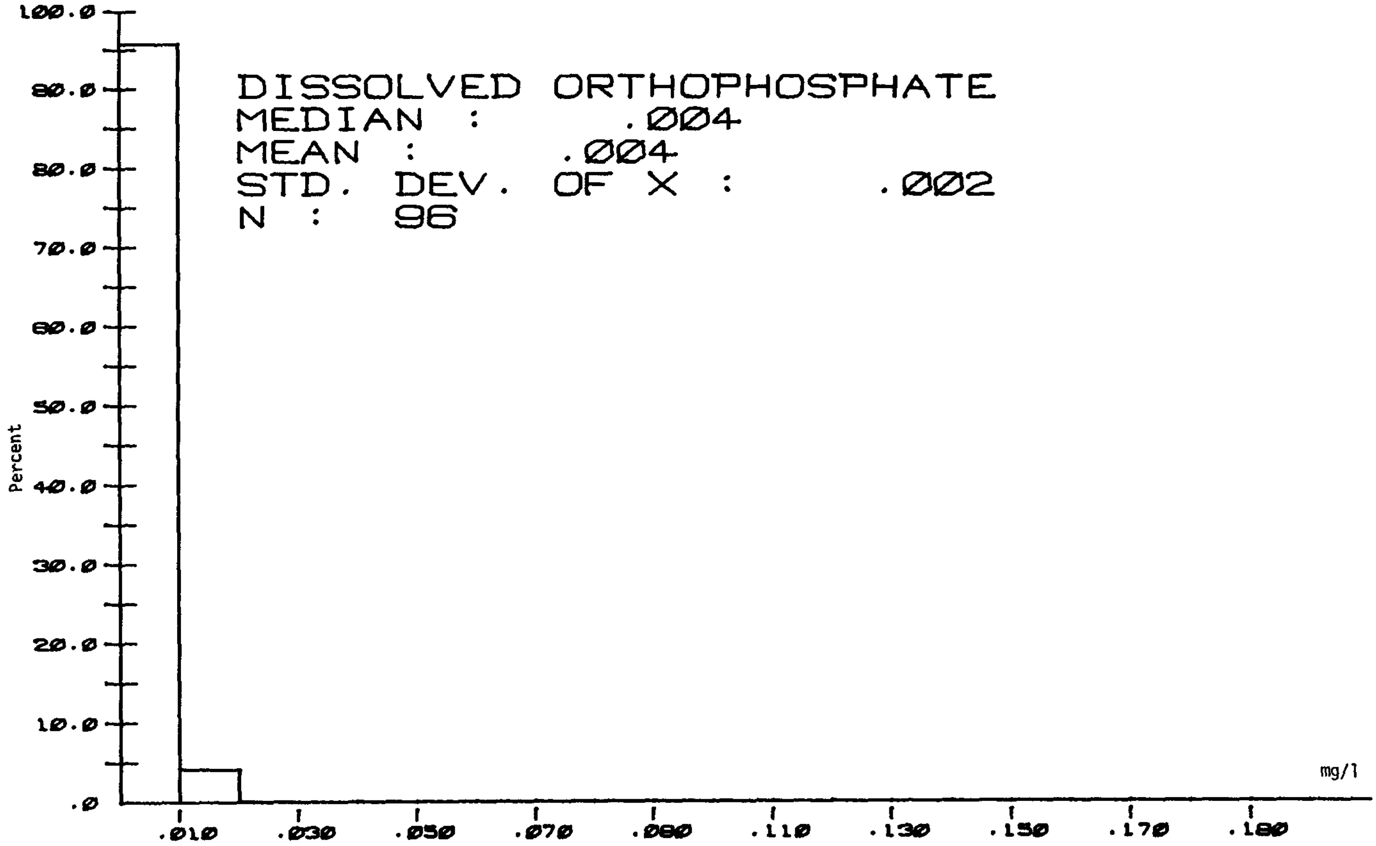


Figure 3.6 Black River Histograms for Dissolved Orthophosphate

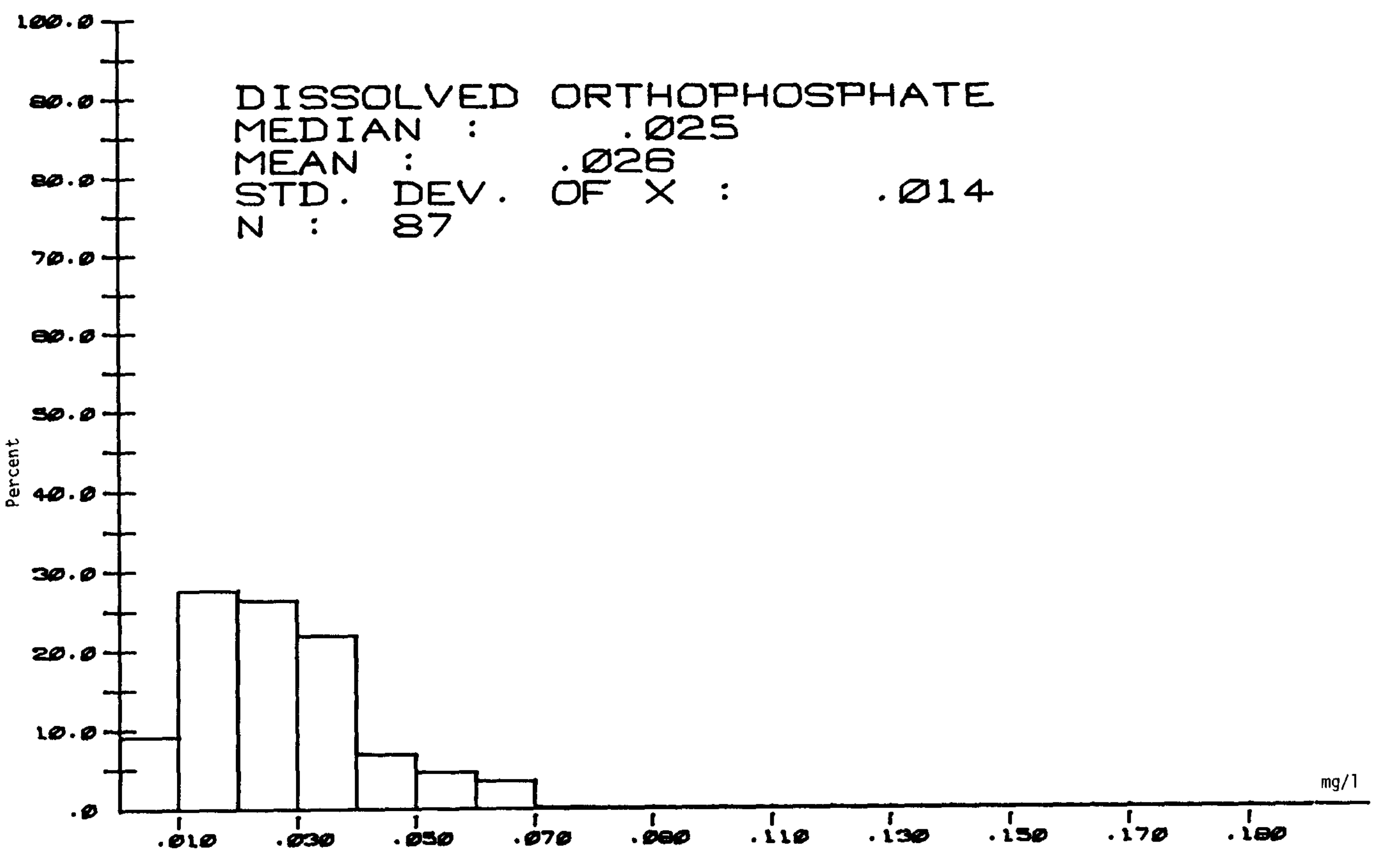


Figure 3.6 Oswego River Histograms for Dissolved Orthophosphate

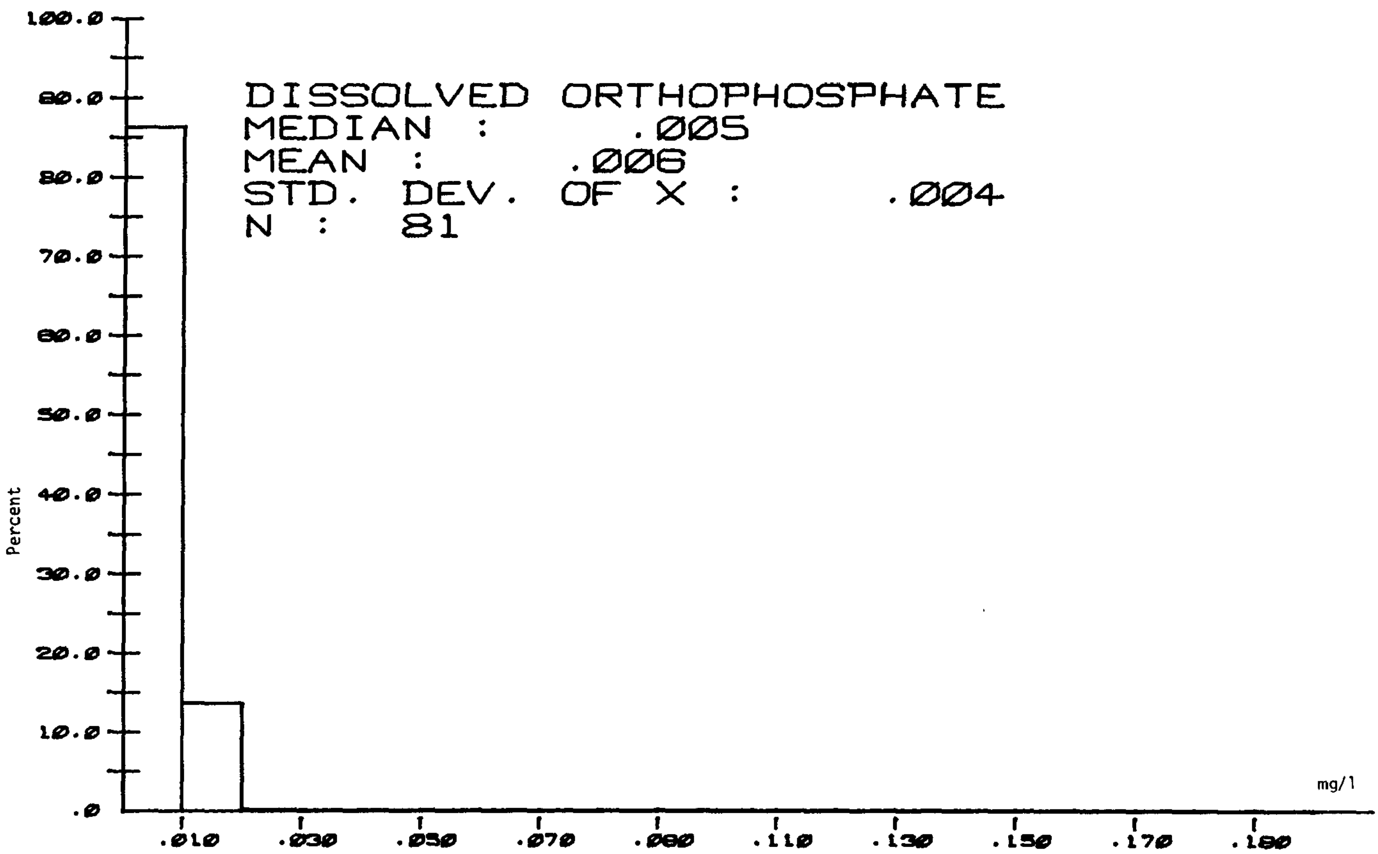


Figure 3.6 St. Lawrence River Histograms for Dissolved Orthophosphate

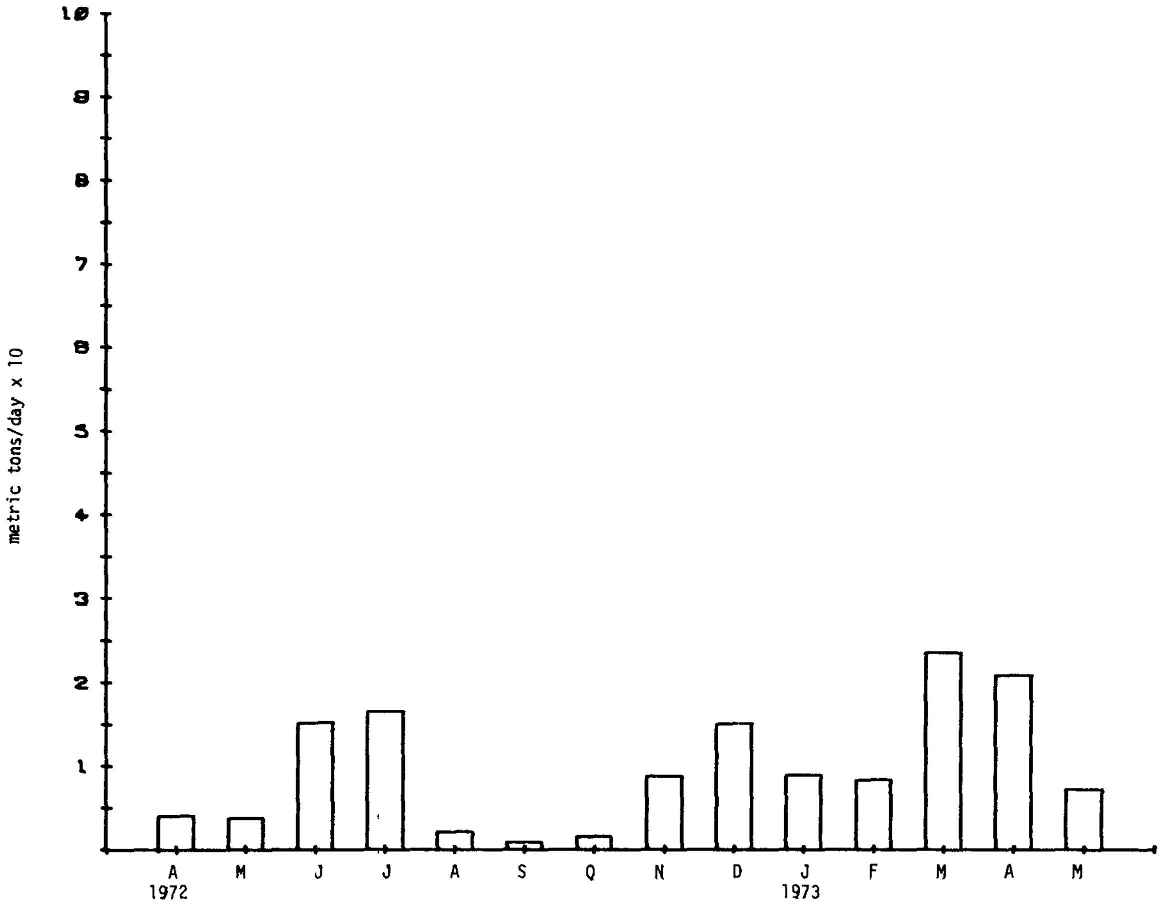


Figure 3.7 Genesee River Monthly Mean Stream Loadings - Nitrite-Nitrate

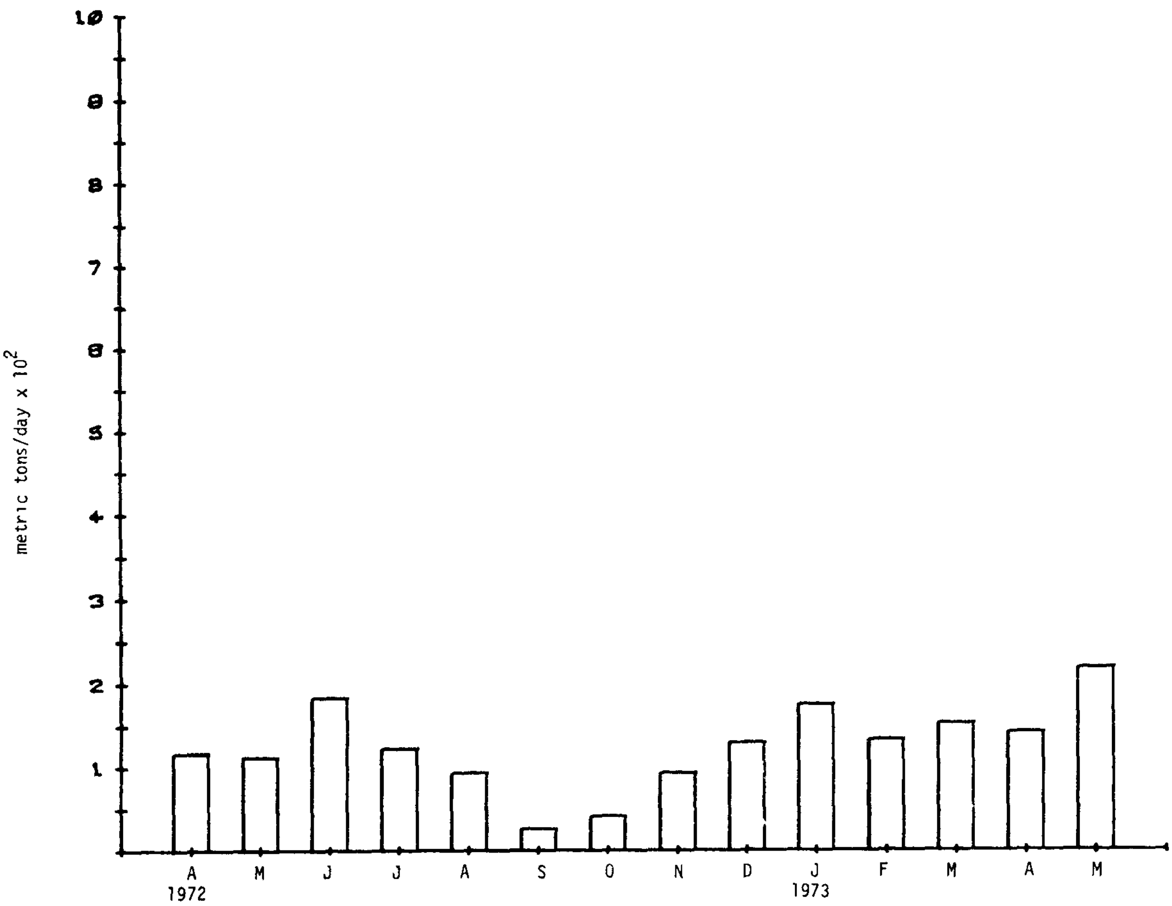


Figure 3.7 Niagara River Monthly Mean Stream Loadings - Nitrite-Nitrate

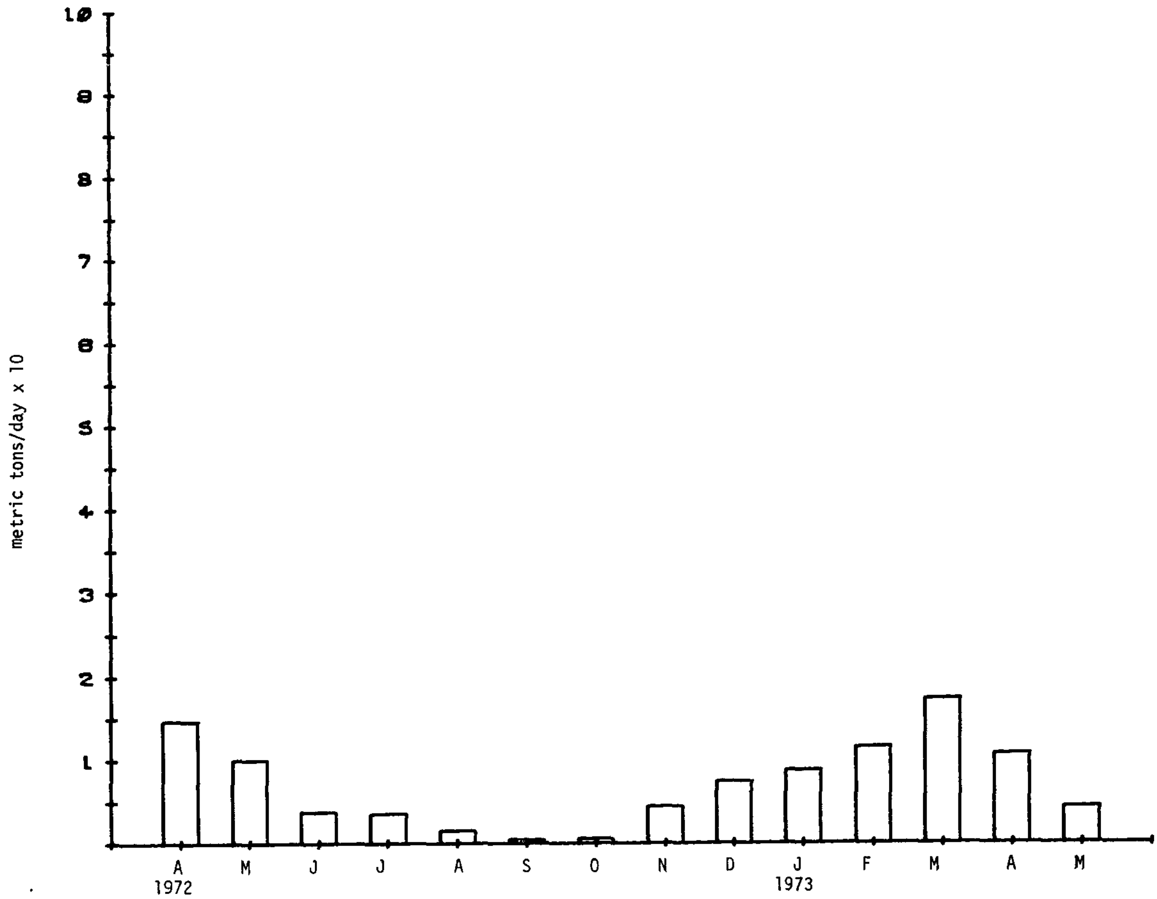


Figure 3.7 Black River Monthly Mean Stream Loadings - Nitrite-Nitrate

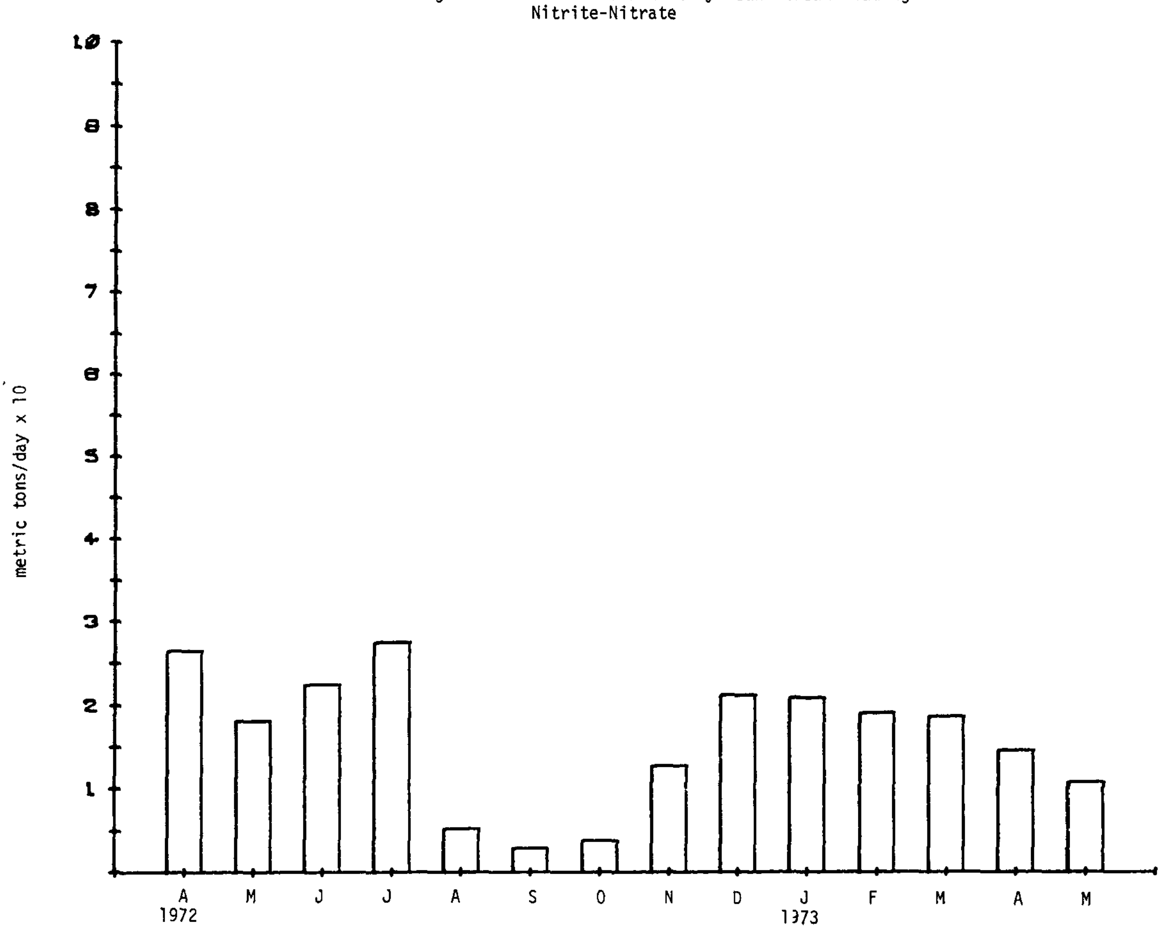


Figure 3.7 Oswego River Monthly Mean Stream Loadings - Nitrite-Nitrate

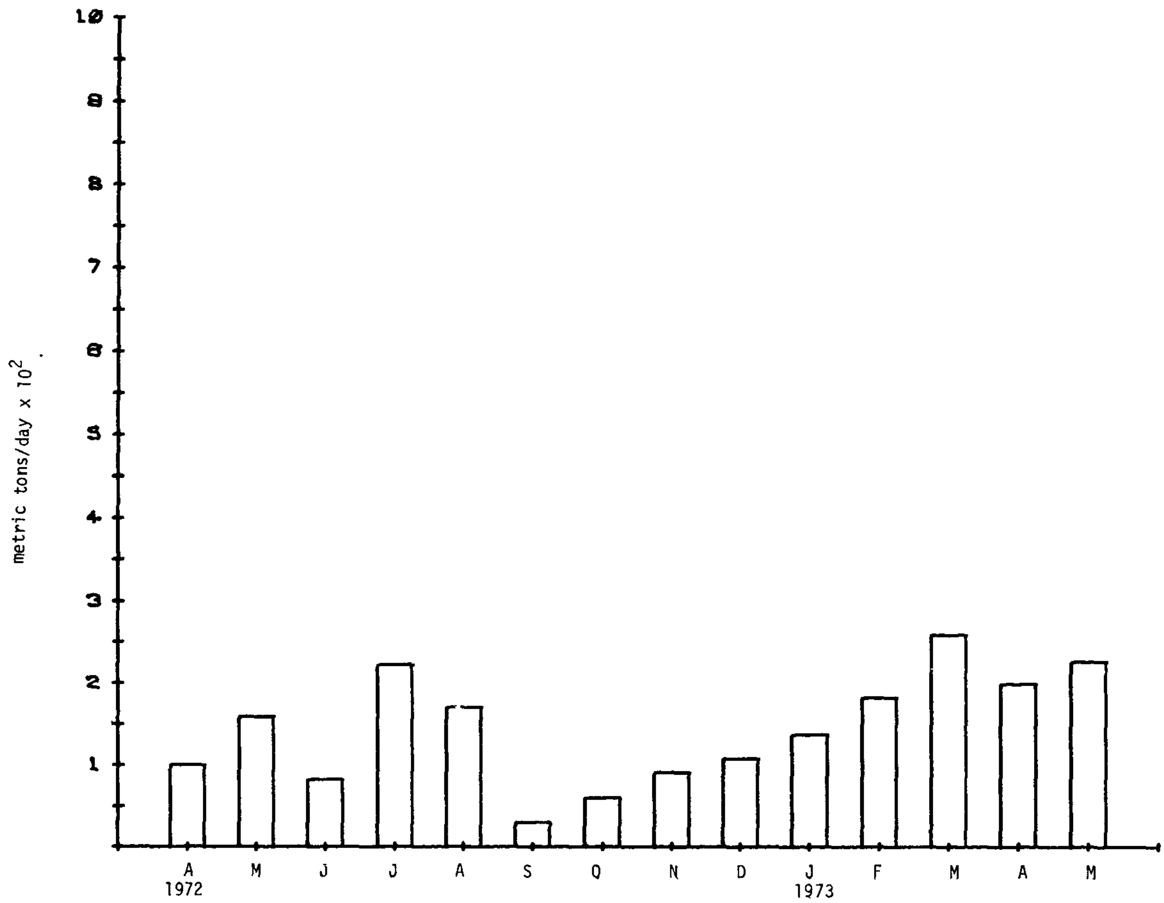


Figure 3.7 St. Lawrence River Monthly Mean Stream Loadings - Nitrite-Nitrate

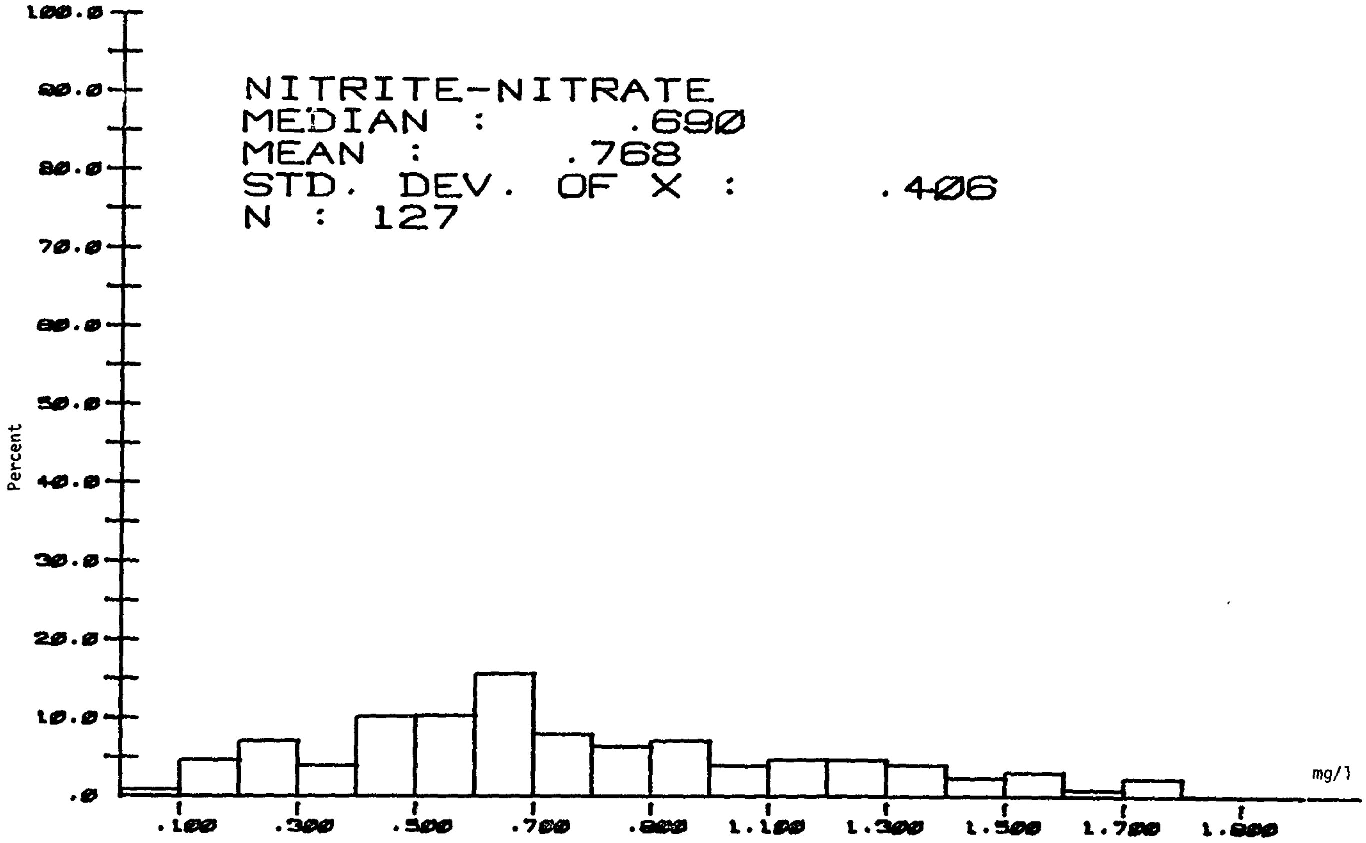


Figure 3.8 Genesee River Histograms for Nitrite-Nitrate

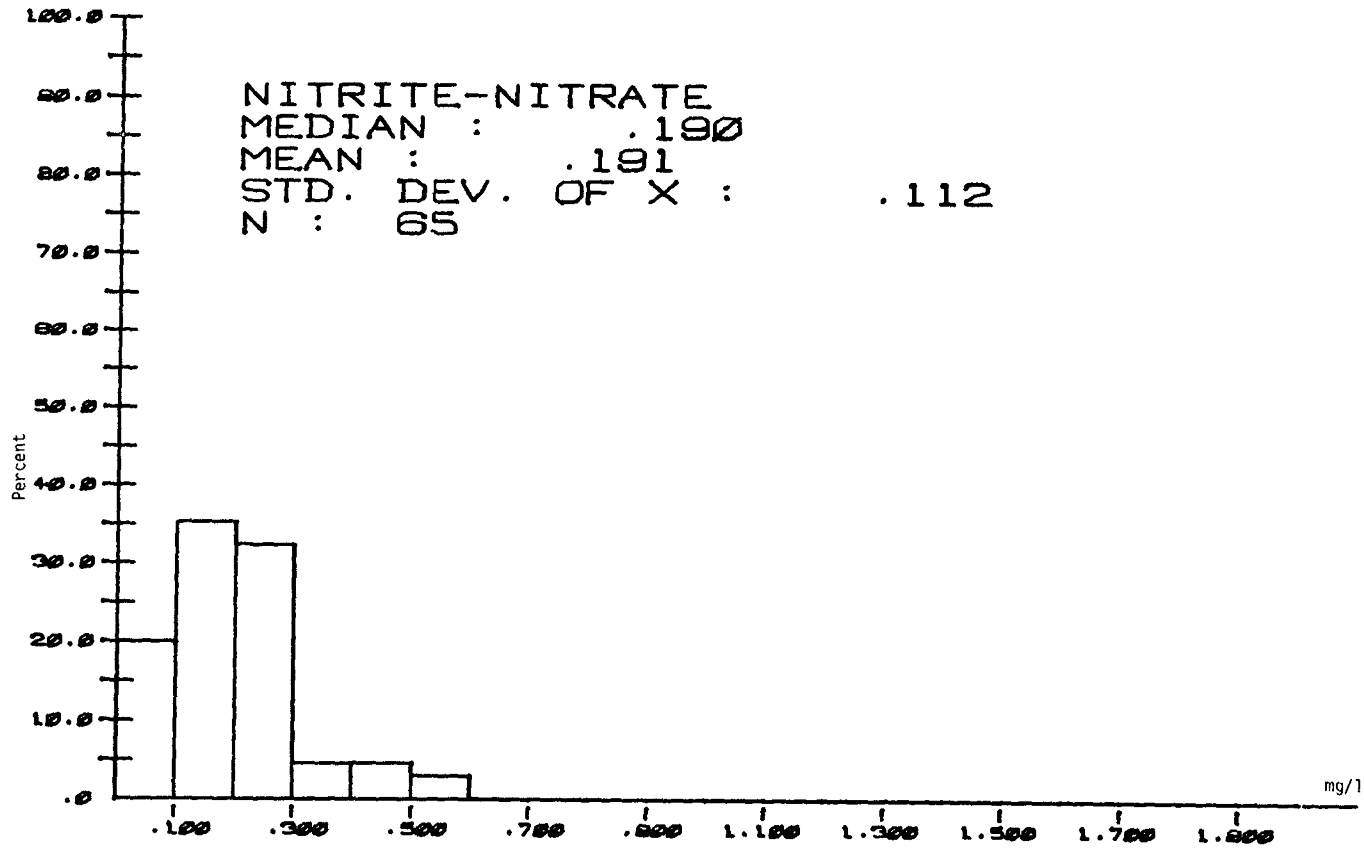
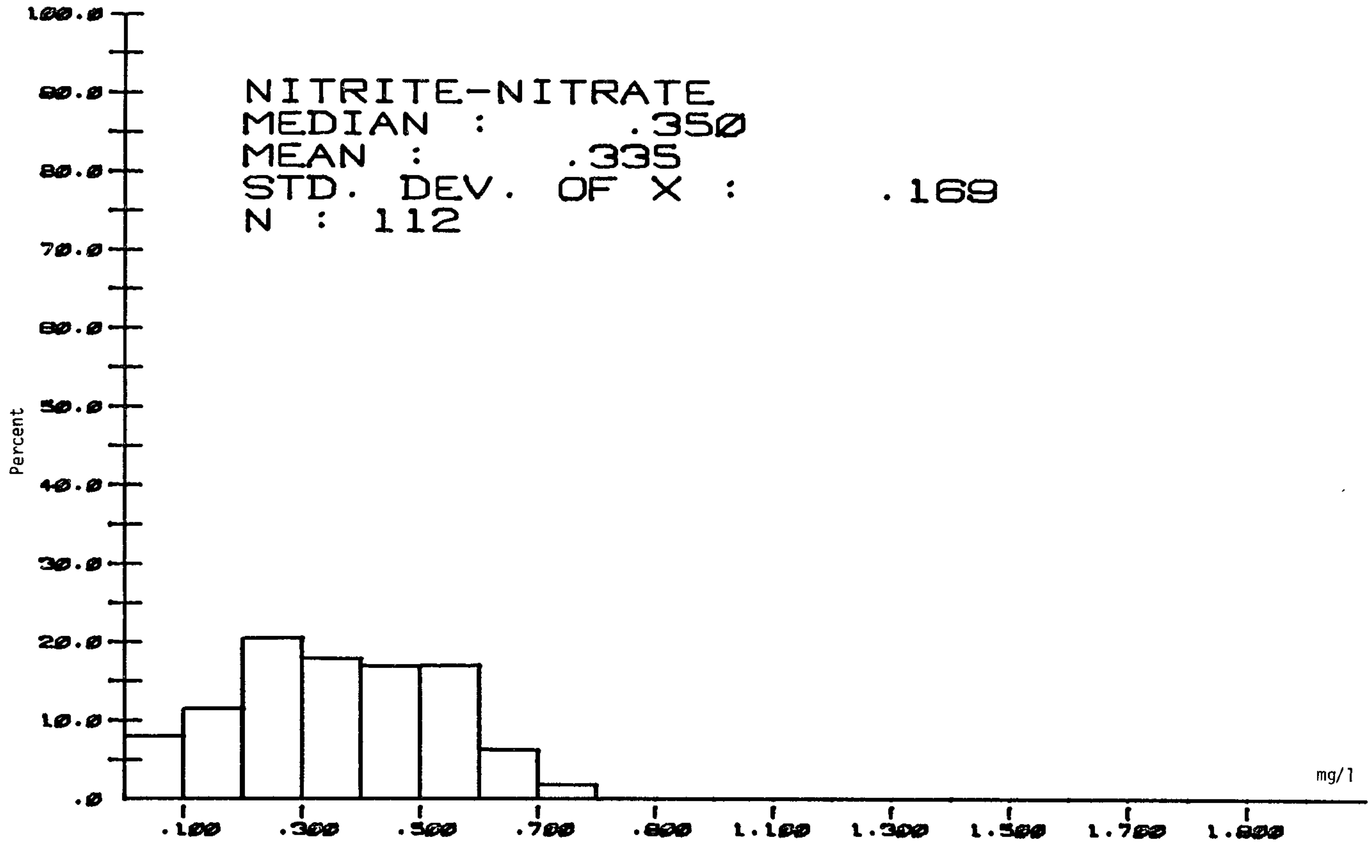


Figure 3.8 Niagara River Histograms for Nitrite-Nitrate



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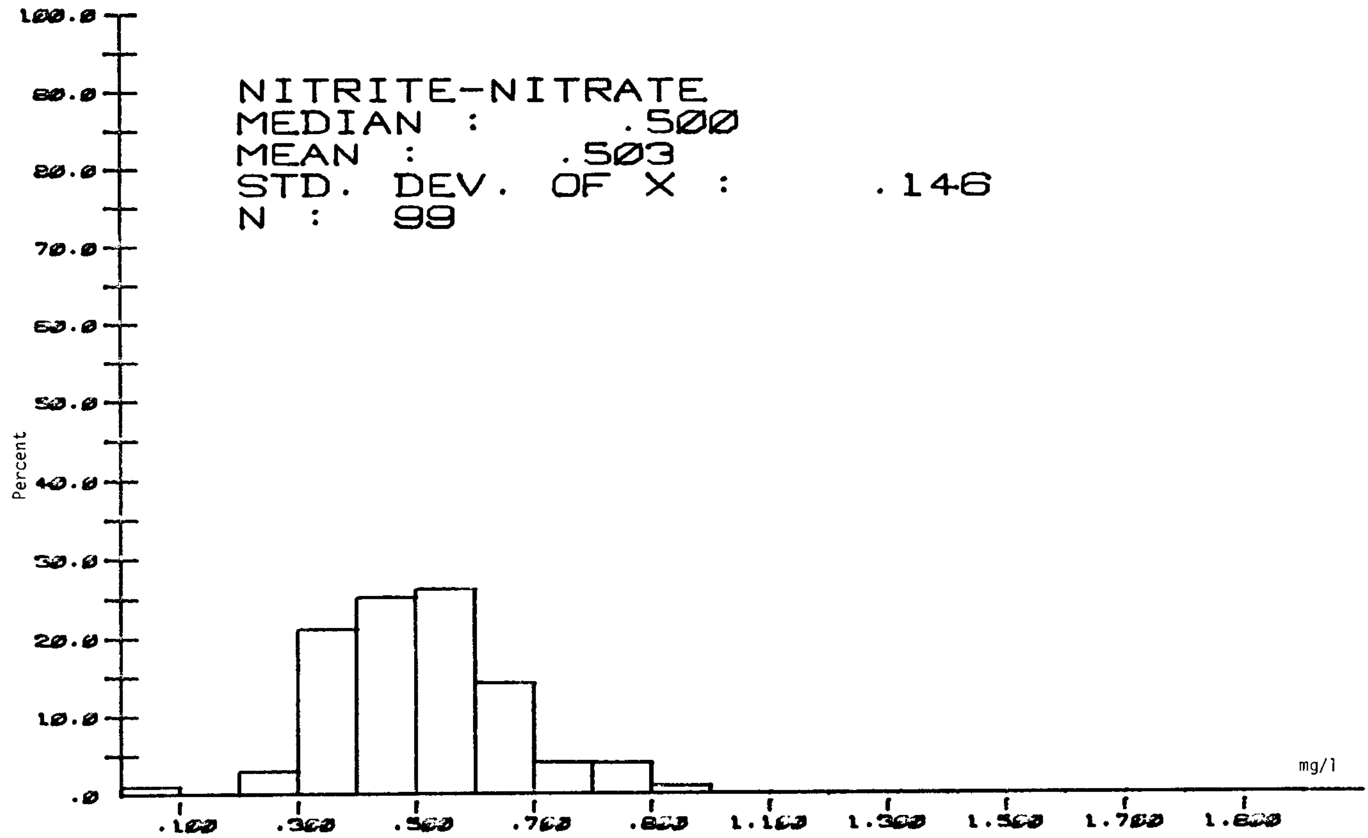


Figure 3.8 Oswego River Histograms for Nitrite-Nitrate

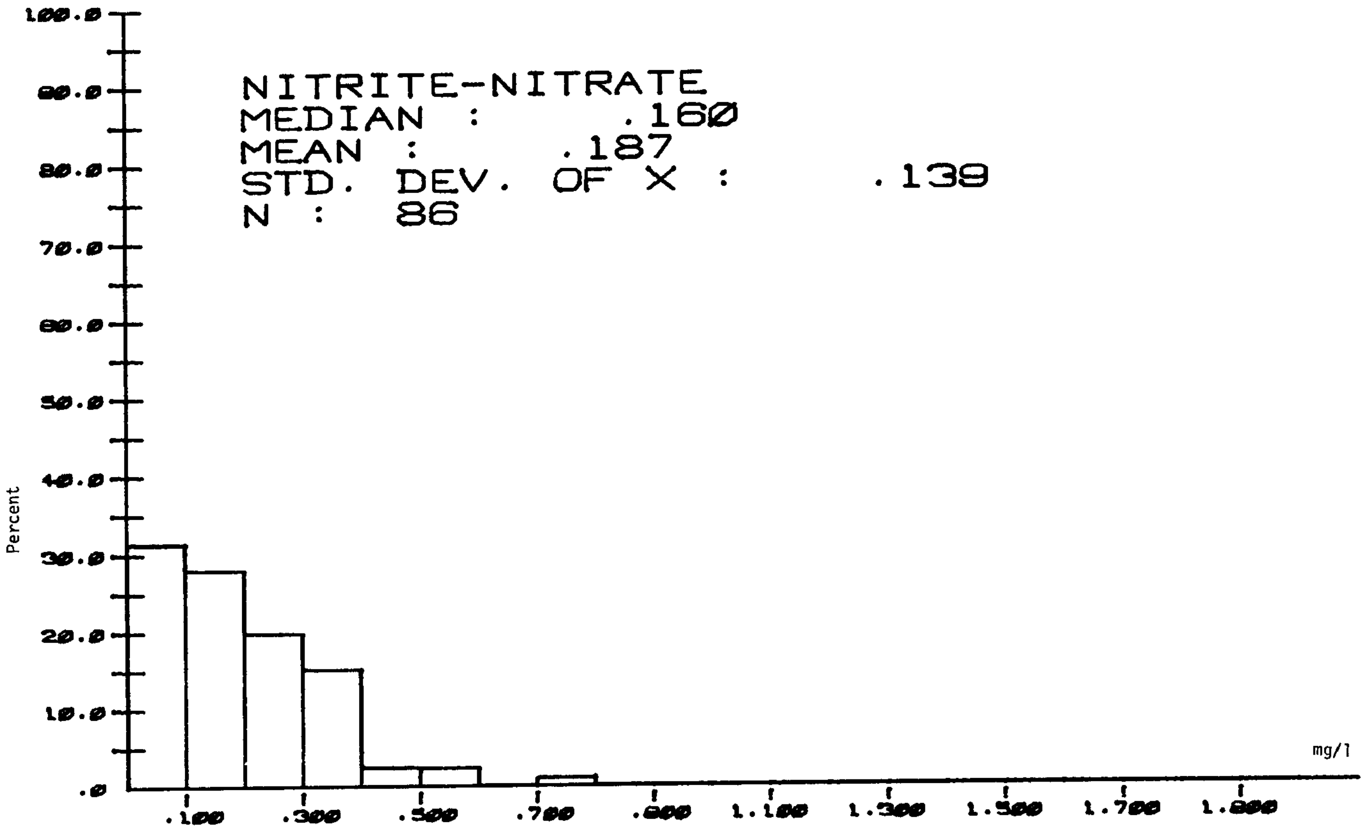


Figure 3.8 St. Lawrence River Histograms for Nitrite-Nitrate

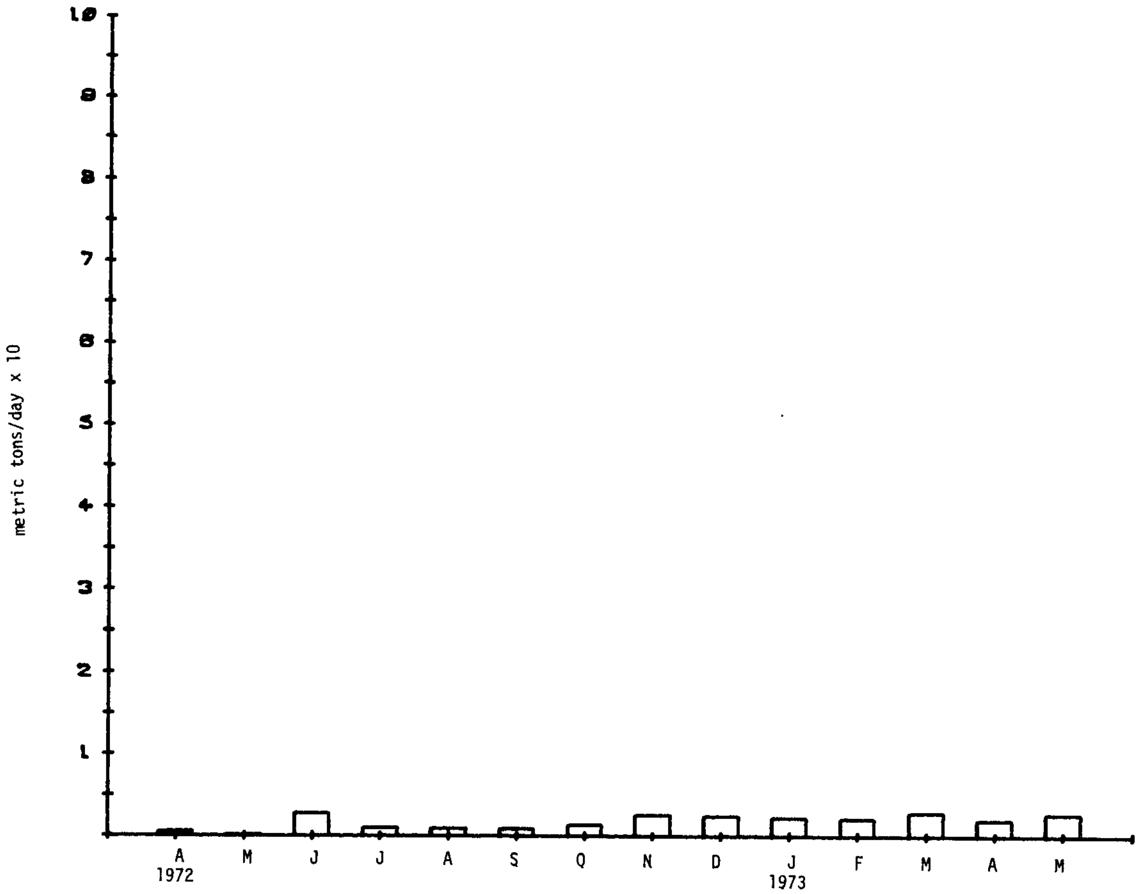
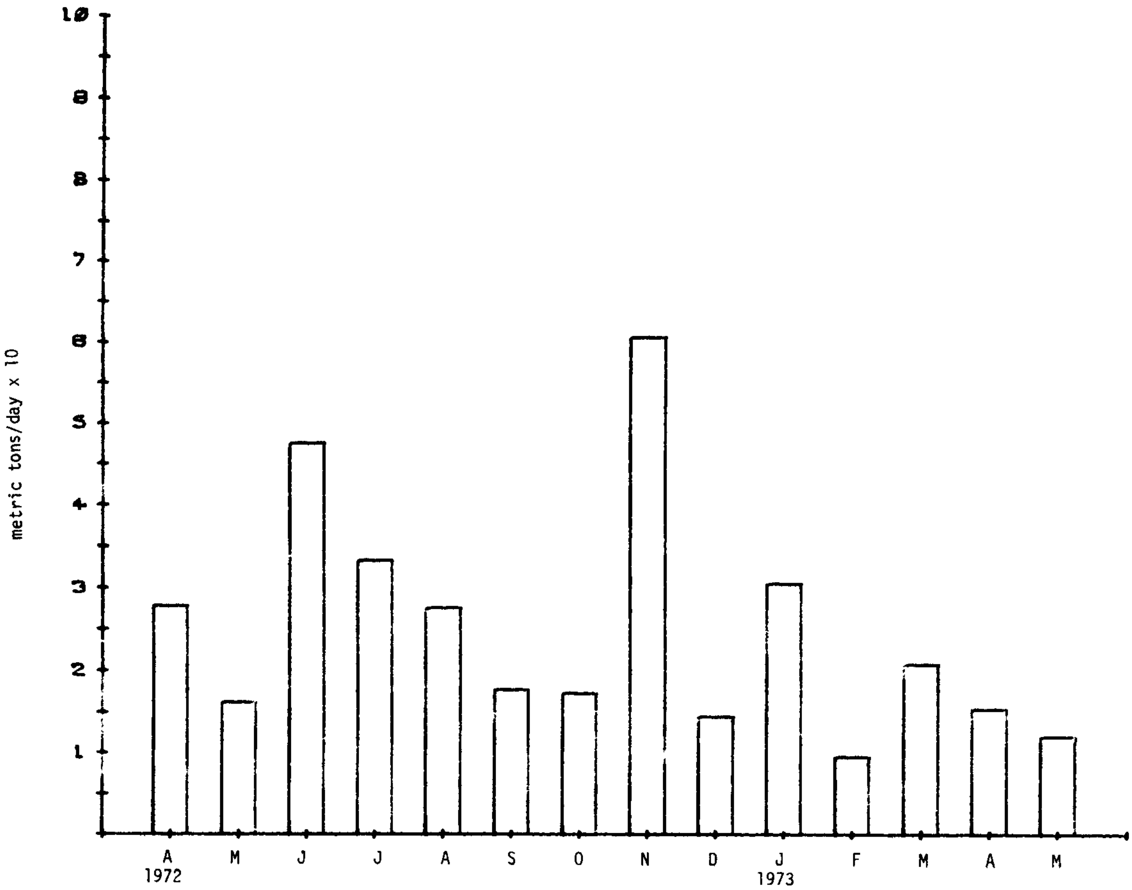


Figure 3.9 Genesee River Monthly Mean Stream Loadings - Ammonia



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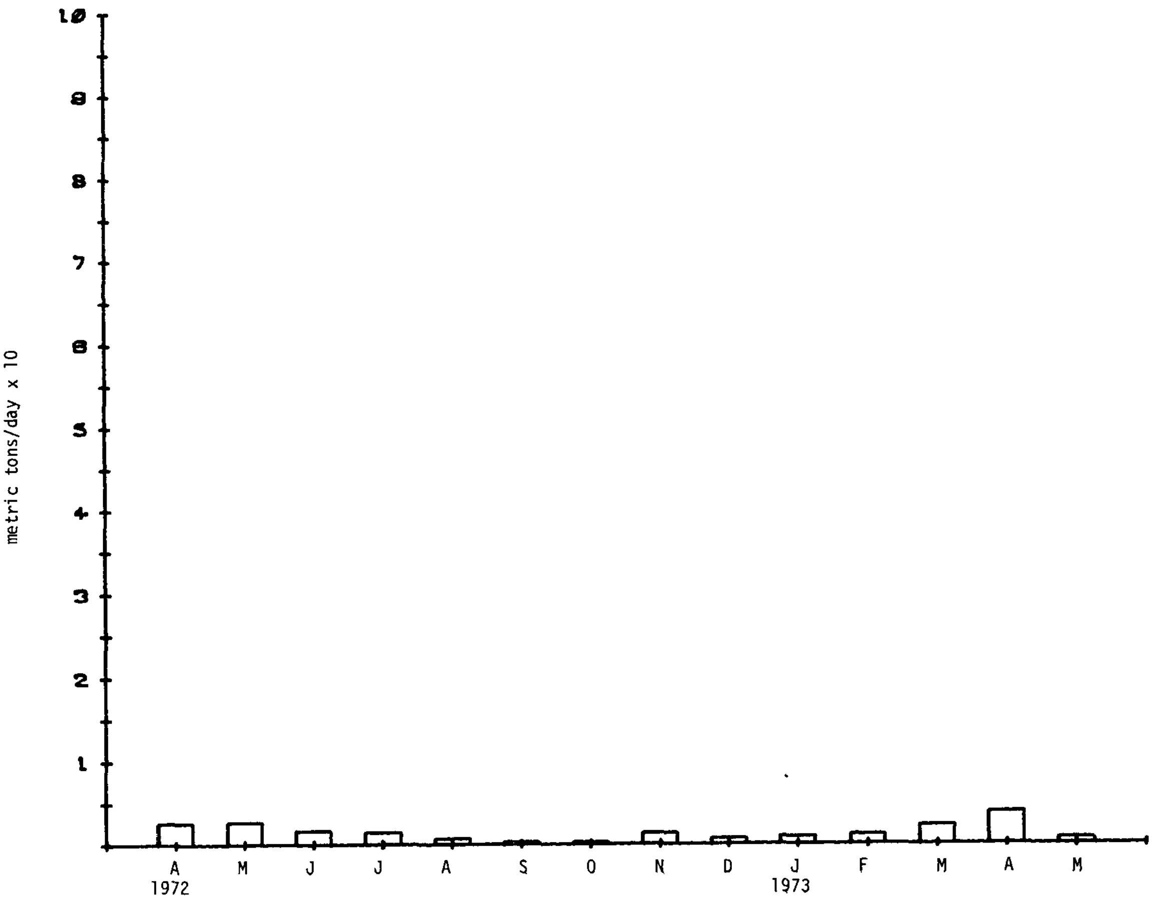

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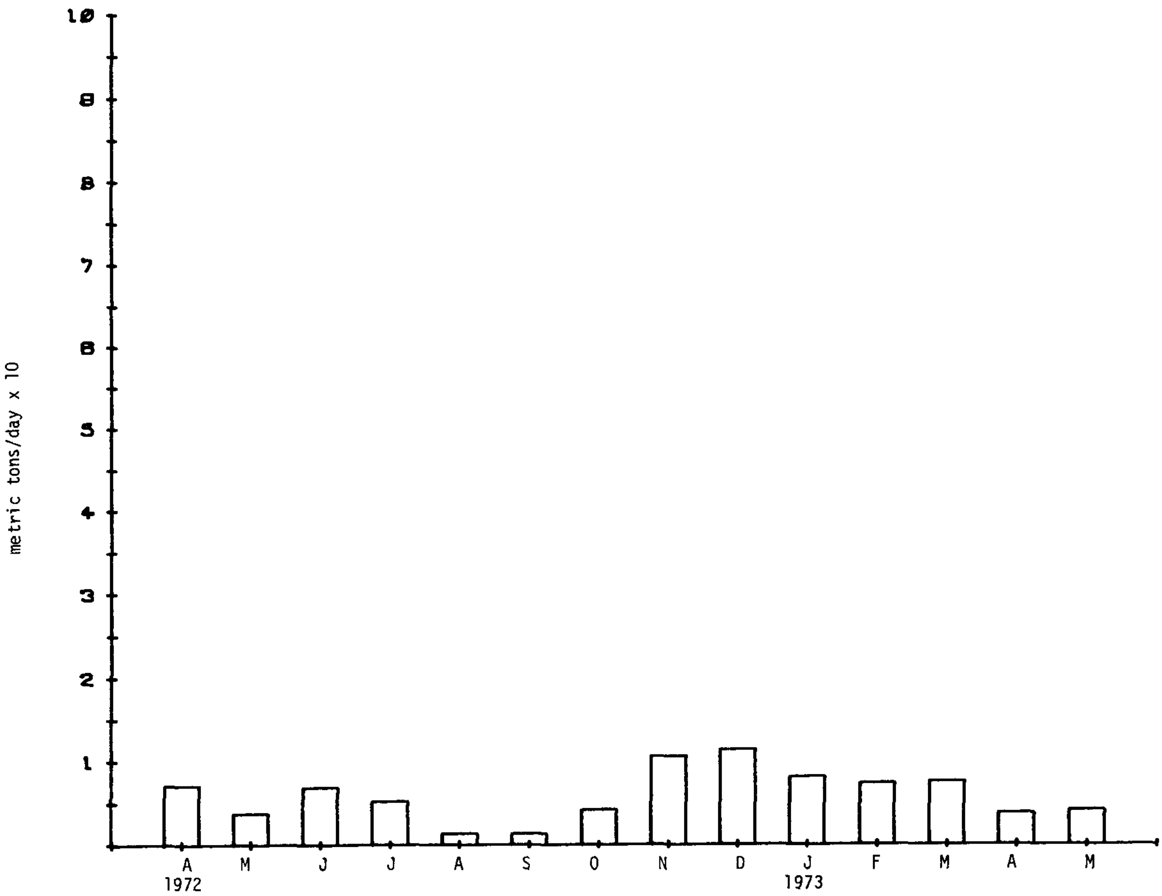


Figure 3.9 Oswego River Monthly Mean Stream Loadings - Ammonia

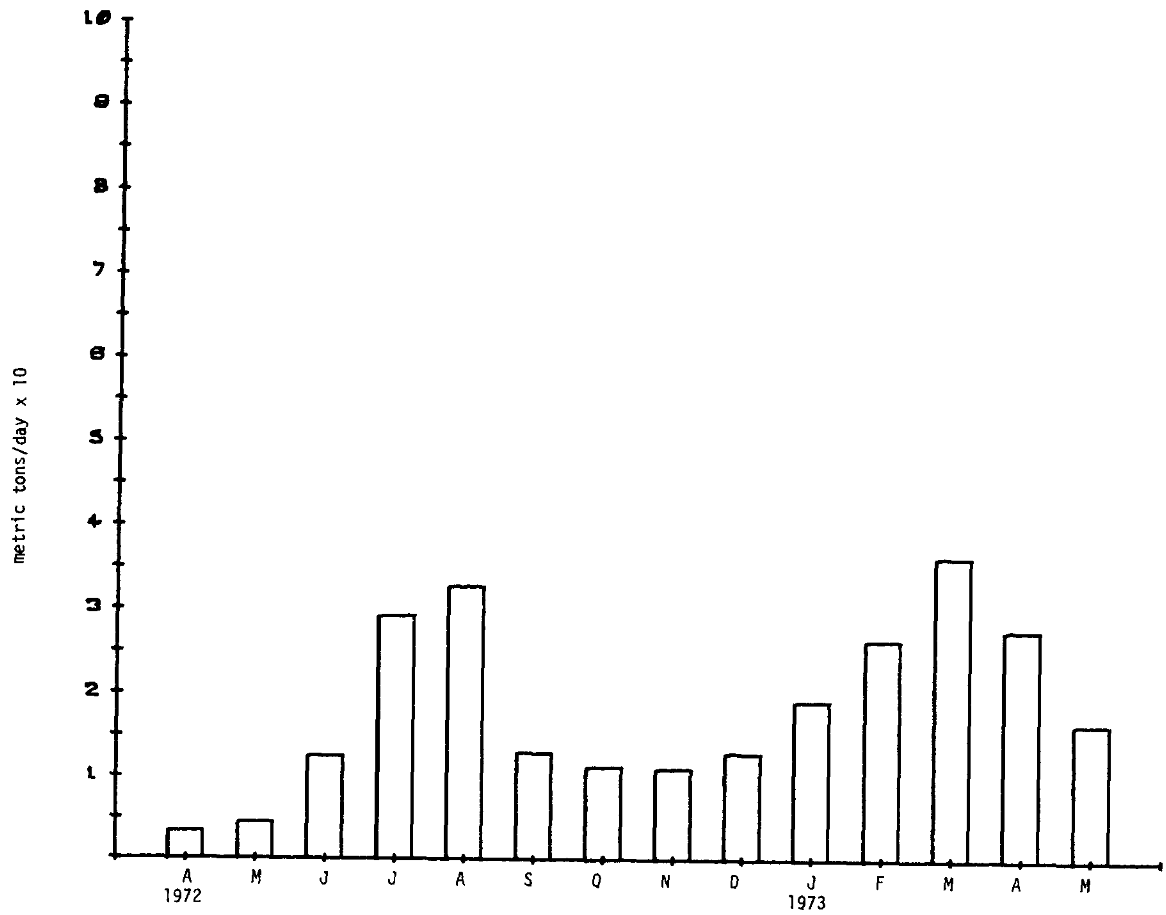


Figure 3.9 St. Lawrence River Monthly Mean Stream Loadings - Ammonia

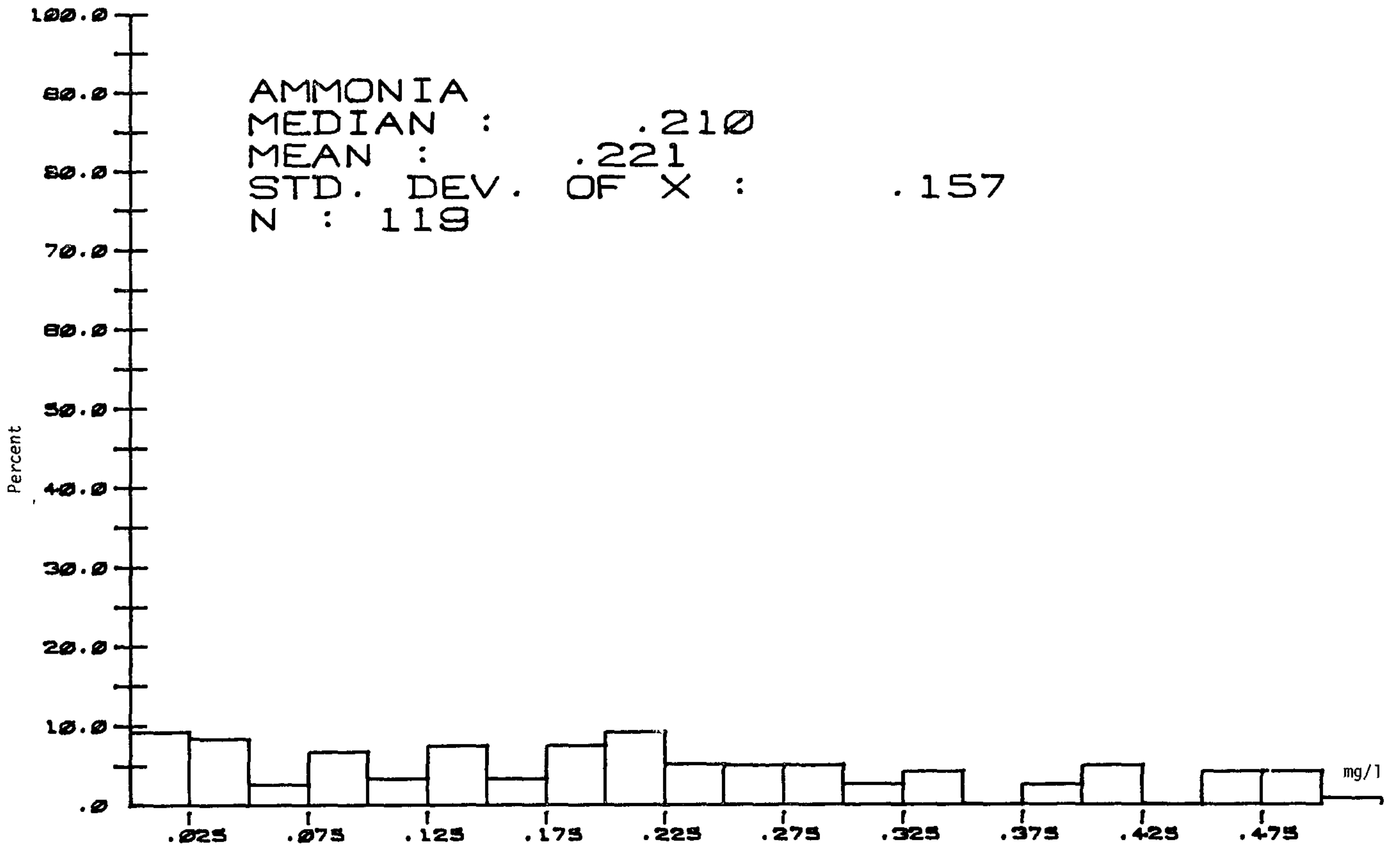
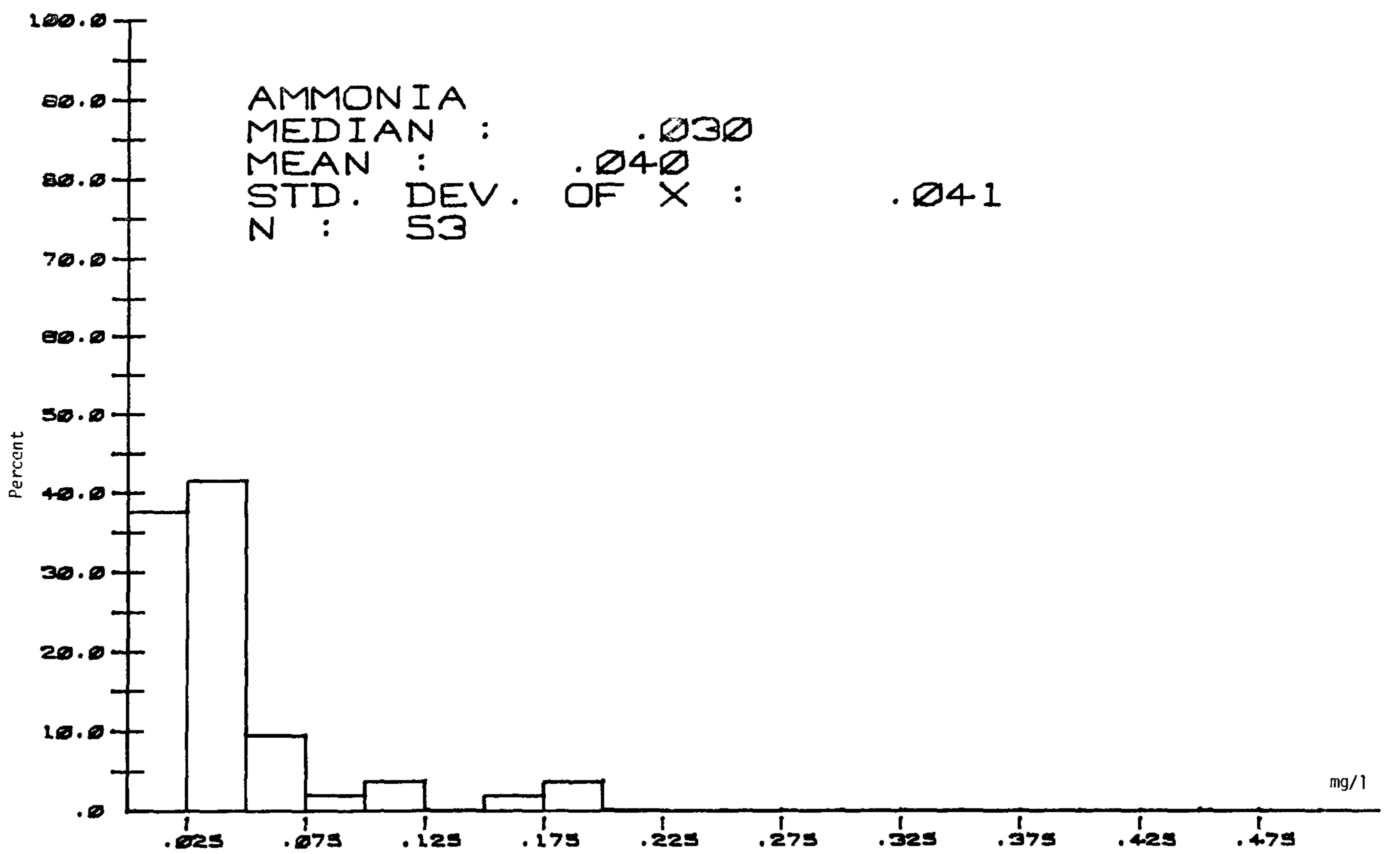


Figure 3.10 Genesee River Histograms for Ammonia



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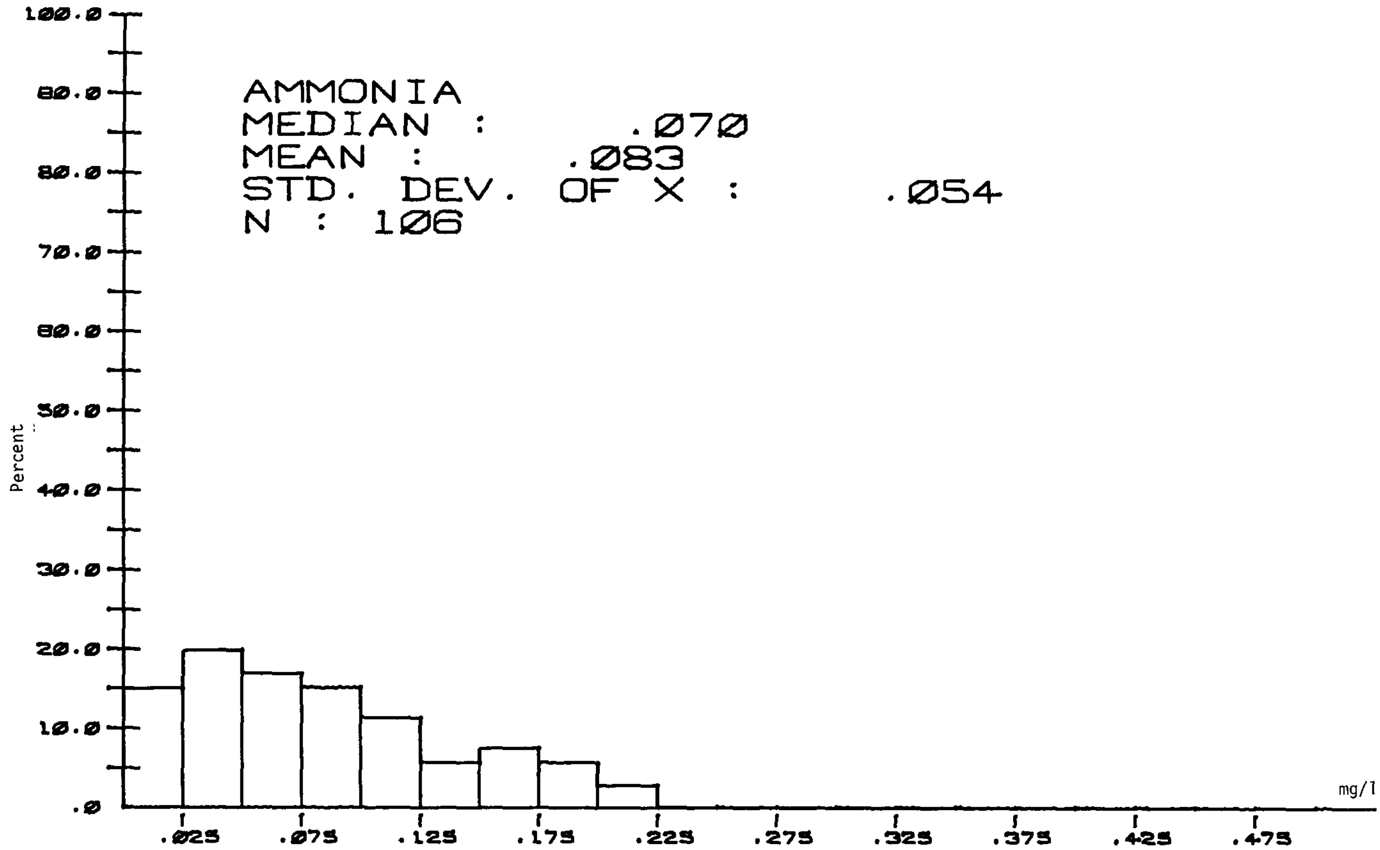

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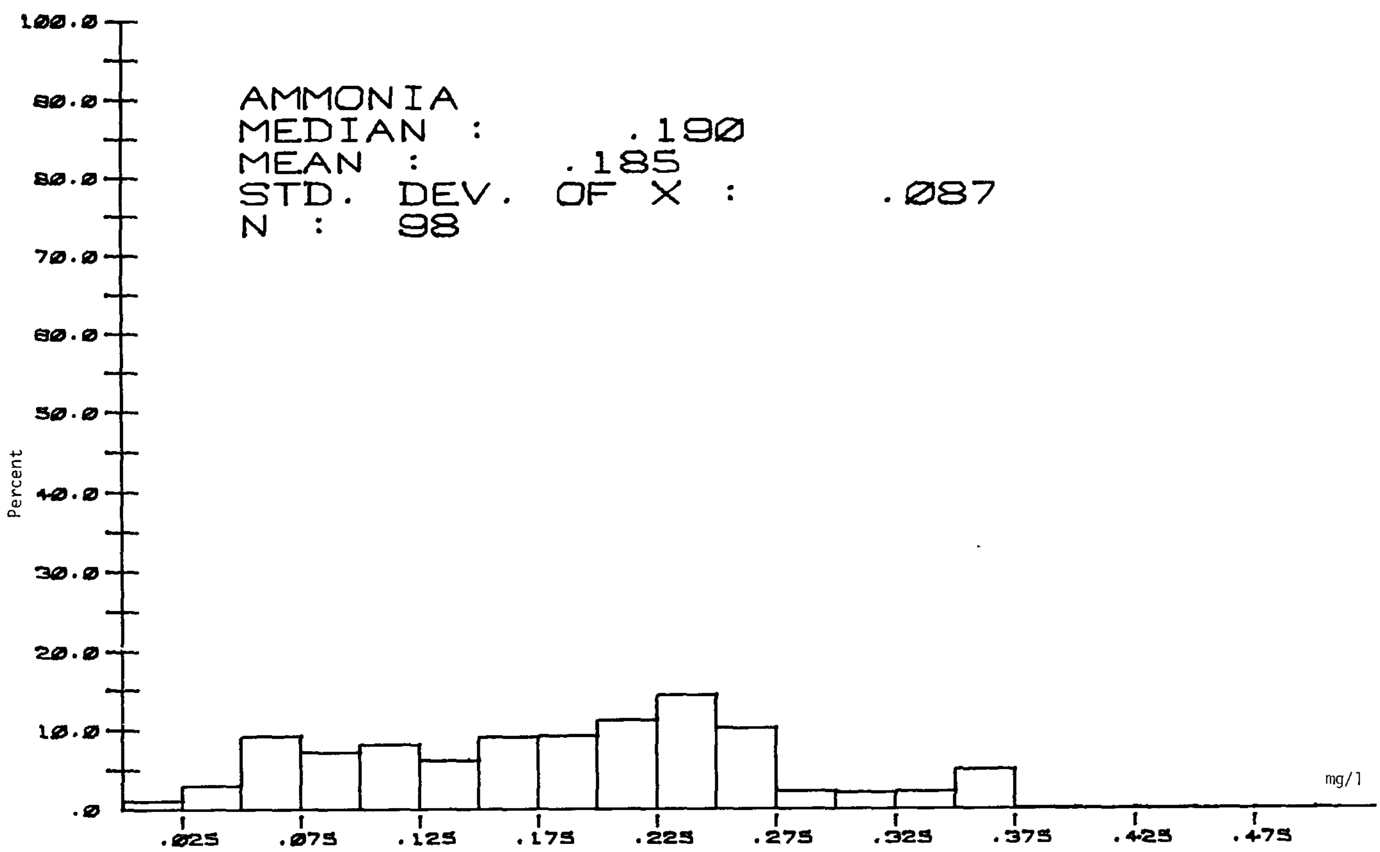


Figure 3.10 Oswego River Histograms for Ammonia

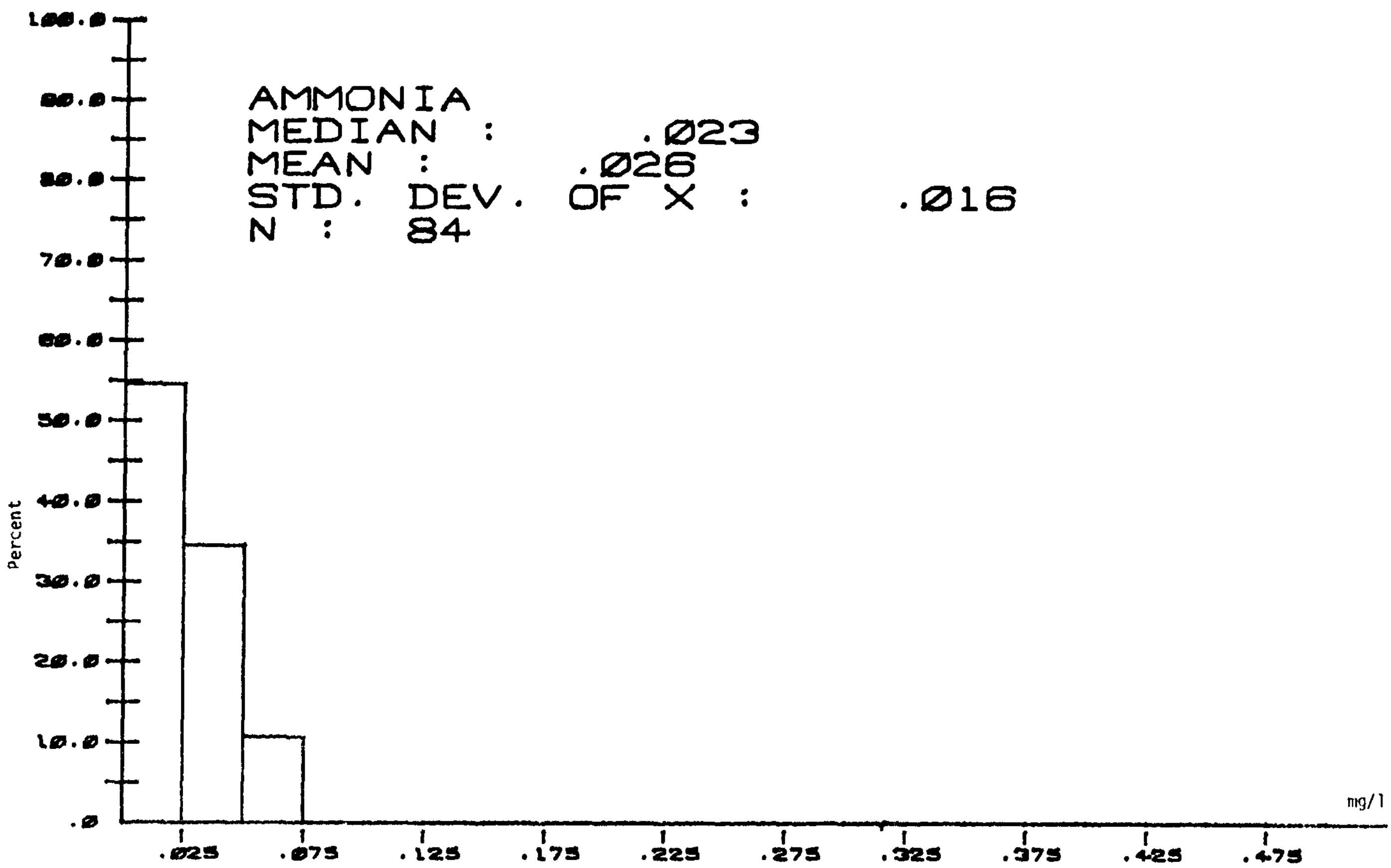


Figure 3.10 St. Lawrence River Histograms for Ammonia

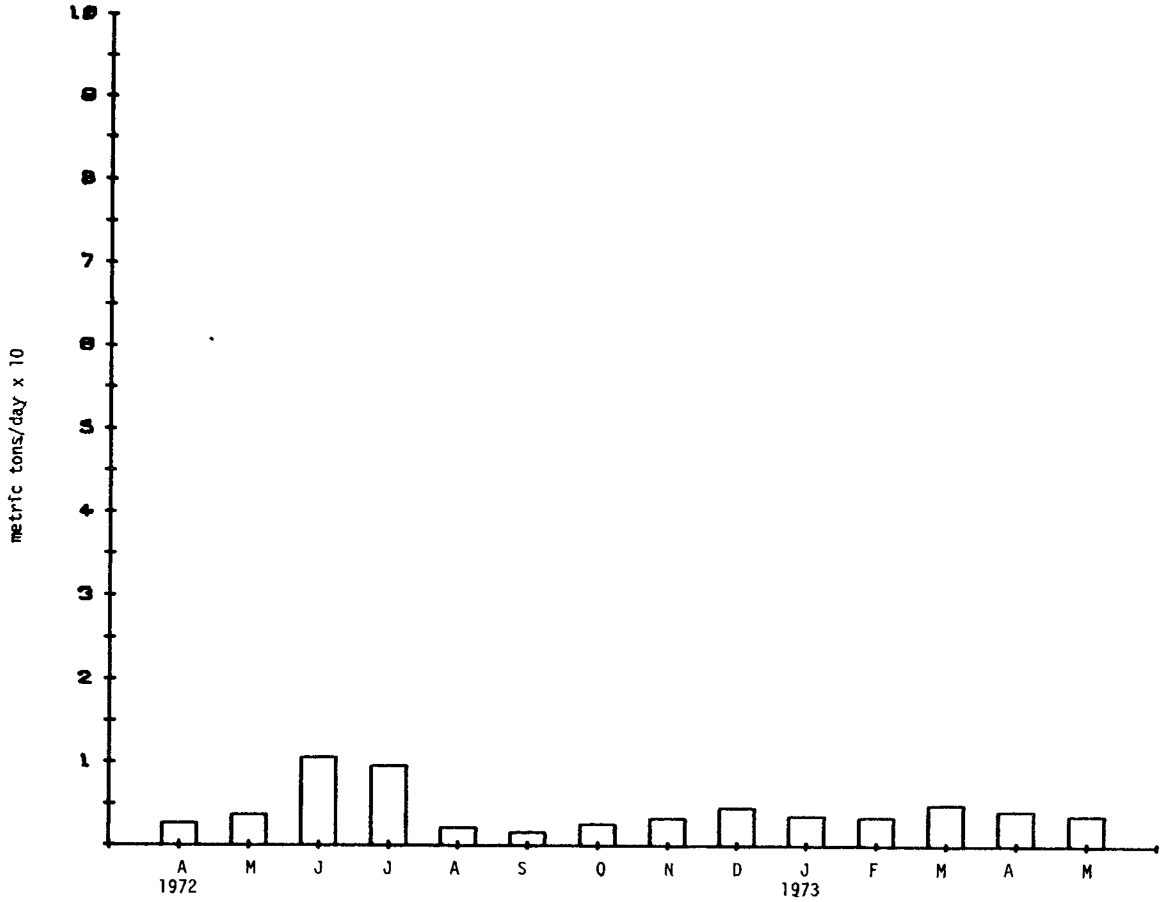


Figure 3.11 Genesee River Monthly Mean Stream Loadings - Total Kjeldahl Nitrogen

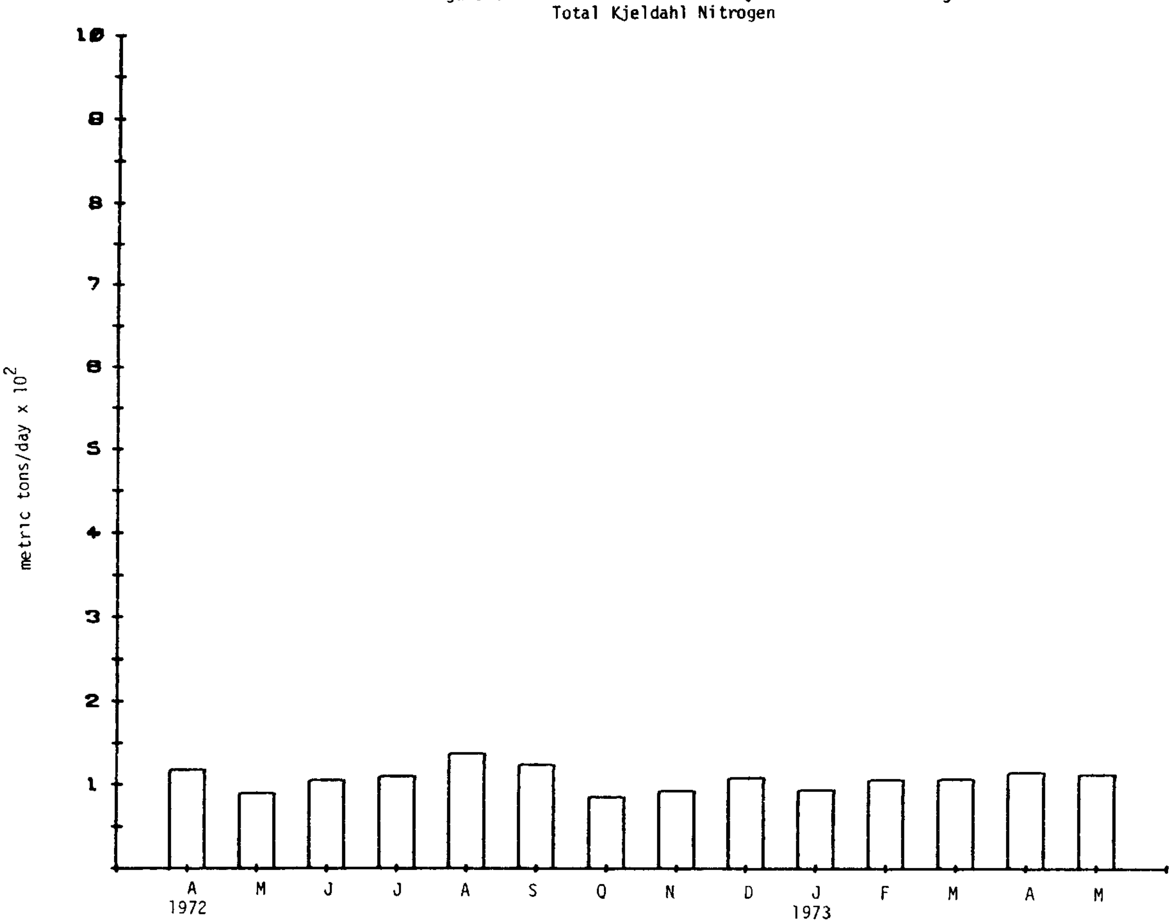


Figure 3.11 Niagara River Monthly Mean Stream Loadings - Total Kjeldahl Nitrogen

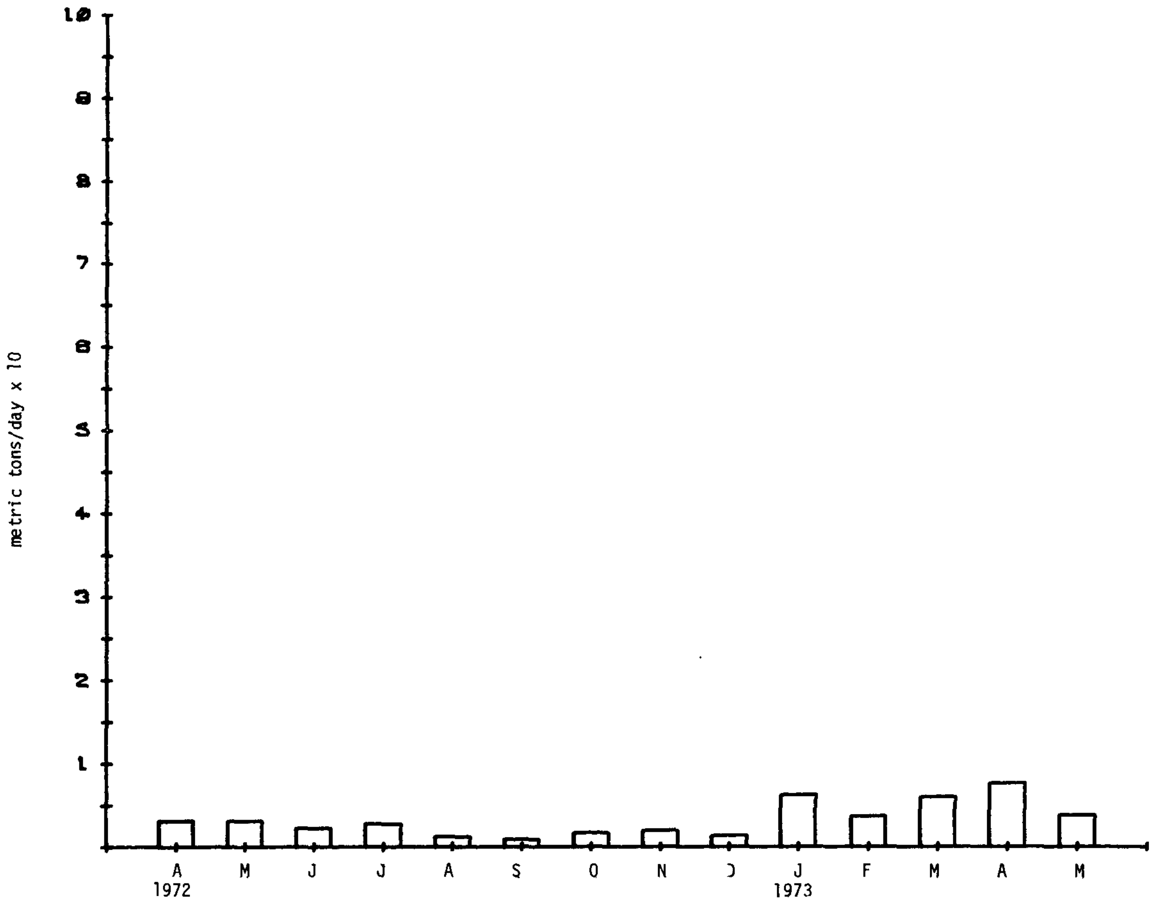


Figure 3.11 Black River Monthly Mean Stream Loadings - Total Kjeldahl Nitrogen

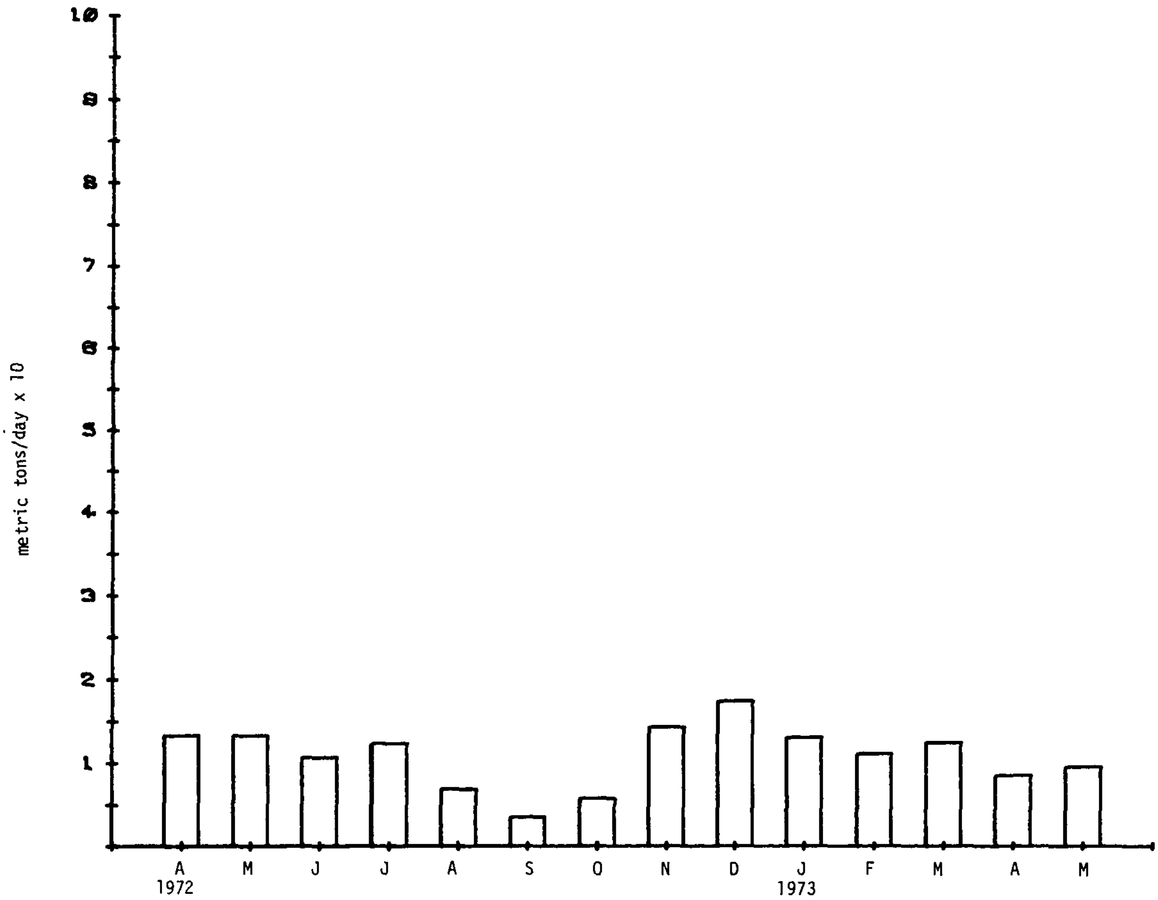


Figure 3.11 Oswego River Monthly Mean Stream Loadings - Total Kjeldahl Nitrogen

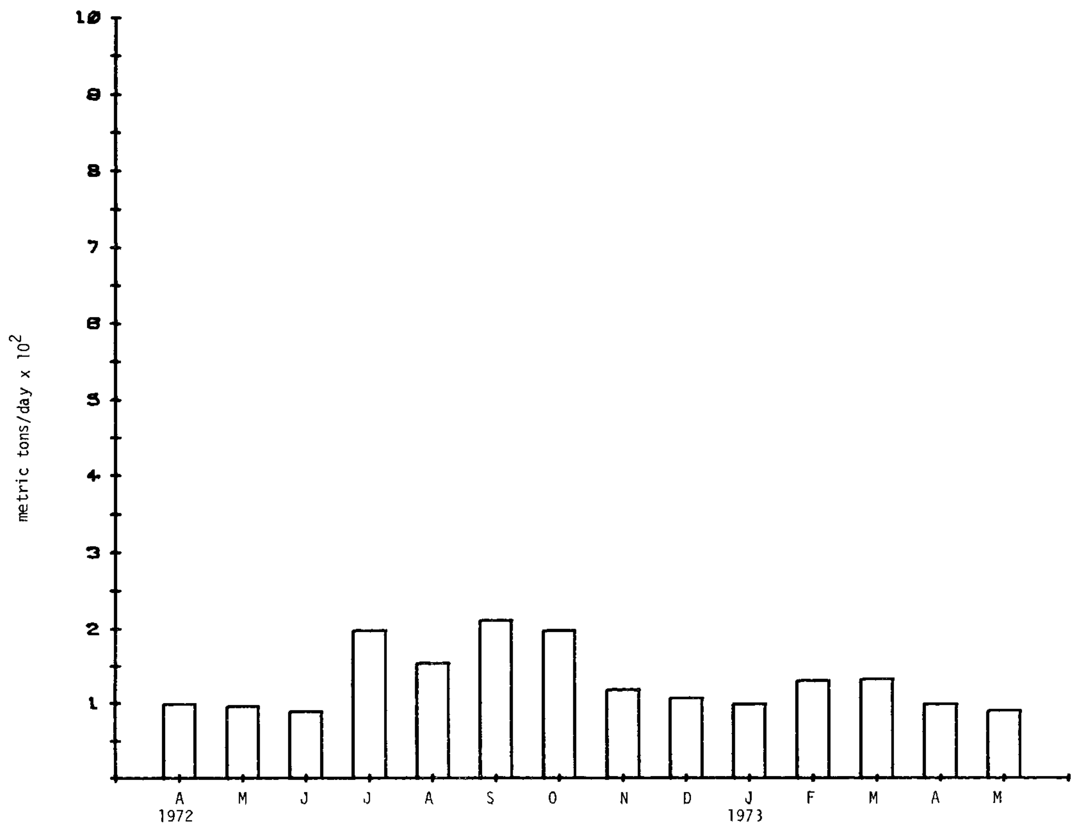


Figure 3 11 St. Lawrence River Monthly Mean Stream Loadings - Total Kjeldahl Nitrogen

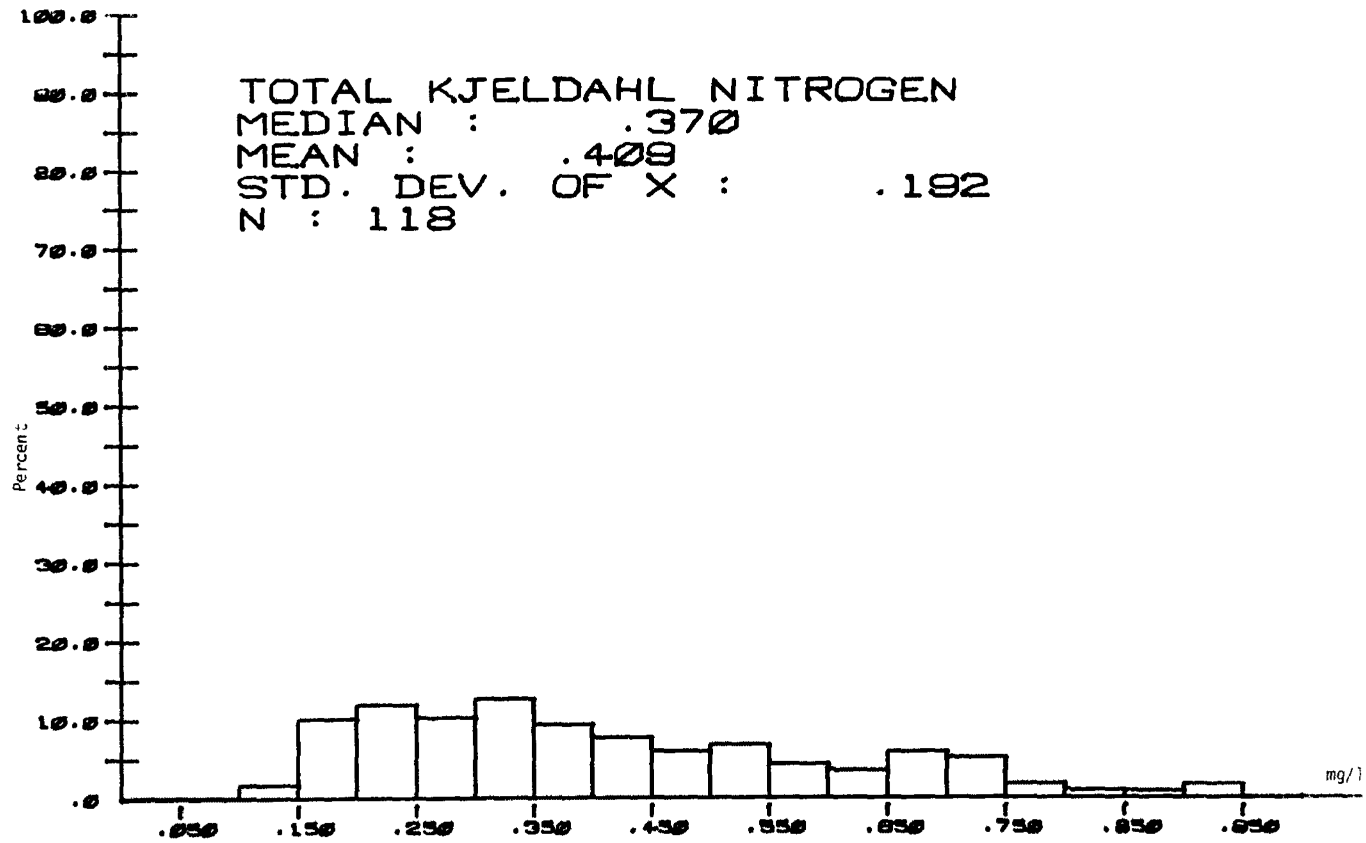
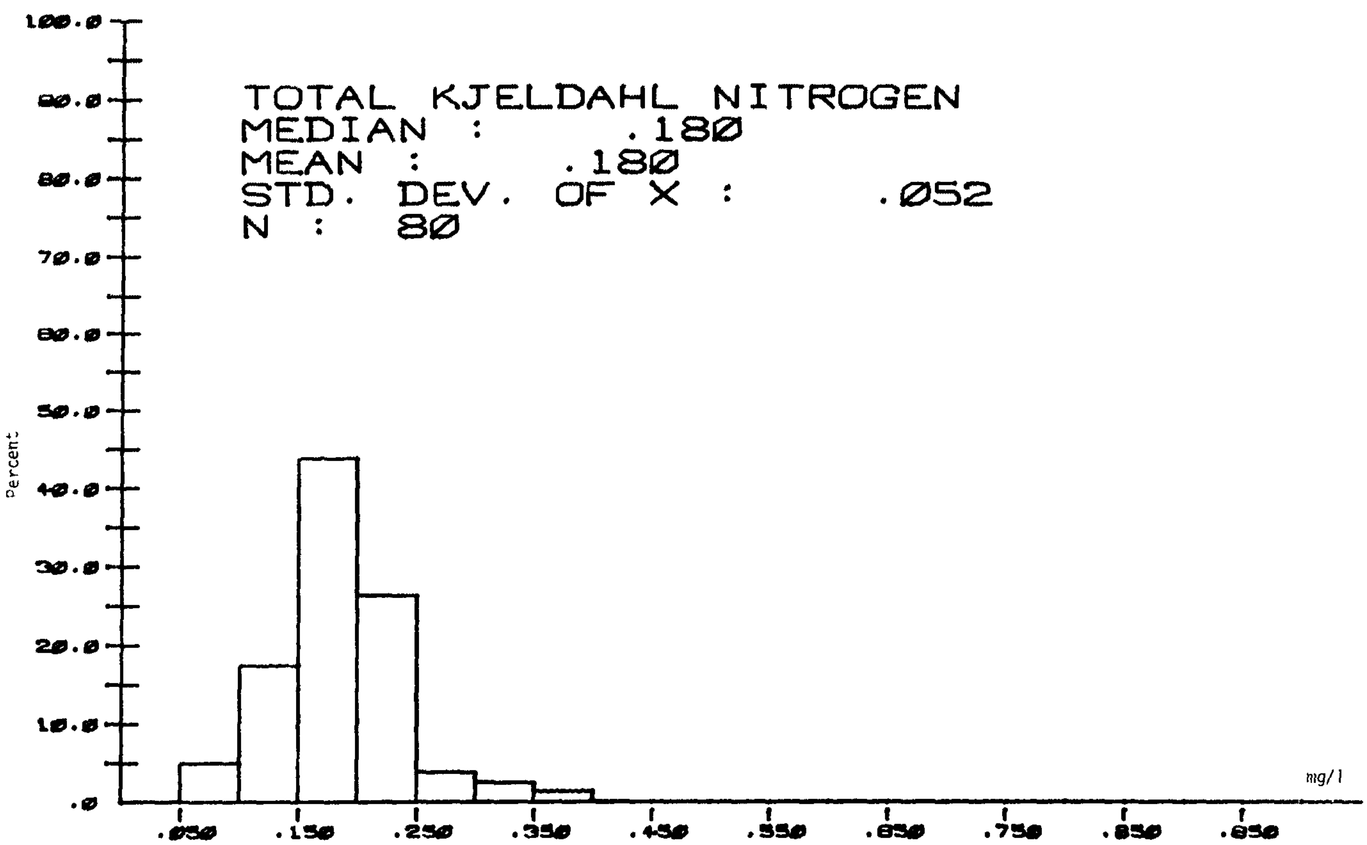


Figure 3.12 Genesee River Histograms for Total Kjeldahl Nitrogen



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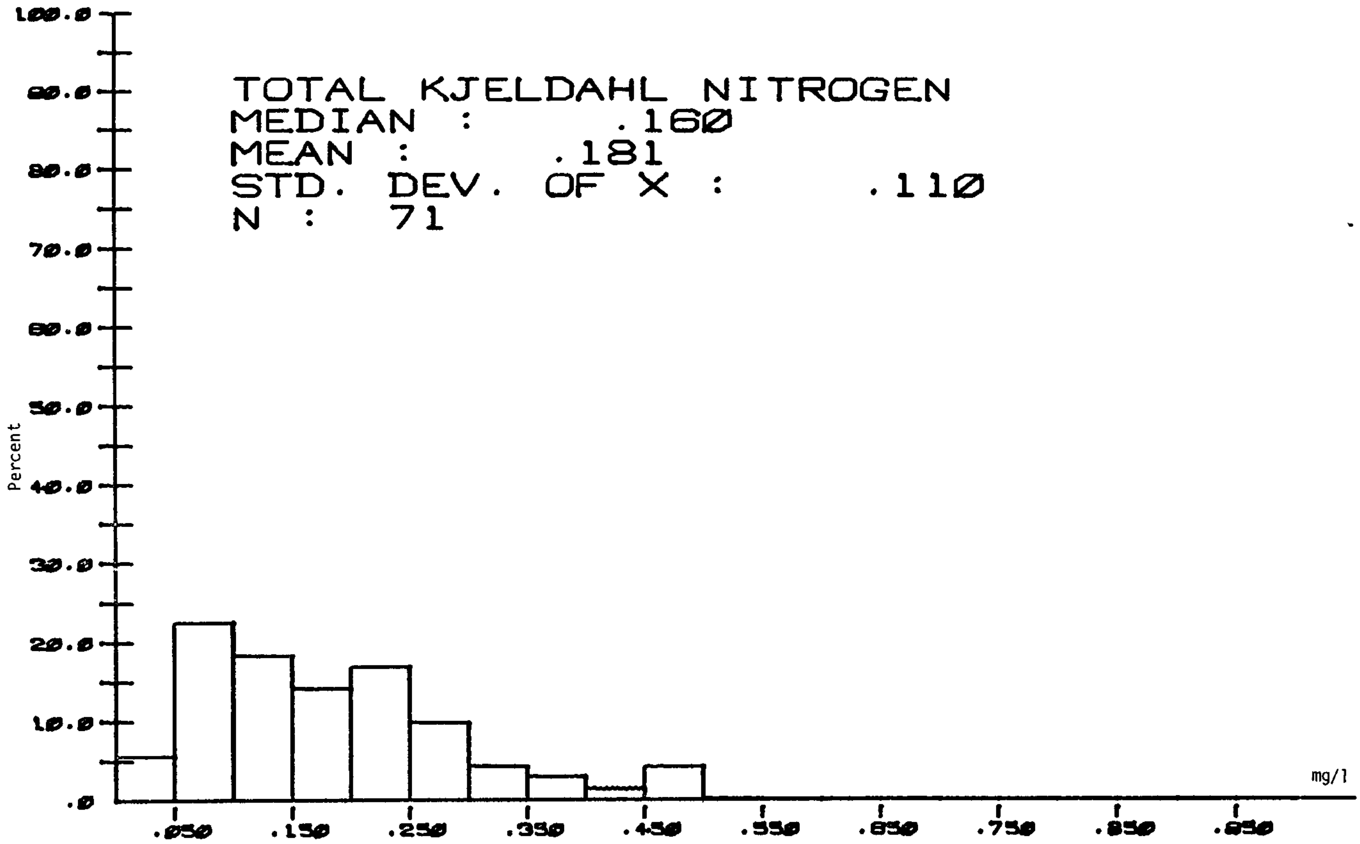

Figure 3.12 Black River Histograms for Total Kjeldahl Nitrogen

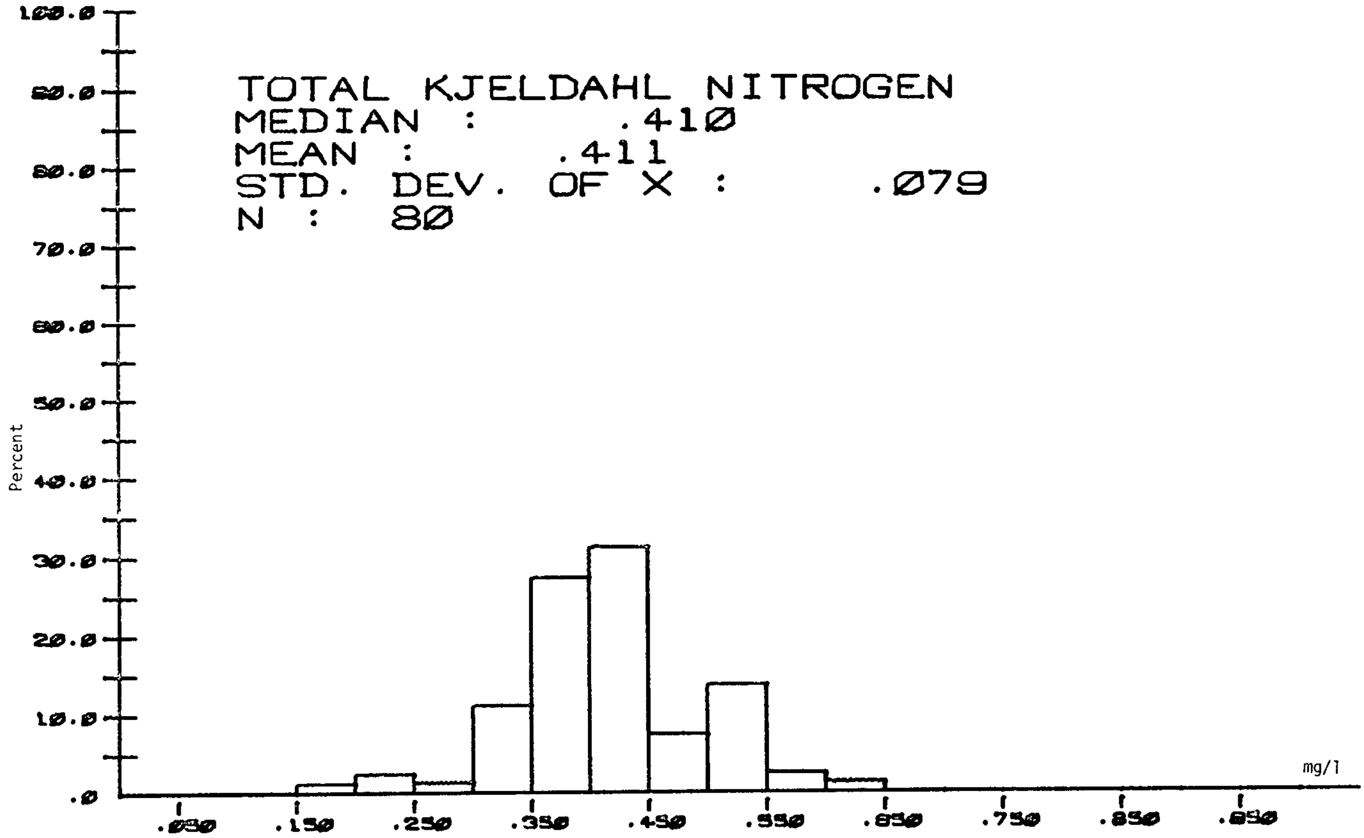

Figure 3.12 Oswego River Histograms for Total Kjeldahl Nitrogen

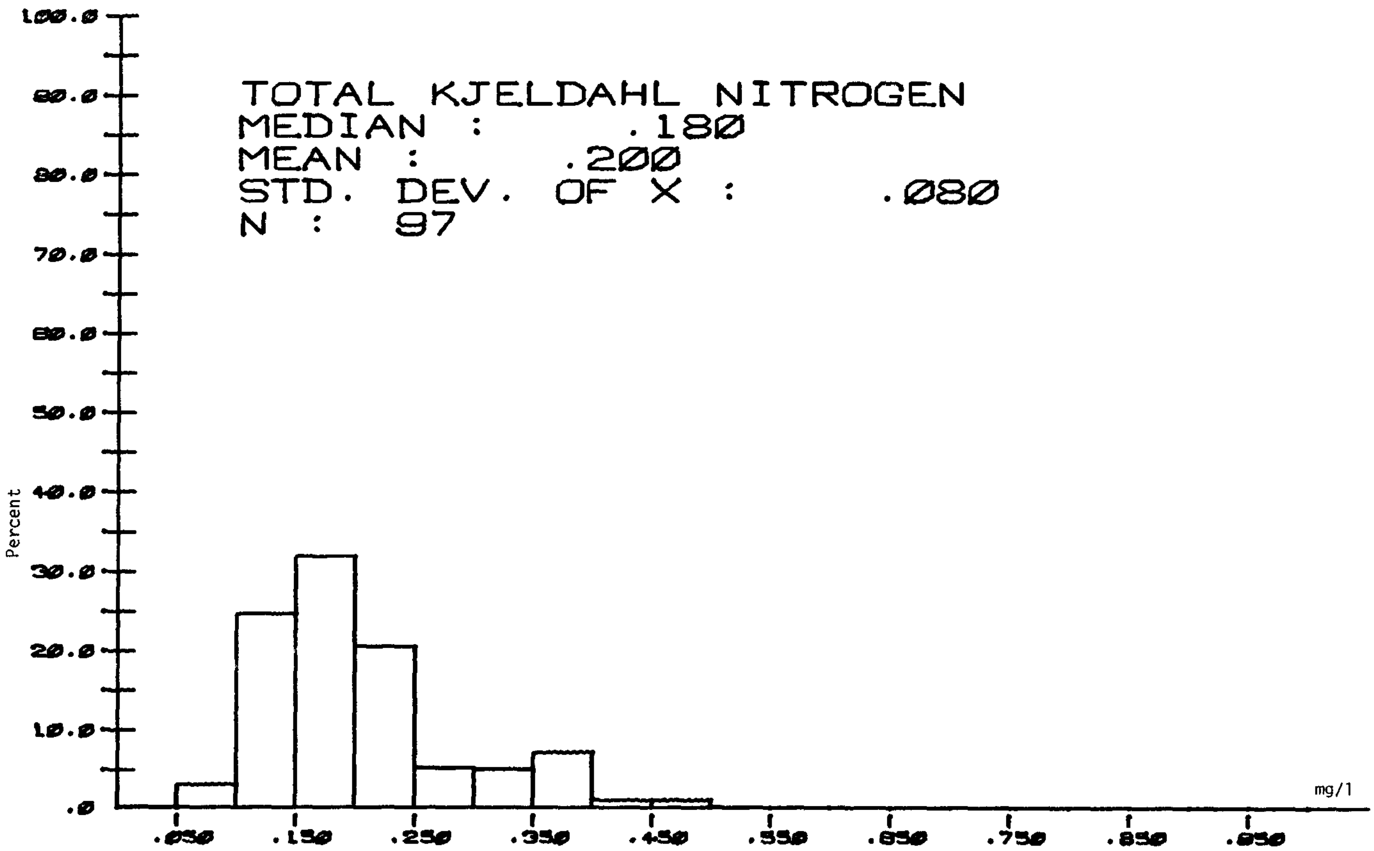

Figure 3.12 St. Lawrence River Histograms for Total Kjeldahl Nitrogen

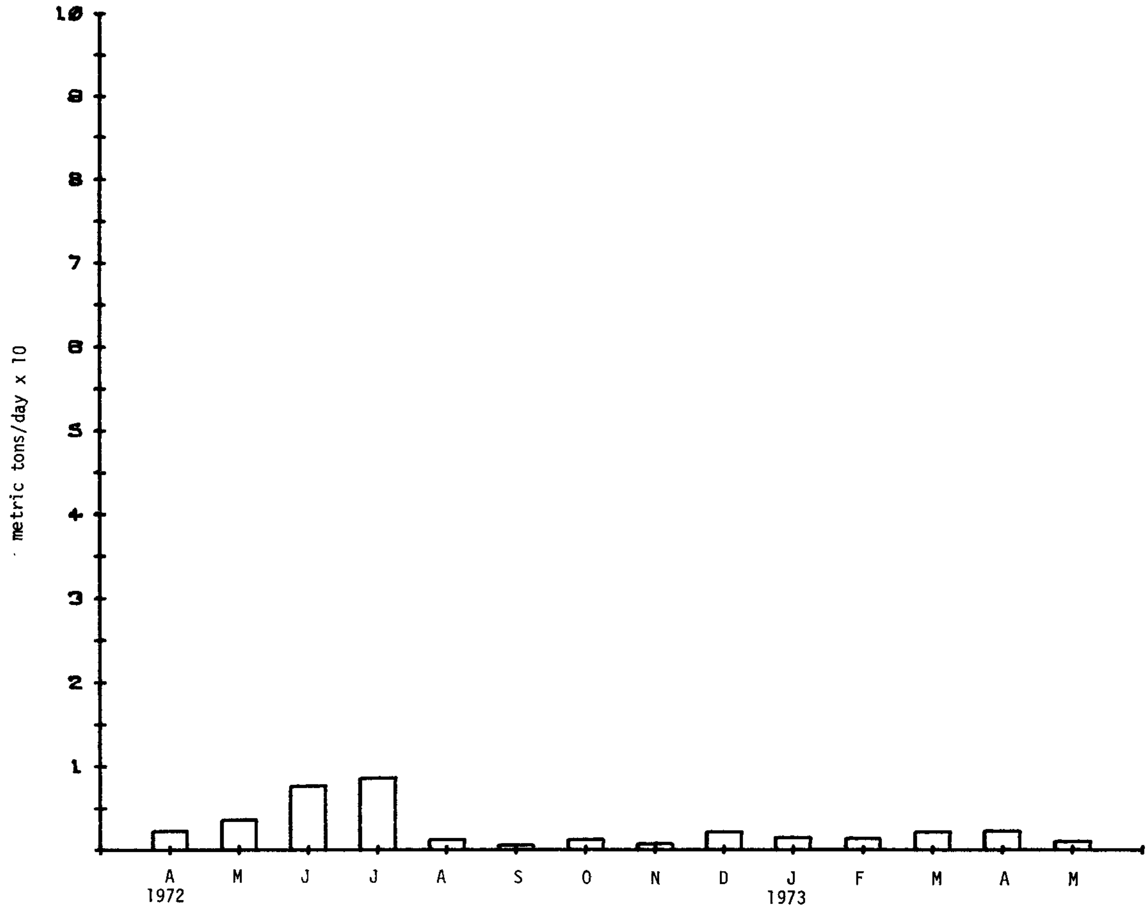

Figure 3.13 Genesee River Monthly Mean Loadings - Organic Nitrogen

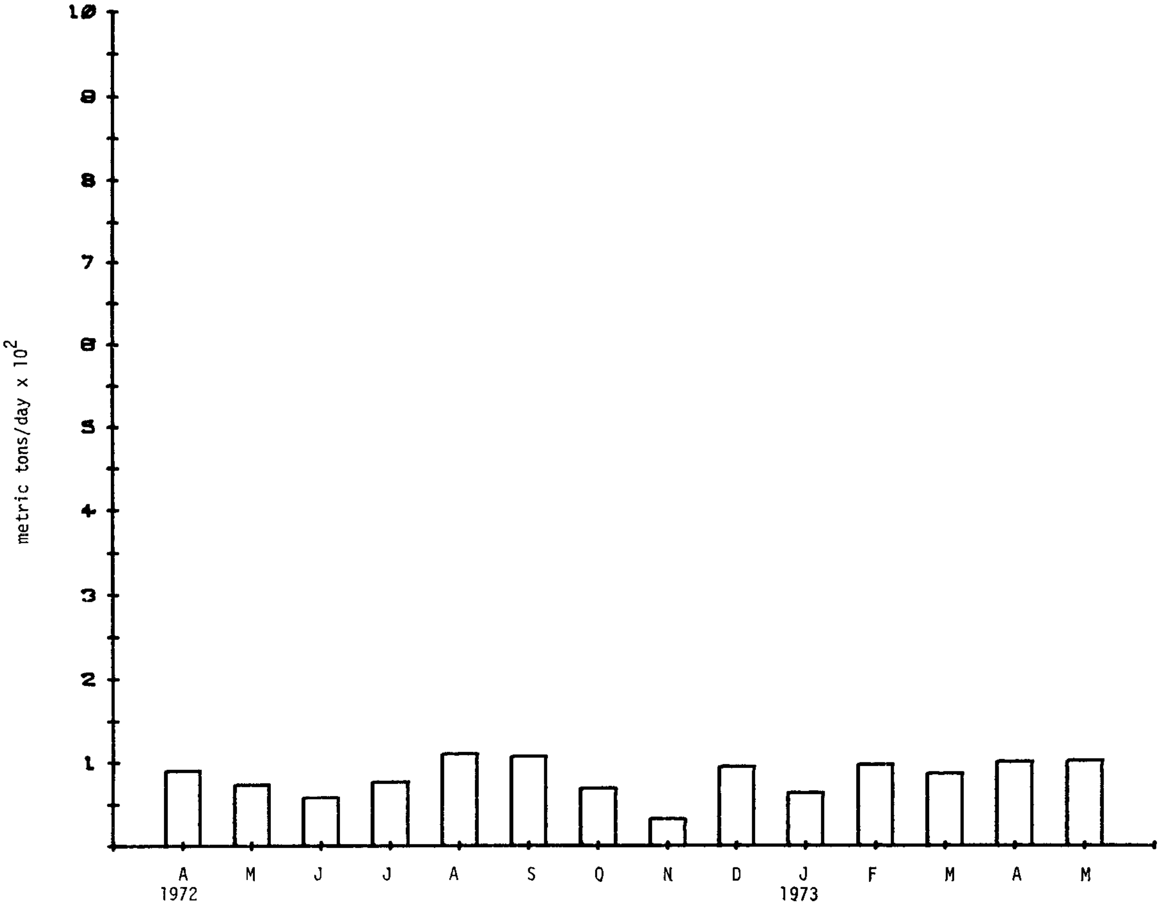

Figure 3.13 Niagara River Monthly Mean Stream Loadings - Organic Nitrogen

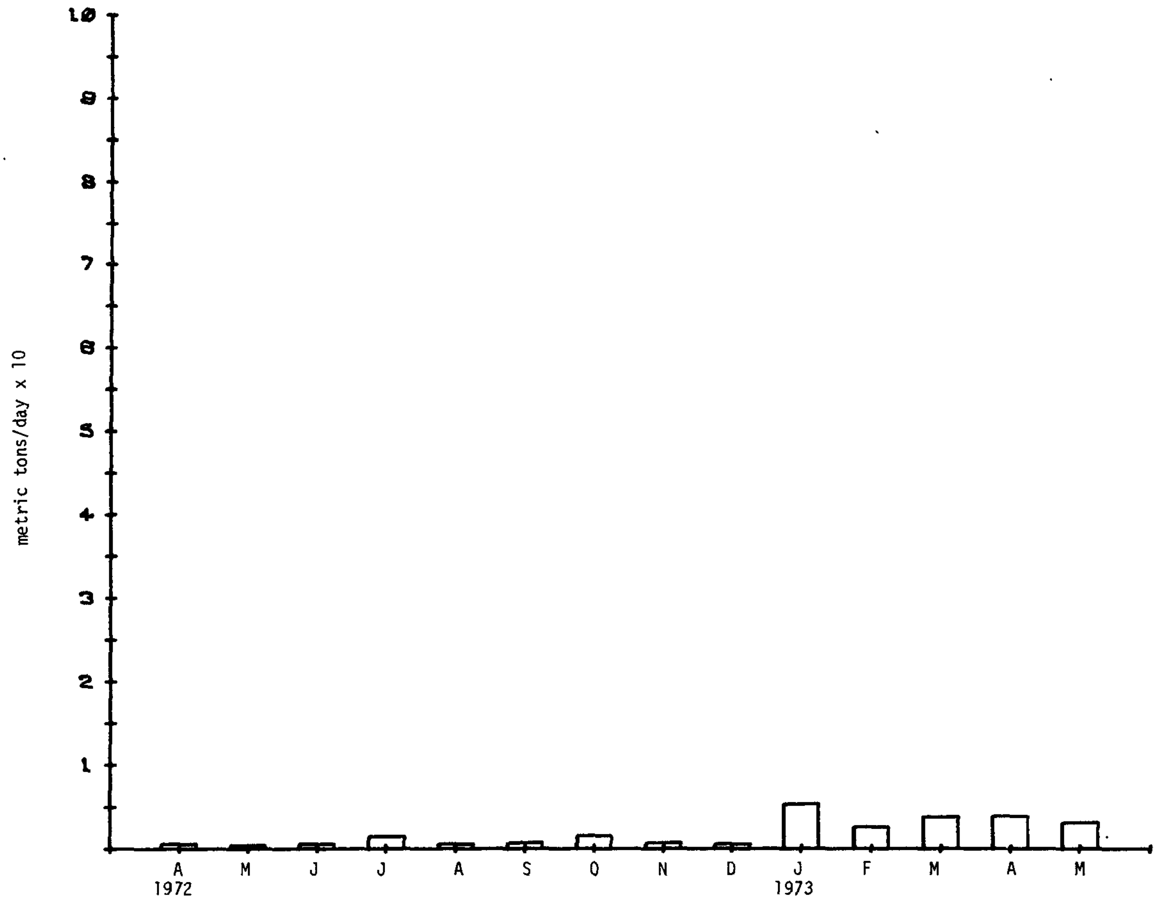

Figure 3.13 Black River Monthly Mean Stream Loadings - Organic Nitrogen

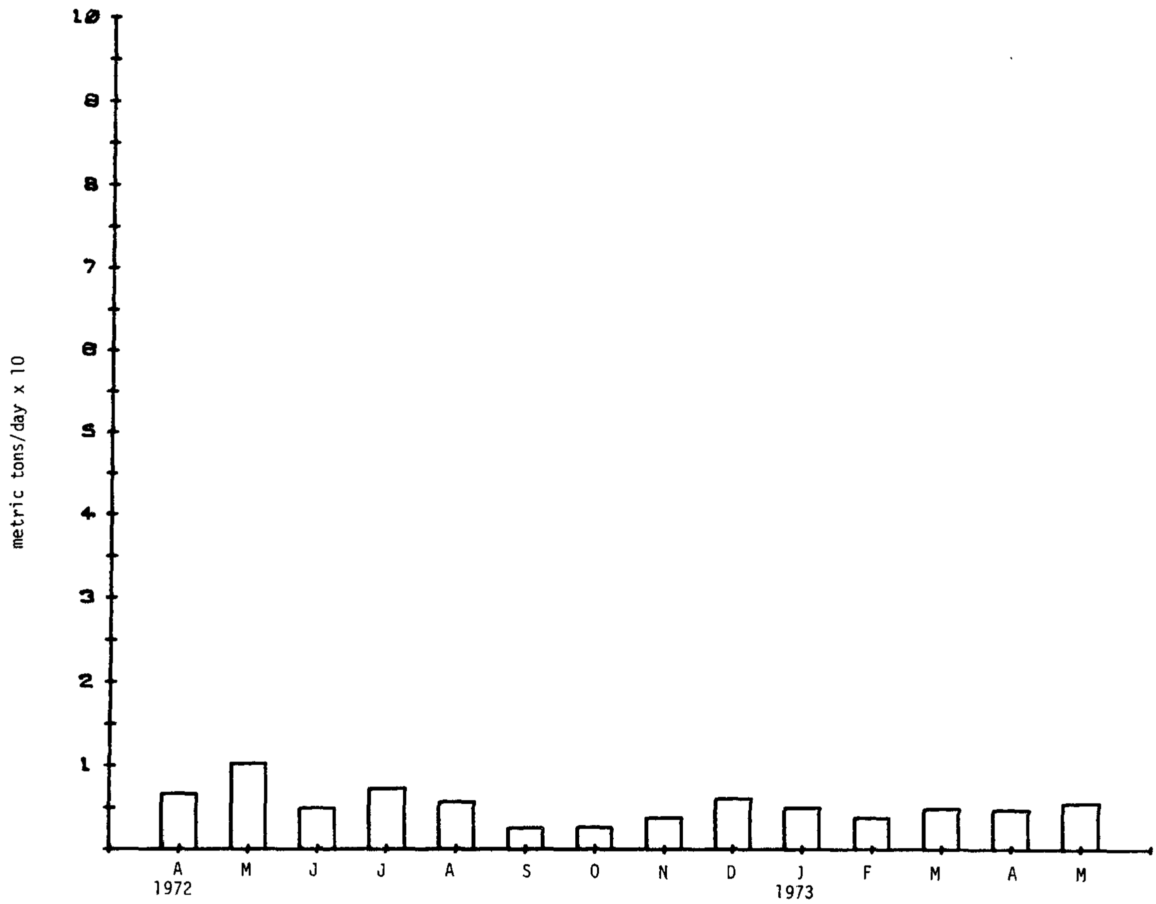

Figure 3.13 Oswego River Monthly Mean Stream Loadings - Organic Nitrogen

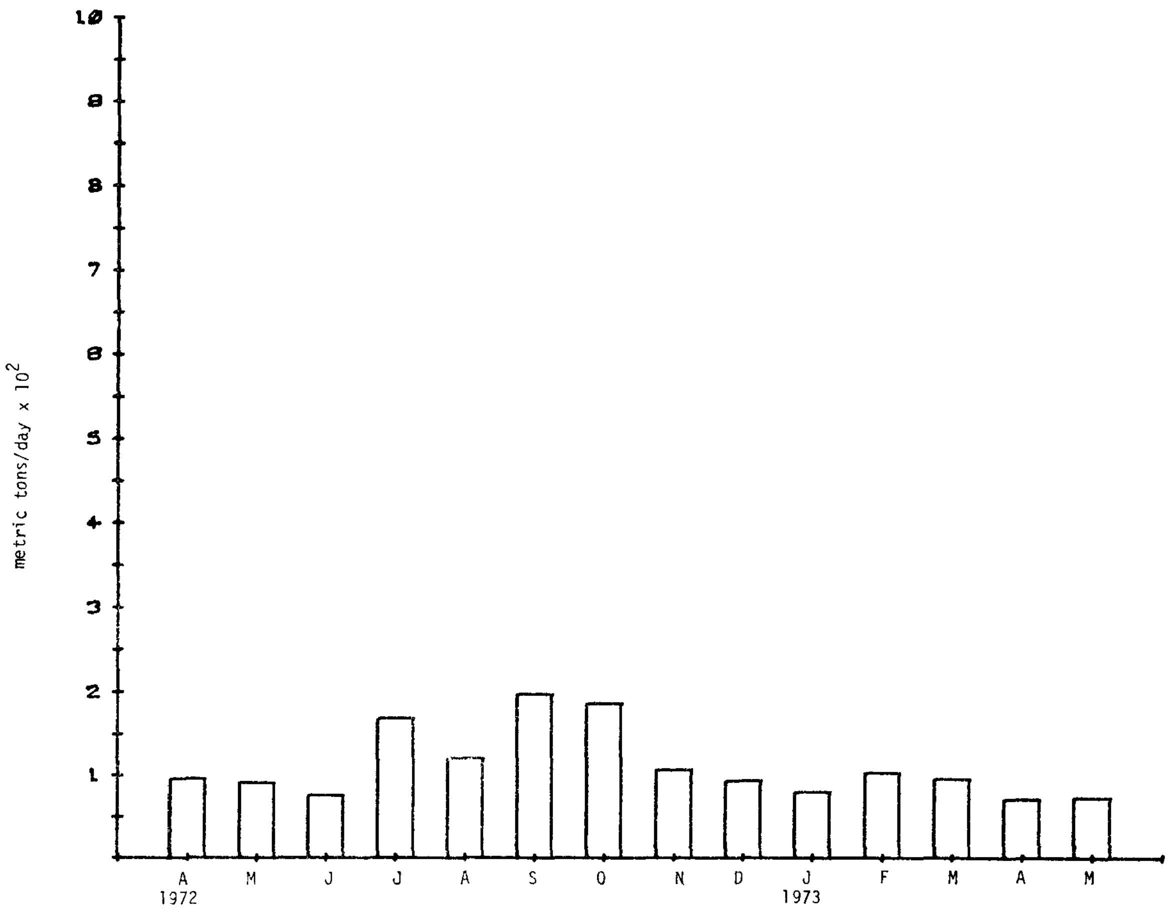

Figure 3.13 St. Lawrence River Monthly Mean Stream Loadings - Organic Nitrogen

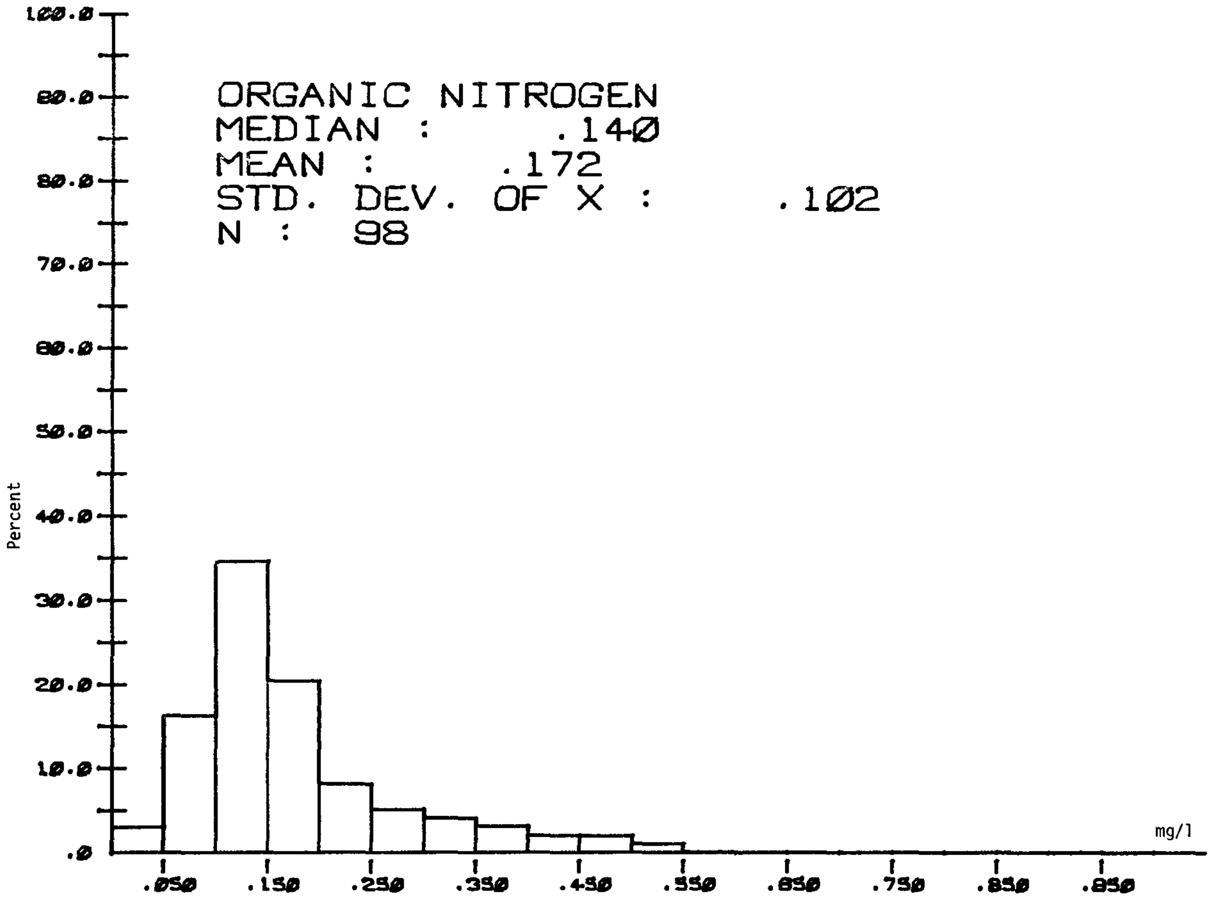

Figure 3.14 Genesee River Histograms for Organic Nitrogen

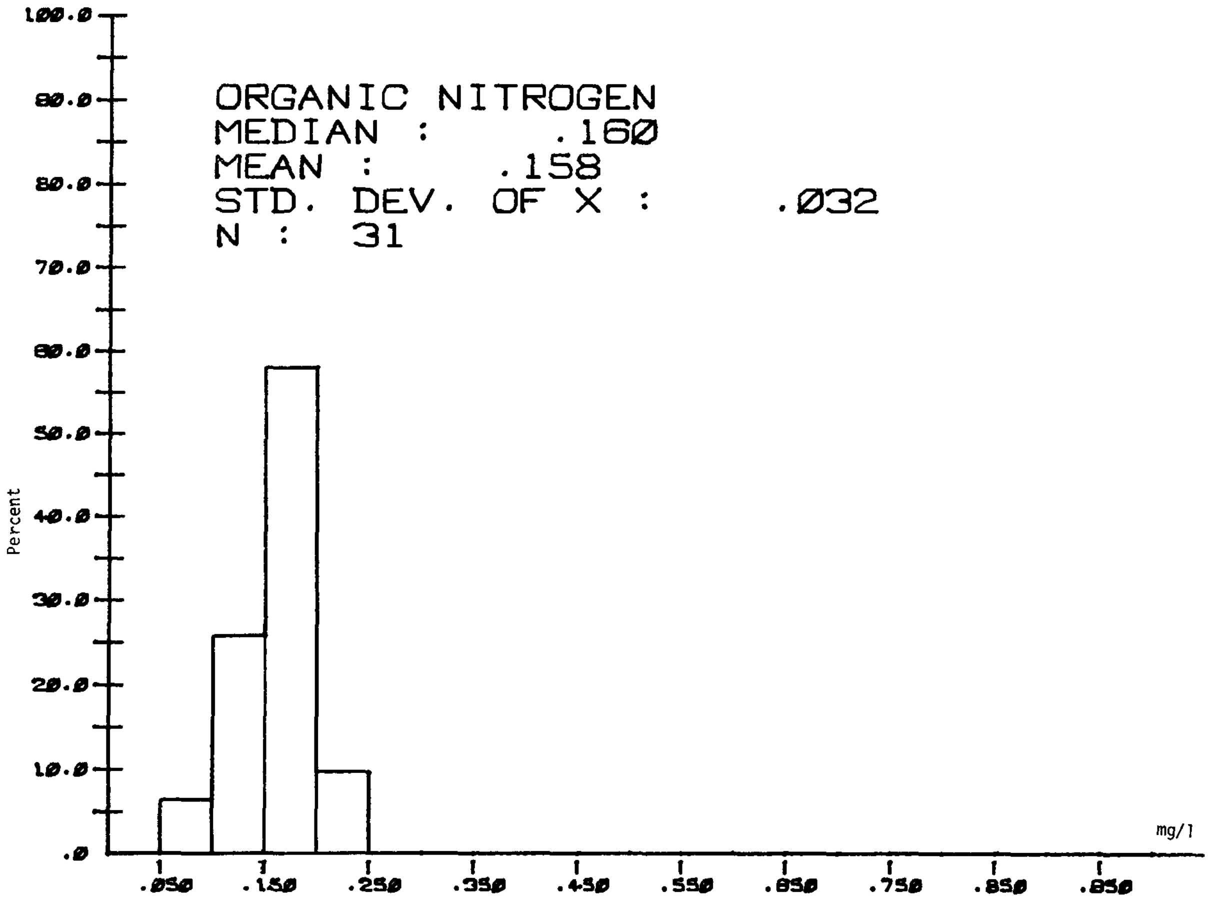

Figure 3.14 Niagara River Histograms for Organic Nitrogen

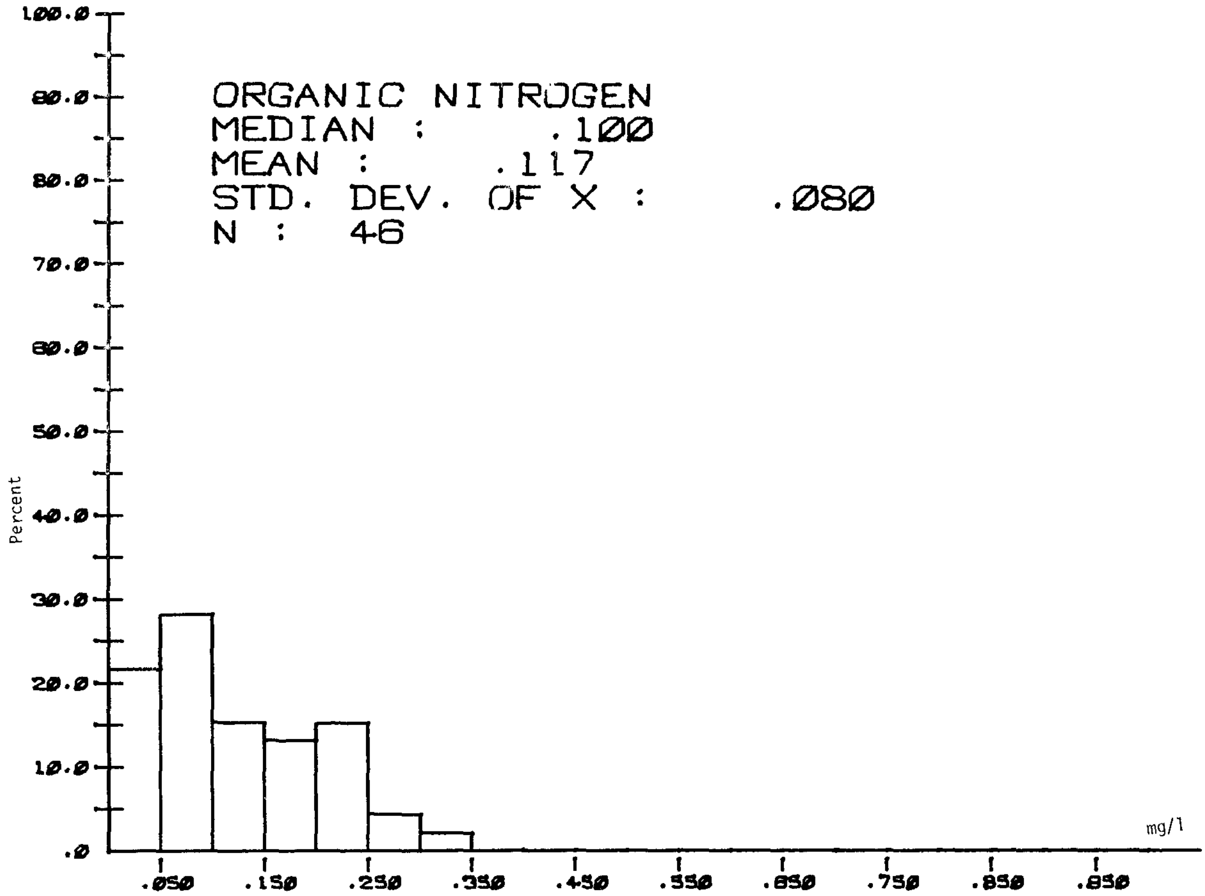

Figure 3.14 Black River Histograms for Organic Nitrogen

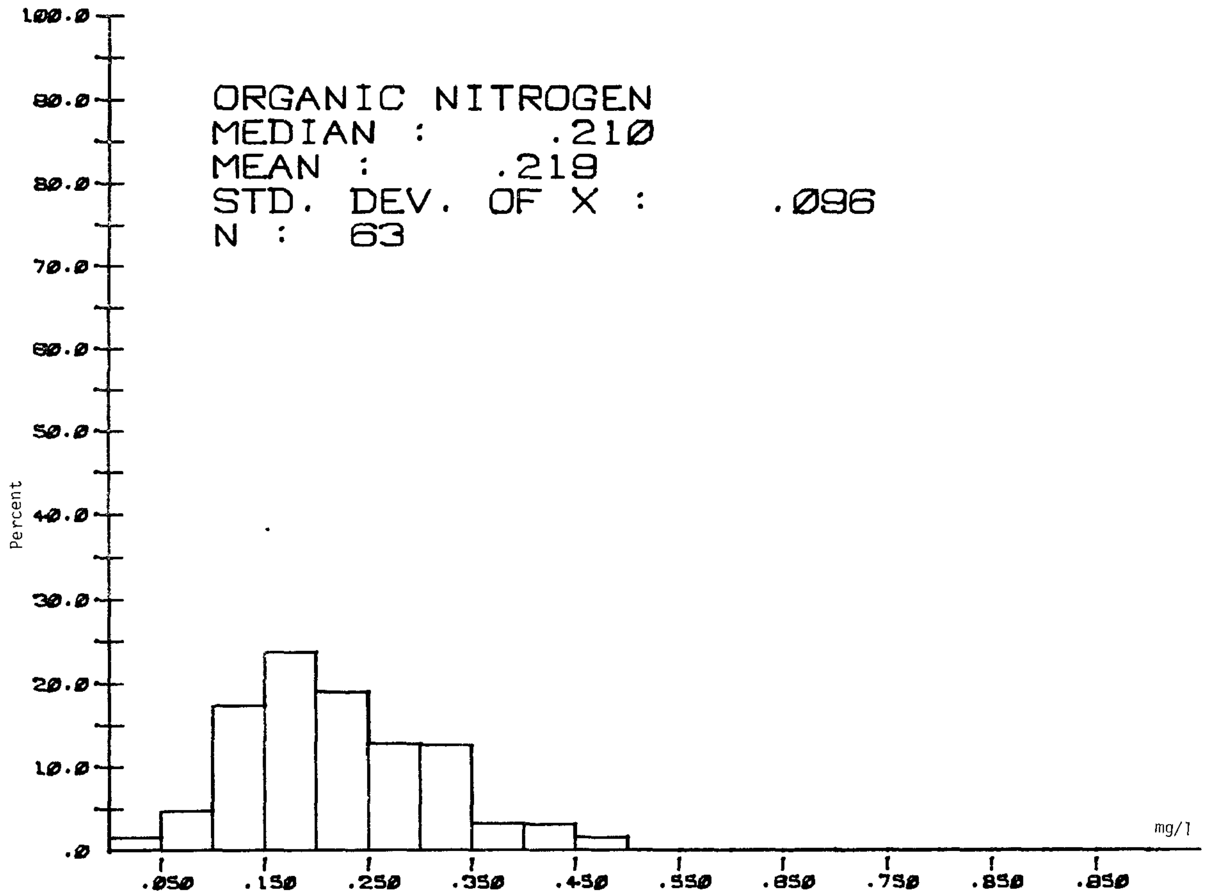

Figure 3.14 Oswego River Histograms for Organic Nitrogen

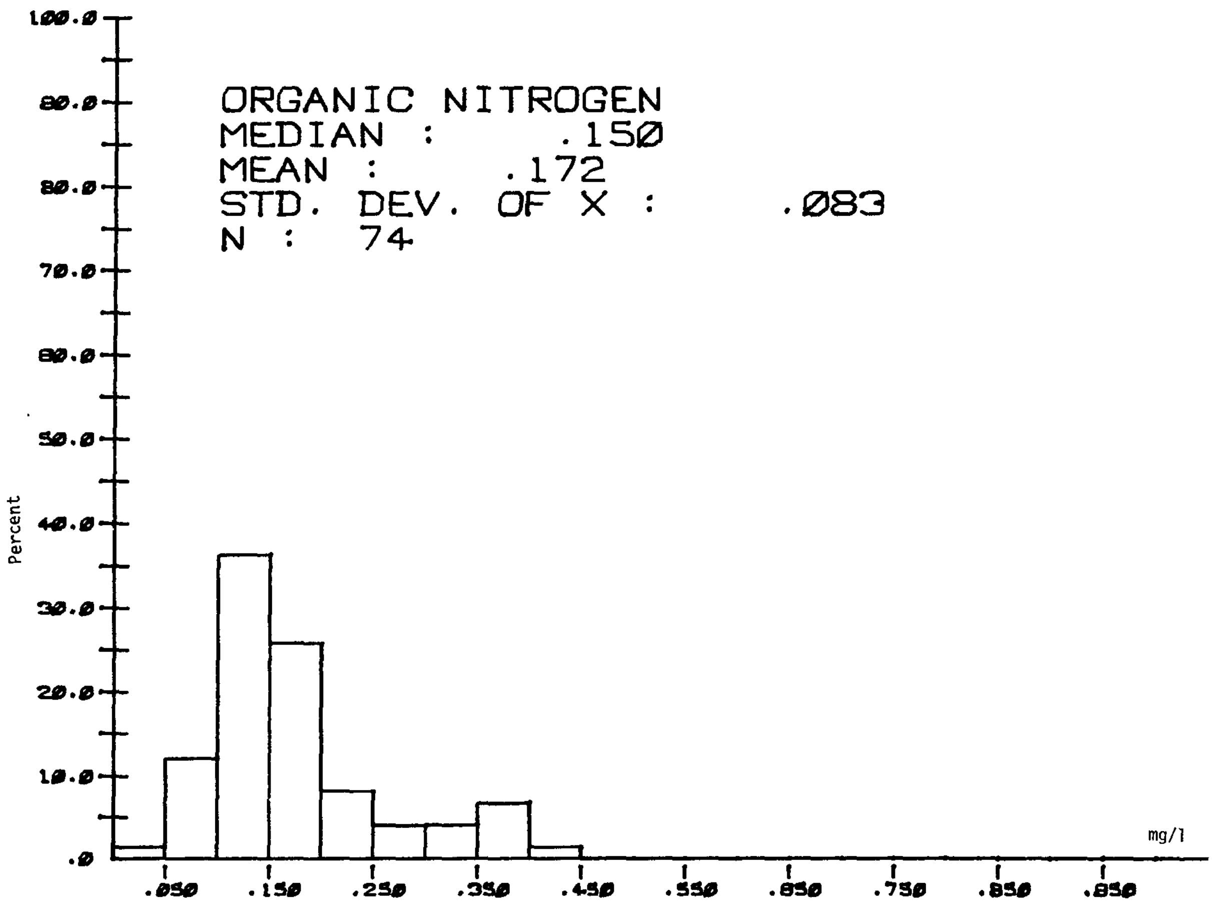

Figure 3.14 St. Lawrence River Histograms for Organic Nitrogen

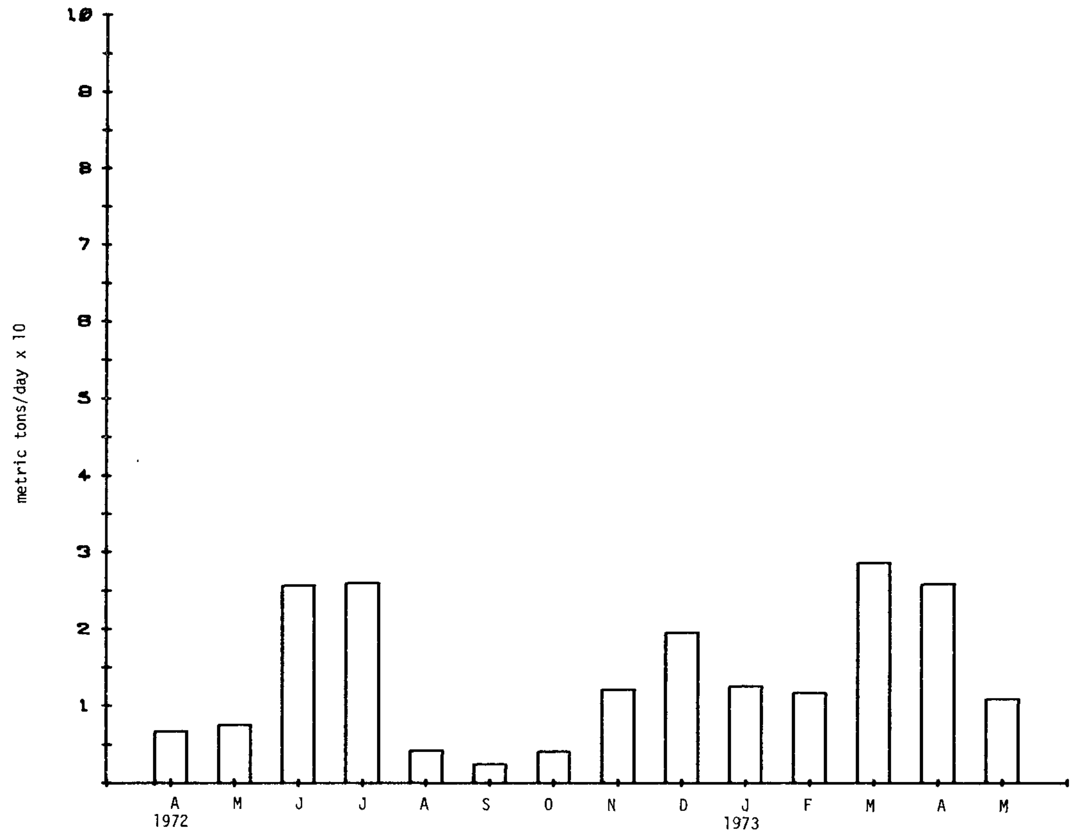

Figure 3.15 Genesee River Monthly Mean Stream Loadings - Total Nitrogen

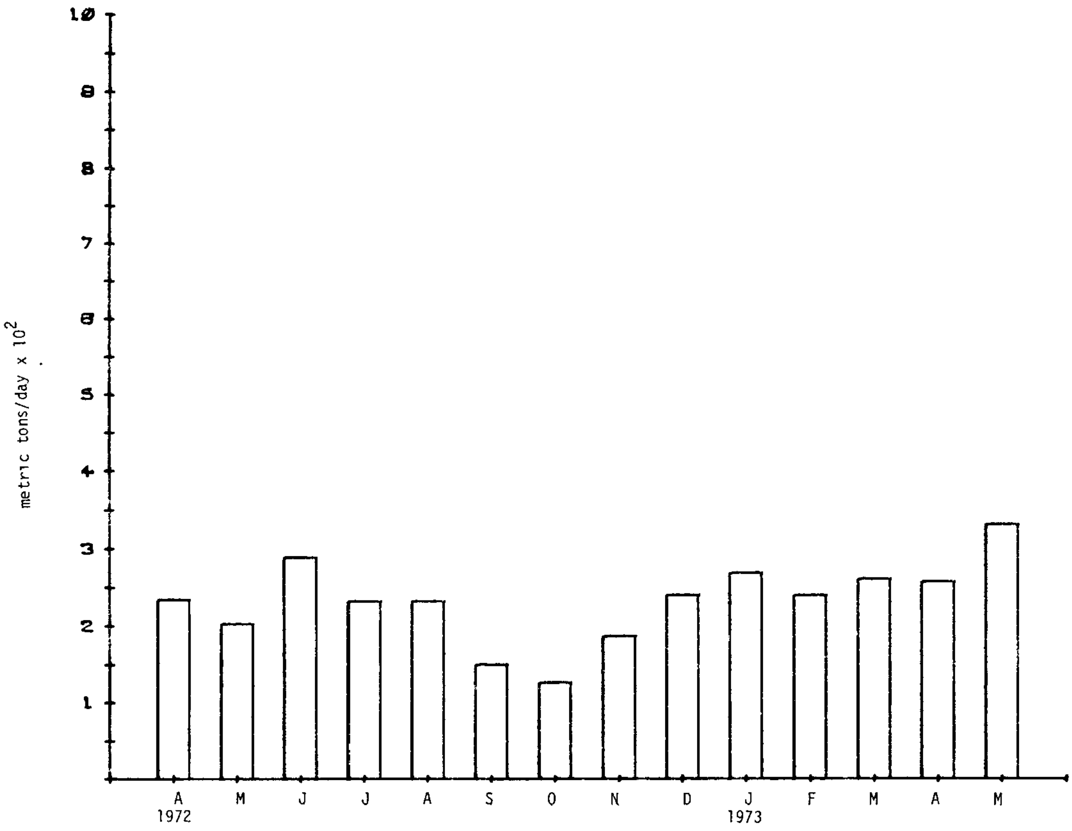

Figure 3.15 Niagara River Monthly Mean Stream Loadings - Total Nitrogen

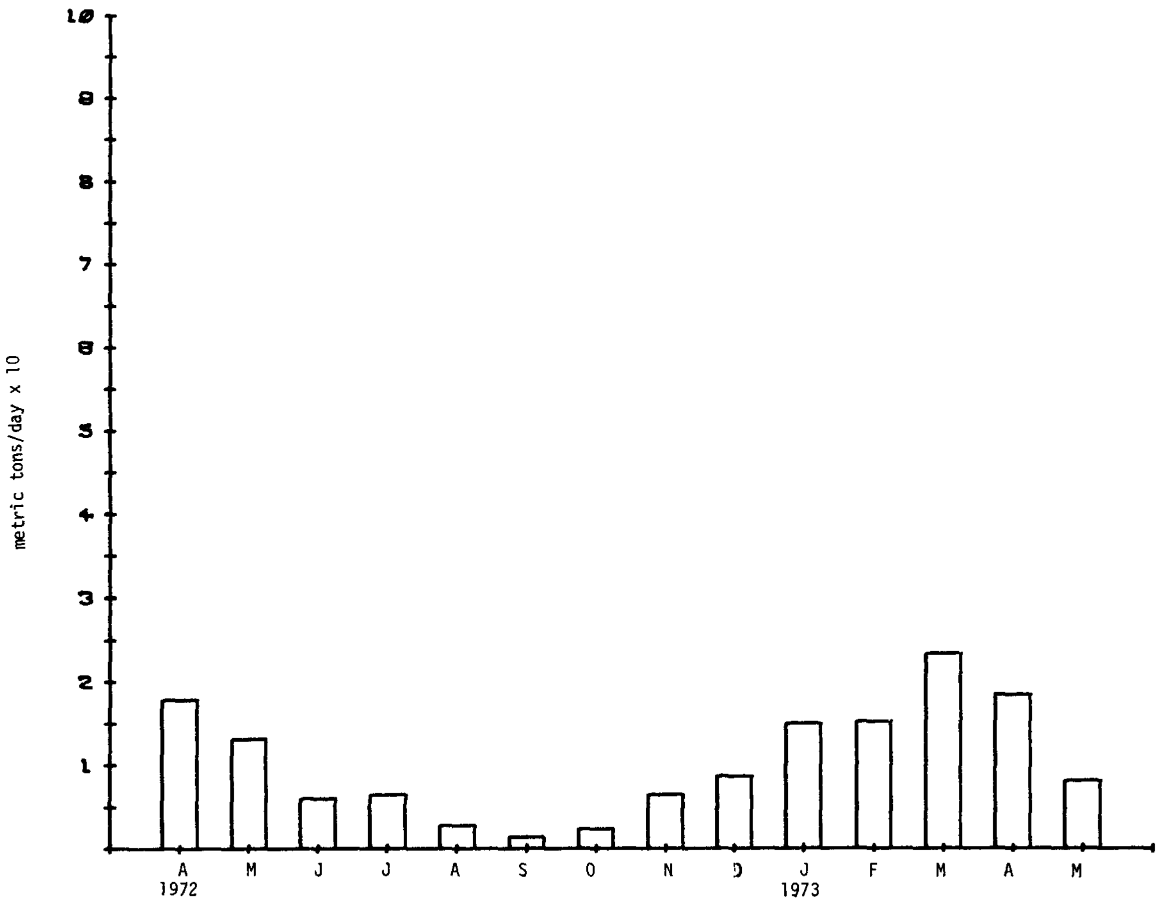

Figure 3.15 Black River Monthly Mean Stream Loadings -
Total Nitrogen

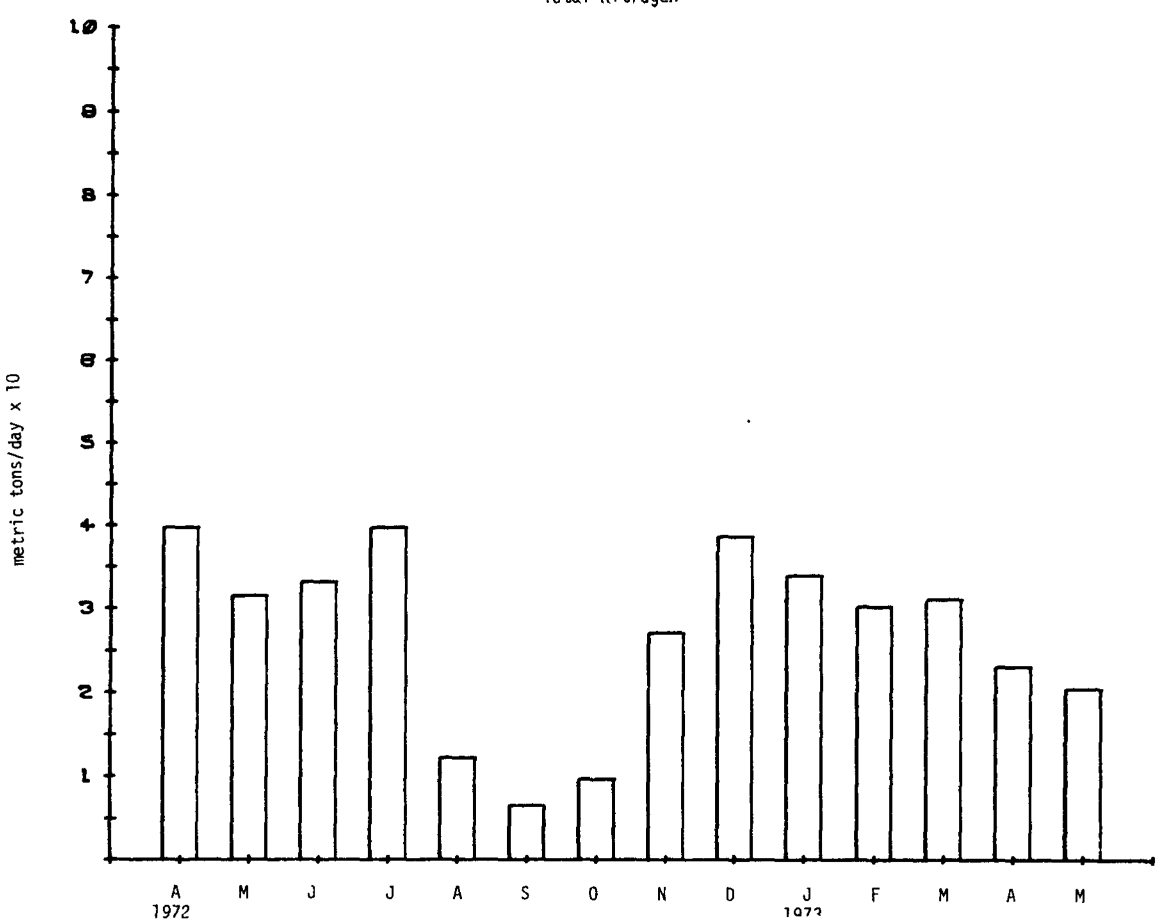

Figure 3.15 Oswego River Monthly Mean Stream Loadings -
Total Nitrogen

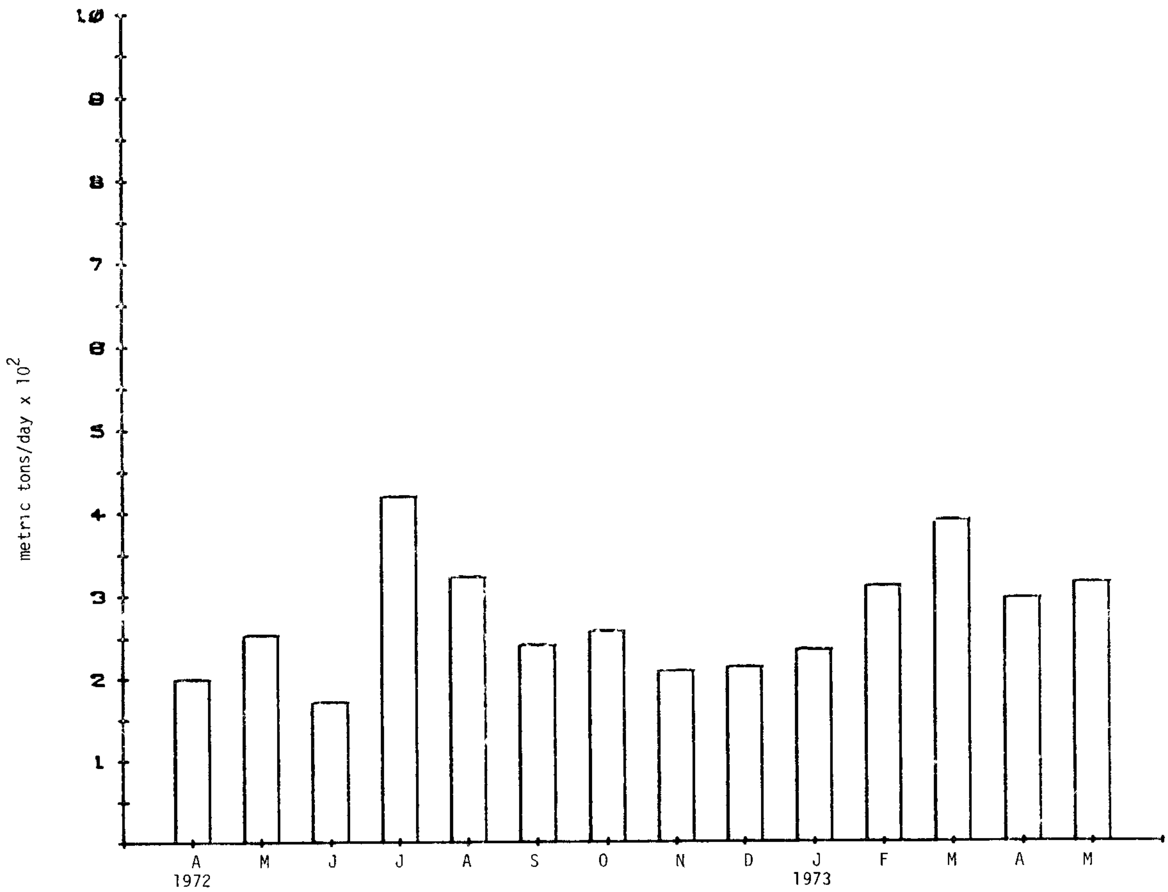

Figure 3.15 St. Lawrence River Monthly Mean Stream Loadings - Total Nitrogen

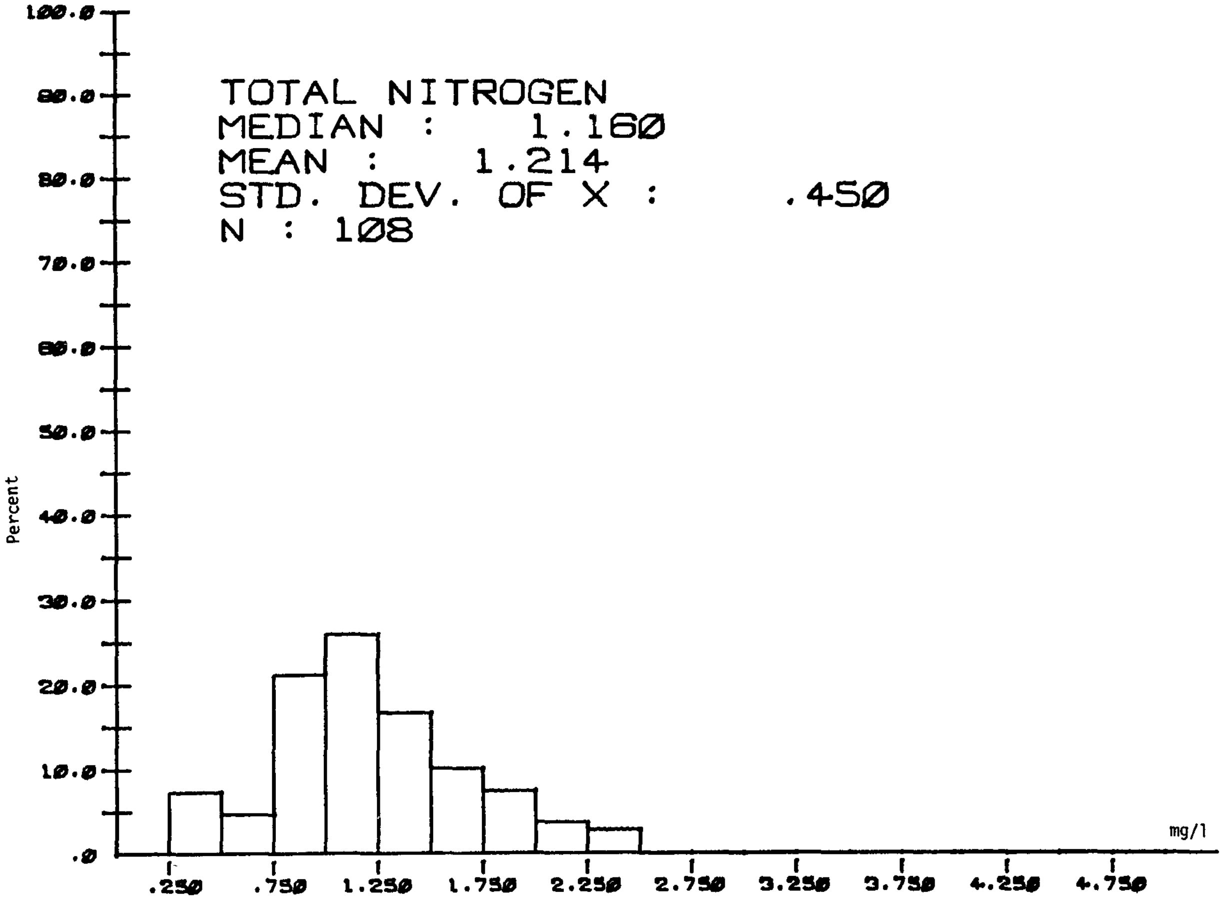

Figure 3.16 Genesee River Histograms for Total Nitrogen

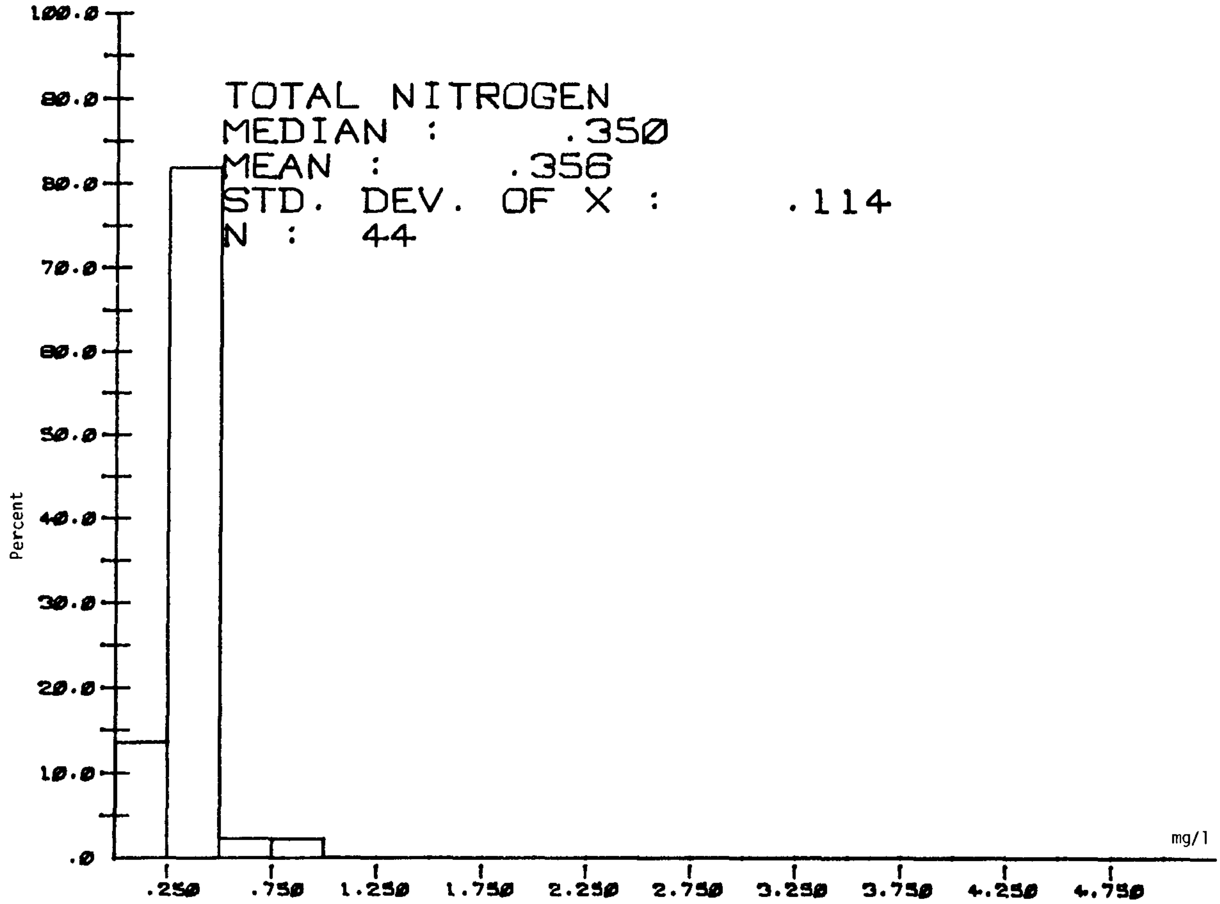

Figure 3.16 Niagara River Histograms for Total Nitrogen

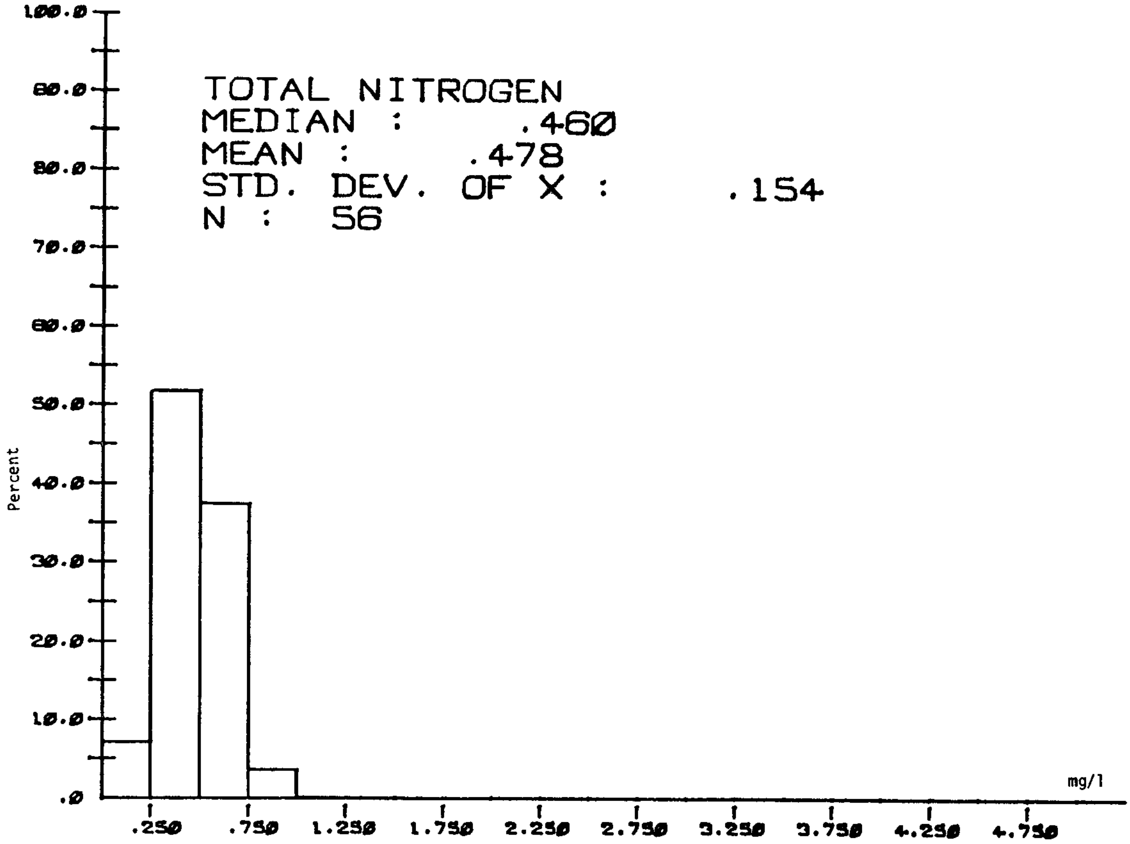

Figure 3.16 Black River Histograms for Total Nitrogen

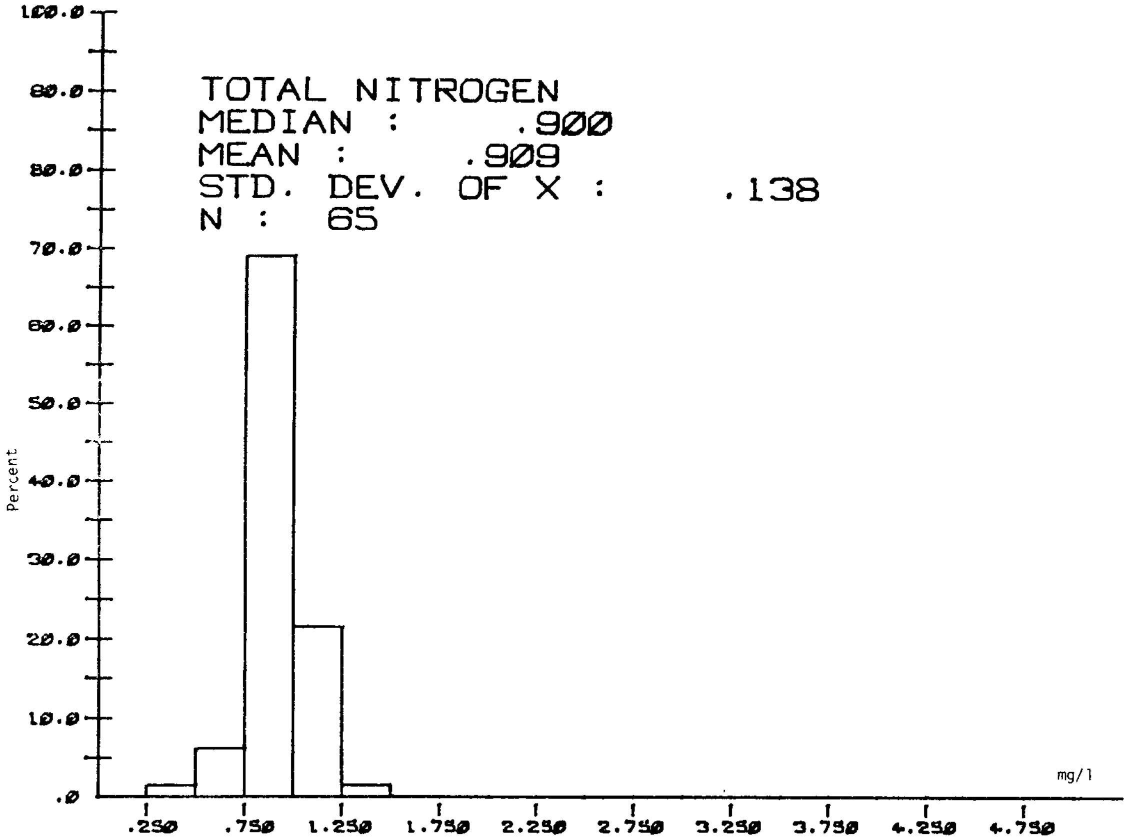

Figure 3.16 Oswego River Histograms for Total Nitrogen

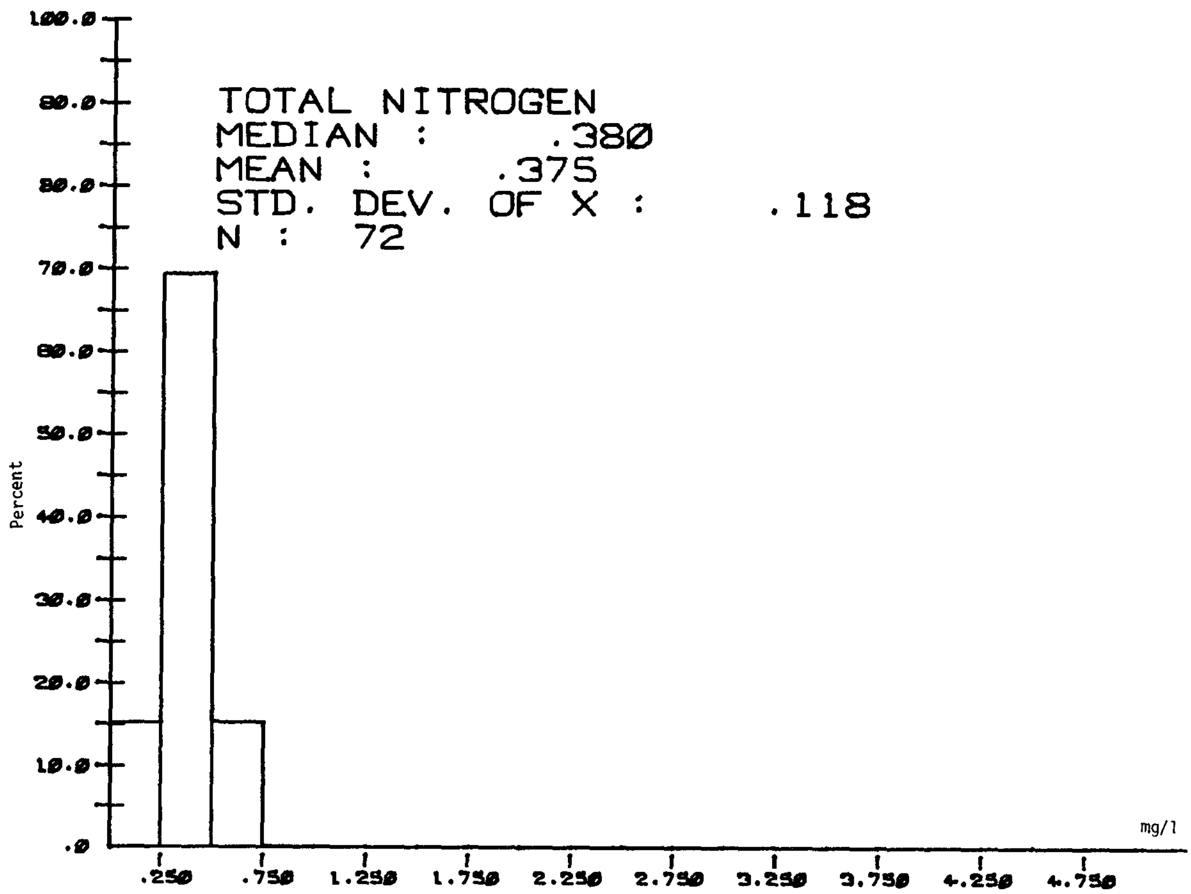

Figure 3.16 St. Lawrence River Histograms for Total Nitrogen

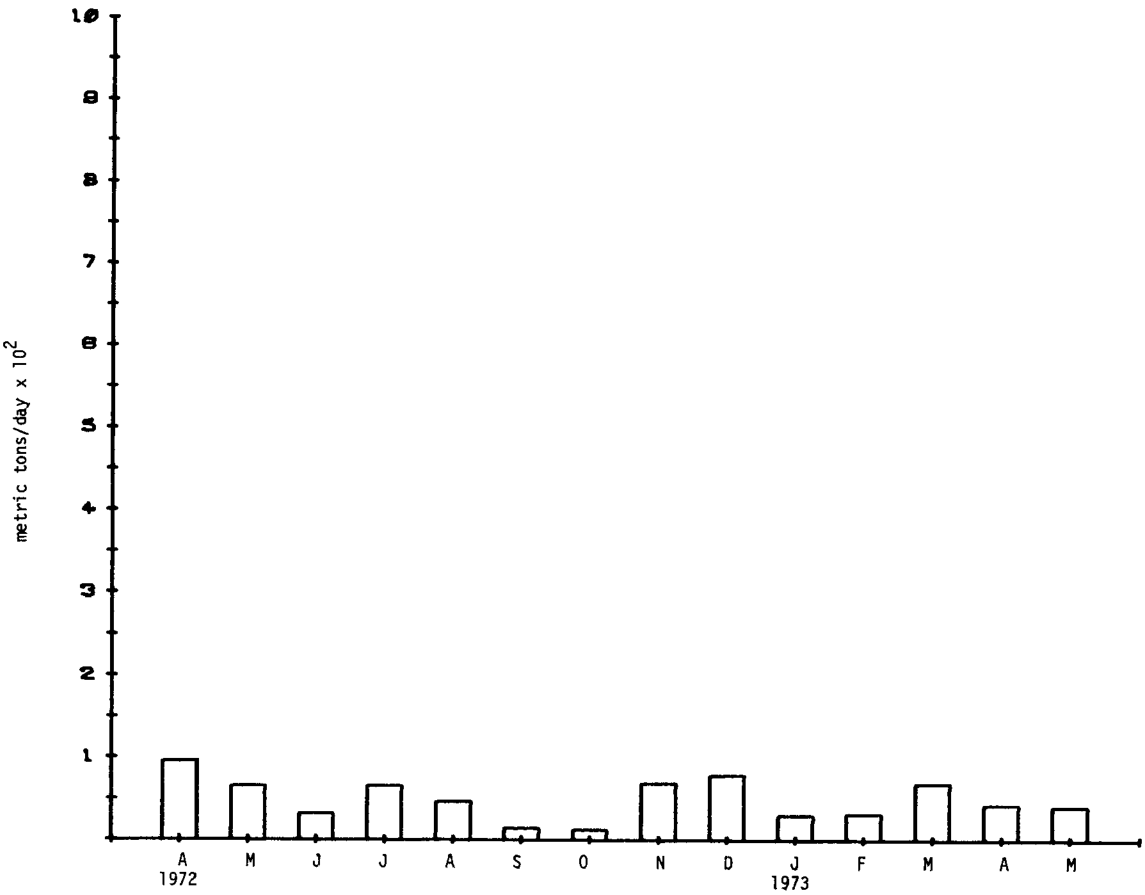

Figure 3.17 Genesee River Monthly Mean Stream Loadings - Total Organic Carbon

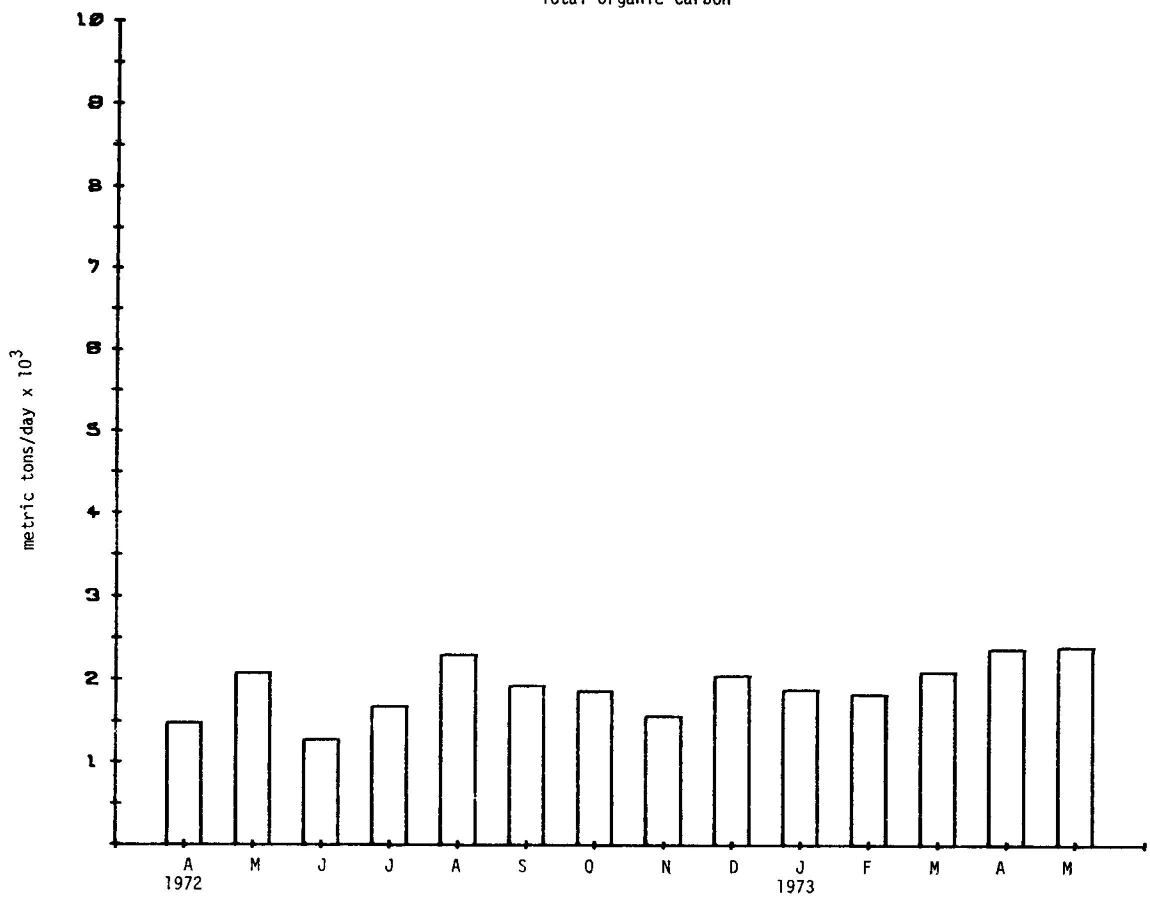

Figure 3.17 Niagara River Monthly Mean Stream Loadings - Total Organic Carbon

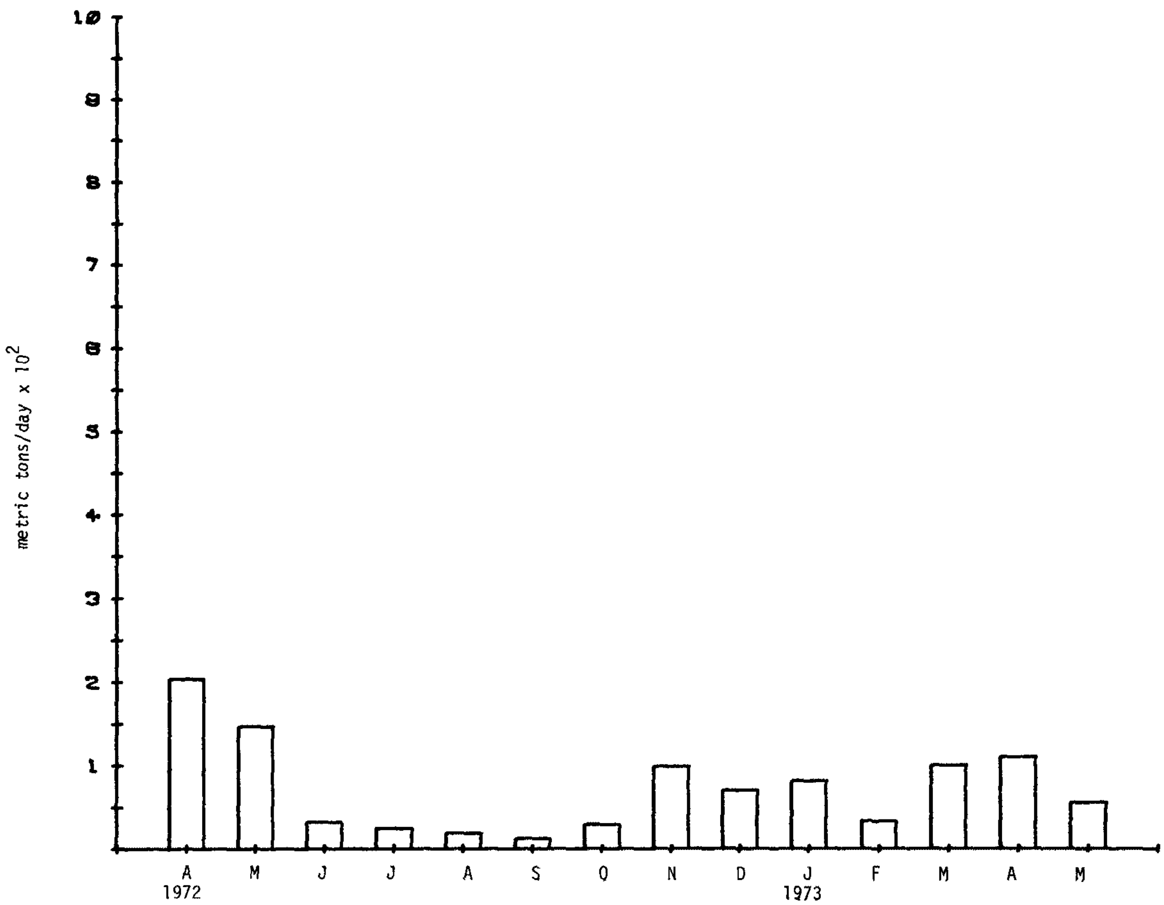

Figure 3.17 Black River Monthly Mean Stream Loadings - Total Organic Carbon

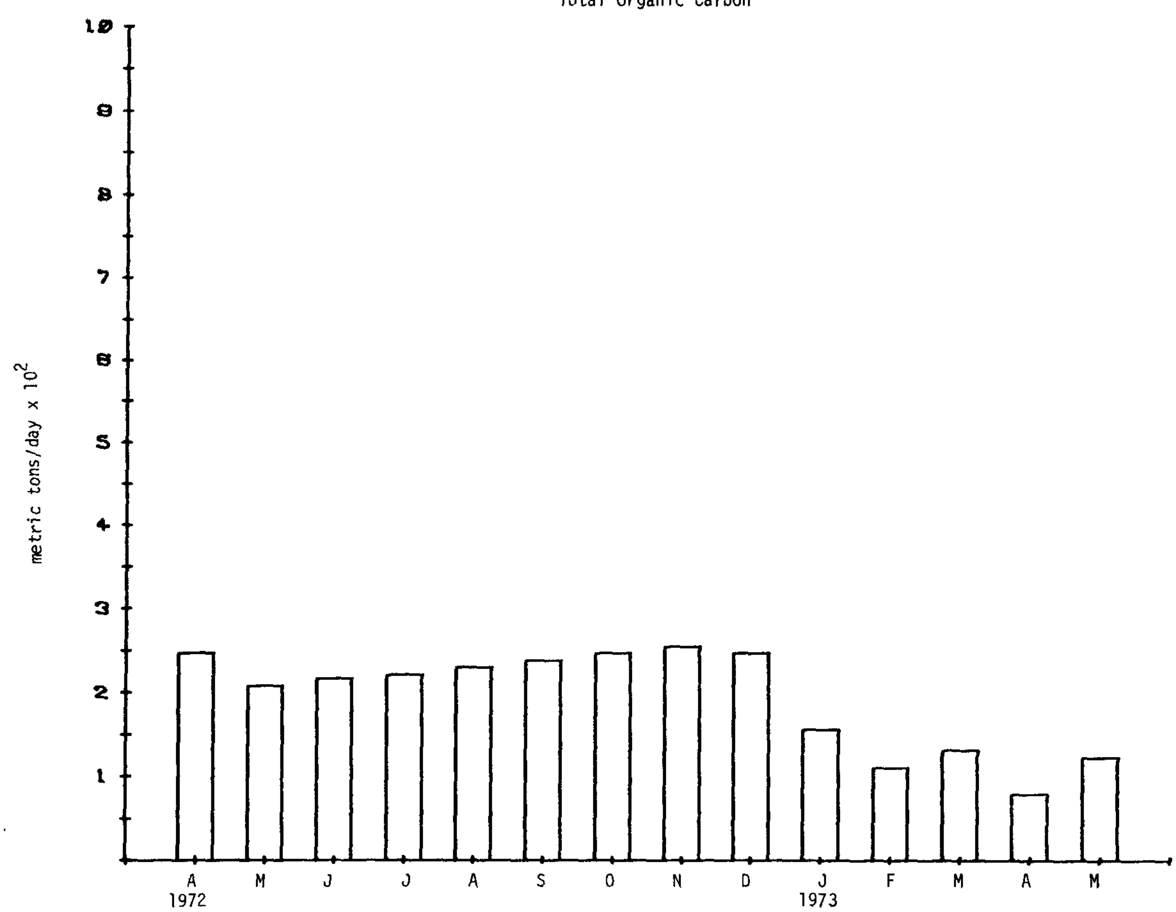

Figure 3.17 Oswego River Monthly Mean Stream Loadings - Total Organic Carbon

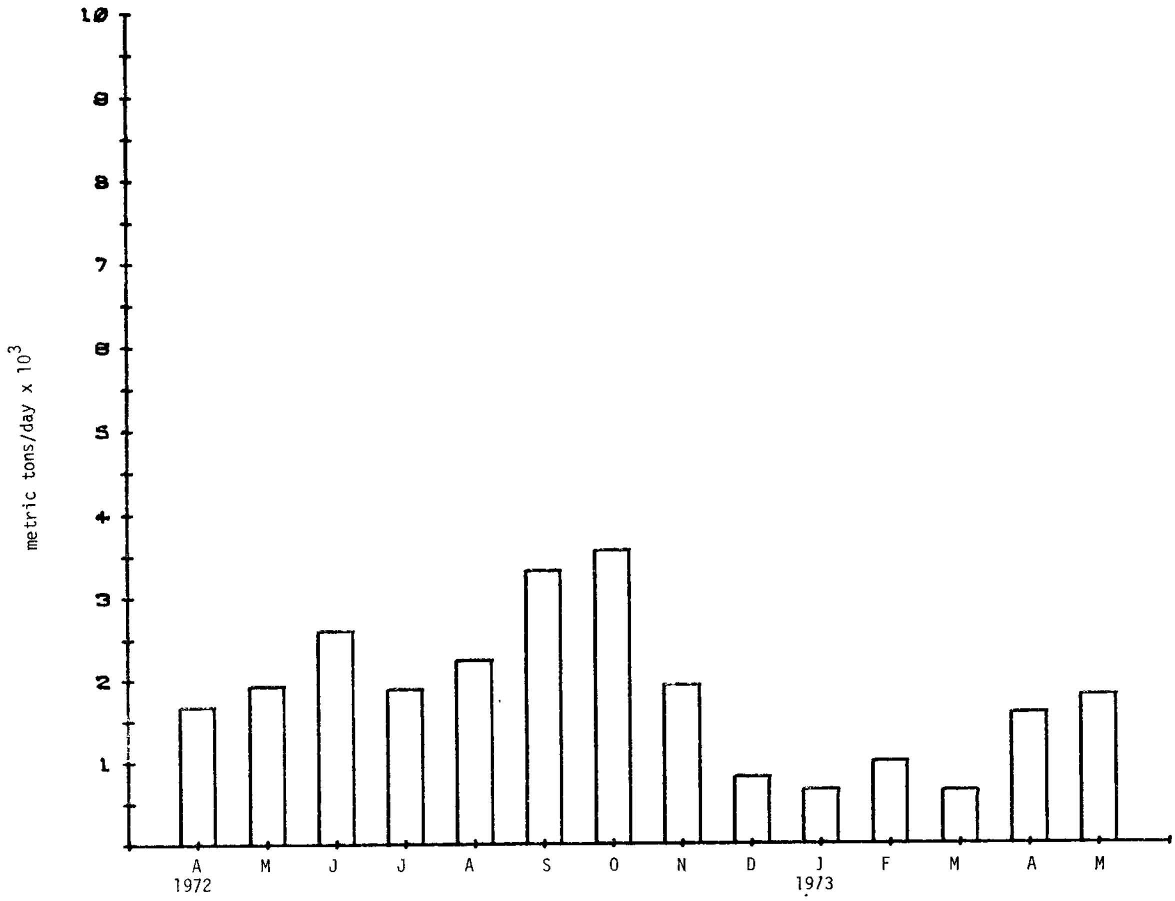

Figure 3.17 St. Lawrence River Monthly Mean Stream Loadings - Total Organic Carbon

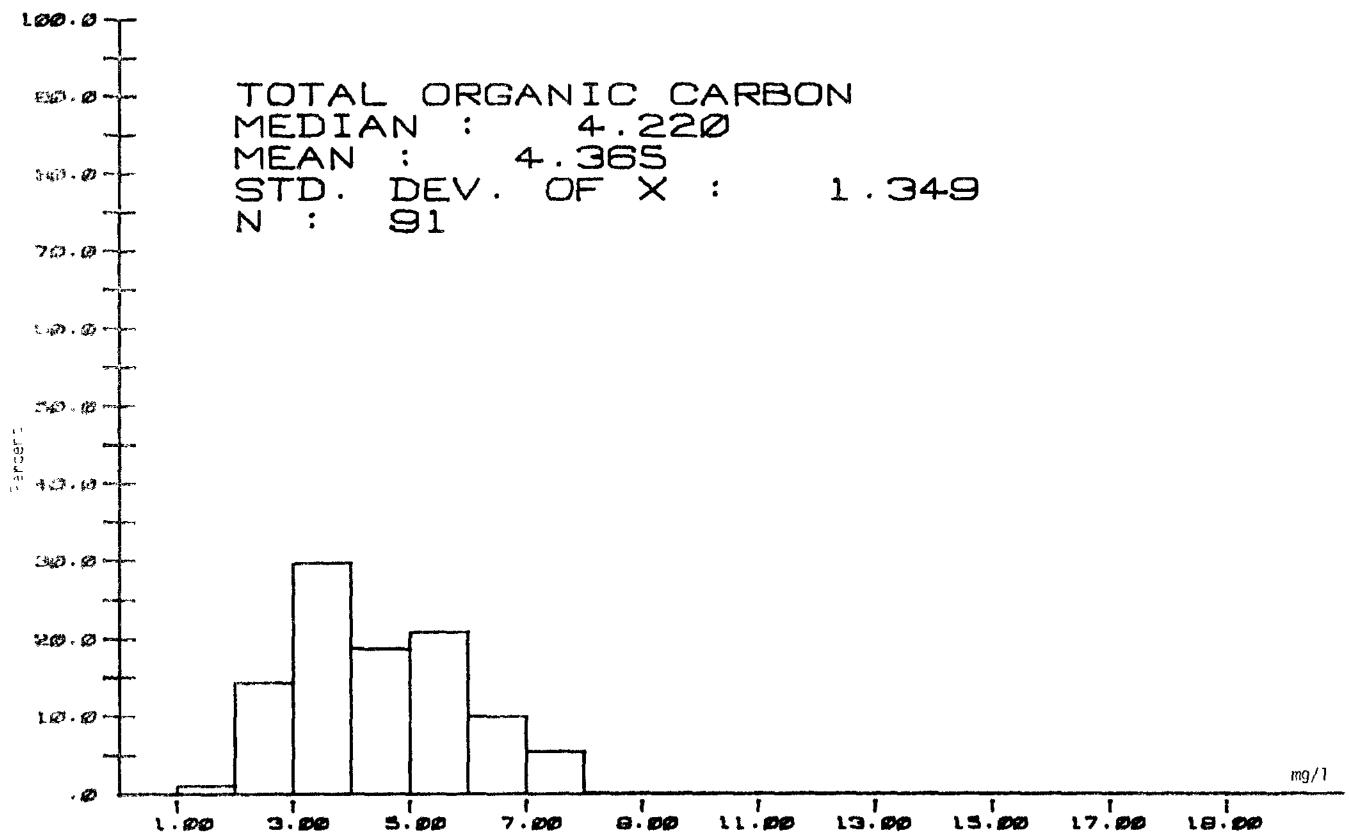

Figure 3.18 Genesee River Histograms for Total Organic Carbon

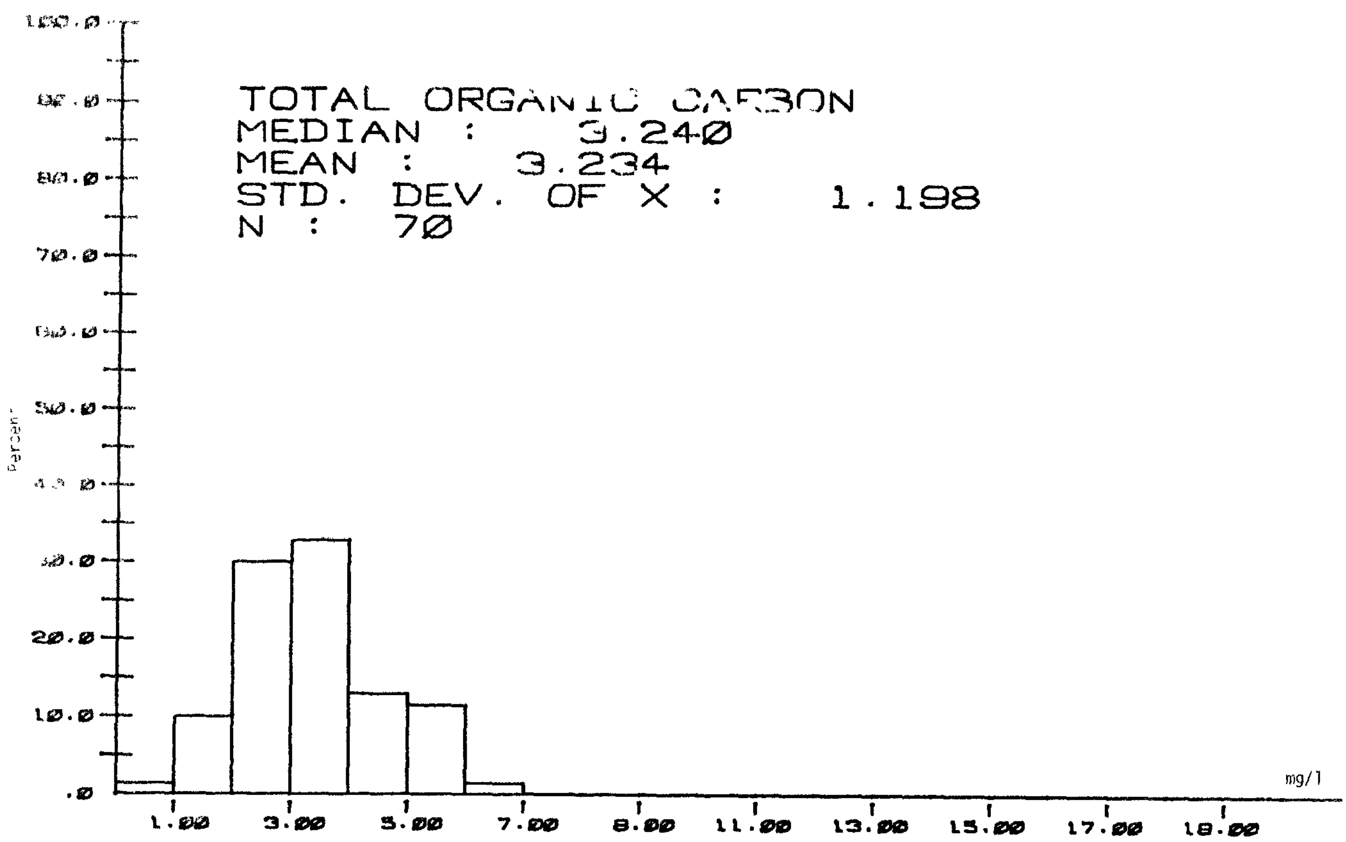

Figure 3.18 Niagara River Histograms for Total Organic Carbon

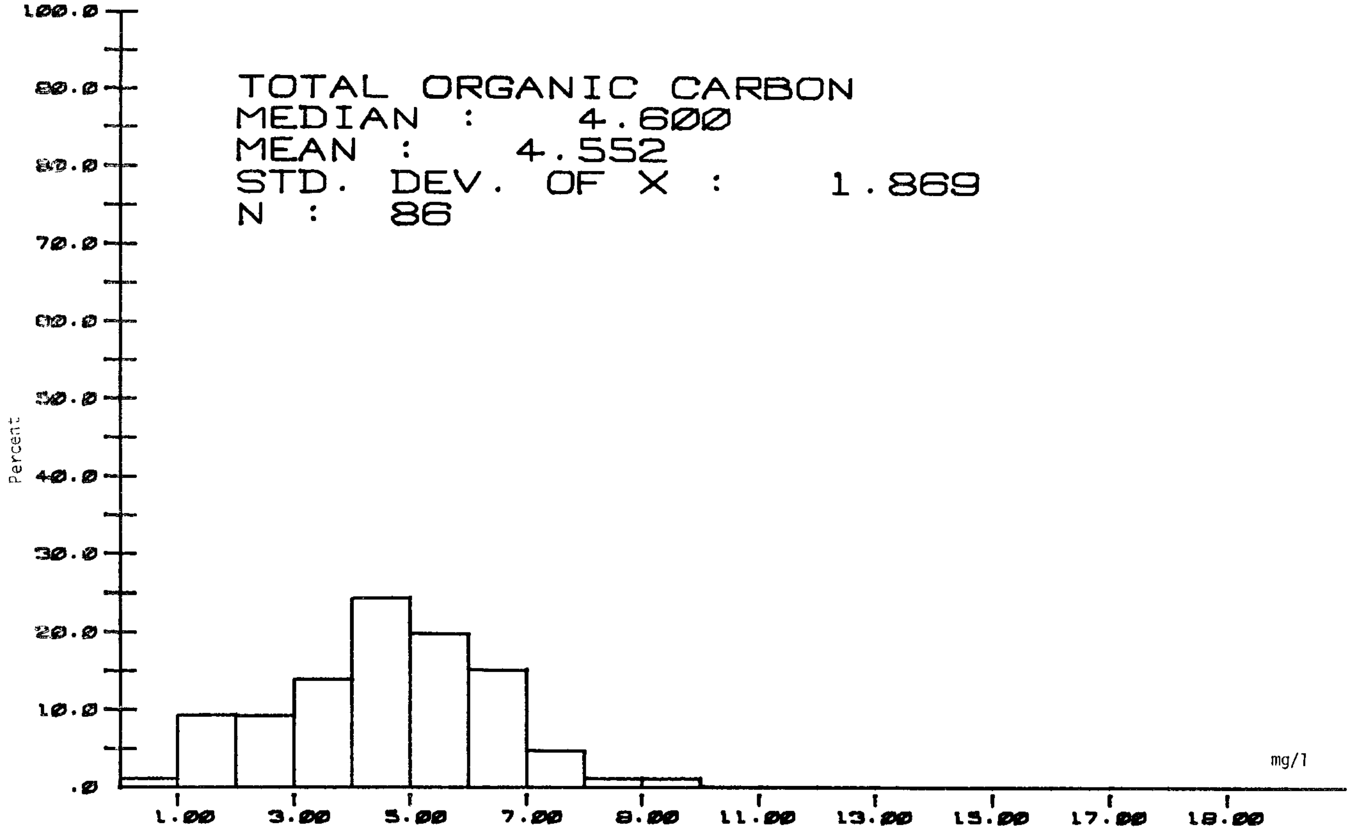

Figure 3.18 Black River Histograms for Total Organic Carbon

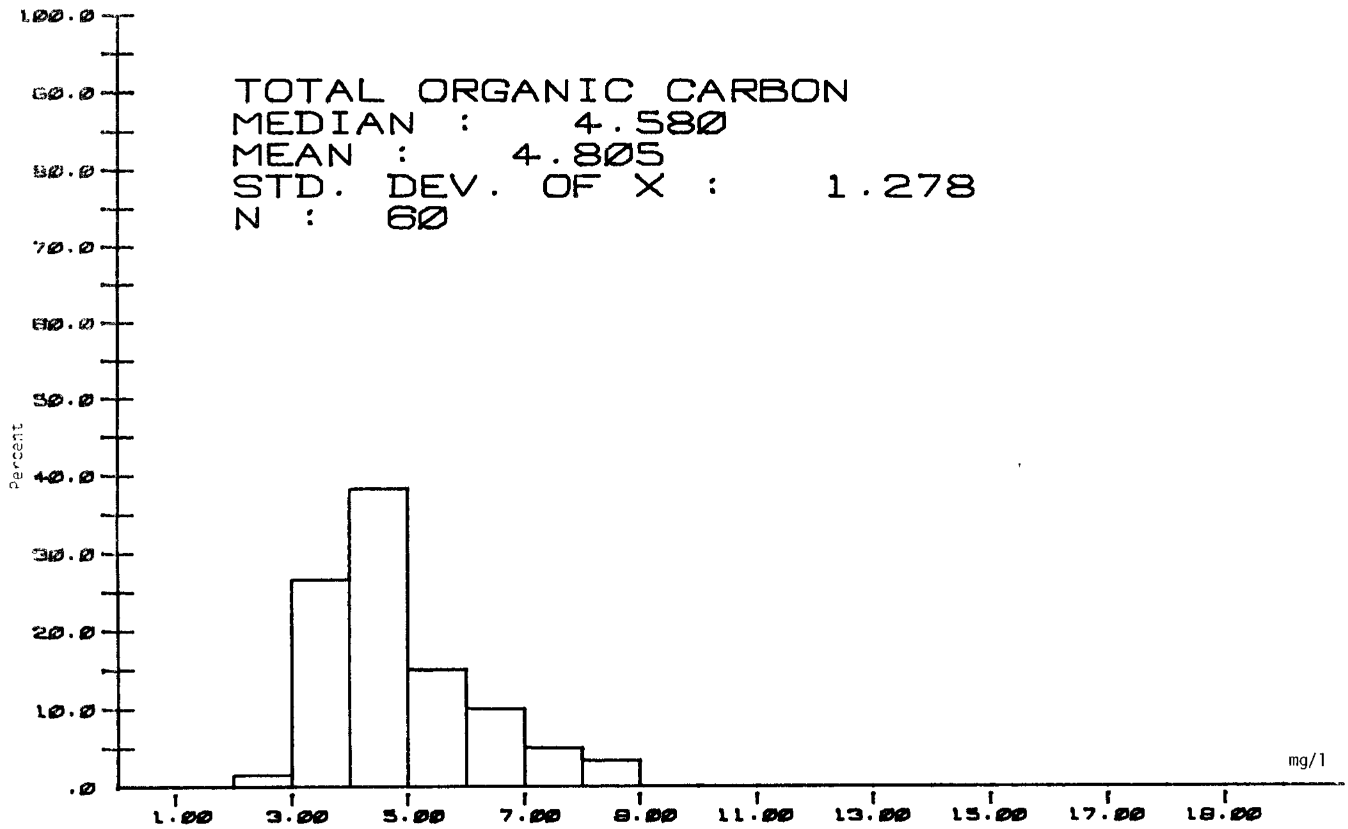

Figure 3.18 Oswego River Histograms for Total Organic Carbon

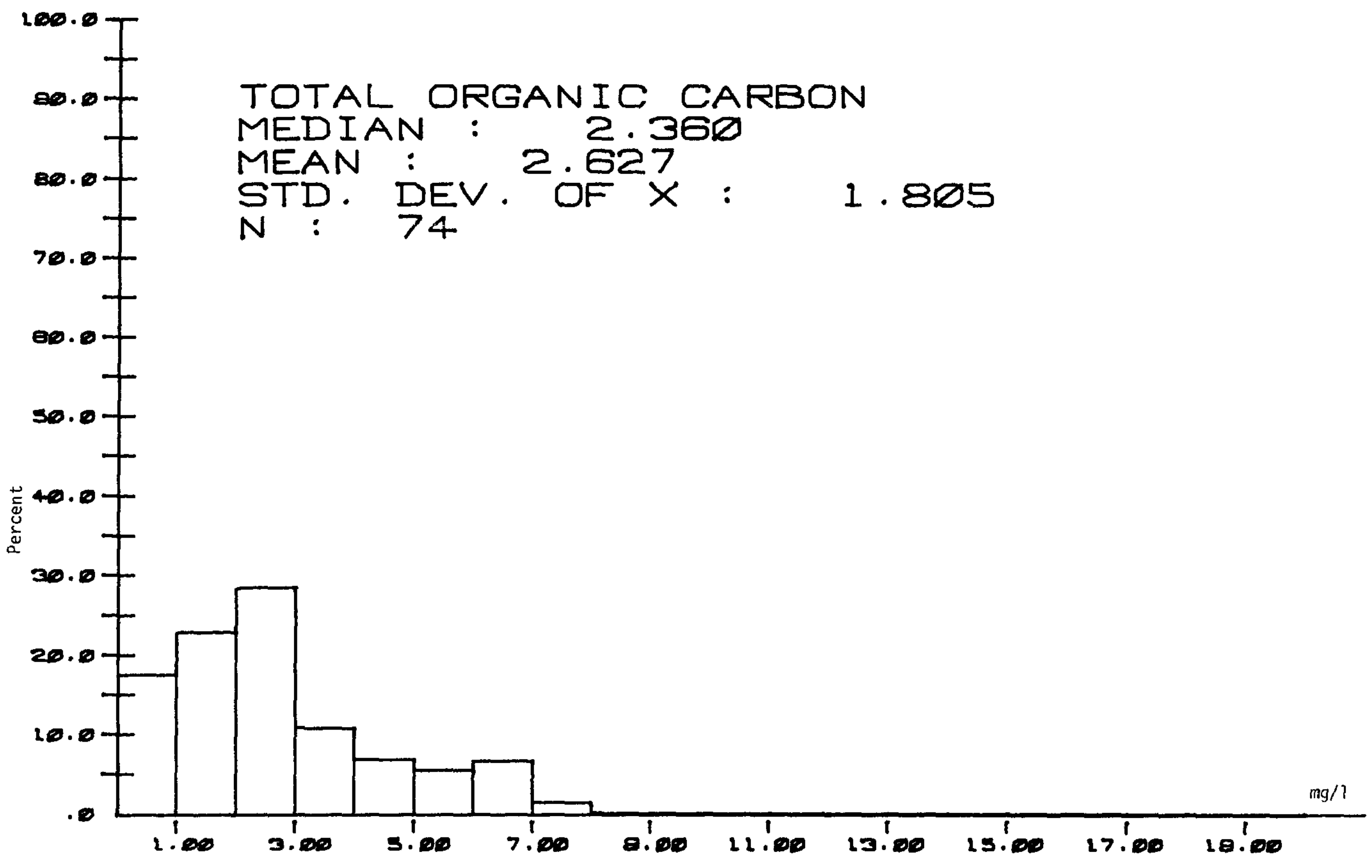

Figure 3.18 St. Lawrence River Histograms for Total Organic Carbon

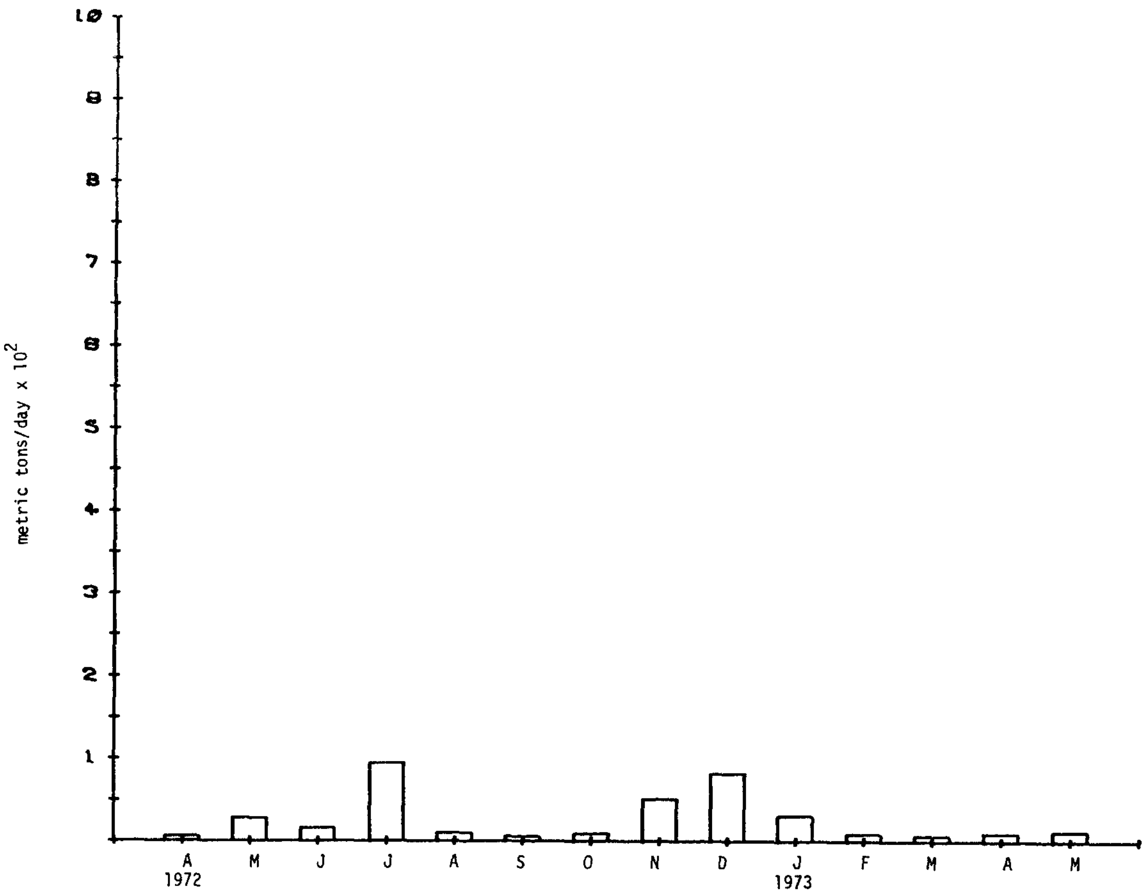

Figure 3.19 Genesee River Monthly Mean Stream Loadings - Silica

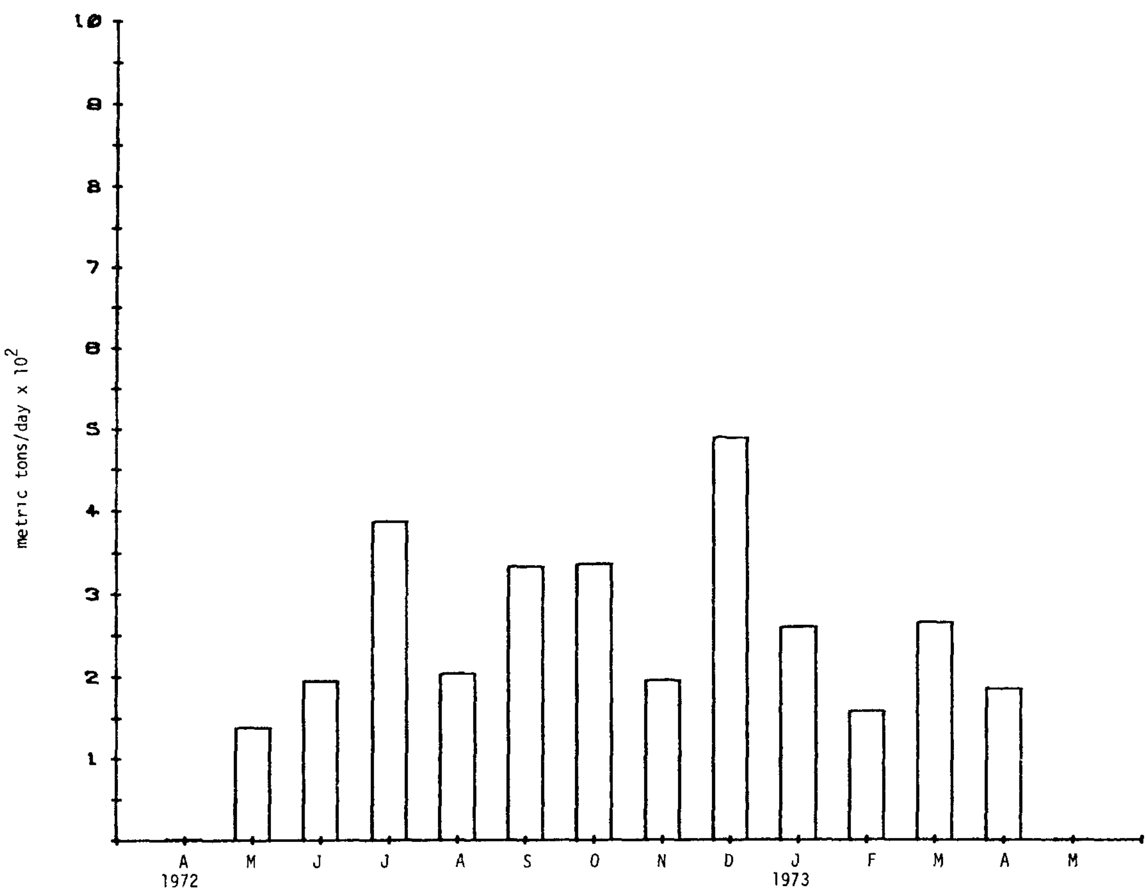

Figure 3.19 Niagara River Monthly Mean Stream Loadings - Silica

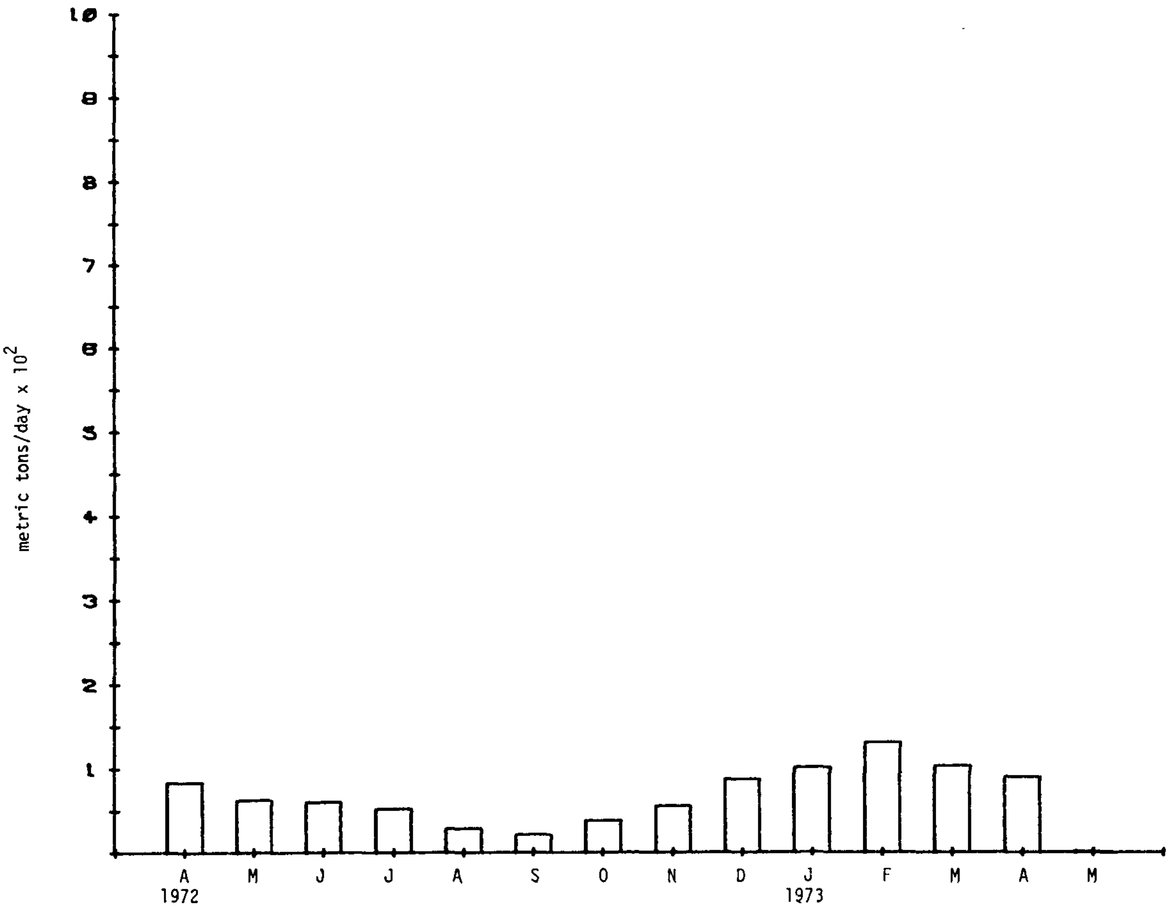

Figure 3.19 Black River Monthly Mean Stream Loadings - Silica

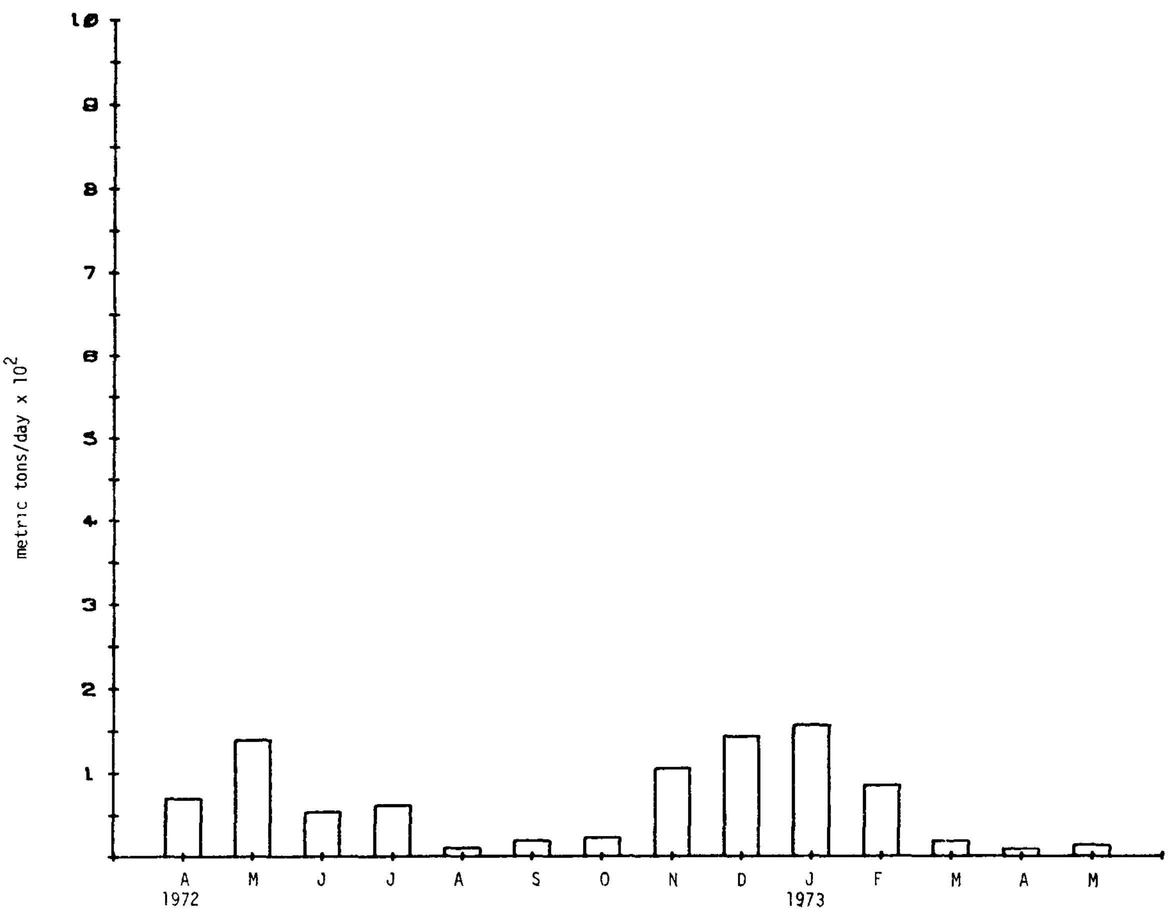

Figure 3.19 Oswego River Monthly Mean Stream Loadings - Silica

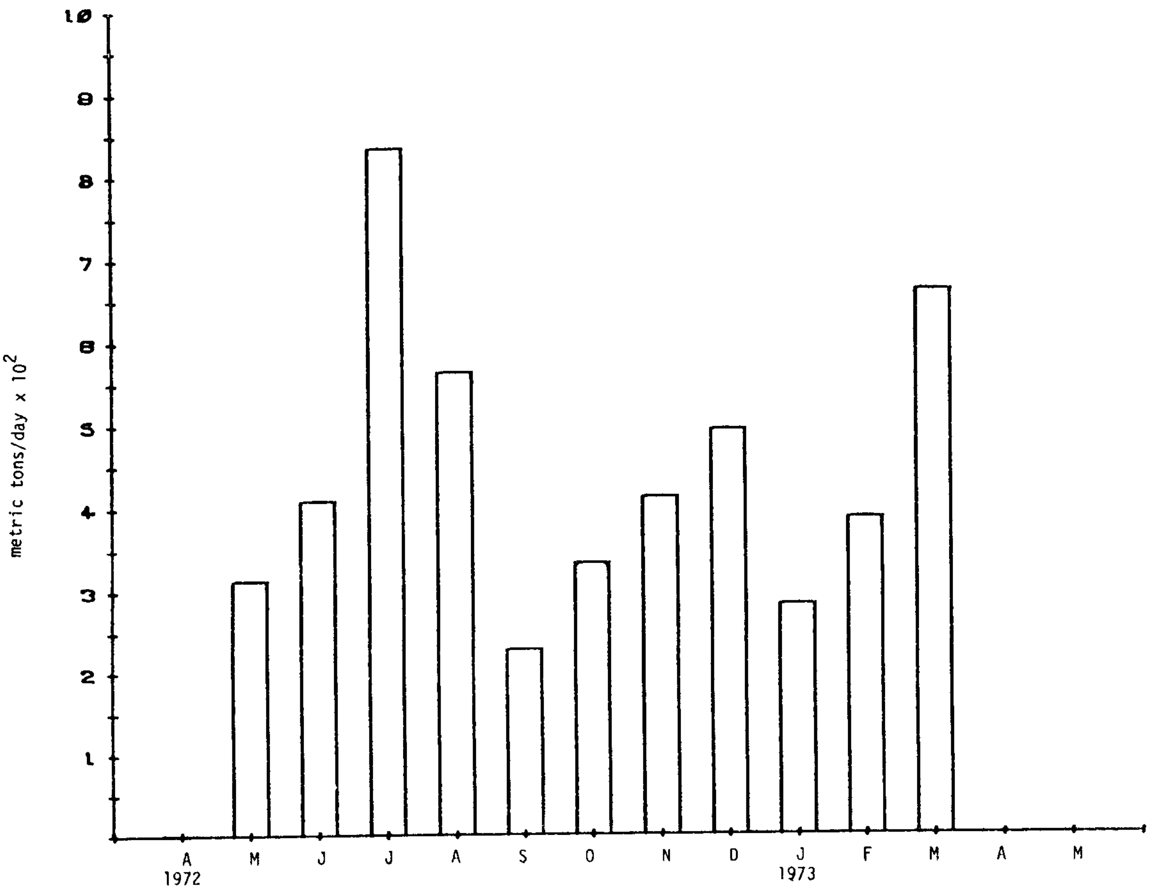

Figure 3.19 St. Lawrence River Monthly Mean Stream Loadings - Silica

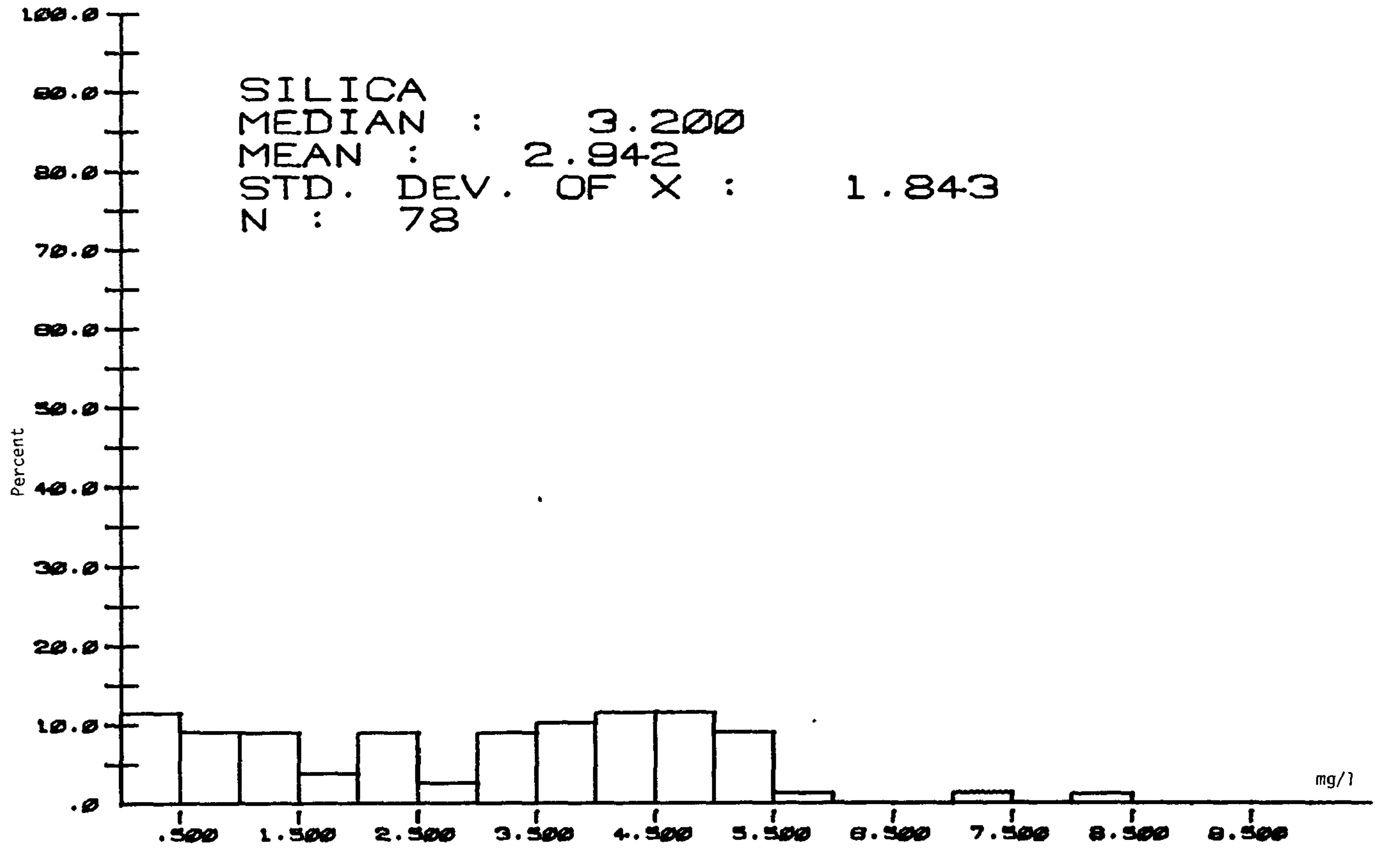

Figure 3.20 Genesee River Histograms for Silica

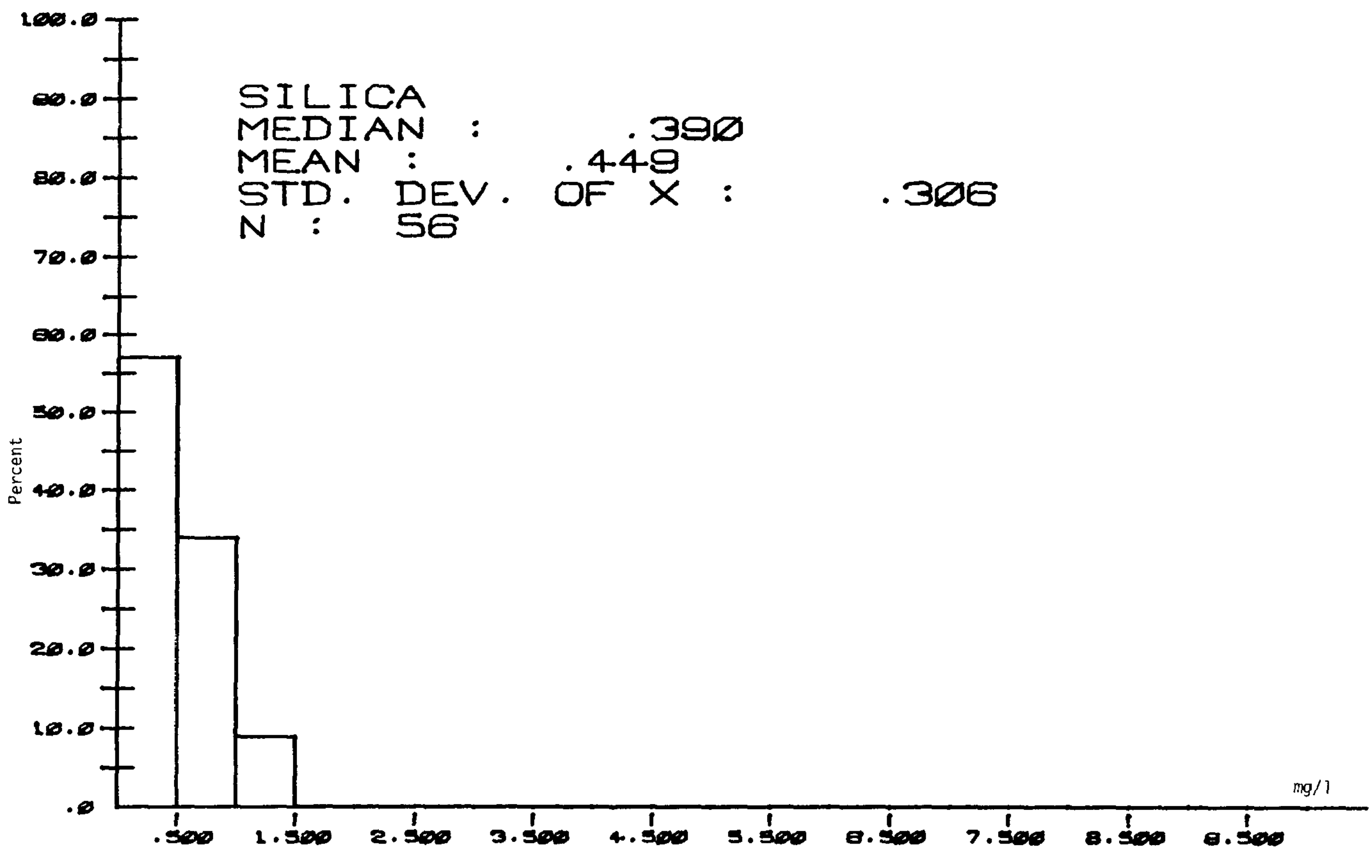

Figure 3.20 Niagara River Histograms for Silica

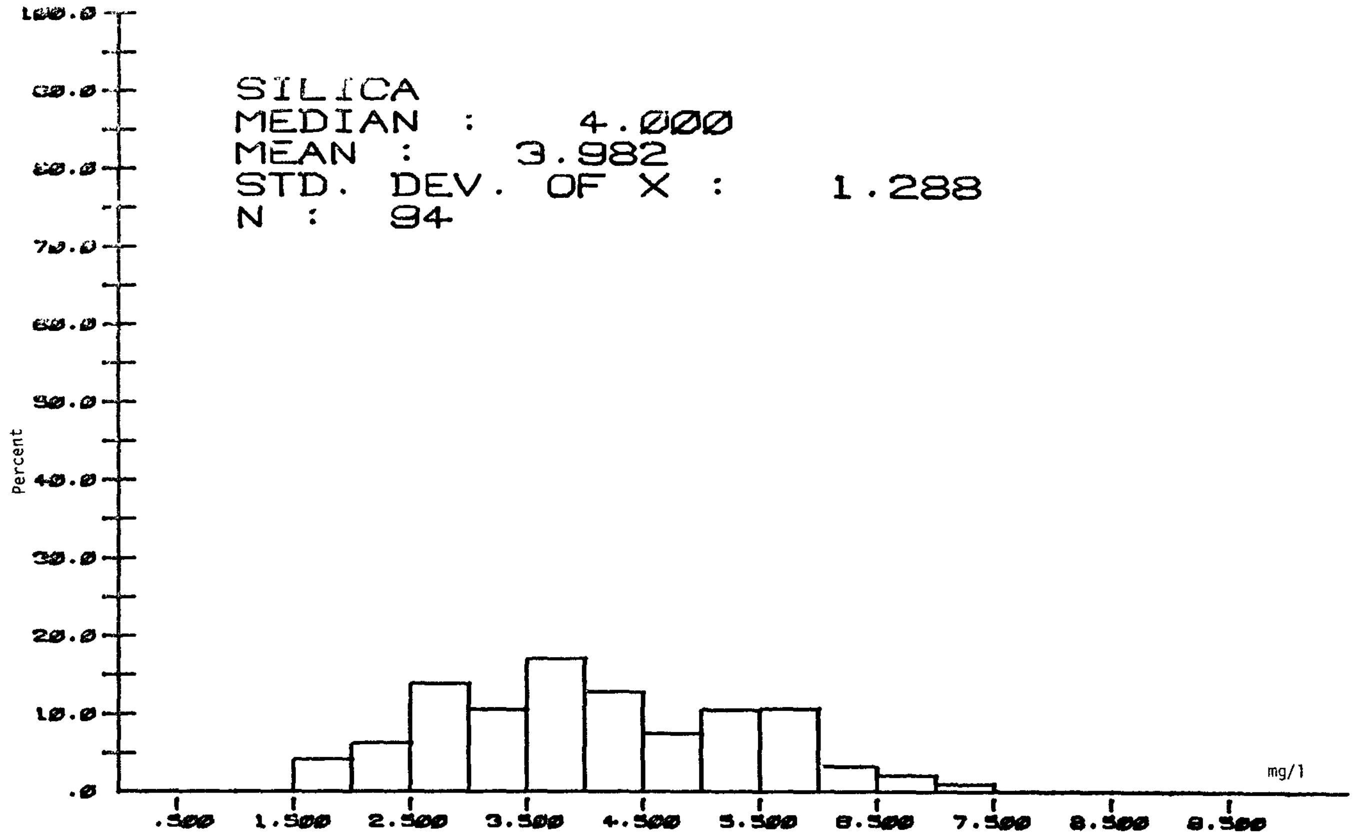

Figure 3.20 Black River Histograms for Silica

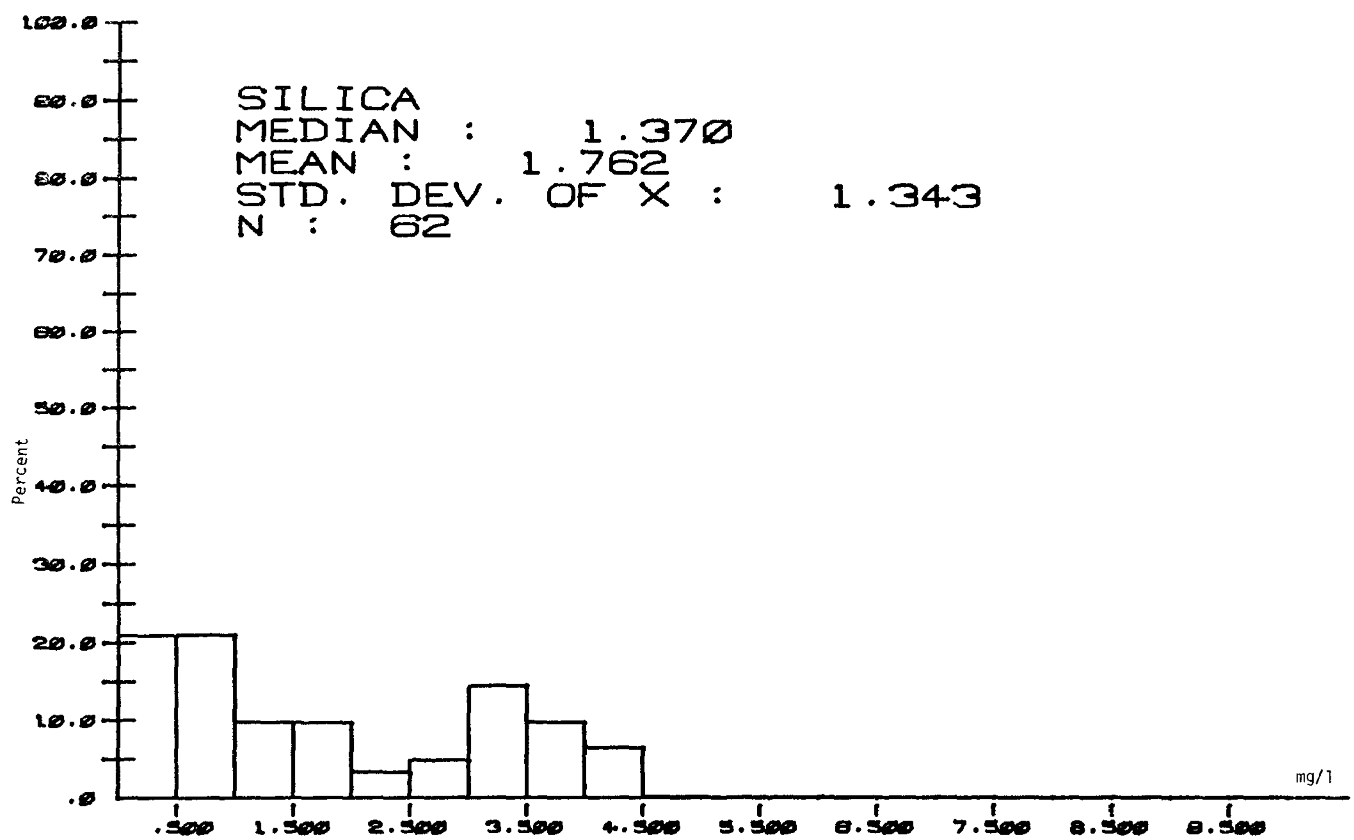

Figure 3.20 Oswego River Histograms for Silica

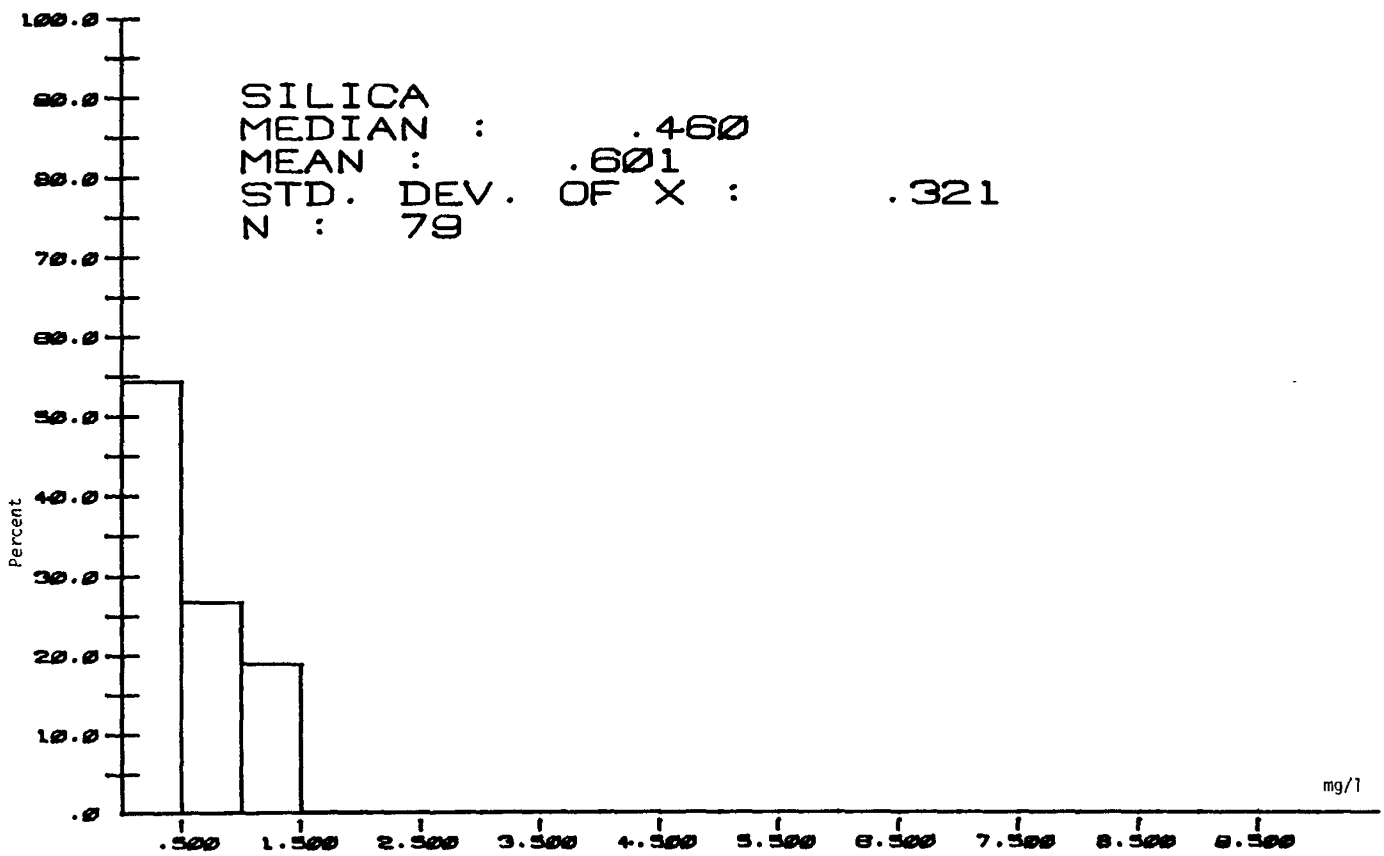

Figure 3.20 St. Lawrence River Histograms for Silica

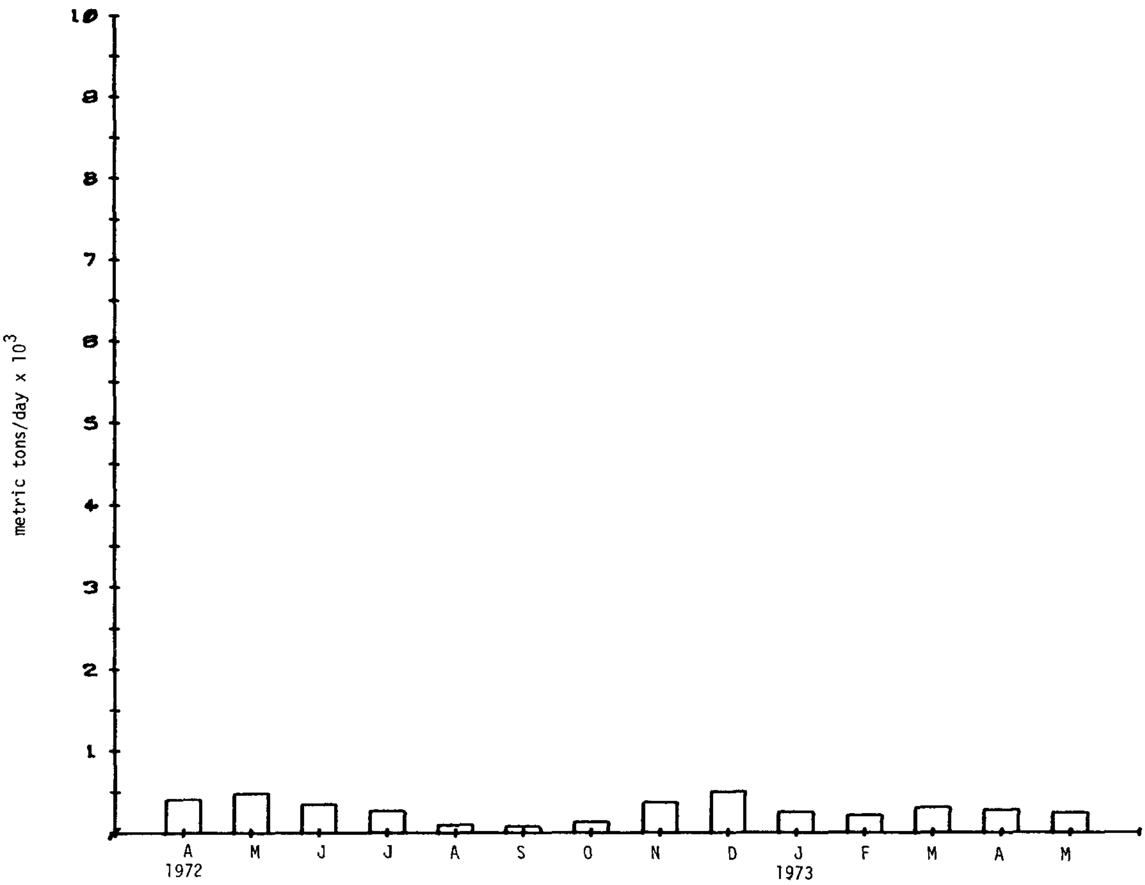

Figure 3.21 Genesee River Monthly Mean Stream Loadings - Sodium

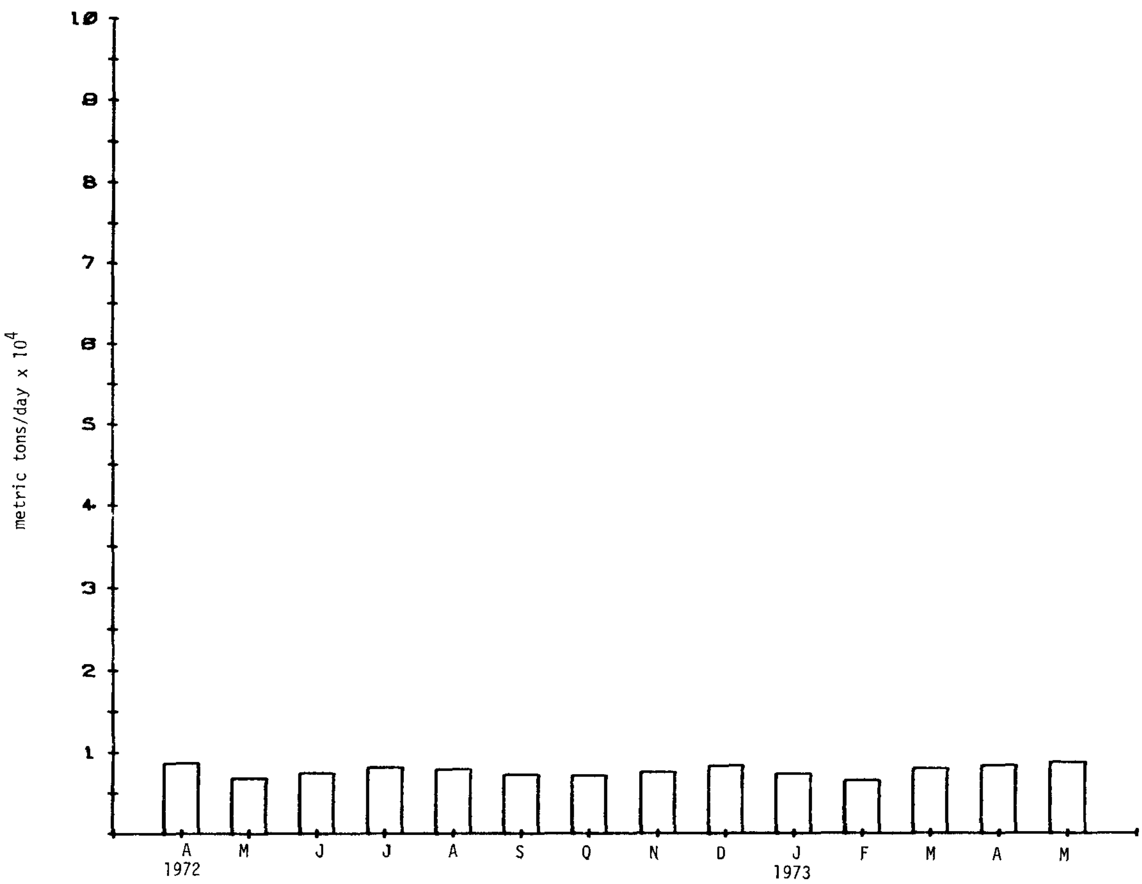

Figure 3.21 Niagara River Monthly Mean Stream Loadings - Sodium

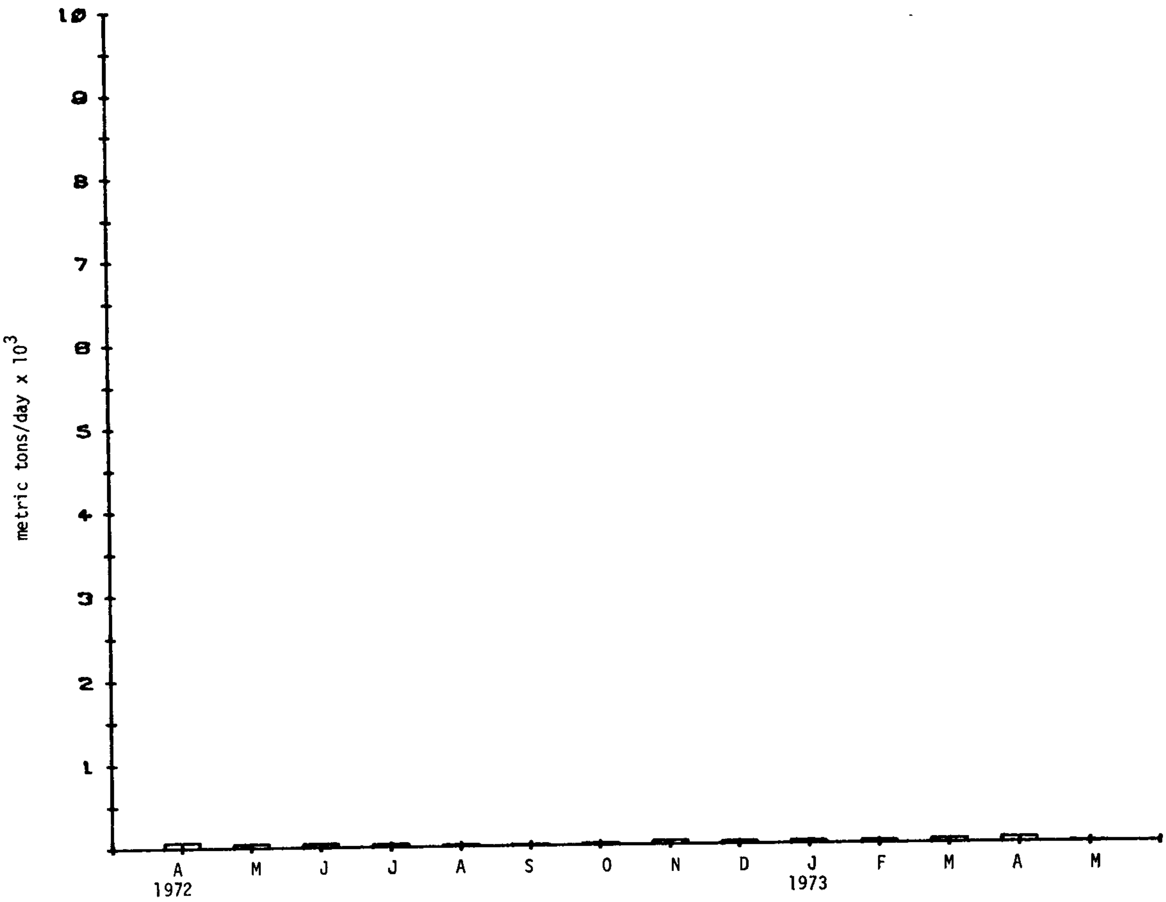

Figure 3.21 Figure 3.21 Black River Monthly Mean Stream Loadings - Sodium

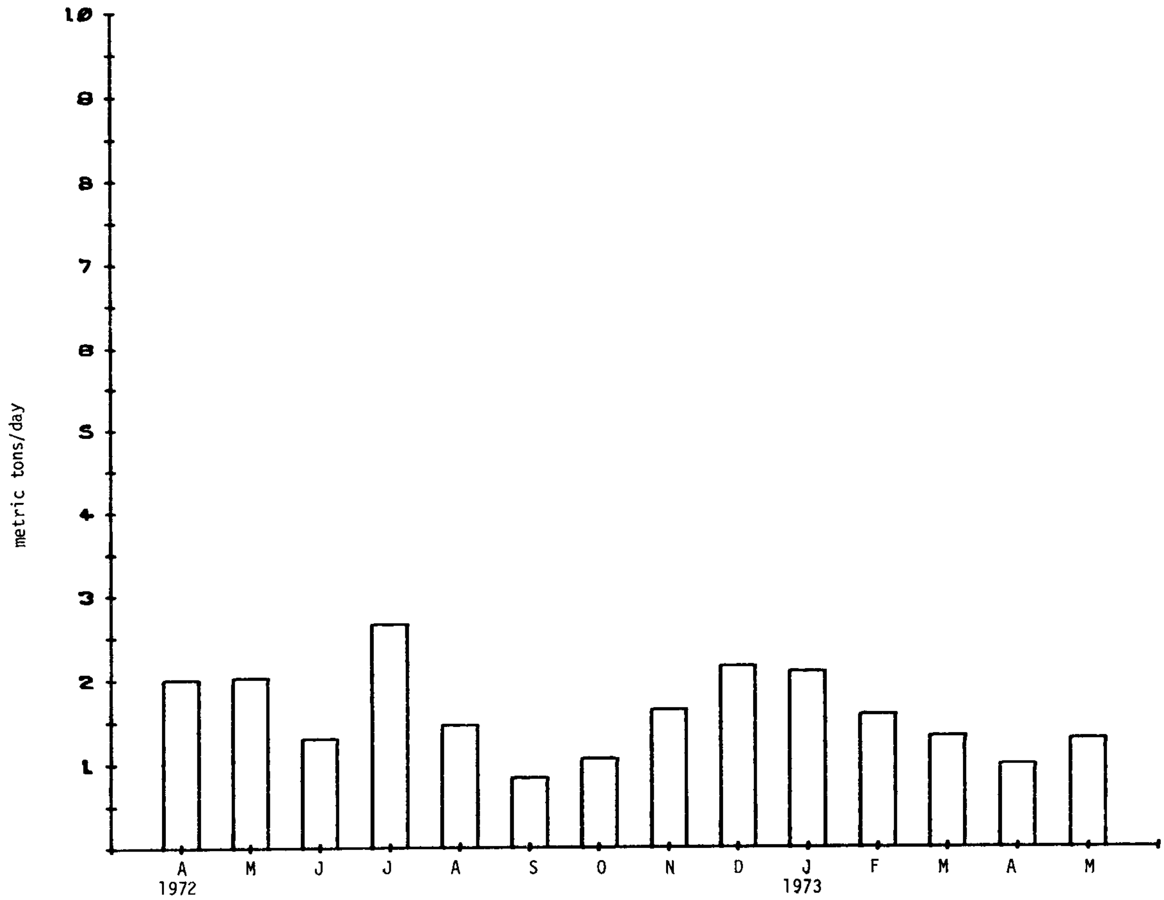

Figure 3.21 Oswego River Monthly Mean Stream Loadings - Sodium

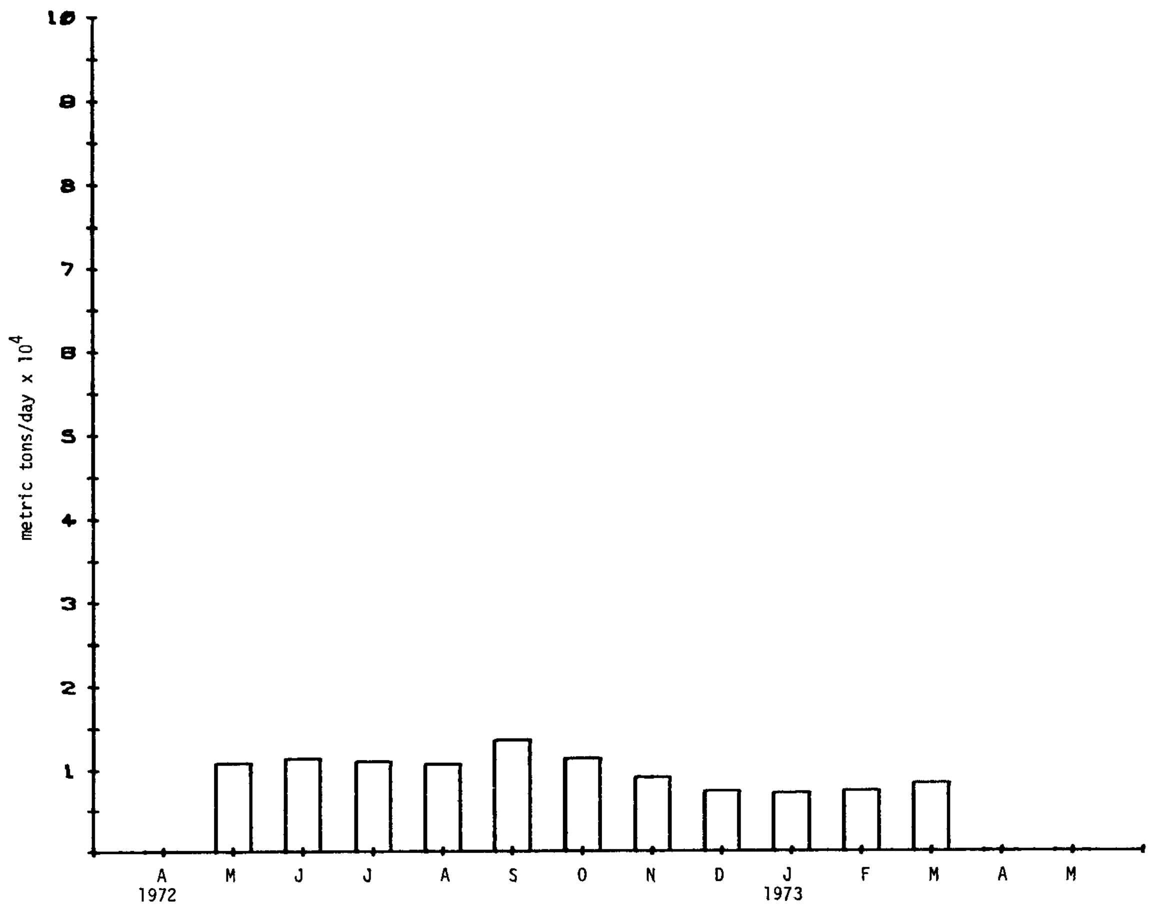

Figure 3.21 St. Lawrence River Monthly Mean Stream Loadings - Sodium

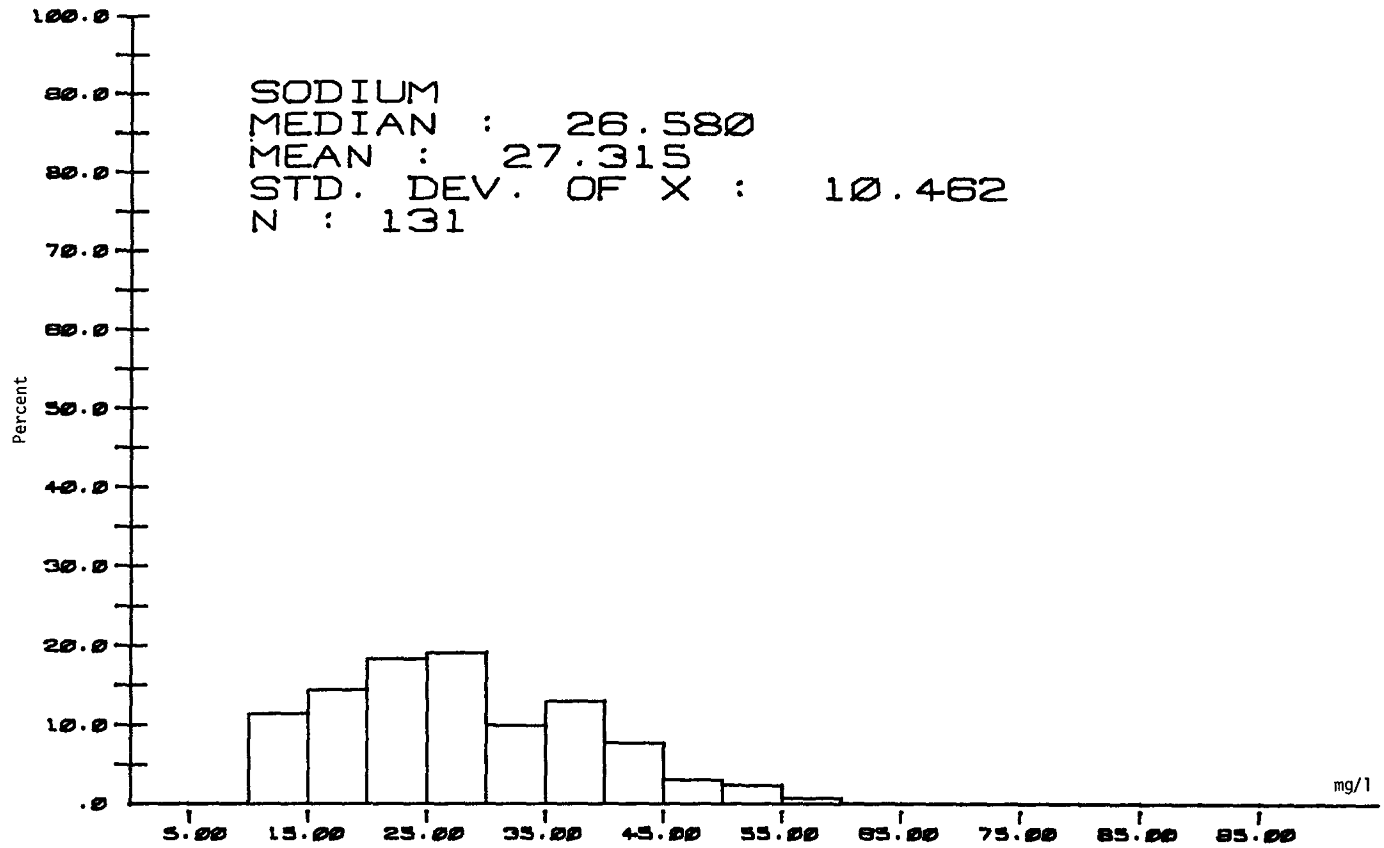

Figure 3.22 Genesee River Histograms for Sodium

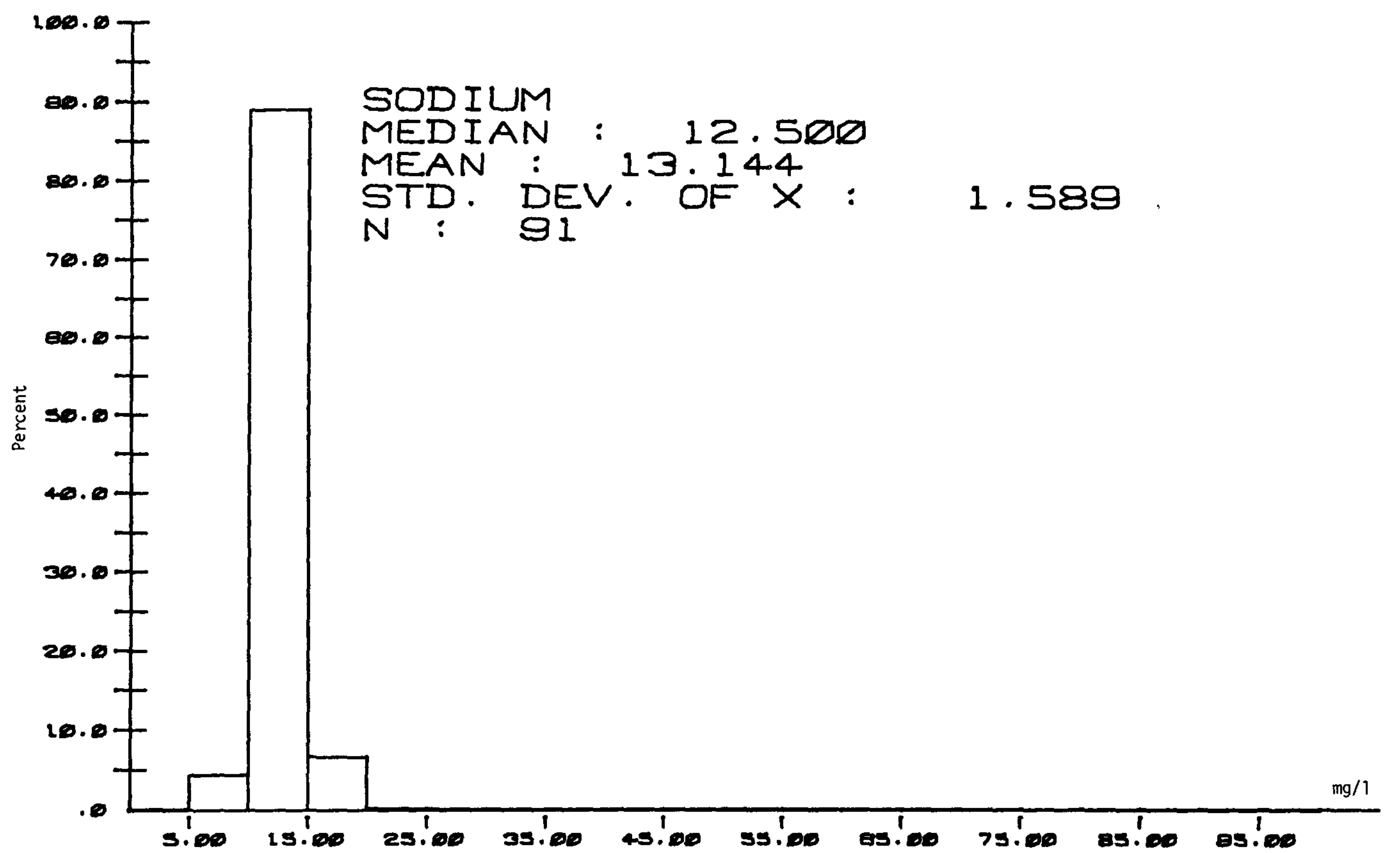

Figure 3.22 Niagara River Histograms for Sodium

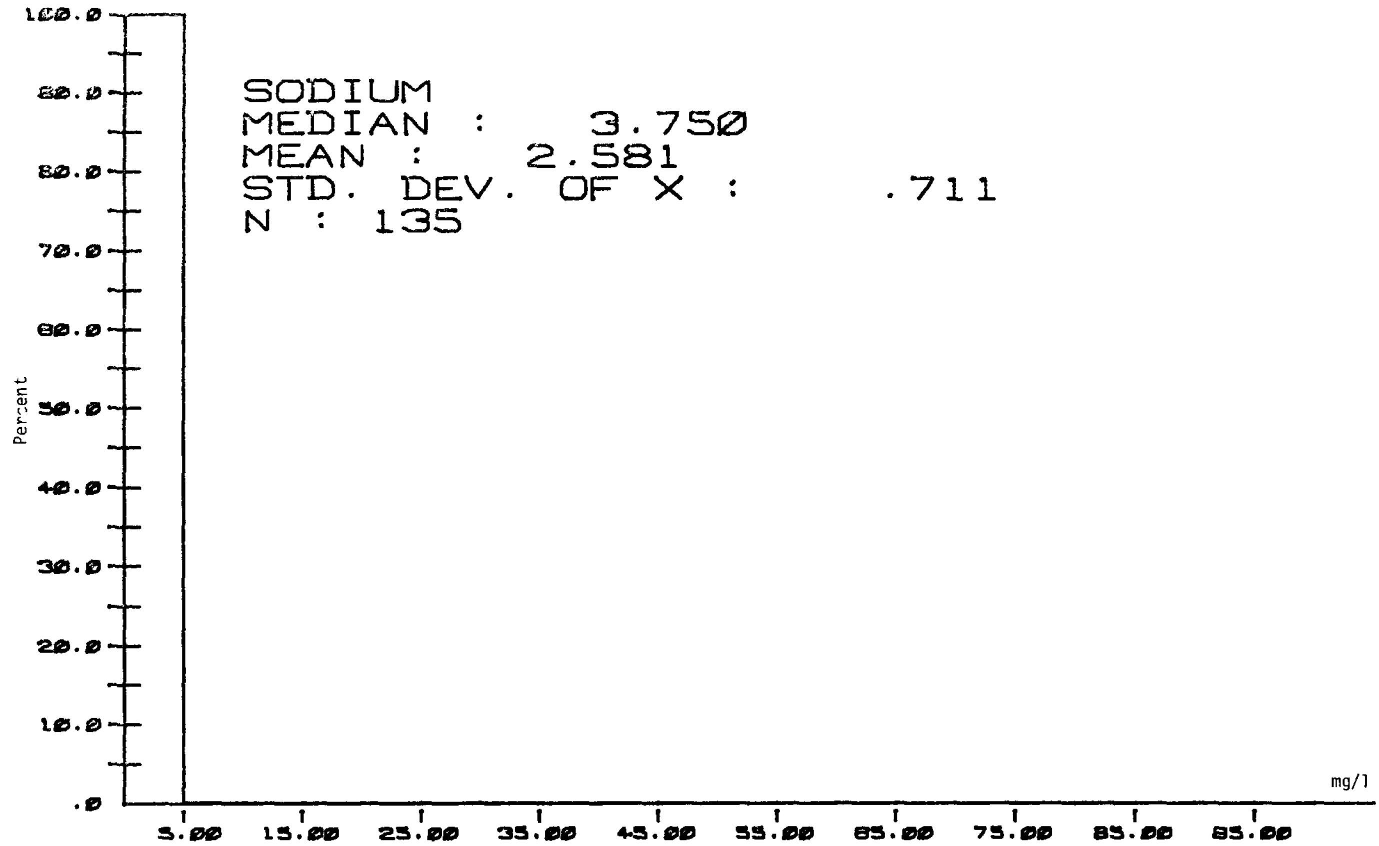

Figure 3.22 Black River Histograms for Sodium

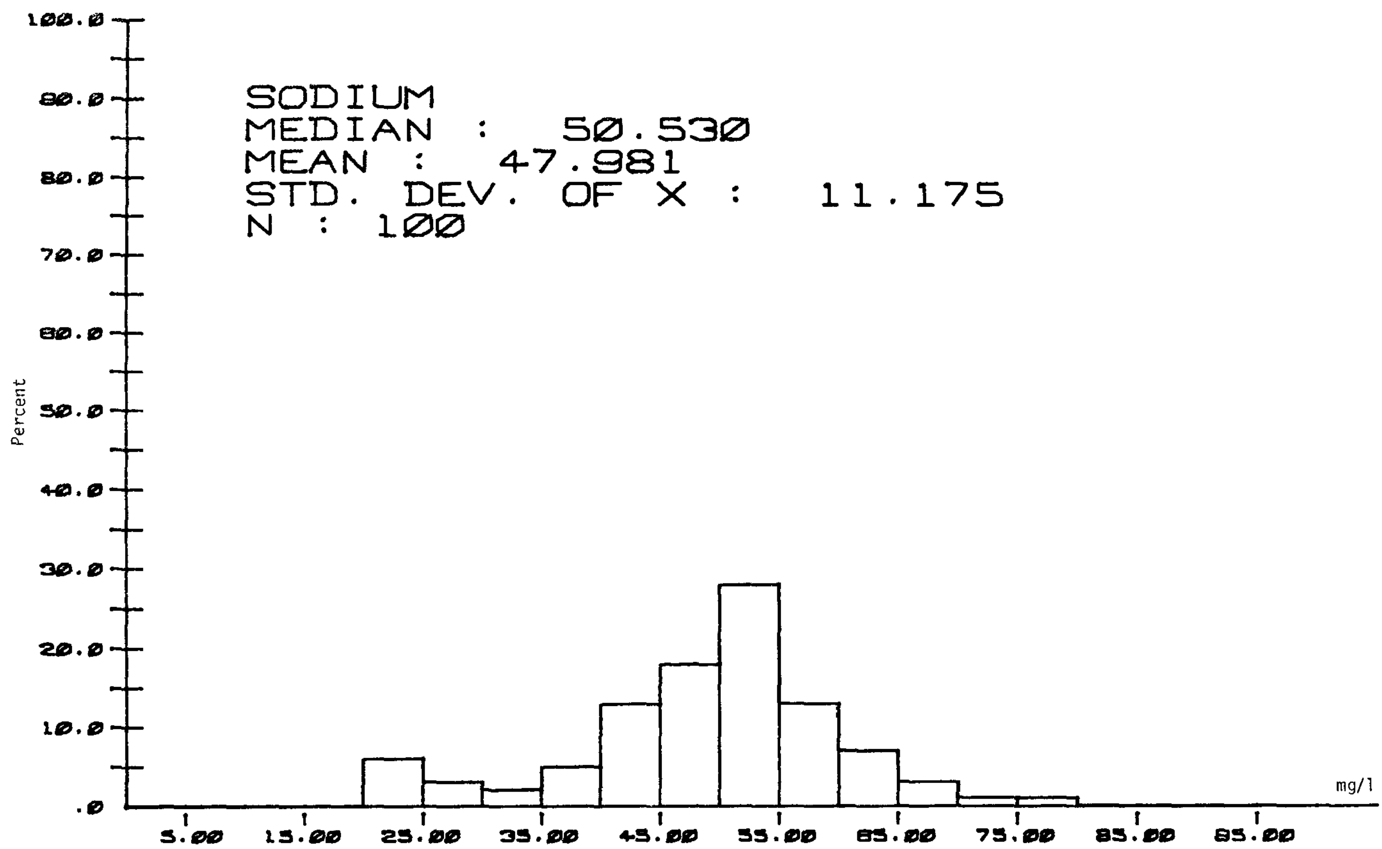

Figure 3.22 Oswego River Histograms for Sodium

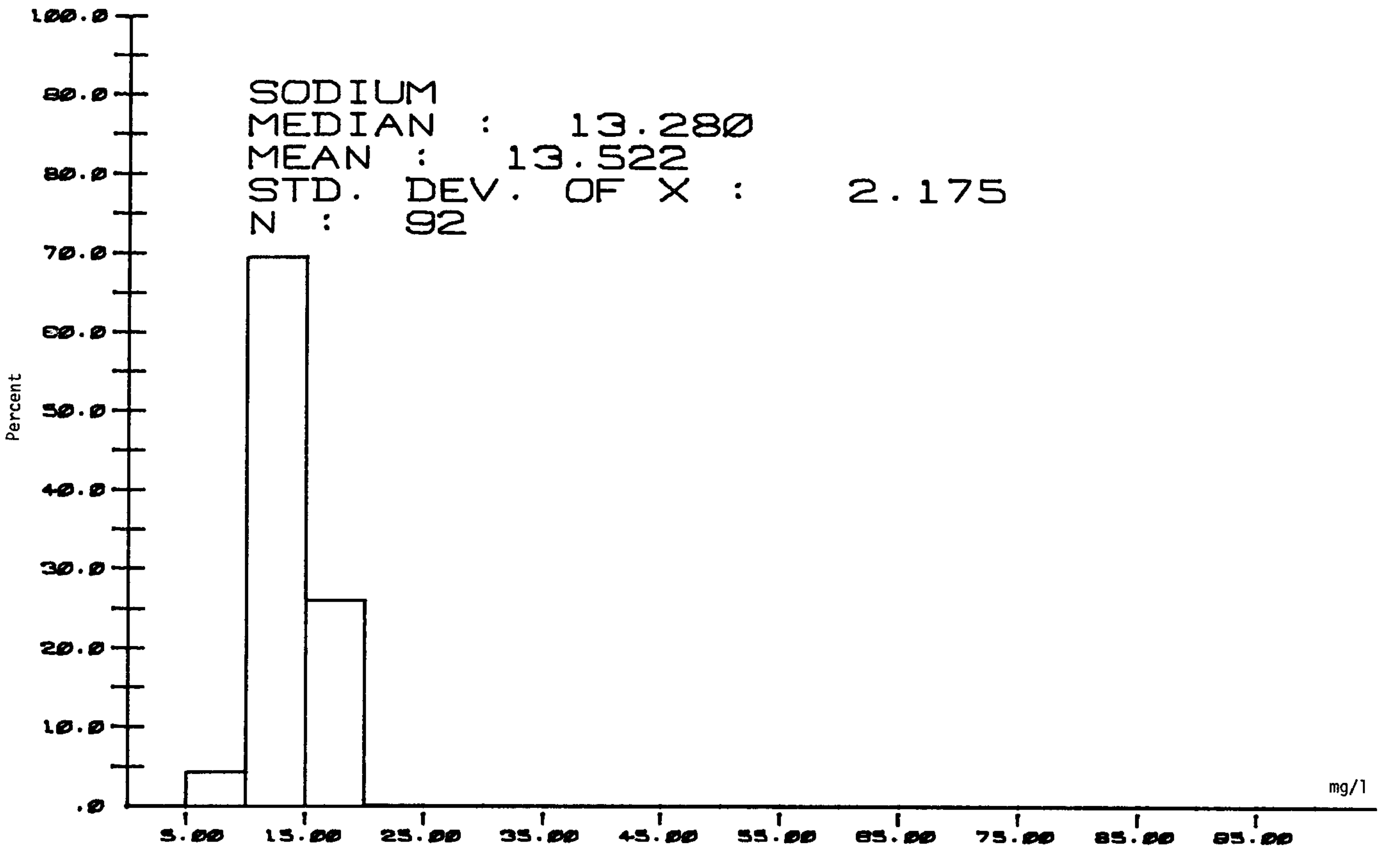

Figure 3.22 St. Lawrence River Histograms for Sodium

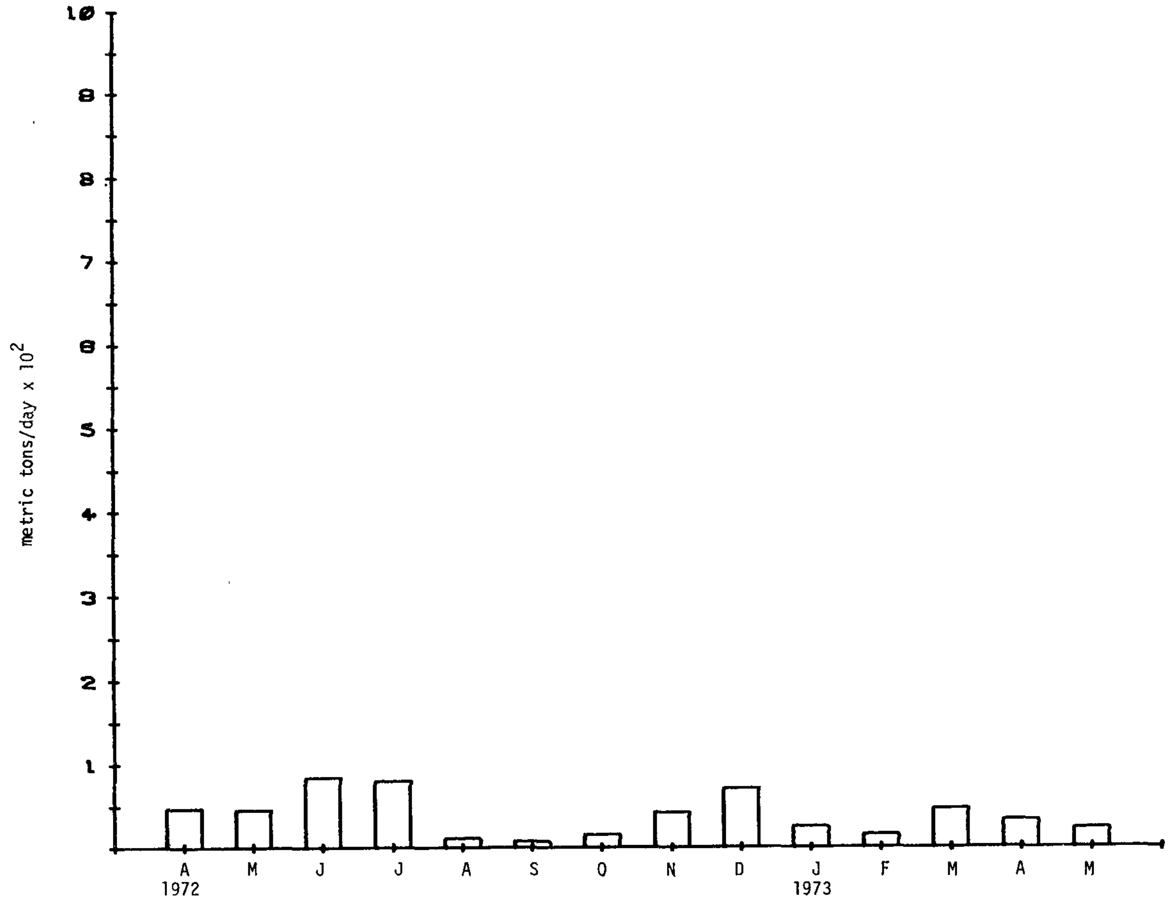

Figure 3.23 Genesee River Monthly Mean Stream Loadings - Potassium

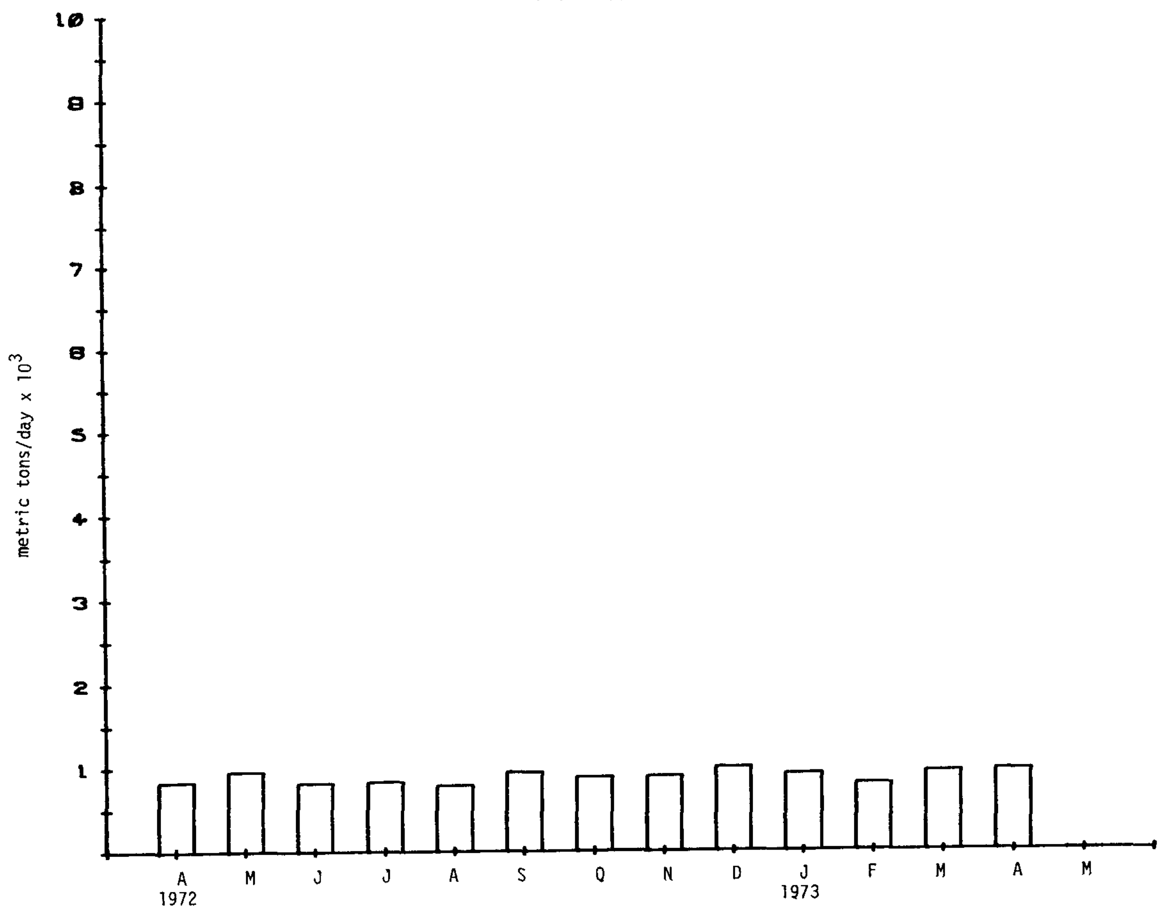

Figure 3.23 Niagara River Monthly Mean Stream Loadings - Potassium

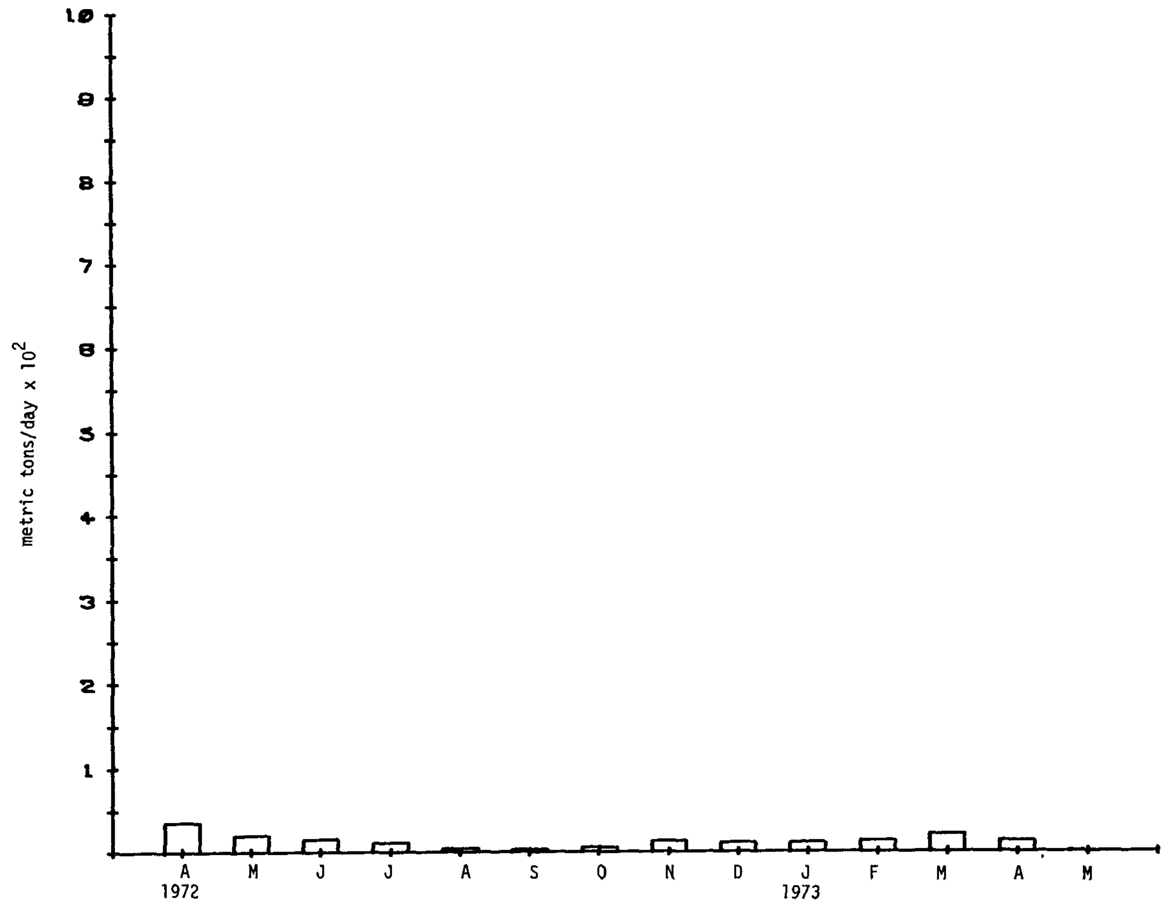

Figure 3.23 Black River Monthly Mean Stream Loadings - Potassium

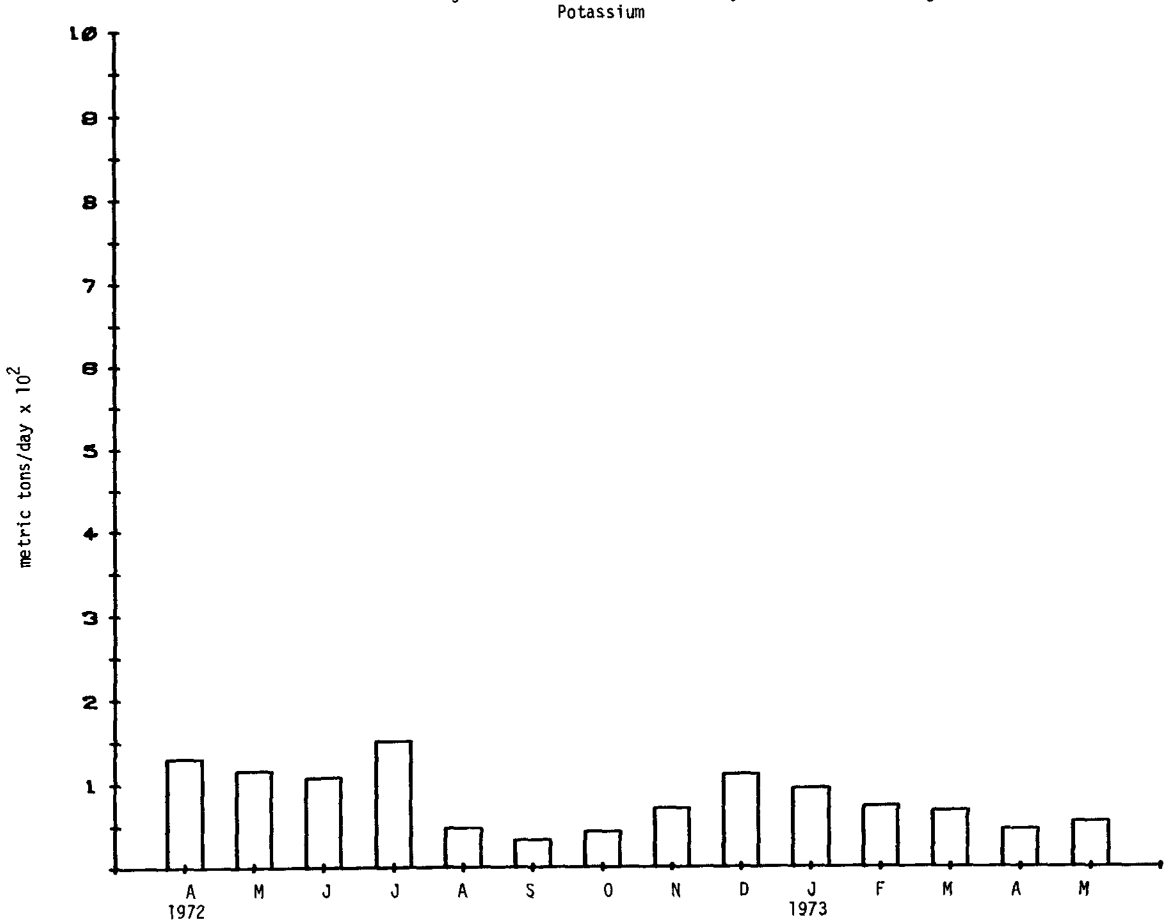

Figure 3.23 Oswego River Monthly Mean Stream Loadings - Potassium

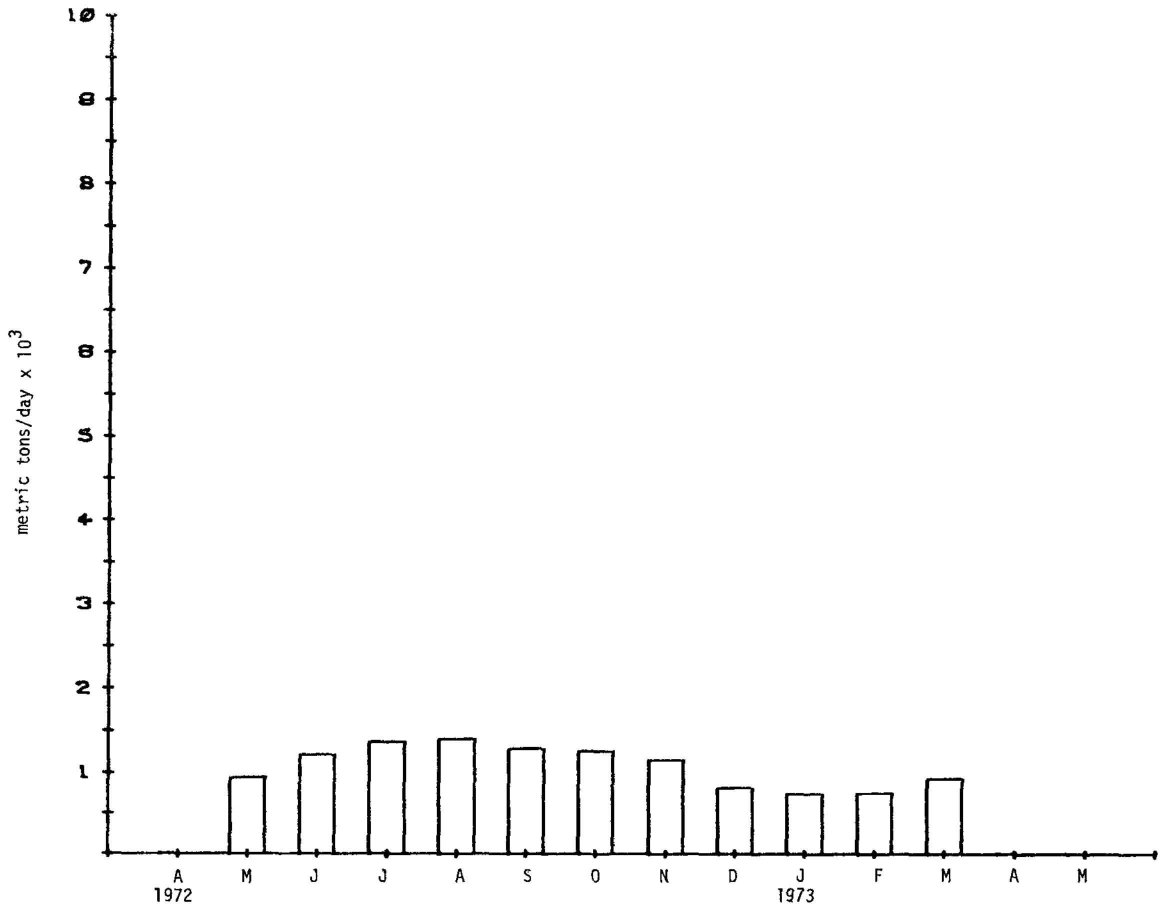

Figure 3.23 St. Lawrence River Monthly Mean Stream Loadings - Potassium

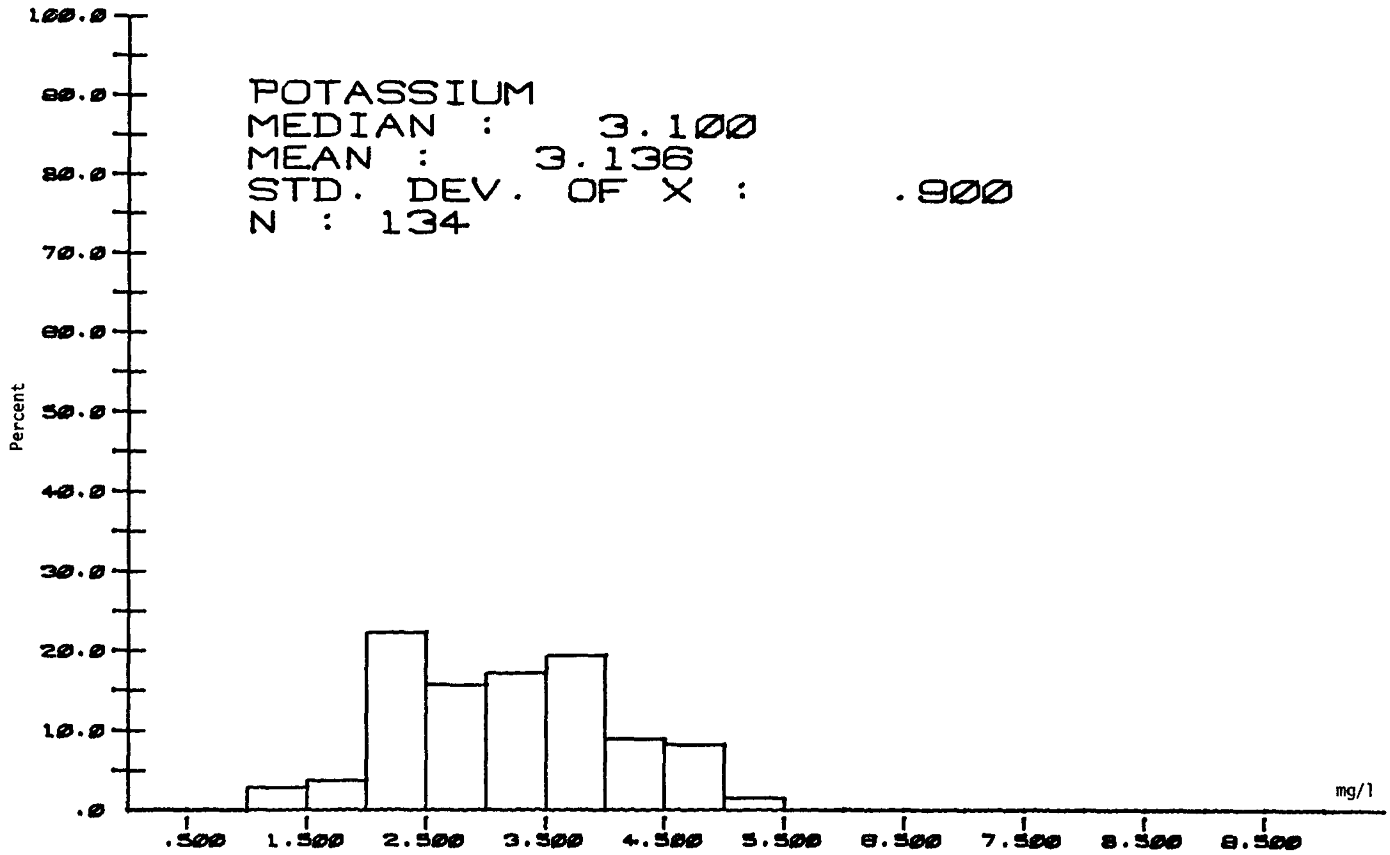

Figure 3.24 Genesee River Histograms for Potassium

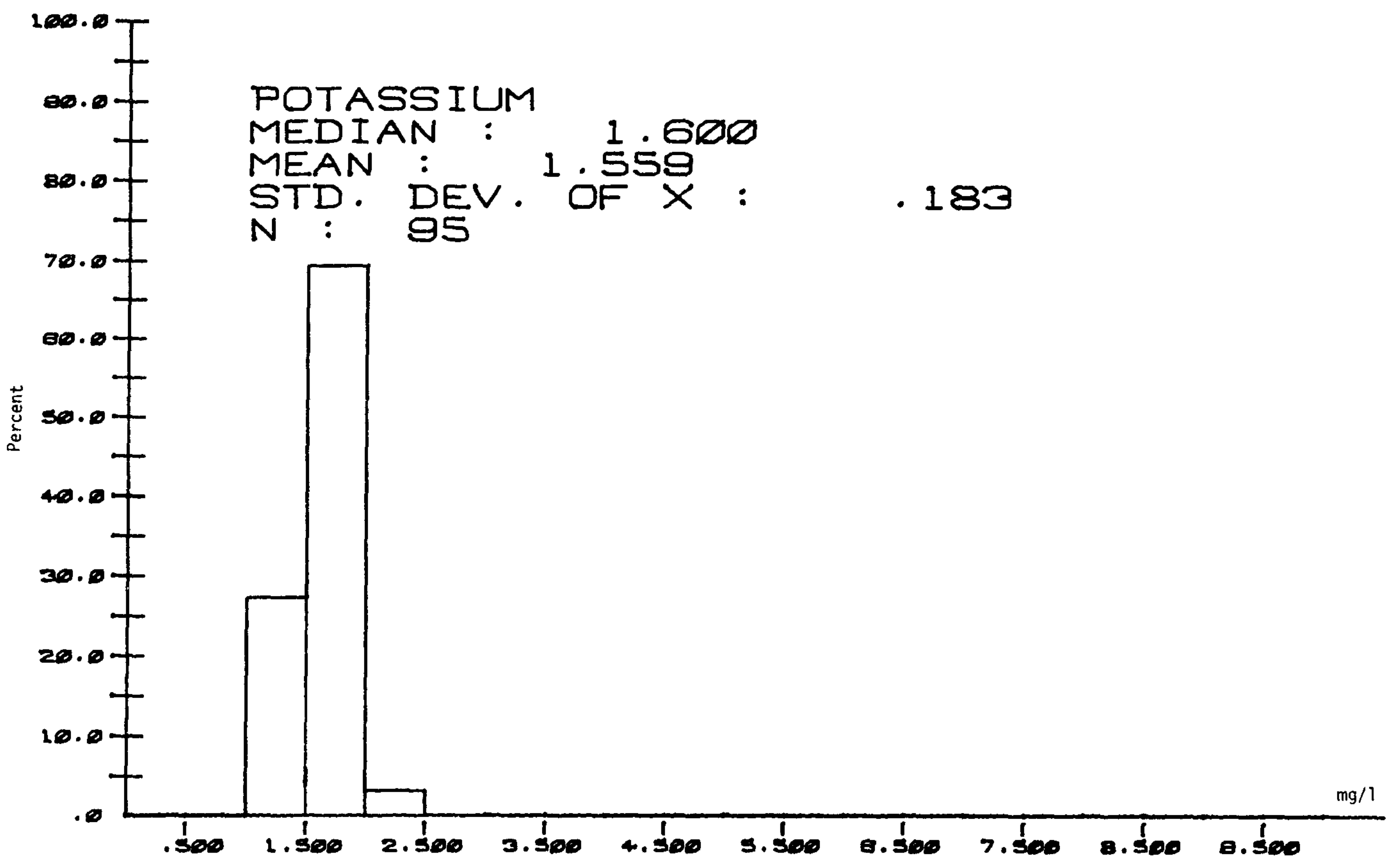

Figure 3.24 Niagara River Histograms for Potassium

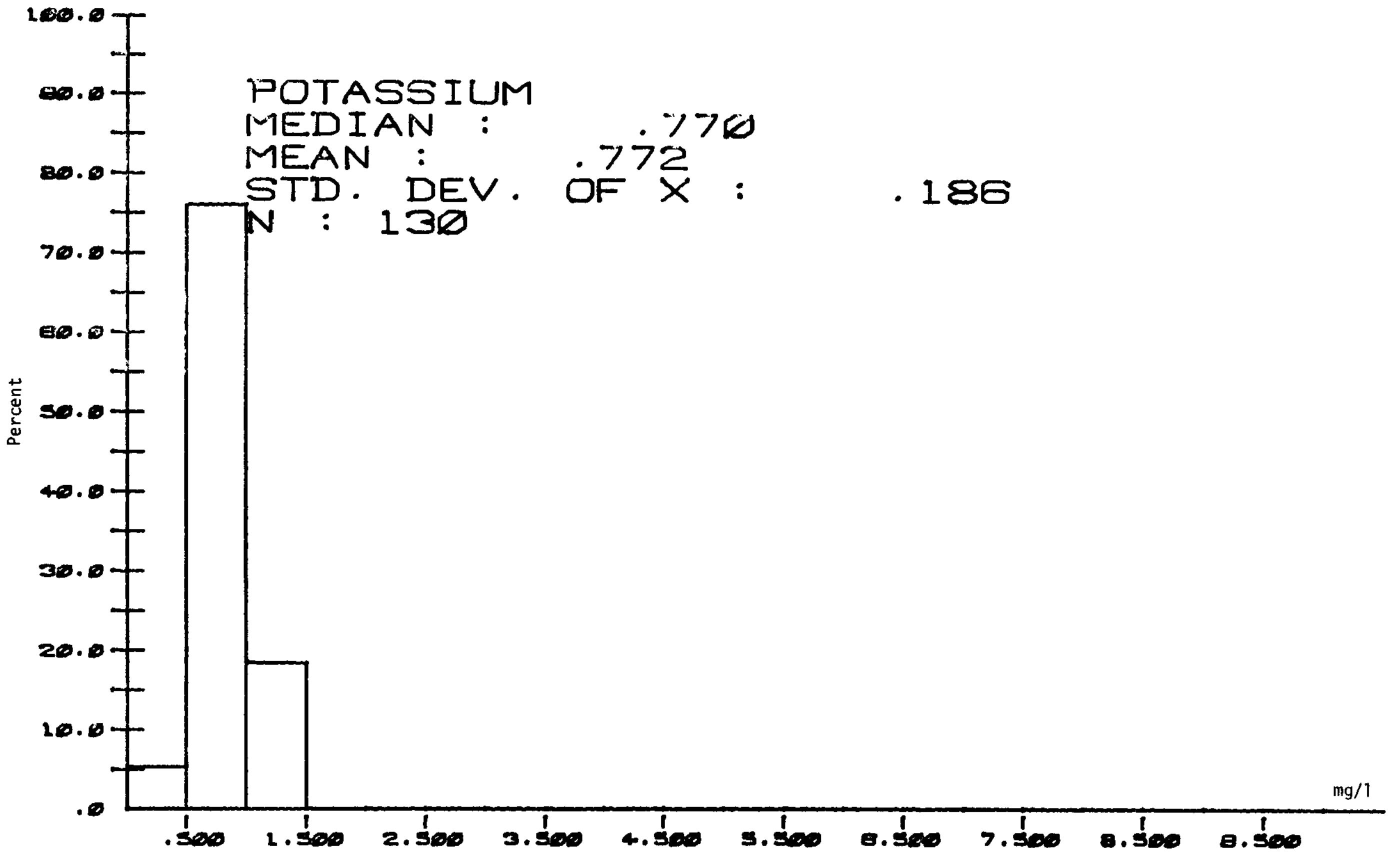

Figure 3.24 Black River Histograms for Potassium

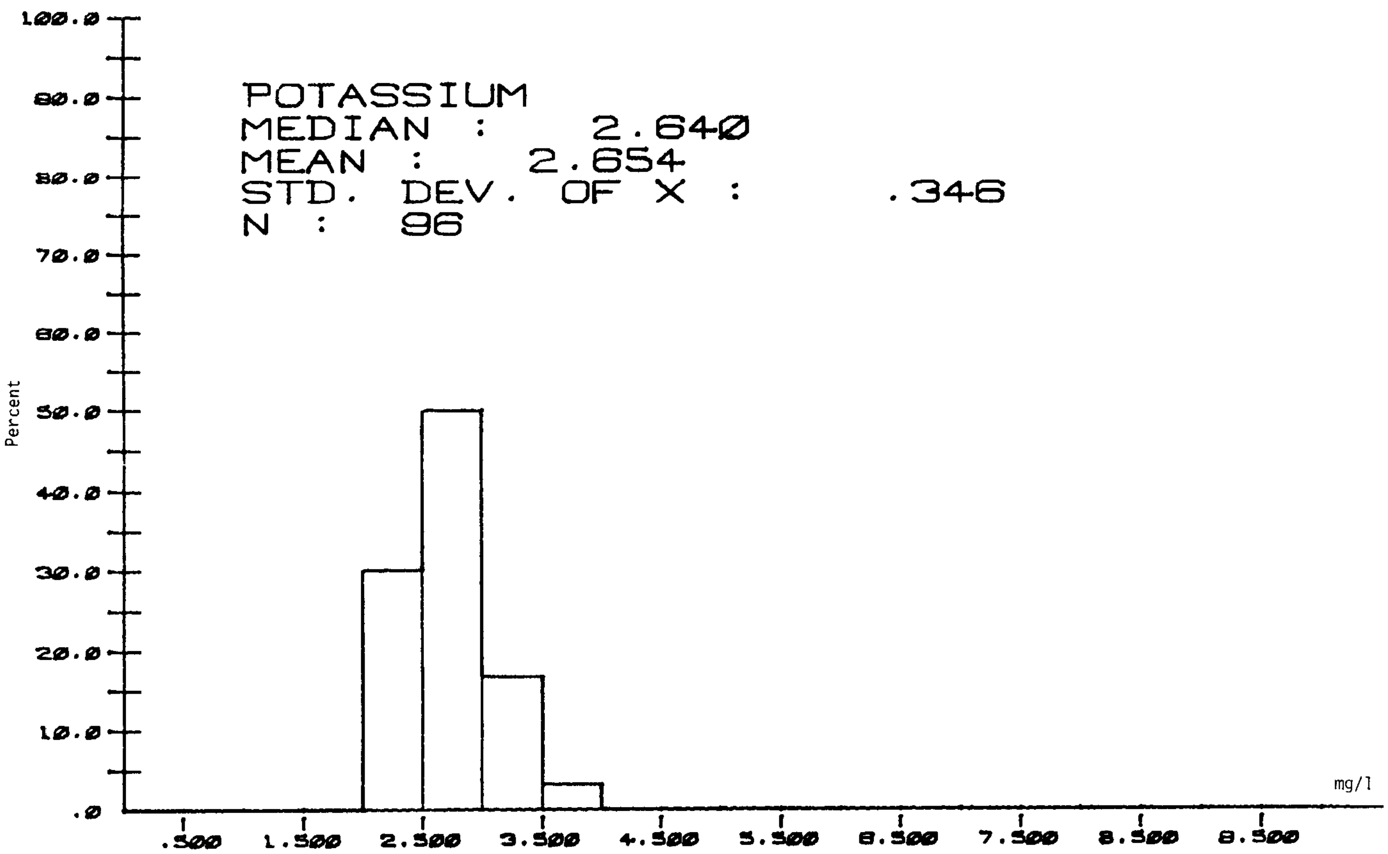

Figure 3.24 Oswego River Histograms for Potassium

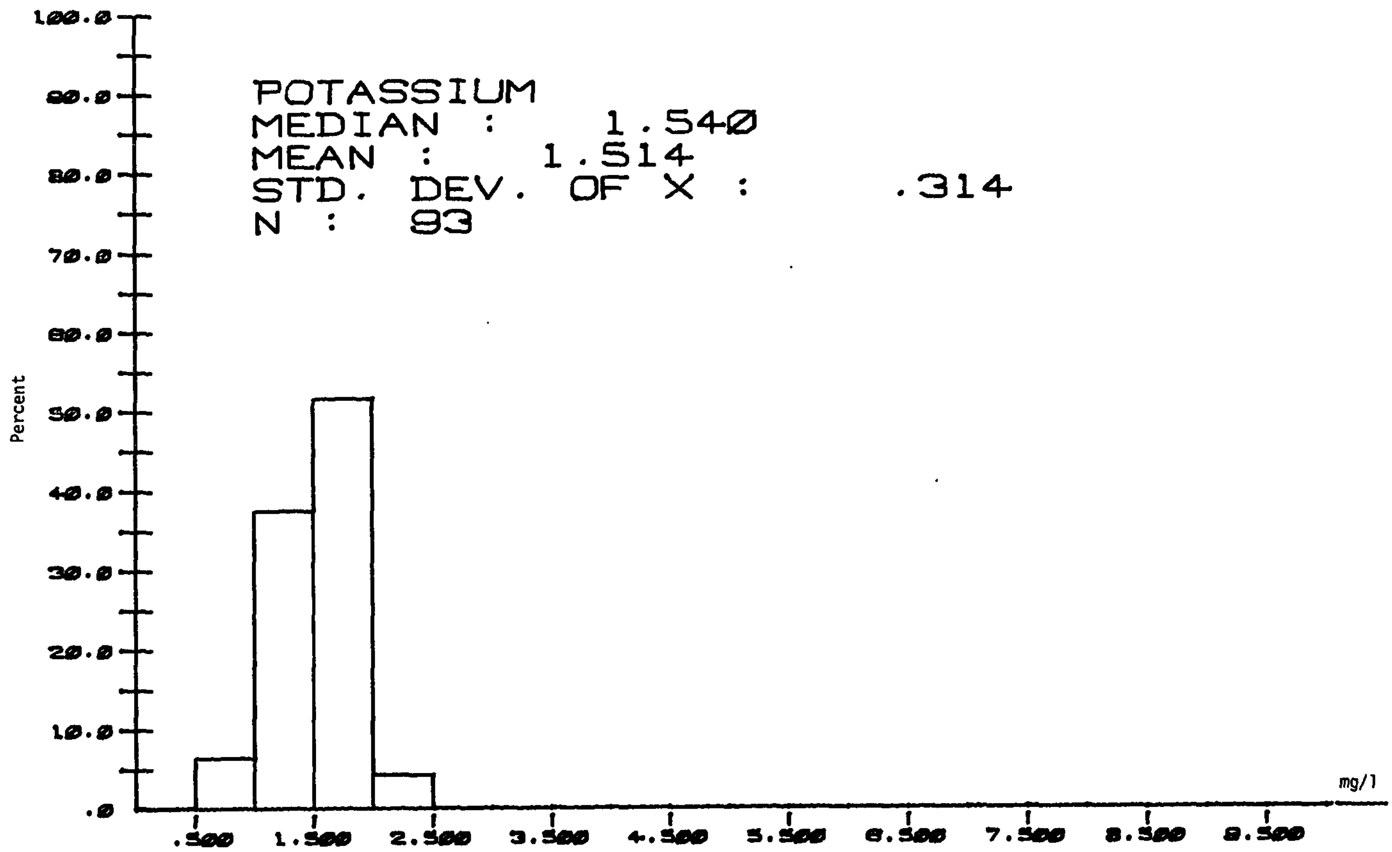

Figure 3.24 St. Lawrence River Histograms for Potassium

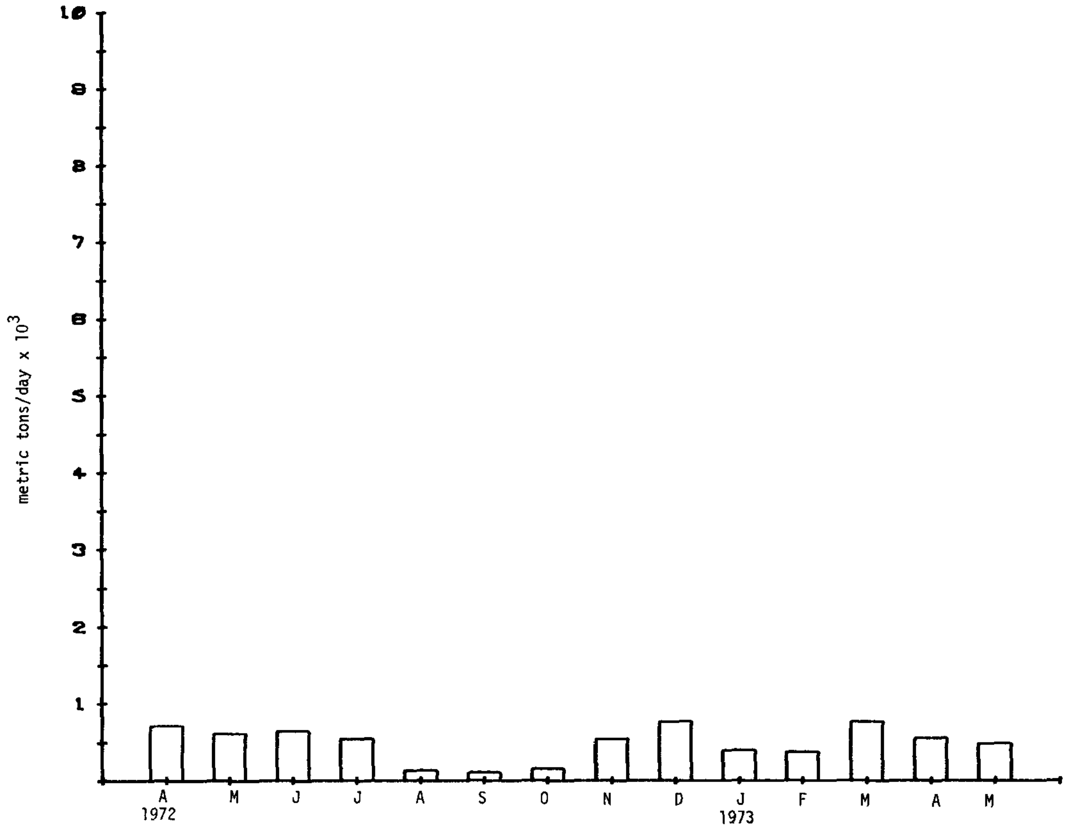

Figure 3.25 Genesee River Monthly Mean Stream Loadings - Calcium

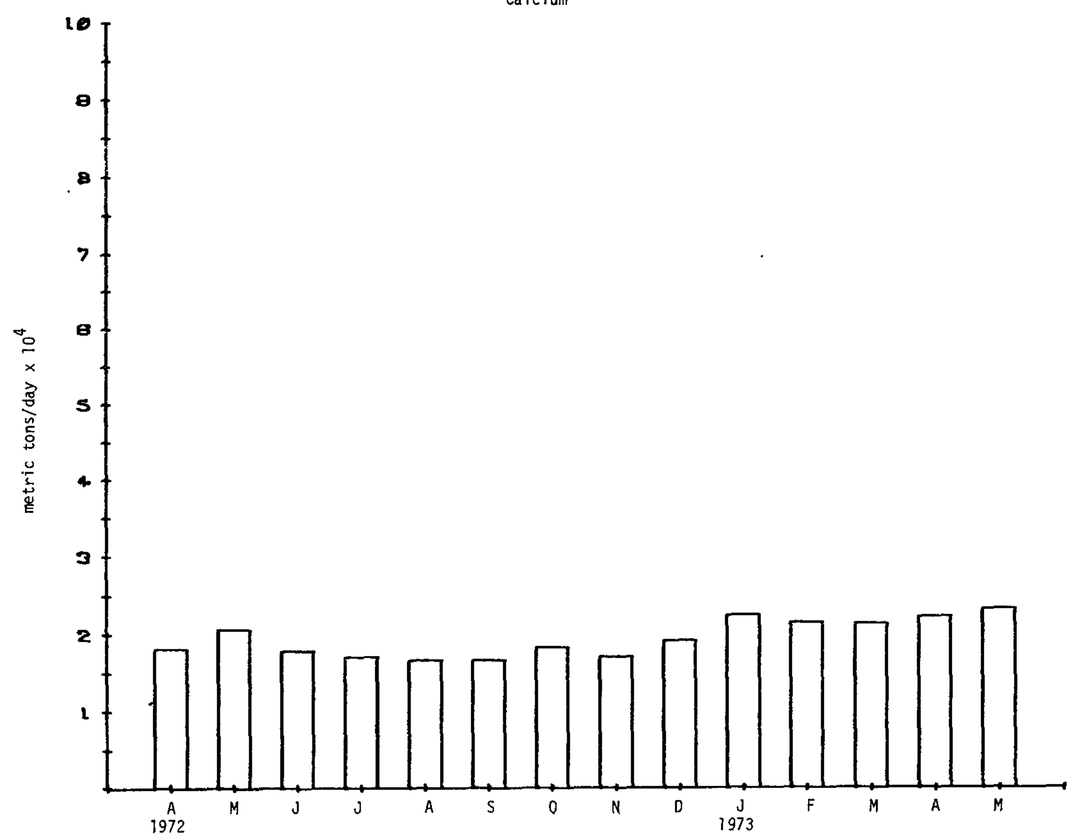

Figure 3.25 Niagara River Monthly Mean Stream Loadings - Calcium

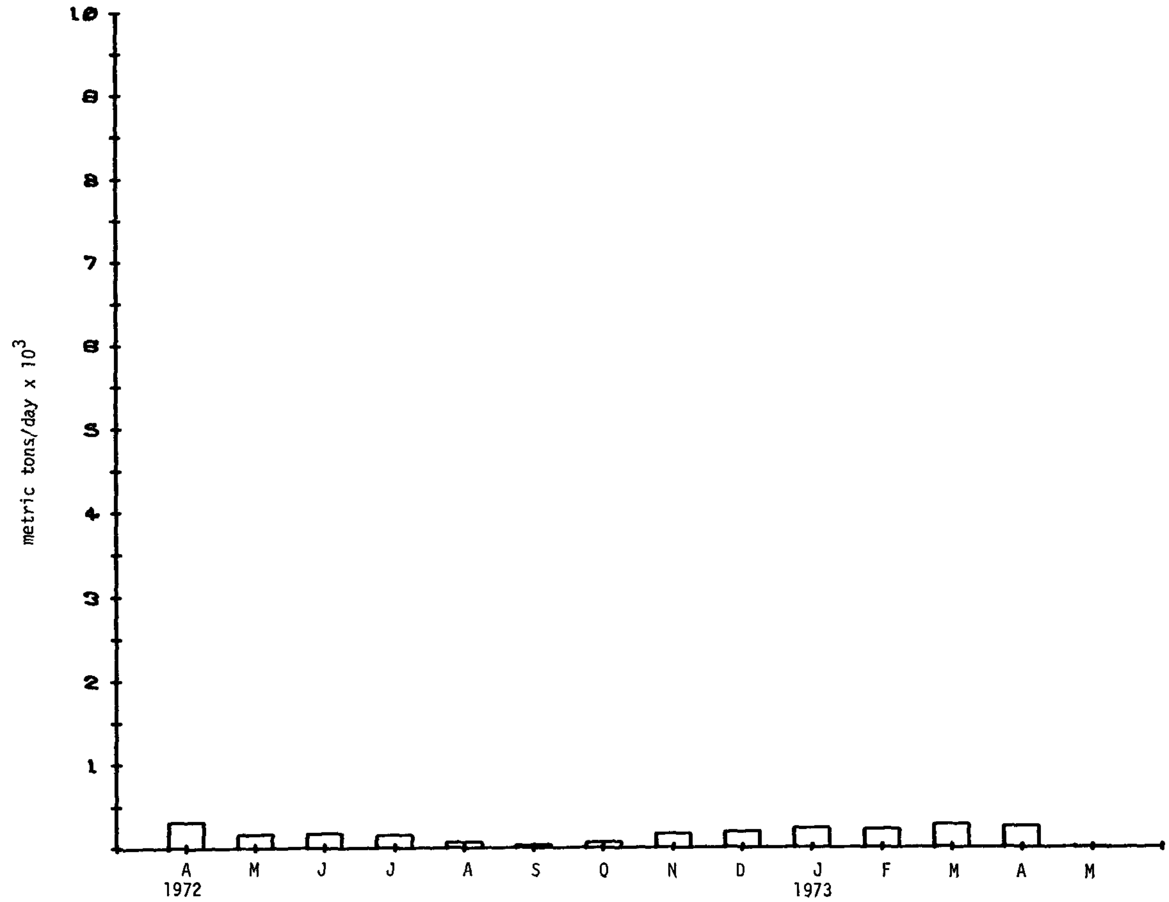

Figure 3.25 Black River Monthly Mean Stream Loadings - Calcium

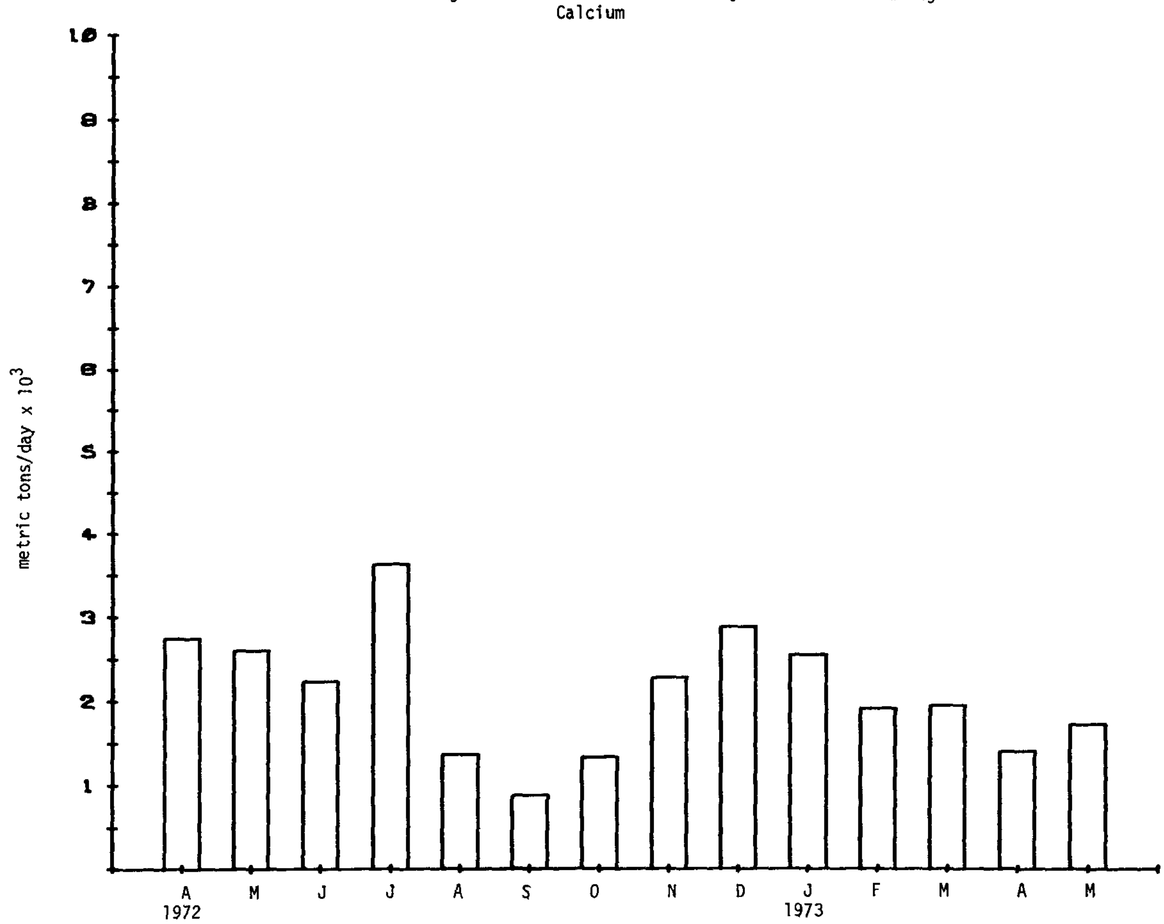

Figure 3.25 Oswego River Monthly Mean Stream Loadings - Calcium

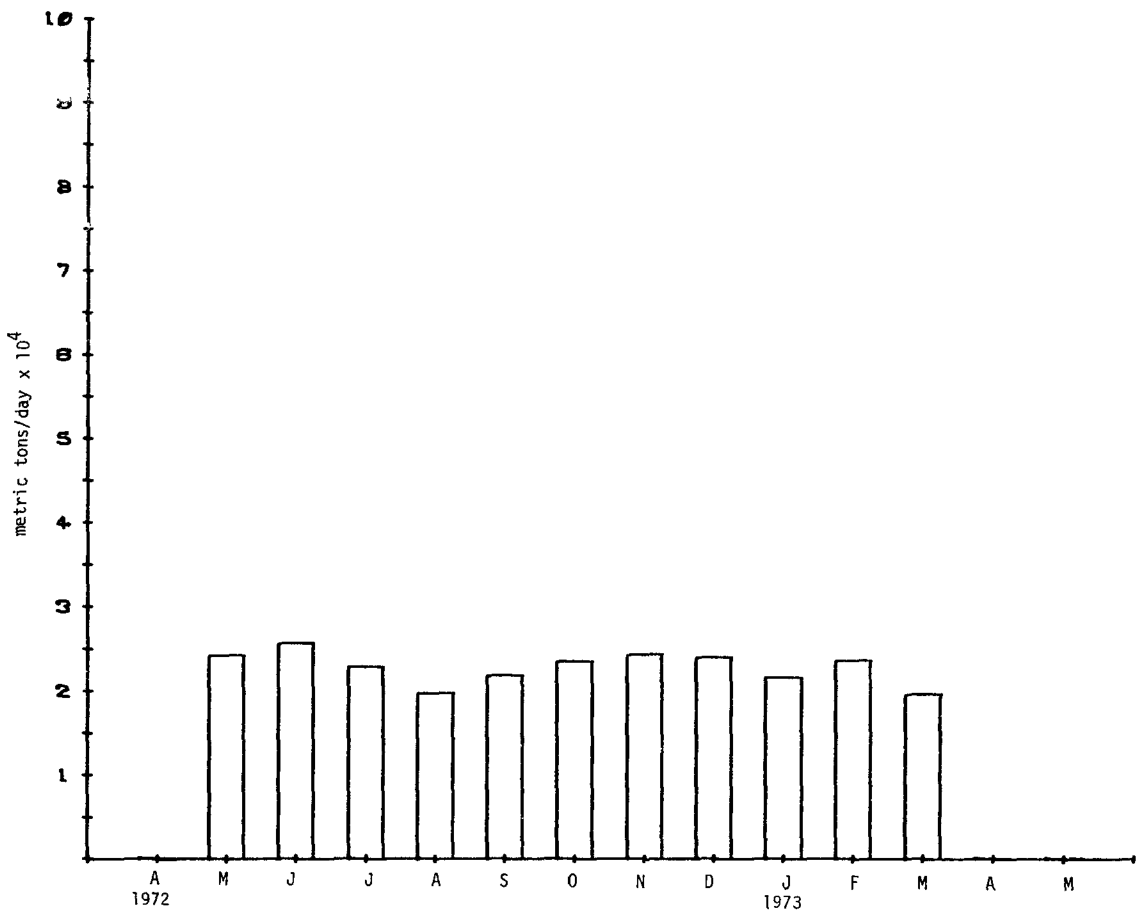

Figure 3.25 St. Lawrence River Monthly Mean Stream Loadings - Calcium

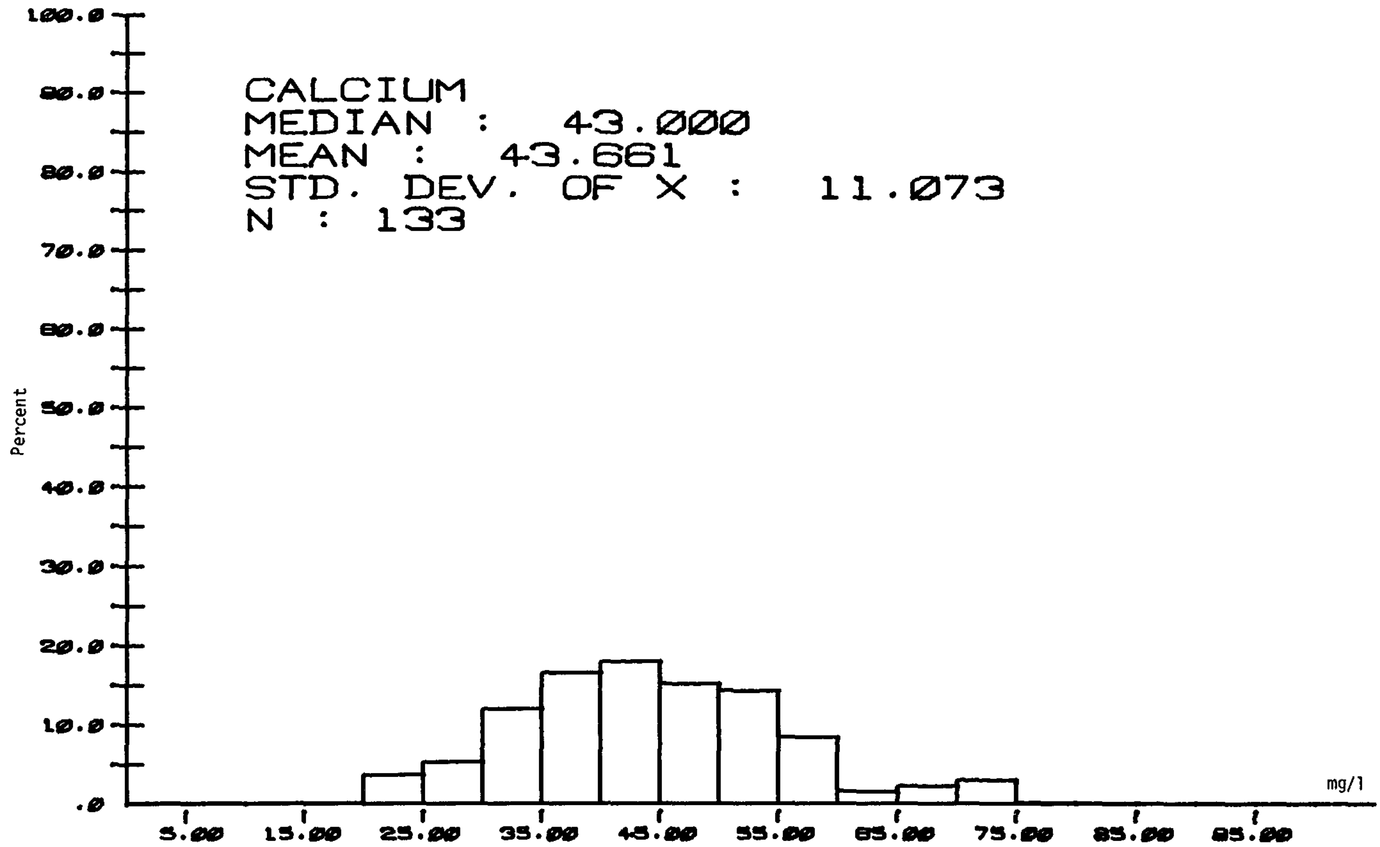

Figure 3.26 Genesee River Histograms for Calcium

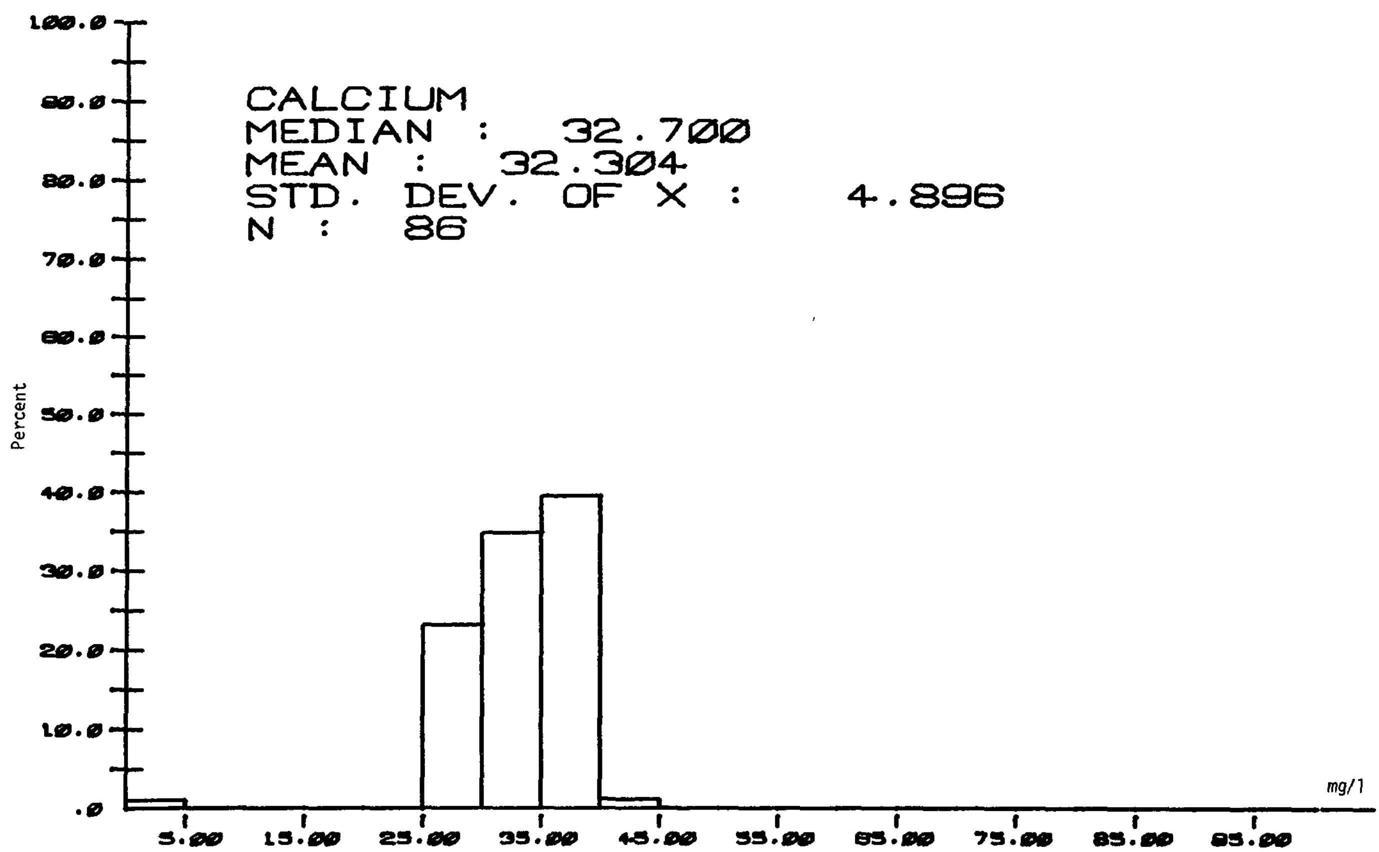

Figure 3.26 Niagara River Histograms for Calcium

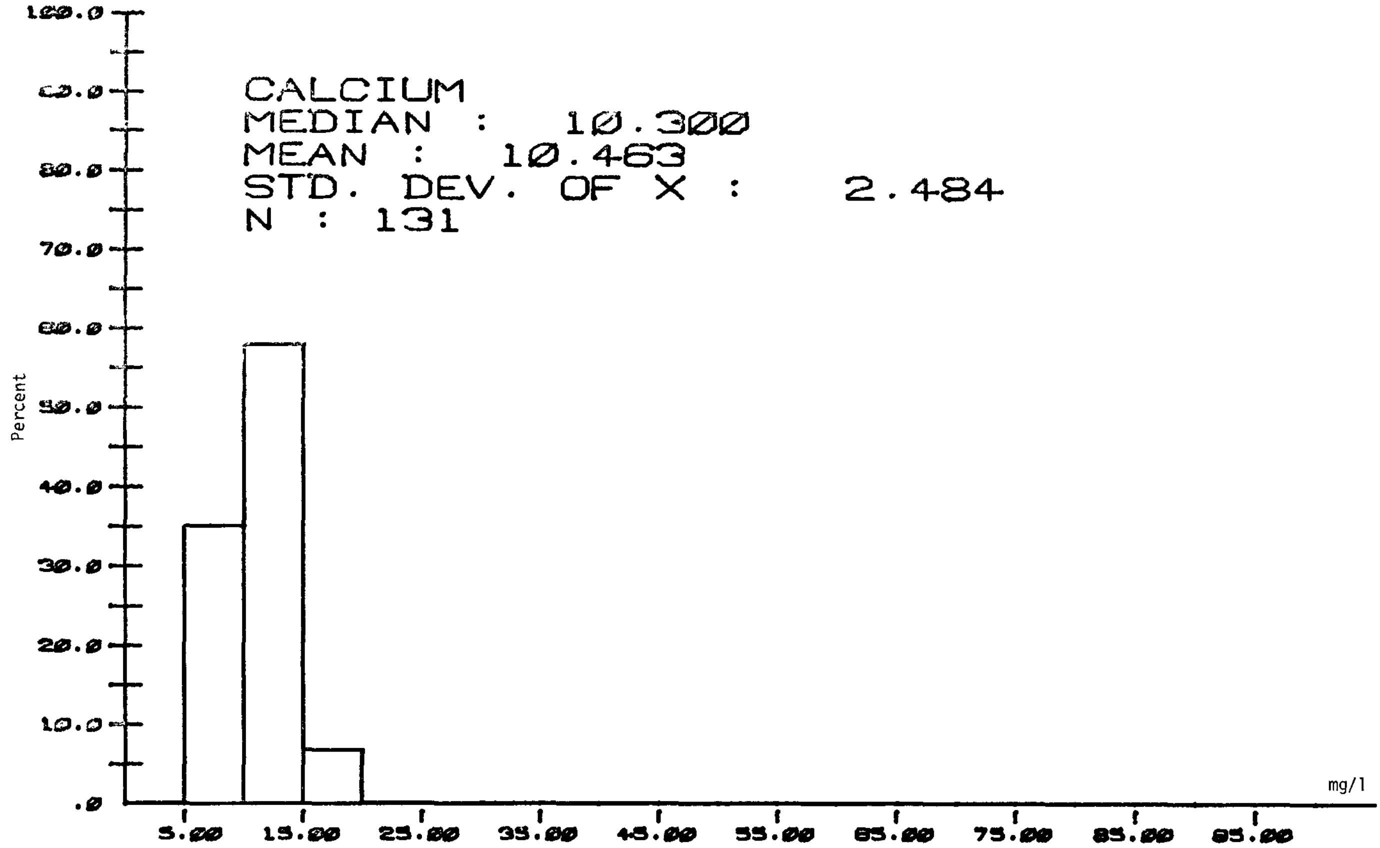

Figure 3.26 Black River Histograms for Calcium

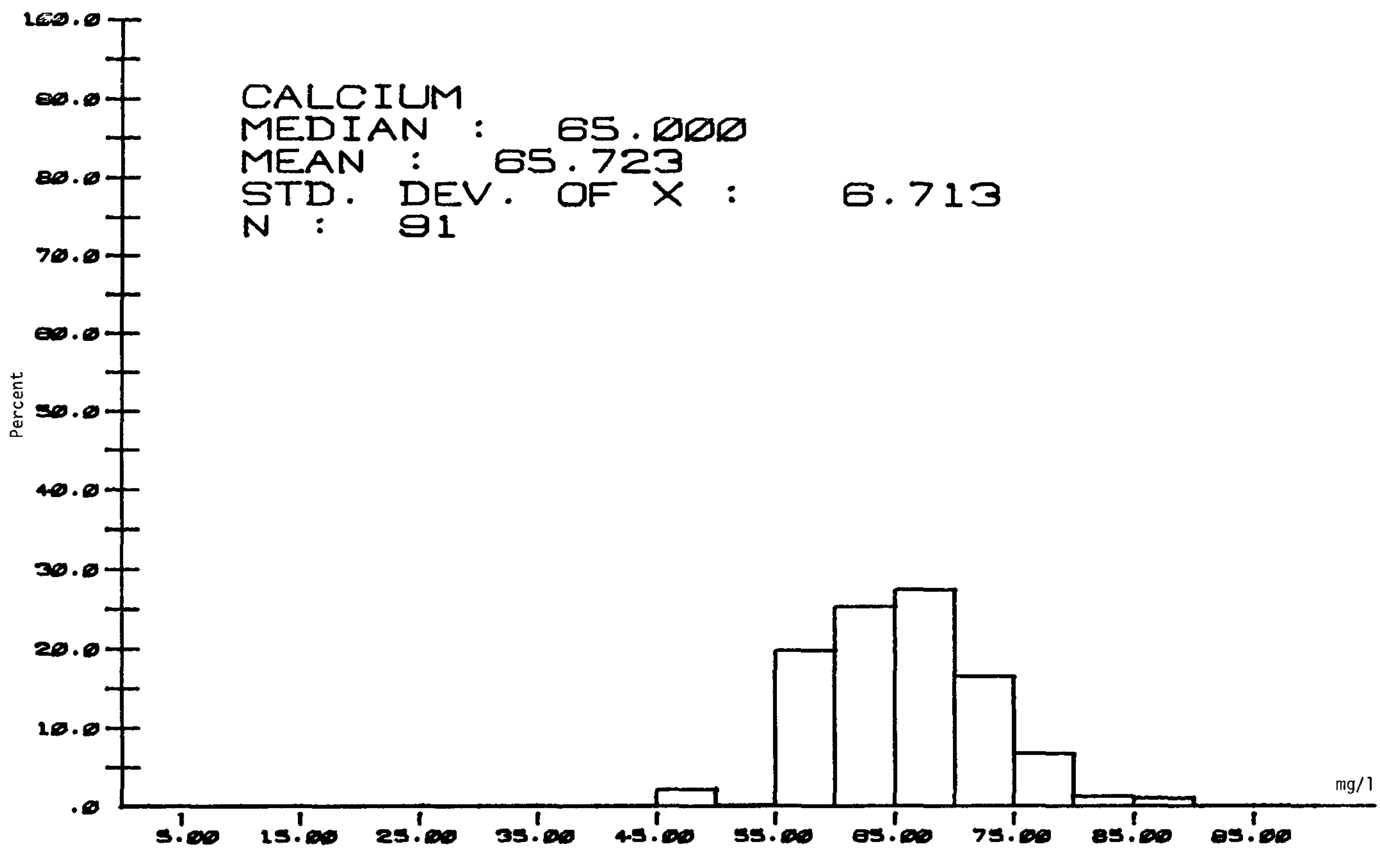

Figure 3.26 Oswego River Histograms for Calcium

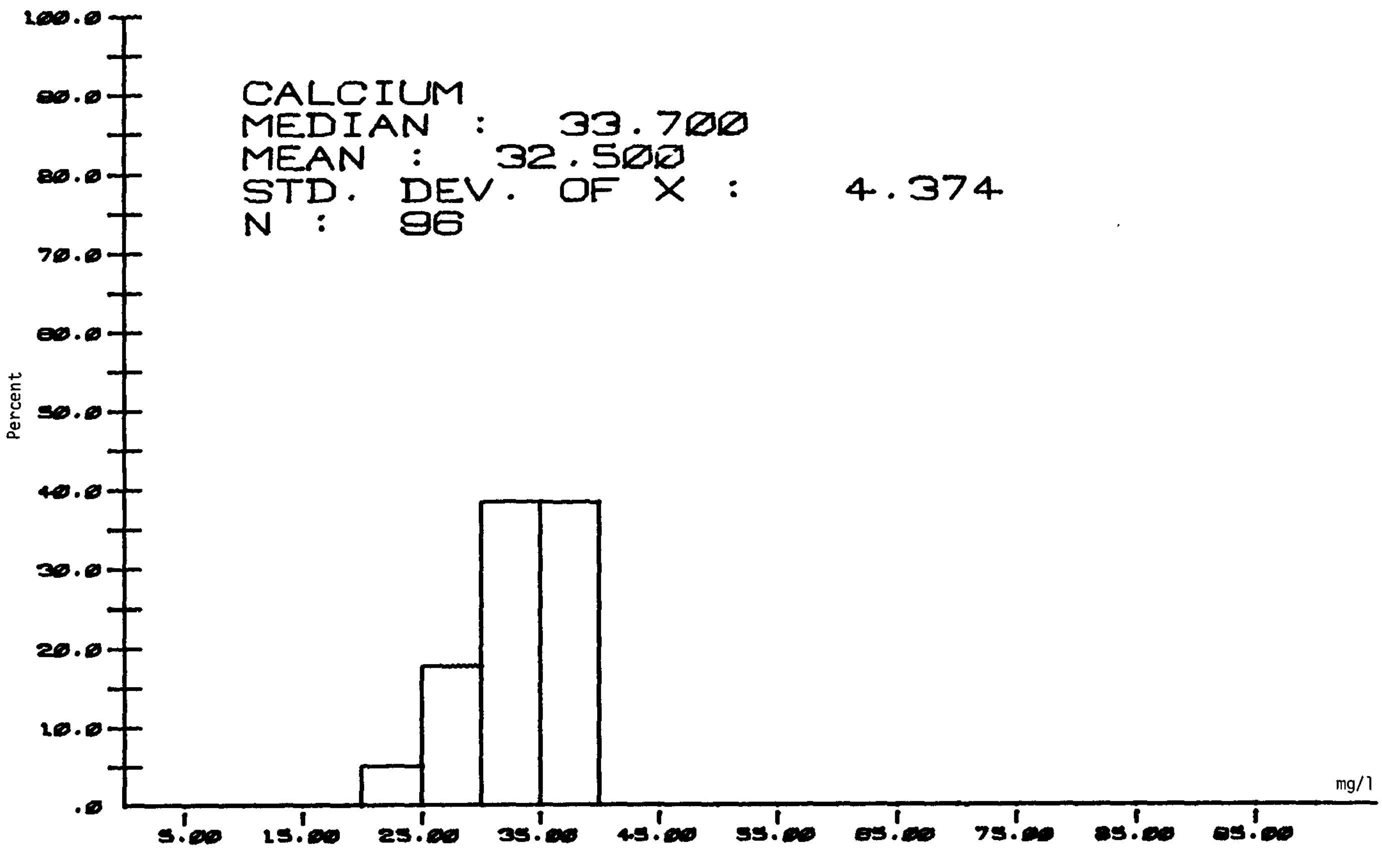

Figure 3.26 St. Lawrence River Histograms for Calcium

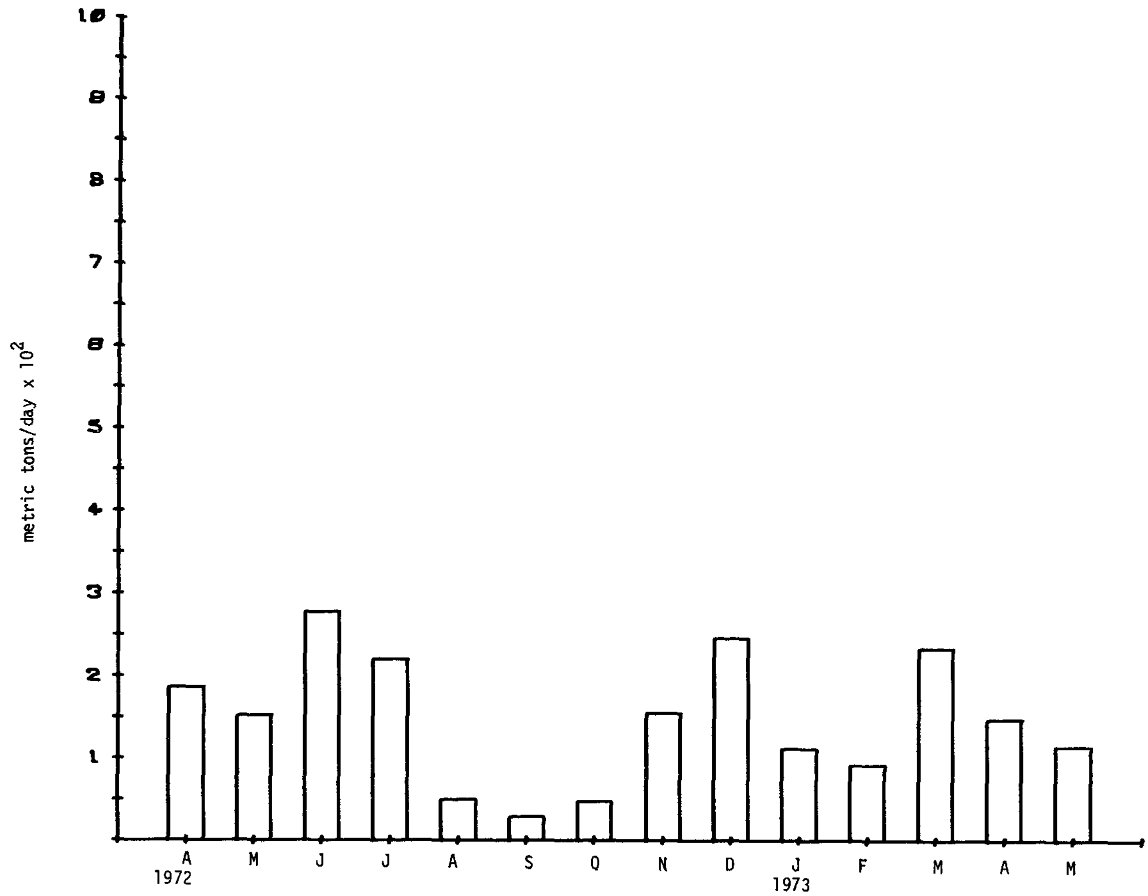

Figure 3.27 Genesee River Monthly Mean Stream Loadings - Magnesium

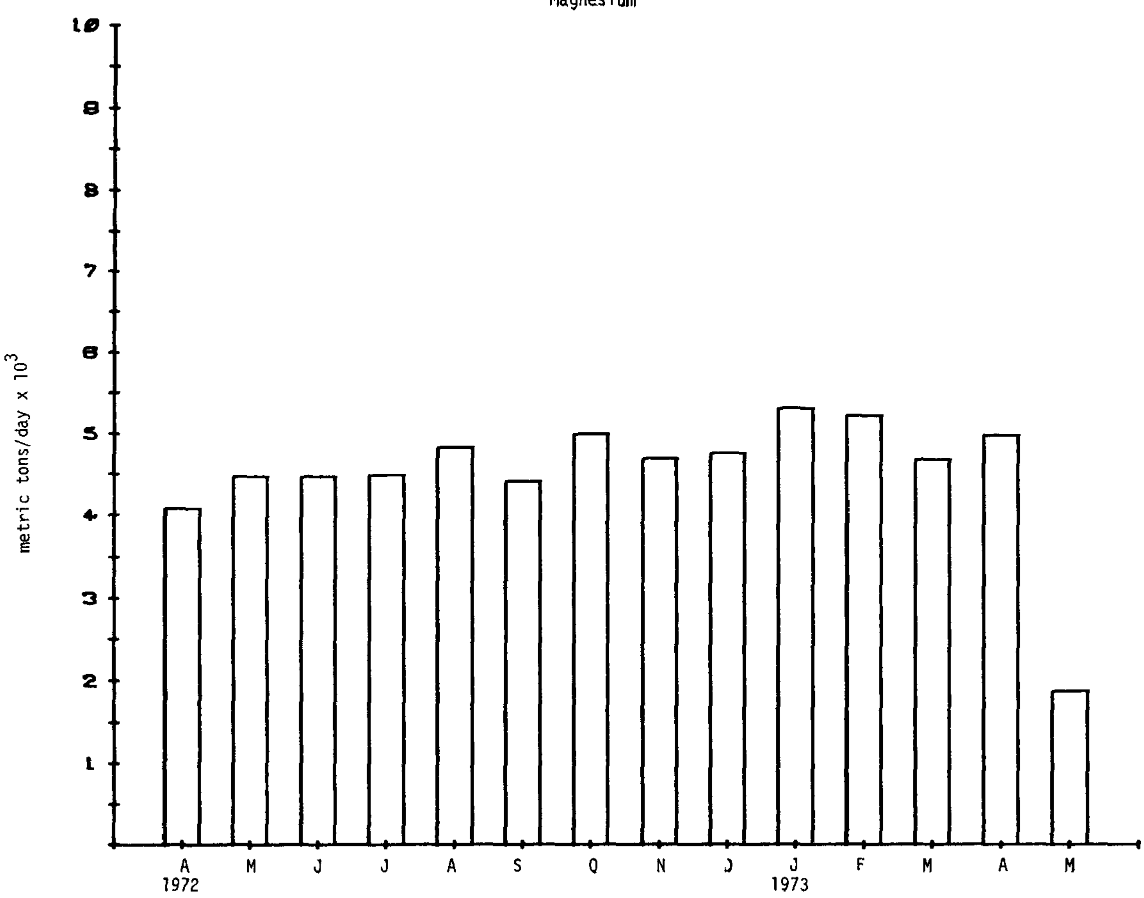

Figure 3.27 Niagara River Monthly Mean Stream Loadings - Magnesium

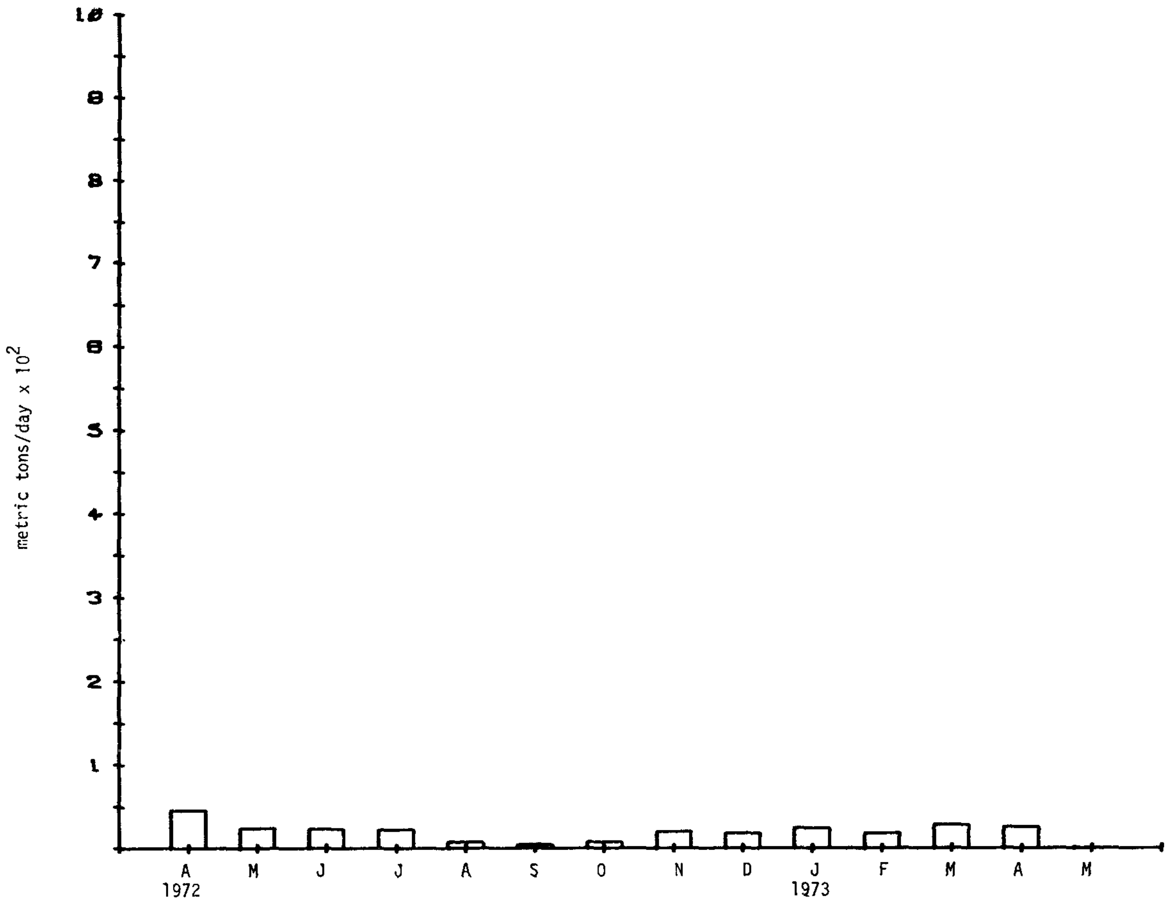

Figure 3.27 Black River Monthly Mean Stream Loadings - Magnesium

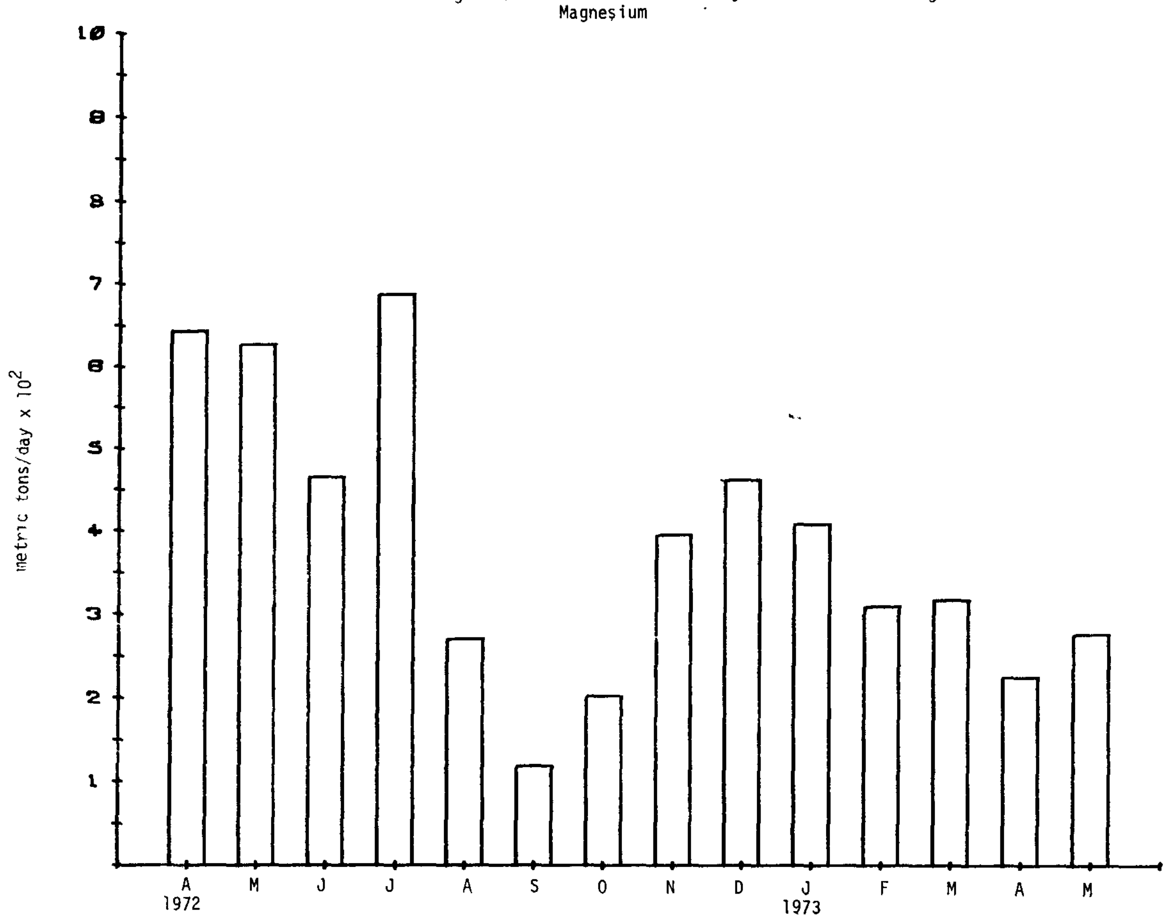

Figure 3.27 Oswego River Monthly Mean Stream Loadings - Magnesium

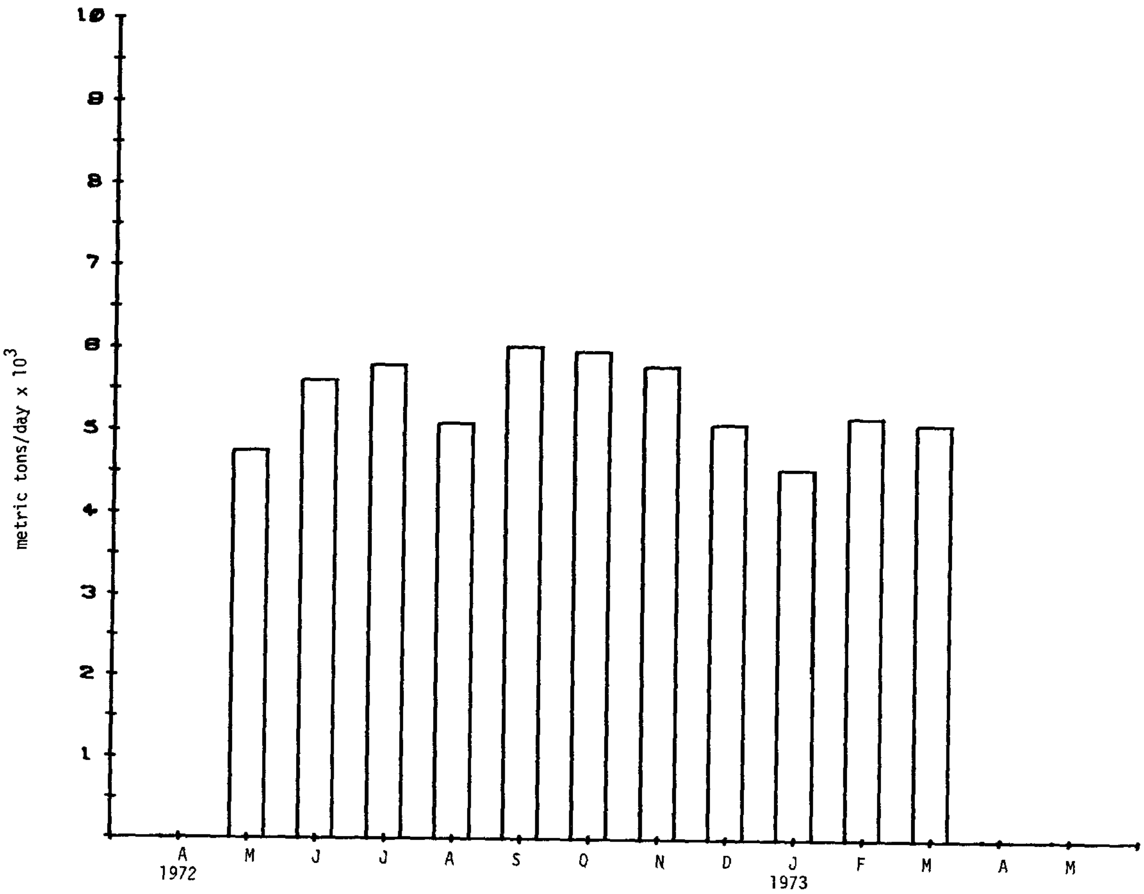

Figure 3.27 St. Lawrence River Monthly Mean Stream Loadings - Magnesium

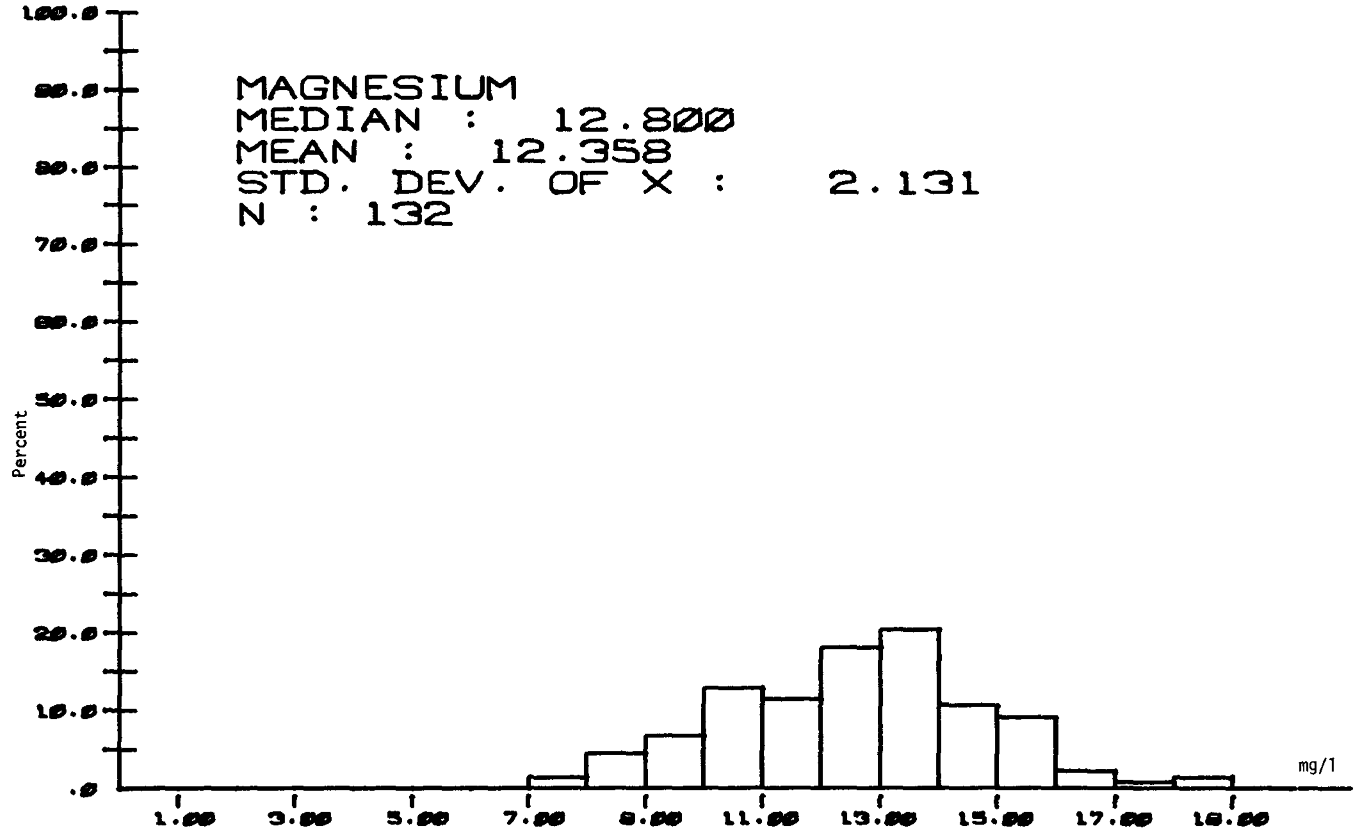

Figure 3.28 Genesee River Histograms for Magnesium

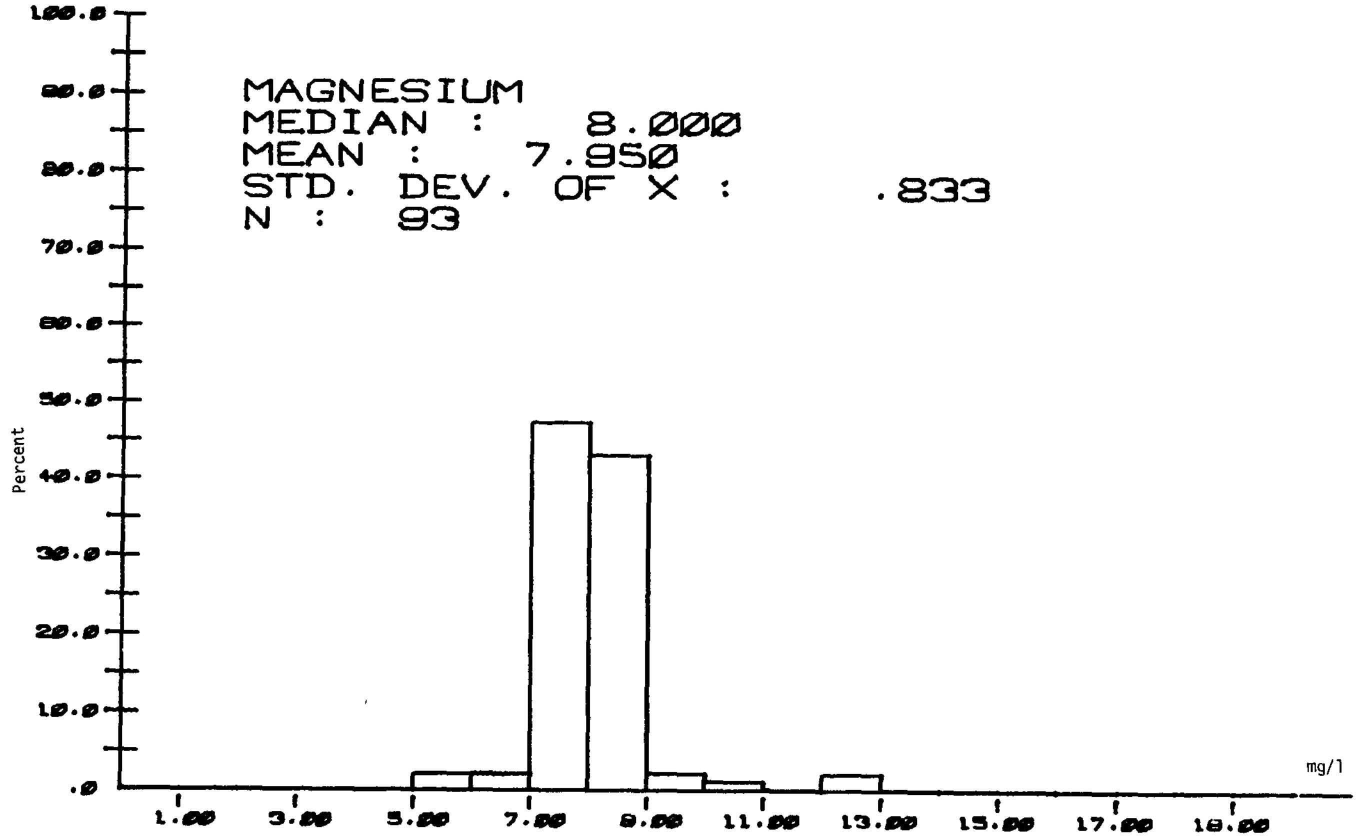

Figure 3.28 Niagara River Histograms for Magnesium

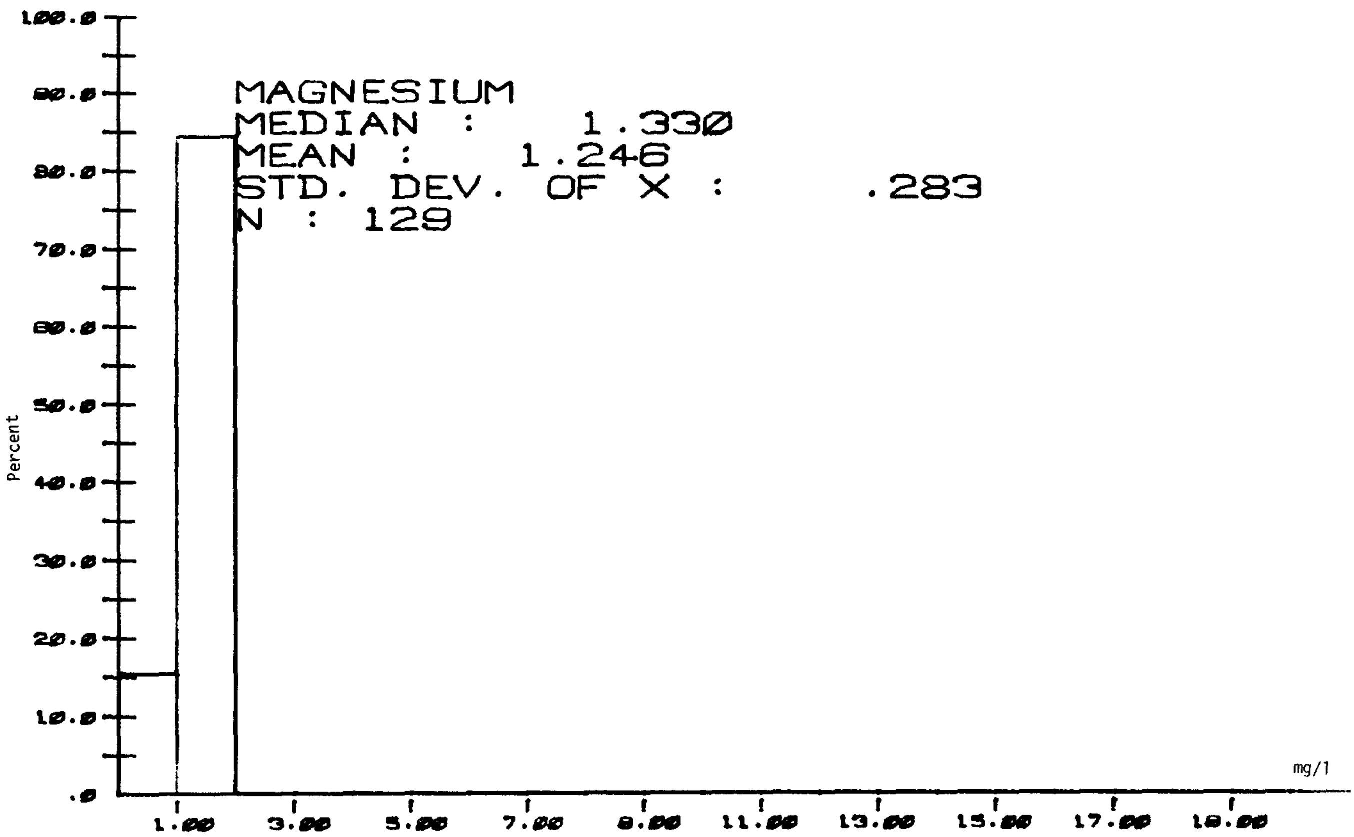

Figure 3.28 Black River Histograms for Magnesium

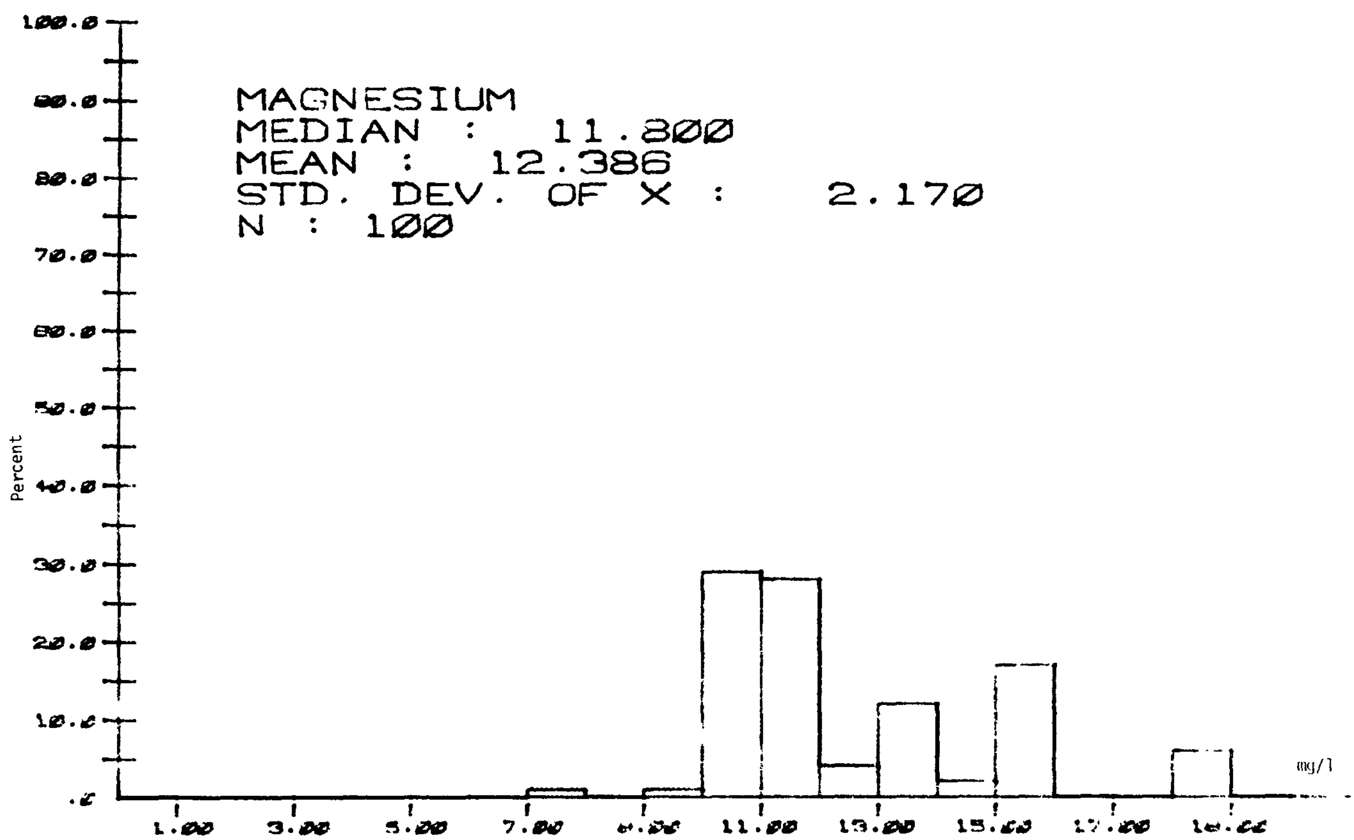

Figure 3.28 Oswego River Histograms for Magnesium

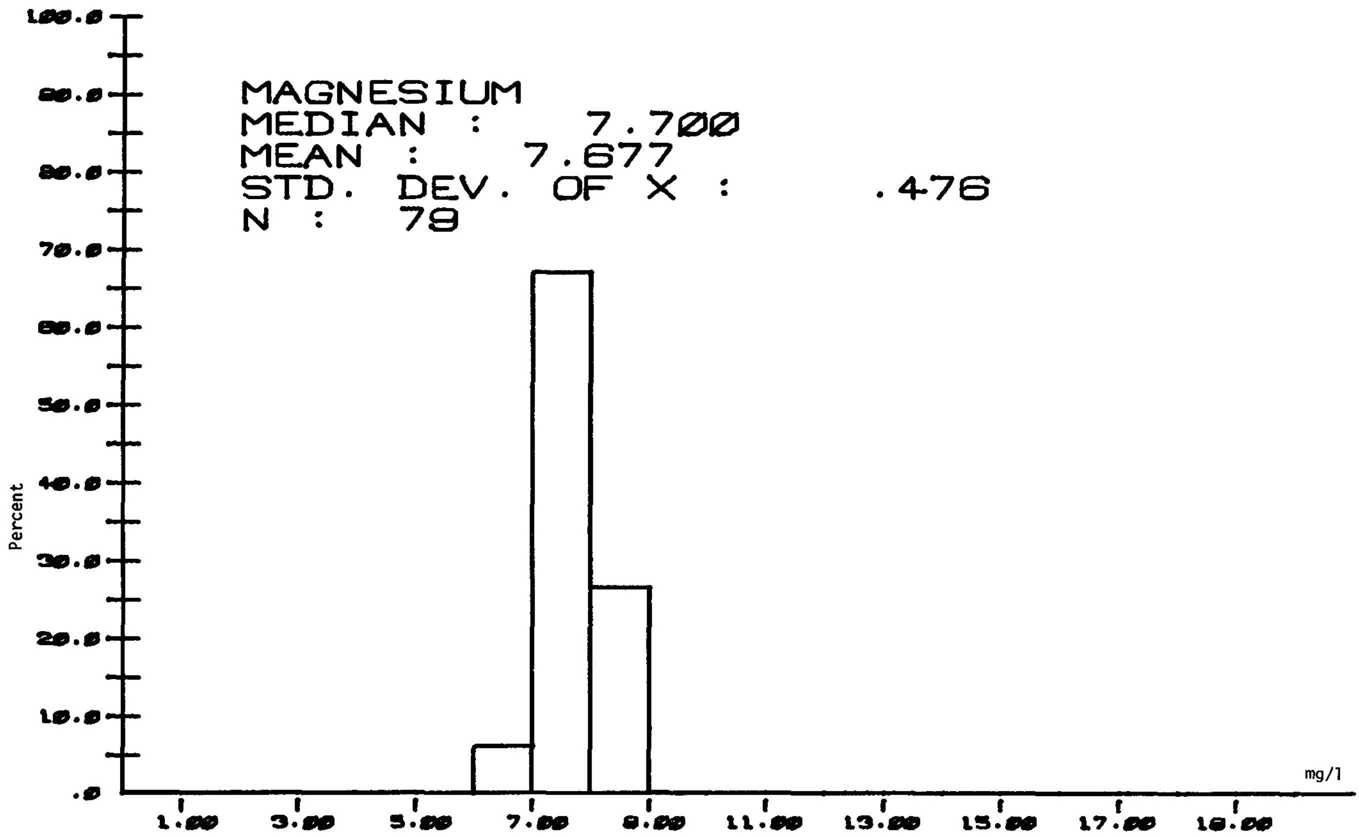

Figure 3.28 St. Lawrence River Histograms for Magnesium

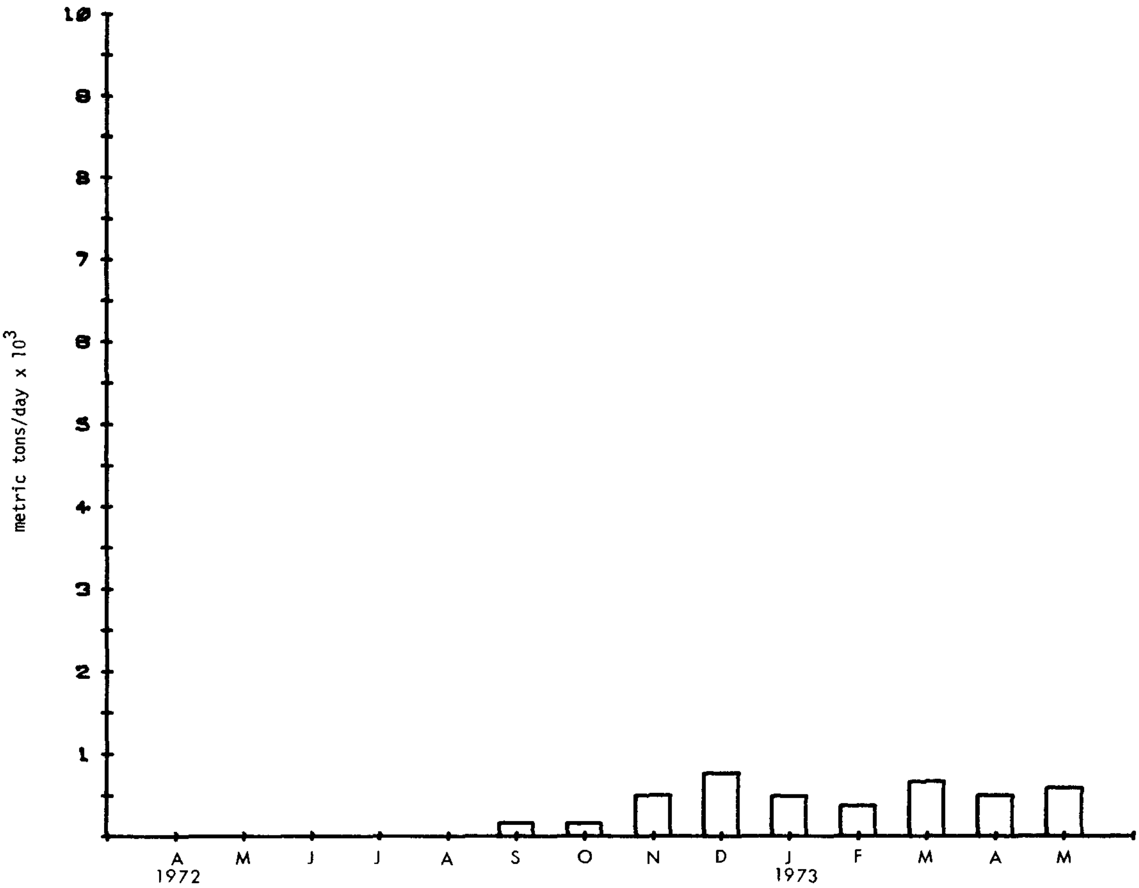

Figure 3.29 Genesee River Monthly Mean Stream Loadings - Sulfate

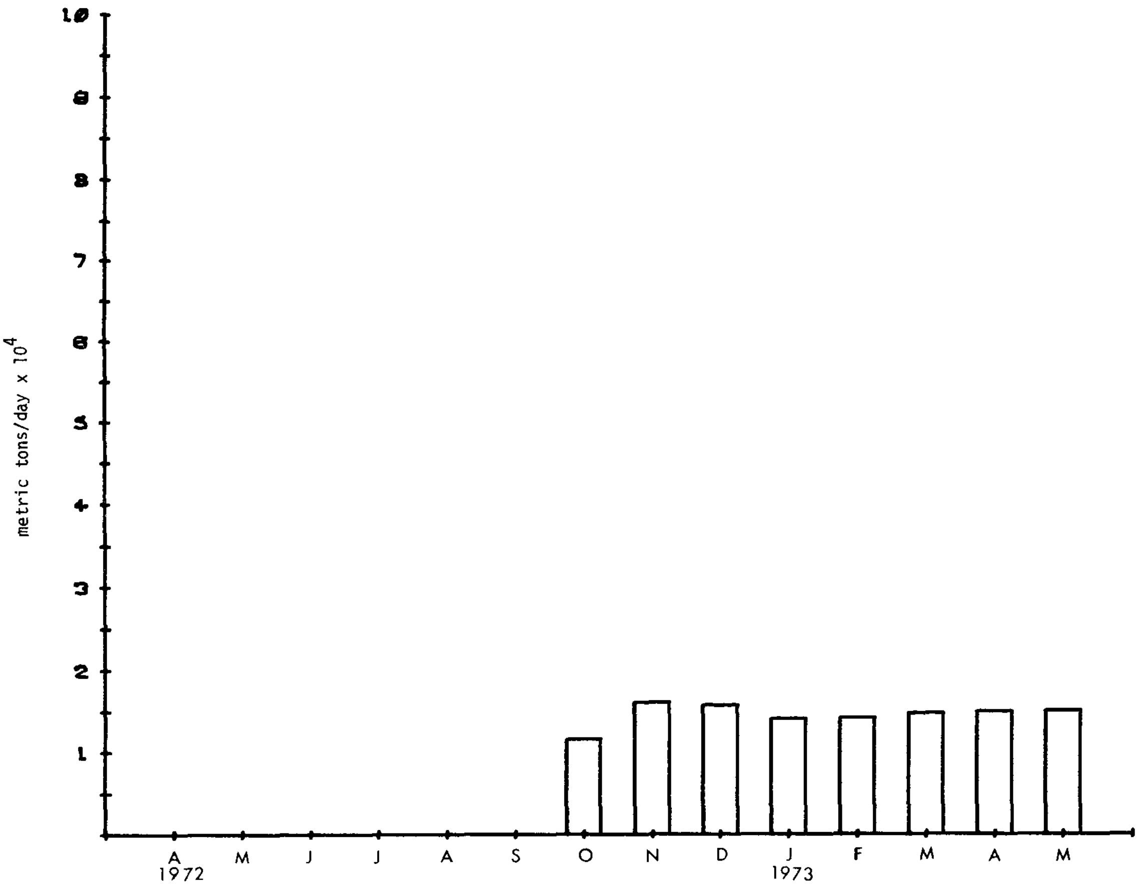

Figure 3.29 Niagara River Monthly Mean Stream Loadings - Sulfate

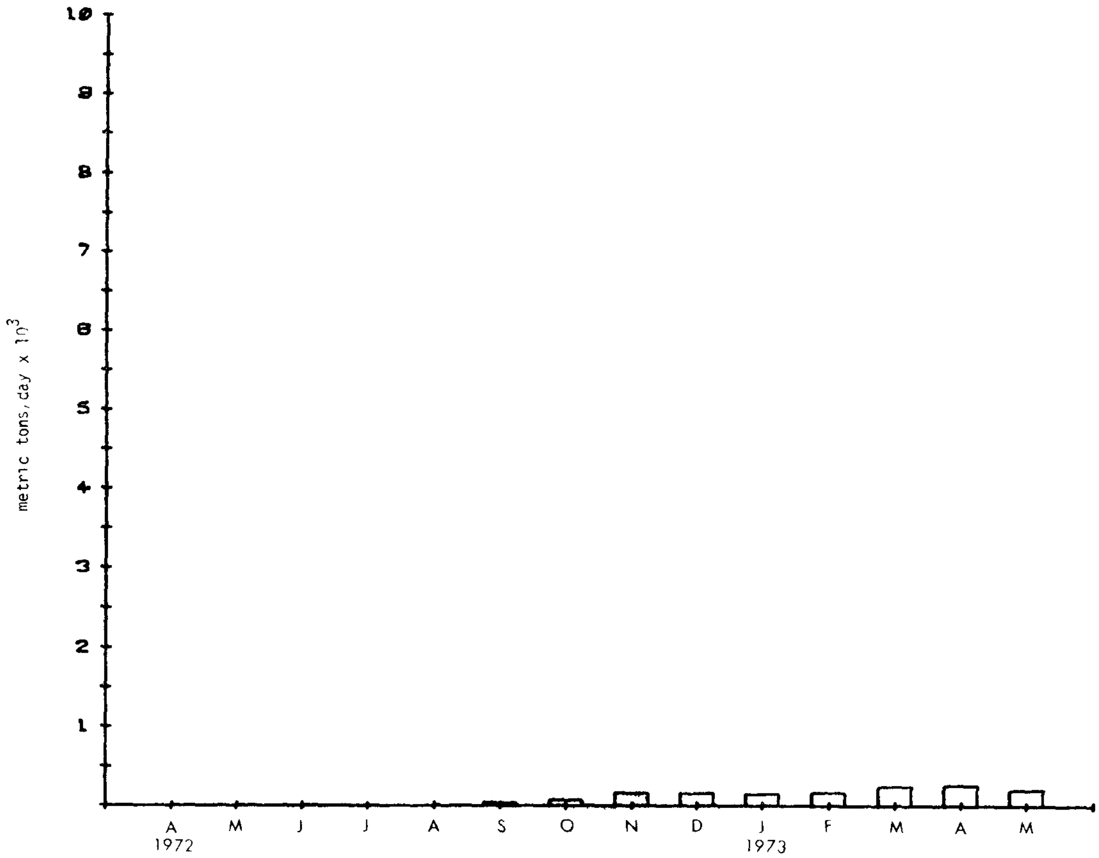

Figure 3.29 Black River Monthly Mean Stream Loadings - Sulfate

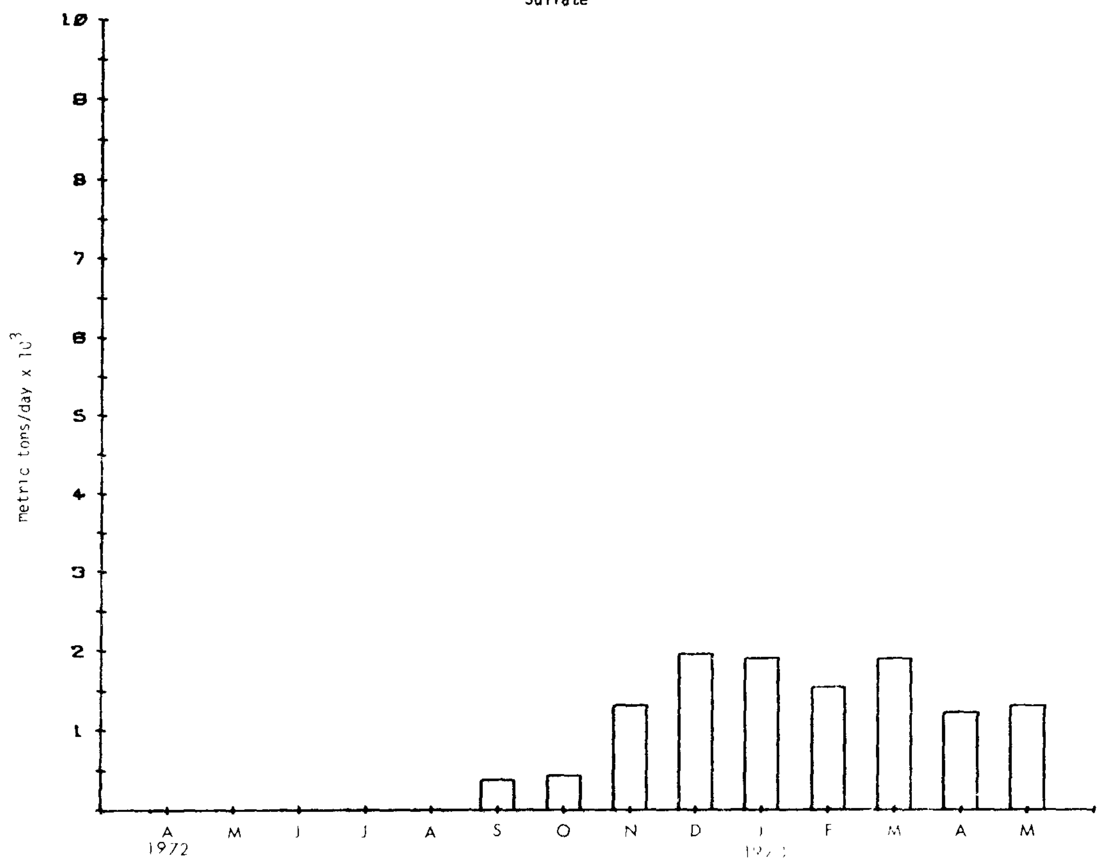

Figure 3.29 Oswego River Monthly Mean Stream Loadings - Sulfate

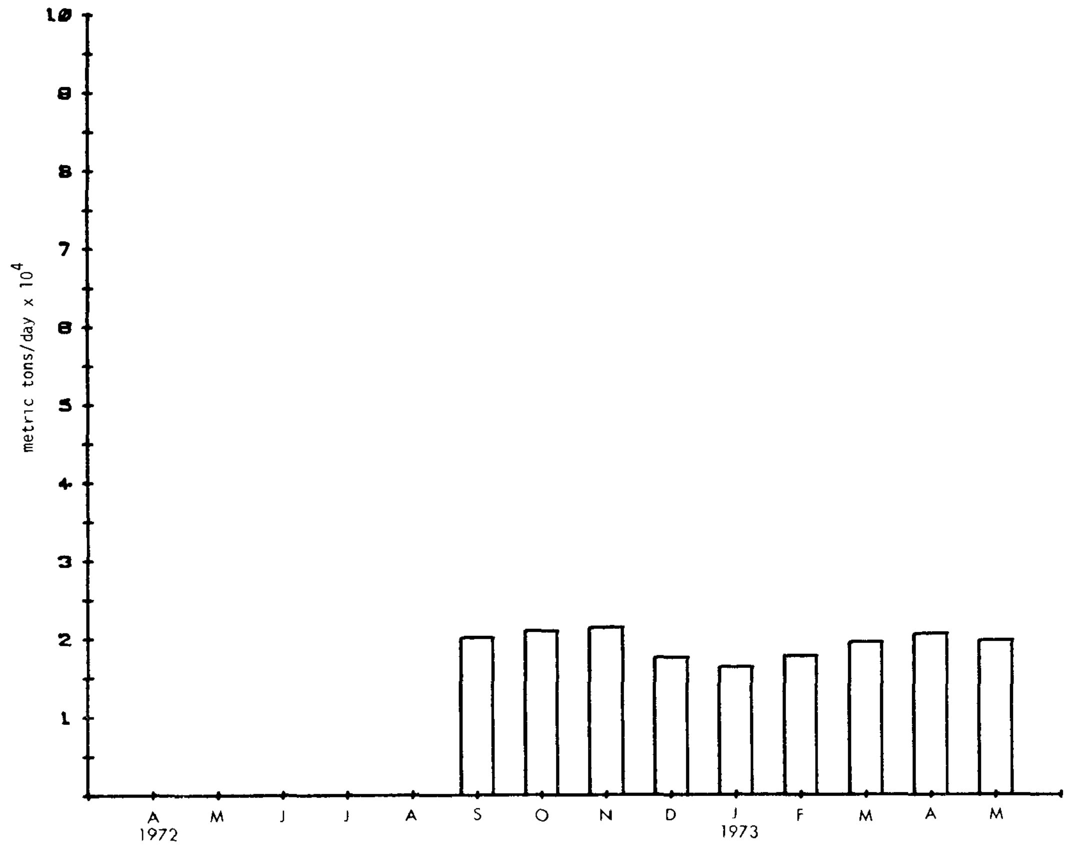

Figure 3.29 St. Lawrence River Monthly Mean Stream Loadings - Sulfate

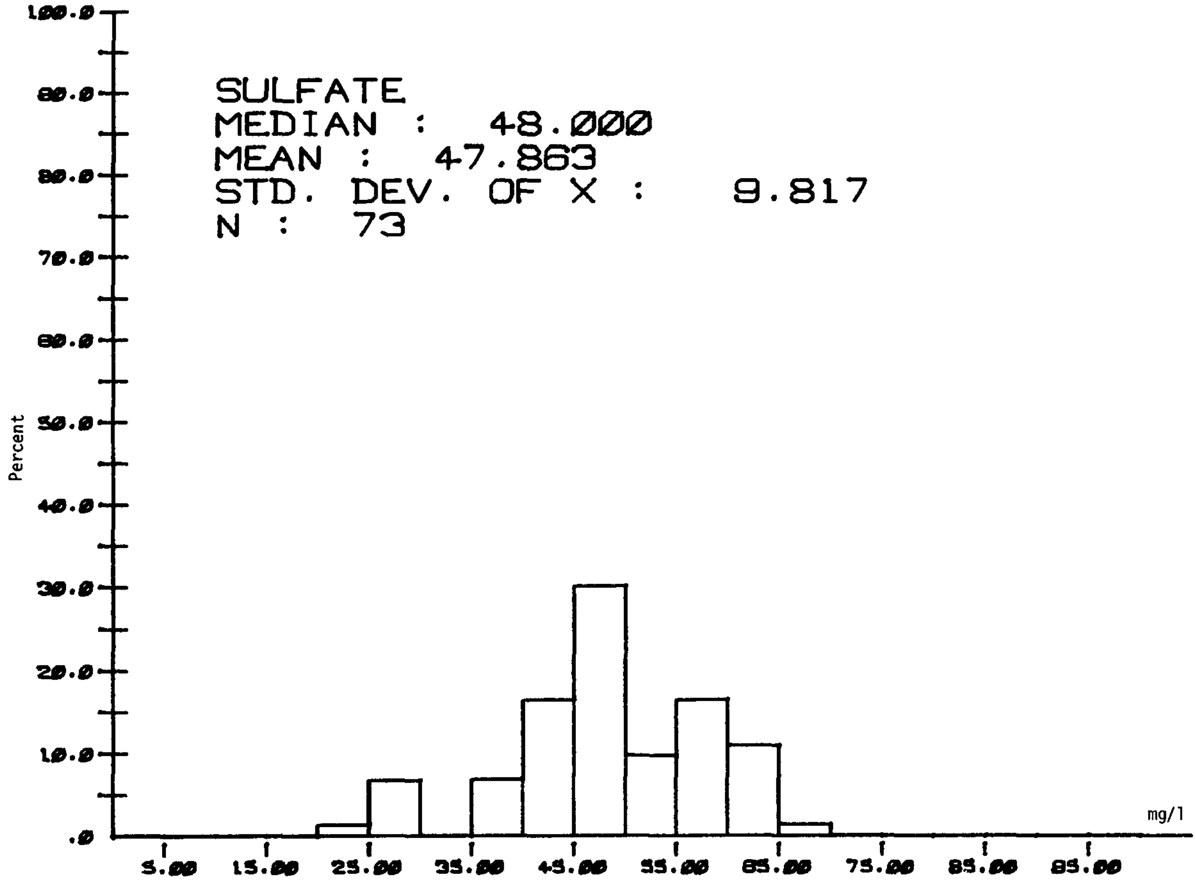

Figure 3.30 Genesee River Histograms for Sulfate

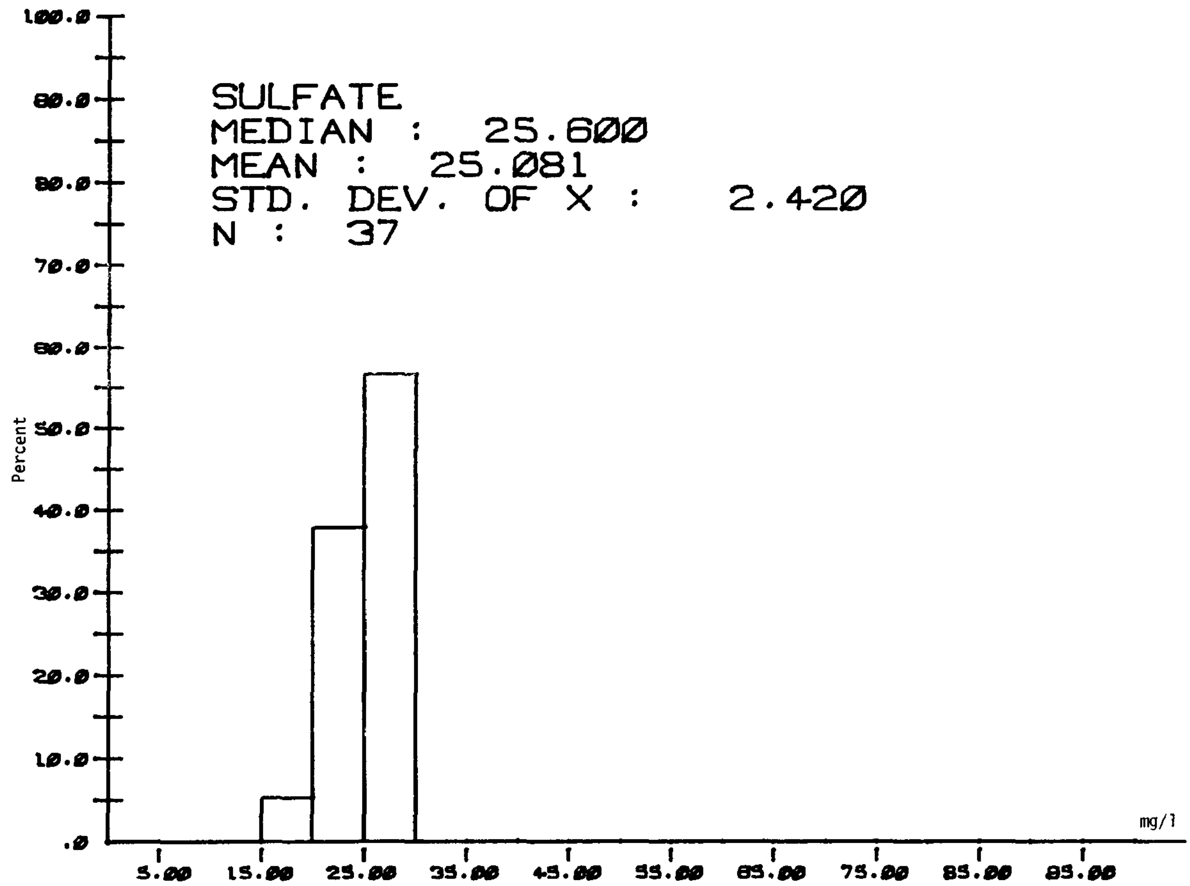

Figure 3.30 Niagara River Histograms for Sulfate

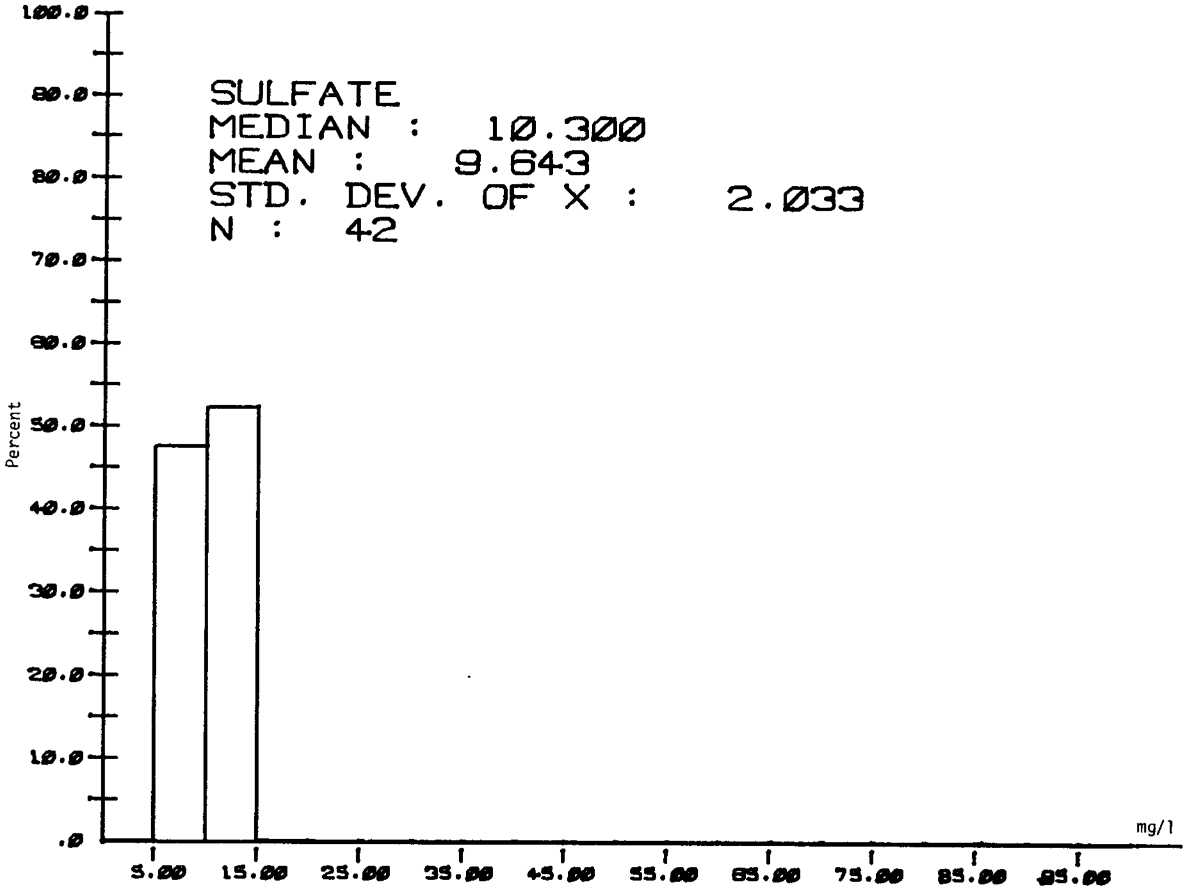

Figure 3.30 Black River Histograms for Sulfate

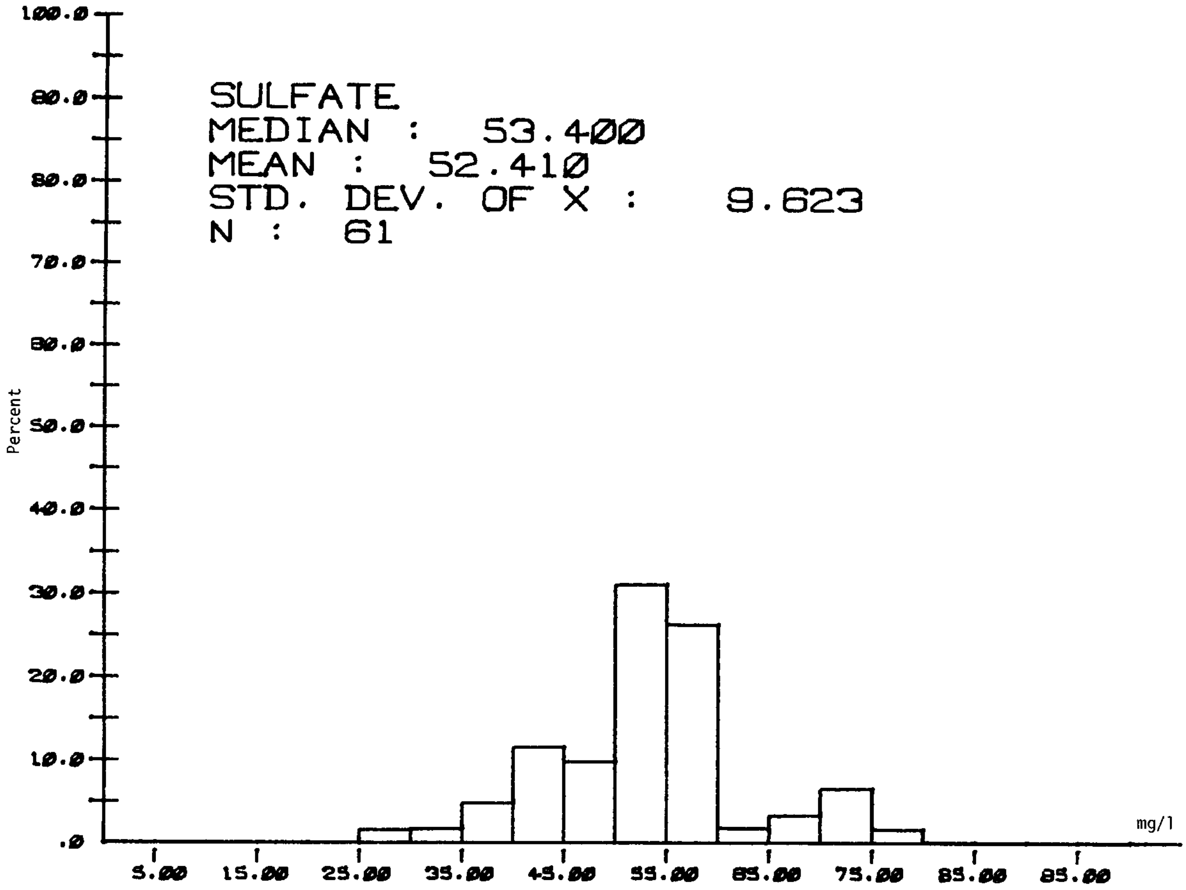

Figure 3.30 Oswego River Histograms for Sulfate

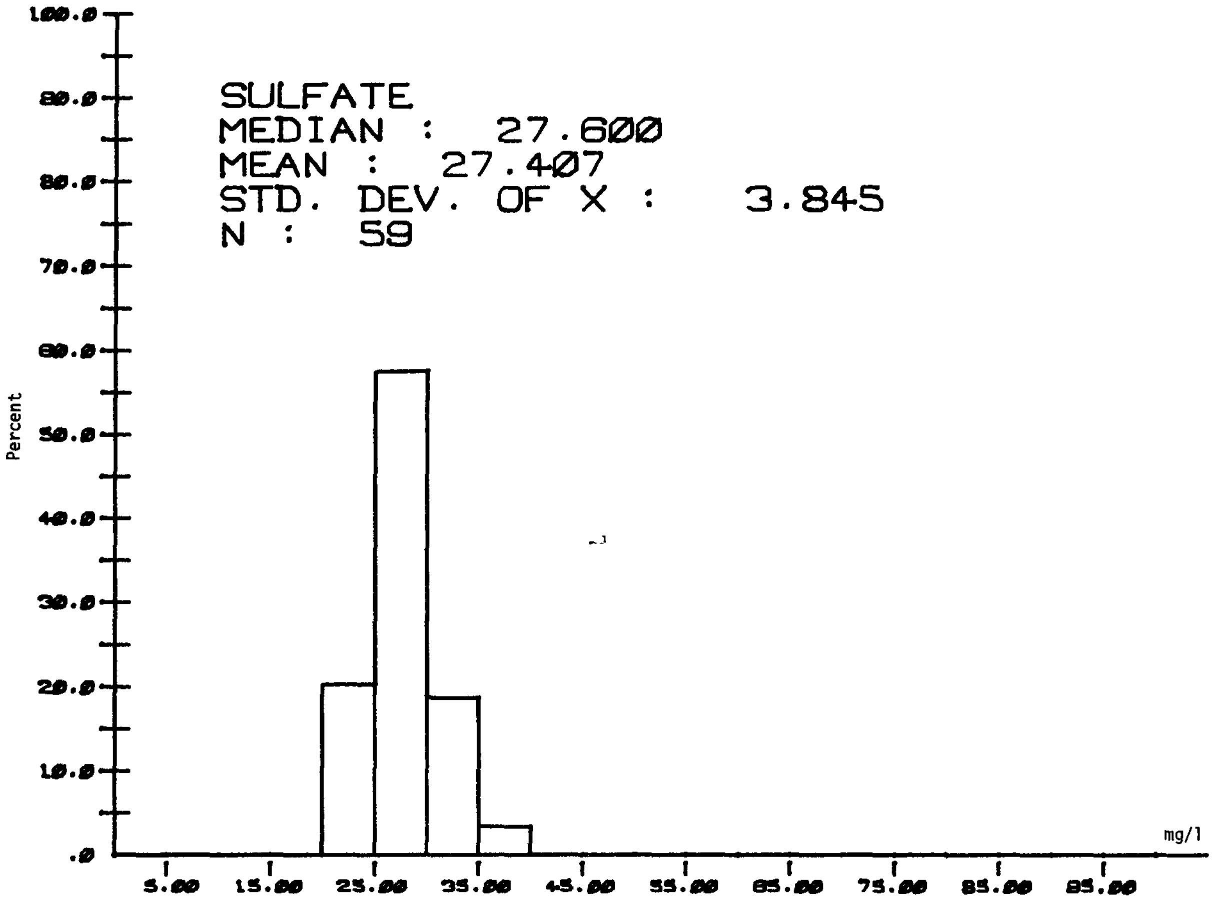

Figure 3.30 St. Lawrence River Histograms for Sulfate

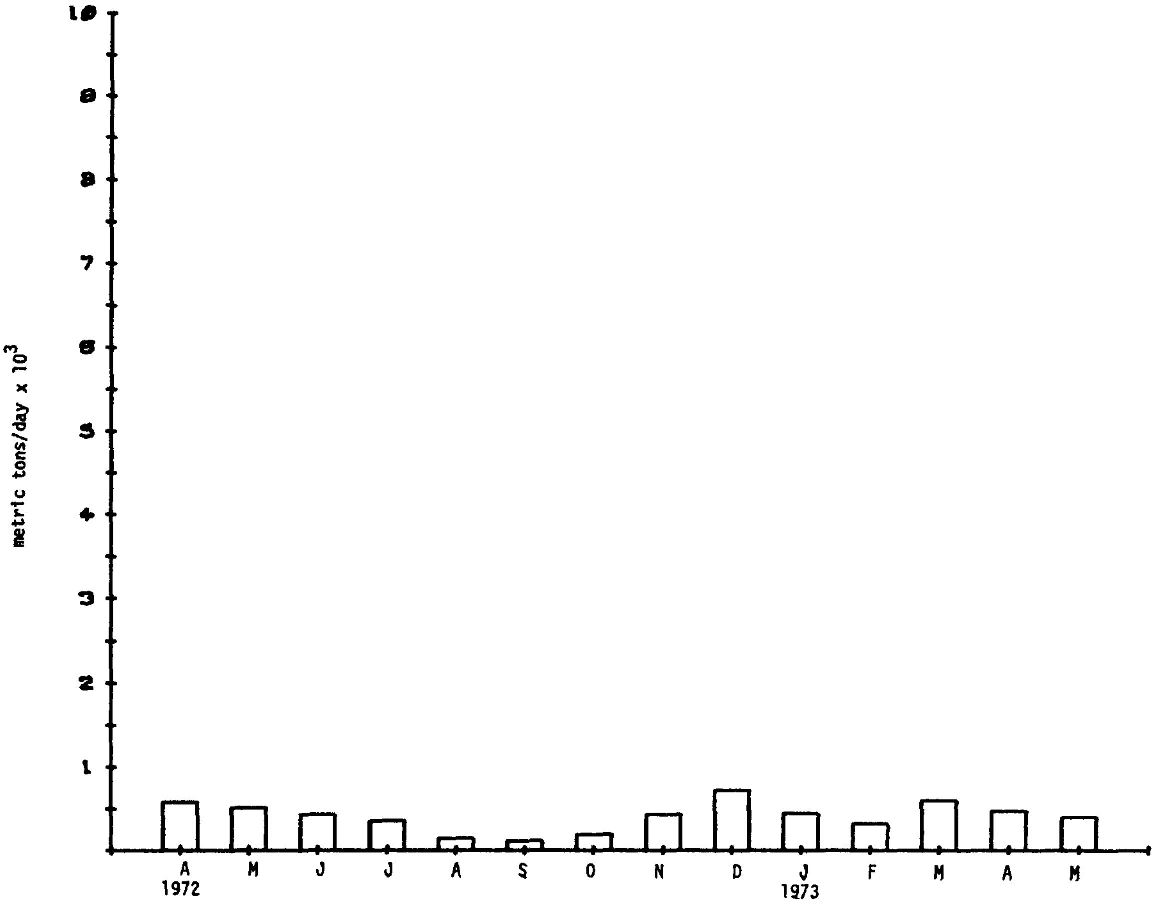

Figure 3.31 Genesee River Monthly Mean Stream Loadings - Chloride

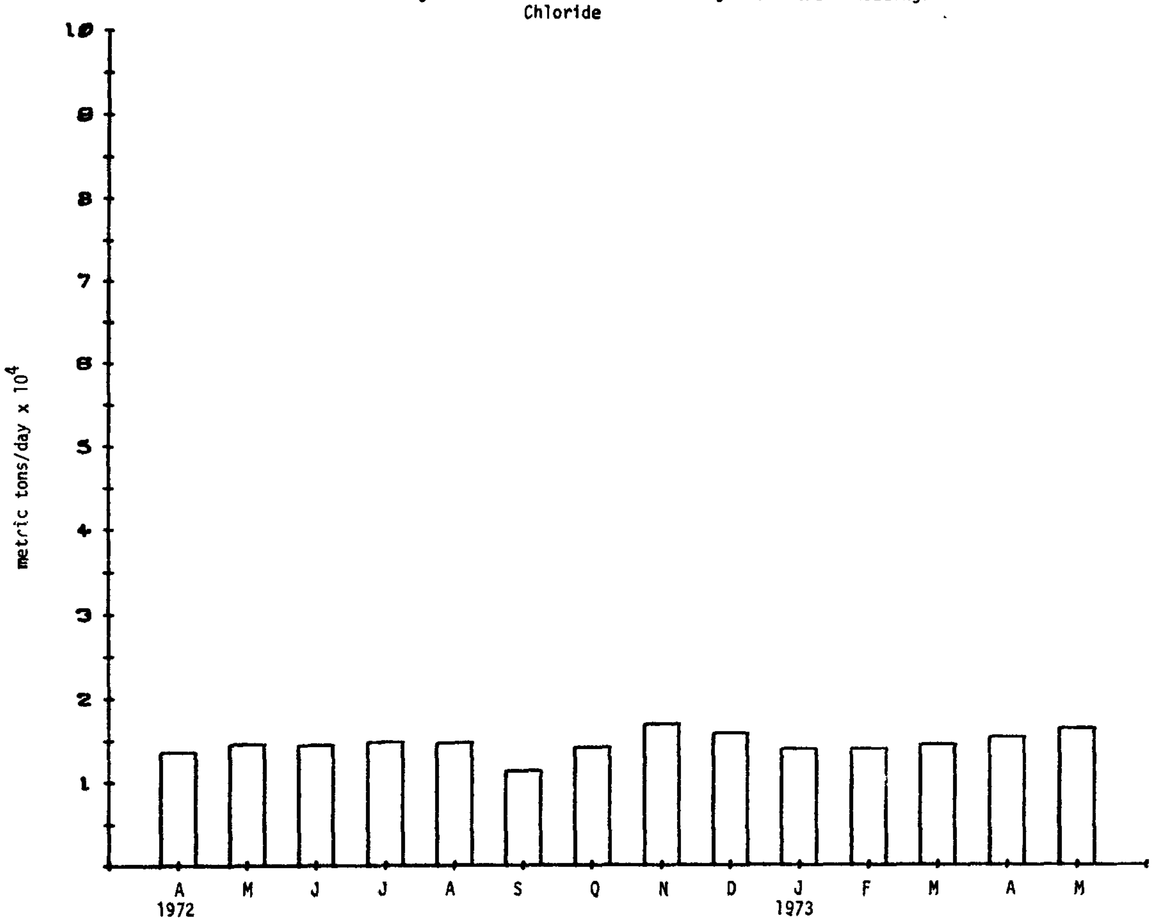

Figure 3.31 Niagara River Monthly Mean Stream Loadings - Chloride

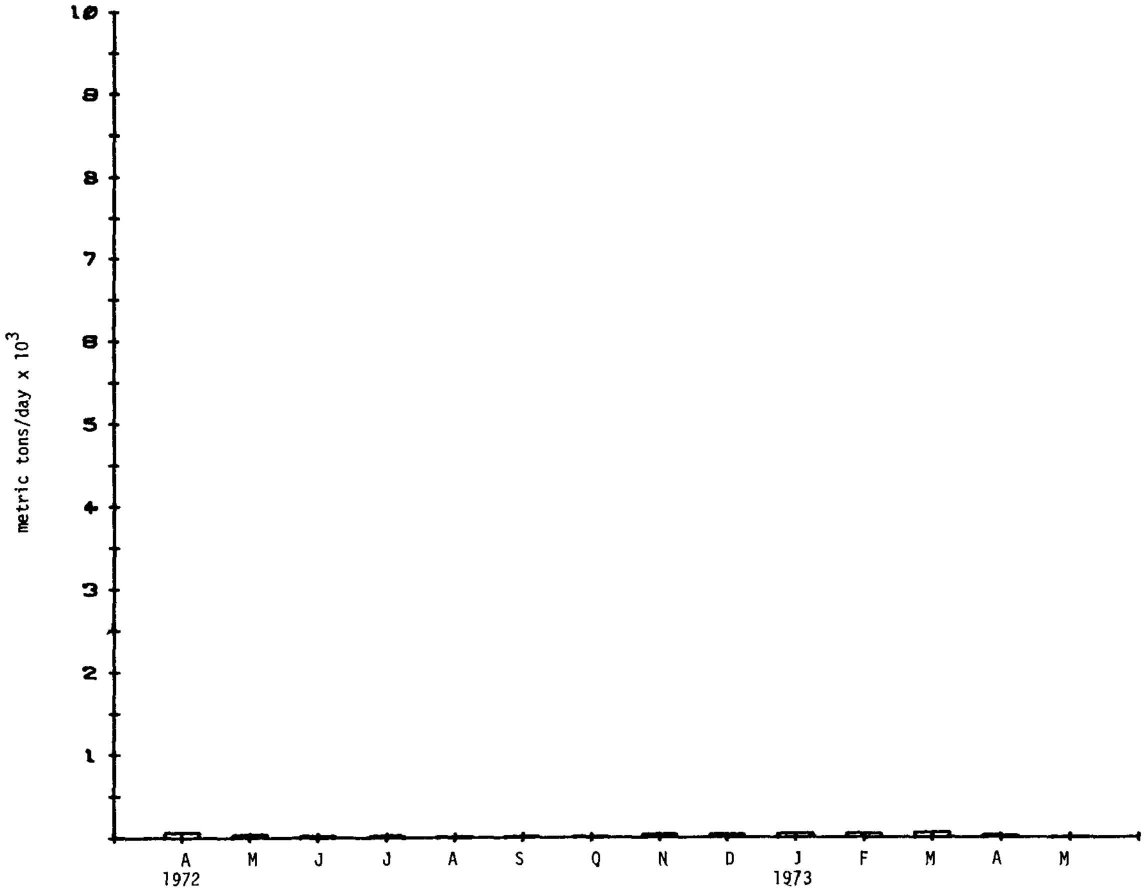

Figure 3.31 Black River Monthly Mean Stream Loadings - Chloride

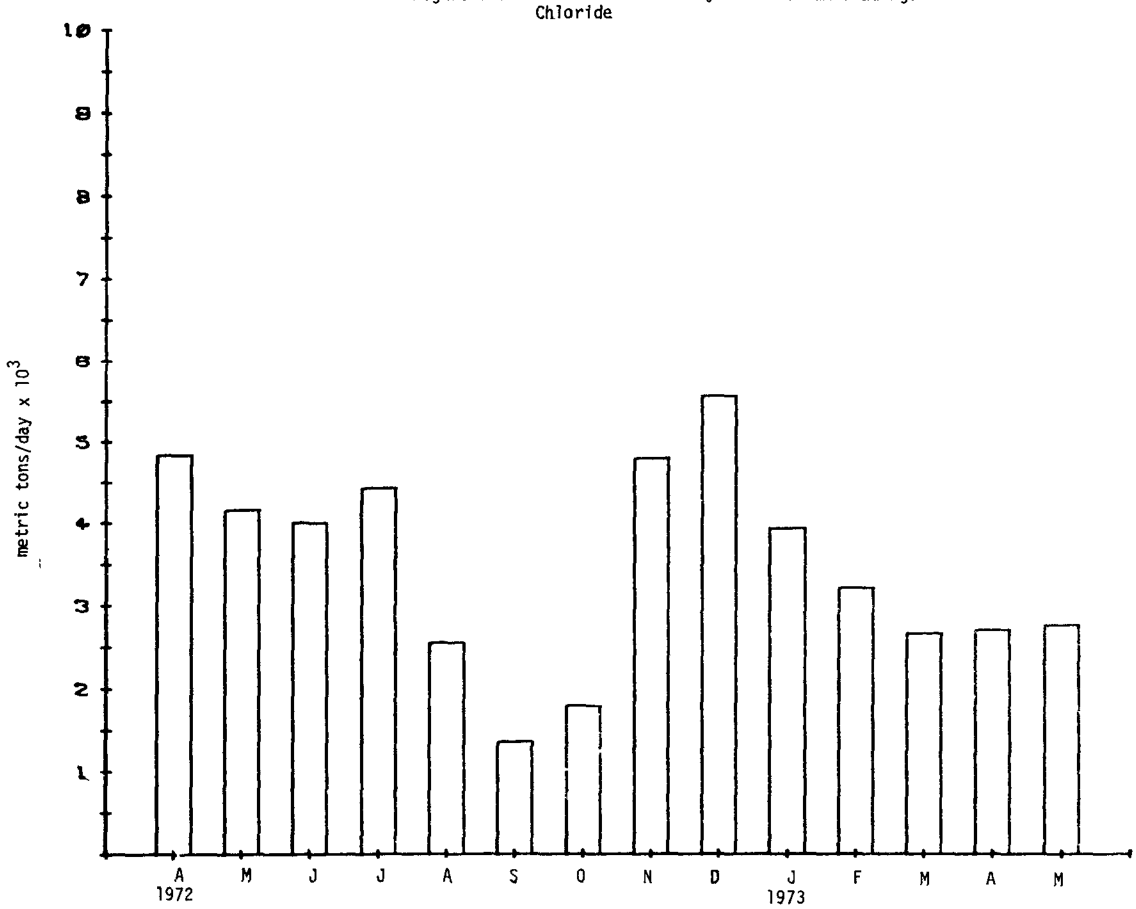

Figure 3.31 Oswego River Monthly Mean Stream Loadings - Chloride

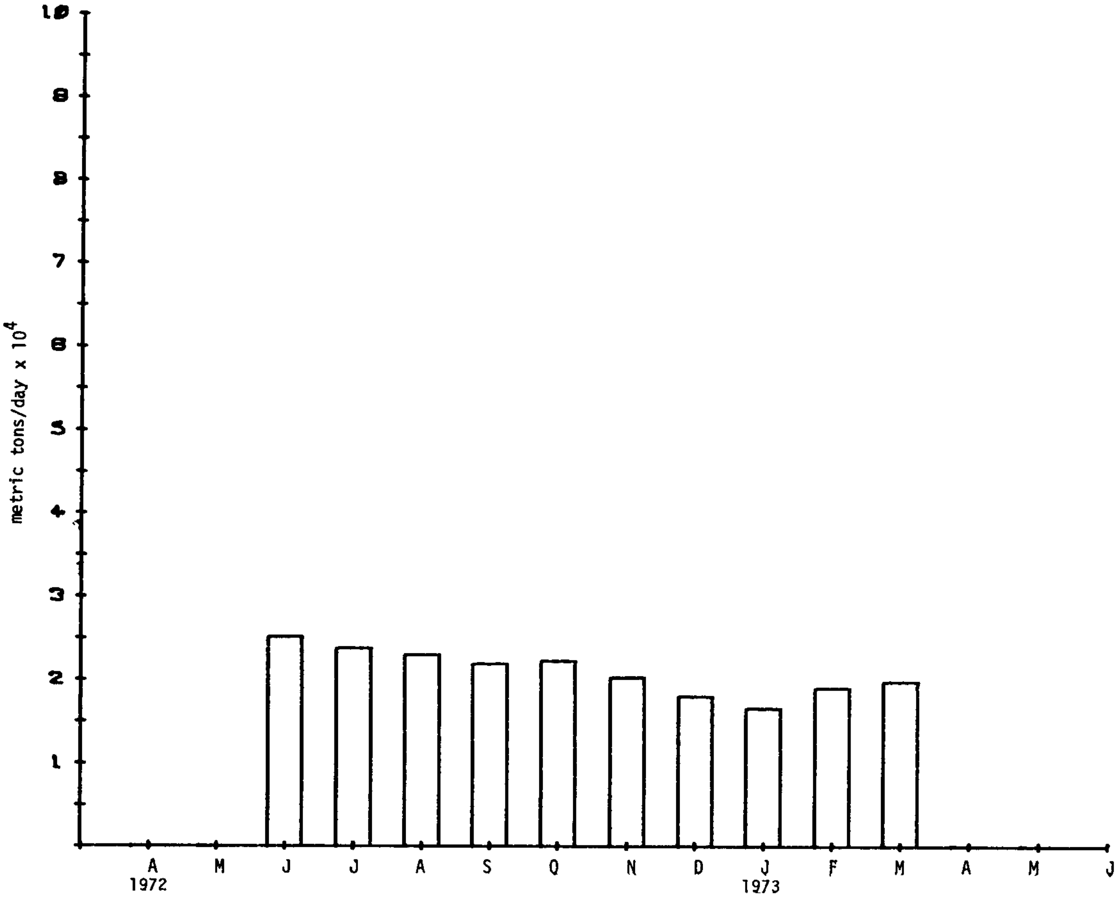

Figure 3.31 St. Lawrence River Monthly Mean Stream Loadings - Chloride

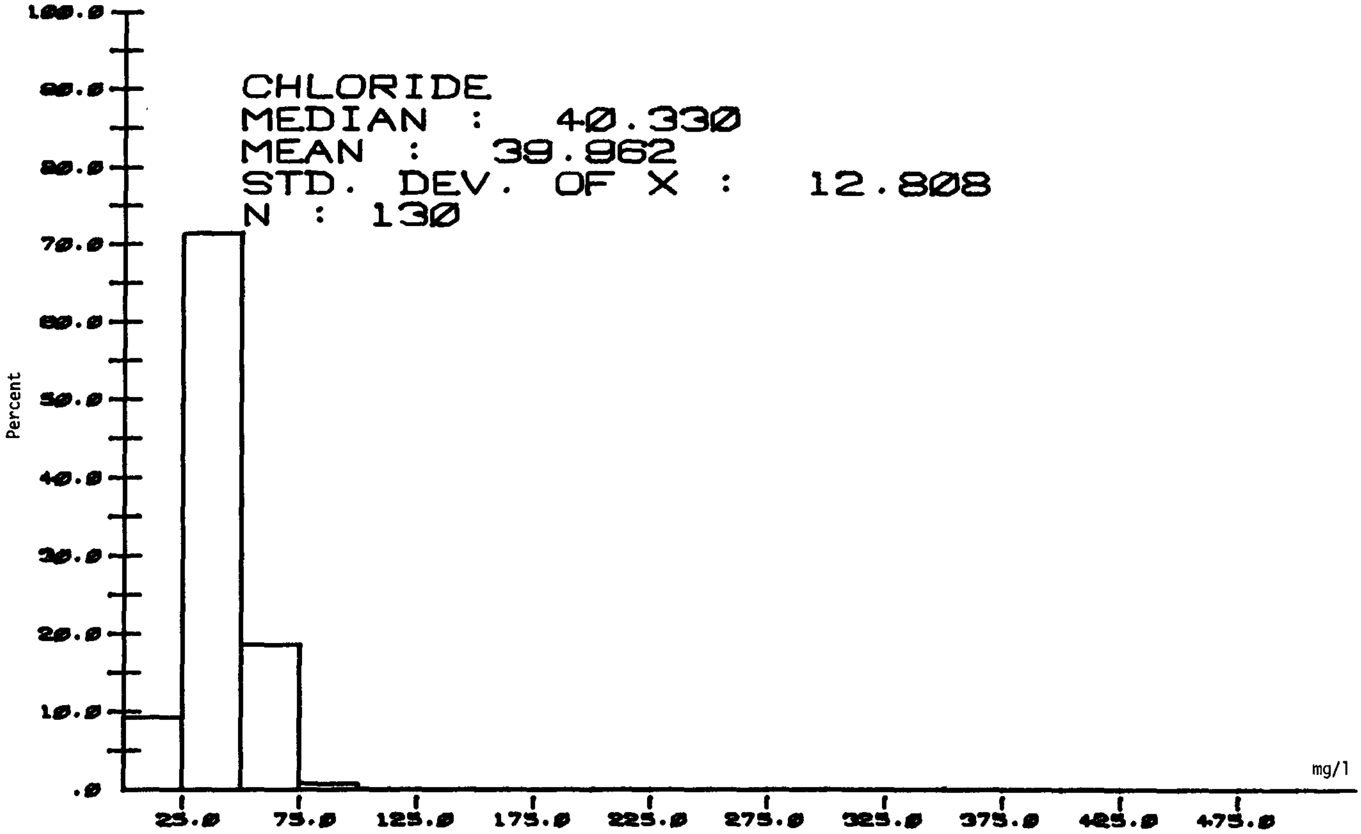

Figure 3.32 Genesee River Histograms for Chloride

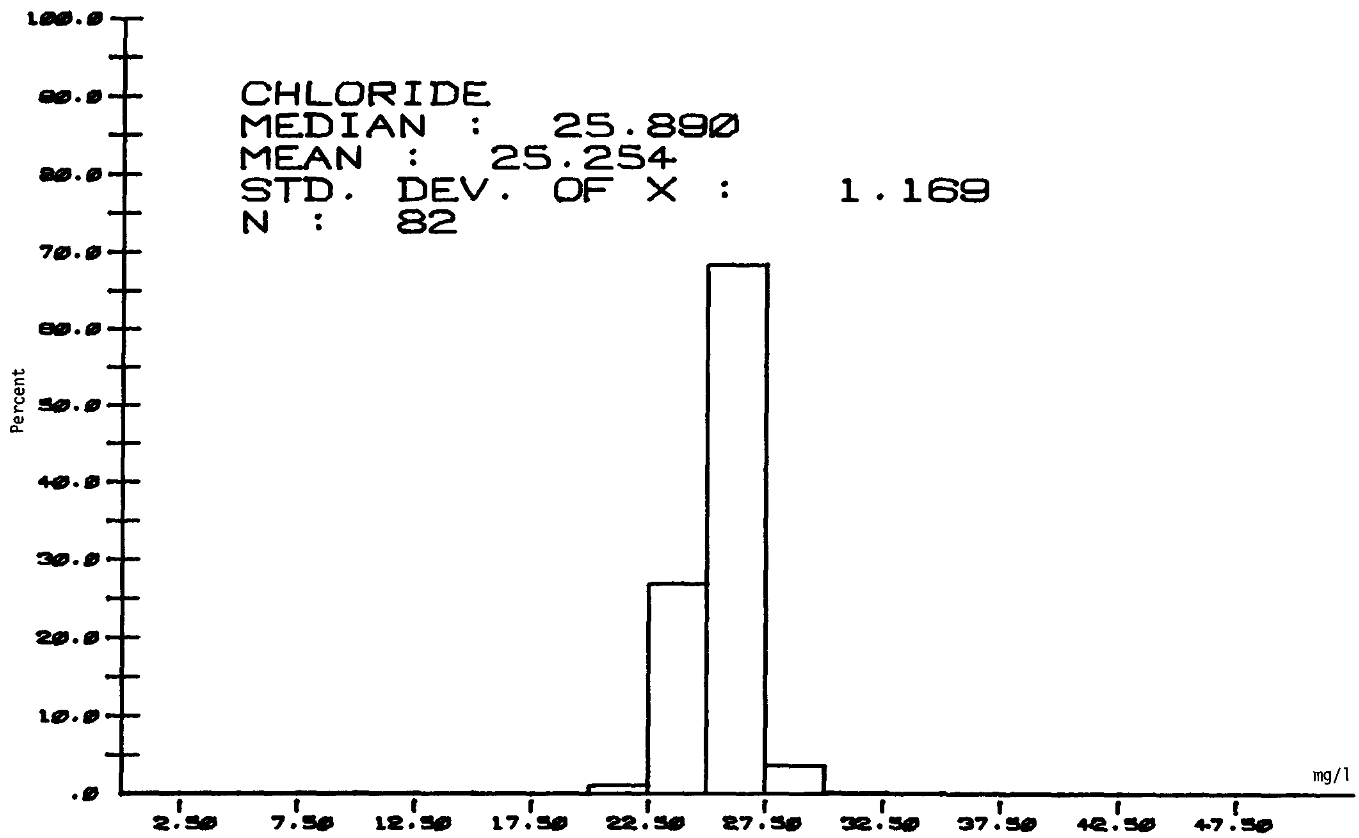

Figure 3.32 Niagara River Histograms for Chloride

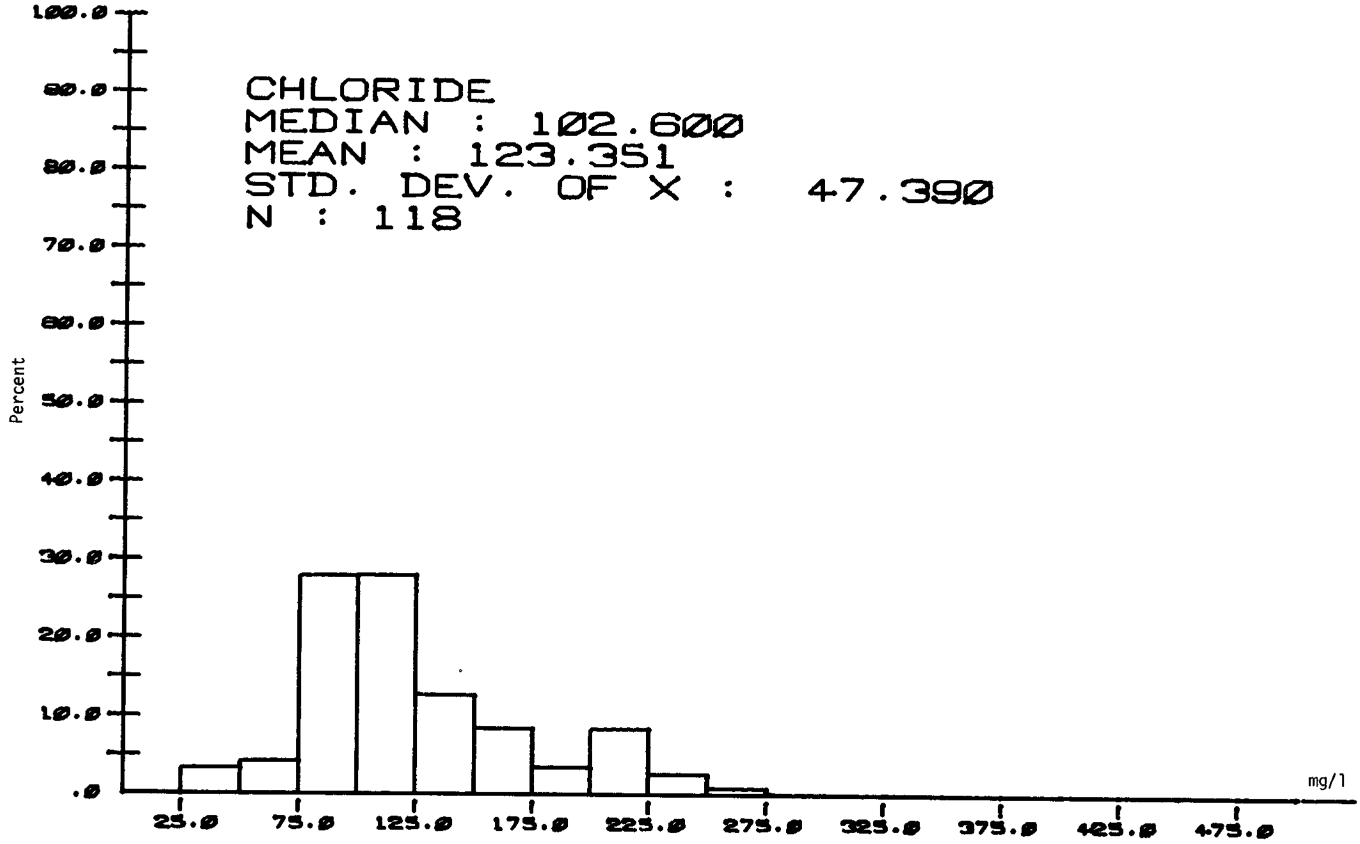

Figure 3.32 Oswego River Histograms for Chloride

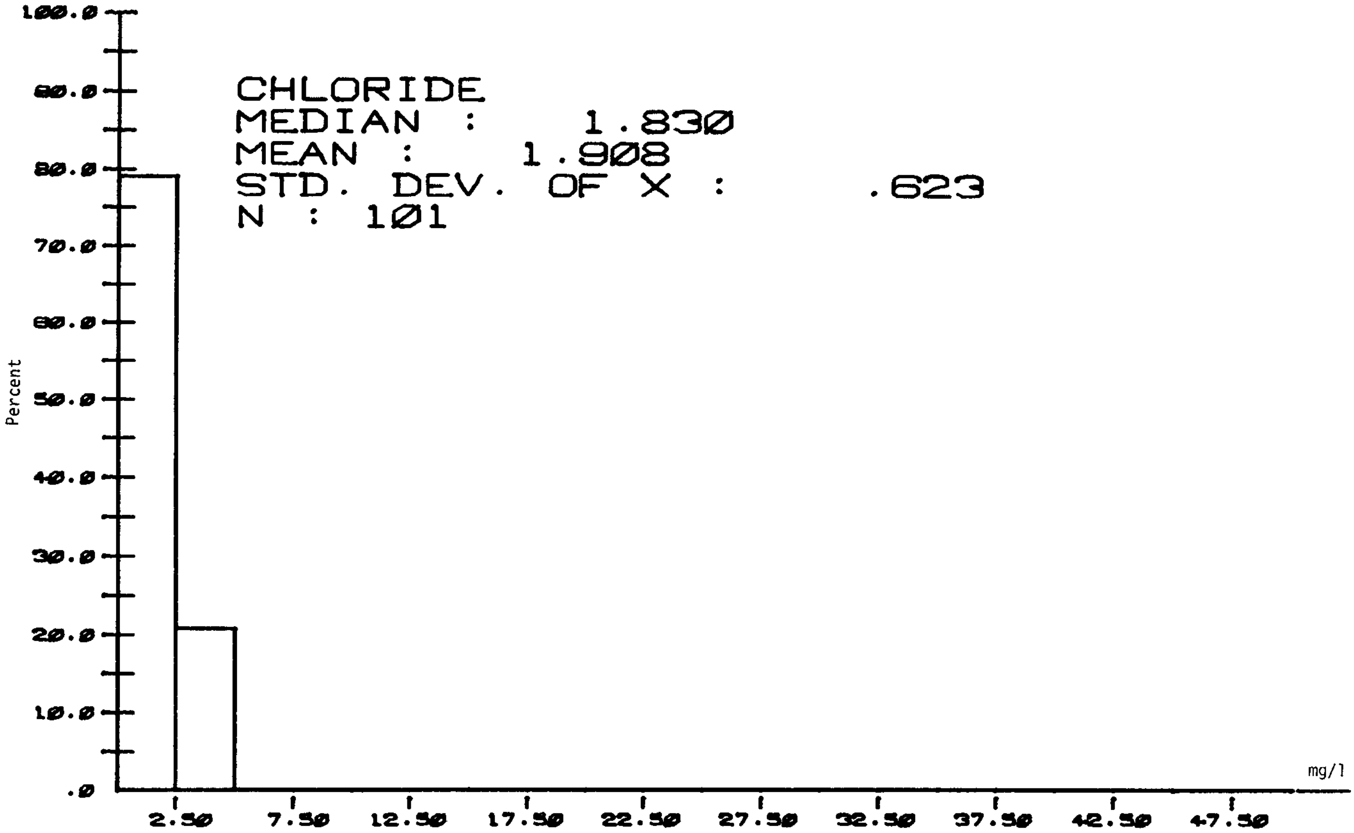

Figure 3.32 Black River Histograms for Chloride

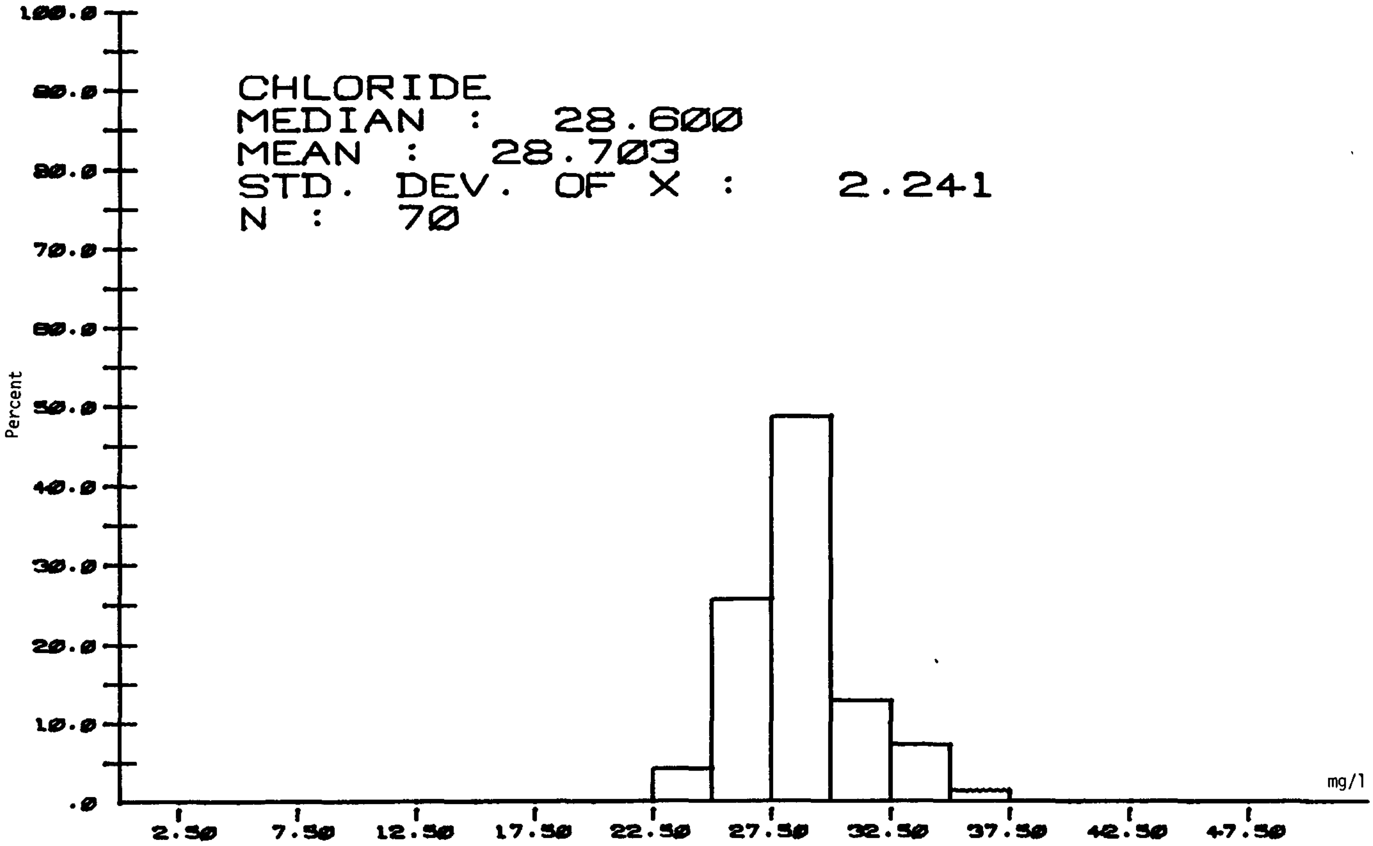

Figure 3.32 St. Lawrence River Histograms for Chloride

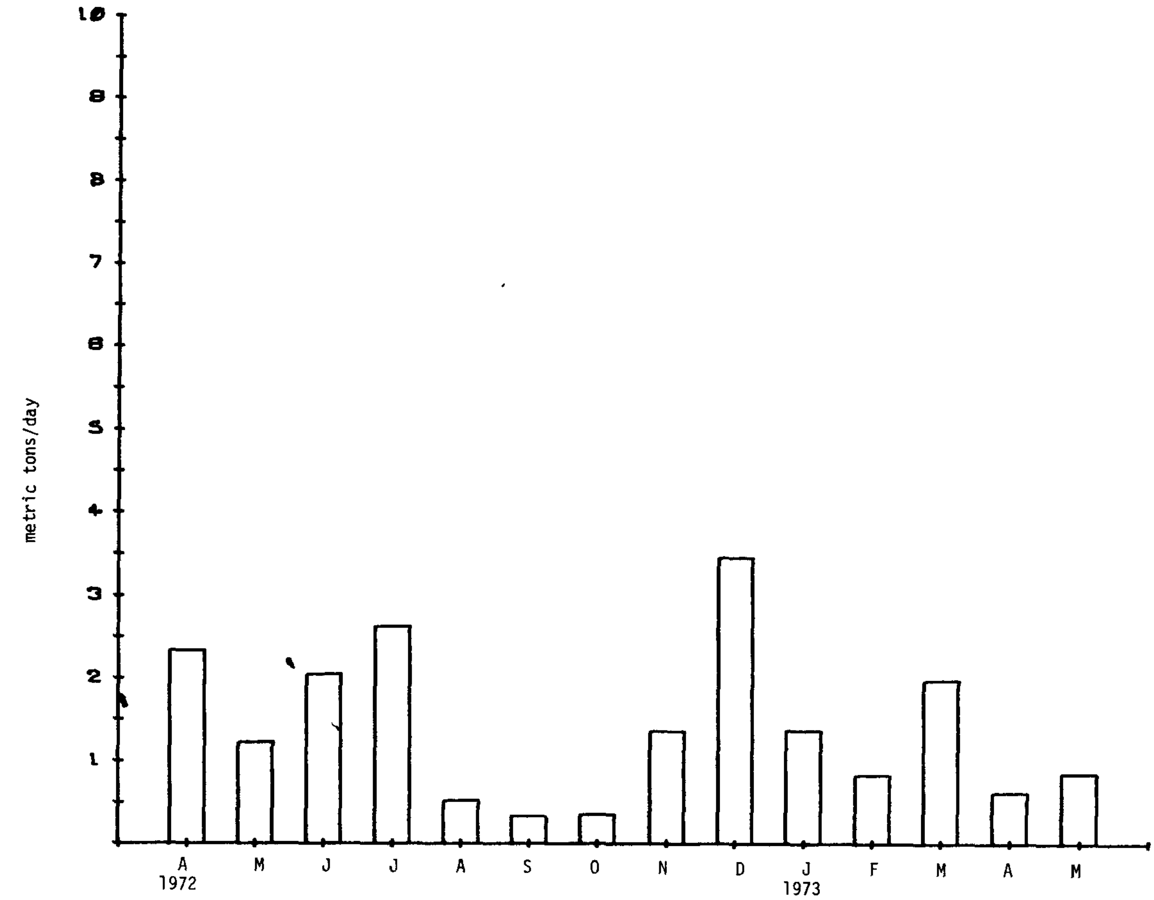

Figure 3.33 Genesee River Monthly Mean Stream Loadings - Fluoride

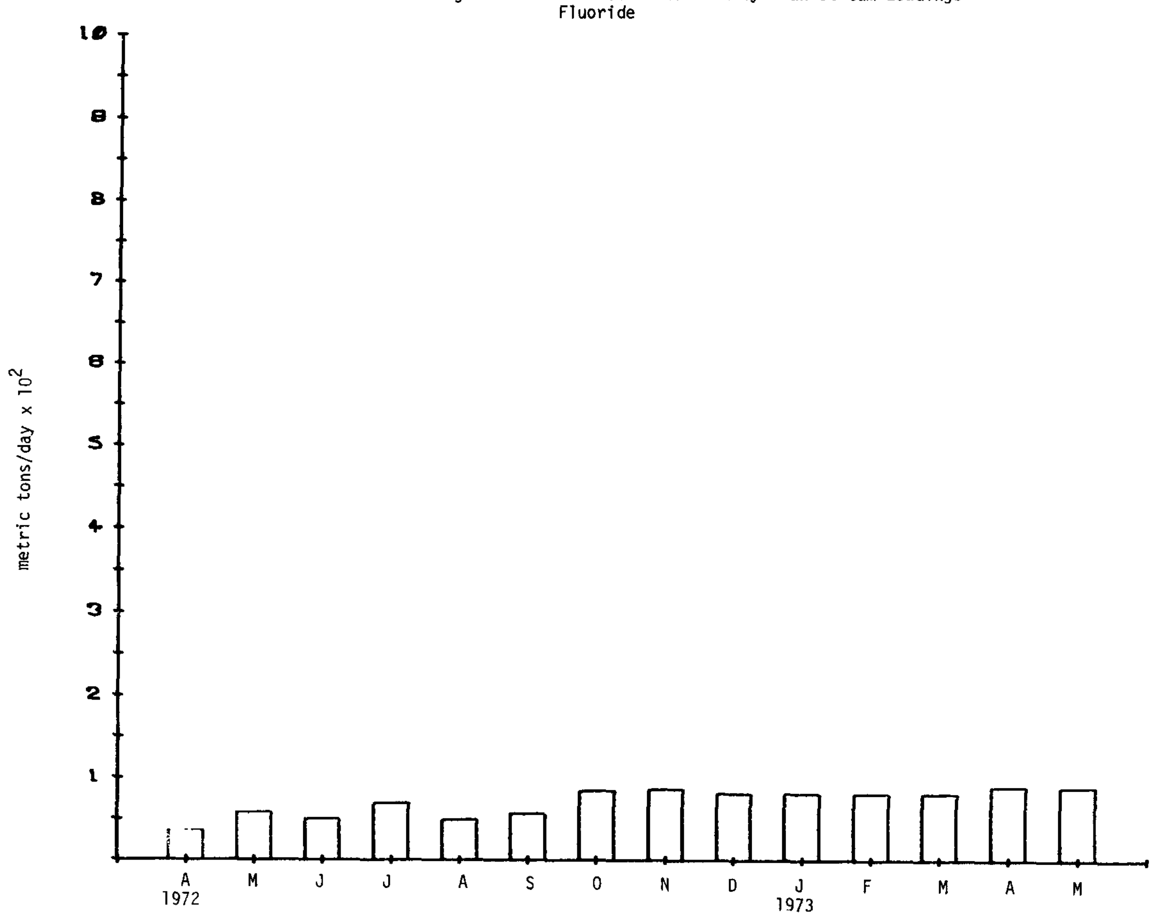

Figure 3.33 Niagara River Monthly Mean Stream Loadings - Fluoride

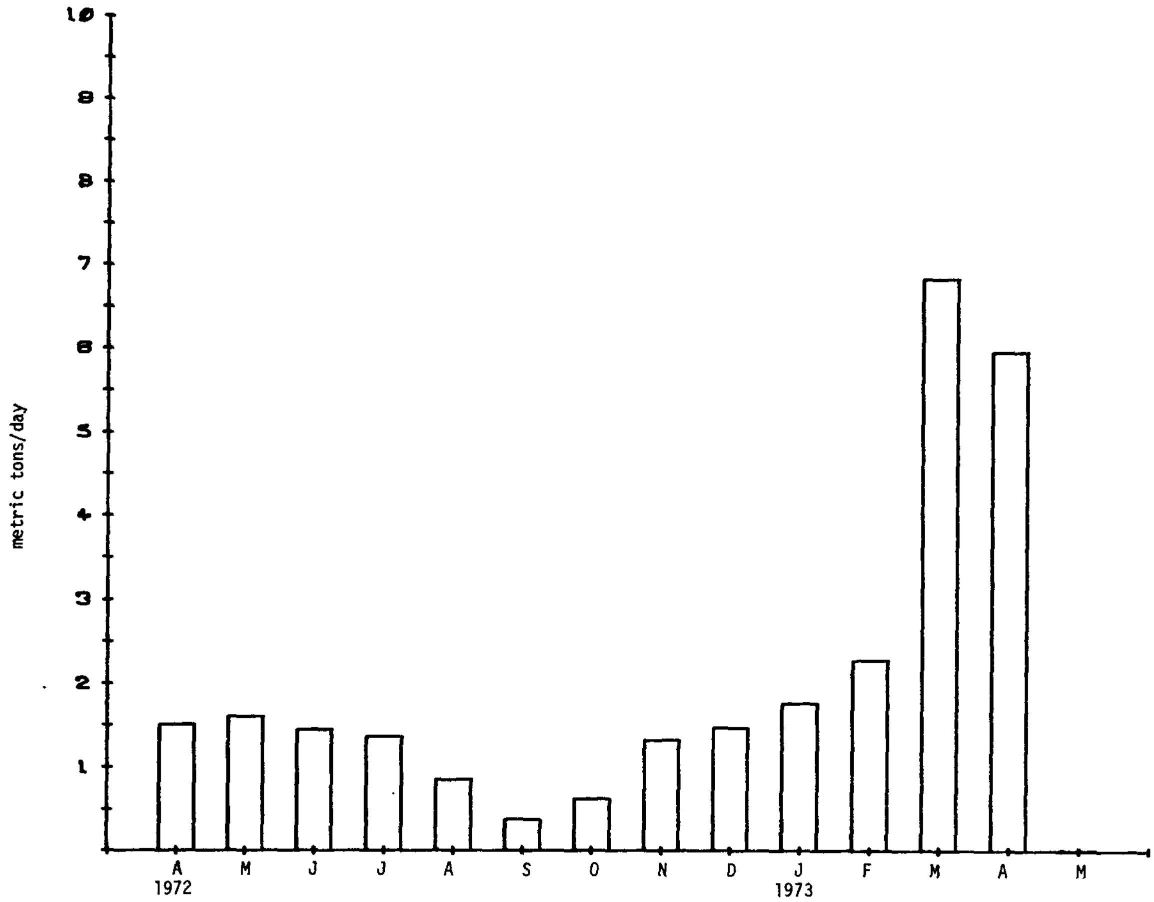

Figure 3.33 Black River Monthly Mean Stream Loadings - Fluoride

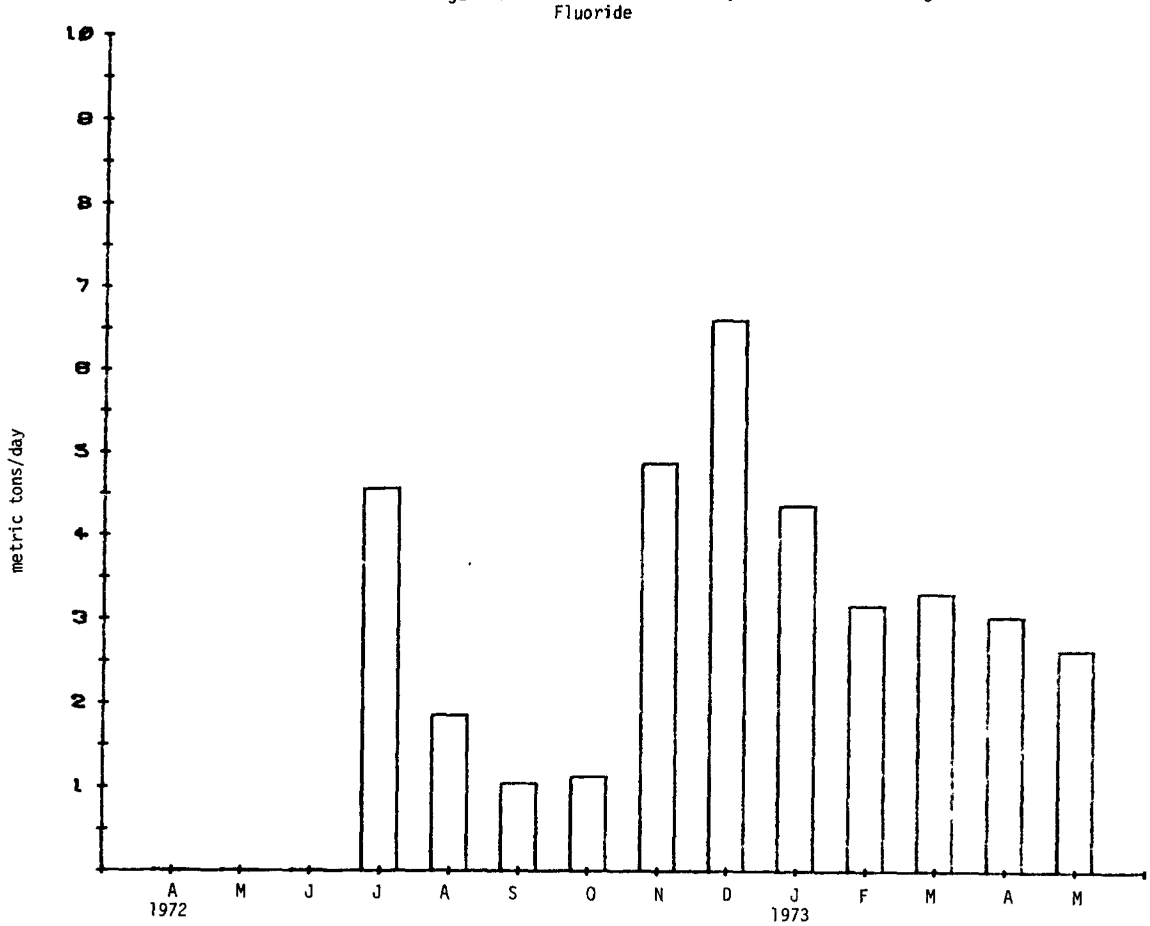

Figure 3.33 Oswego River Monthly Mean Stream Loadings - Fluoride

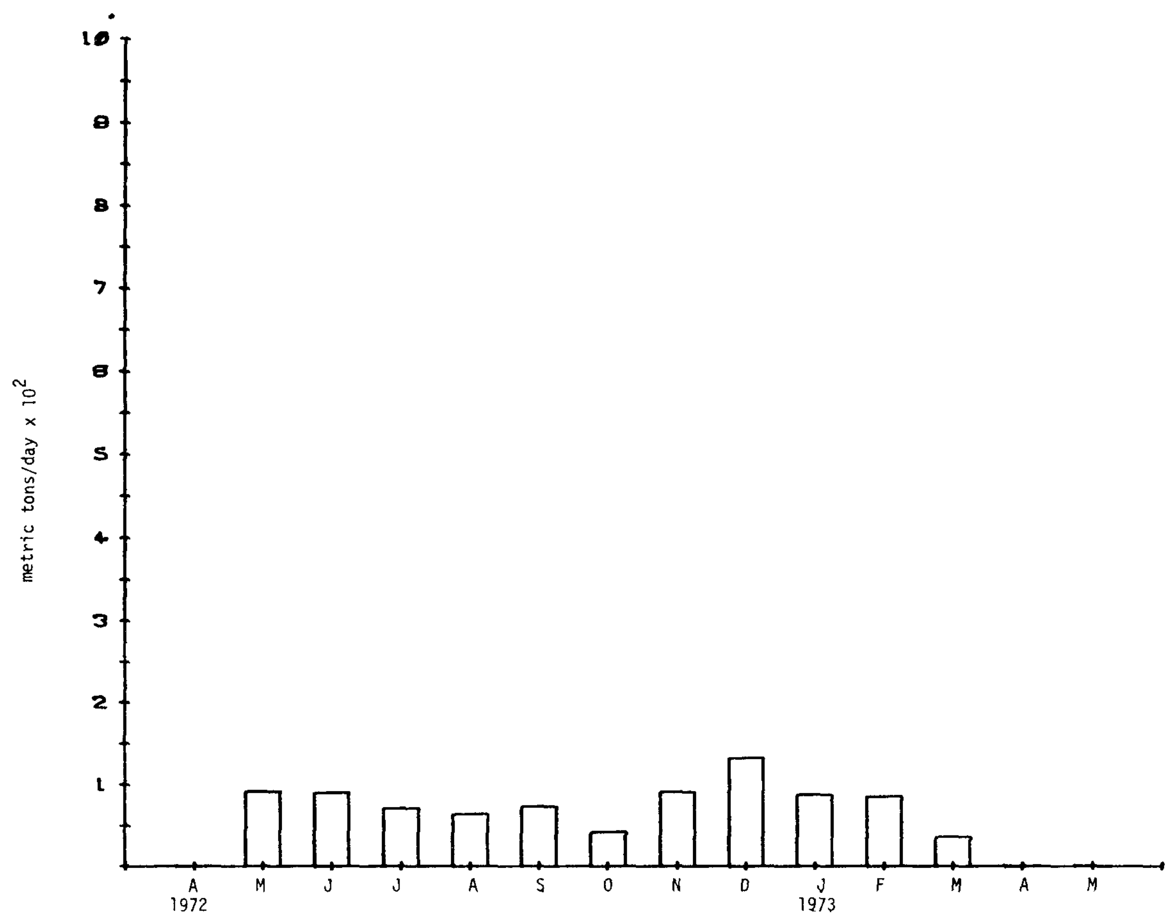

Figure 3.33 St. Lawrence River Monthly Mean Stream Loadings - Fluoride

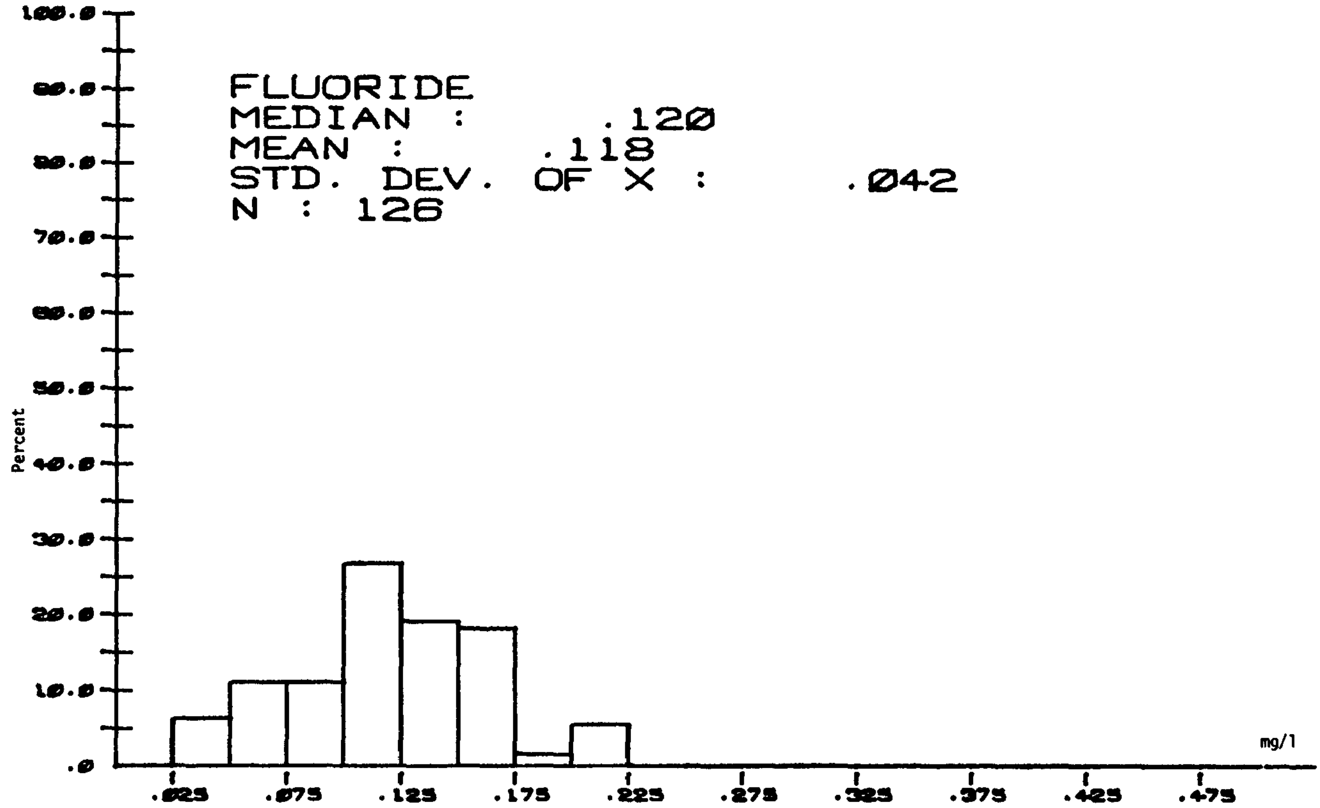

Figure 3.34 Genesee River Histograms for Fluoride

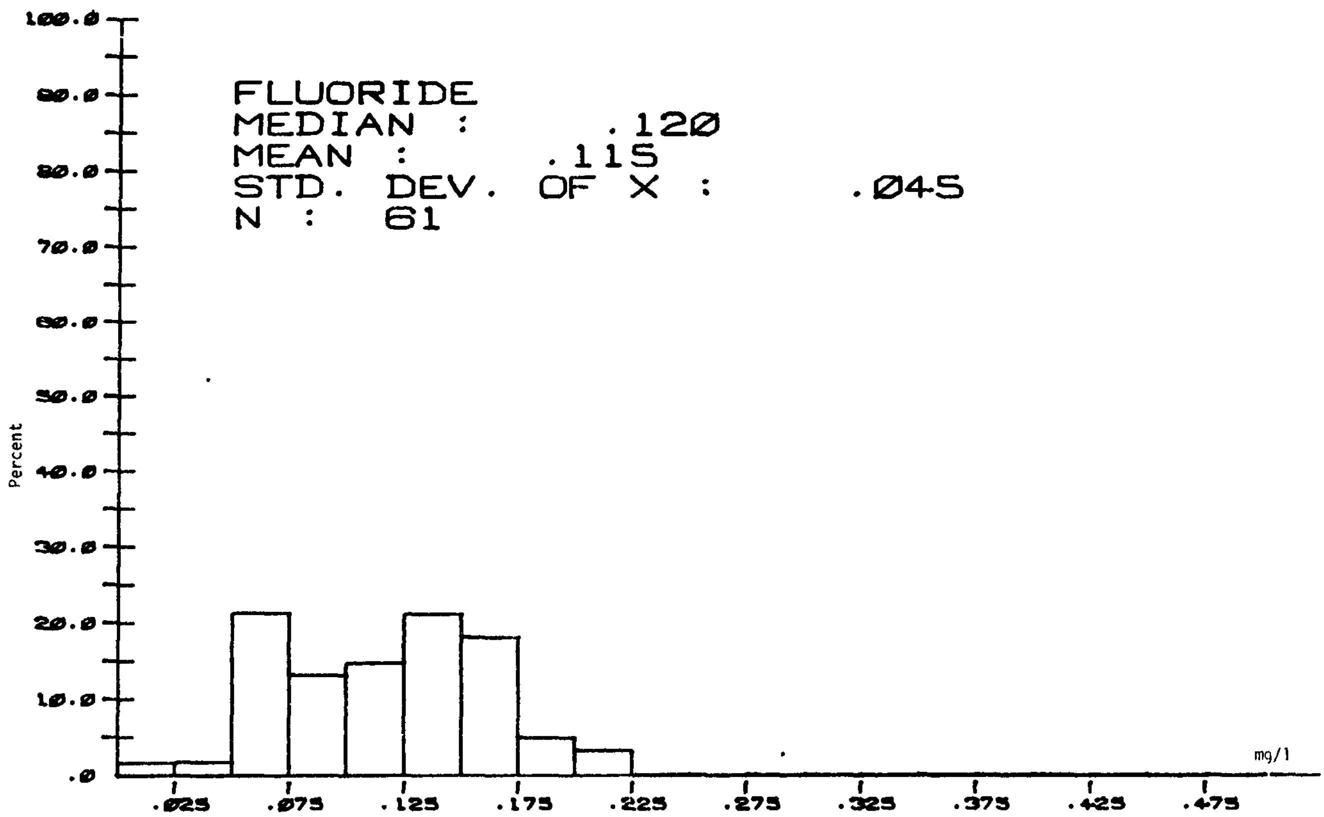

Figure 3.34 Niagara River Histograms for Fluoride

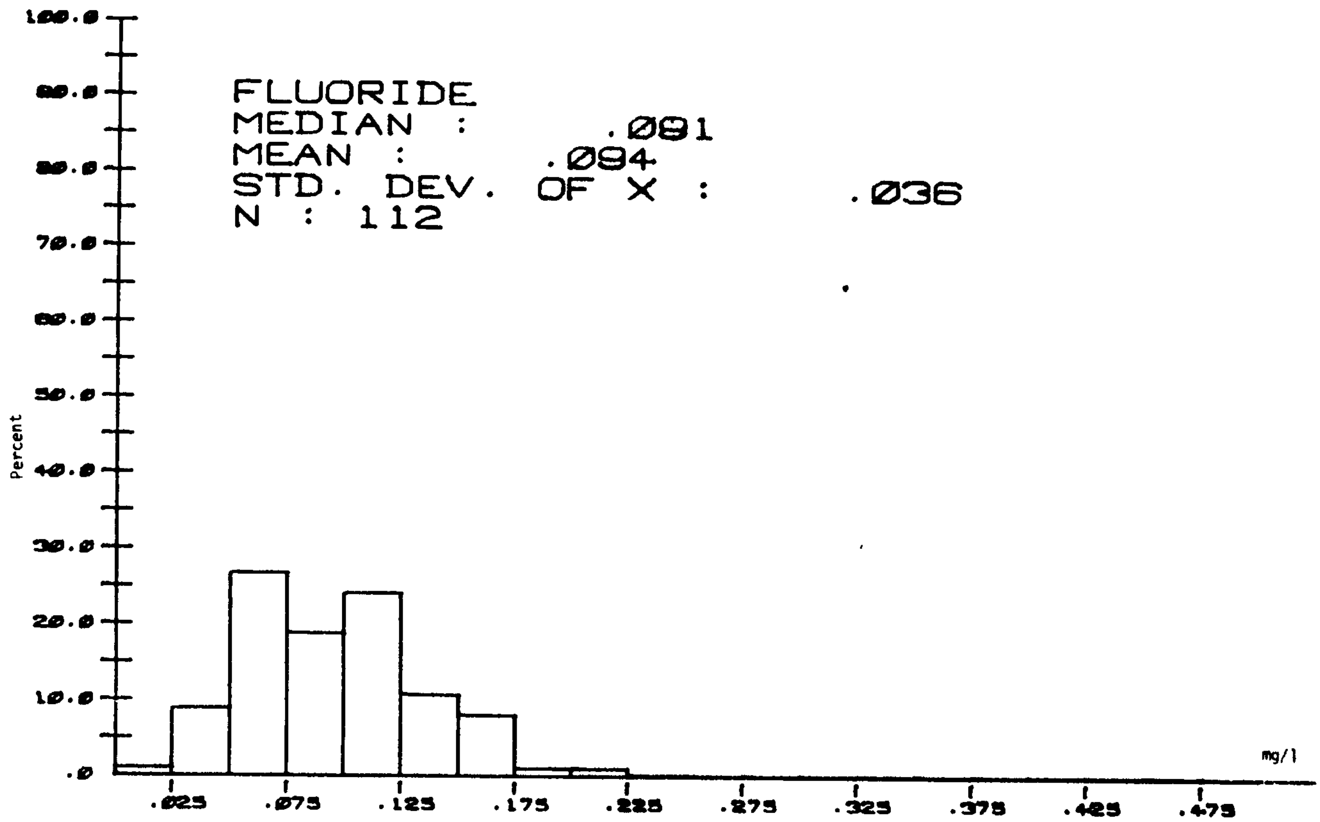

Figure 3.34 Black River Histograms for Fluoride

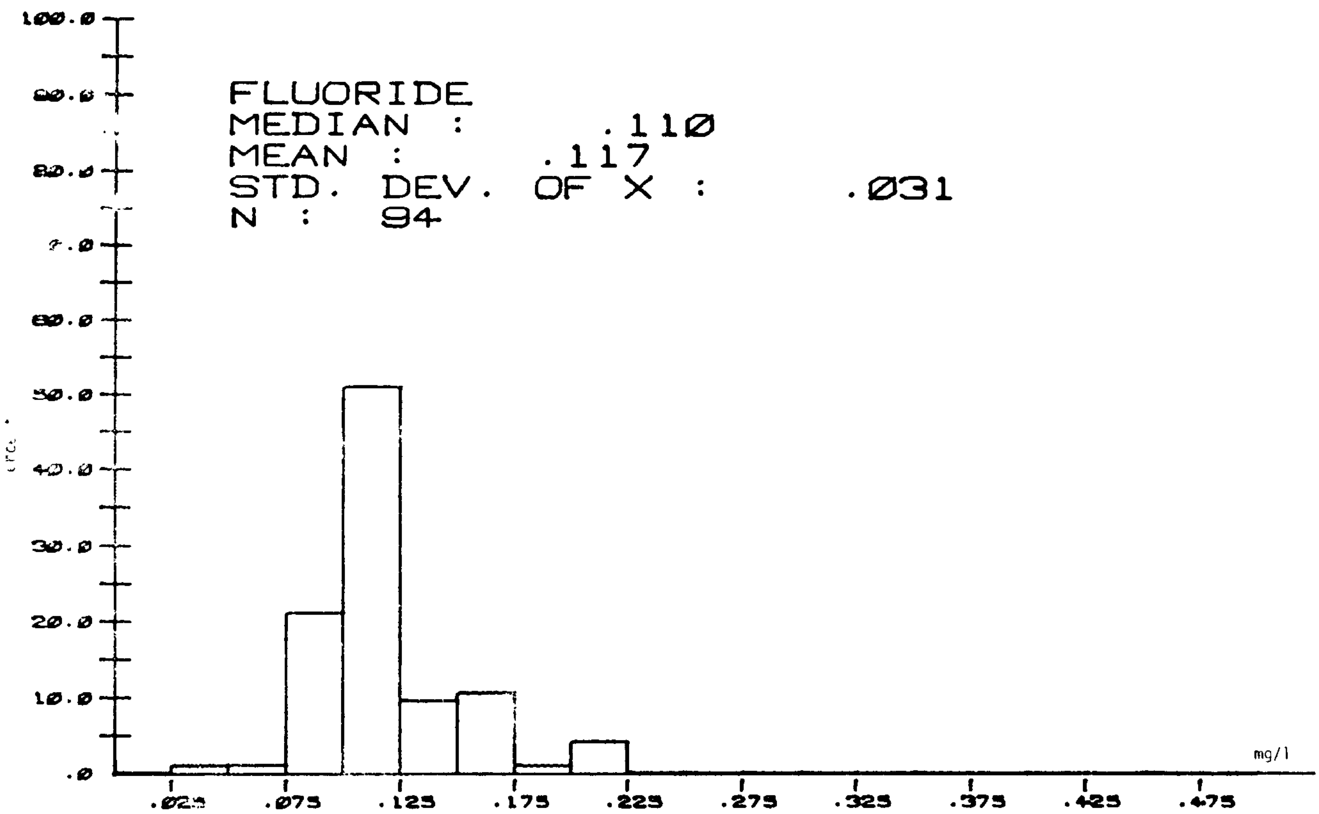

Figure 3 34 Oswego River Histograms for Fluoride

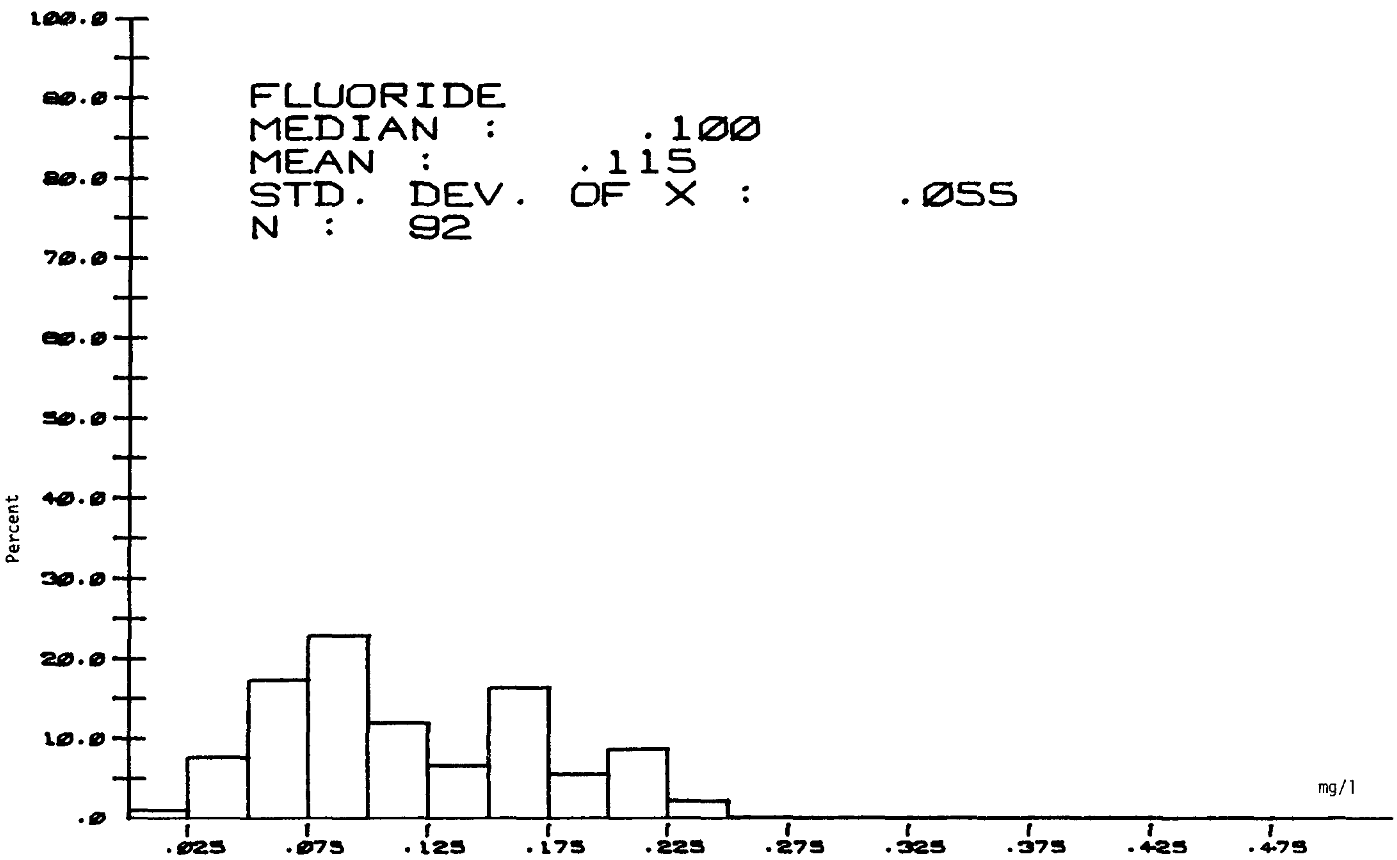

Figure 3.34 St. Lawrence River Histograms for Fluoride

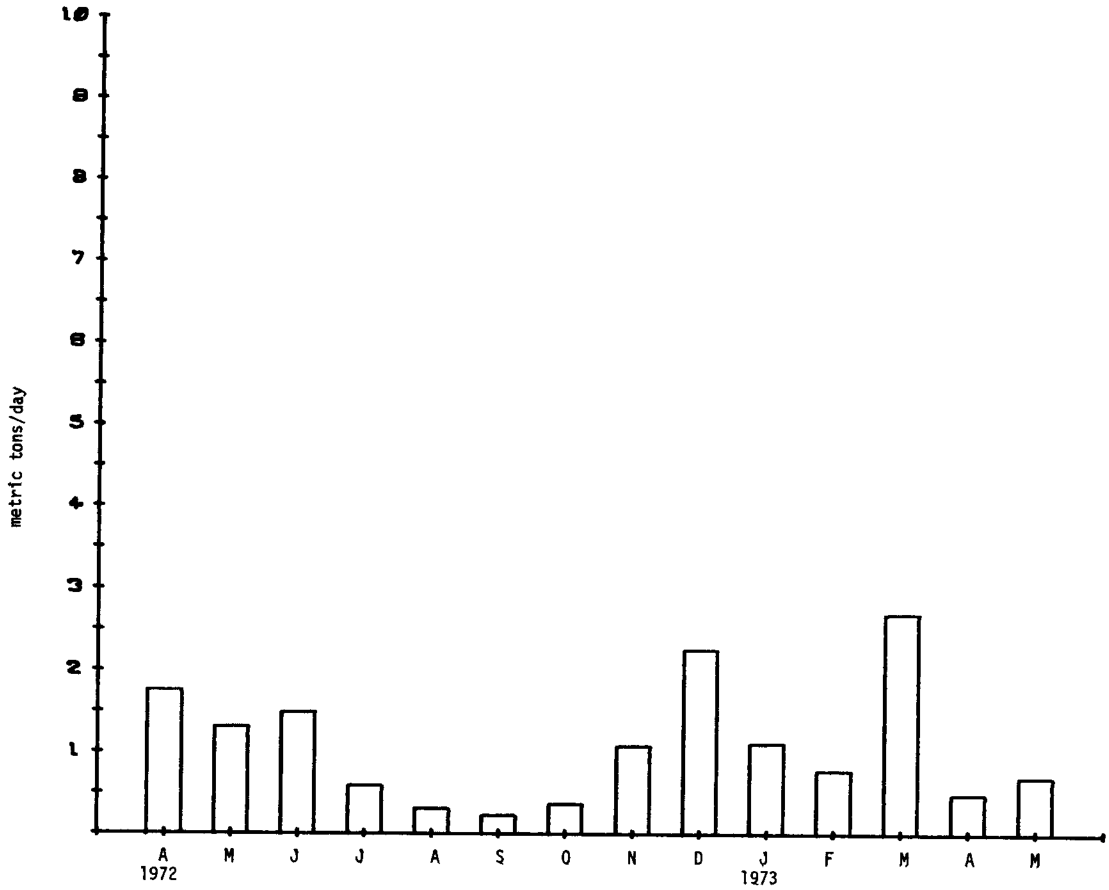

Figure 3.35 Genesee River Monthly Mean Stream Loadings - Manganese

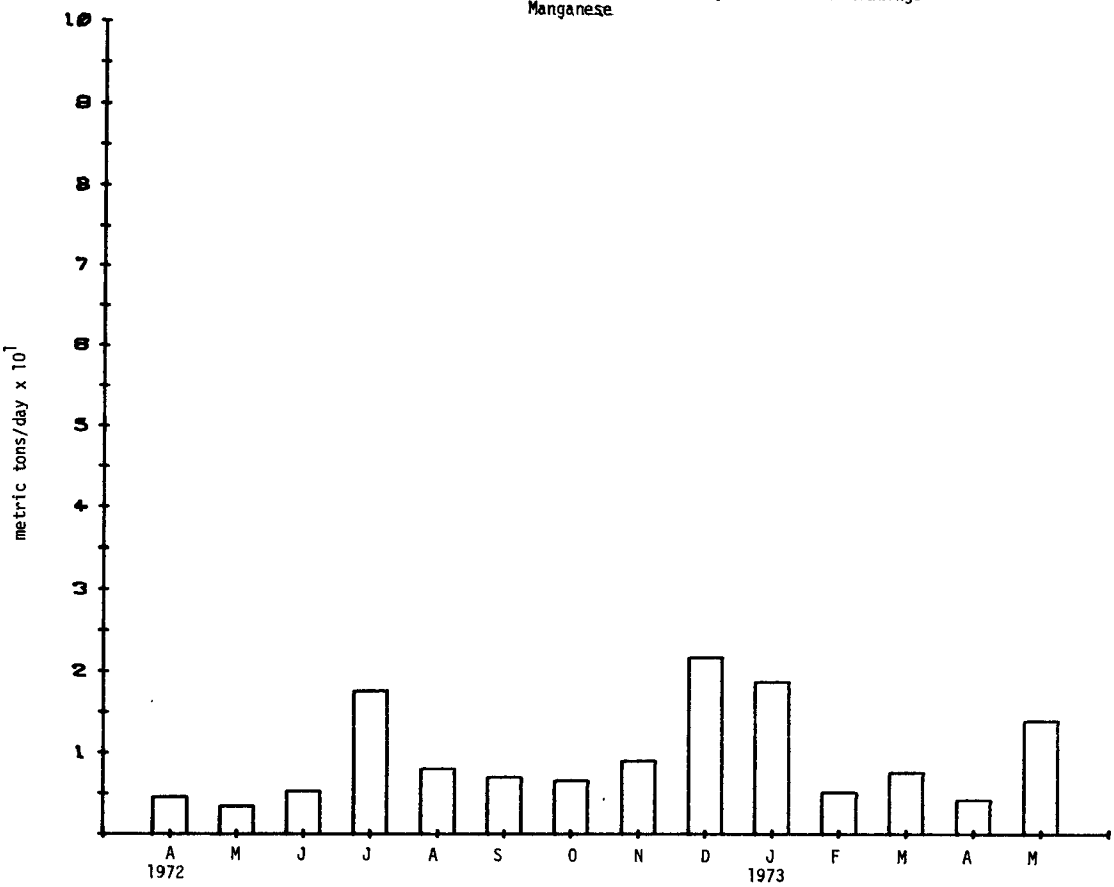

Figure 3.35 Niagara River Monthly Mean Stream Loadings - Manganese

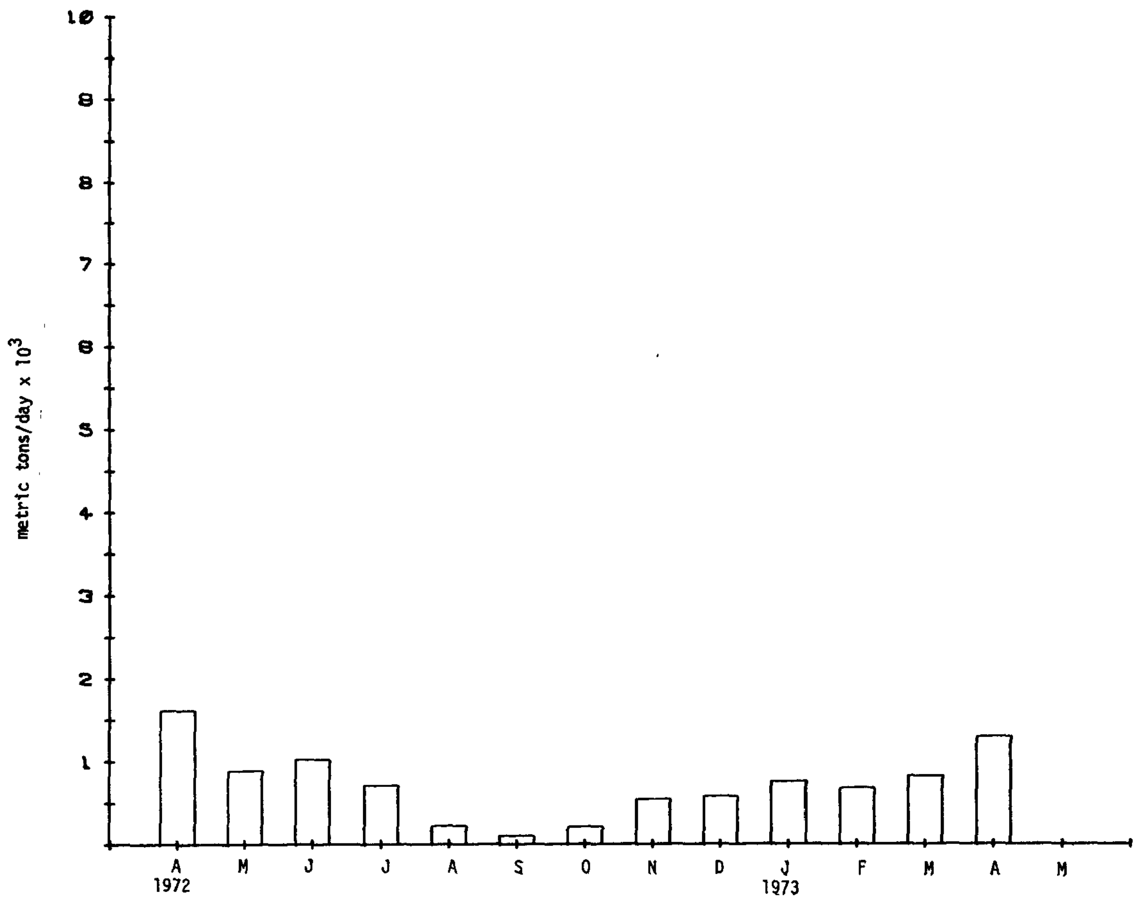

Figure 3.35 Black River Monthly Mean Stream Loadings - Manganese

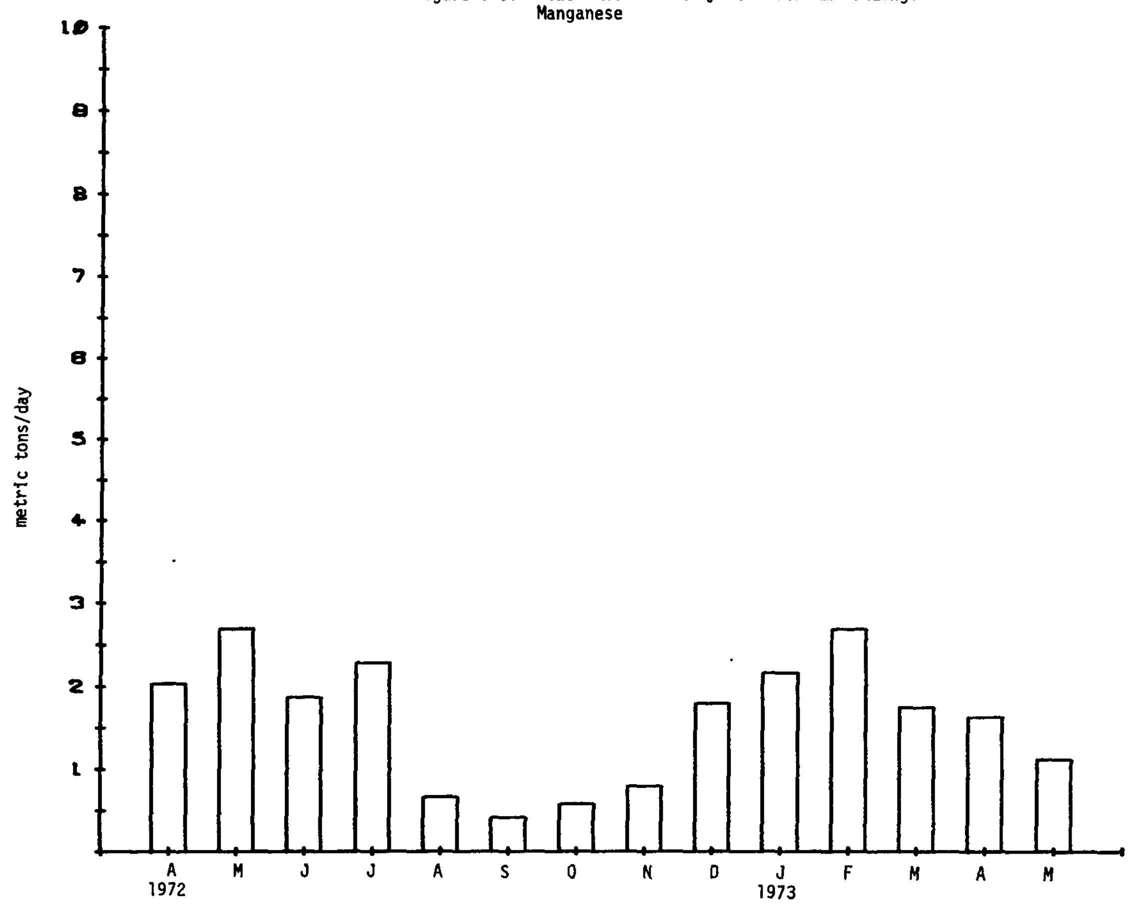

Figure 3.35 Oswego River Monthly Mean Stream Loadings - Manganese

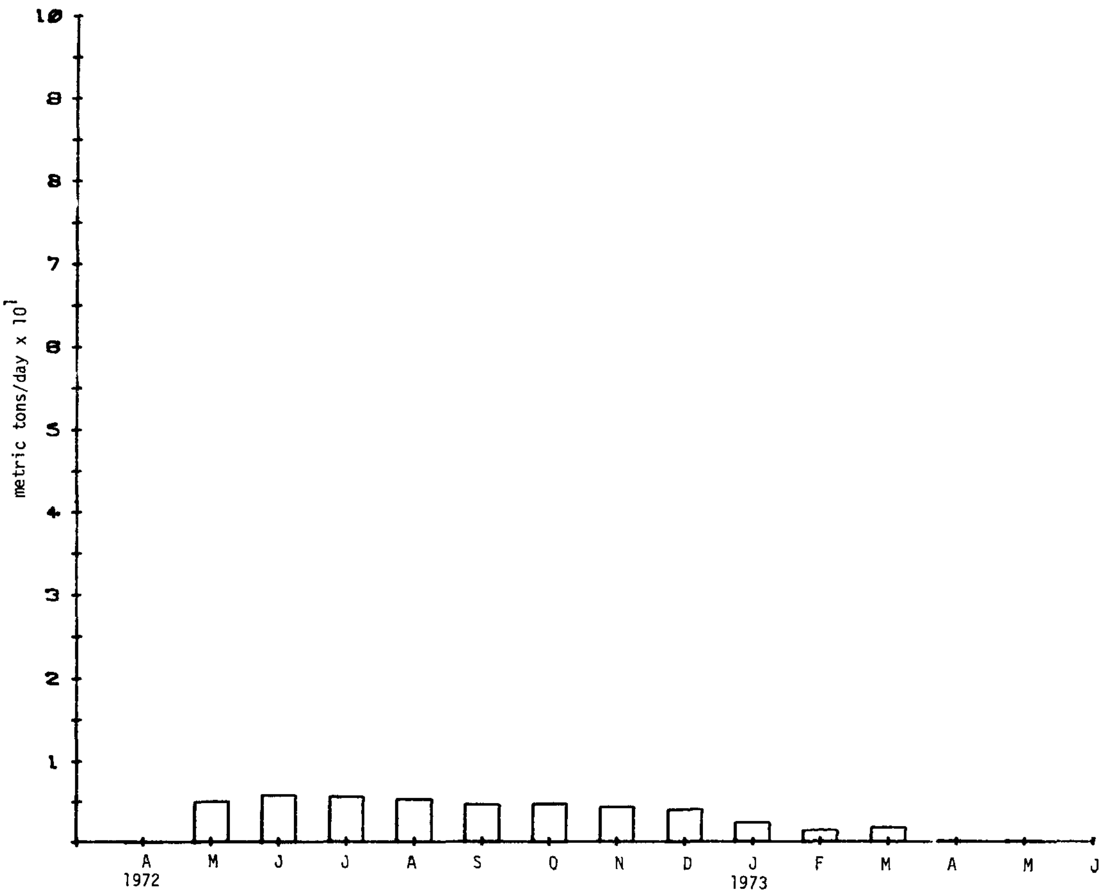

Figure 3.35 St. Lawrence River Monthly Mean Stream Loadings - Manganese

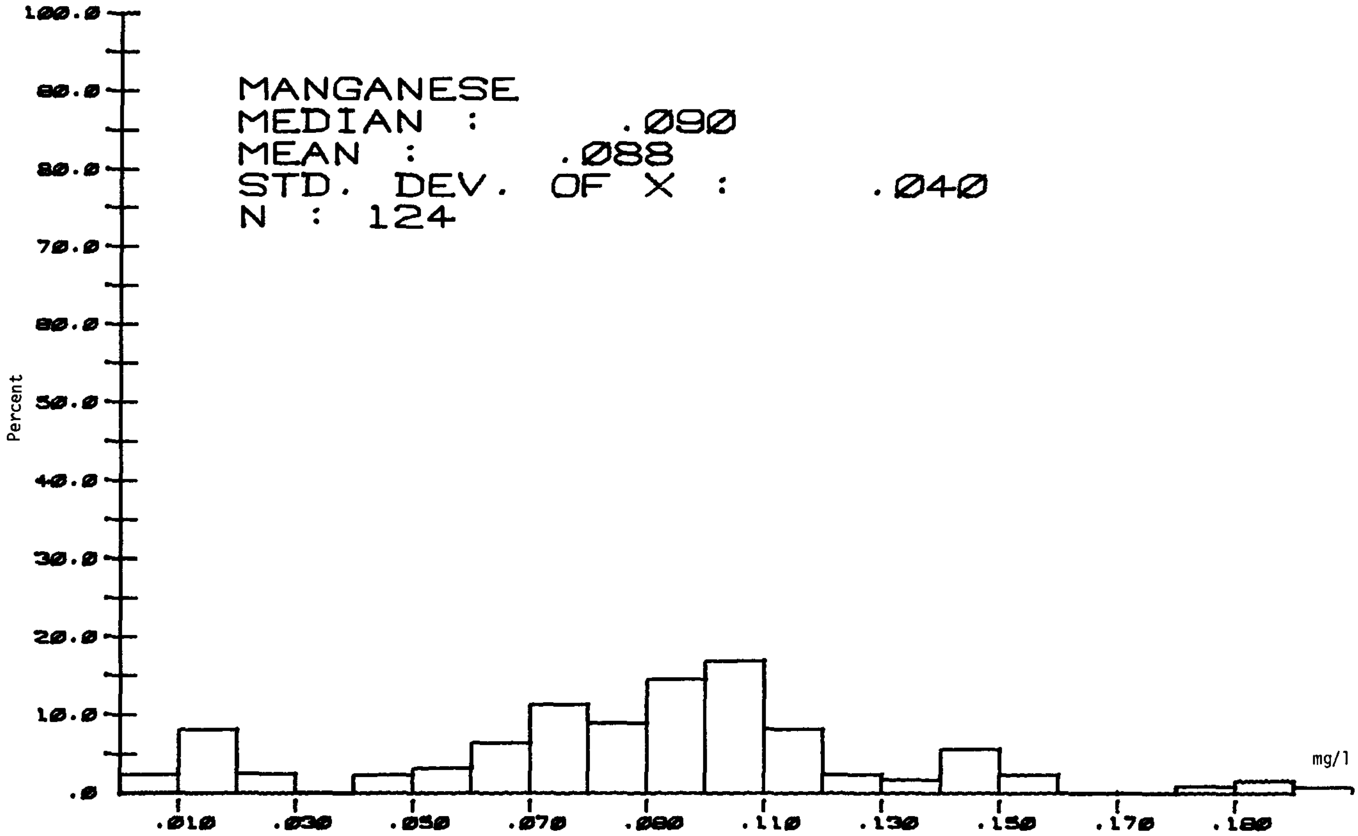

Figure 3.36 Genesee River Histograms for Manganese

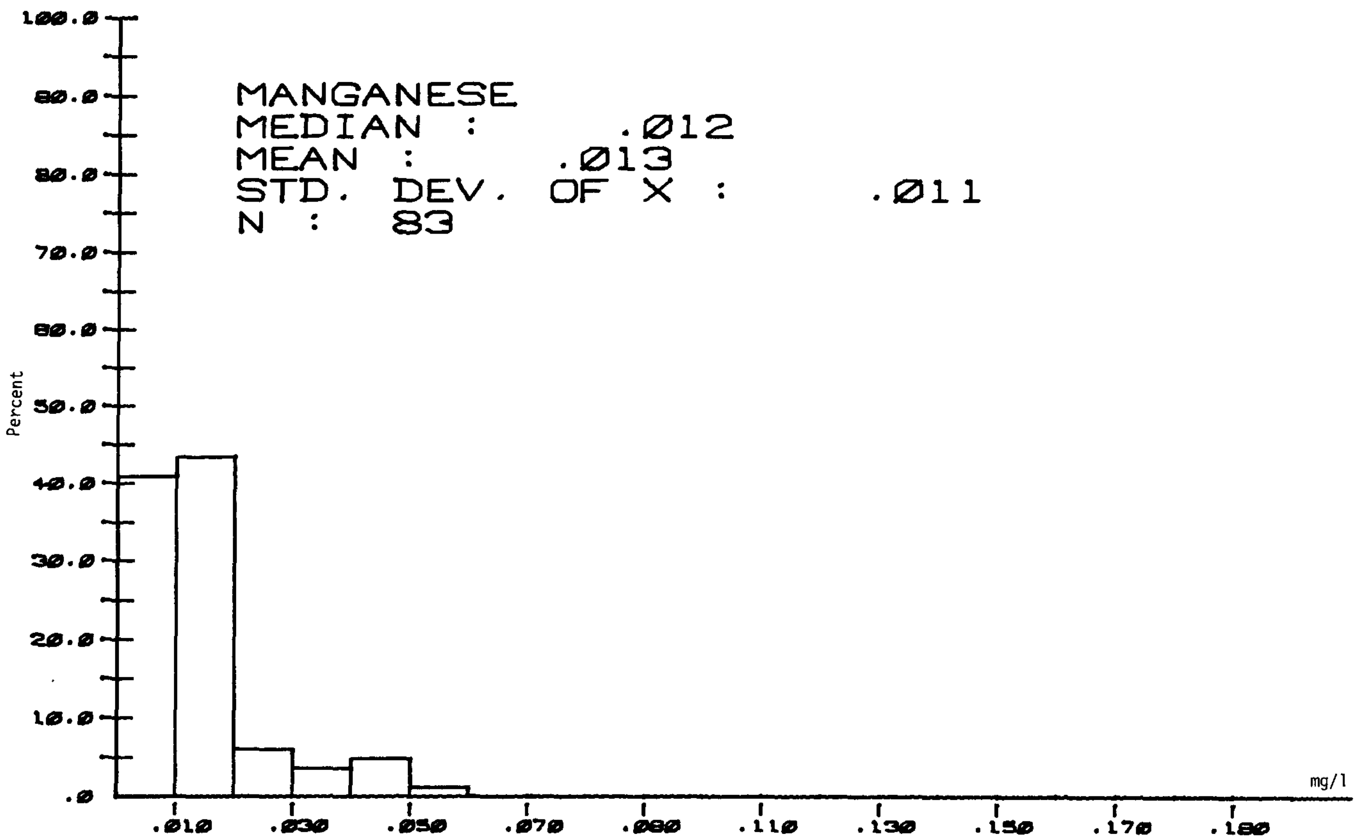

Figure 3.36 Niagara River Histograms for Manganese

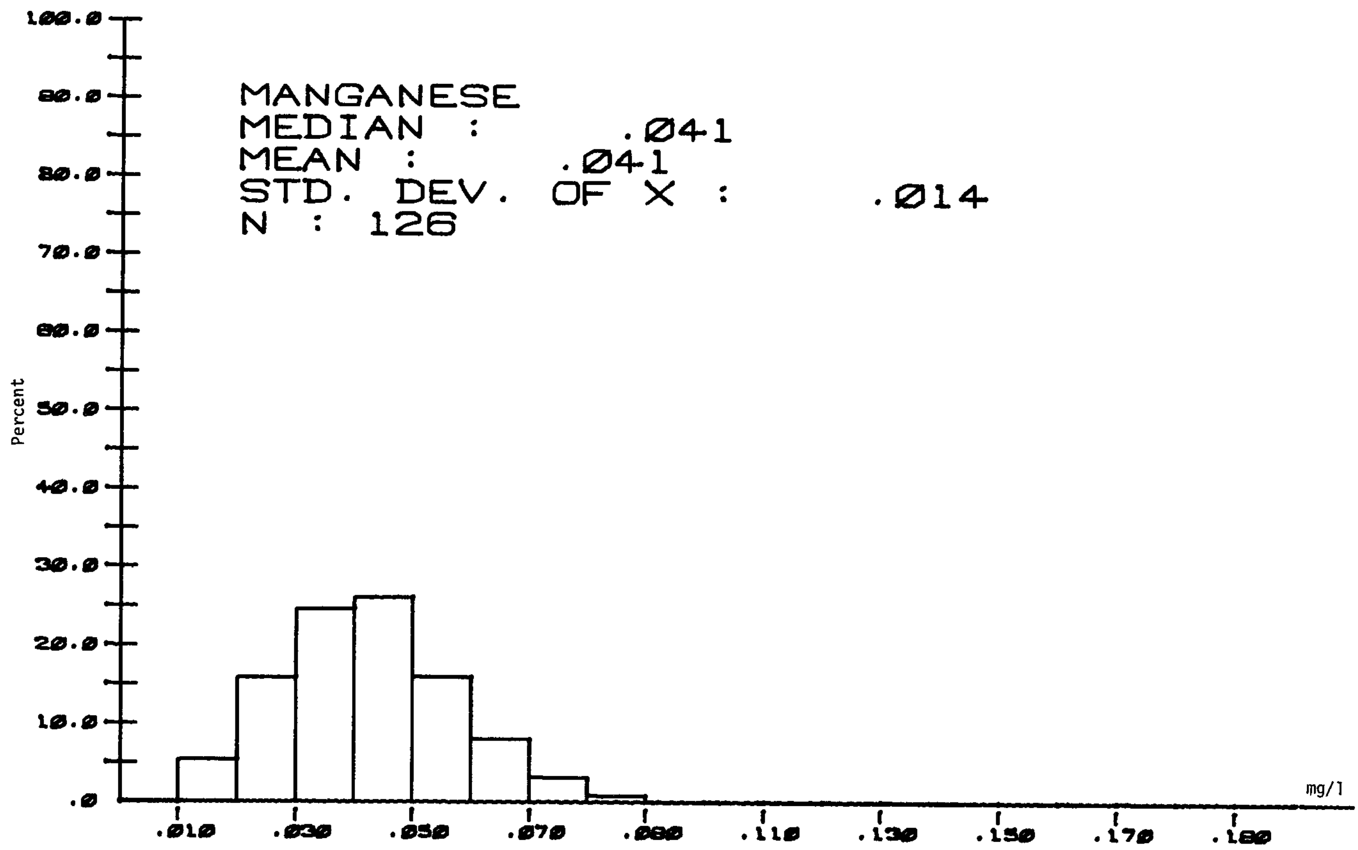

Figure 3.36 Black River Histograms for Manganese

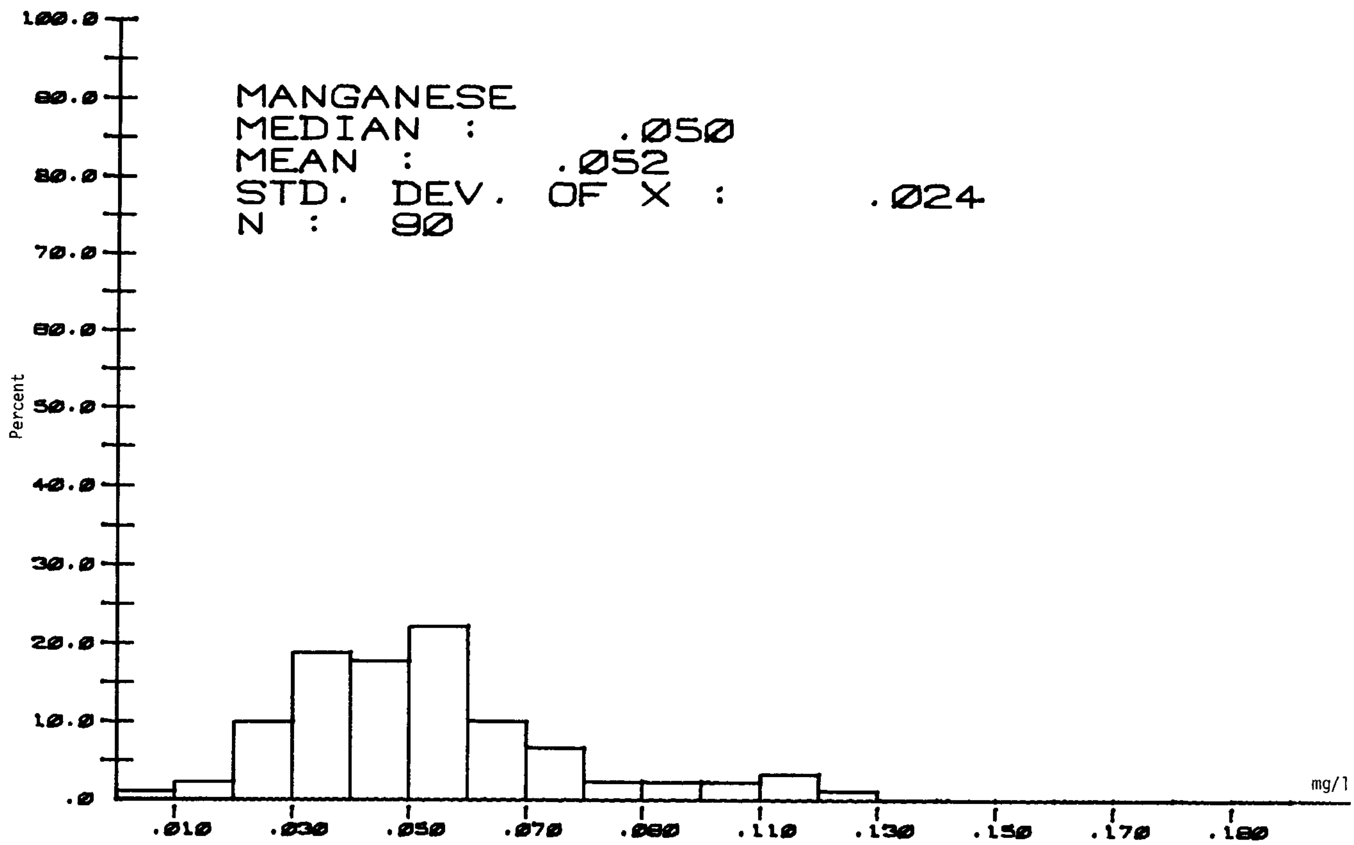

Figure 3.36 Oswego River Histograms for Manganese

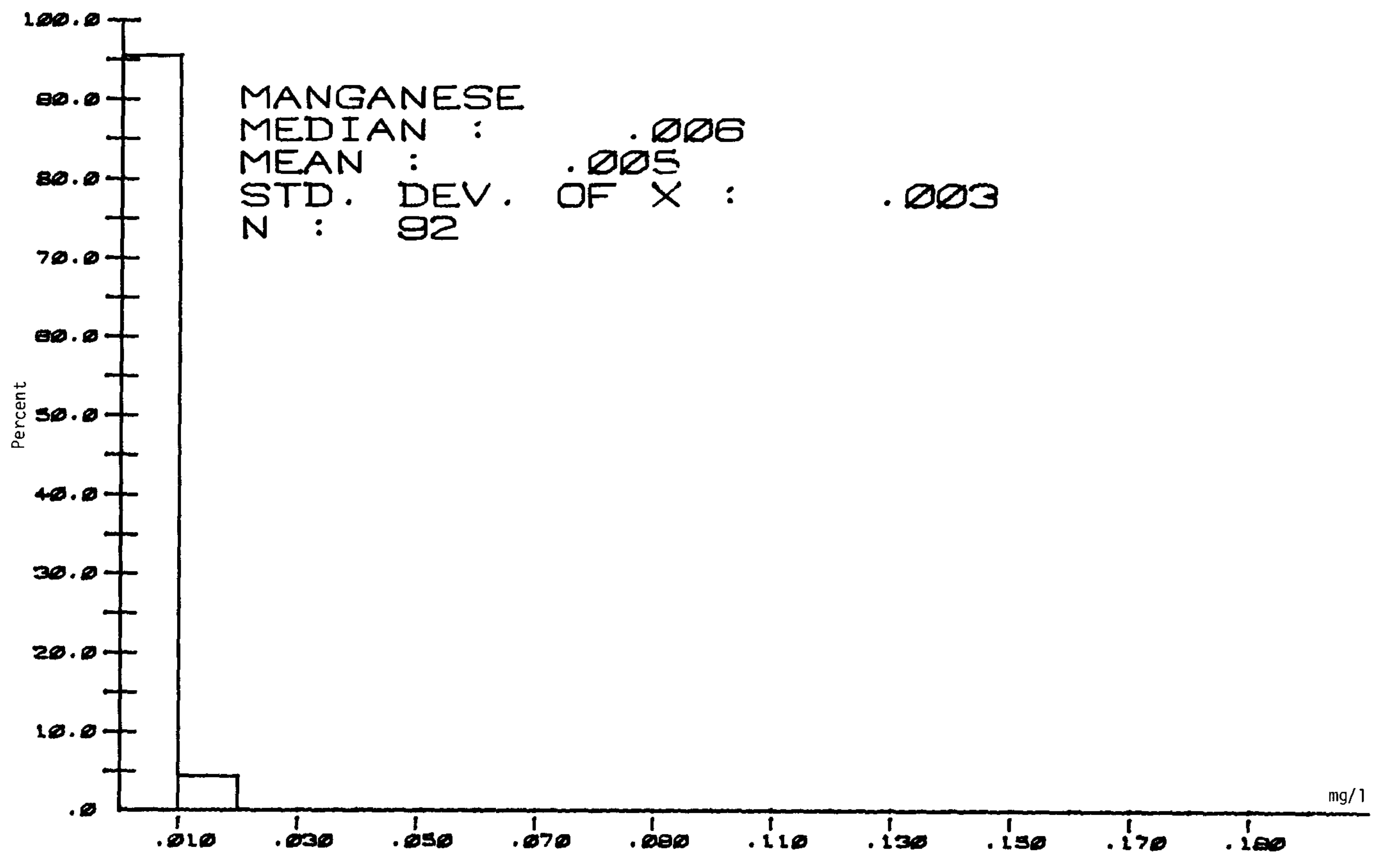

Figure 3.36 St. Lawrence River Histograms for Manganese

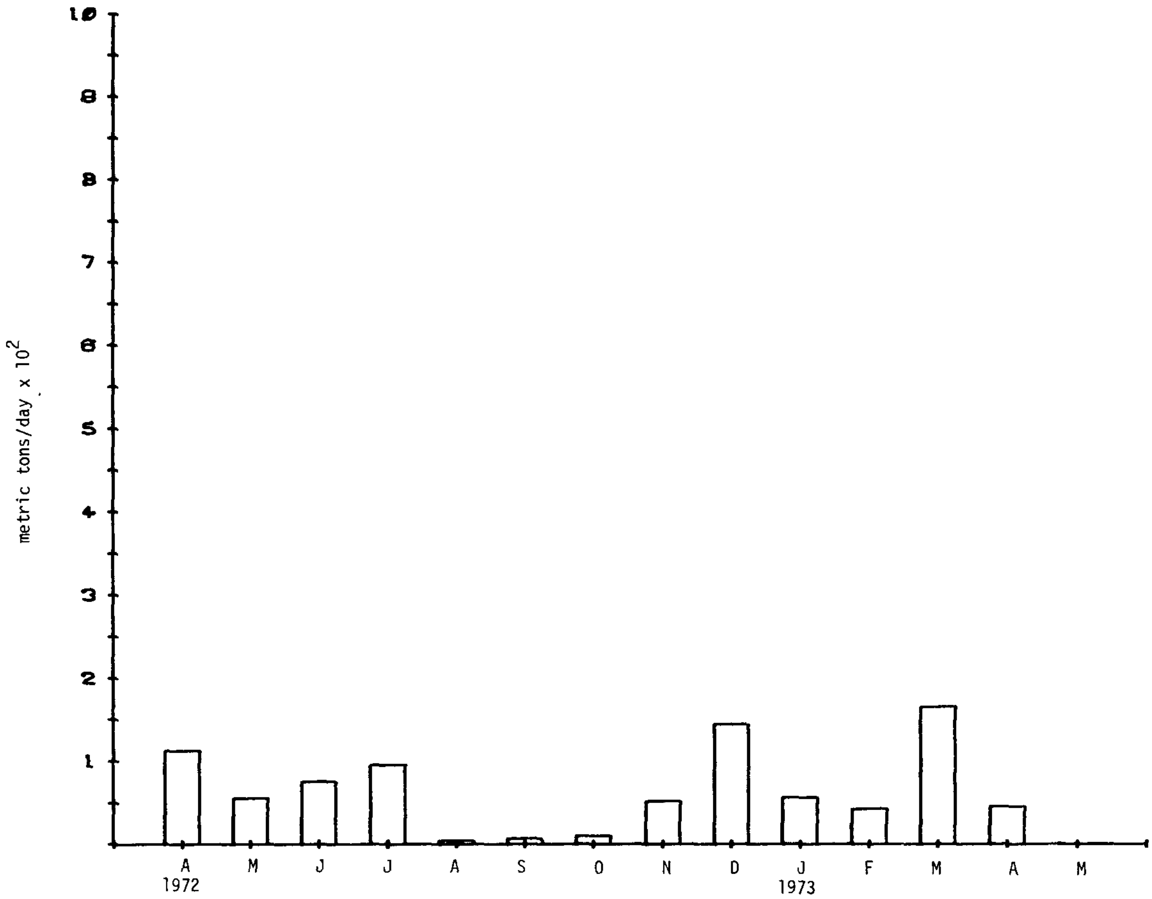

Figure 3.37 Genesee River Monthly Mean Stream Loadings - Iron

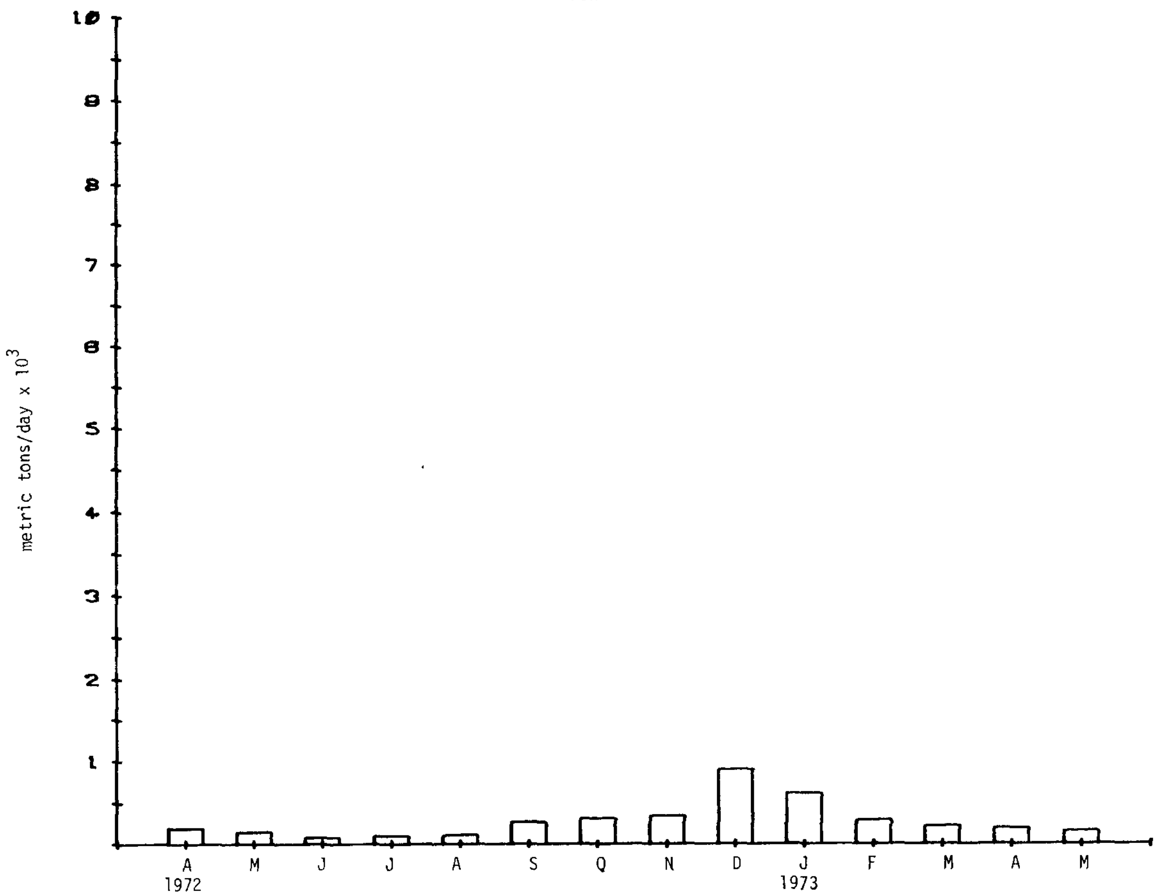

Figure 3.37 Niagara River Monthly Mean Stream Loadings - Iron

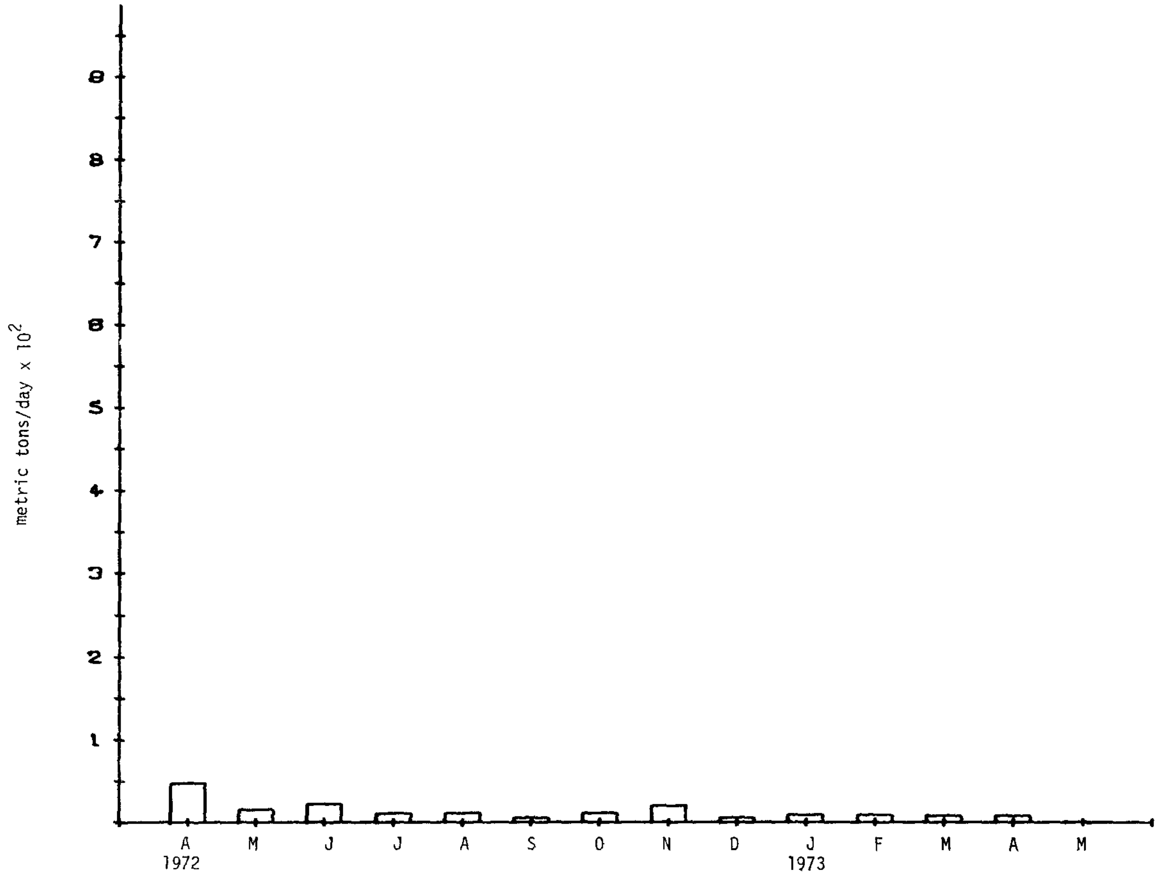

Figure 3.37 Black River Monthly Mean Stream Loadings - Iron

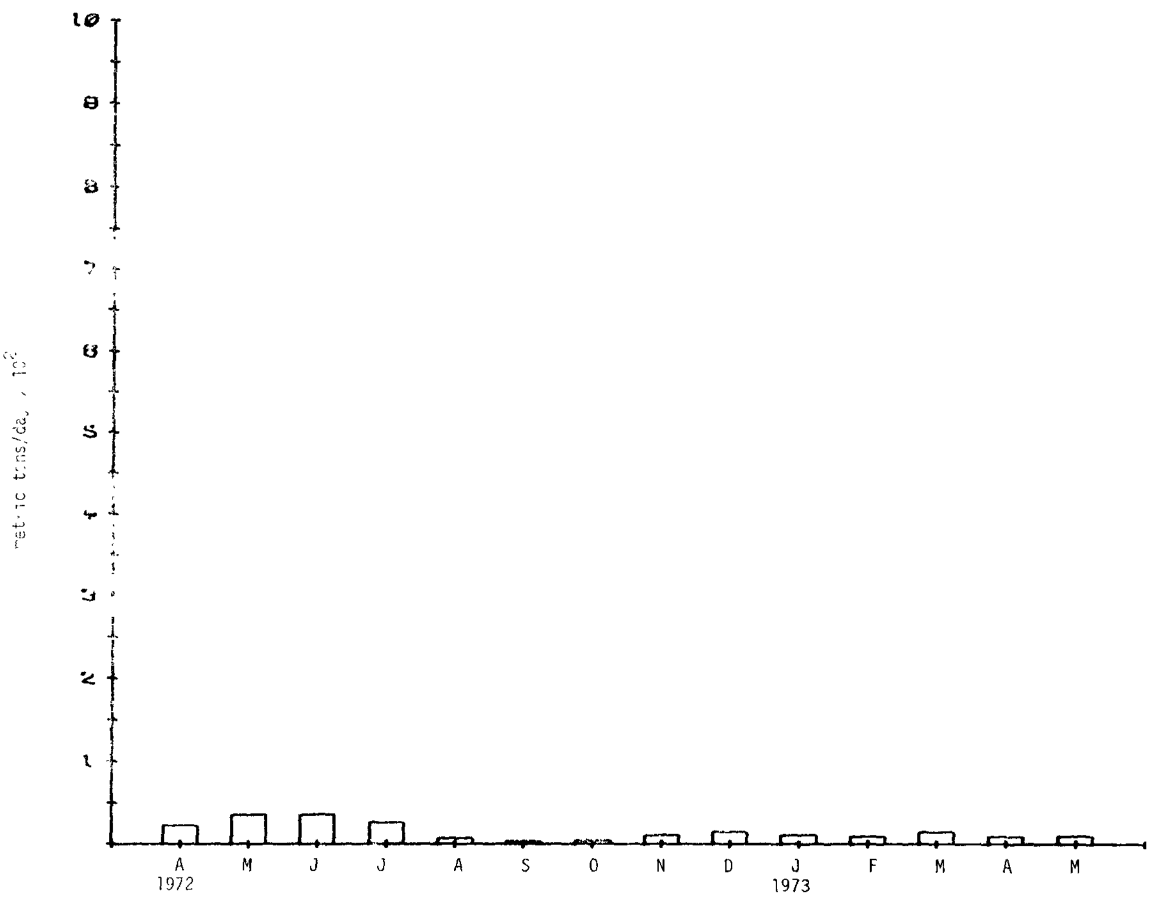

Figure 3.37 Oswego River Monthly Mean Stream Loadings - Iron

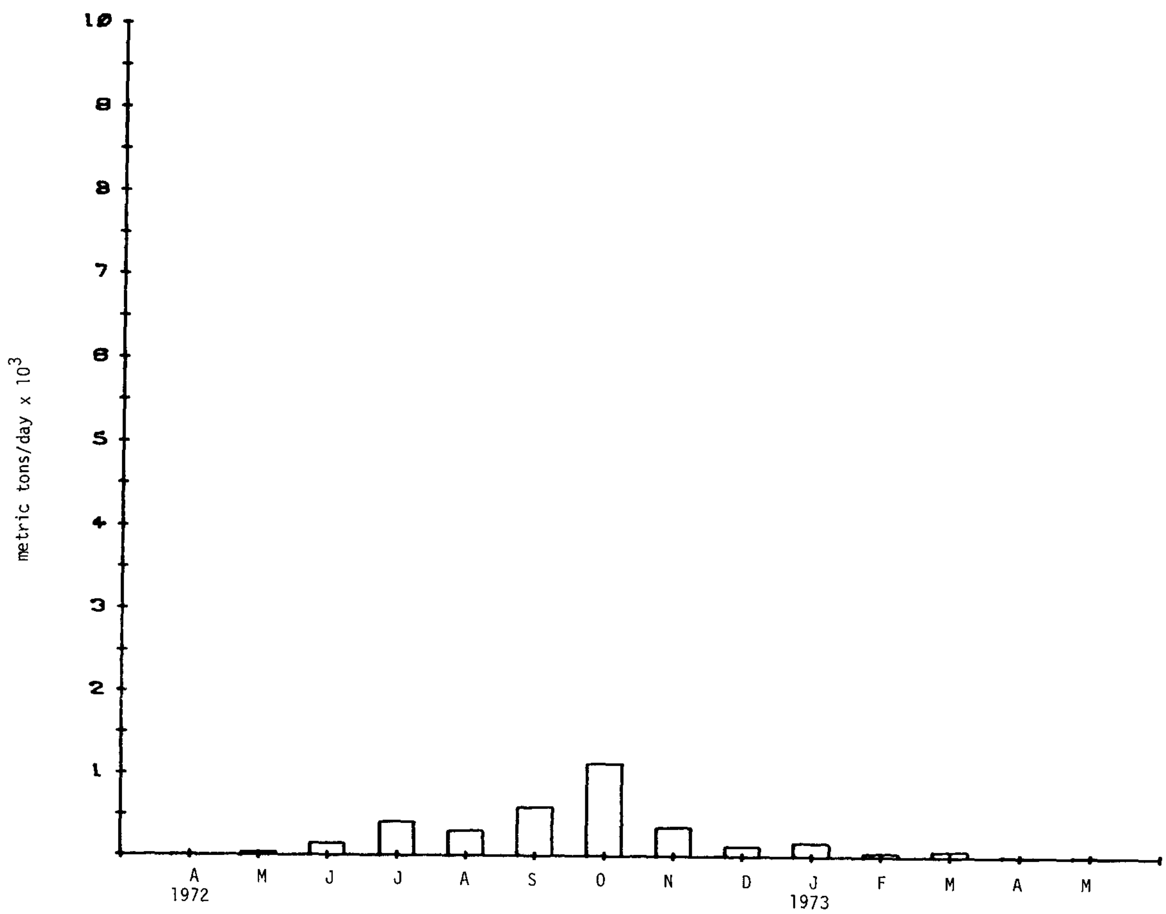

Figure 3.37 St. Lawrence River Monthly Mean Stream Loadings - Iron

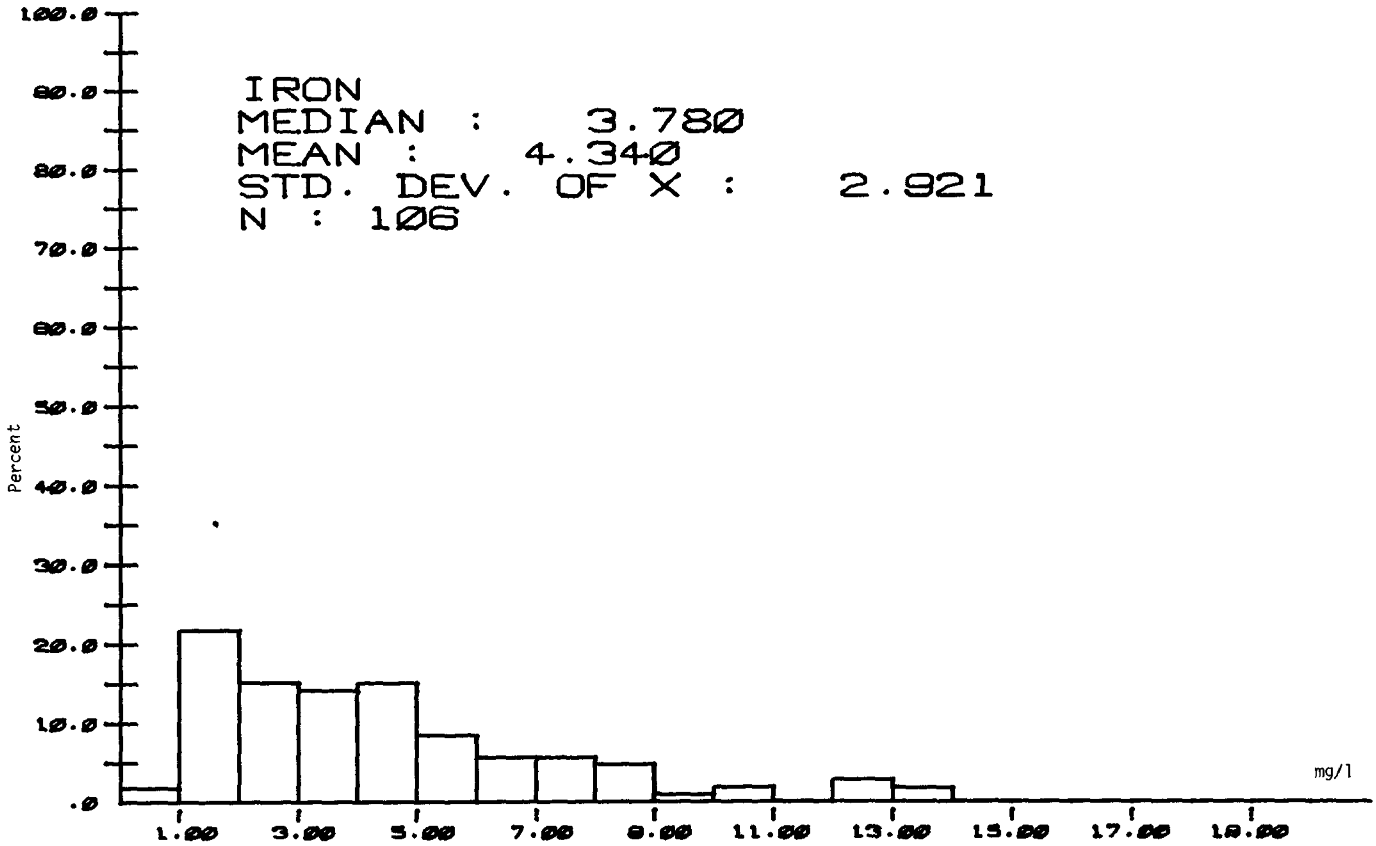

Figure 3.38 Genesee River Histograms for Iron

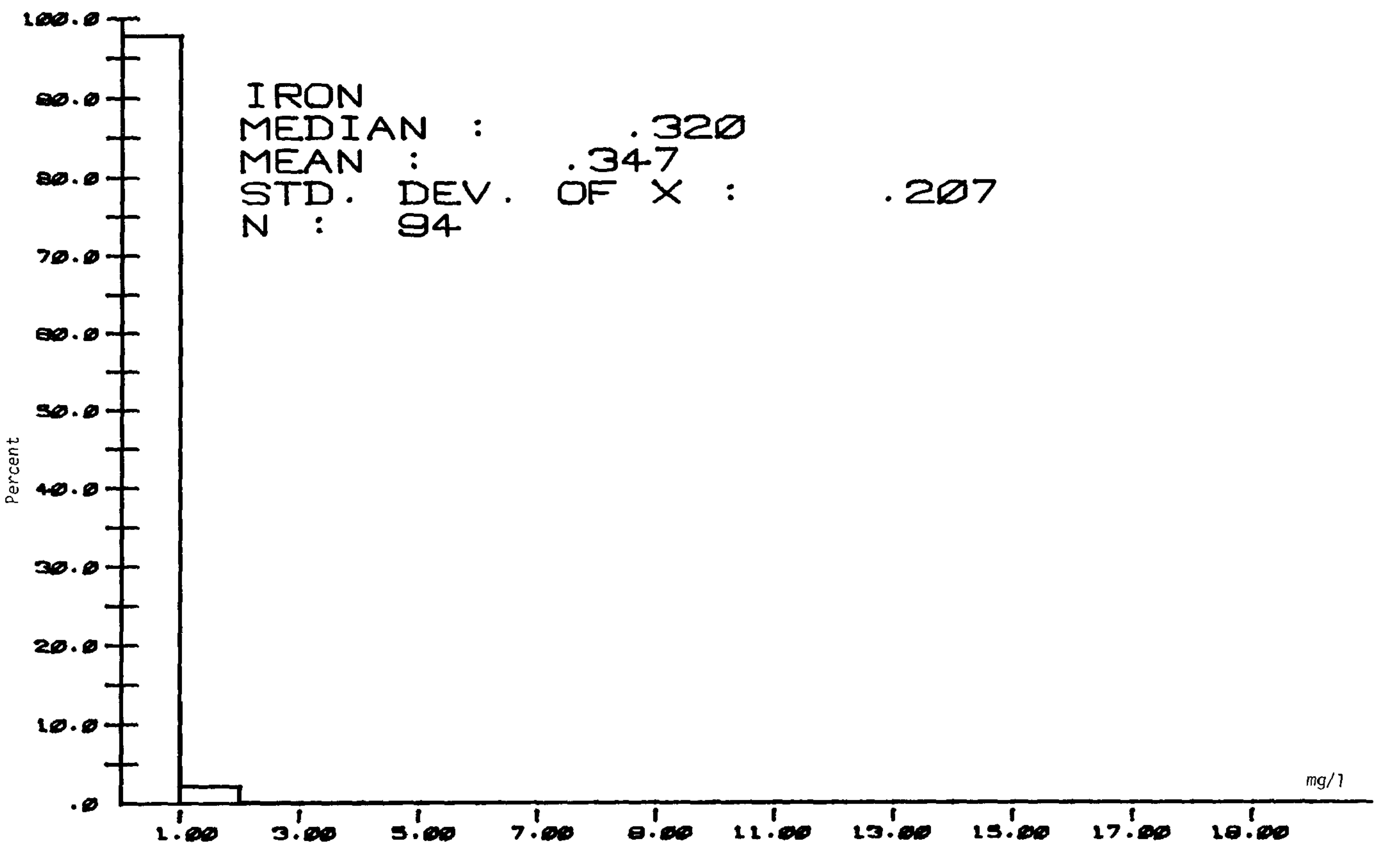

Figure 3.38 Niagara River Histograms for Iron

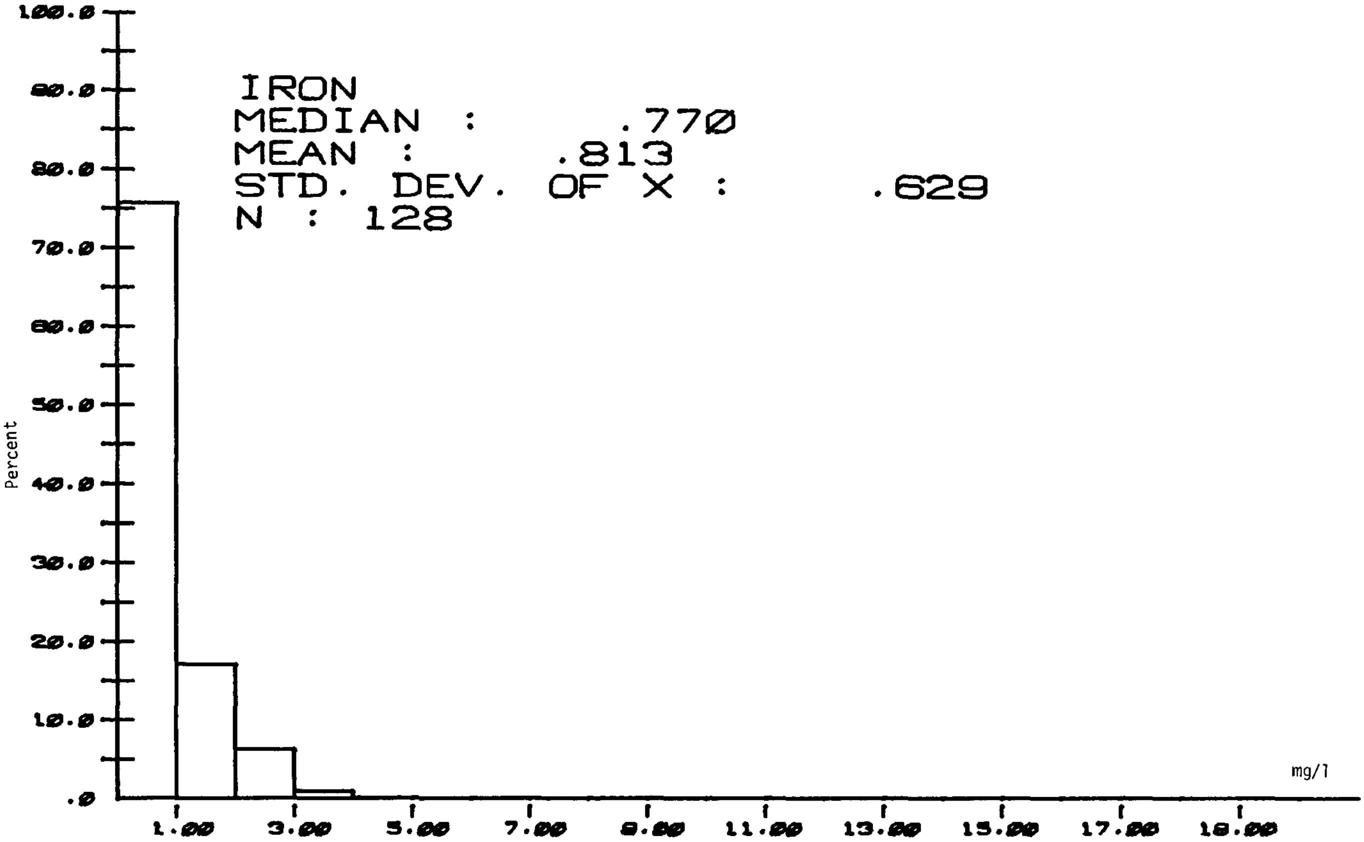

Figure 3.38 Black River Histograms for Iron

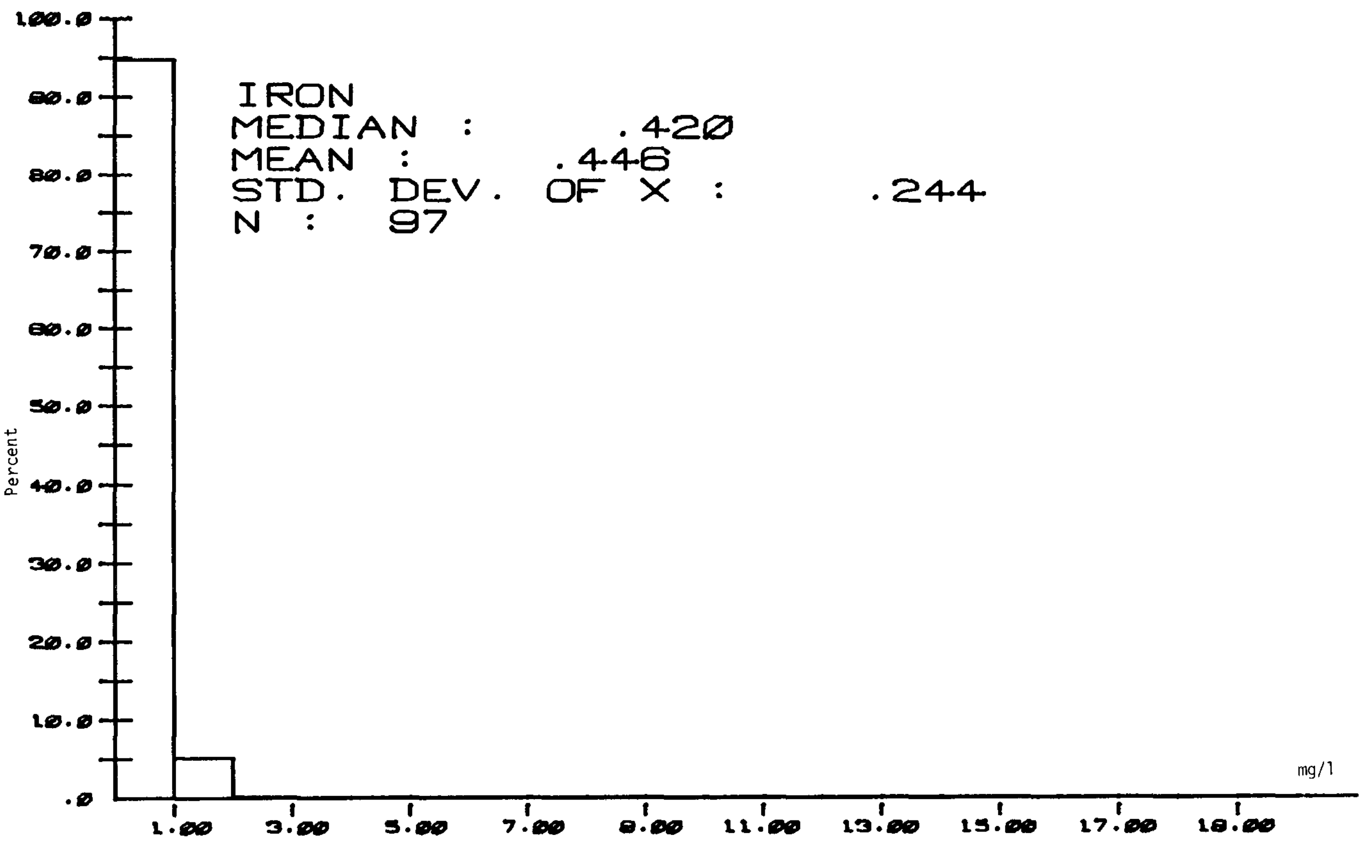

Figure 3.38 Oswego River Histograms for Iron

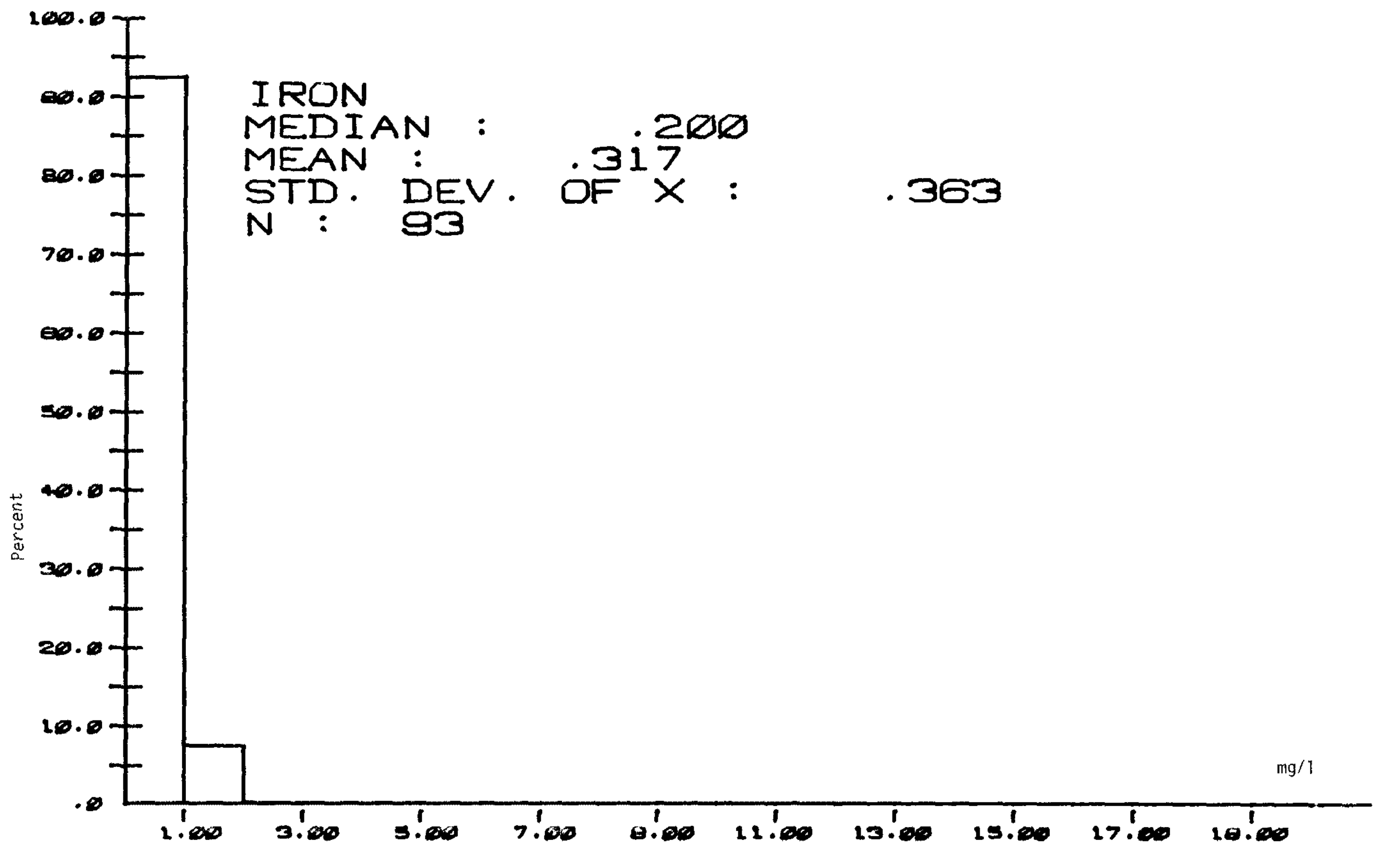

Figure 3.38 St. Lawrence River Histograms for Iron

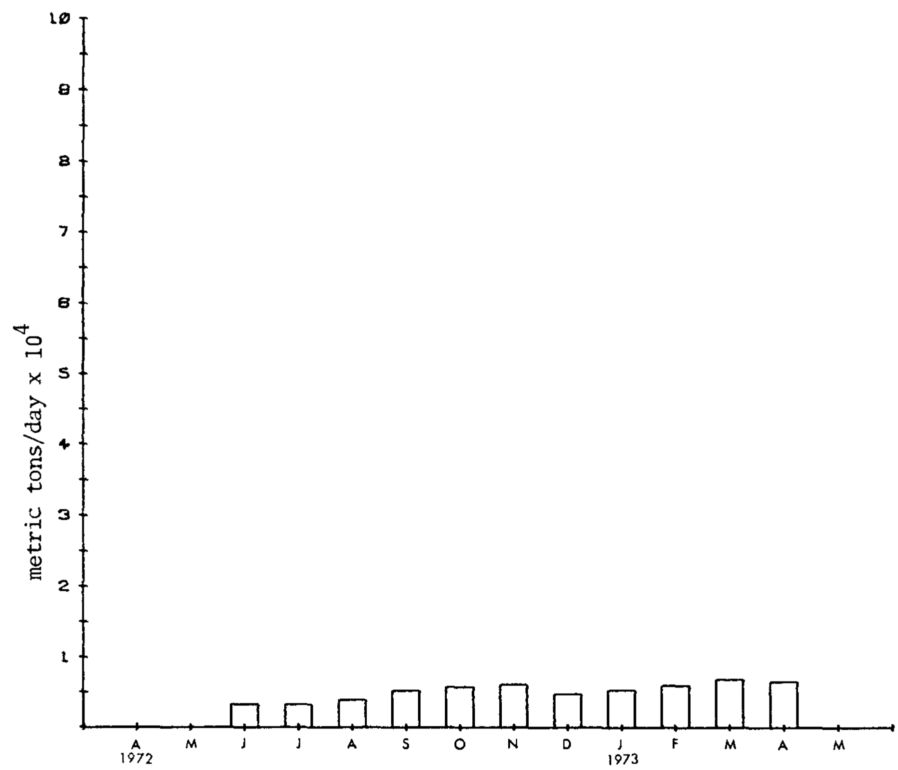

Figure 3.39 Niagara River Monthly Mean Stream Loadings - Nickel

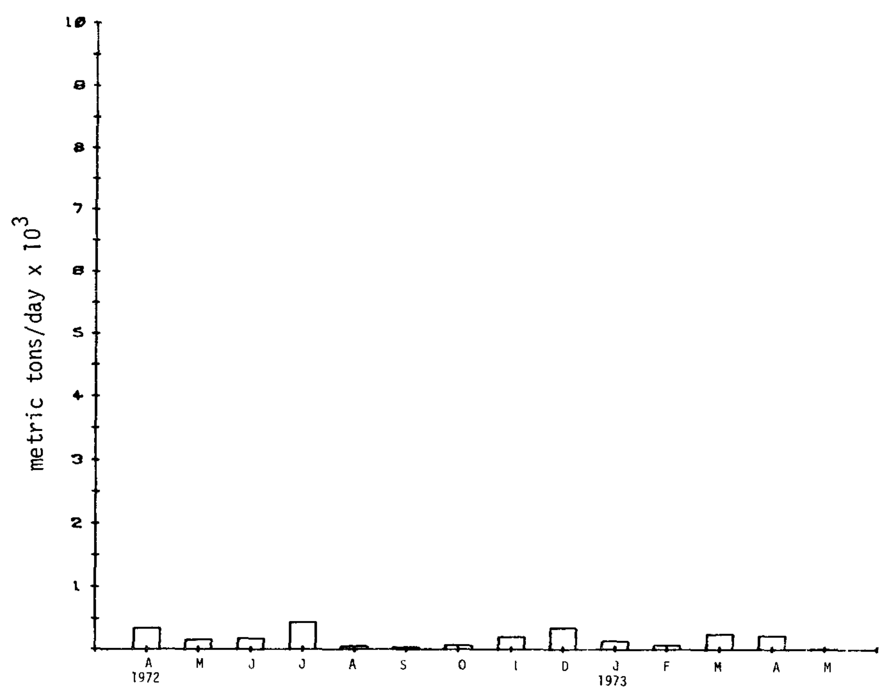

Figure 3.39 Genesee River Monthly Mean Stream Loadings - Nickel

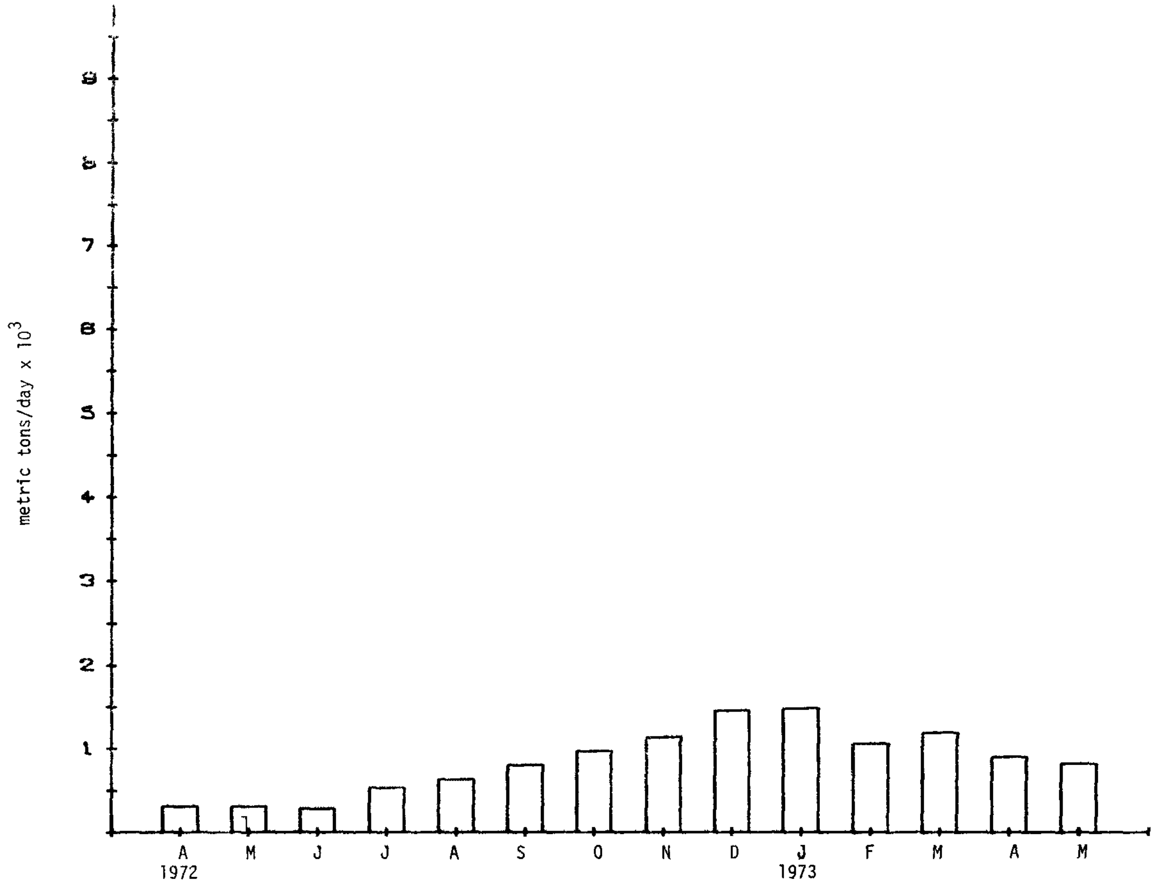

Figure 3.39 Oswego River Monthly Mean Stream Loadings - Nickel

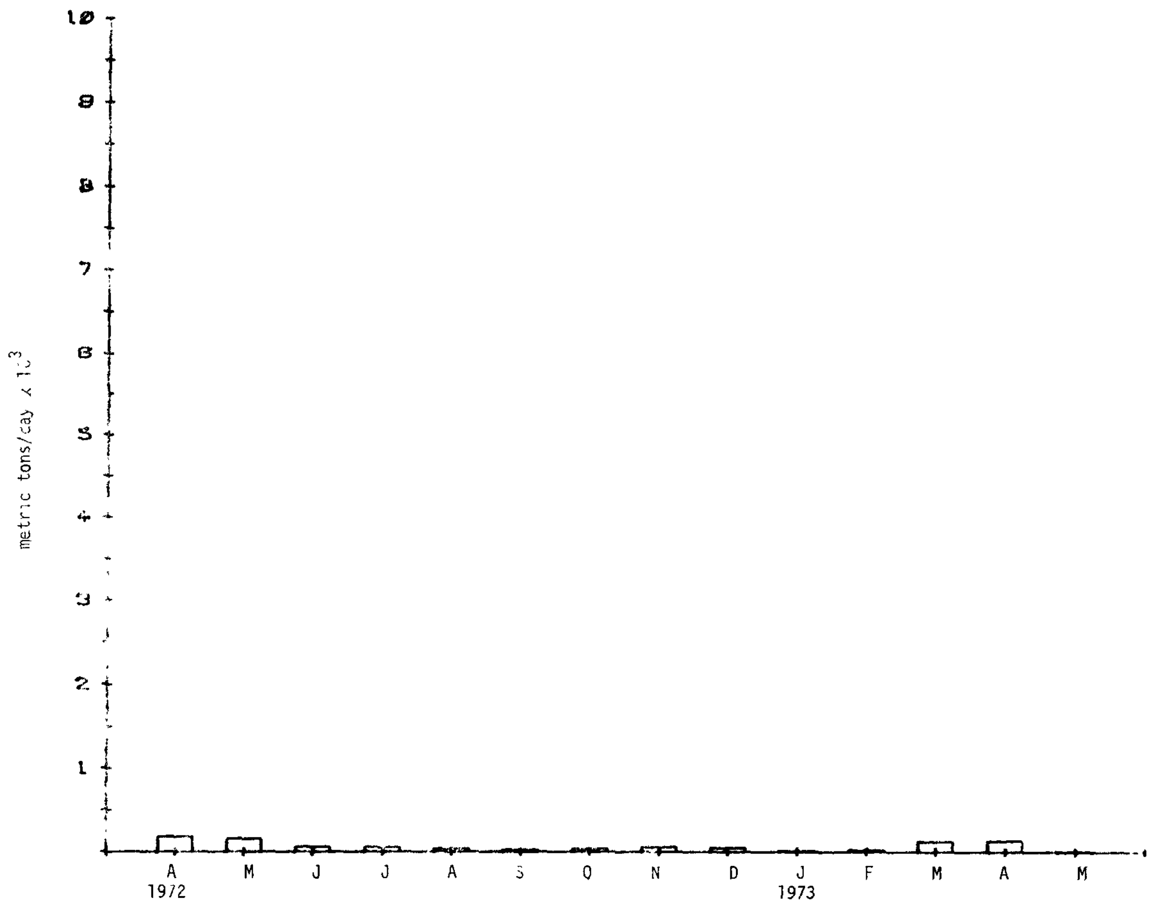

Figure 3.39 Black River Monthly Mean Stream Loadings - Nickel

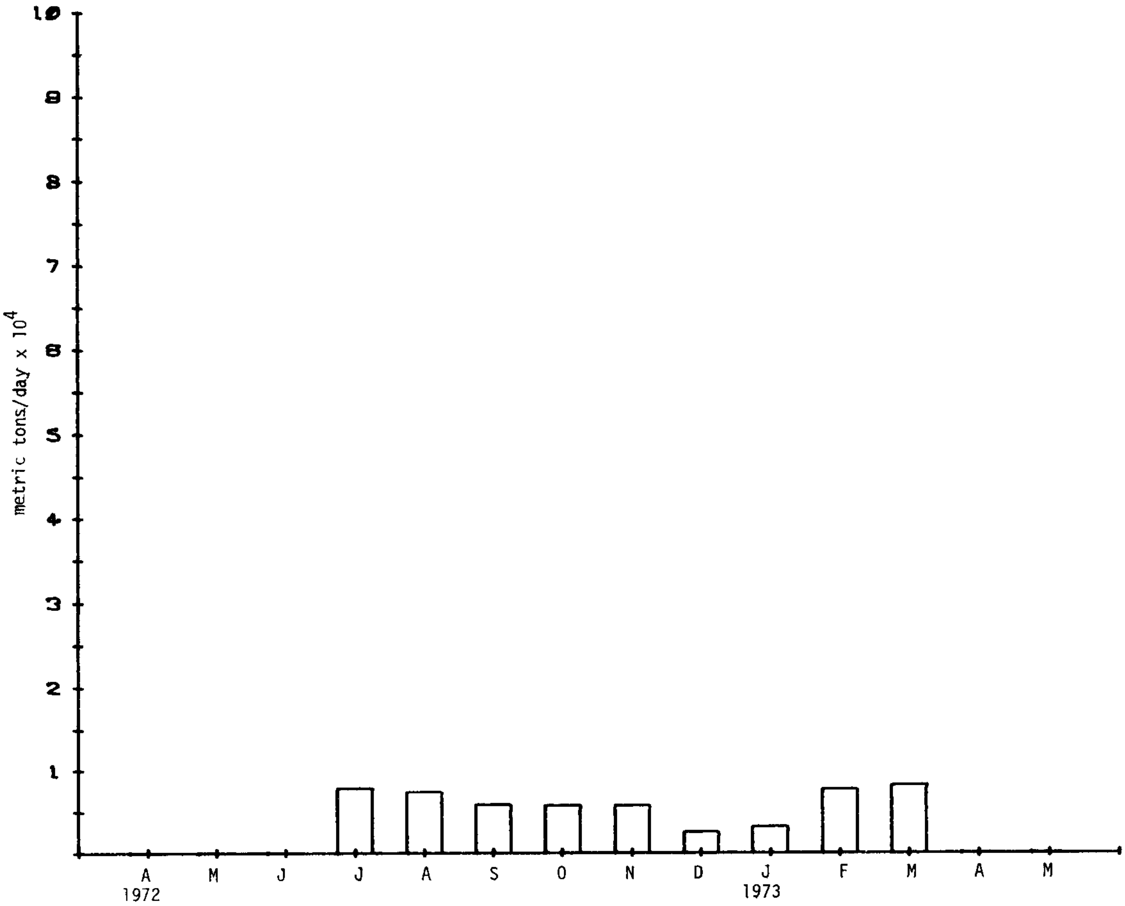

Figure 3.39 St. Lawrence River Monthly Mean Stream Loadings - Nickel

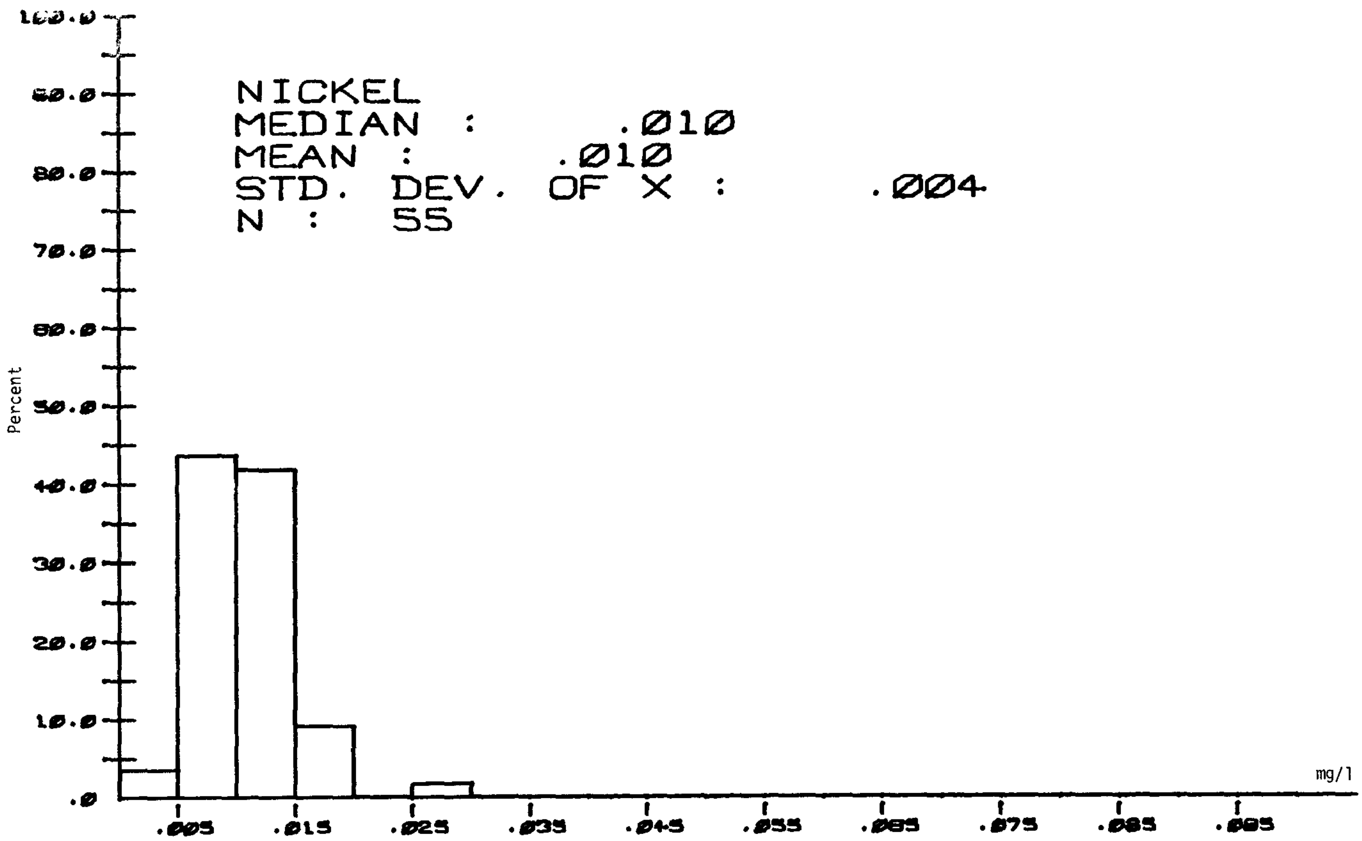

Figure 3.40 Niagara River Histograms for Nickel

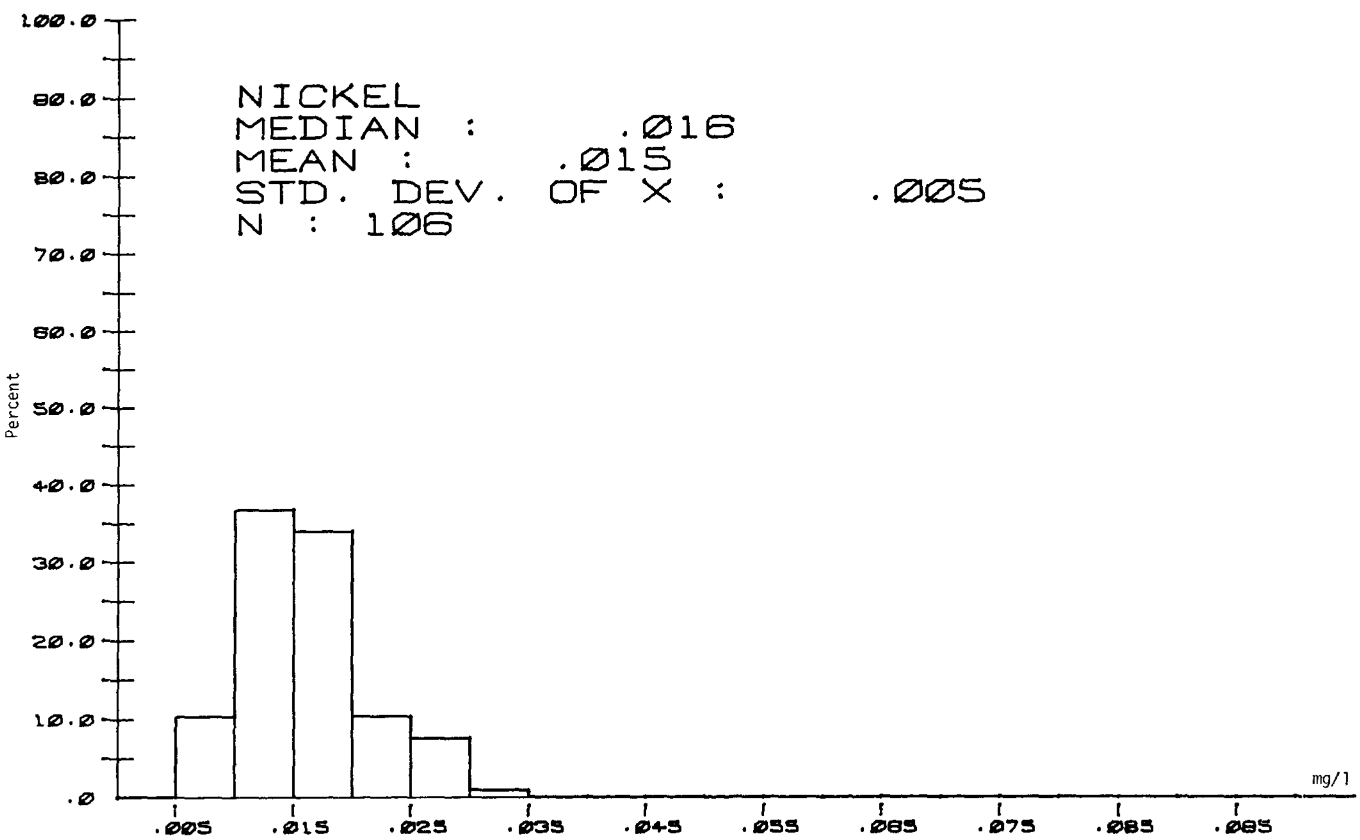

Figure 3.40 Genesee River Histograms for Nickel

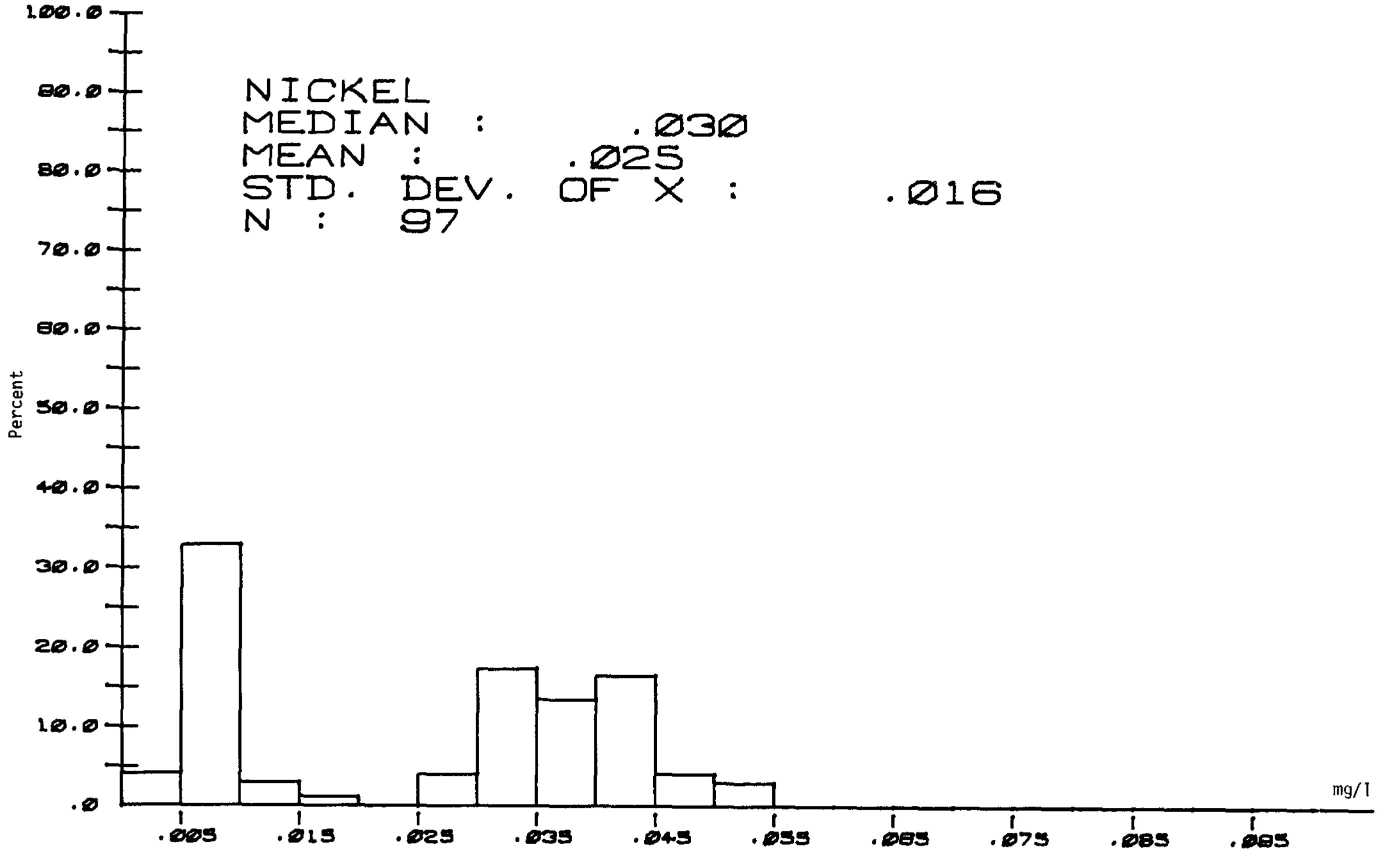

Figure 3.40 Oswego River Histograms for Nickel

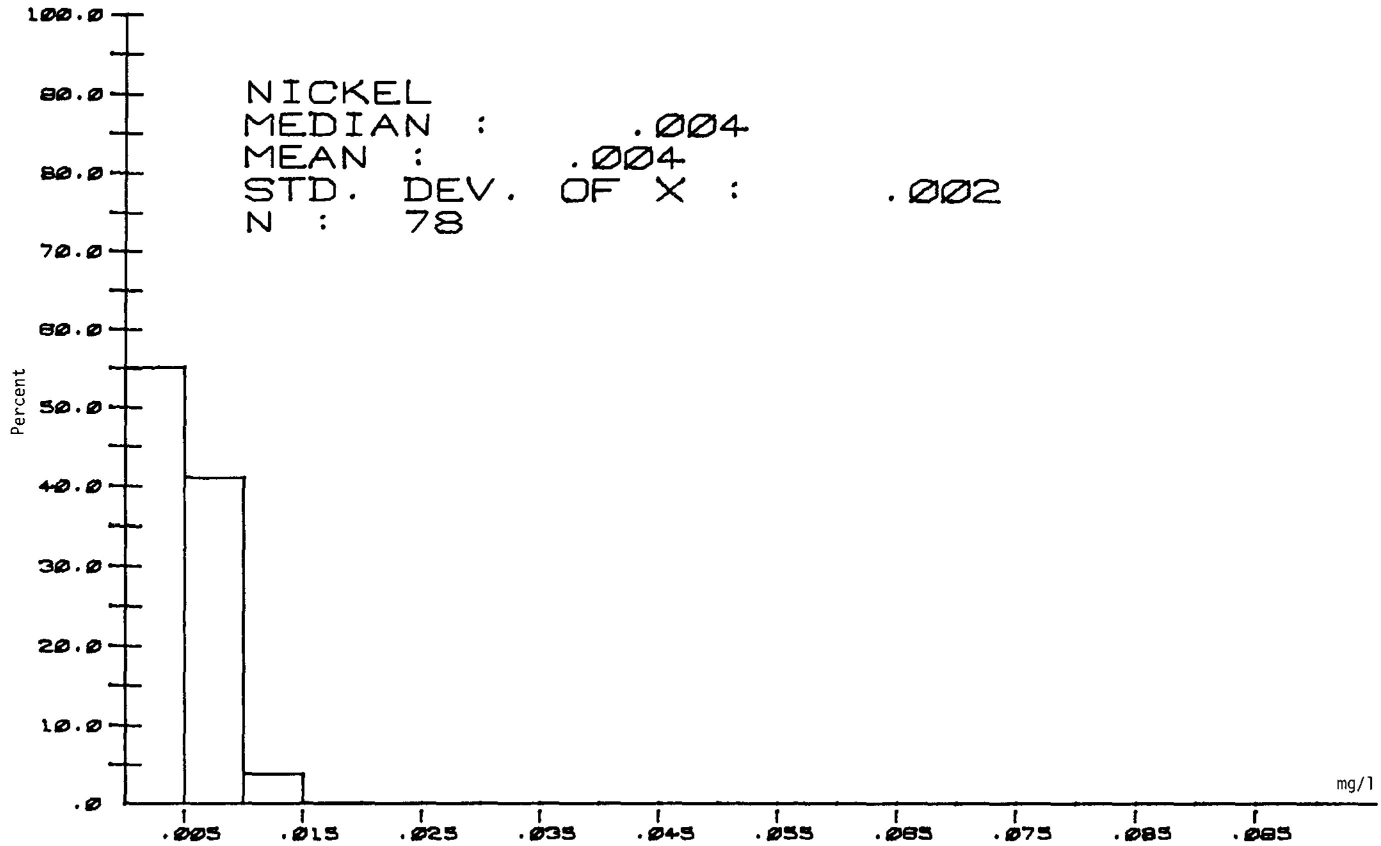

Figure 3.40 Black River Histograms for Nickel

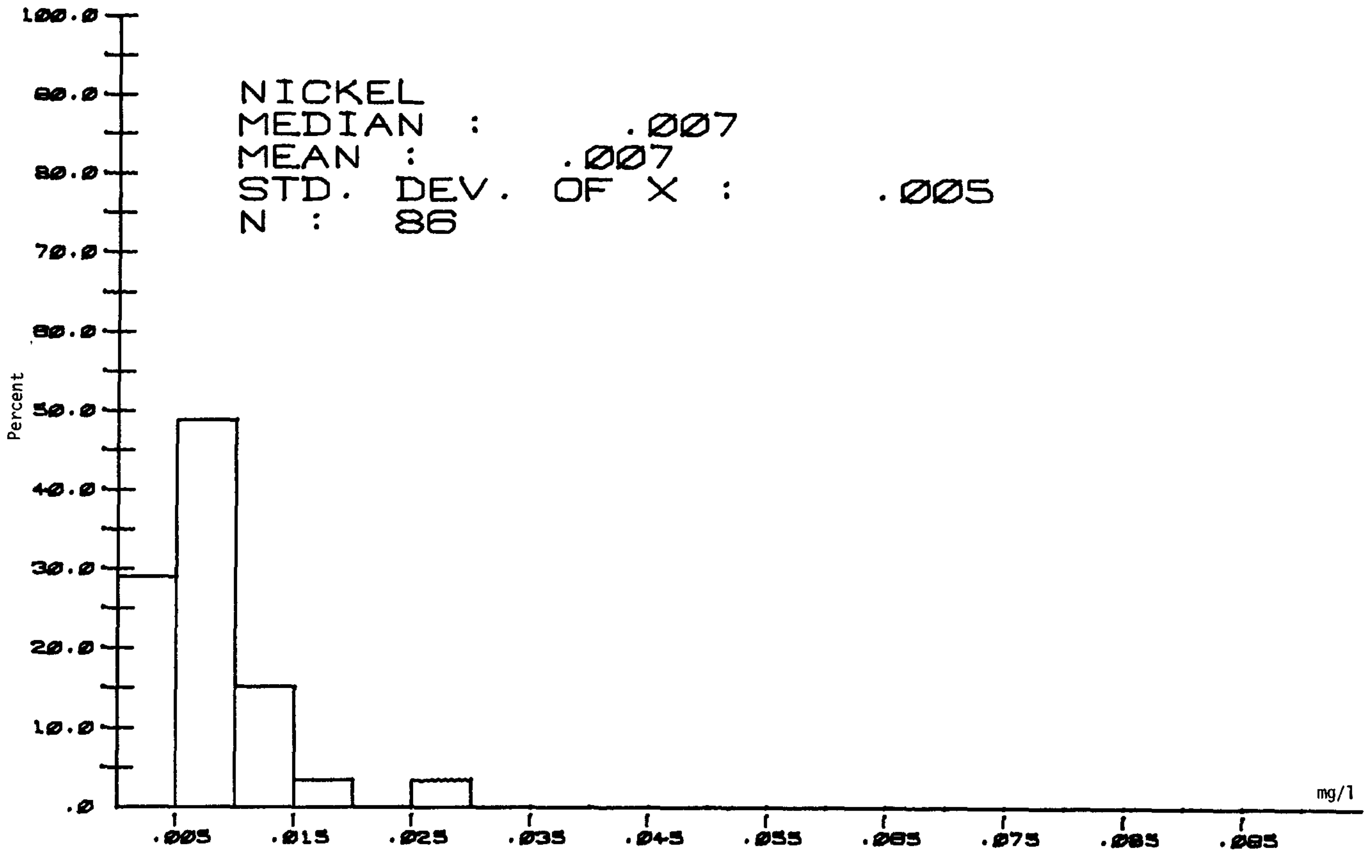

Figure 3.40 St. Lawrence River Histograms for Nickel

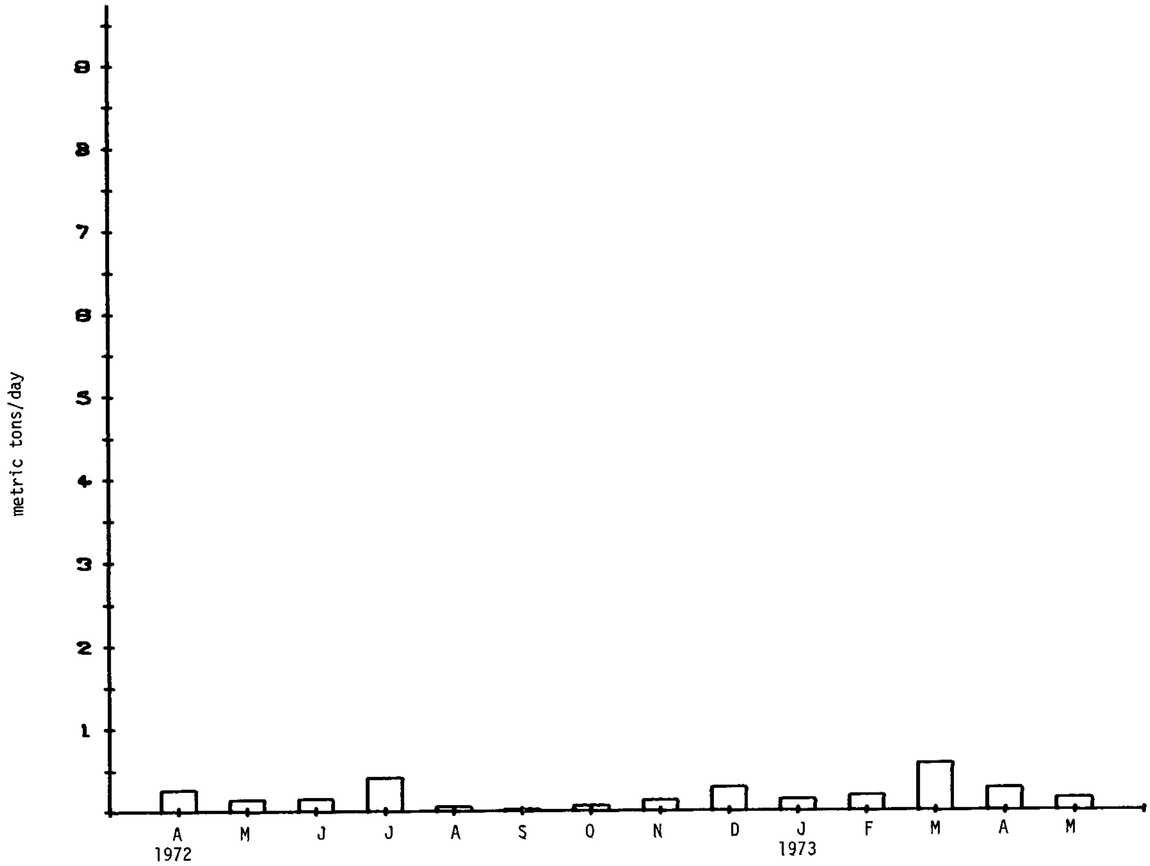

Figure 3.41 Genesee River Monthly Mean Stream Loadings - Copper

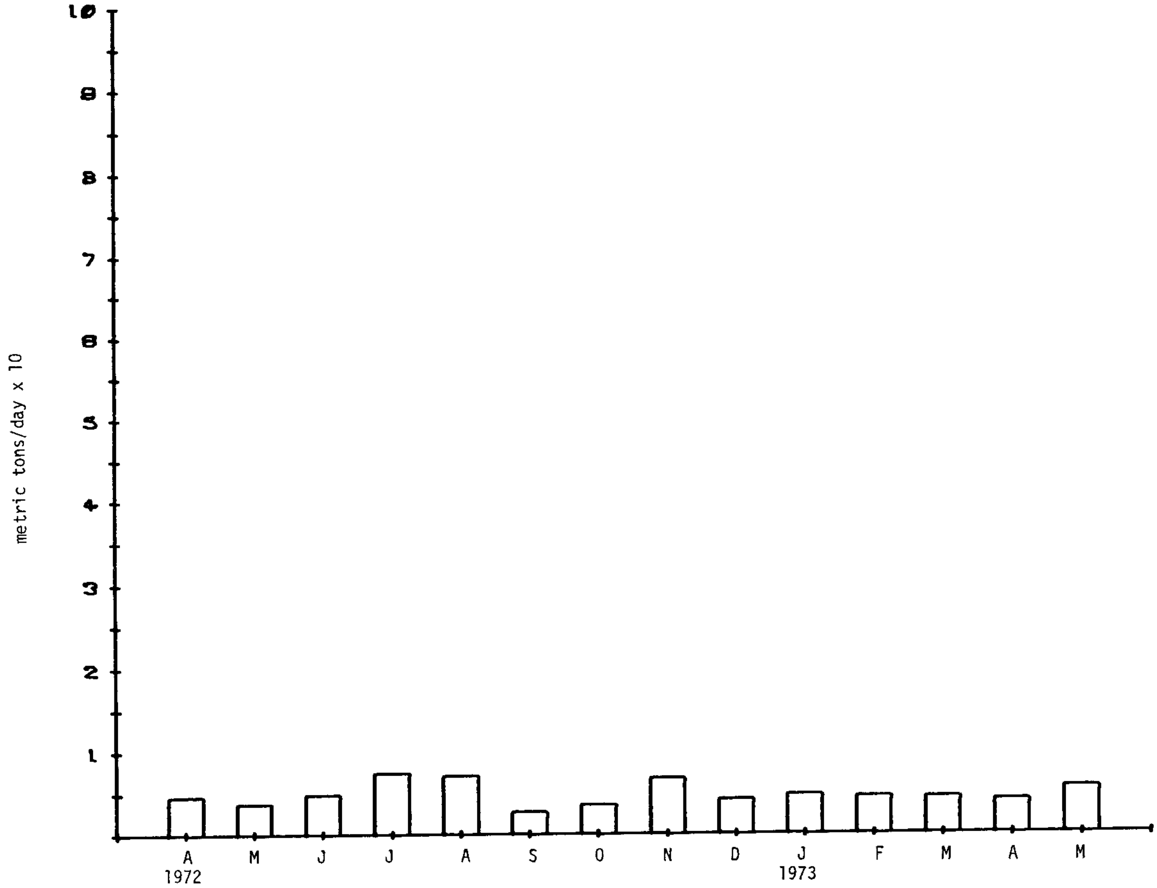

Figure 3.41 Niagara River Monthly Mean Stream Loadings - Copper

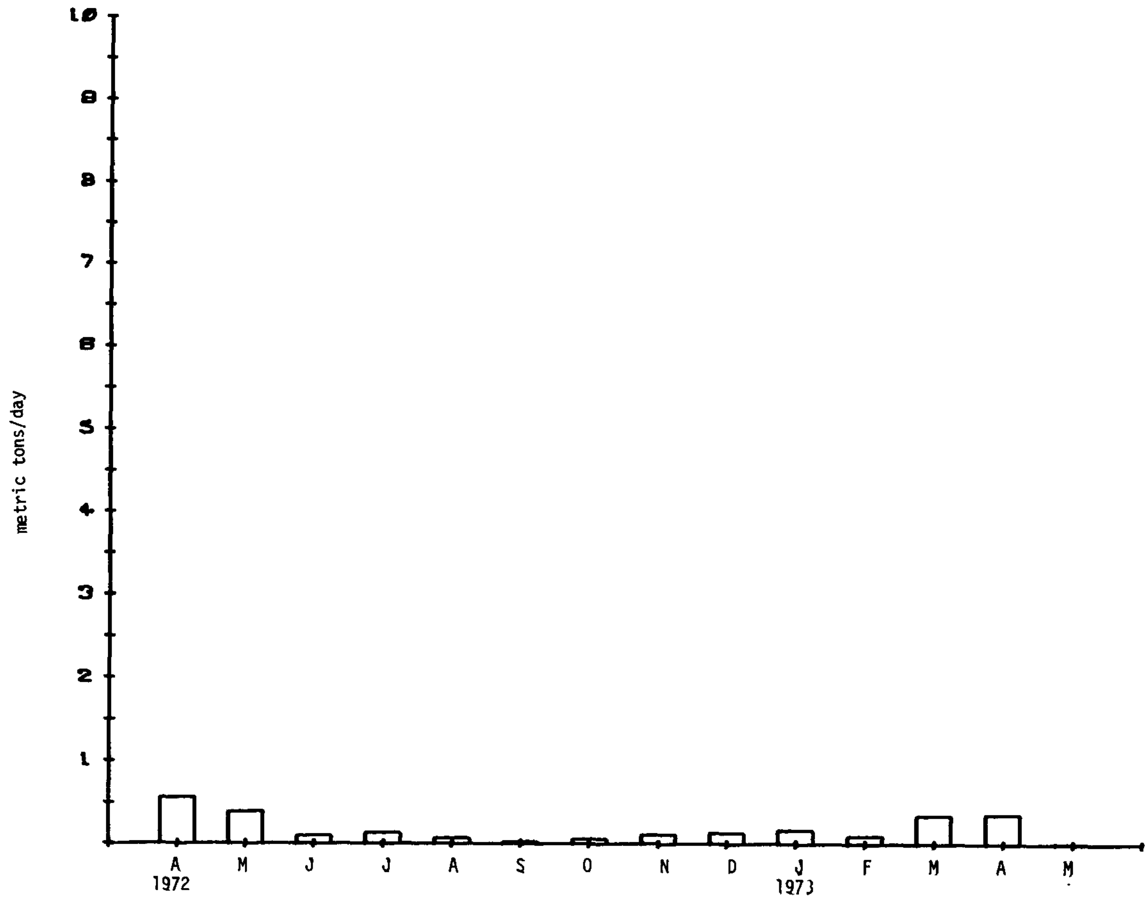

Figure 3.41 Black River Monthly Mean Stream Loadings - Copper

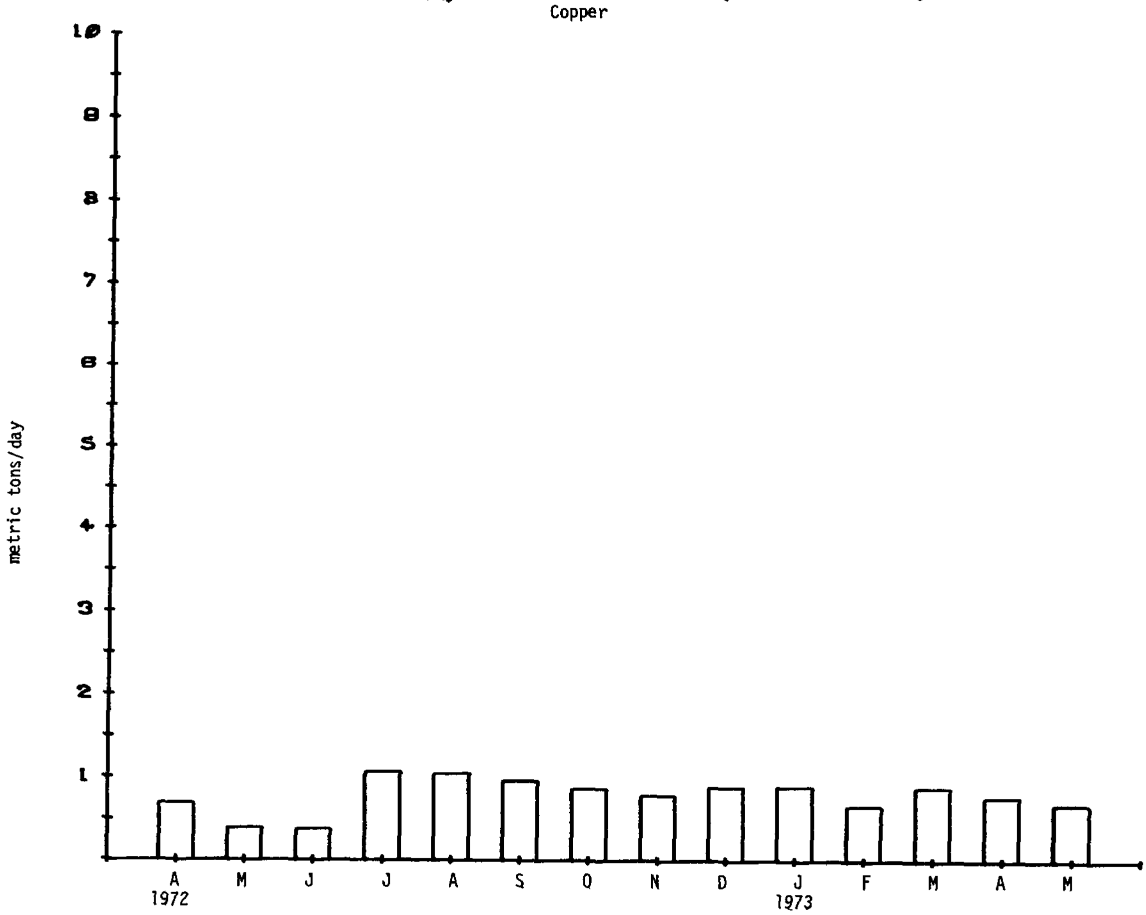

Figure 3.41 Oswego River Monthly Mean Stream Loadings - Copper

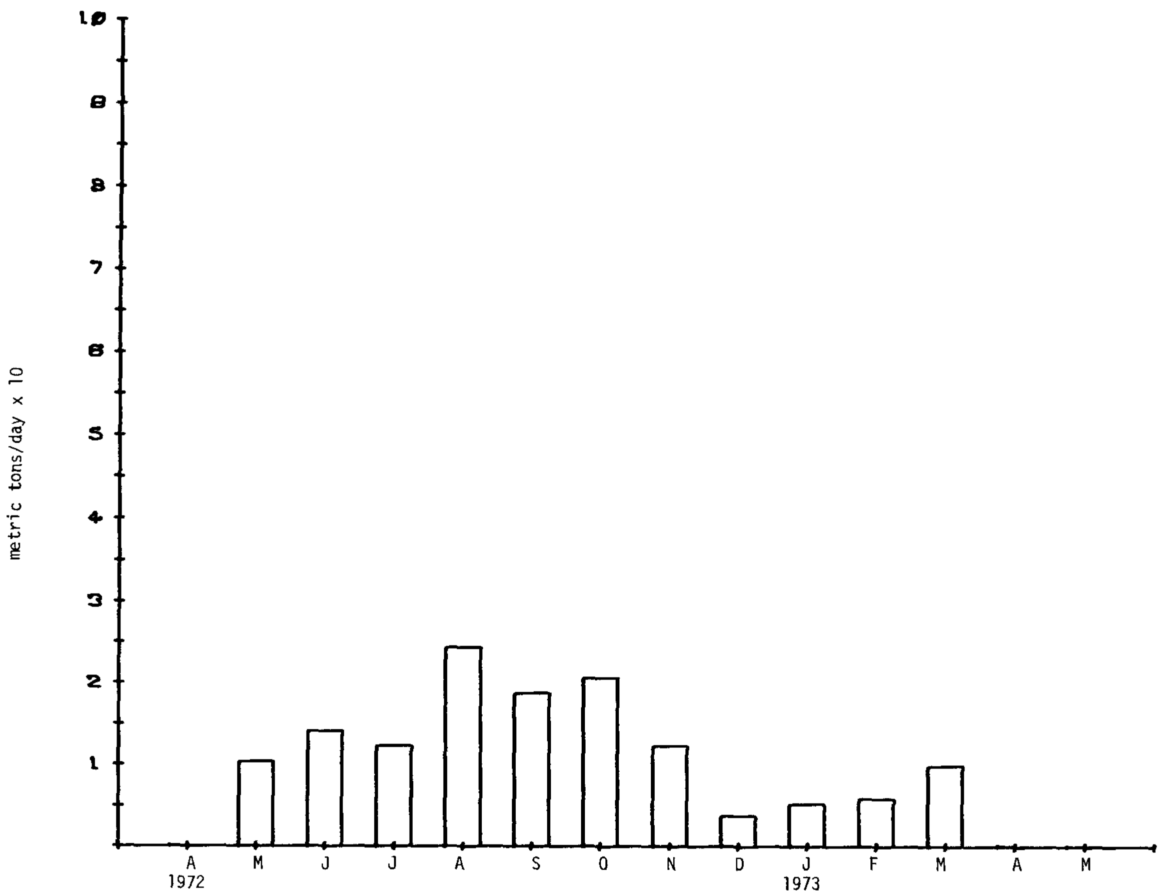

Figure 3.41 St. Lawrence River Monthly Mean Stream Loadings - Copper

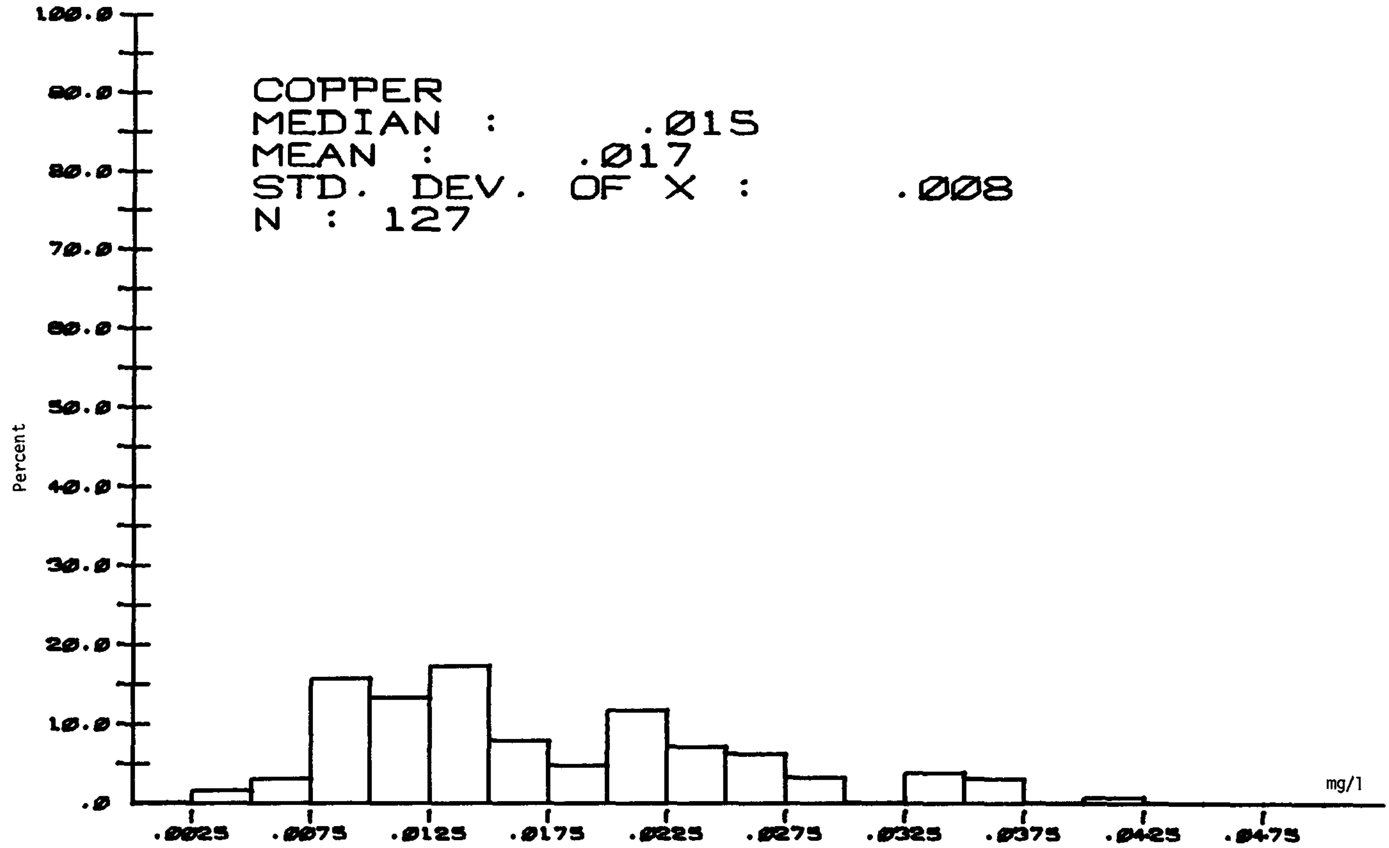

Figure 3.42 Genesee River Histograms for Copper

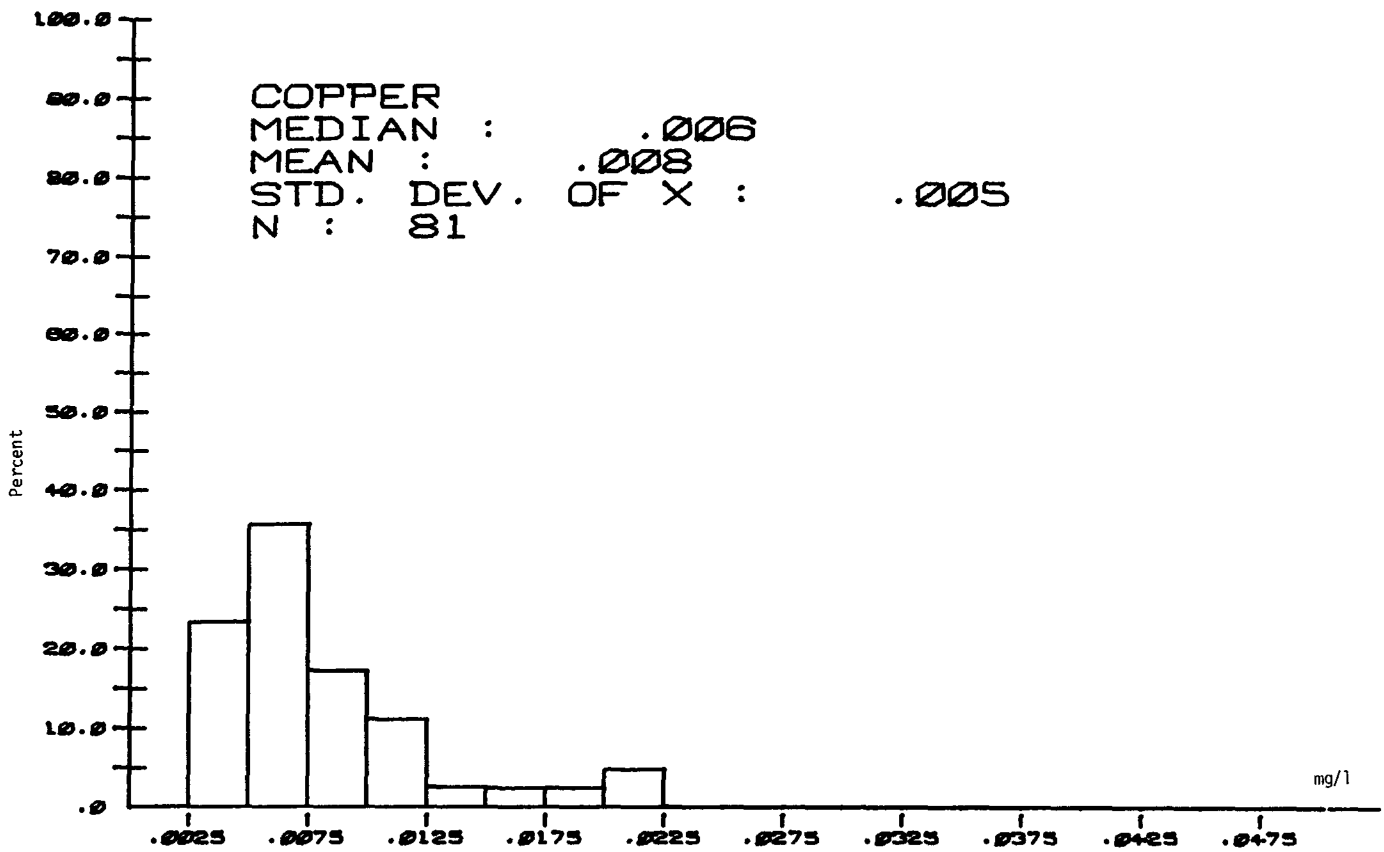

Figure 3.42 Niagara River Histograms for Copper

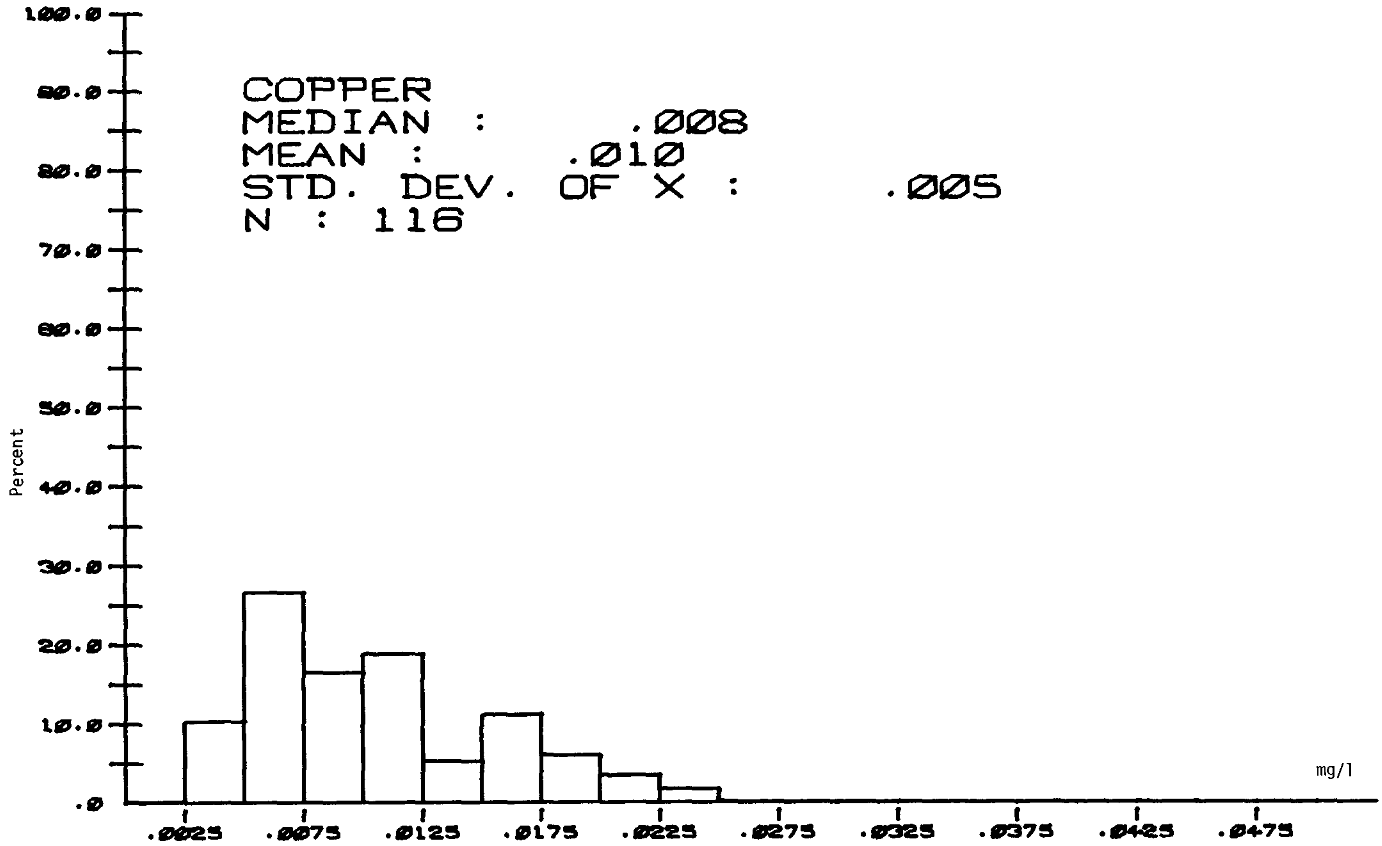

Figure 3.42 Black River Histograms for Copper

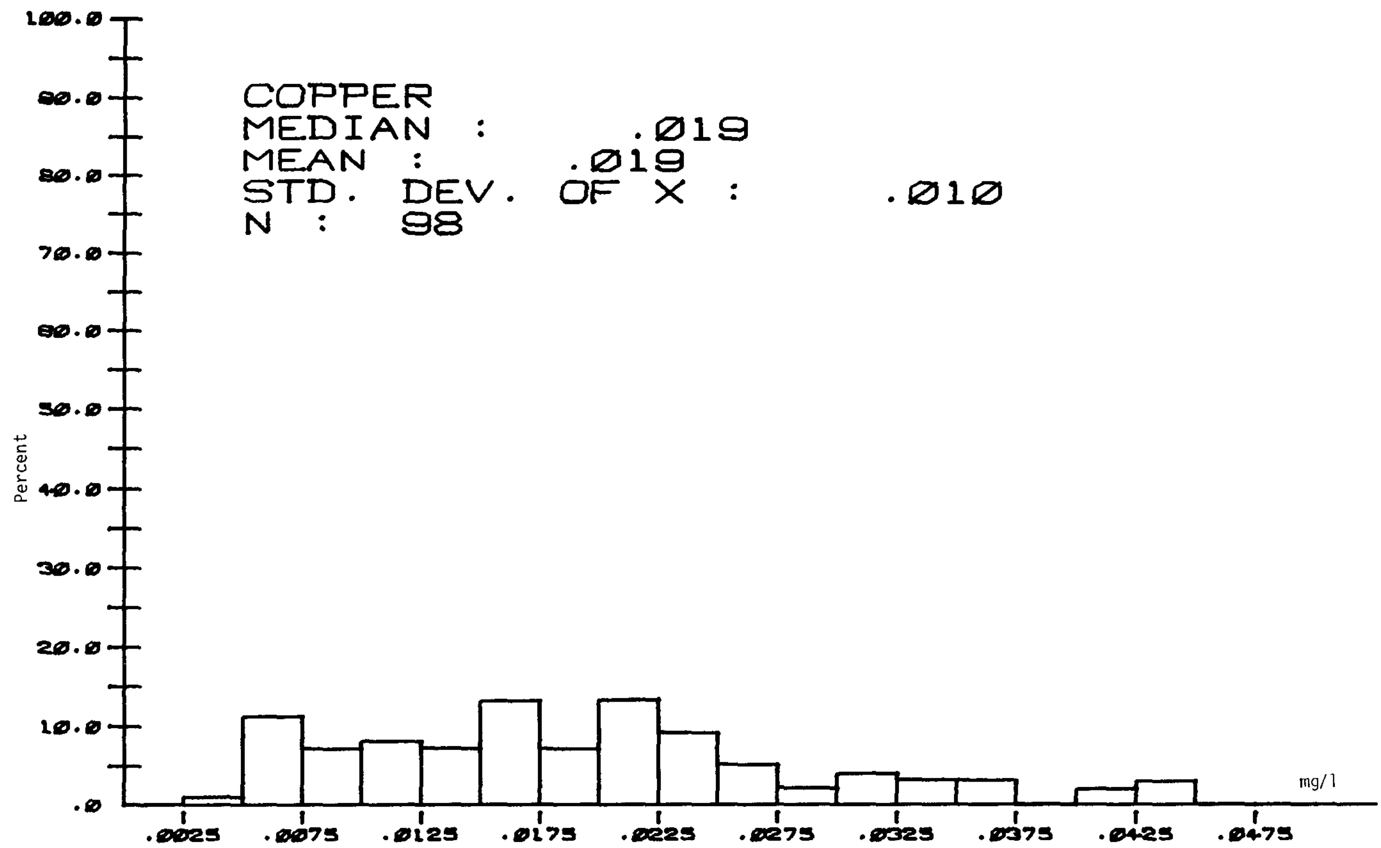

Figure 3.42 Oswego River Histograms for Copper

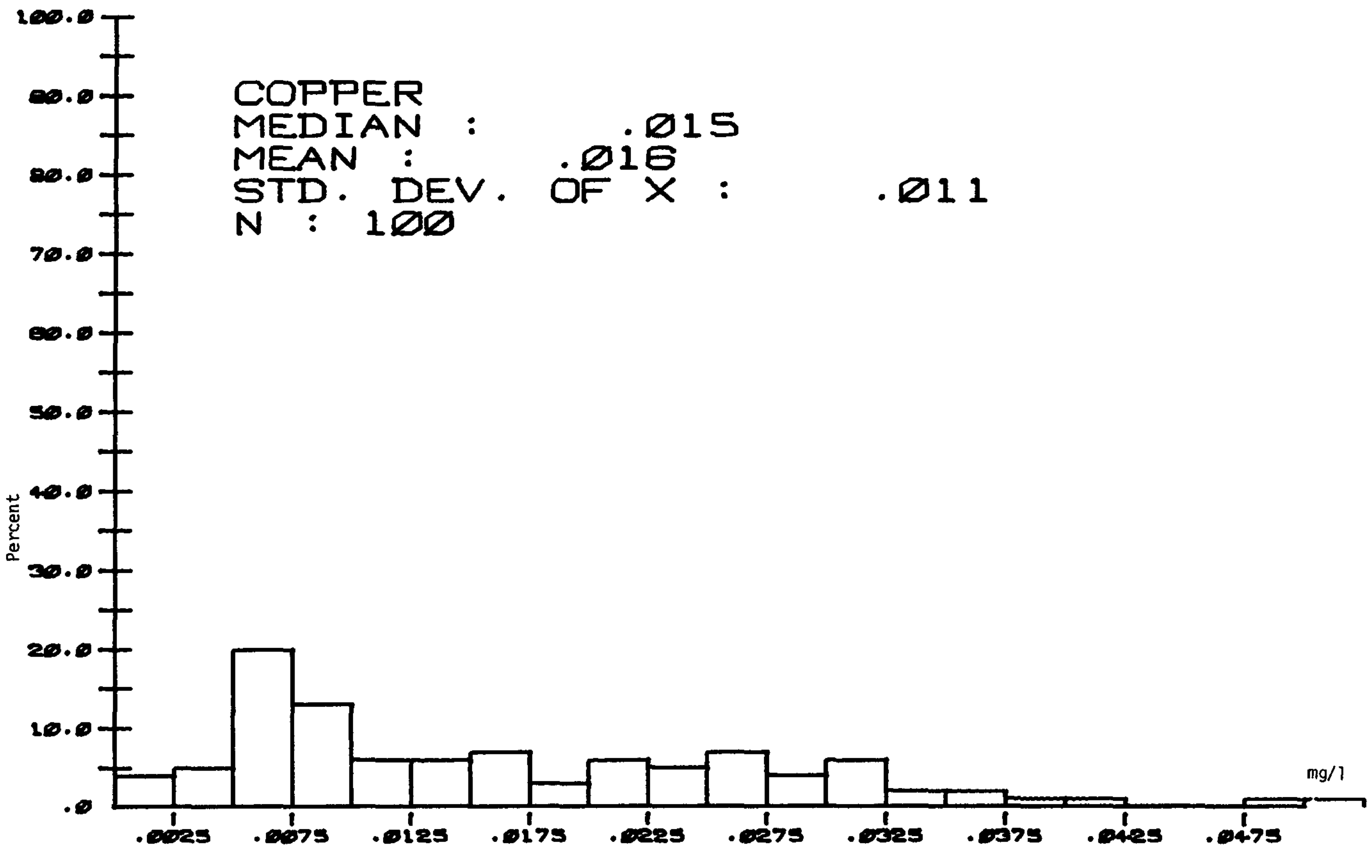

Figure 3.42 St. Lawrence River Histograms for Copper

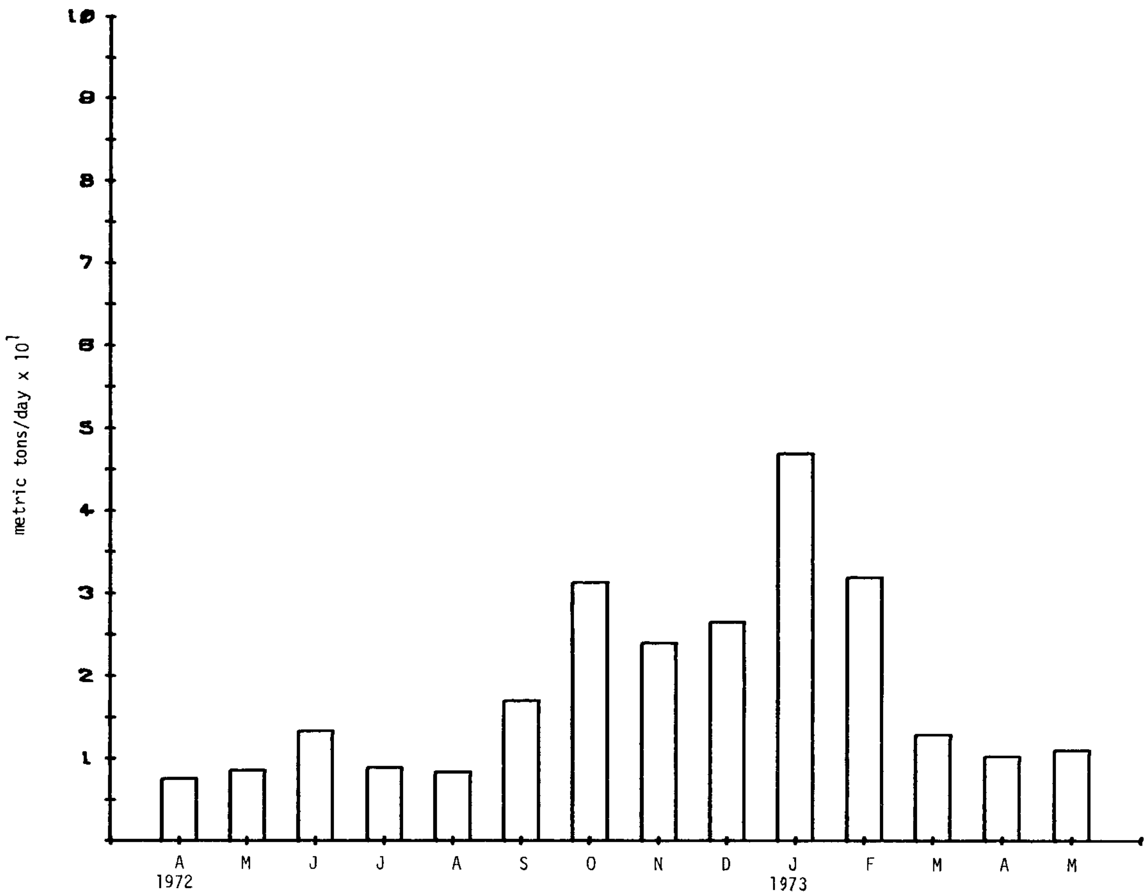

Figure 3.43 Niagara River Monthly Mean Stream Loadings - Zinc

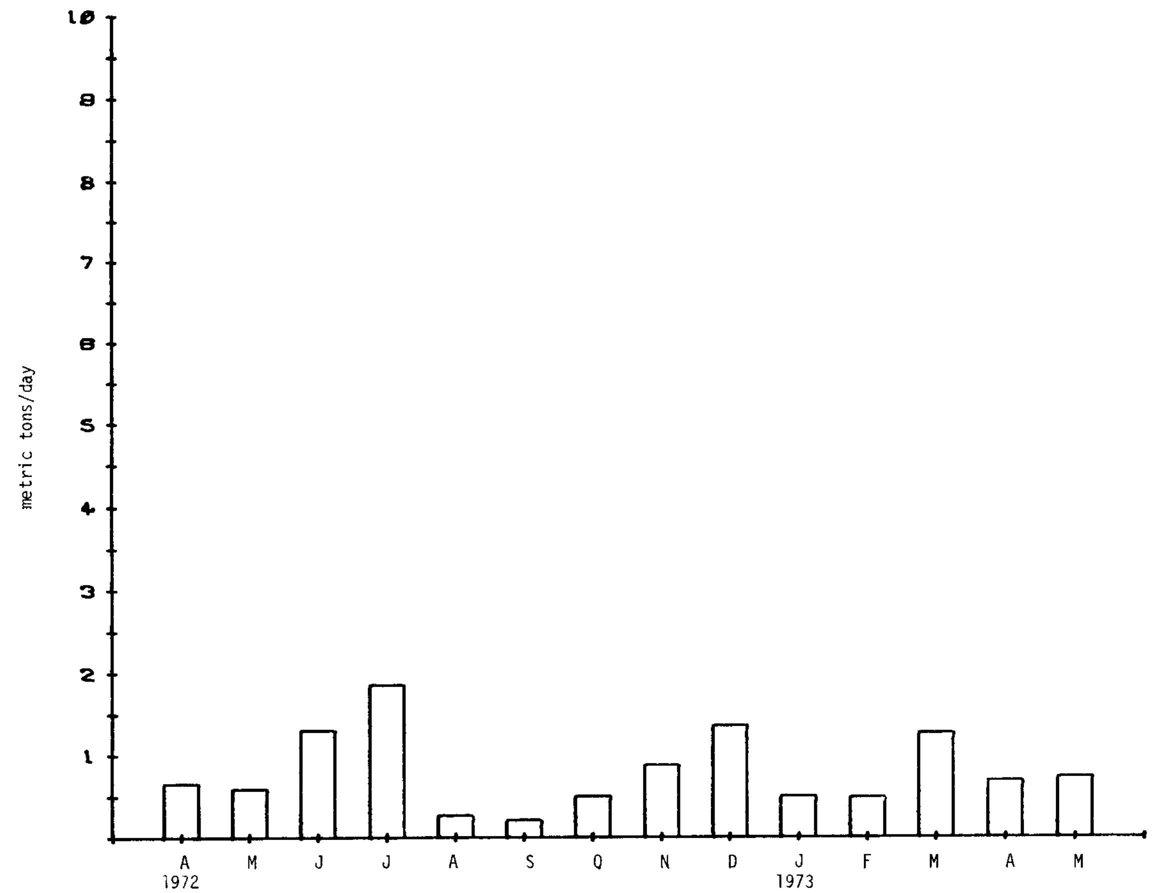

Figure 3.43 Genesee River Monthly Mean Stream Loadings - Zinc

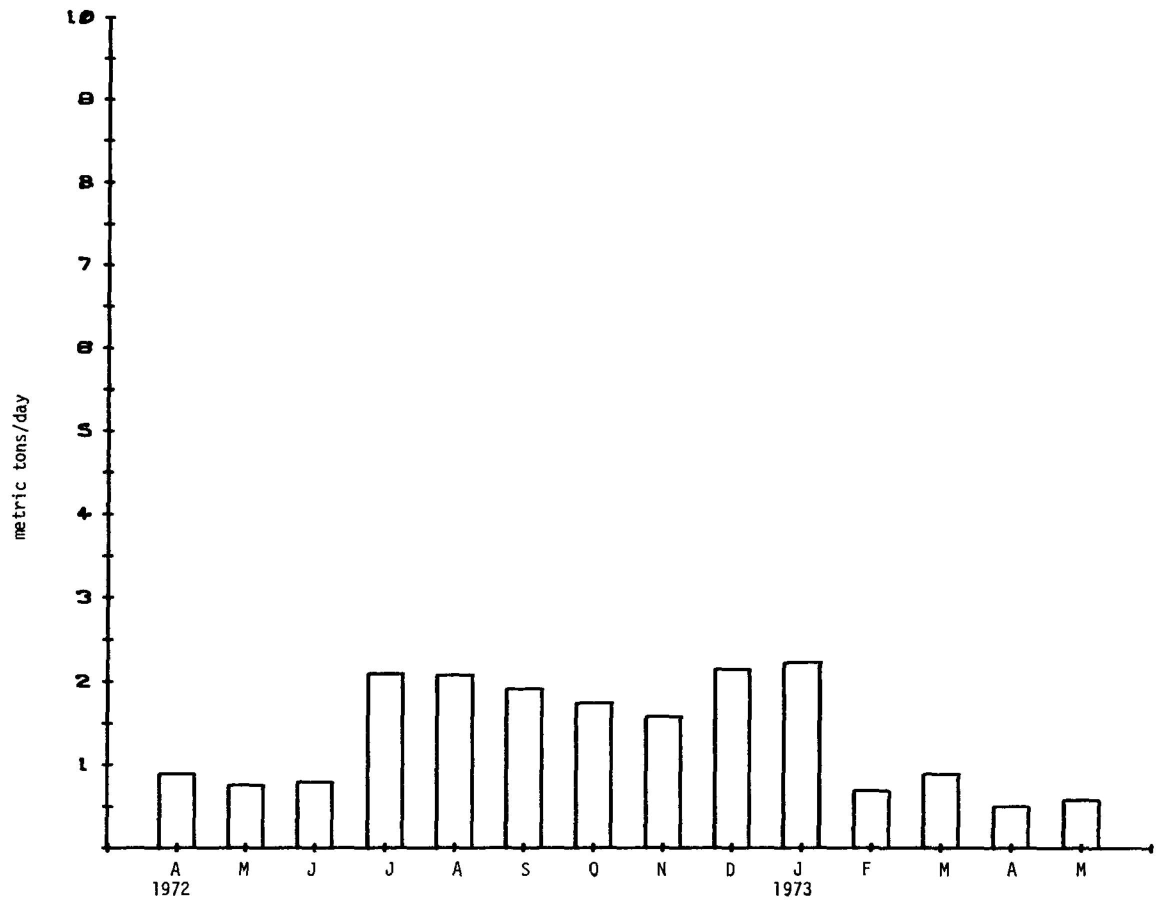

Figure 3.43 Oswego River Monthly Mean Stream Loadings - Zinc

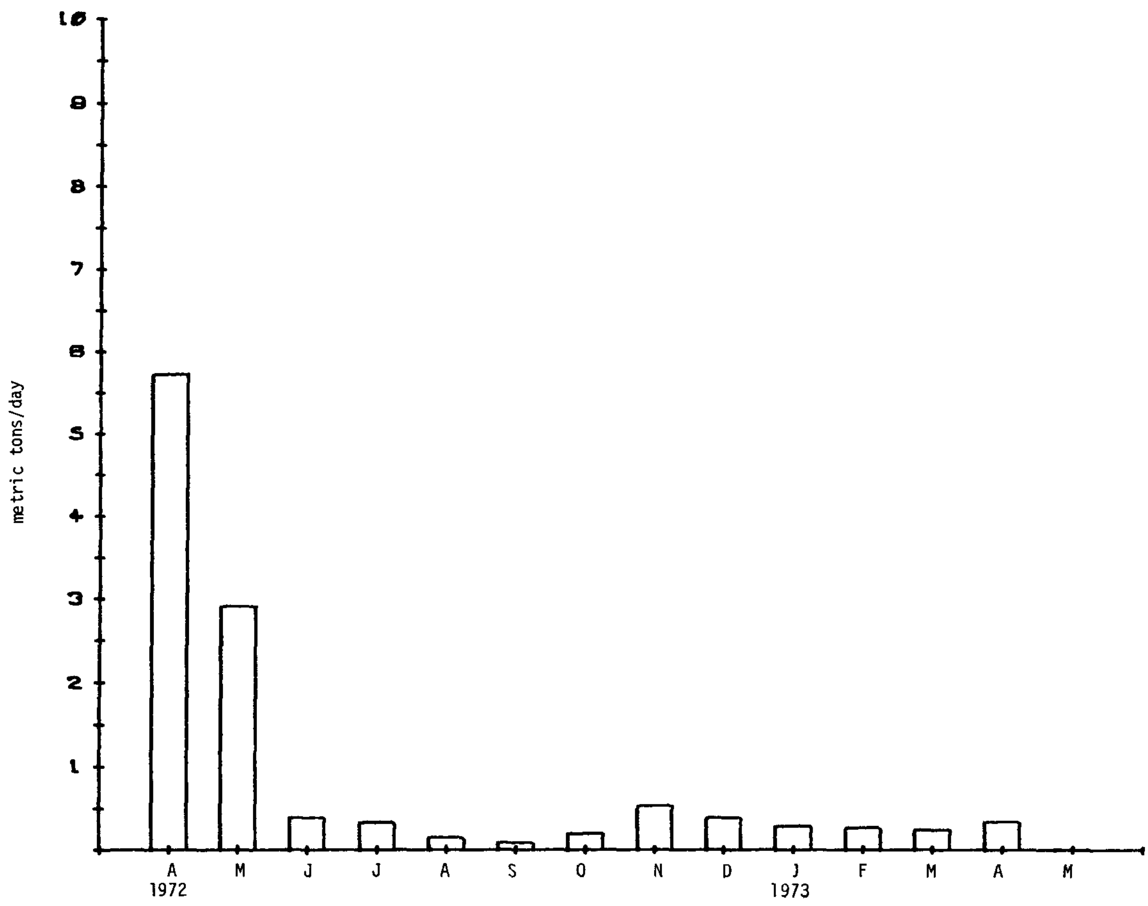

Figure 3.43 Black River Monthly Mean Stream Loadings - Zinc

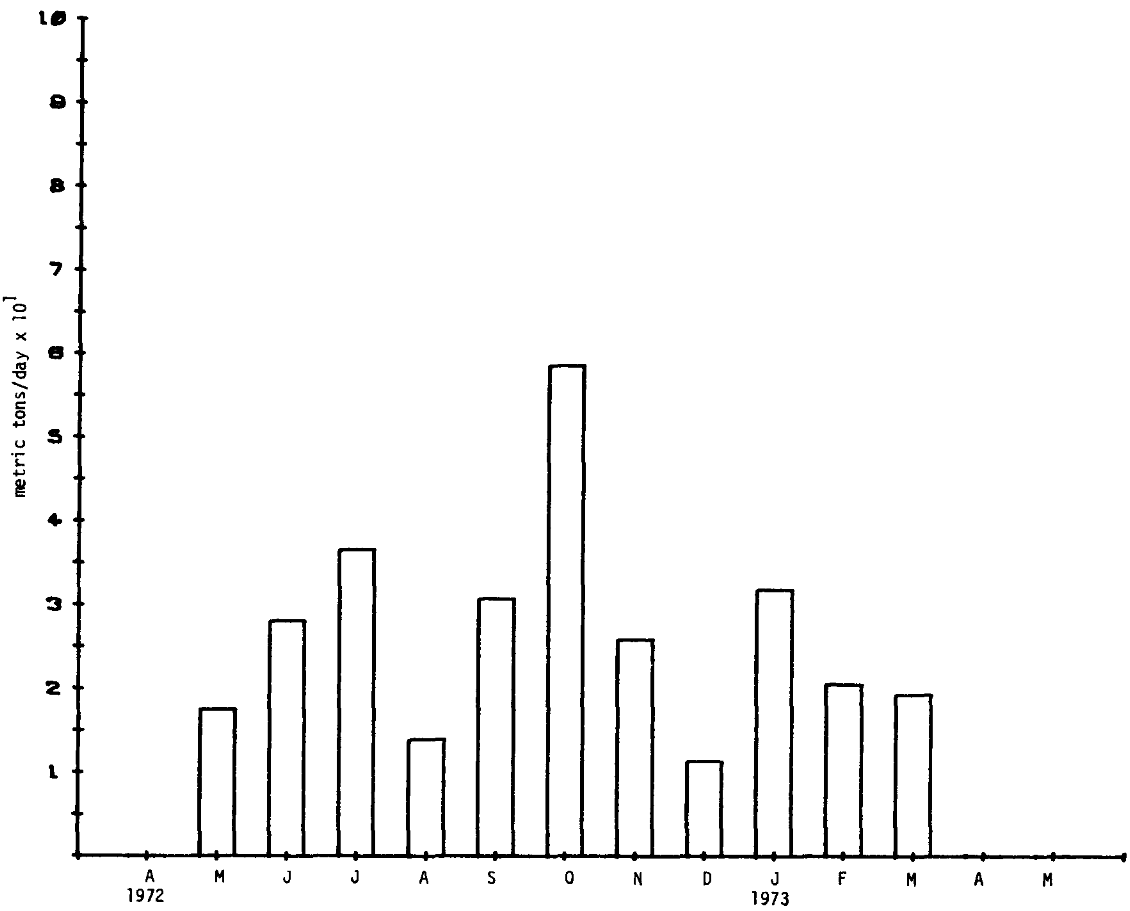

Figure 3.43 St. Lawrence River Monthly Mean Stream Loadings - Zinc

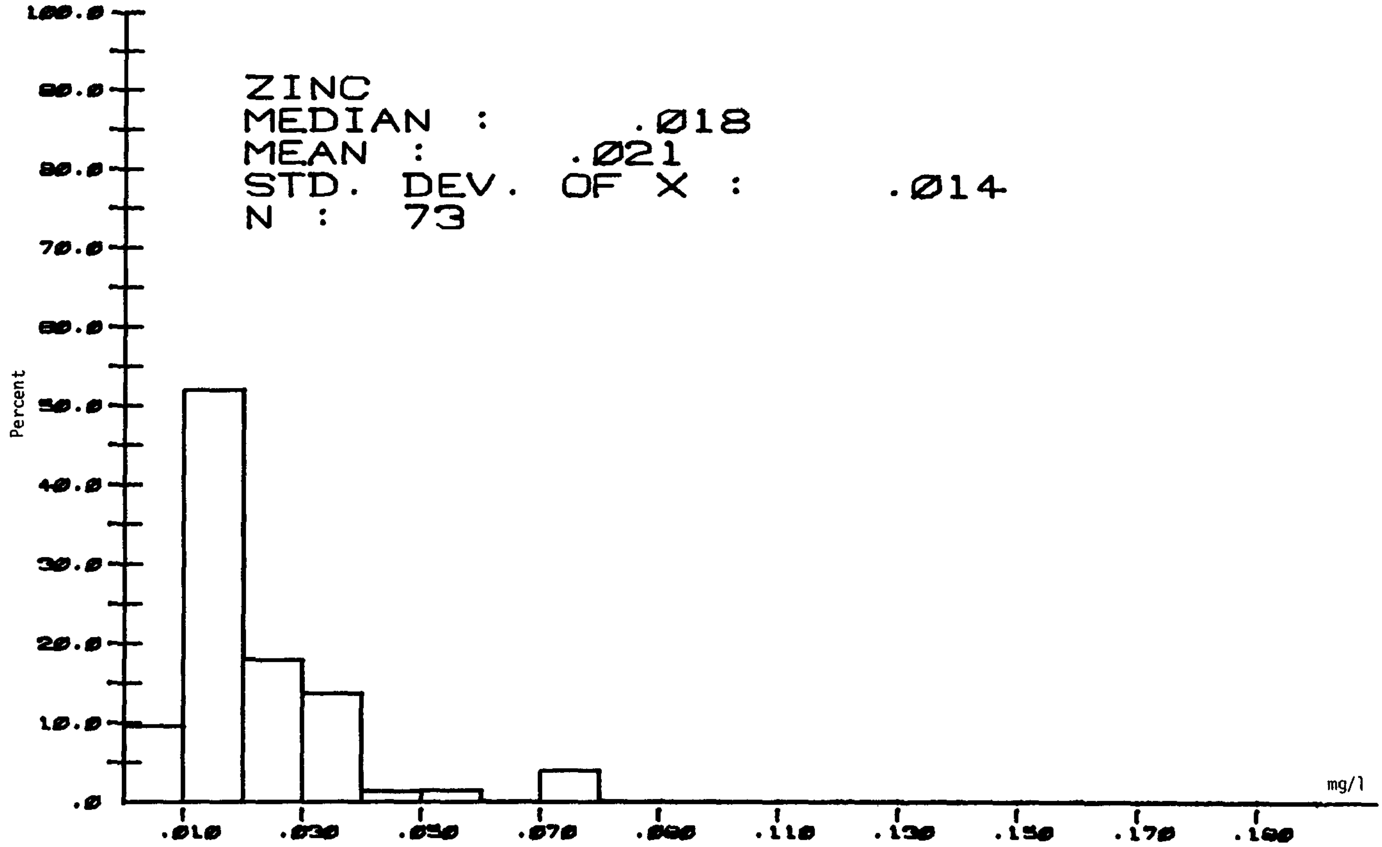

Figure 3.44 Niagara River Histograms for Zinc

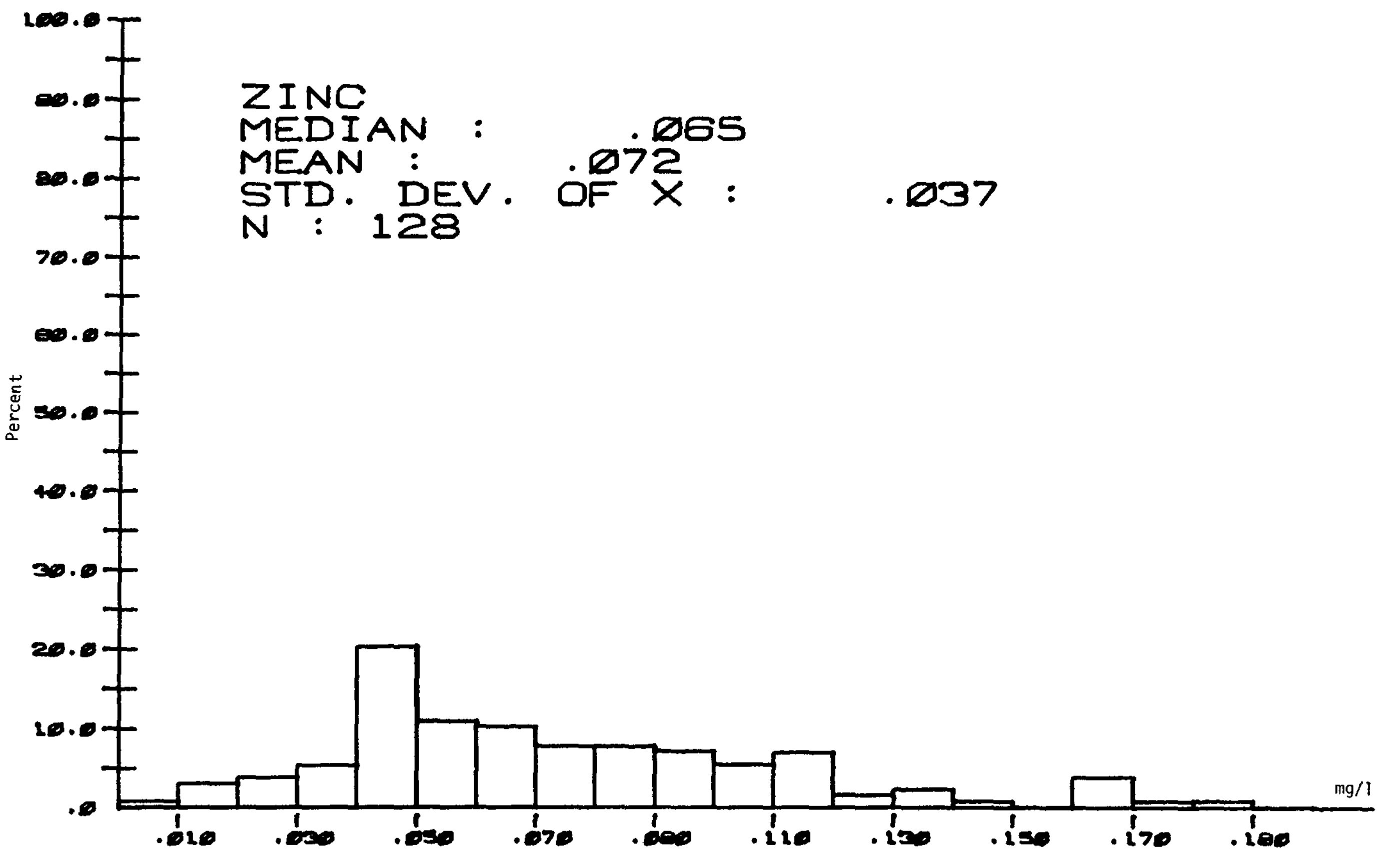

Figure 3.44 Genesee River Histograms for Zinc

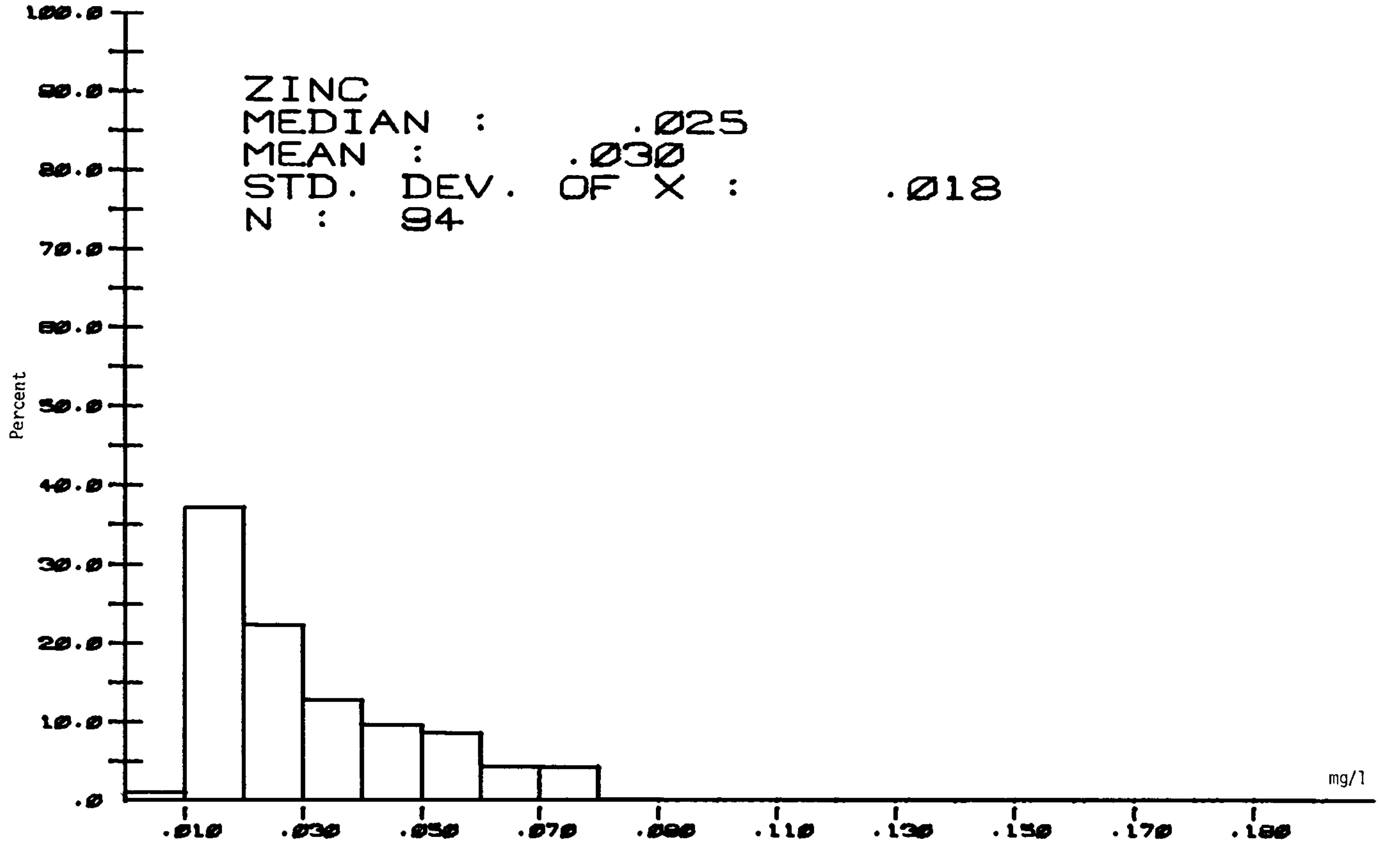

Figure 3.44 Oswego River Histograms for Zinc

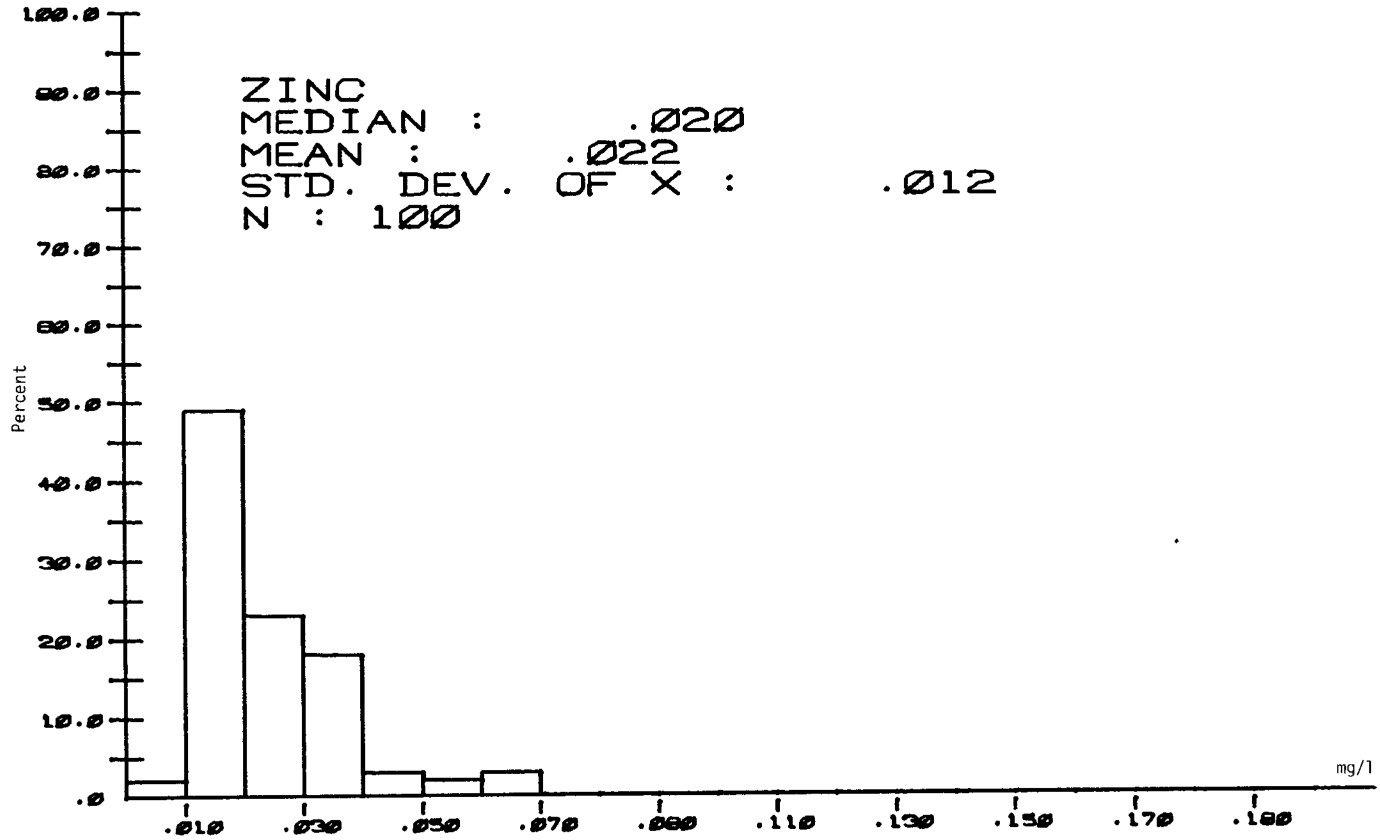

Figure 3.44 Black River Histograms for Zinc

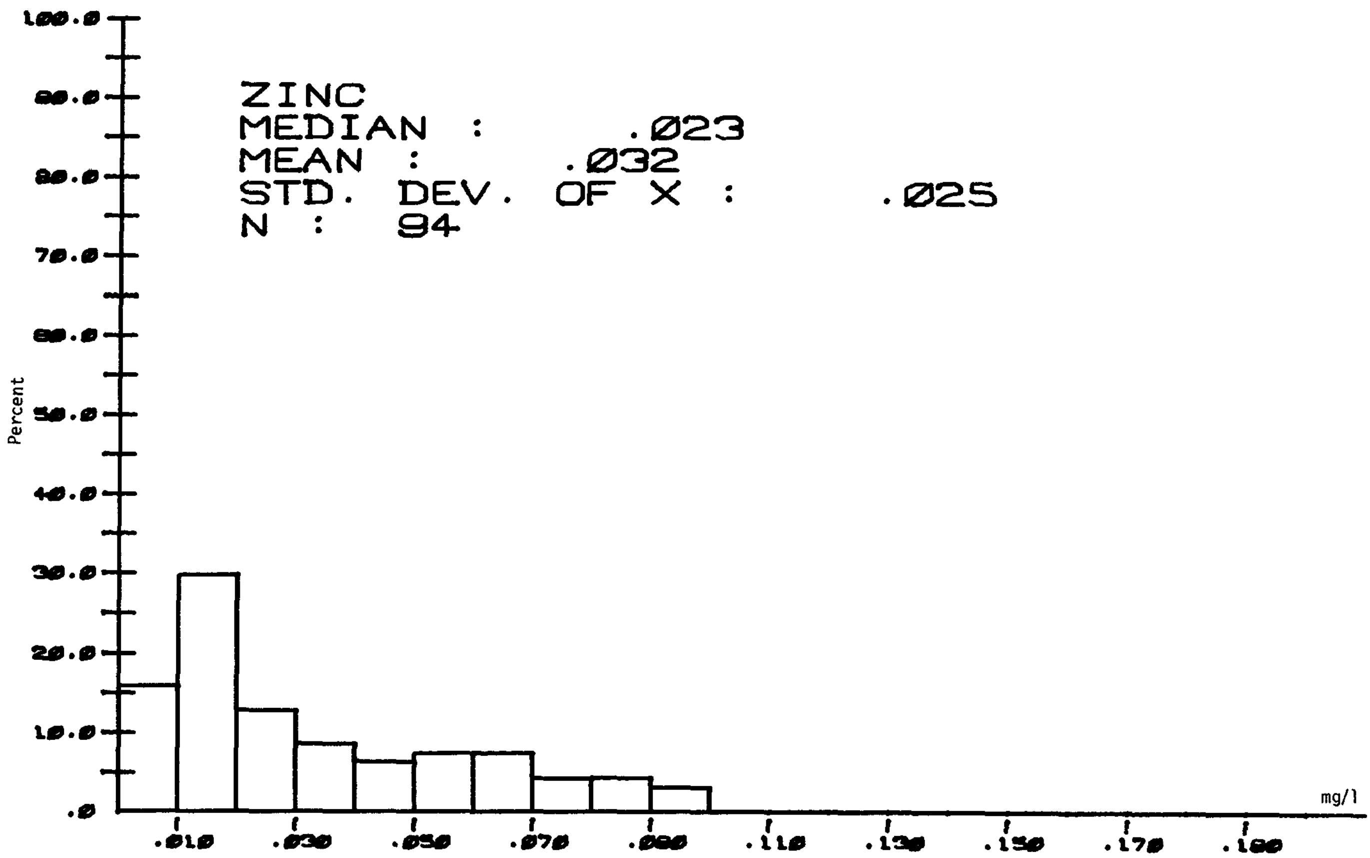

Figure 3.44 St. Lawrence River Histograms for Zinc

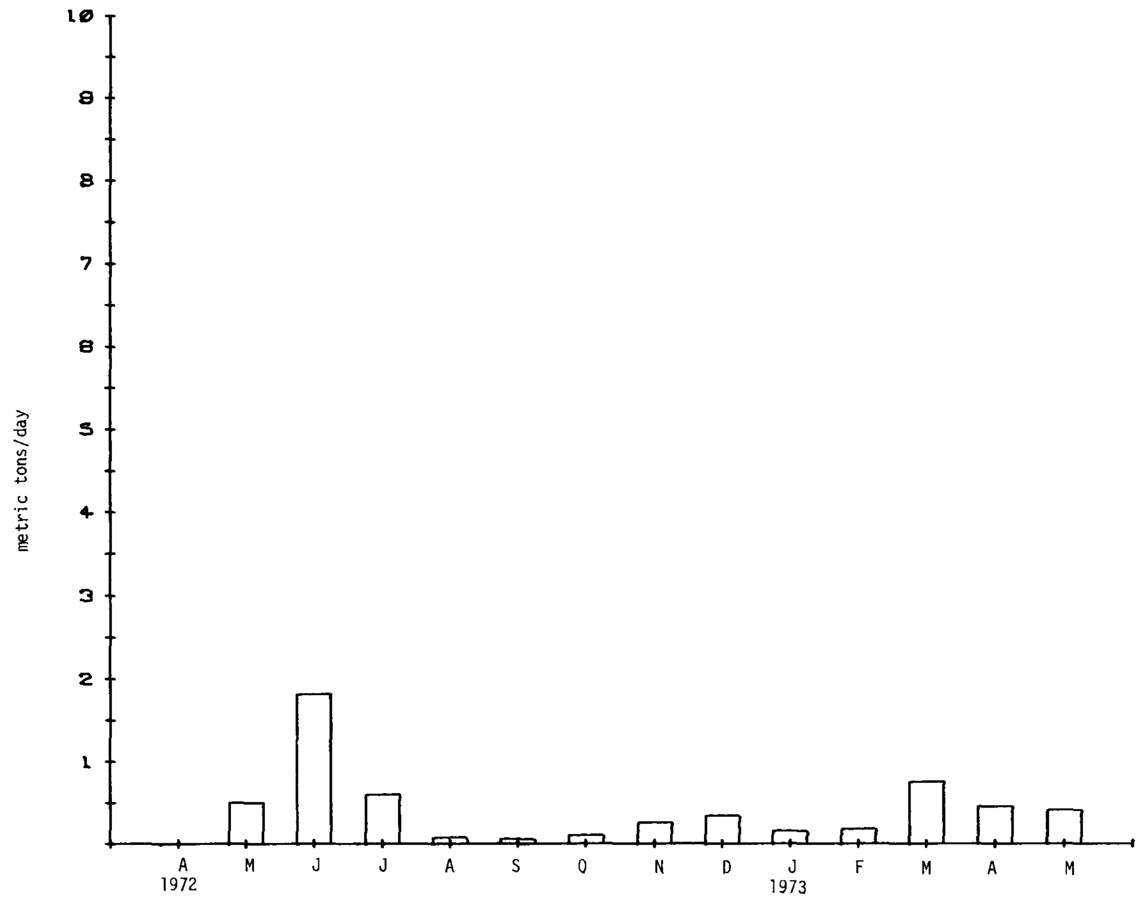

Figure 3.45 Genesee River Monthly Mean Stream Loadings - Lead

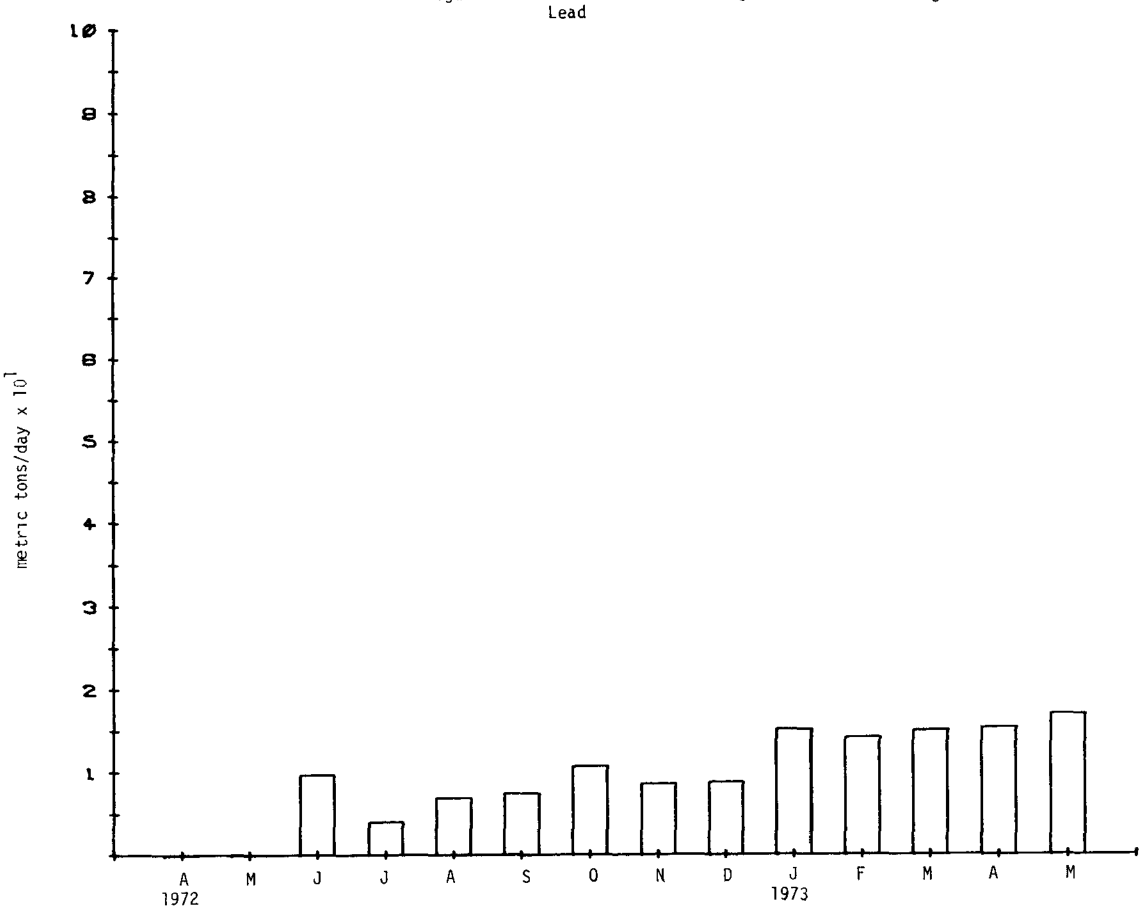

Figure 3.45 Niagara River Monthly Mean Stream Loadings - Lead

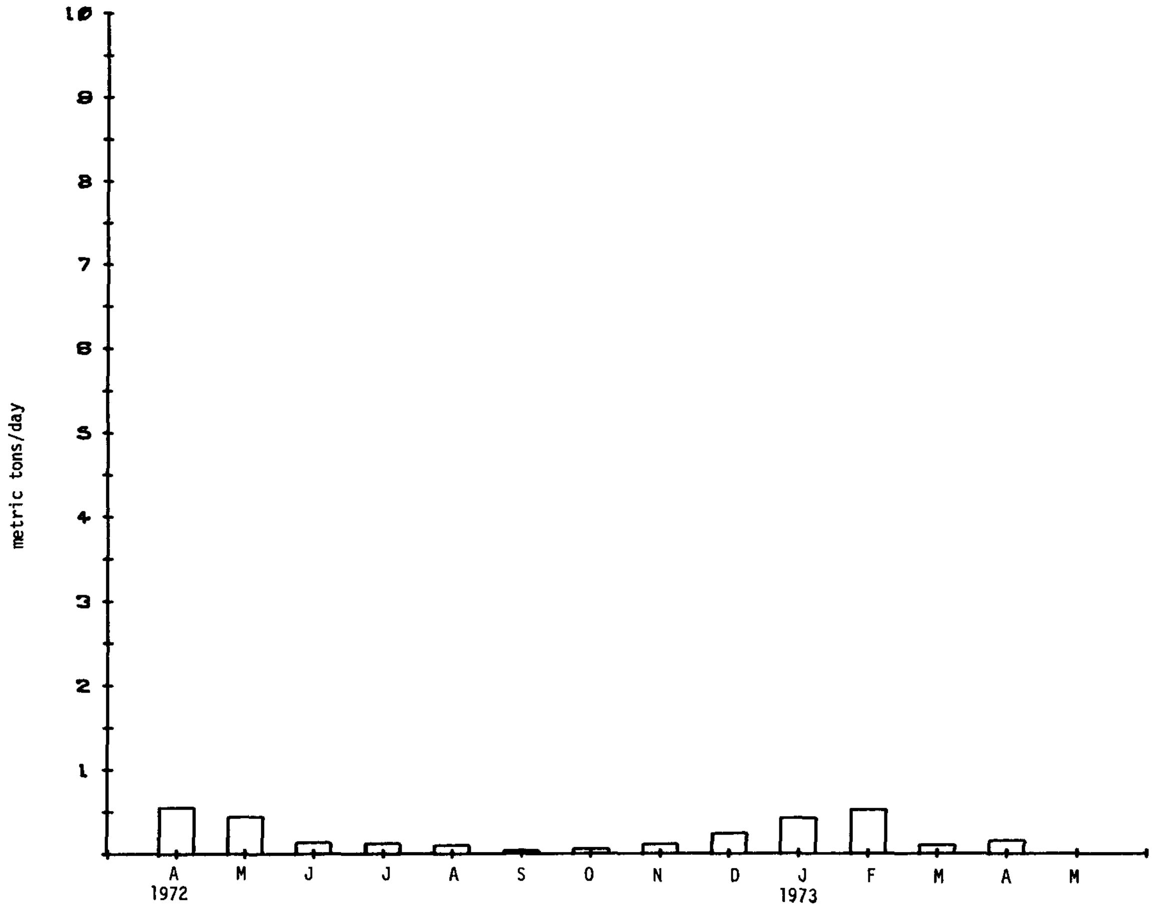

Figure 3.45 Black River Monthly Mean Stream Loadings - Lead

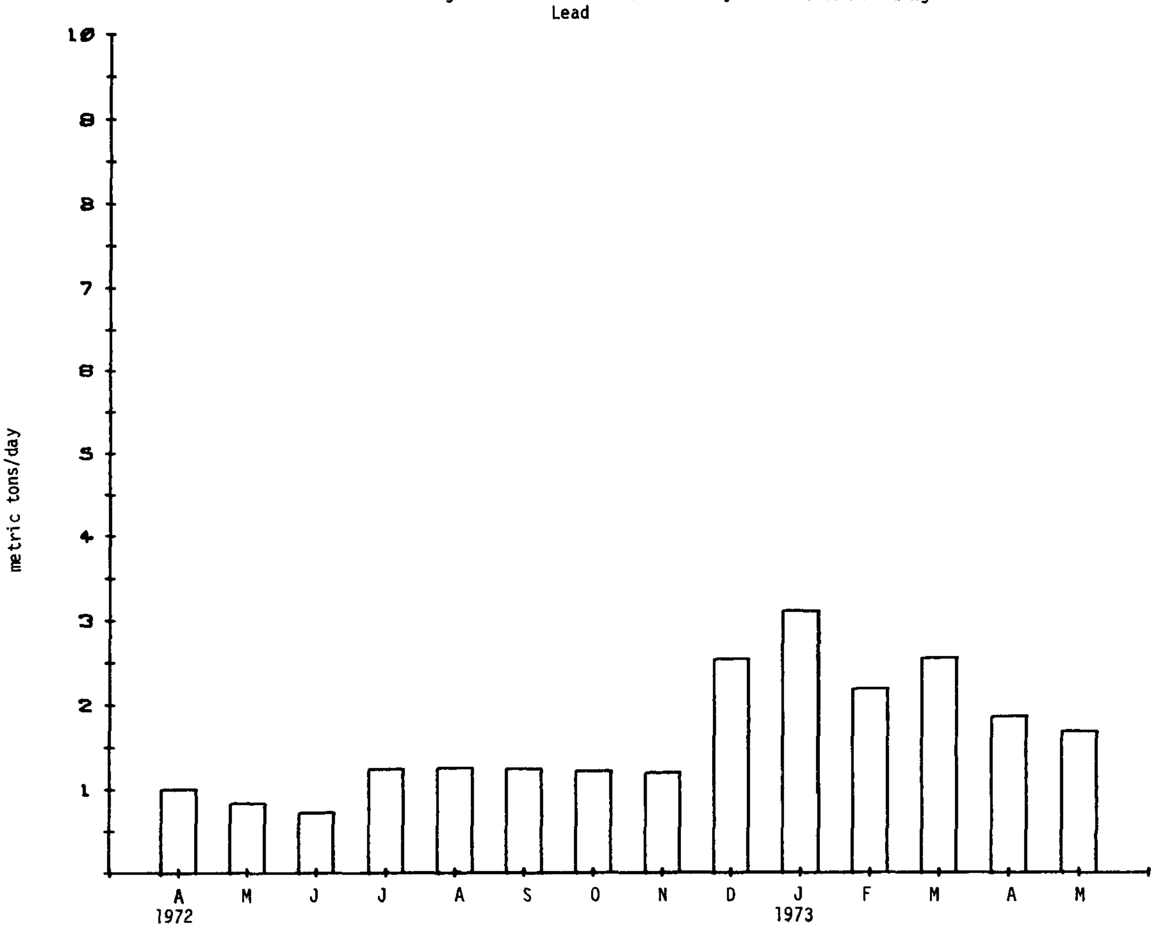

Figure 3.45 Oswego River Monthly Mean Stream Loadings - Lead

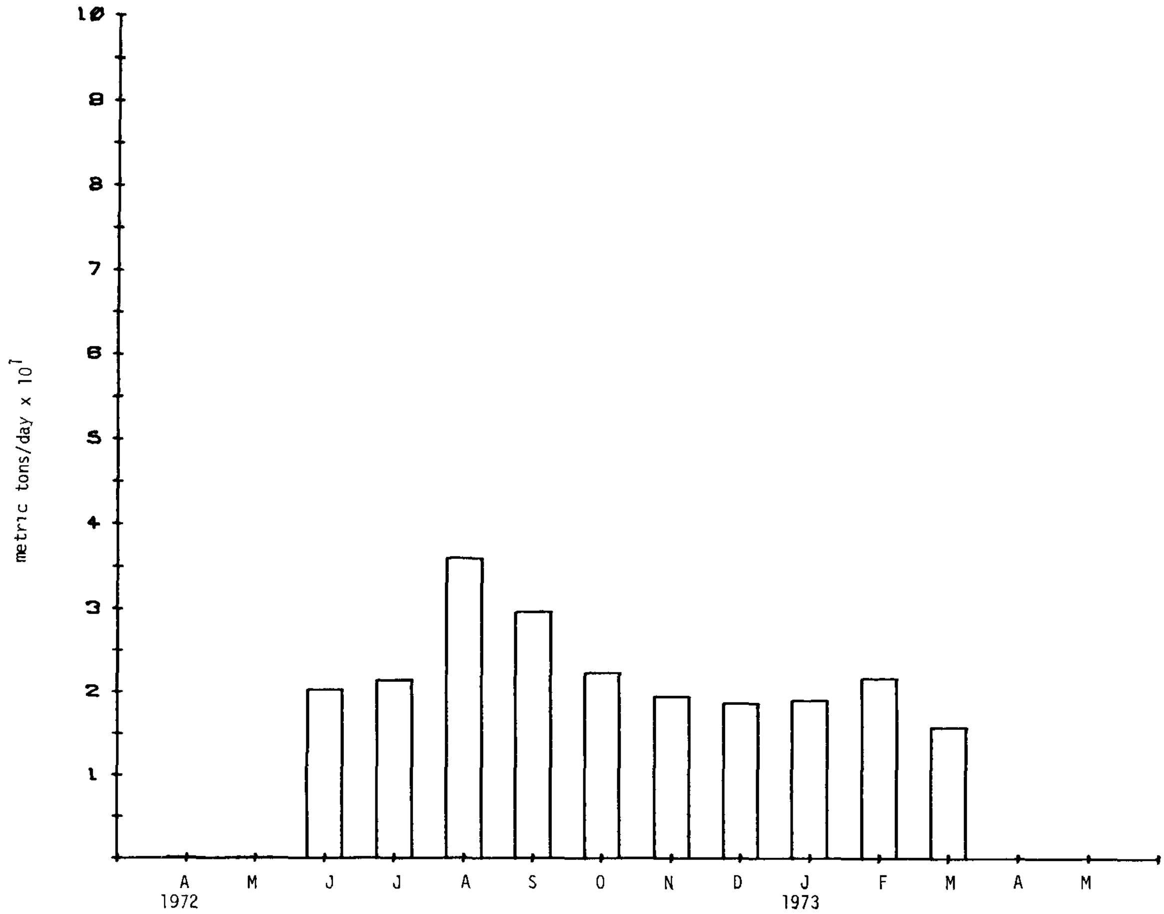

Figure 3.45 St. Lawrence River Monthly Mean Stream Loadings - Lead

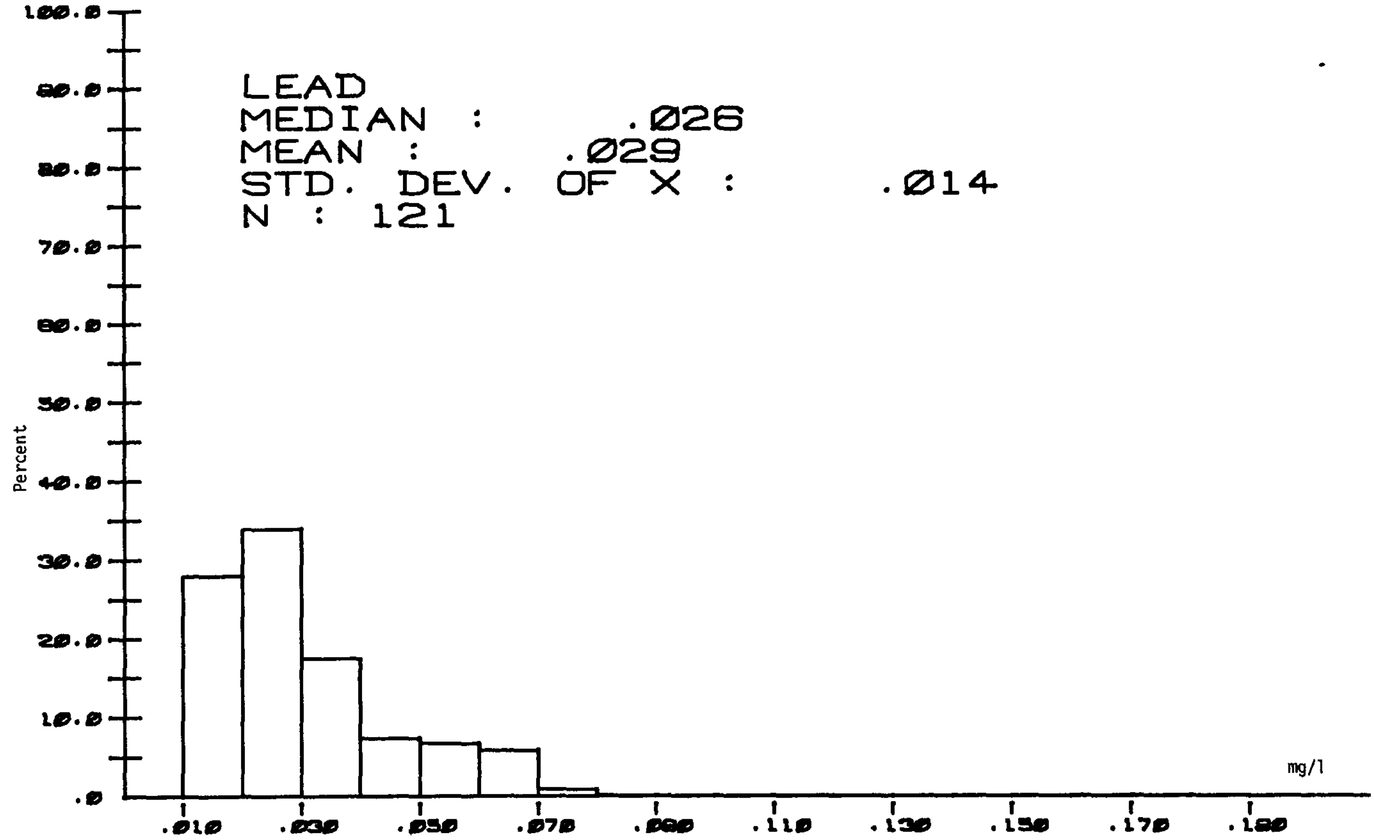

Figure 3.46 Genesee River Histograms for Lead

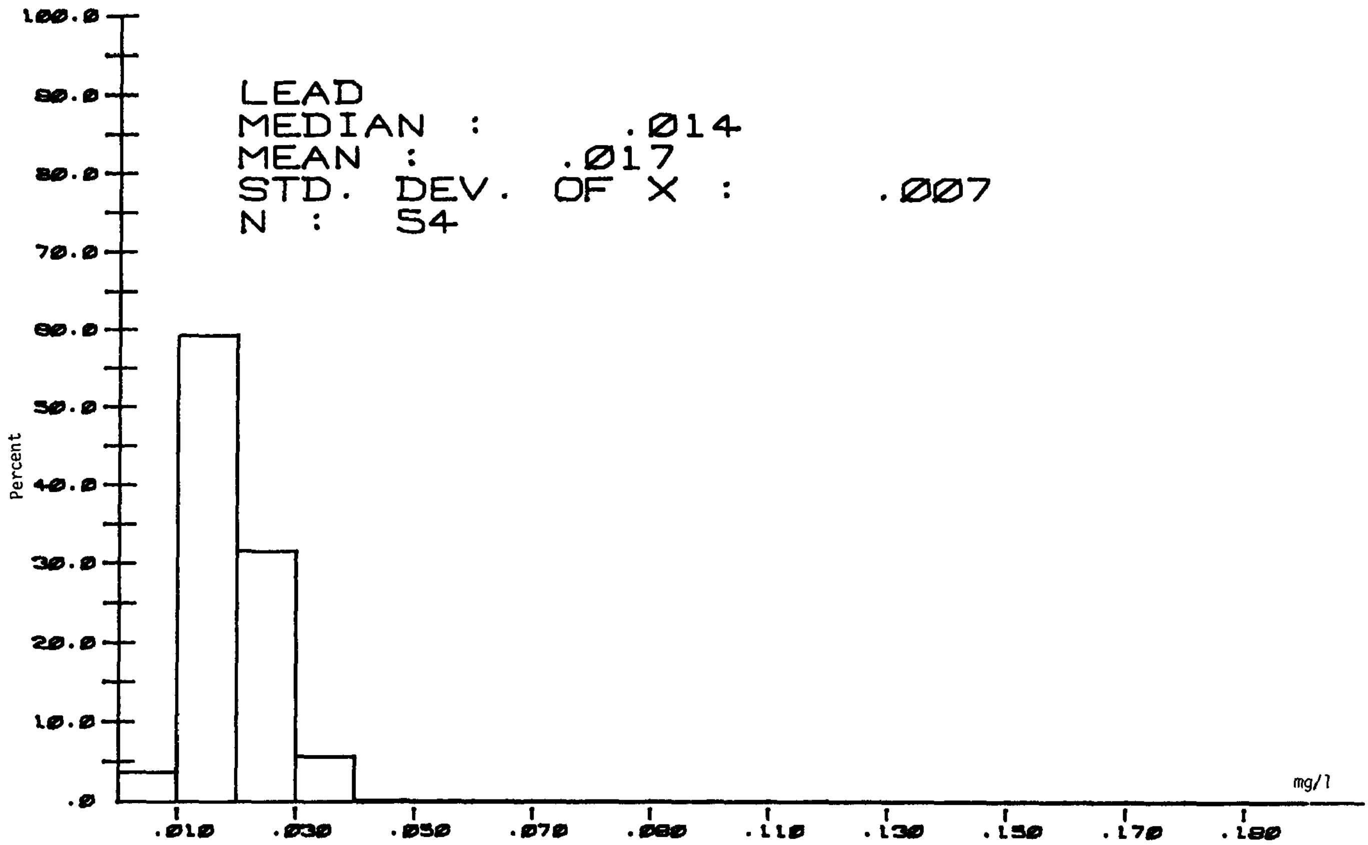

Figure 3.46 Niagara River Histograms for Lead

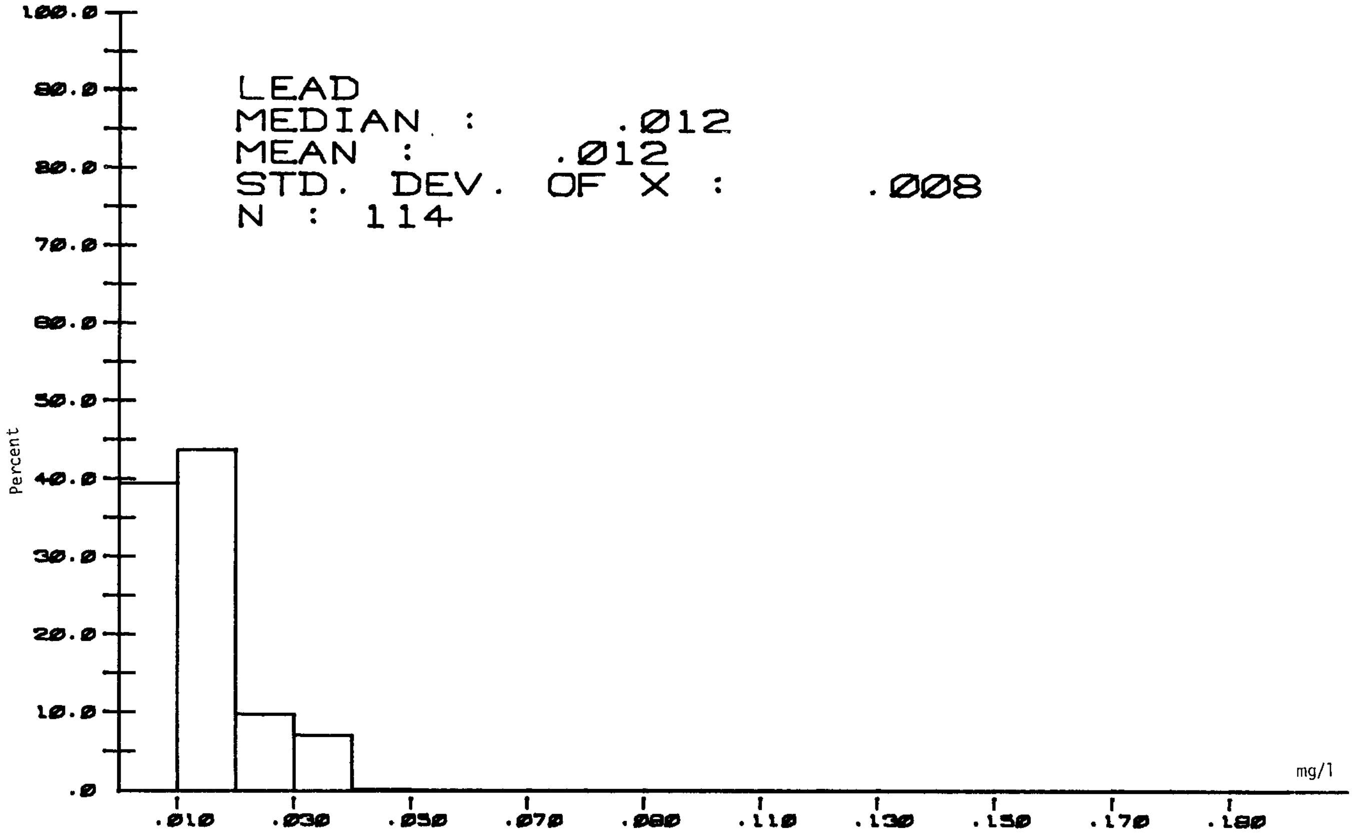

Figure 3.46 Black River Histograms for Lead

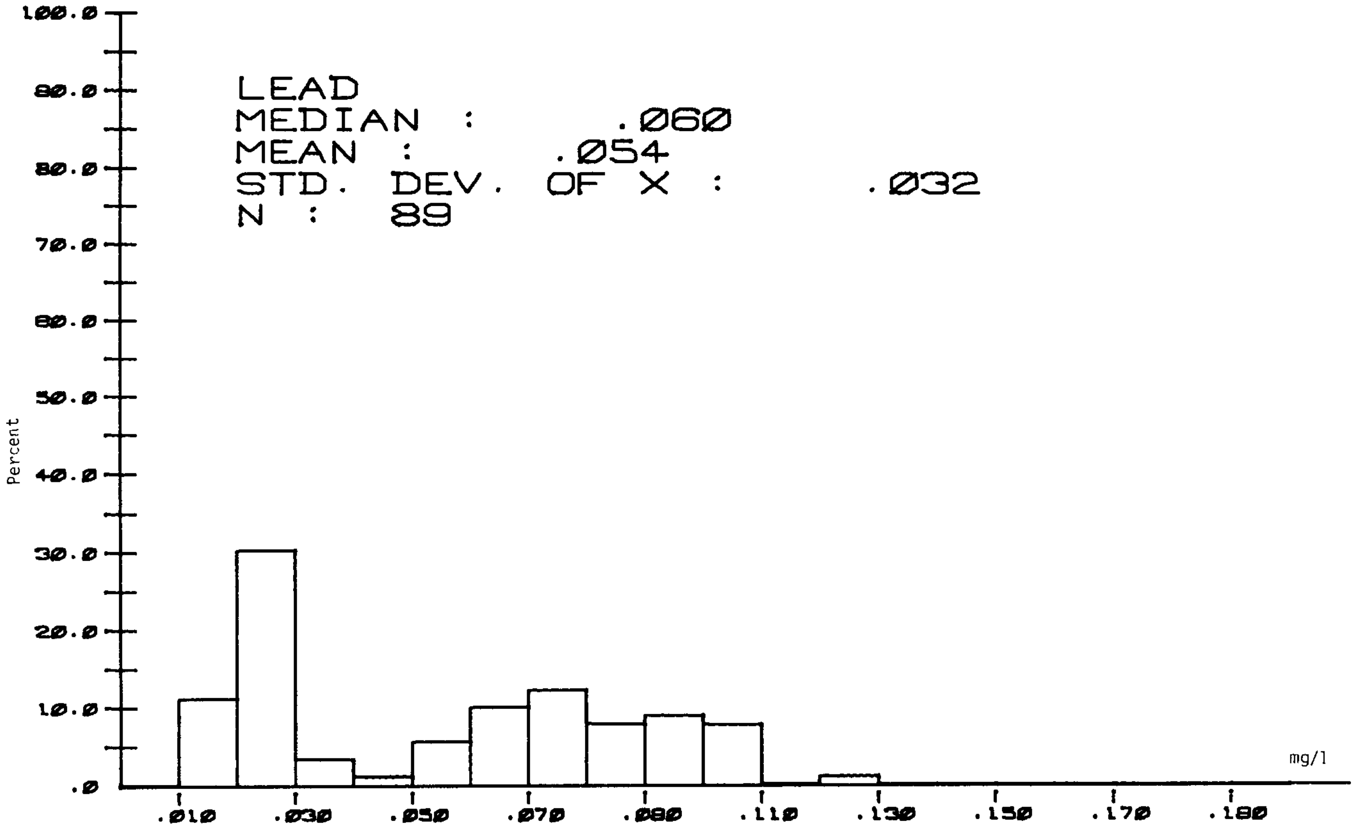

Figure 3.46 Oswego River Histograms for Lead

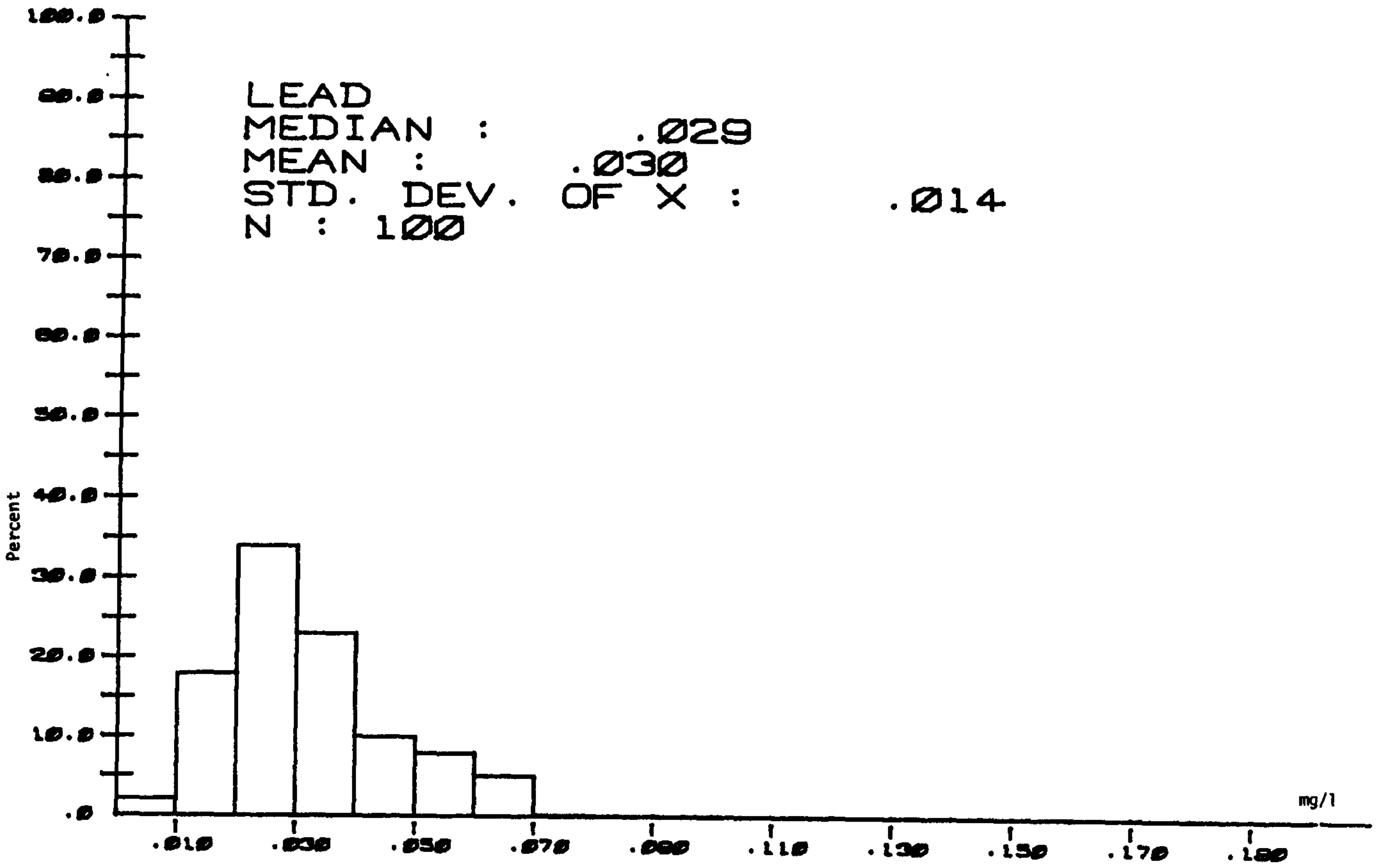

Figure 3.46 St. Lawrence River Histograms for Lead

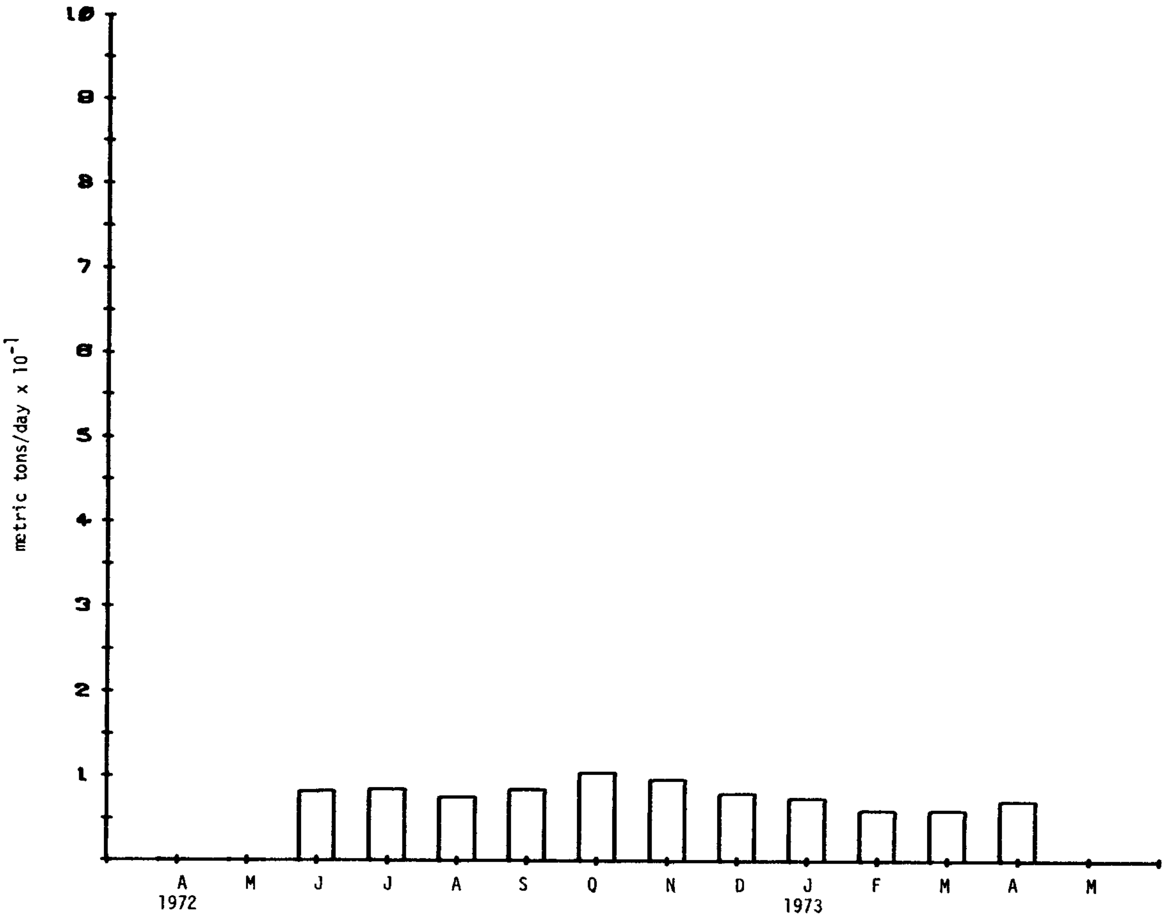

Figure 3.47 Niagara River Monthly Mean Stream Loadings - Cadmium

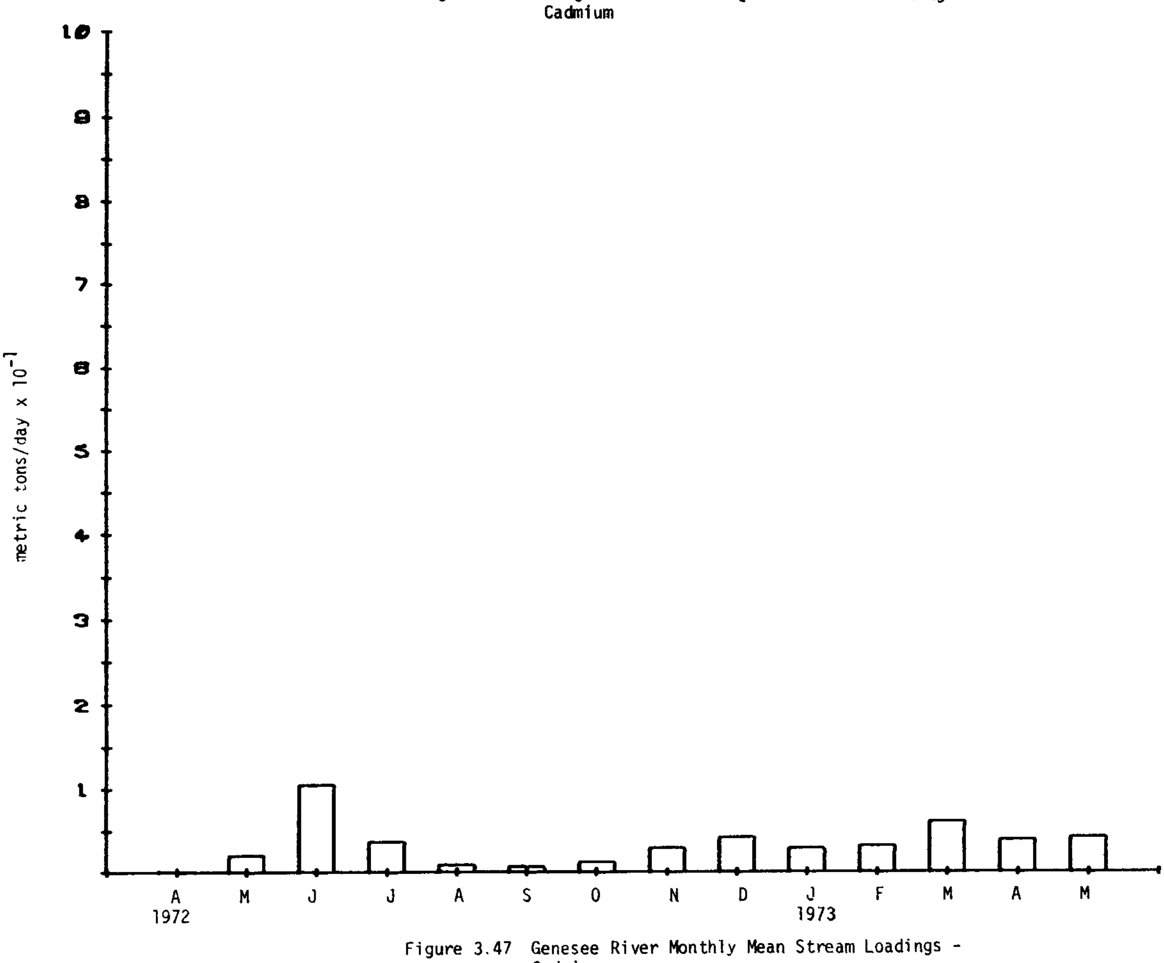

Figure 3.47 Genesee River Monthly Mean Stream Loadings - Cadmium

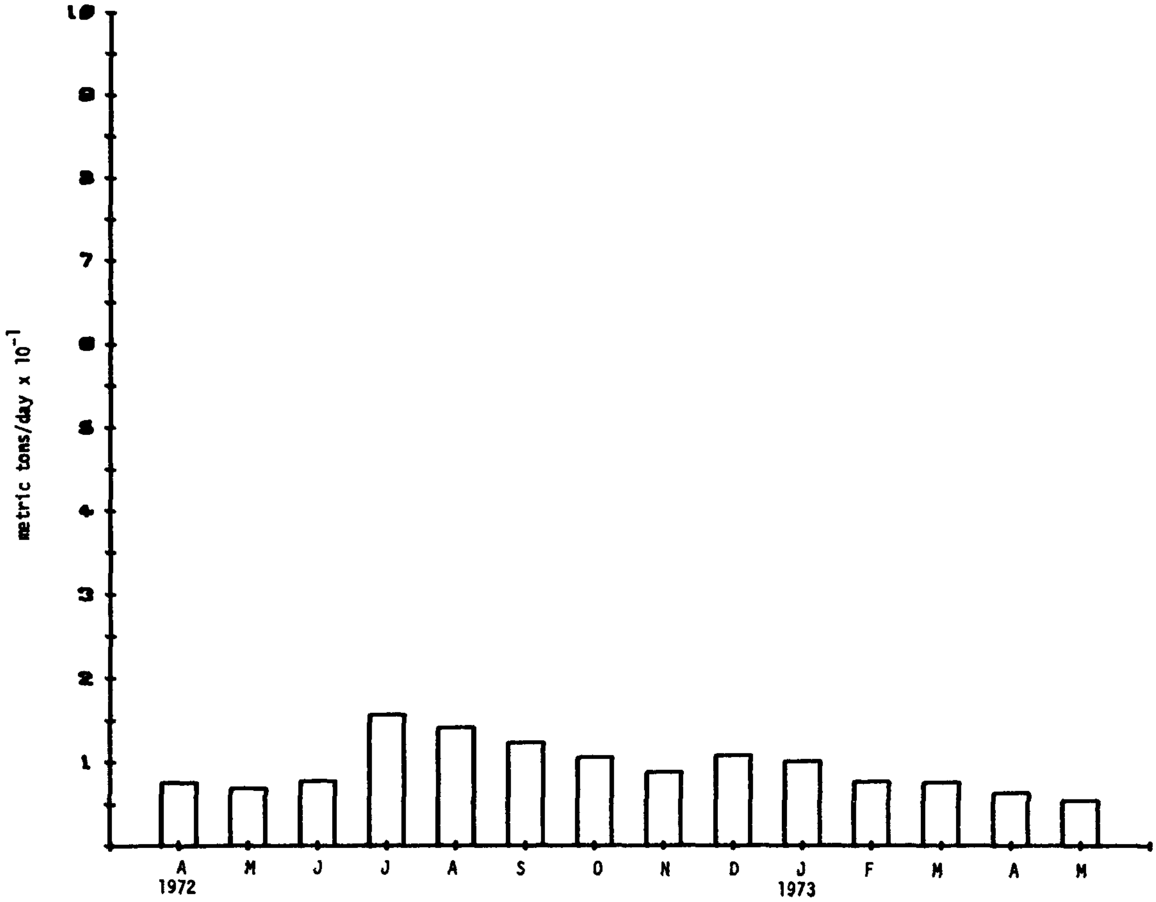

Figure 3.47 Oswego River Monthly Mean Stream Loadings - Cadmium

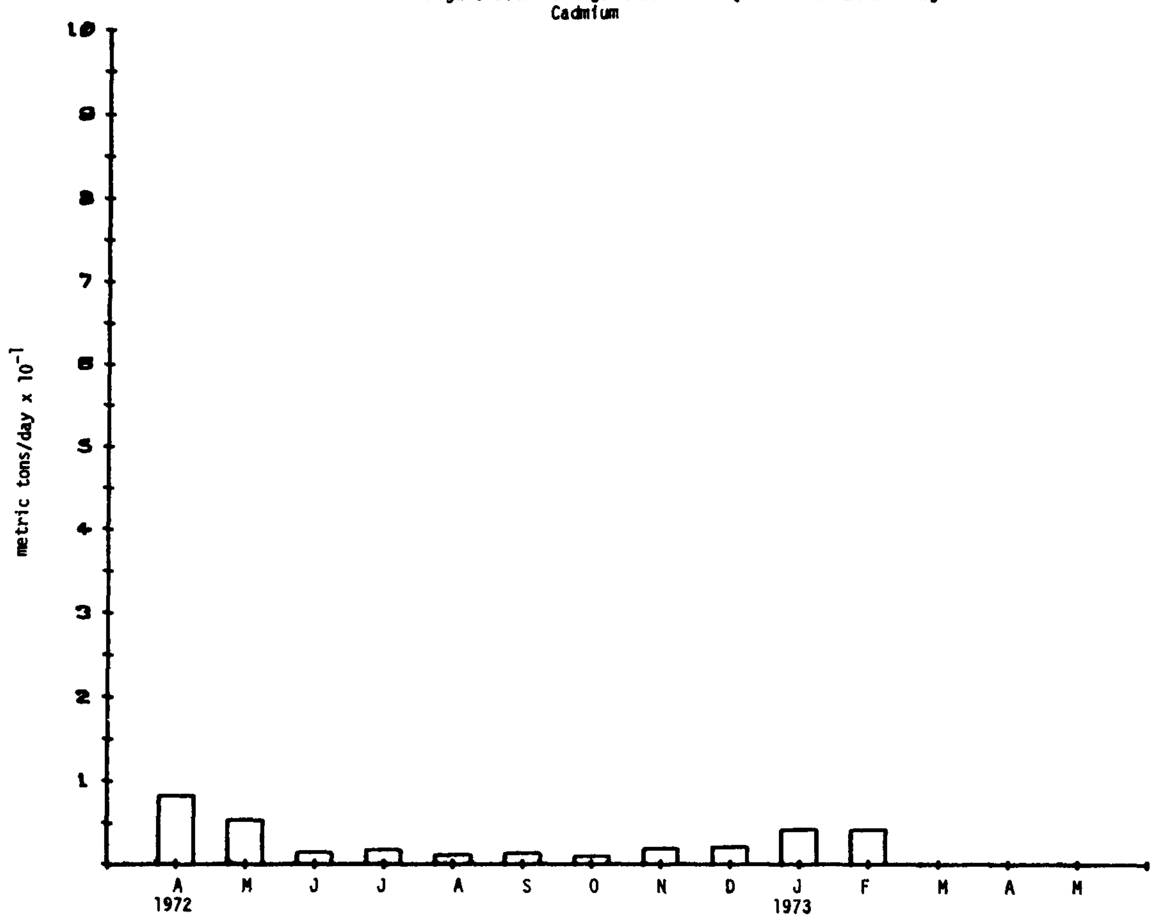

Figure 3.47 Black River Monthly Mean Stream Loadings - Cadmium

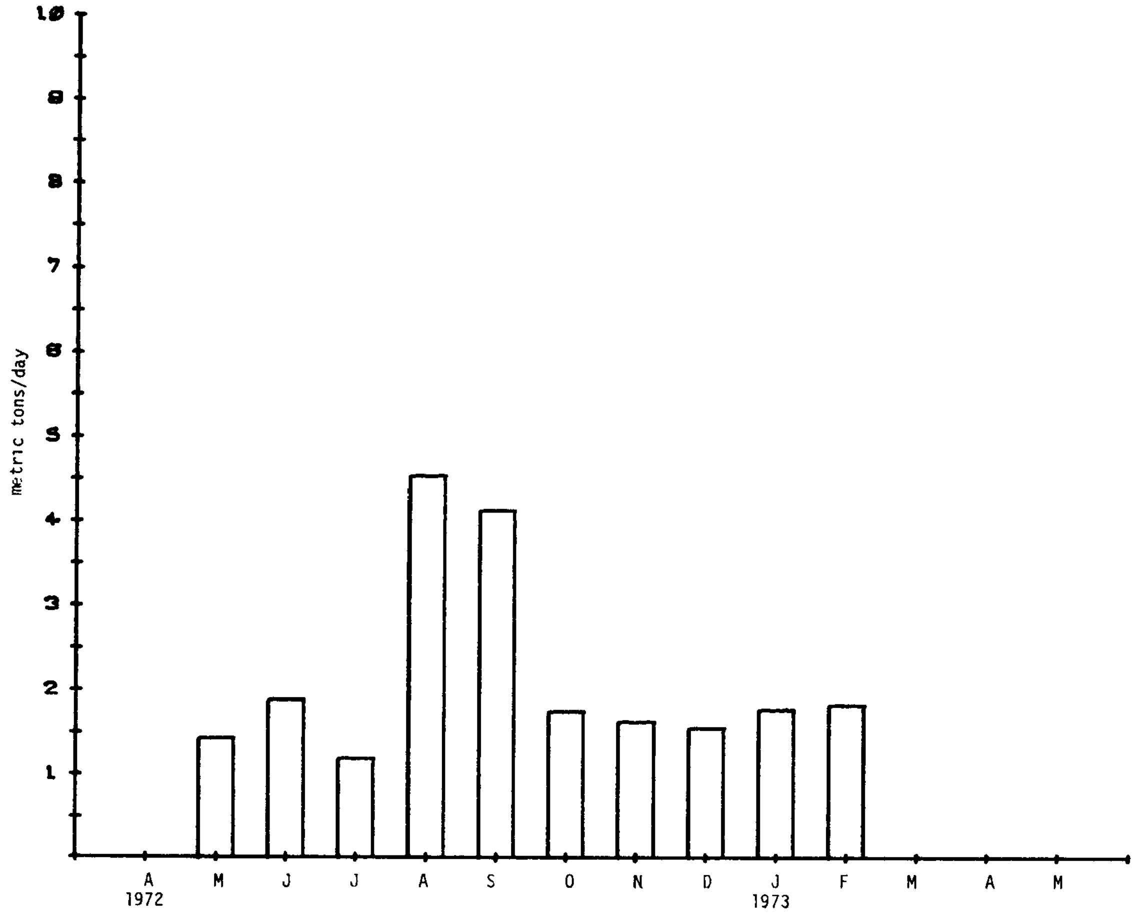

Figure 3.47 St. Lawrence River Monthly Mean Stream Loadings - Cadmium

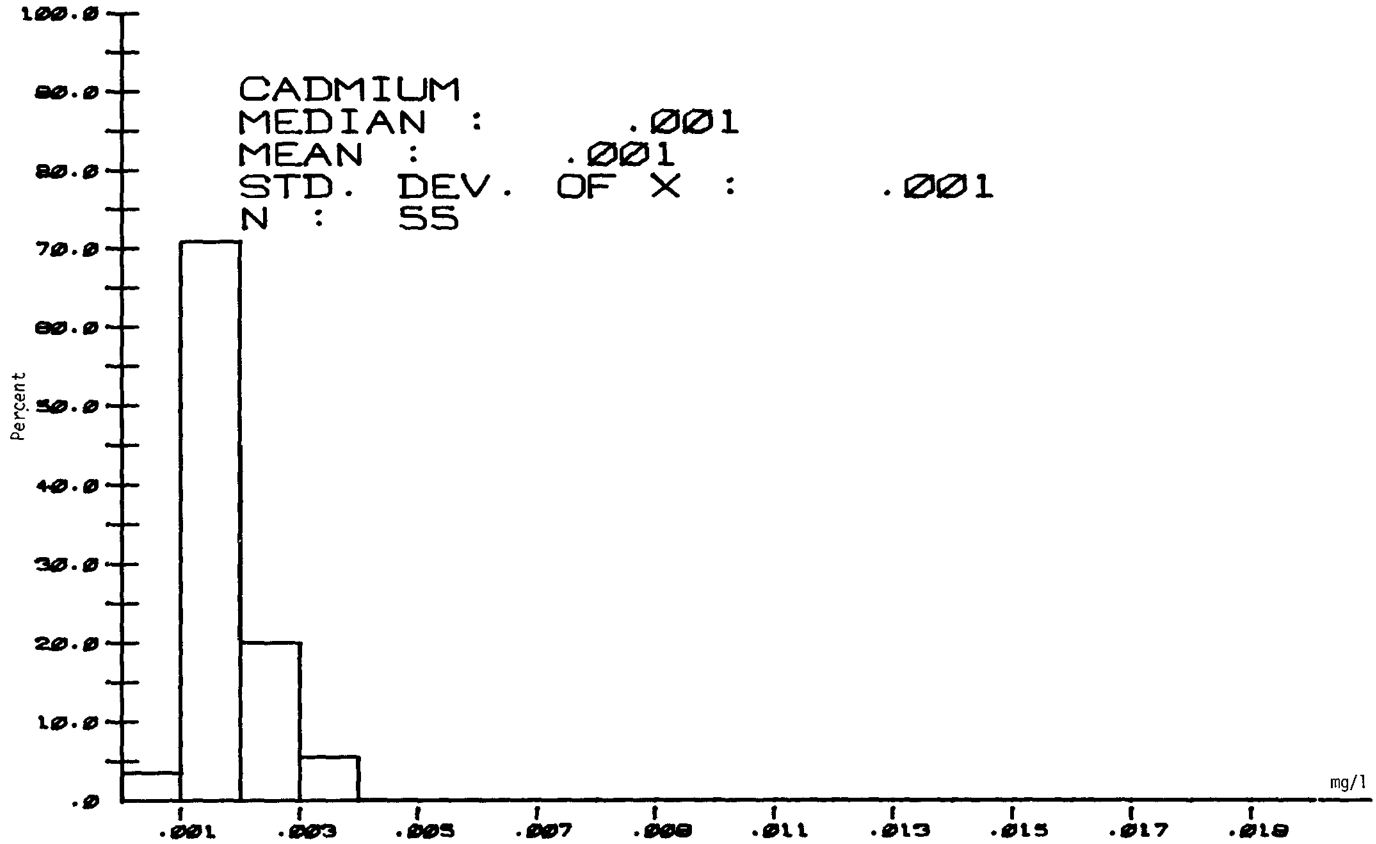

Figure 3.48 Niagara River Histograms for Cadmium

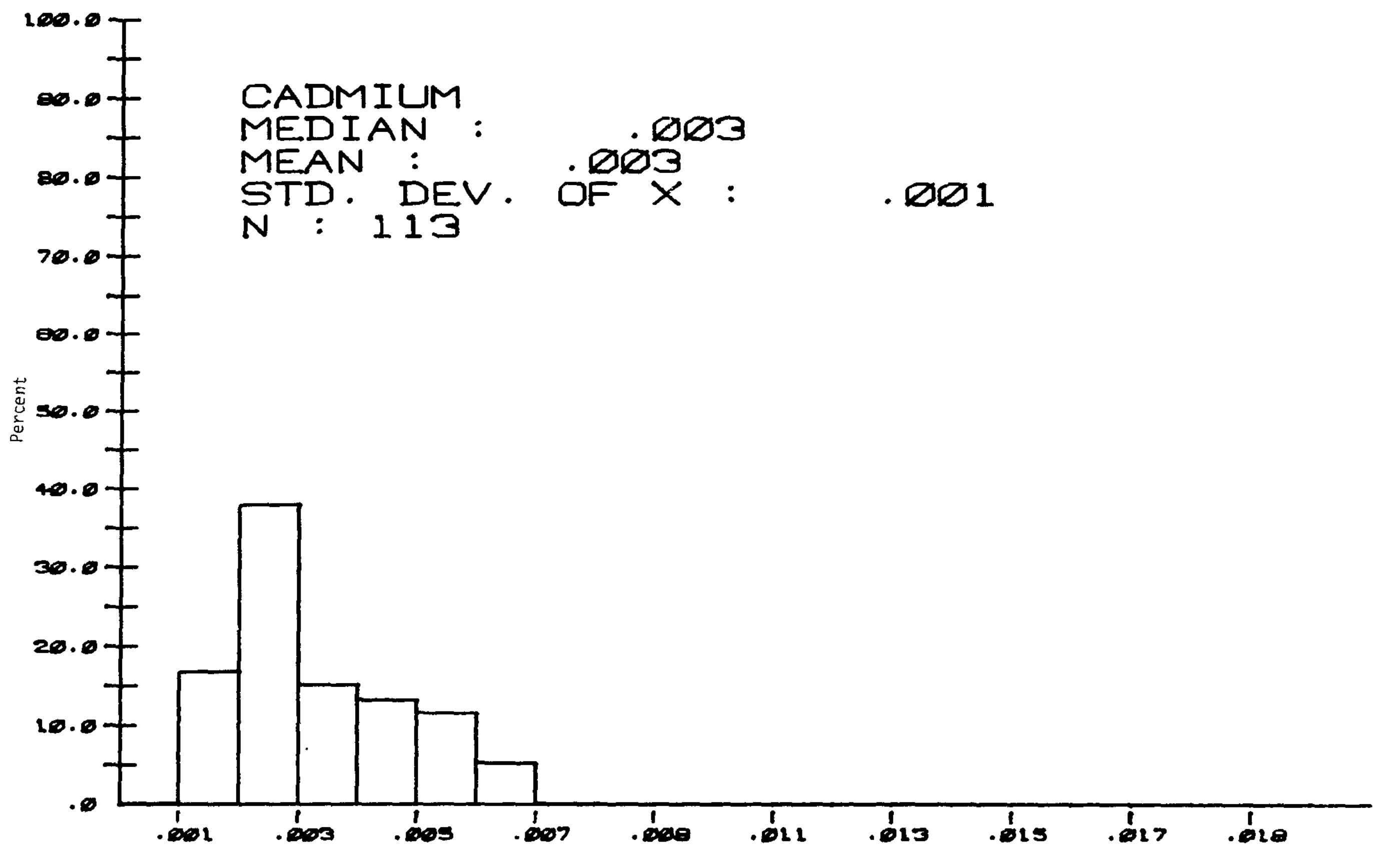

Figure 3.48 Genesee River Histograms for Cadmium

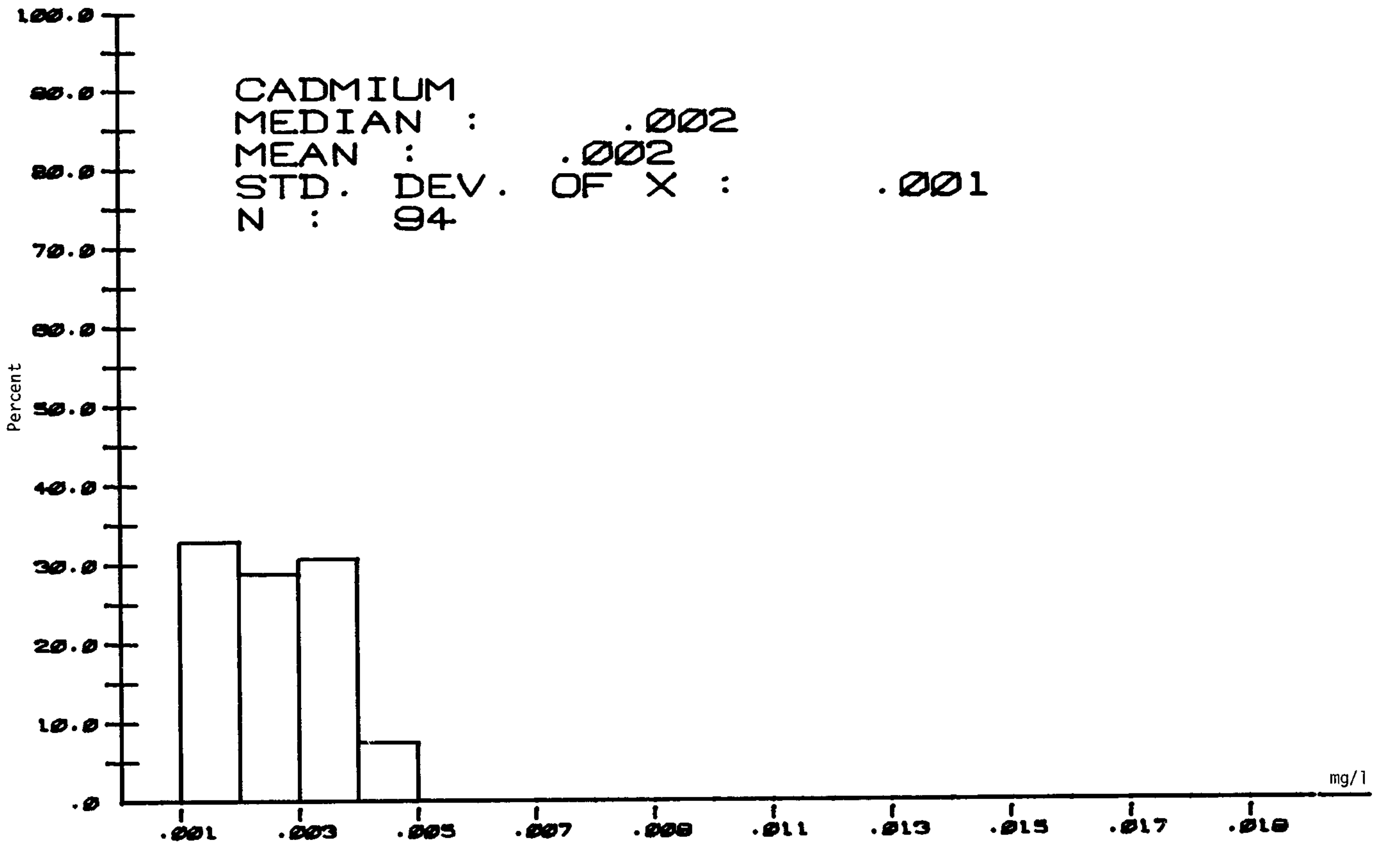

Figure 3.48 Oswego River Histograms for Cadmium

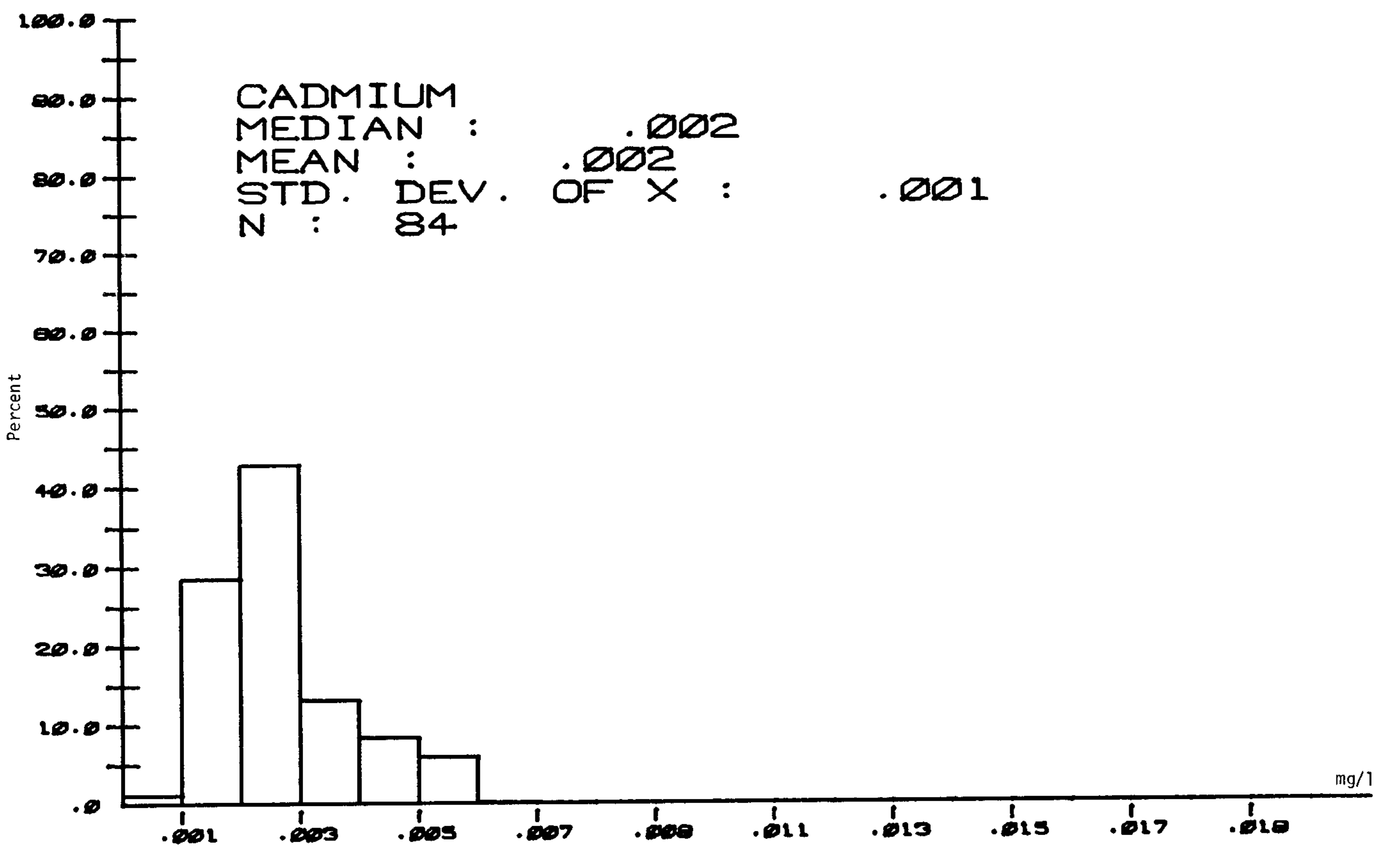

Figure 3.48 Black River Histograms for Cadmium

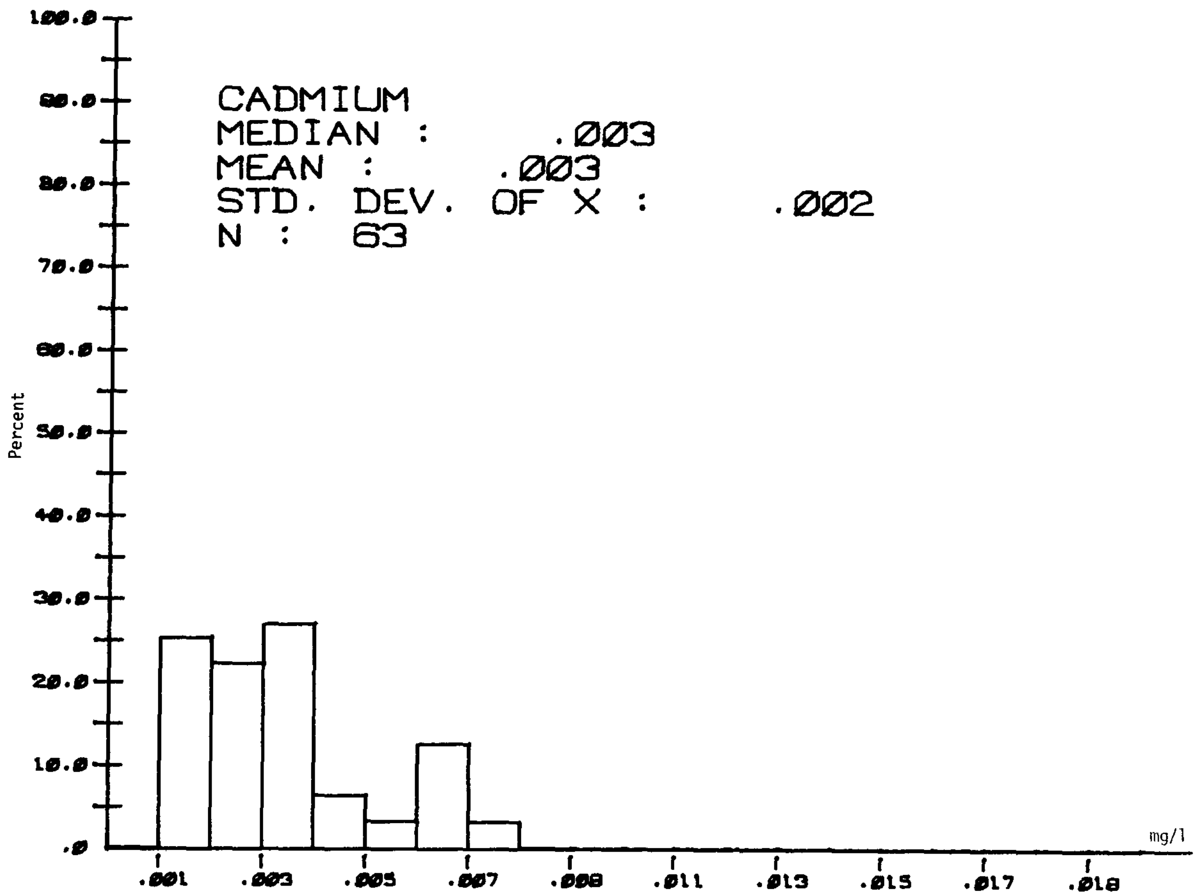

Figure 3.48 St. Lawrence River Histograms for Cadmium

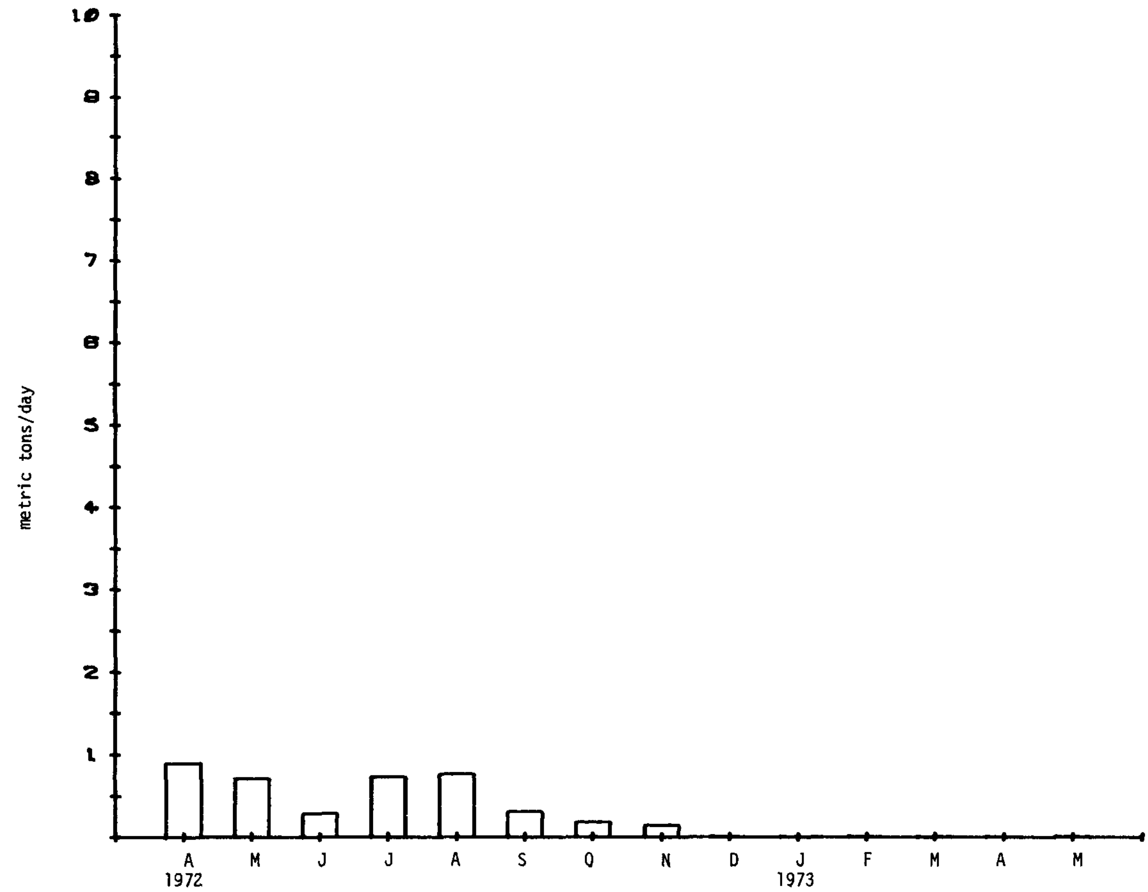

Figure 3.49 Niagara River Monthly Mean Stream Loadings - Mercury

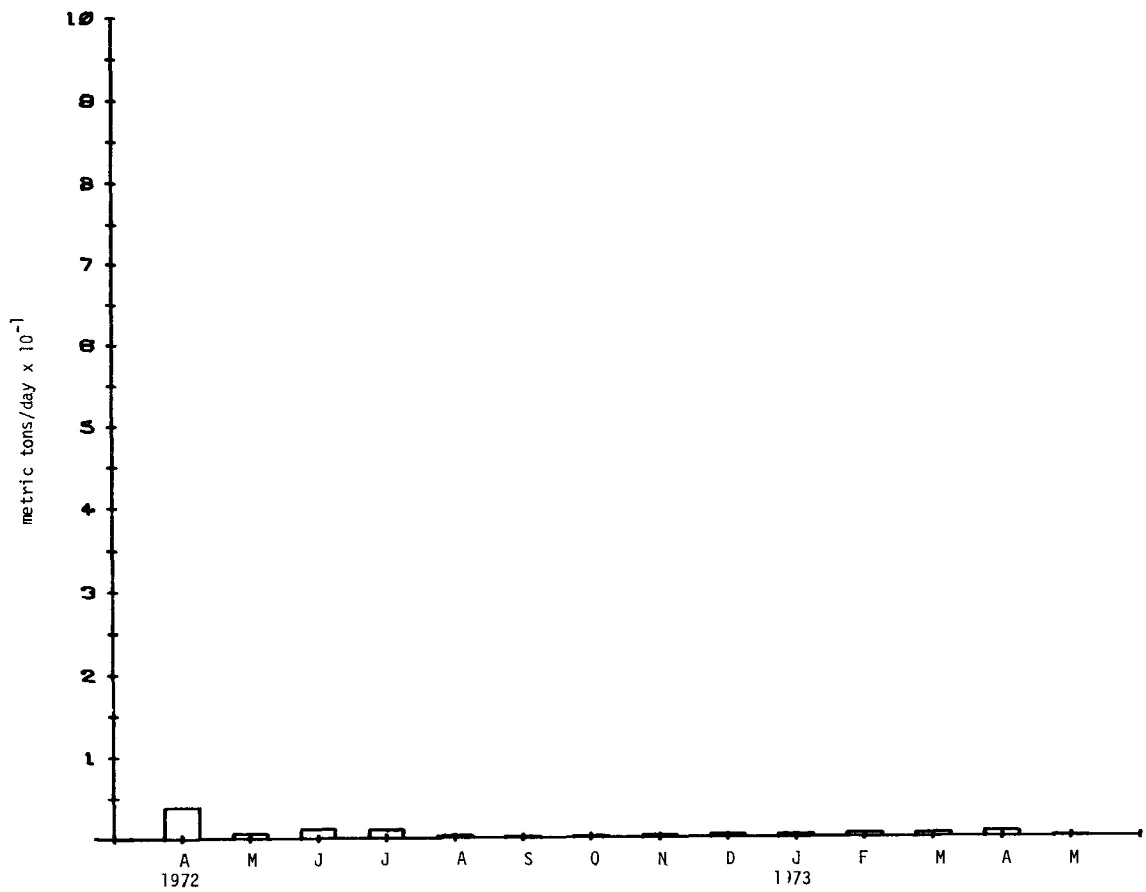

Figure 3.49 Genesee River Monthly Mean Stream Loadings - Mercury

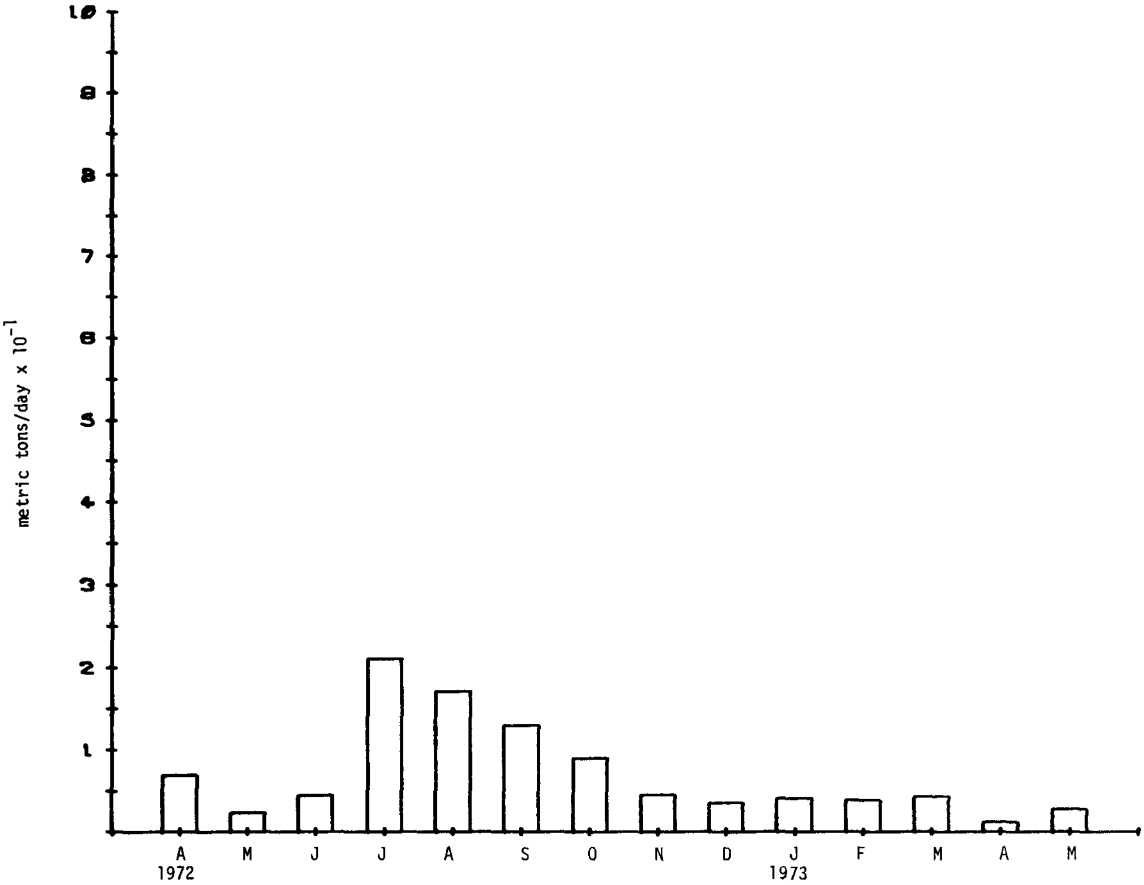

Figure 3.49 Oswego River Monthly Mean Stream Loadings - Mercury

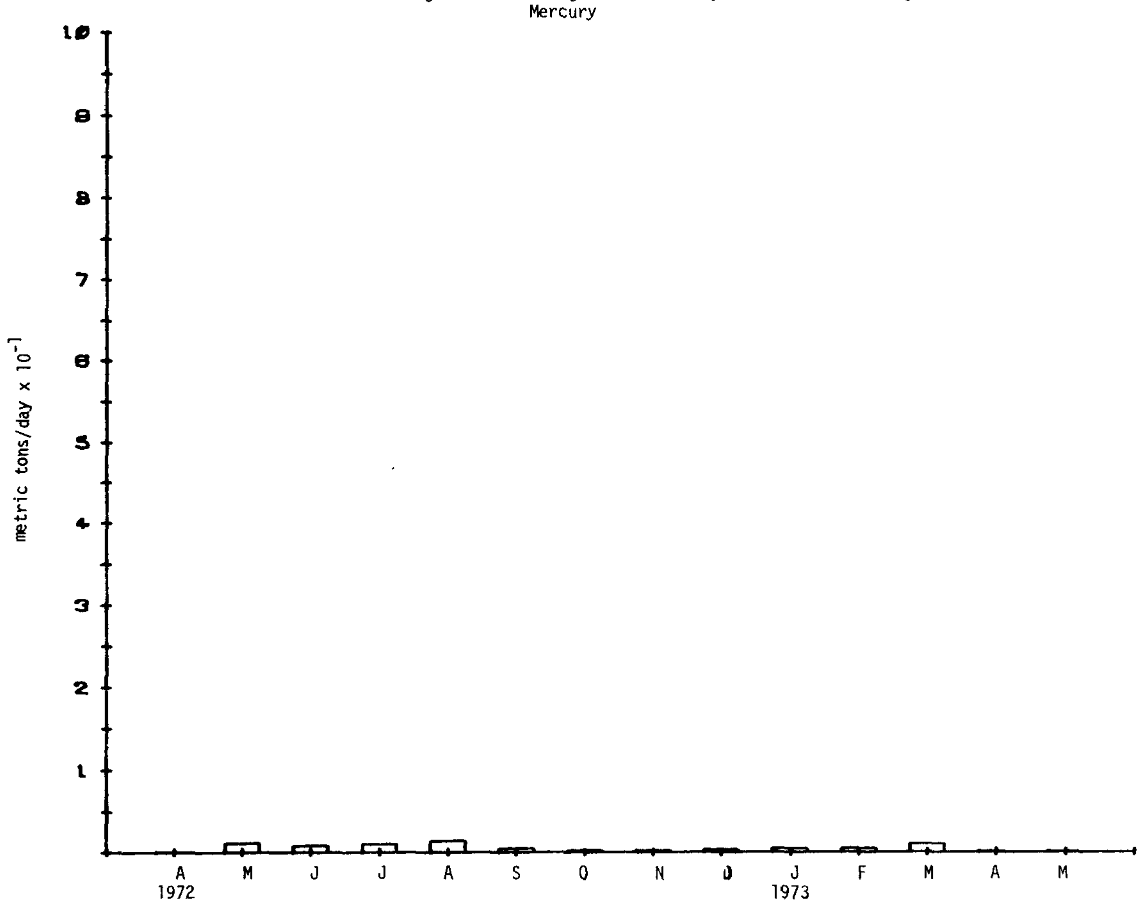

Figure 3.49 Black River Monthly Mean Stream Loadings - Mercury

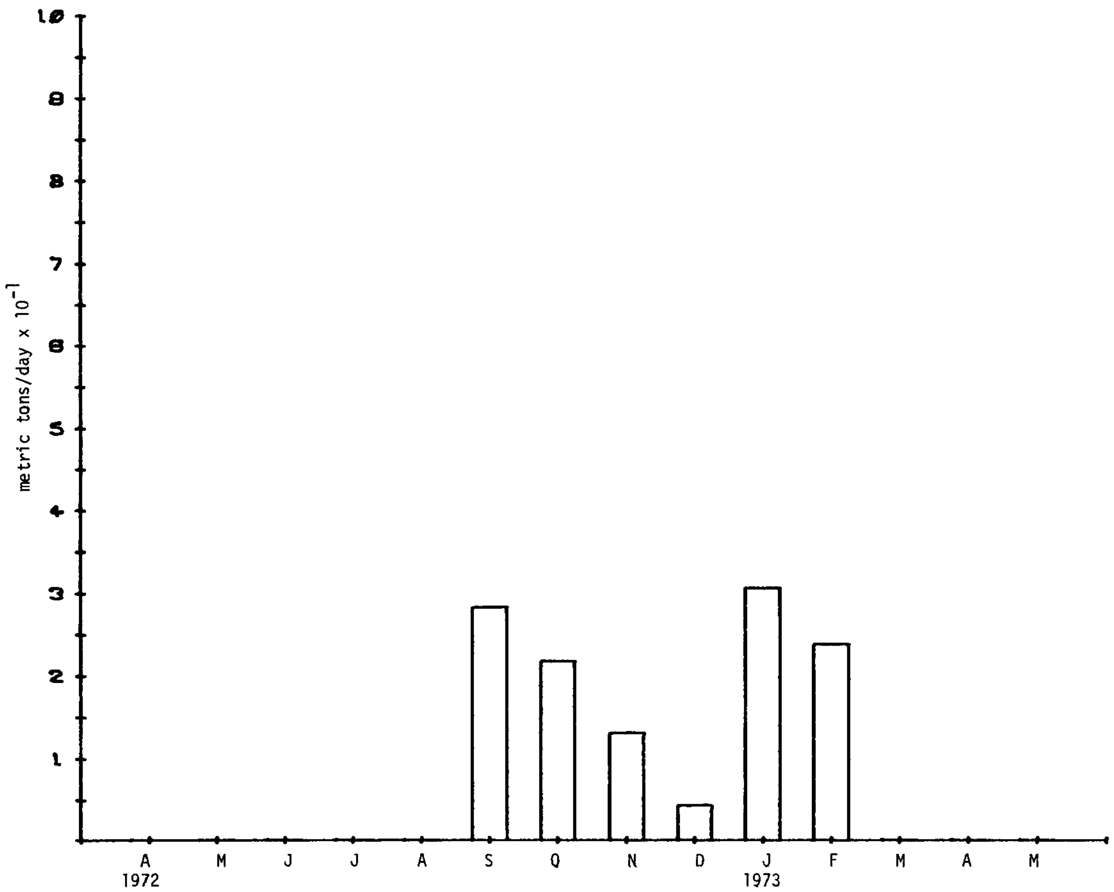

Figure 3.49 St. Lawrence River Monthly Mean Stream Loadings - Mercury

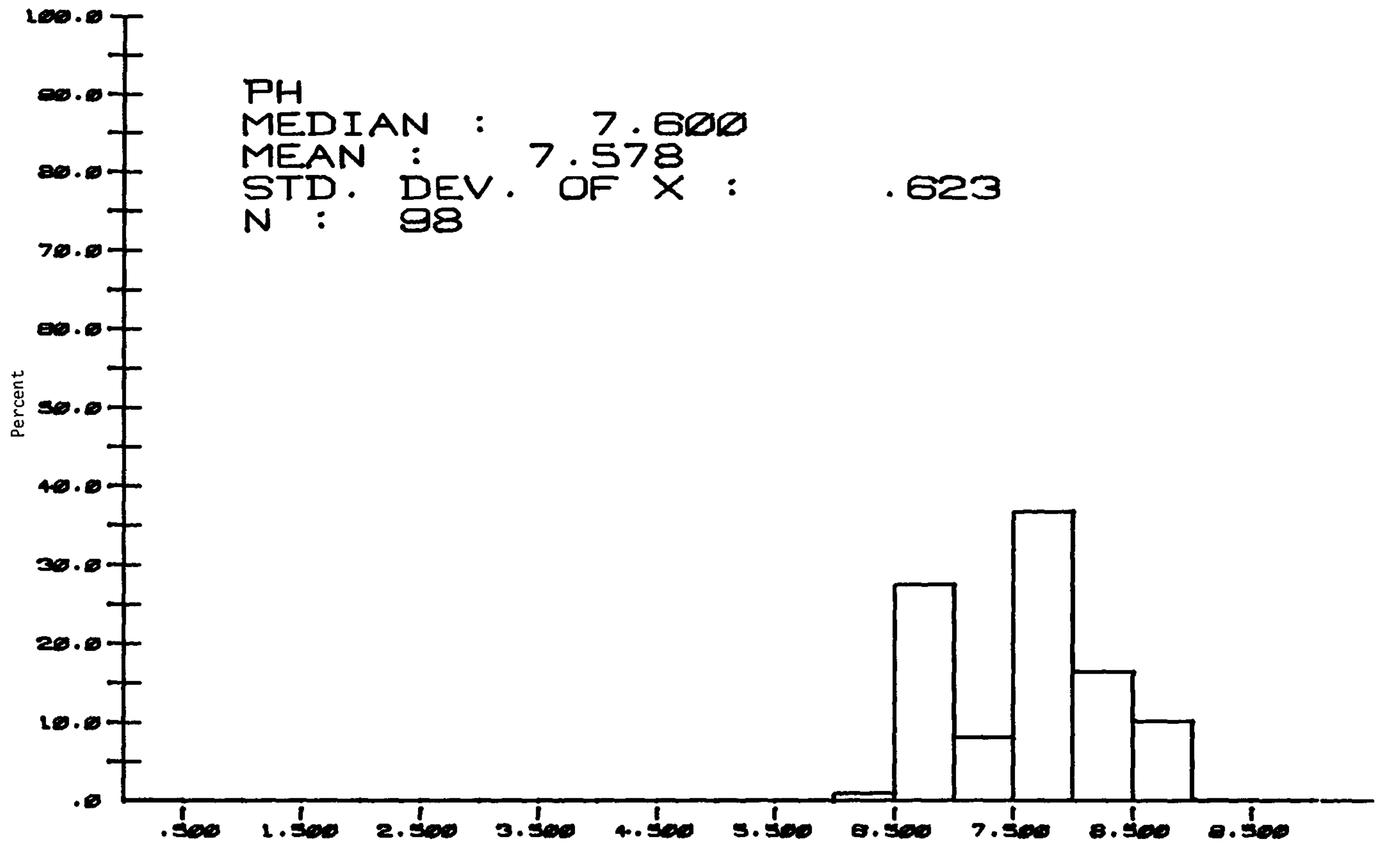

Figure 3.50 Niagara River Histograms for pH

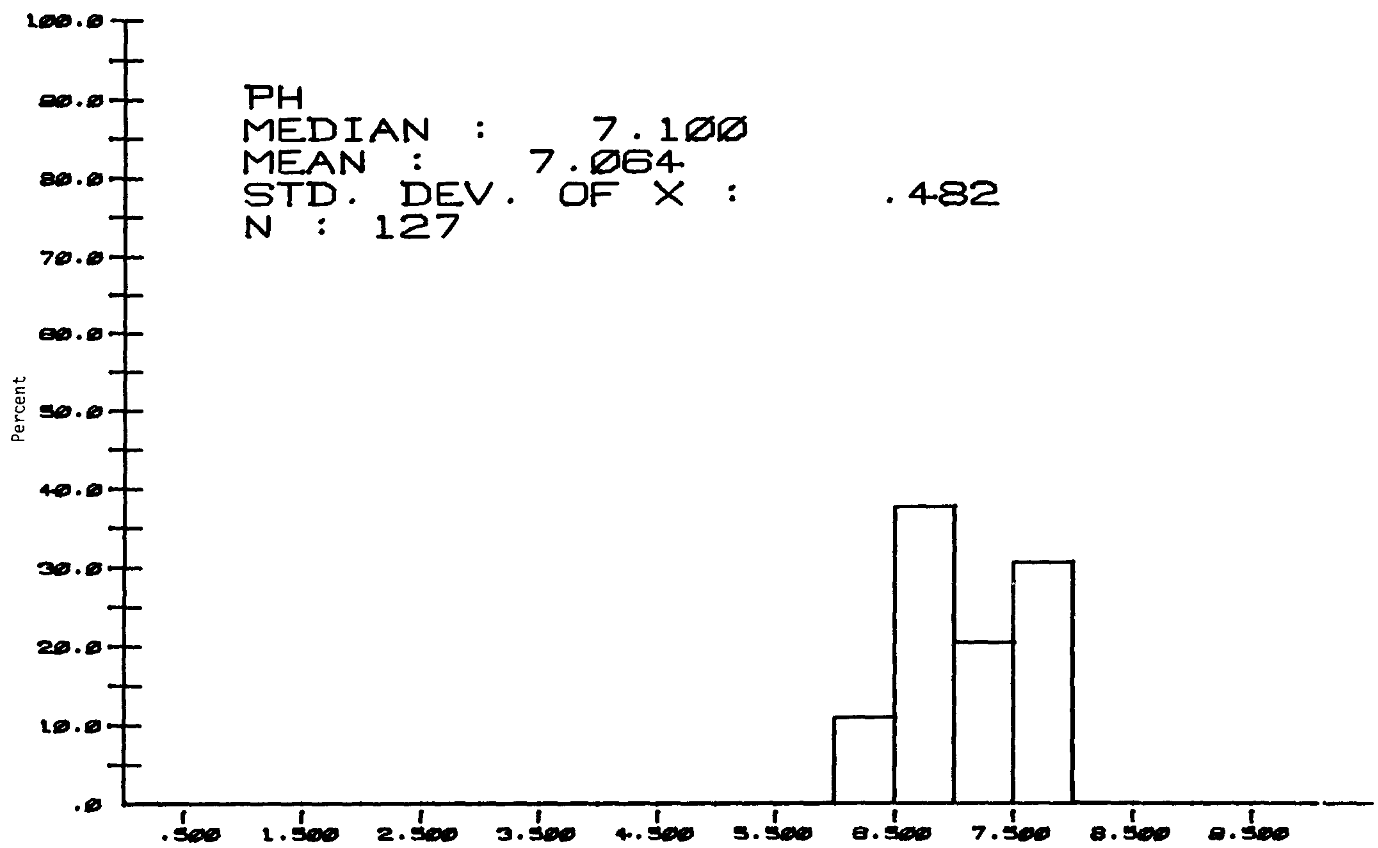

Figure 3.50 Genesee River Histograms for pH

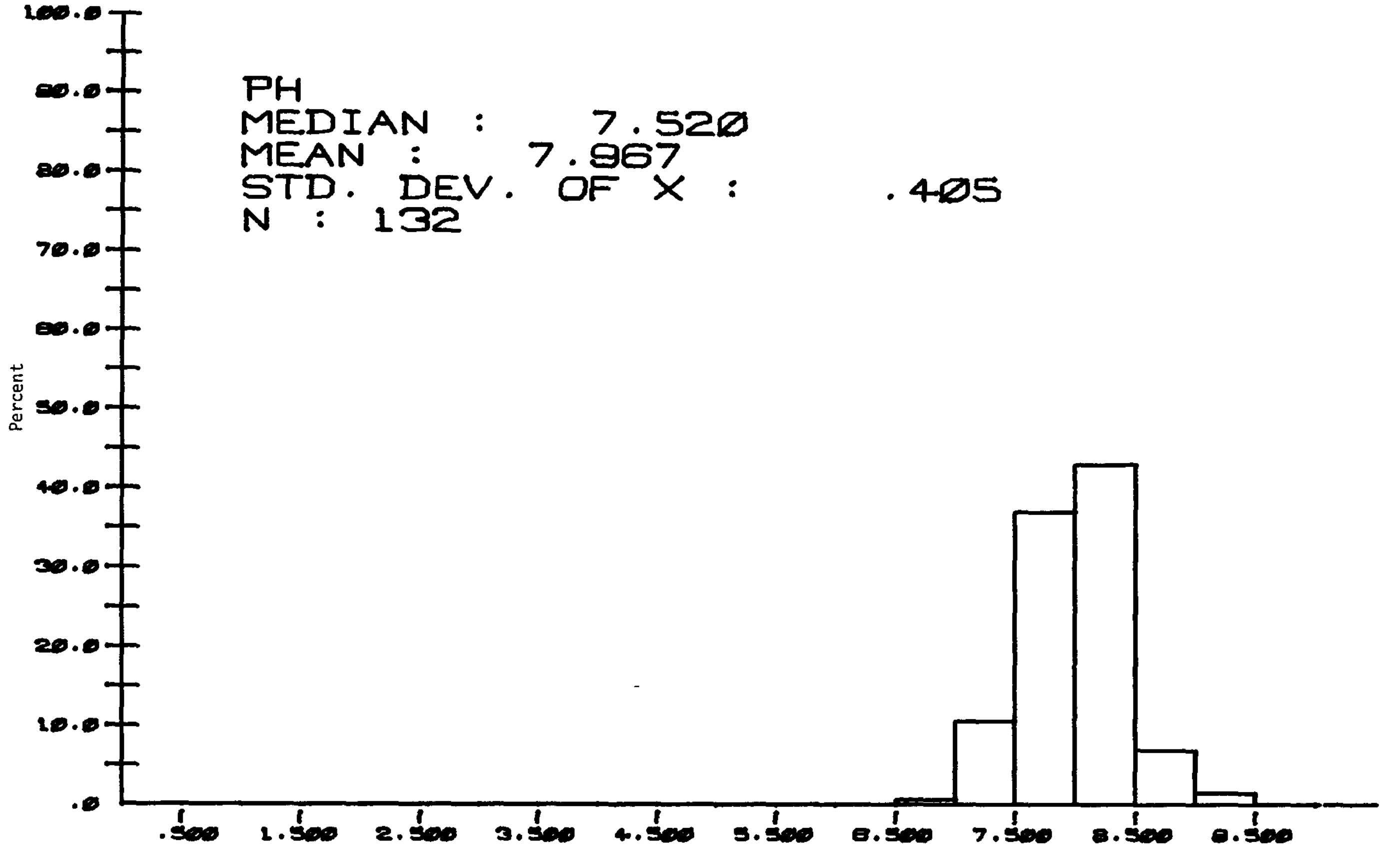

Figure 3.50 .Oswego River Histograms for pH

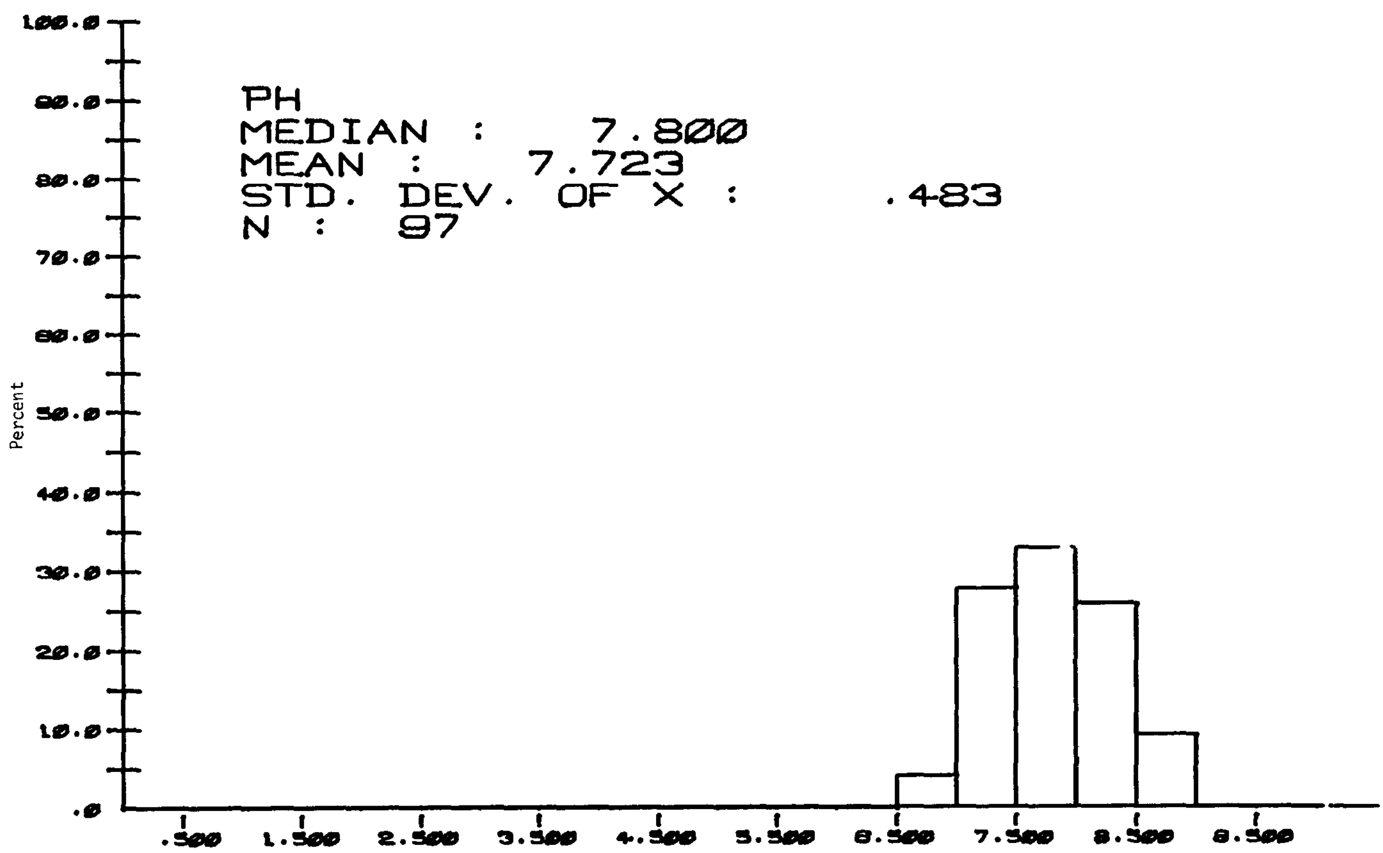

Figure 3.50 St. Lawrence River Histograms for pH

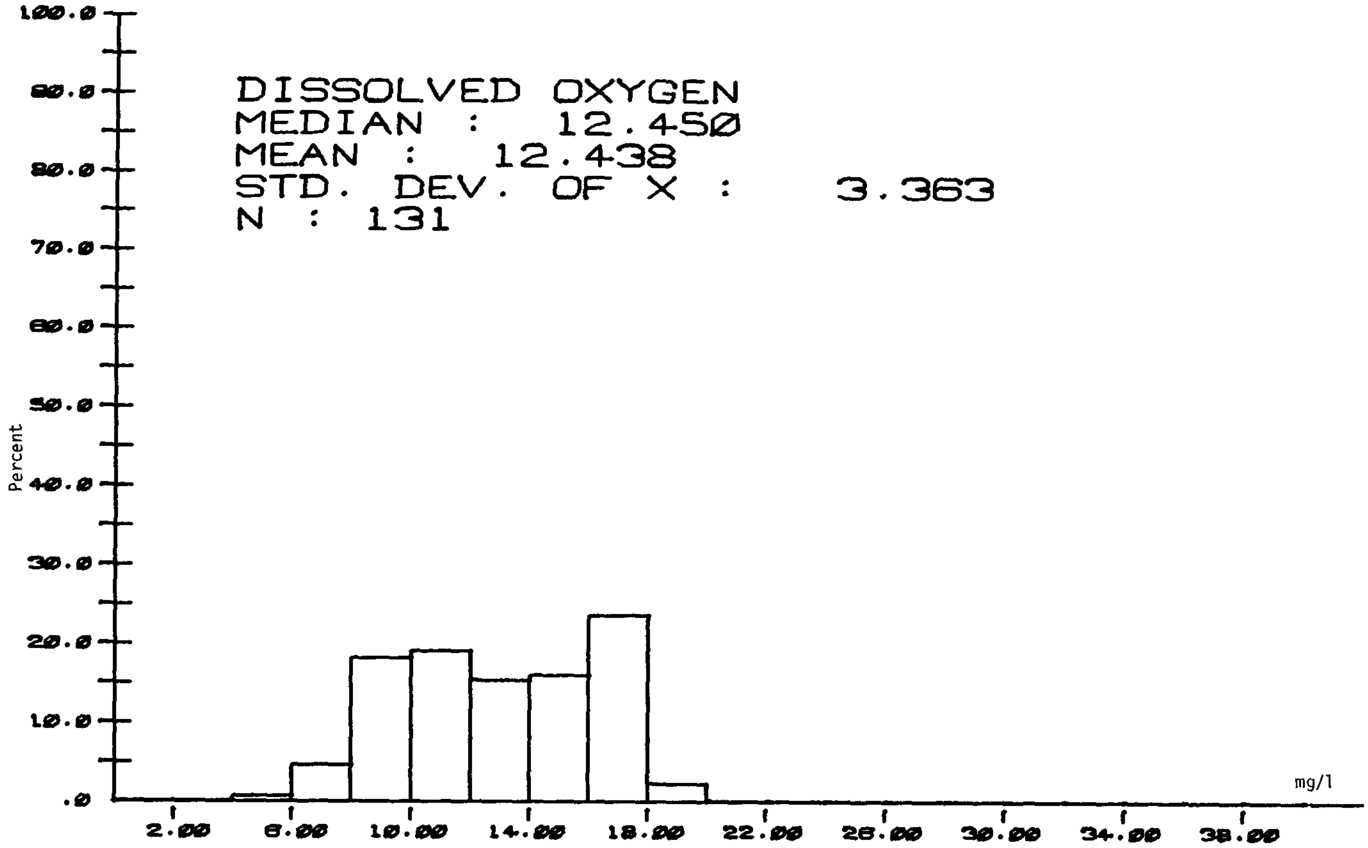

Figure 3.51 Genesee River Histograms for Dissolved Oxygen

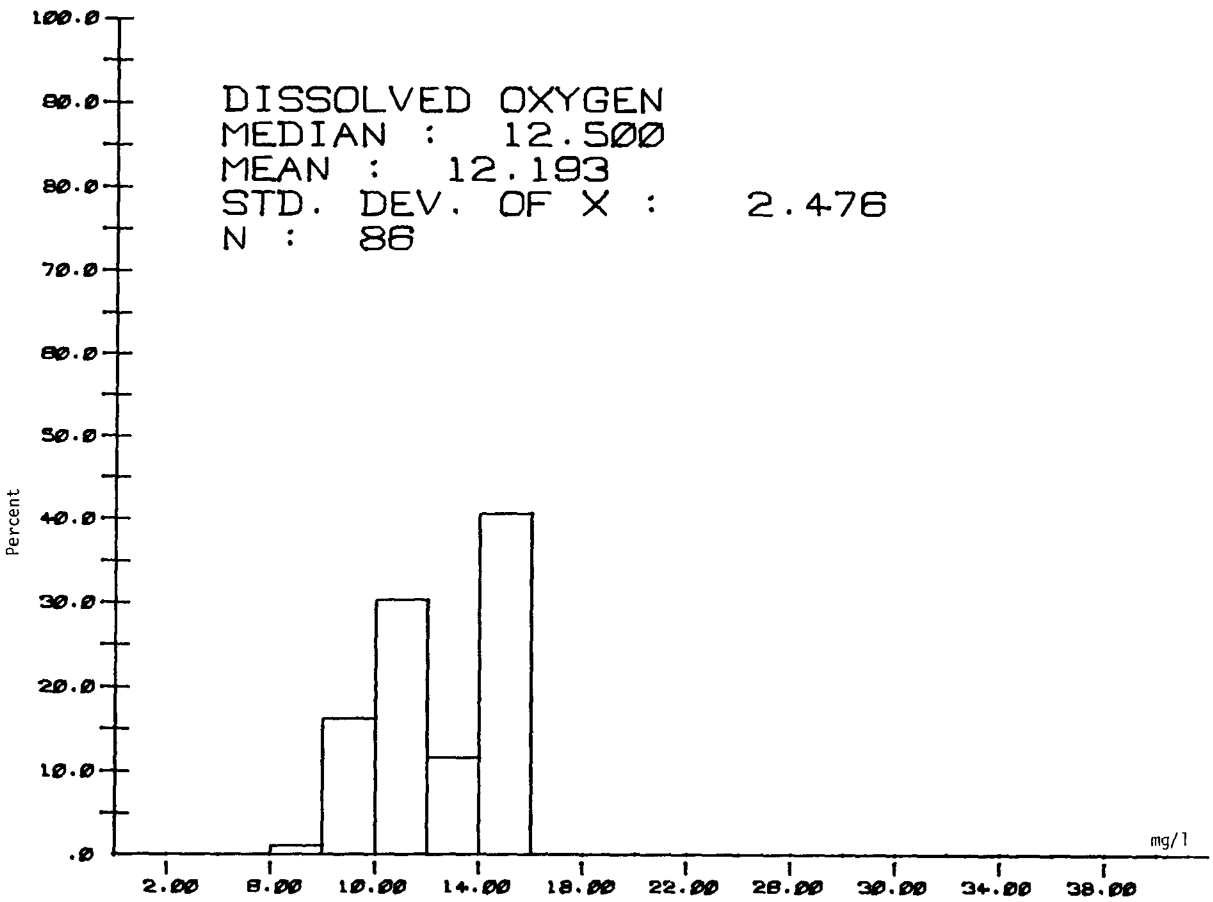

Figure 3.51 Niagara River Histograms for Dissolved Oxygen

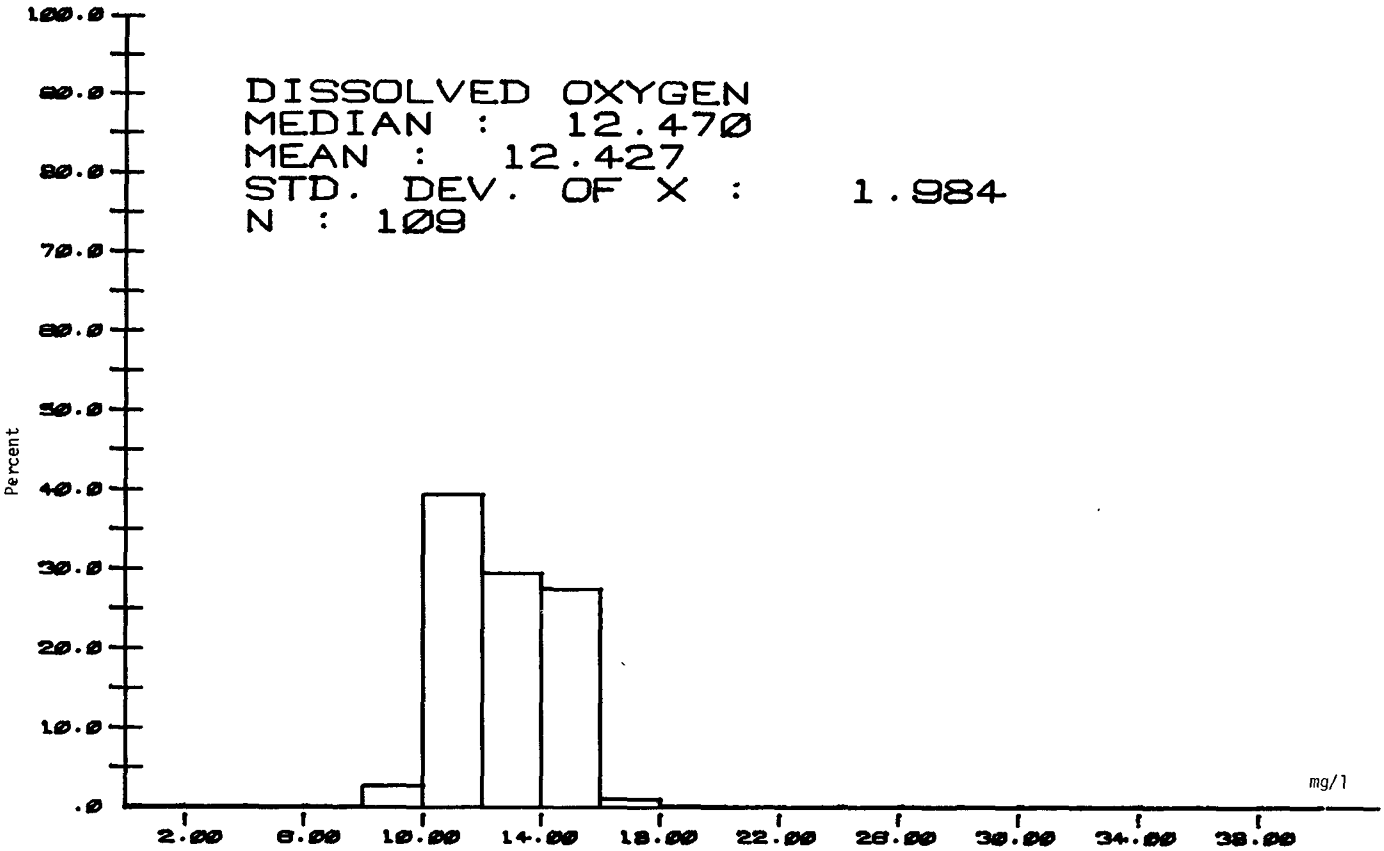

Figure 3.51 St. Lawrence River Histograms for Dissolved Oxygen

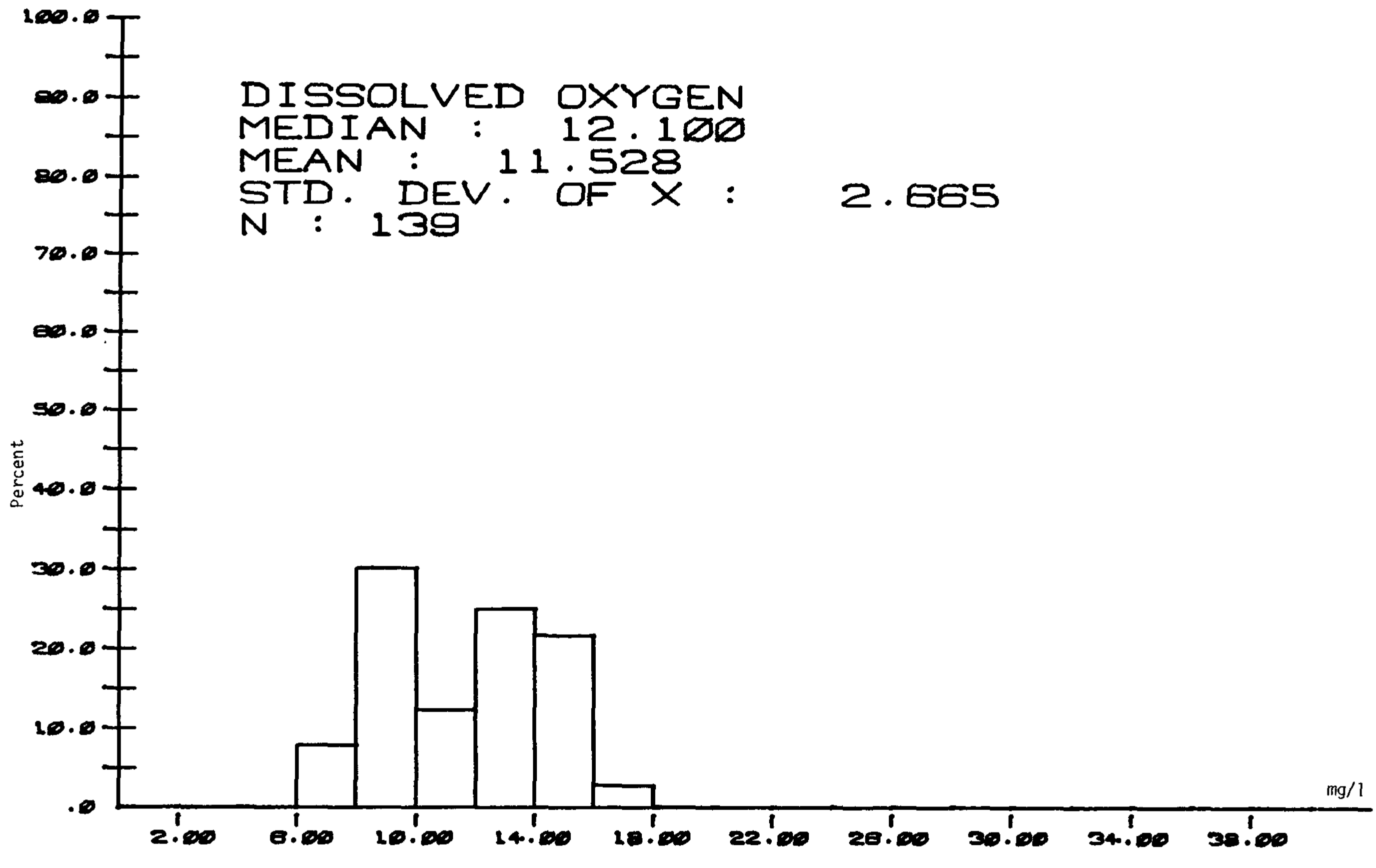

Figure 3.51 Oswego River Histograms for Dissolved Oxygen

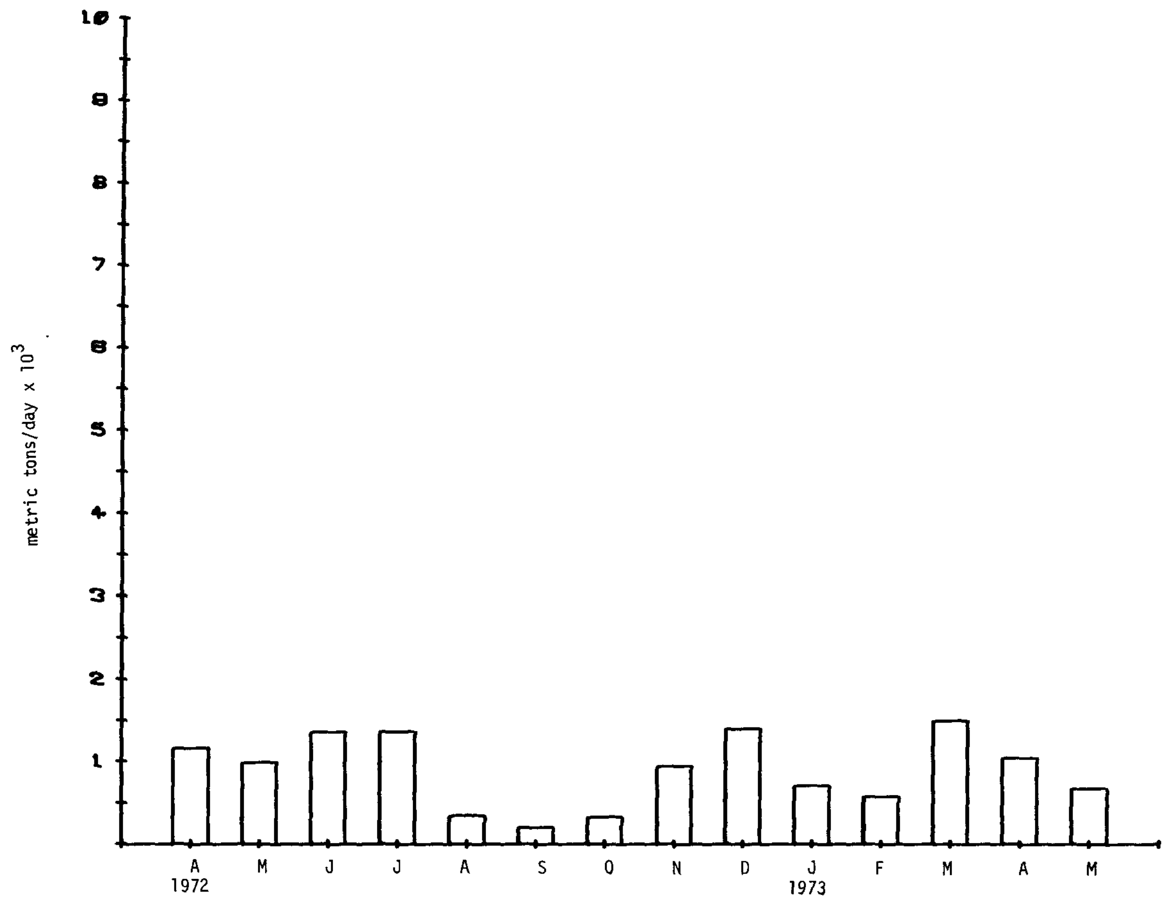

Figure 3.52 Genesee River Monthly Mean Stream Loadings - Total Alkalinity

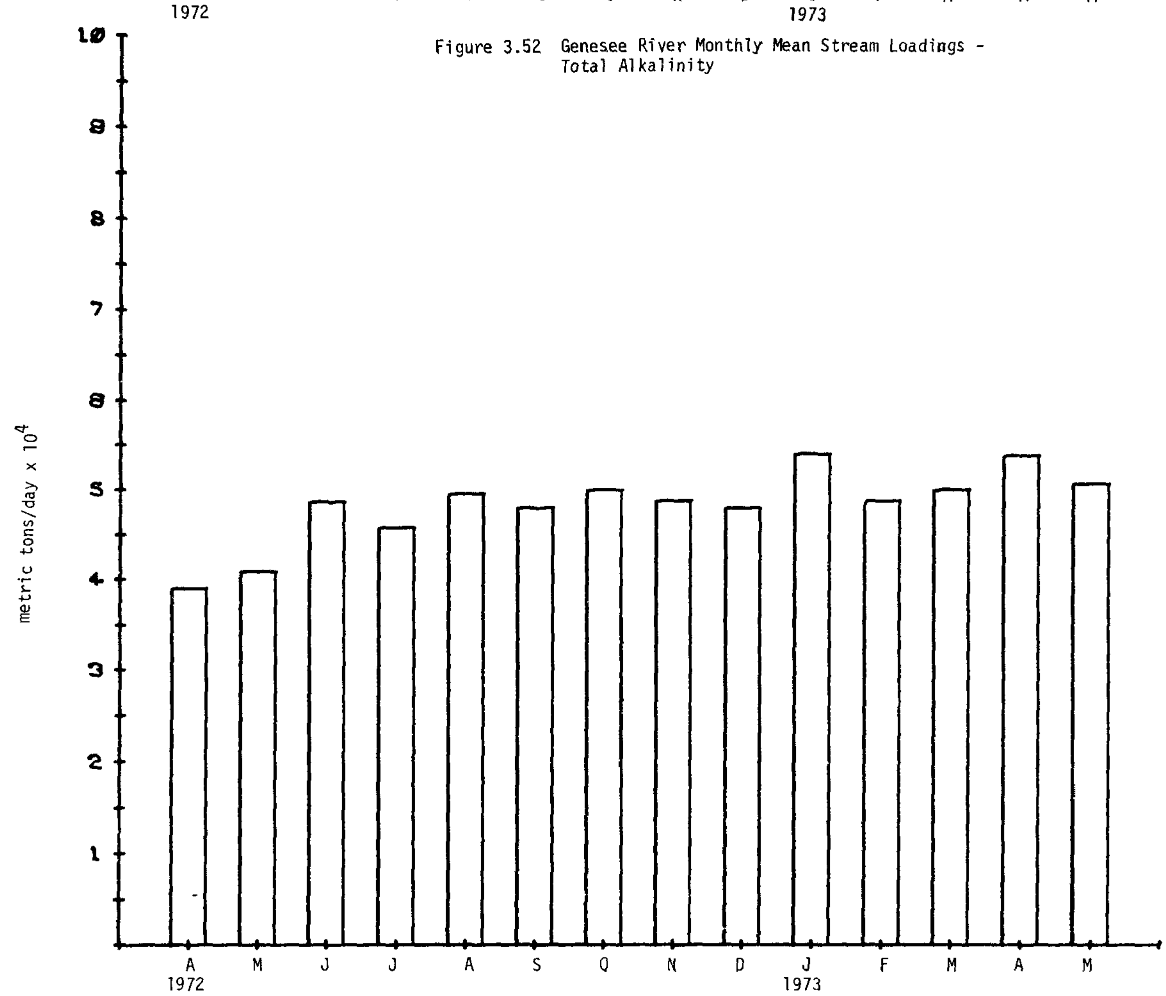

Figure 3.52 Niagara River Monthly Mean Stream Loadings - Total Alkalinity

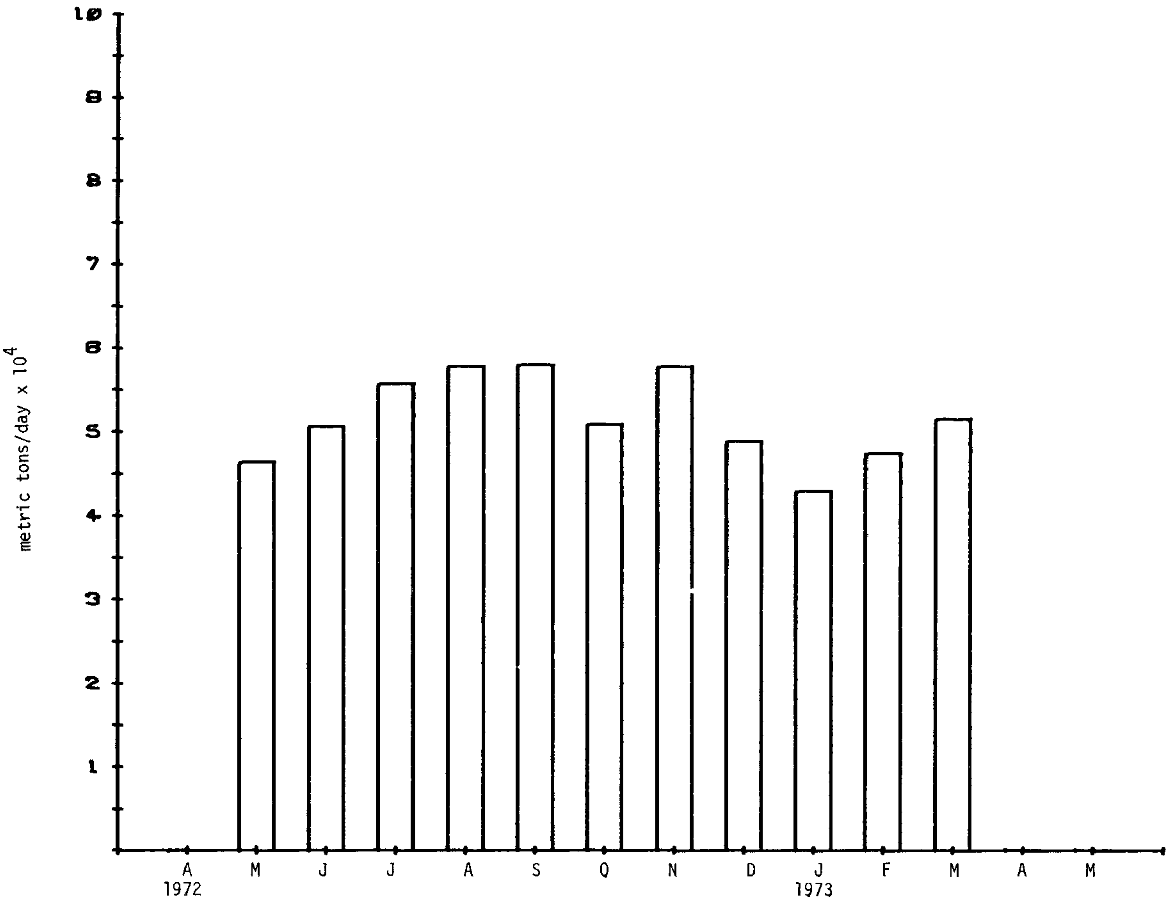

Figure 3.52 St. Lawrence River Monthly Mean Stream Loadings - Total Alkalinity

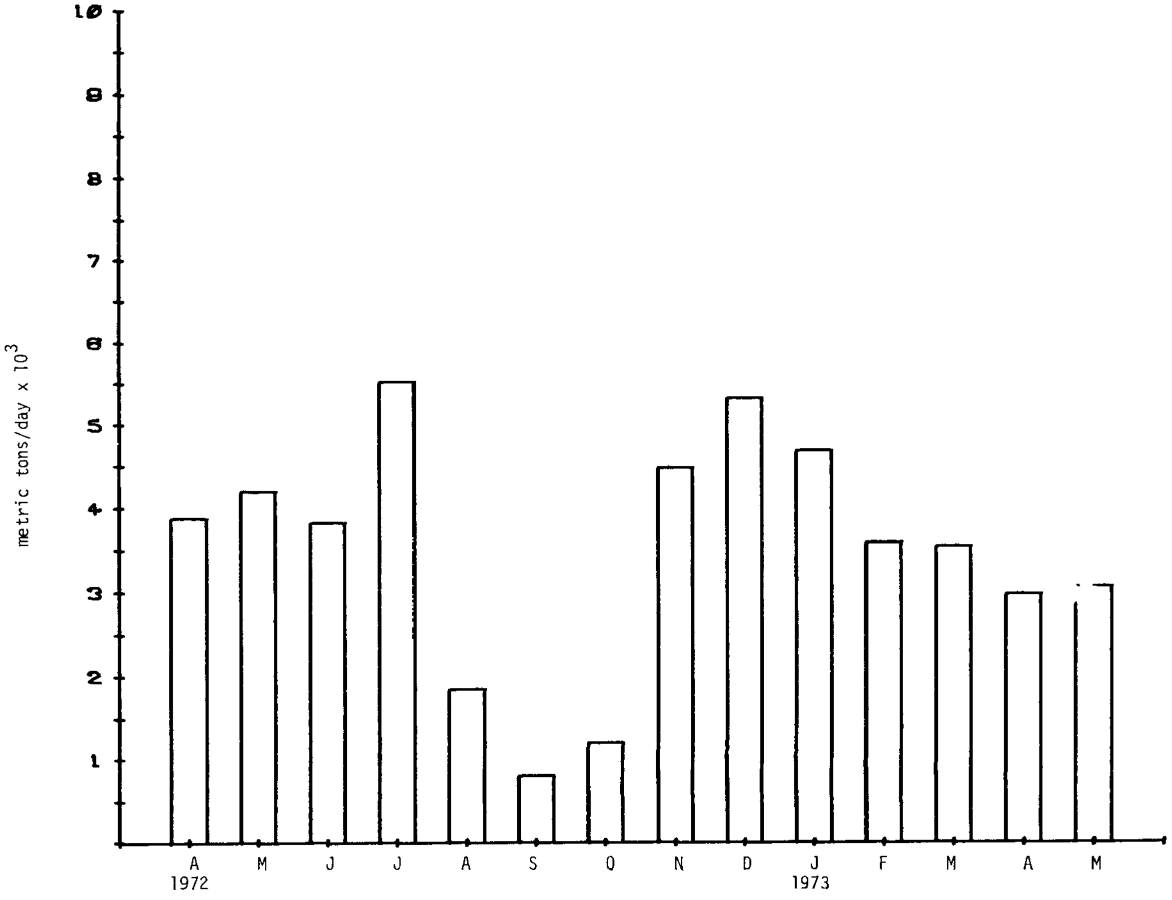

Figure 3.52 Oswego River Monthly Mean Stream Loadings - Total Alkalinity

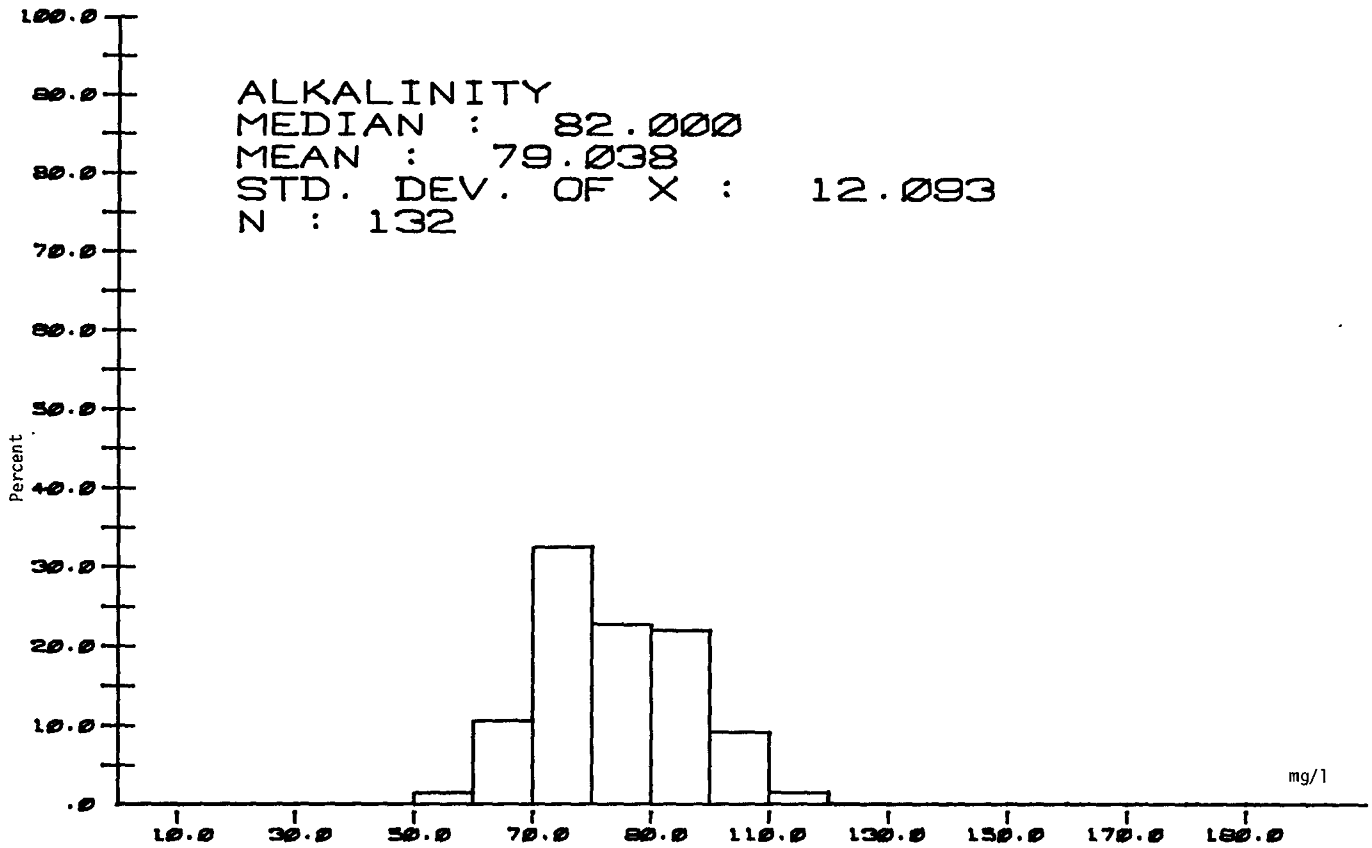

Figure 3.53 Genesee River Histograms for Total Alkalinity

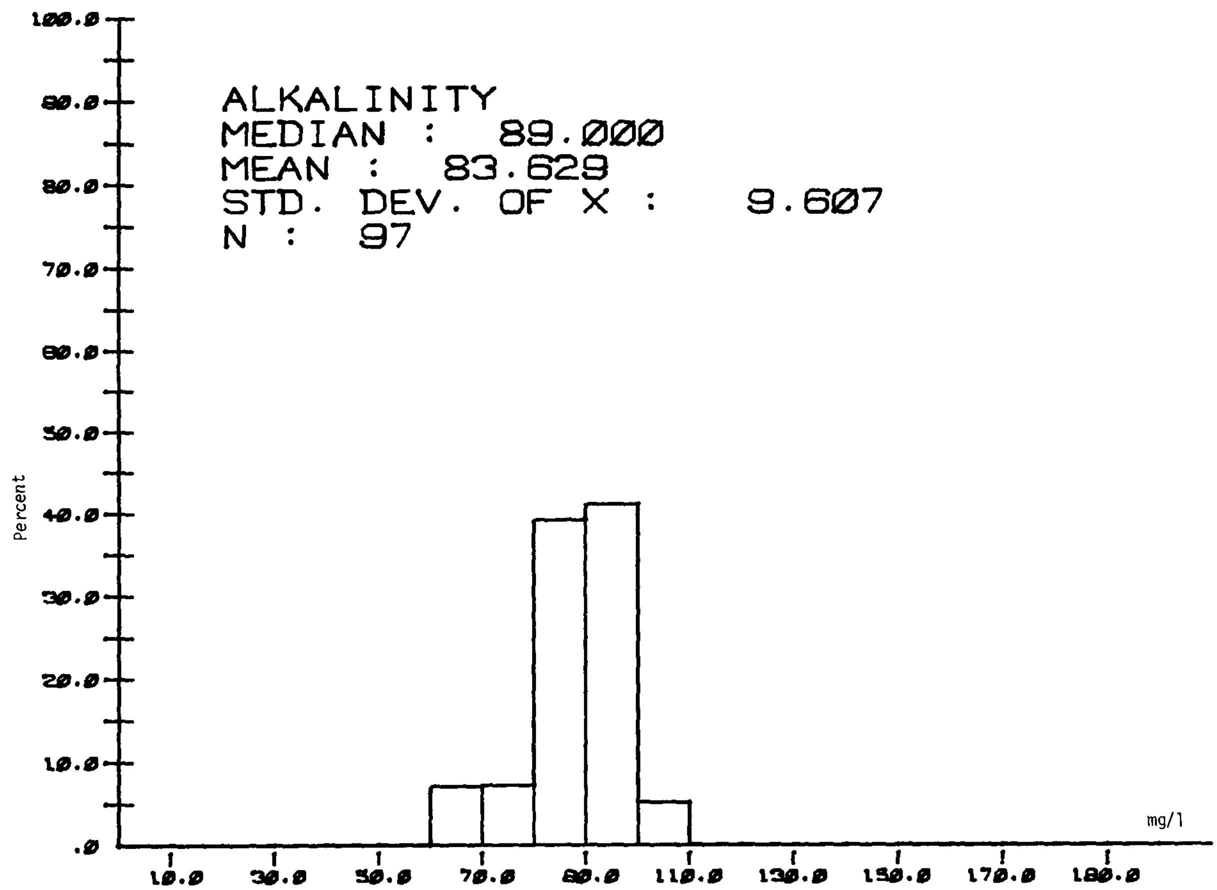

Figure 3.53 Niagara River Histograms for Total Alkalinity

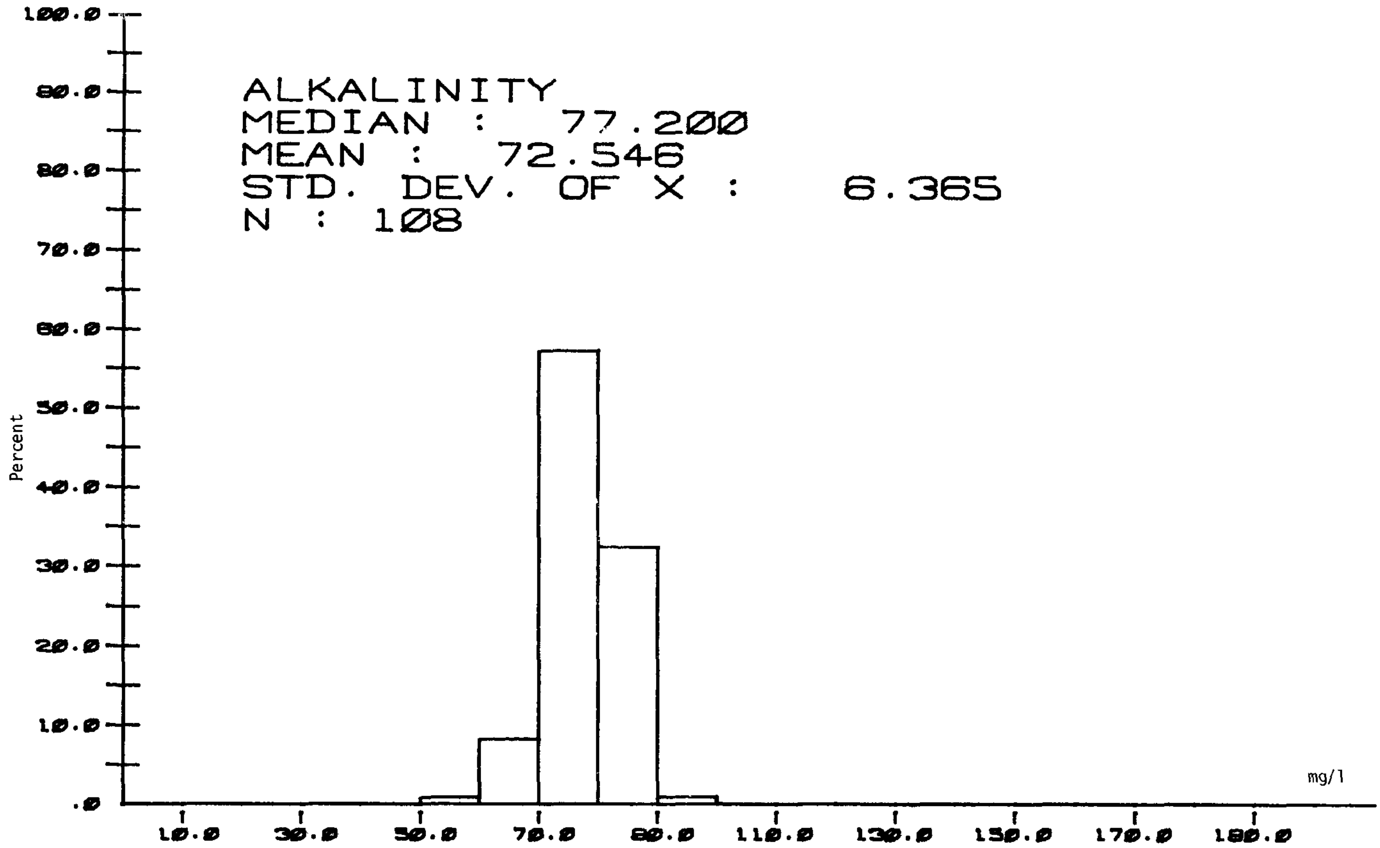

Figure 3.53 St. Lawrence River Histograms for Total Alkalinity

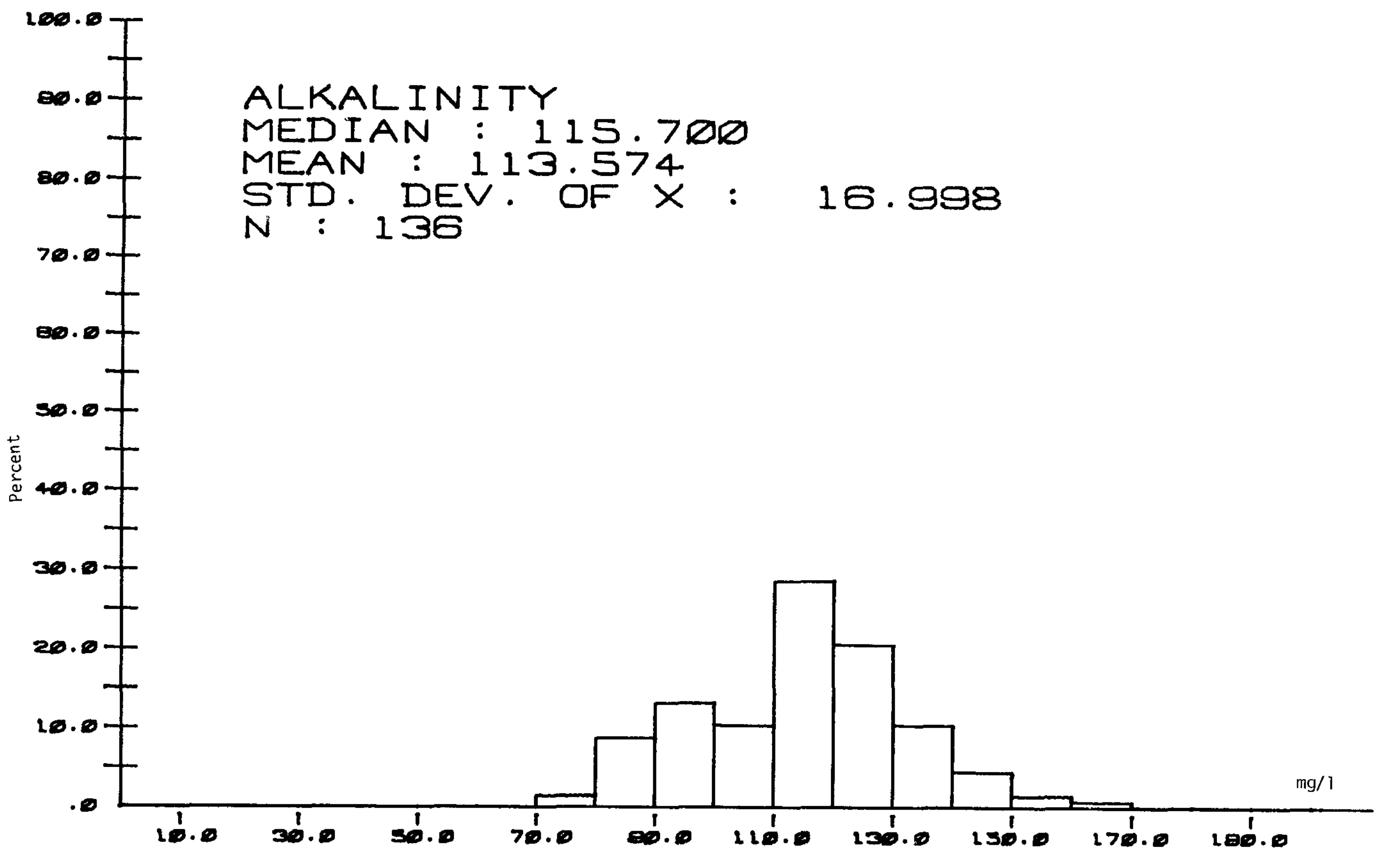

Figure 3.53 Oswego River Histograms for Total Alkalinity

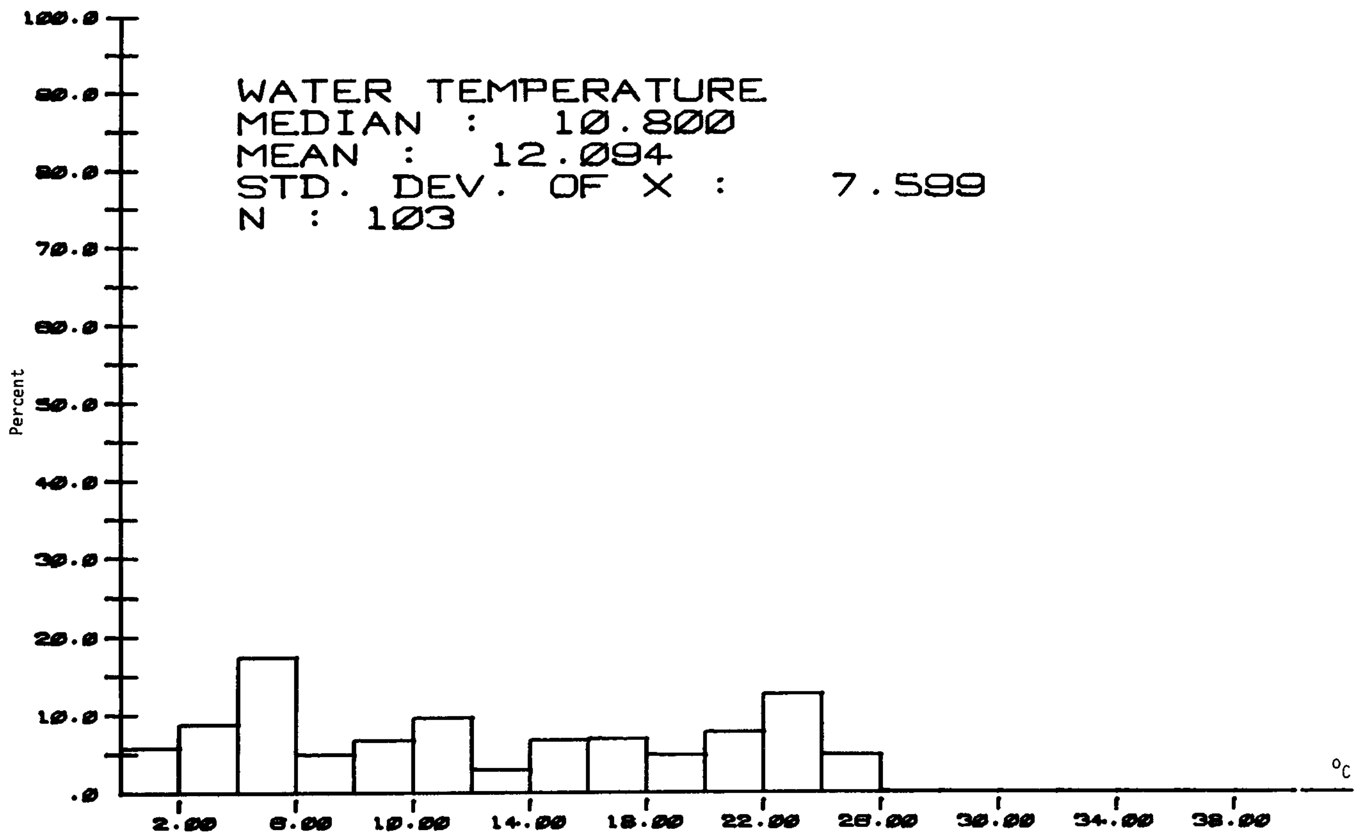

Figure 3.54 Niagara River Histograms for Water Temperature

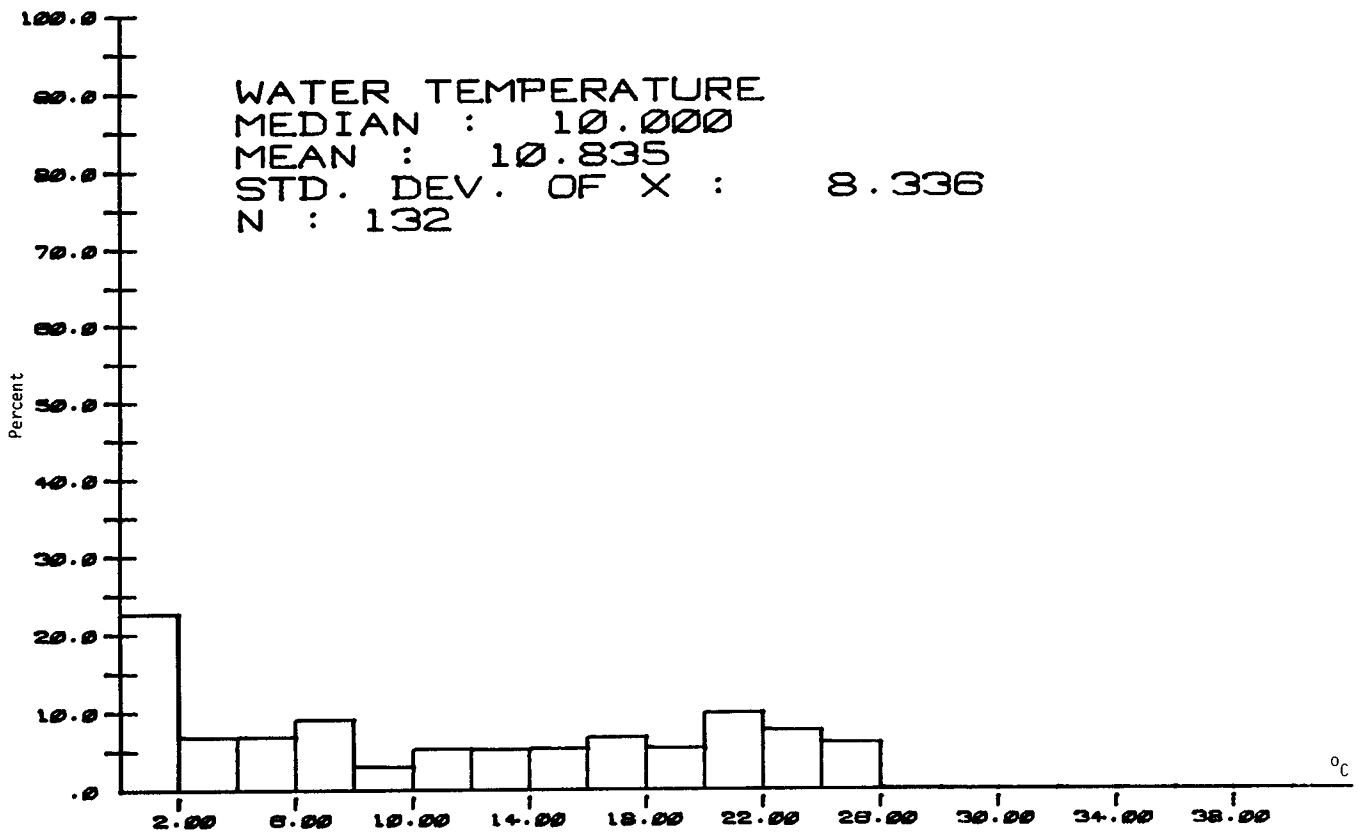

Figure 3.54 Genesee River Histograms for Water Temperature

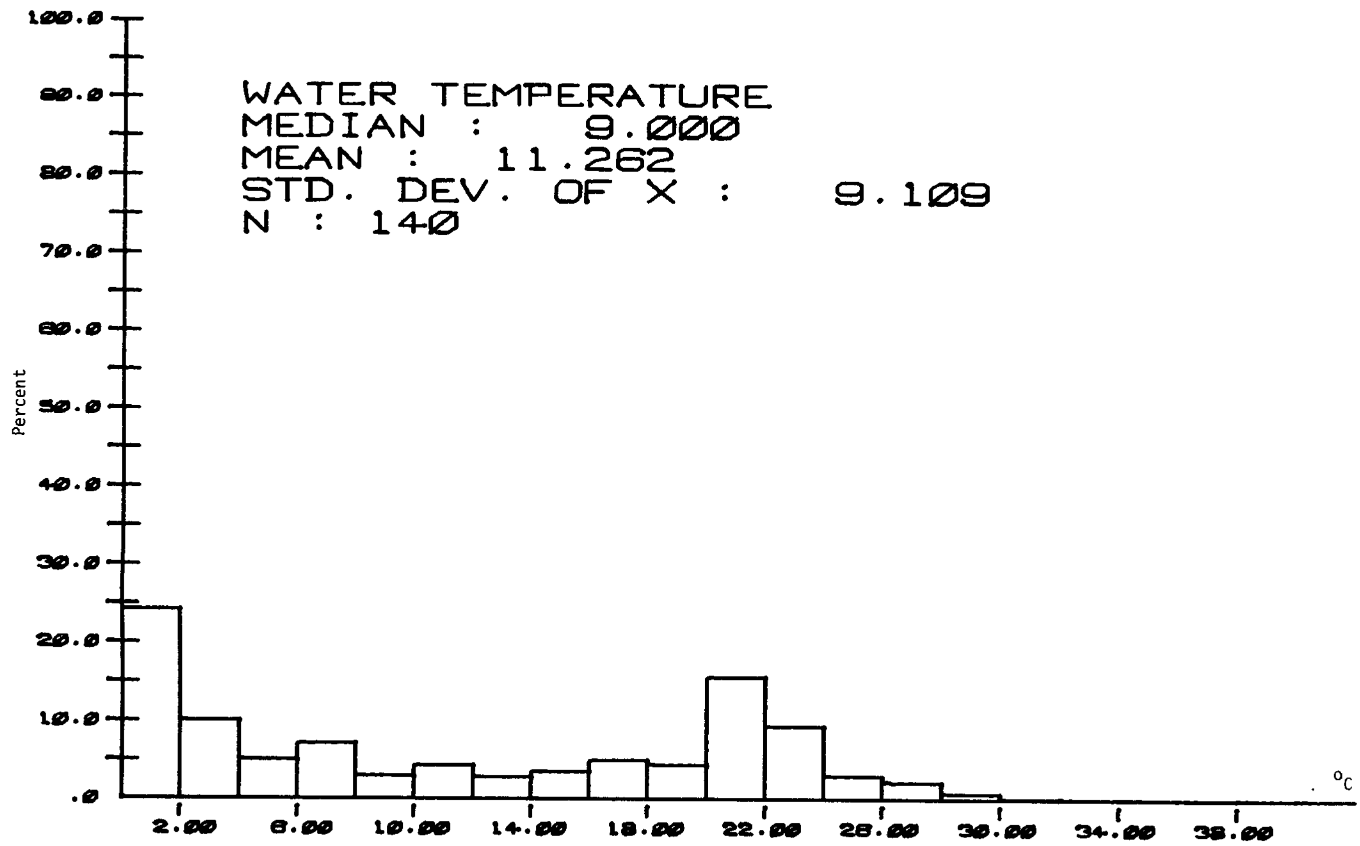

Figure 3.54 Oswego River Histograms for Water Temperature

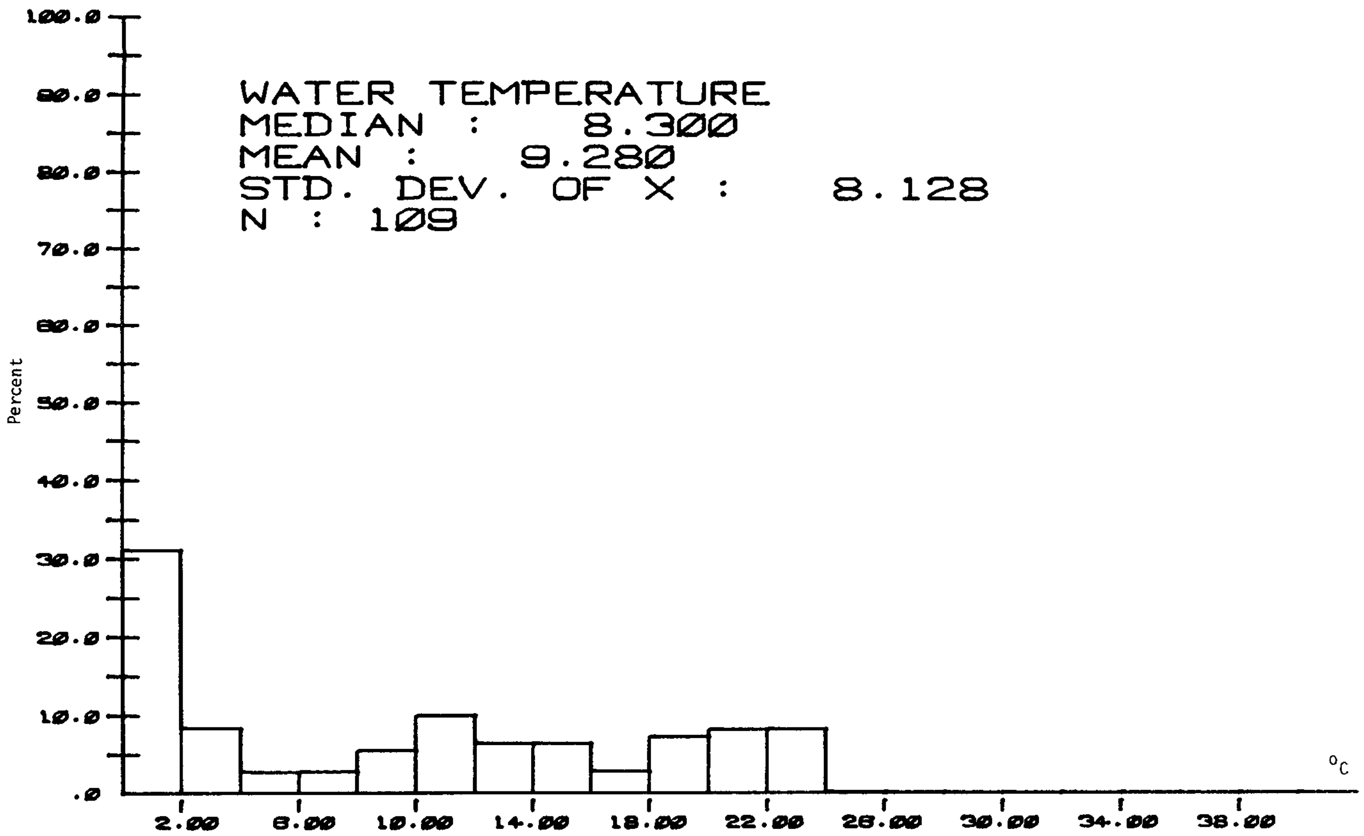

Figure 3.54 St. Lawrence River Histograms for Water Temperature