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The Effects of Metal Mines on Aquatic Ecosystems in the Northwest Territories
II. Giant Yellowknife Mines Limited

Northwest Region
Environmental Protection Service
Fisheries and Environmental Canada

Report EPS 5-NW-78-9
June, 1978

THE EFFECTS OF METAL MINES ON AQUATIC ECOSYSTEMS IN THE NORTHWEST TERRITORIES

II. GIANT YELLOWKNIFE MINES LIMITED

by

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Environmental Protection Service
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ABSTRACT

A biological, sediment and water quality survey was conducted between 1974 and 1977 to determine the impact of the operations of Giant Yellowknife Mines Ltd. on Baker Creek and Yellowknife Bay.

The discharge of effluent from the tailings ponds of the mine has caused a marked elevation in the concentration of toxicants in Baker Creek water. Arsenic and cyanide, for example, were occasionally recorded at 9 and 6 g/m^3 respectively. The density of aquatic biota below the mine was extremely low. The sediments of Yellowknife Bay contained high levels of toxicants up to at least 3 km from the mouth of Baker Creek. There was a marked reduction in the density of benthic organisms within 3 km from the mine. The water in Yellowknife Bay occasionally contained very high levels of arsenic (0.74 g/m^3), well above the maximum limits for potable water, 0.05 g/m^3. Several recommendations are made regarding the high level of contaminants in the tailings pond effluent. The most important of these is immediate improvement in effluent quality.

RÉSUMÉ

Entre 1974 et 1977, on a effectué une enquête sur les aspects biologiques, les sédiments et la qualité des eaux pour déterminer les effets des activités de la Giant Yellowknife Mines Ltd sur le ruisseau Baker et la baie Yellowknife.

Le rejet des effluents des étangs de stériles de la mine a causé une élévation marquée du contenu toxique du ruisseau Baker. On y a, par exemple, enregistré occasionnellement des taux respectifs de 9 et 6 g/m^3 d'arsenic et de cyanures. En aval de la mine, on a retrouvé une très faible densité de vie aquatique. Les sédiments de la baie Yellowknife contenaient des niveaux de matières toxiques très élevés, jusqu'à trois kilomètres au moins de l'embouchure du ruisseau Baker. La densité du benthos se trouvait également réduite de façon marquée jusqu'à trois kilomètres de la mine. L'eau de la baie Yellowknife contenait parfois des niveaux d'arsenic (0.74 g/m^3) de beaucoup supérieurs à la limite maximale de 0.05 g/m^3 permise pour l'eau potable. Le rapport présente plusieurs recommandations touchant les niveaux élevés de contaminants que contient l'effluent de l'étang de stériles. La plus importante consiste à améliorer sans délai la qualité de ce dernier.

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CONCLUSIONS

1. The discharge of effluent from the tailings ponds of Giant Yellowknife Mines Ltd. has severely contaminated the lower section of Baker Creek and caused almost complete destruction of the native biota.

2. The sediments of Yellowknife Bay are highly contaminated with arsenic, mercury, copper, lead, zinc and other heavy metals.

3. The density of bottom living organisms within parts of Yellowknife Bay has been greatly reduced.

4. A zone of influence extends at least 3 km from the mouth of Baker Creek.

5. The level of arsenic in the water of Yellowknife Bay reached 0.74 g/m^3 far above the maximum level for potable water (0.05 g/m^3).

6. The phytoplankton and zooplankton of Yellowknife Bay were greatly reduced in densities near the mouth of Baker Creek.

7. The ongoing discharge of highly lethal waste into Yellowknife Bay will probably cause: i) a further expansion of the zone of influence, ii) further destruction of the bottom fauna, iii) maintenance of very high arsenic levels in the water of Yellowknife Bay.

8. The ongoing discharge of highly lethal effluent into Yellowknife Bay may be in contravention of Section 33(2) of the Fisheries Act.

RECOMMENDATIONS

1. The quality of the tailings pond effluent should be improved so that the water in Baker Creek is not deleterious to fish or fish habitat.

2. Following improvement of effluent quality, restoration of Baker Creek should be undertaken in order to permit the growth of normal indigenous aquatic organisms.

1 INTRODUCTION

1.1 General

The mining and milling of base metals and gold in the Northwest Territories are known to produce toxic wastes, originating from overflow and seepage from tailings disposal areas, mine wastewater and runoff from tailings deposits and waste rock-piles (8-10). These wastes include a wide variety of toxicants including mercury, arsenic, cyanide and heavy metals. There have been several studies into the effects of metal mining on aquatic ecosystems in the Northwest Territories, though many have been of short duration. These include investigations into the effects of Canada Tungsten Mining Co. on the Flat River (4, 6), a survey of the effects of 2 gold mines and 2 silver mines (2) and a chemical contamination survey at Pine Point (2).

Giant Yellowknife Mines Ltd. is one of the 2 operating gold mines in the Northwest Territories, with an average milling capacity of 1100 tons/day. Its mill is known to produce lethal effluents which flow from the tailings pond into Baker Creek and then to Yellowknife Bay (9, 10). The mine has been in operation since 1949 and it is therefore possible that this discharge has had a substantial impact on the aquatic flora and fauna. Falk, Miller and Kostiuk (2) were the first to conduct a biological survey of Yellowknife Bay in relation to metal pollution. Although they concluded that the mine was not having a substantial impact on the biota, it must be pointed out that their study was of very short duration. Subsequently, the Northwest Territories District Office of the Environmental Protection Service conducted a biological, sediment and water quality survey of Baker Creek and Yellowknife Bay between 1974 and 1977. The purpose of the study was to obtain a detailed data base to define: i) the zone of influence of tailings disposal on the aquatic environment, ii) the concentration of metal contamination in sediments and water, and iii) the need for future study.

1.2 Description of Study Area

Yellowknife Bay, located on the north shore of Great Slave Lake at Lat. $62^{o}29'N$, Long. $114^{o}22'W$, has an approximate area of 32 km^2 (Figure 1). It measures 11.3 km long, 2.8 km wide and is situated at an elevation of 165 m above sea level. The bay has a maximum depth of 40 m but near Baker Creek the water is 3-10 m deep. The bay receives discharge from Yellowknife River to the north and communicates directly with Great Slave Lake to the south (Figure 2). There are 2 populated areas in the vicinity of the bay. The largest of the two is the City of Yellowknife with a population of 11,000, located on the western shore (Figure 2). The other is a small village called Detah, with a population of about 200, situated near the southeastern shore of Yellowknife Bay.

Giant Mine lies about 5 km north of the City of Yellowknife on the western shore (Figure 2). Production started at an average of 232 tons of ore milled daily in 1949, and had increased to 1000 tons per day by 1961. Between 1949 and the middle of the 1960's, gold was extracted from the ore using a combination of mercury amalgamation and cyanidation. Subsequent extraction, however, depended entirely on cyanidation. Tailings are currently piped to a series of ponds which decant directly into Baker Creek (Figure 3), although in the early 1960's some tailings were deposited directly into Yellowknife Bay just north of Baker Creek. Chemical characteristics of the effluent draining from the tailings ponds into Baker Creek are given in Table 1.

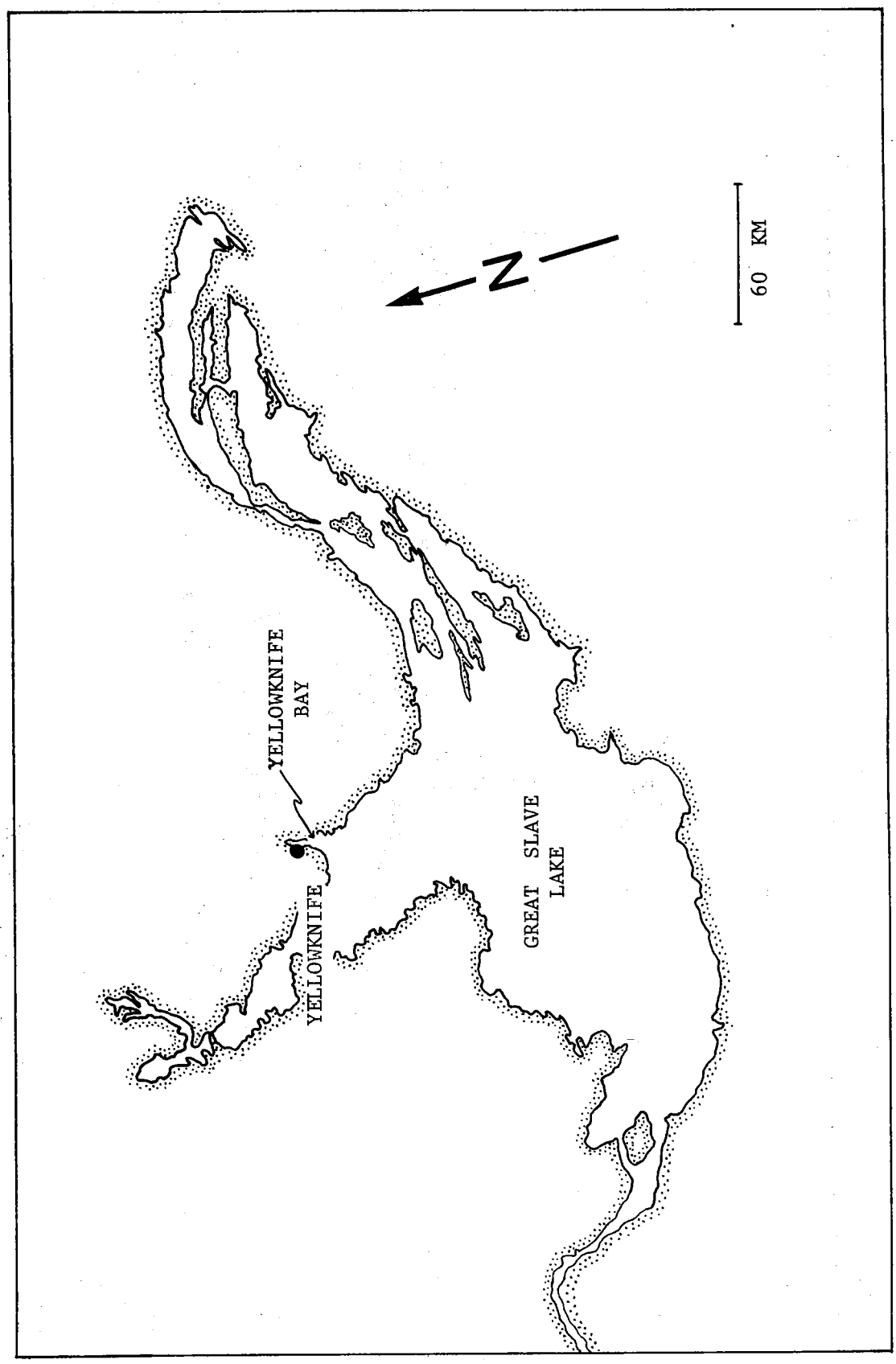

FIGURE 1 MAP OF GREAT SLAVE LAKE SHOWING LOCATION OF YELLOWKNIFE BAY.

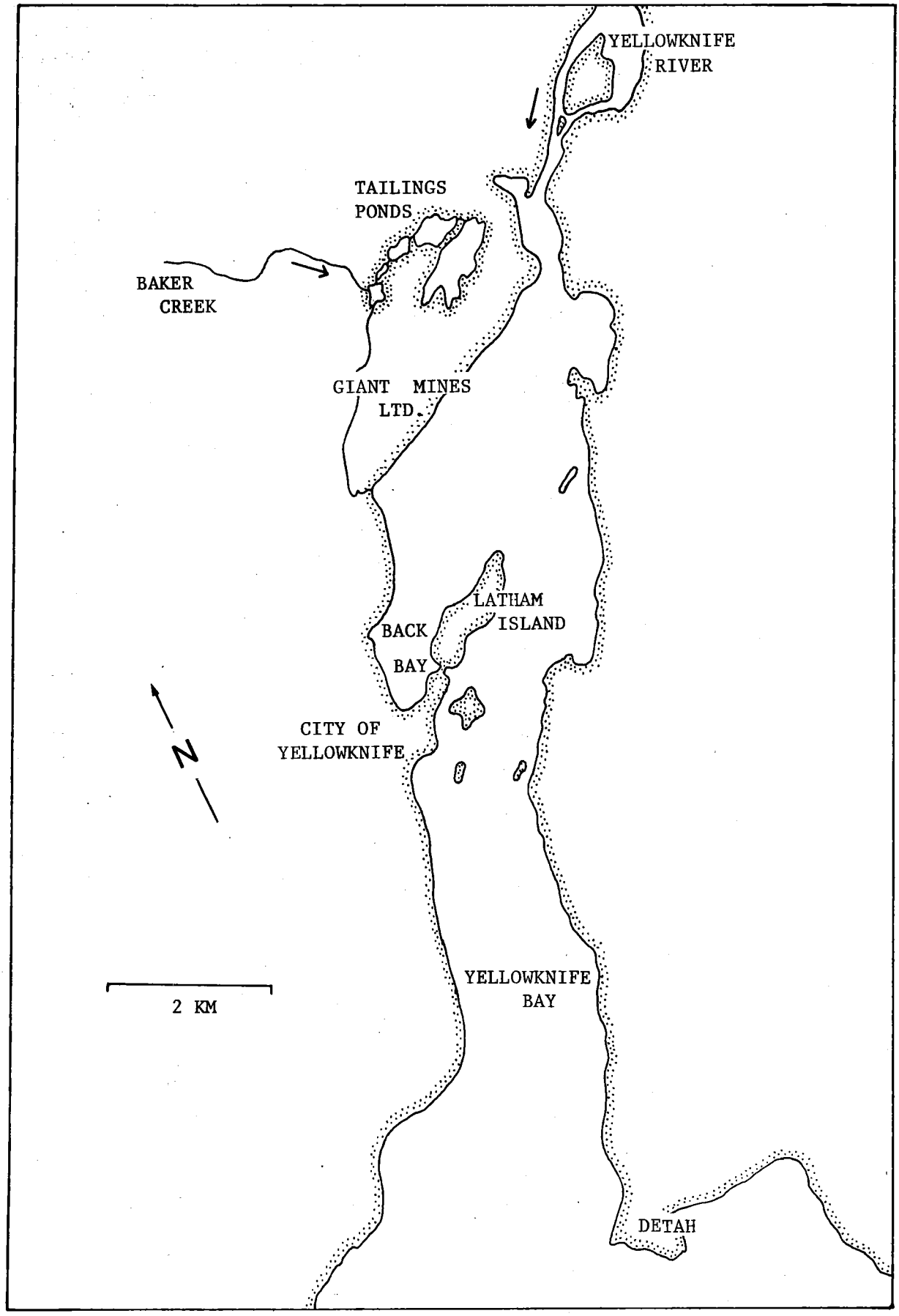

FIGURE 2 MAP OF YELLOWKNIFE AREA SHOWING IMPORTANT LAND MARKS.

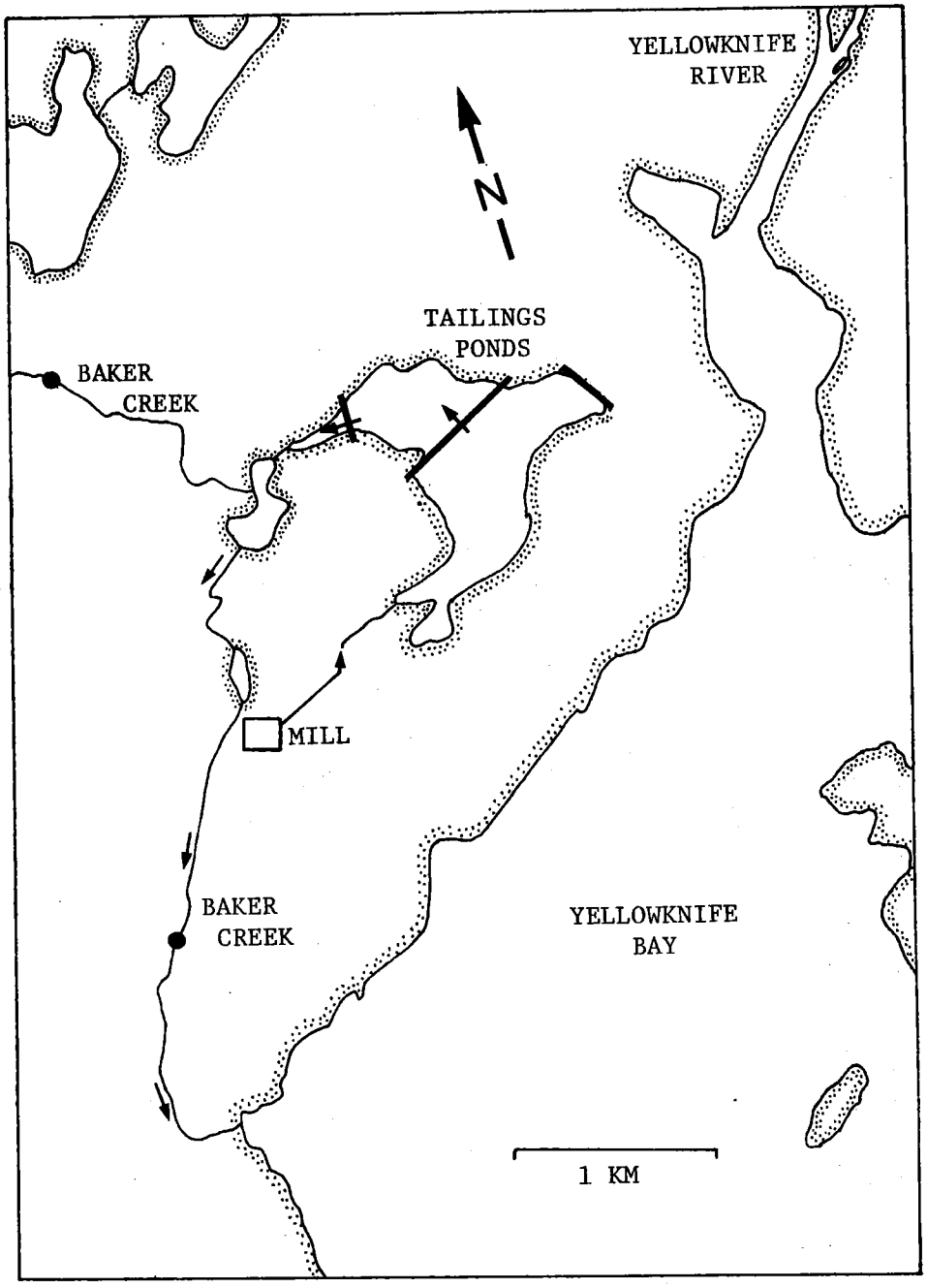

FIGURE 3 MAP OF TAILINGS DISPOSAL SYSTEM AT GIANT YELLOWKNIFE MINES LTD. Arrows show the flow of effluent from the mill. Dots show collection sites at Baker Creek.

TABLE 1

PHYSICO-CHEMICAL CHARACTERISTICS OF WATER SAMPLES FROM
TAILINGS POND EFFLUENT FLOWING INTO BAKER CREEK DURING 1975

METAL	DATE	09/04	18/04	25/04	28/05	18/09	21/10
Arsenic		4.8	14.2	10.7	1.5	20.4	10.4
Iron		0.35	0.20	0.87	0.17	1.06	0.56
Zinc		2.85	2.20	0.83	0.23	0.90	0.03
Copper		24.8	15.8	8.4	13.6	7.28	6.93
Nickel		1.2	0.78	0.55	0.55	0.80	0.50
Lead		0.05	NA	NA	NA	NA	NA

All values in g/m^3 unless otherwise indicated
NA = analysis not done

2 MATERIALS AND METHODS

2.1 General

The effect of the mining operations on Baker Creek was determined from collections of water and biota samples taken at one station situated 2 km upstream from the mine and at one station 1 km downstream from the point where tailings decant into the creek.

In order to obtain a detailed picture of the impact of the mine on Yellowknife Bay, samples of water, sediment and aquatic biota were collected over the period June 1974 to March 1977 (Table 2). To determine the levels of metal contamination in sediments throughout Yellowknife Bay, samples were collected at 70 stations during 1974 (Figure 4). To facilitate the analysis of this large amount of data, the samples were pooled into 6 groups according to their distance from the mine. Additional samples of sediment were collected during September of 1975 at 10 stations in Yellowknife Bay, and at depth increments of 0-5, 5-10 and 10-15 cm (Figure 5).

In 1976, 24 transects for the collection of water, aquatic biota and additional sediment samples were established from the mouth of Baker Creek into Yellowknife Bay, and up the middle of Back Bay (Figure 6 - Table 2). These transects provided representative sample sites closely following the mine waste dispersal pattern predicted for this study. Collections were made at 400 m intervals during June of 1976. All population estimates were calculated as means. Triplicate sediment sampling was also completed during this period. This program involved sampling at 4 stations (e, f, i, j) (Figure 5). Station e was situated 1.3 km from the mouth of Baker Creek while f, i and j were located at distances of 1.6, 6.5 and 9.5 km, respectively. Details of sampling dates are recorded in Table 2.

Metal analysis of fish flesh was conducted on specimens collected from Back Bay and Yellowknife Bay by personnel from the Fisheries and Marine Service during 1974 and 1975. A summary of the data recorded from these studies is given in Section 4 of this report.

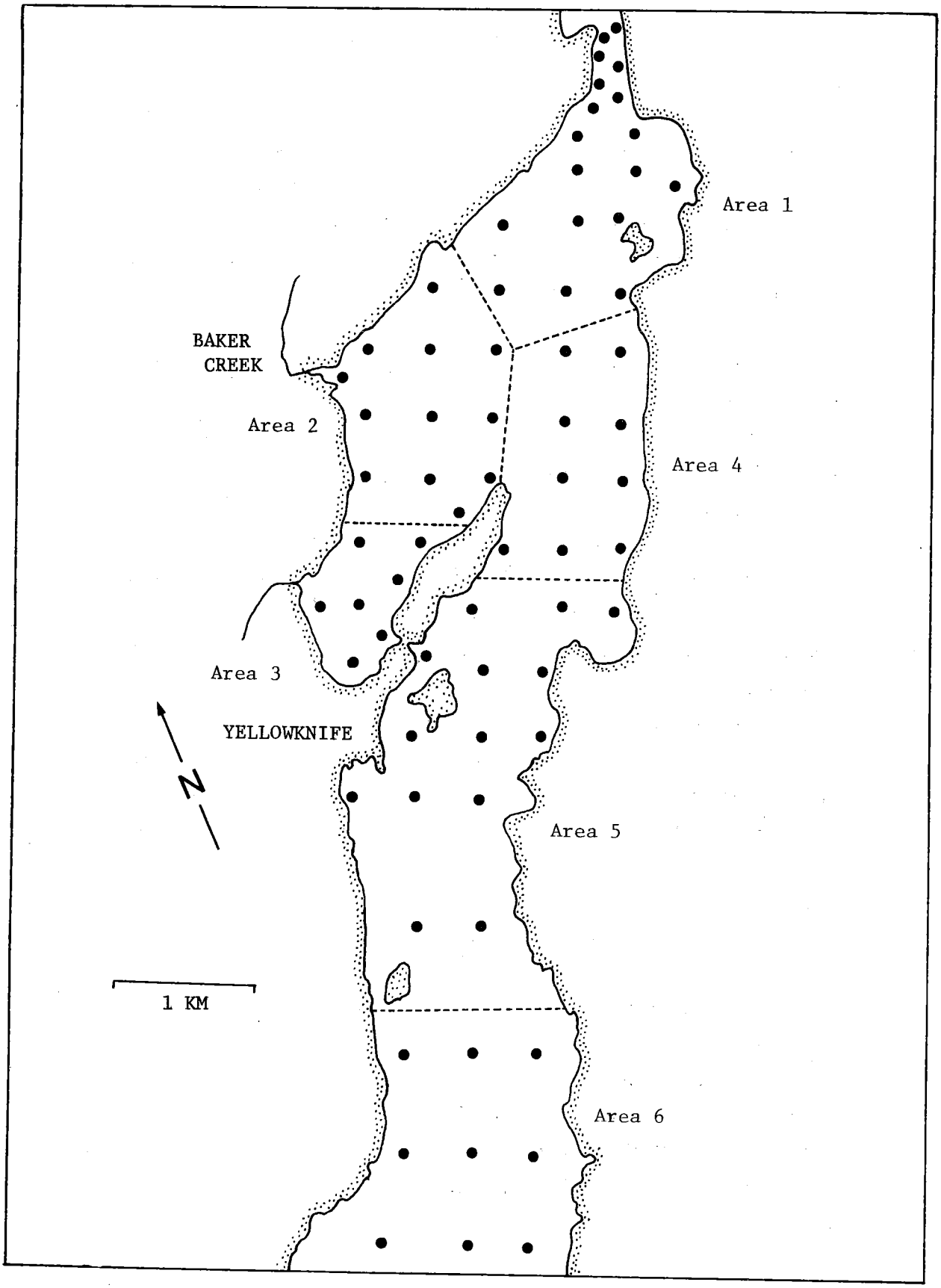

FIGURE 4 LOCATION OF SEDIMENT SAMPLING STATIONS USED DURING 1974.

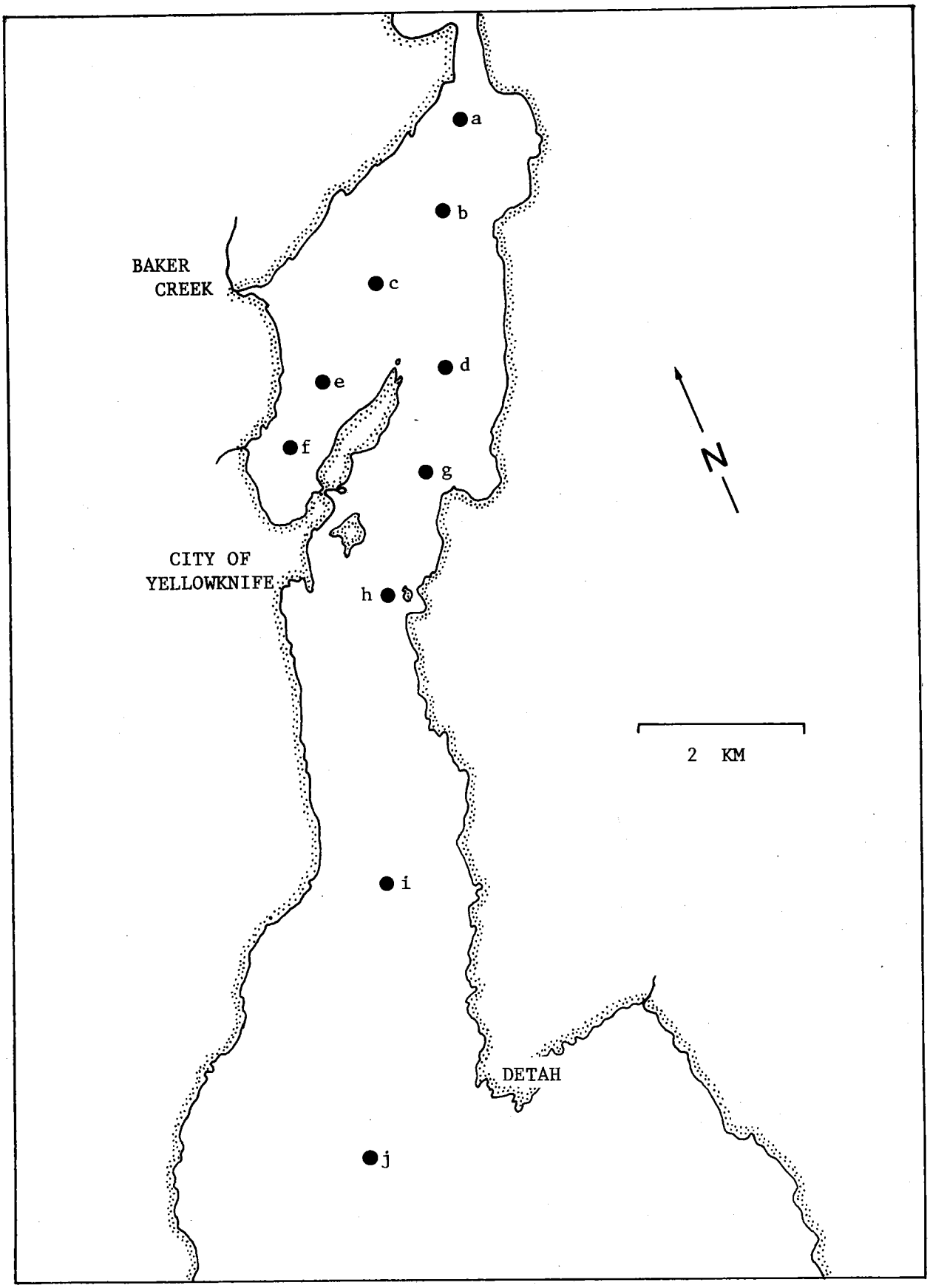

FIGURE 5 LOCATION OF COLLECTION SITES a-j IN YELLOWKNIFE BAY USED DURING 1976.

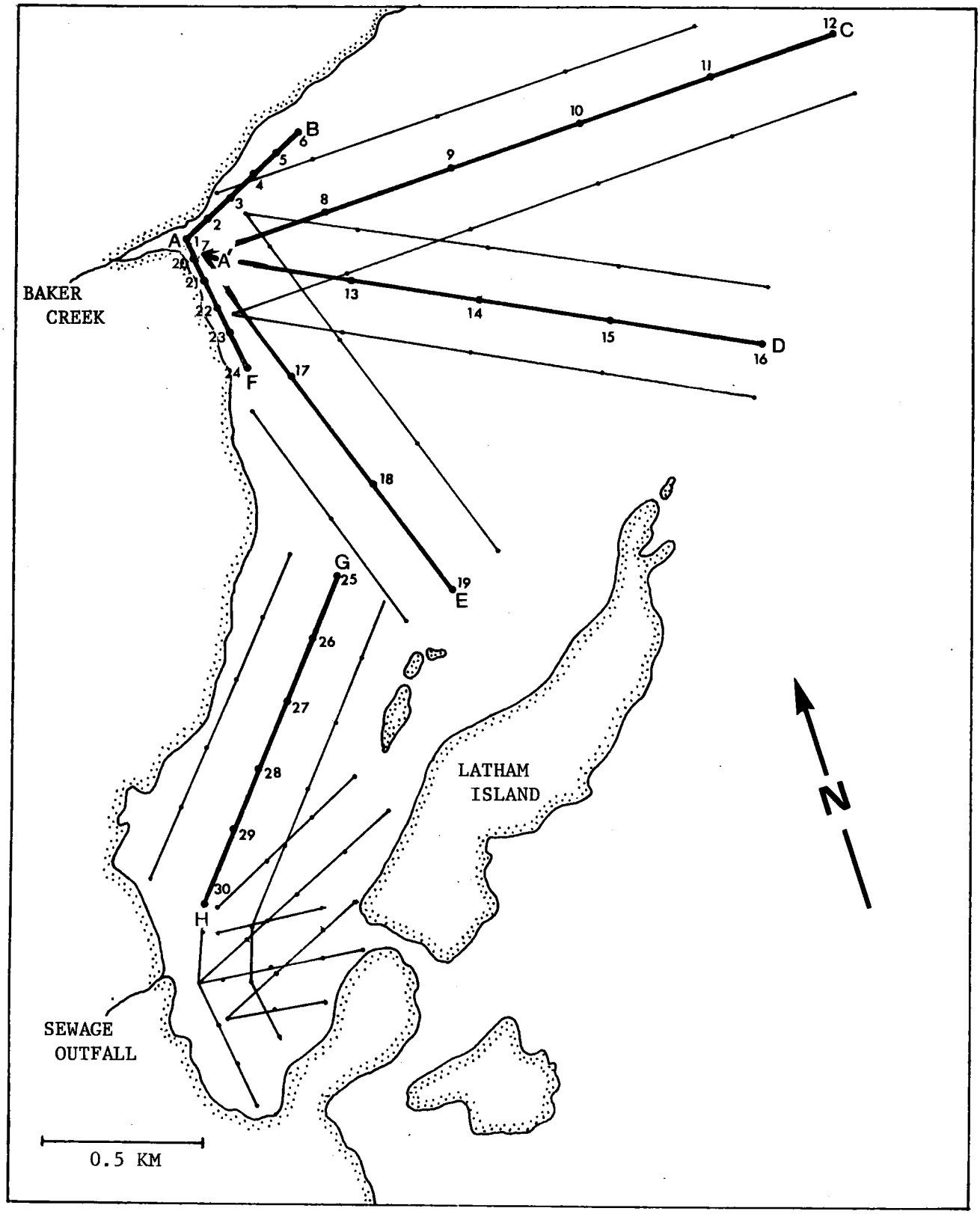

FIGURE 6 TRANSECTS USED FOR THE COLLECTION OF SAMPLES. Dark transects indicate water, sediment, and aquatic biota sampling. Light transects indicate additional aquatic biota sampling. Samples taken during June, July and August 1976.

TABLE 2 COLLECTION DATES FOR PHYSICO-CHEMICAL & BIOLOGICAL SAMPLES IN YELLOWKNIFE BAY & BAKER CREEK

HEAVY METAL SEDIMENT SAMPLING OF AREA 1-6 (FIGURE 4) CONDUCTED ON YELLOWKNIFE BAY DURING 1974

SAMPLES/DATES	JUNE	JULY	AUGUST
Sediment	x	x	x

WATER QUALITY, SEDIMENT & AQUATIC BIOTA SAMPLING OF 24 TRANSECTS (FIGURE 6) IN YELLOWKNIFE & BACK BAYS

SAMPLES/DATES	01/06/78
Water	x
Sediment	x
Aquatic Biota	every 2 weeks from June 1975 to November 1976

WATER QUALITY, SEDIMENT & AQUATIC BIOTA SAMPLING OF STATIONS a-j (FIGURE 5) IN YELLOWKNIFE BAY

SAMPLES/DATES	09/75	17/05/76	28/05/76	09/06/76	23/06/76	08/07/76	26/07/76	05/08/76	18/08/76	06/10/76
Water		x	x	x	x	x	x	x	x	x
Sediment	x					x		x		
Aquatic Biota		every two weeks from June 1976 to March 1977								

WATER QUALITY & BIOLOGICAL SAMPLING OF STATIONS UPSTREAM & DOWNSTREAM OF BAKER CREEK

SAMPLES/DATES	11/12/74	13/01/75	17/02/75	25/04/75	28/05/75	18/09/75	11/10/75	18/12/75
Water	x	x	x	x	x	x	x	x
Aquatic Biota		every two weeks from June 1975 to November 1976						

2.2 Water and Sediment Quality

Water samples for chemical analysis were collected using a 4 litre plastic Van Dorn bottle at the surface and at 10 m depth intervals. Samples taken for the determination of nutrient levels were frozen within 2 hours of collection. Those taken for the measurement of heavy metals and arsenic were preserved by acidification to pH 2 or lower with concentrated HNO_3. Samples for mercury determination were preserved by acidifying with concentrated H_2SO_4 to a pH of 2 or lower. Metal and nutrient analyses were performed by the Edmonton Laboratories of the Environmental Protection Service using the methods of Traversey (6). Water temperatures and conductivity were determined at 1 m depth intervals using a portable meter (Model 33, Yellow Spring Instrument Co.).

Sediments were collected using a coring tube lined with plastic (Model 2400 H, Wildco). The material was frozen within 2 hours of collection and most metals were analyzed by Barringer Research Ltd. (Toronto) using plasma emission spectrometry. However, arsenic was analyzed by hydride generation followed by colorimetric determination with silver diethyldithio-carbonate and mercury by flameless atomic absorption spectrometry by Barringer Research Ltd.

2.3 Biological Measurements

Samples of attached and planktonic algae from 2 stations on Baker Creek (Figure 3) were collected and analyzed as outlined in Moore (3). The zoobenthos was taken using a Surber sampler with a mesh size of 0.75 mm. It was found that a large number of invertebrates occurred deep in the substrate (0.5 m), making their recovery difficult. Therefore, quantitative determinations of the zoobenthos were not made. The downstream drift of Baker Creek was collected using a tow net (mesh size: 45 µm: diameter at mouth 50 cm) set for 15 minute intervals on each sampling date.

Phytoplankton samples in Yellowknife Bay were taken at 5 m depth intervals using a 4 litre Van Dorn bottle and analyzed within 1-2 hours of collection (3). Zooplankton was sampled at the same stations in 5 m depth intervals using the trap described

by Schindler (5). In the laboratory, the samples of zooplankton were made up to 100 ml with distilled water and subsampled so that approximately 100 animals could be conveniently counted/sample. The zoobenthos was taken using a 15 x 15 x 25 cm Ekman dredge. The samples were returned immediately to the laboratory and sorted using a screen with 0.25 mm openings.

3 RESULTS

3.1 Physical and Chemical Conditions

3.1.1 Baker Creek

Upstream from the mine (Figure 3), arsenic concentrations in the water reached 0.09 g/m^3 (Appendix I). Other toxicants such as zinc, copper, nickel and cyanide seldom exceeded 0.005 g/m^3. The hydrologic regime was characterized by maximum discharge (30 m^3/sec) in May followed by a gradual decrease to 0.05 m^3/sec in December (Figure 7). Temperatures rose to a maximum of 19°C in August and remained above freezing between April and October. Toxicant levels in Baker Creek, downstream from the mine, were occasionally very high (Appendix I). For example, arsenic was recorded at 9.1 g/m^3 while the corresponding values for zinc, copper, nickel and cyanide were 0.4, 4.1, 0.3 and 6.1 g/m^3 respectively. Suspended solids were also high, occasionally reaching 68 g/m^3 (Appendix I).

3.1.2 Yellowknife Bay

The concentration of metals in the sediments along transects A-B, A-A'-C, A-A'-D, A-A'-E and A-F decreased as distance from the mouth of Baker Creek increased (Figure 8, Appendix II). All levels were very high with arsenic, for example, ranging up to 3000 ppm 100 m from the mouth of Baker Creek and up to 2400 ppm at a distance of 1600 m. Similarly, mercury had a maximum of 496 ppb at 100 m and 420 ppb at 1600 m. Metal levels along transect G-H in Back Bay were elevated (Appendix II), showing a mean arsenic value of 153 ppm. Large quantities of mercury were also present with a maximum value of 478 ppb being recorded. Based on the cumulative data collected from

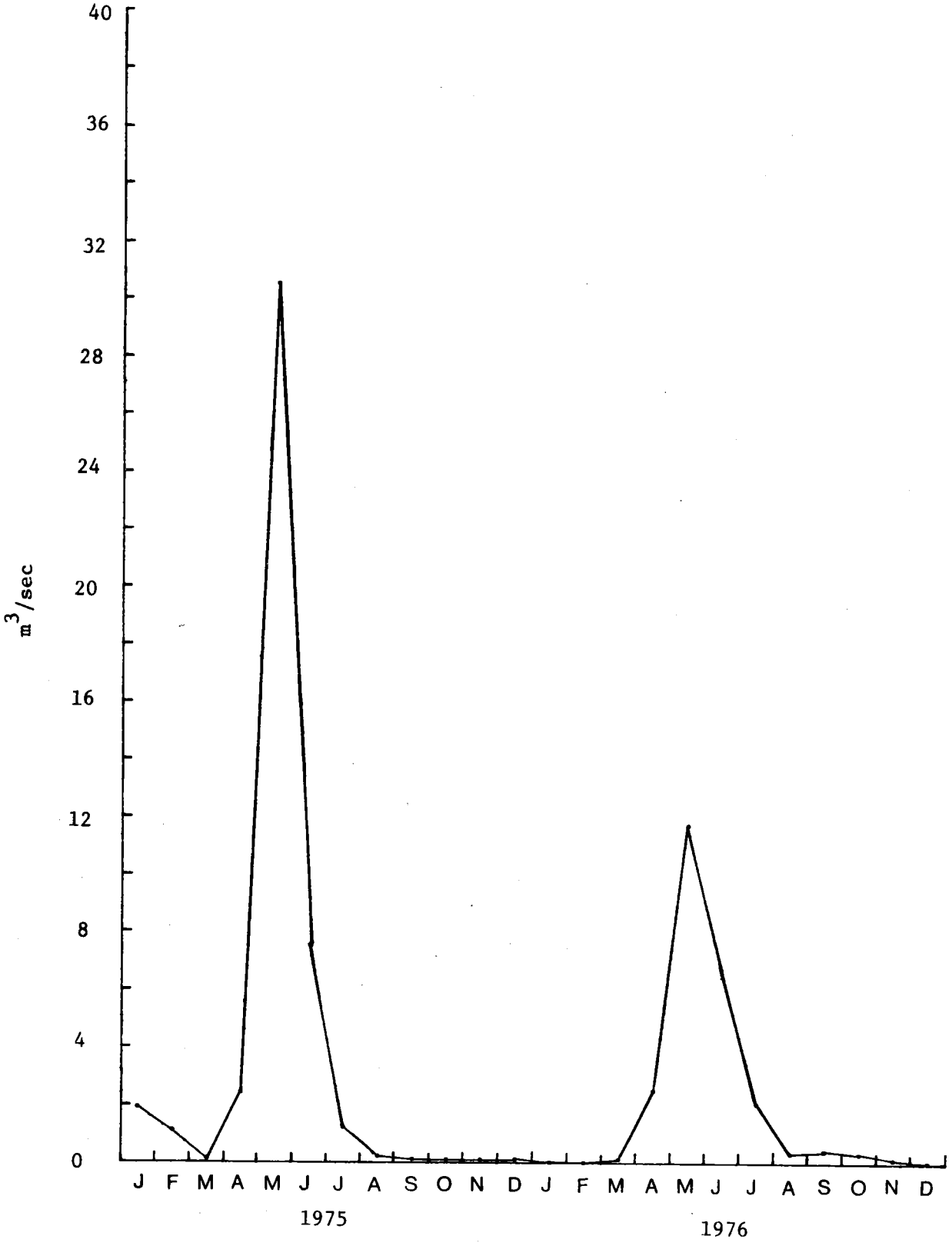

FIGURE 7 DISCHARGE RATE OF BAKER CREEK DURING 1975 AND 1976. Values obtained from Inland Waters Directorate in Yellowknife NWT. Rates were measured at the upstream sampling site on Baker Creek.

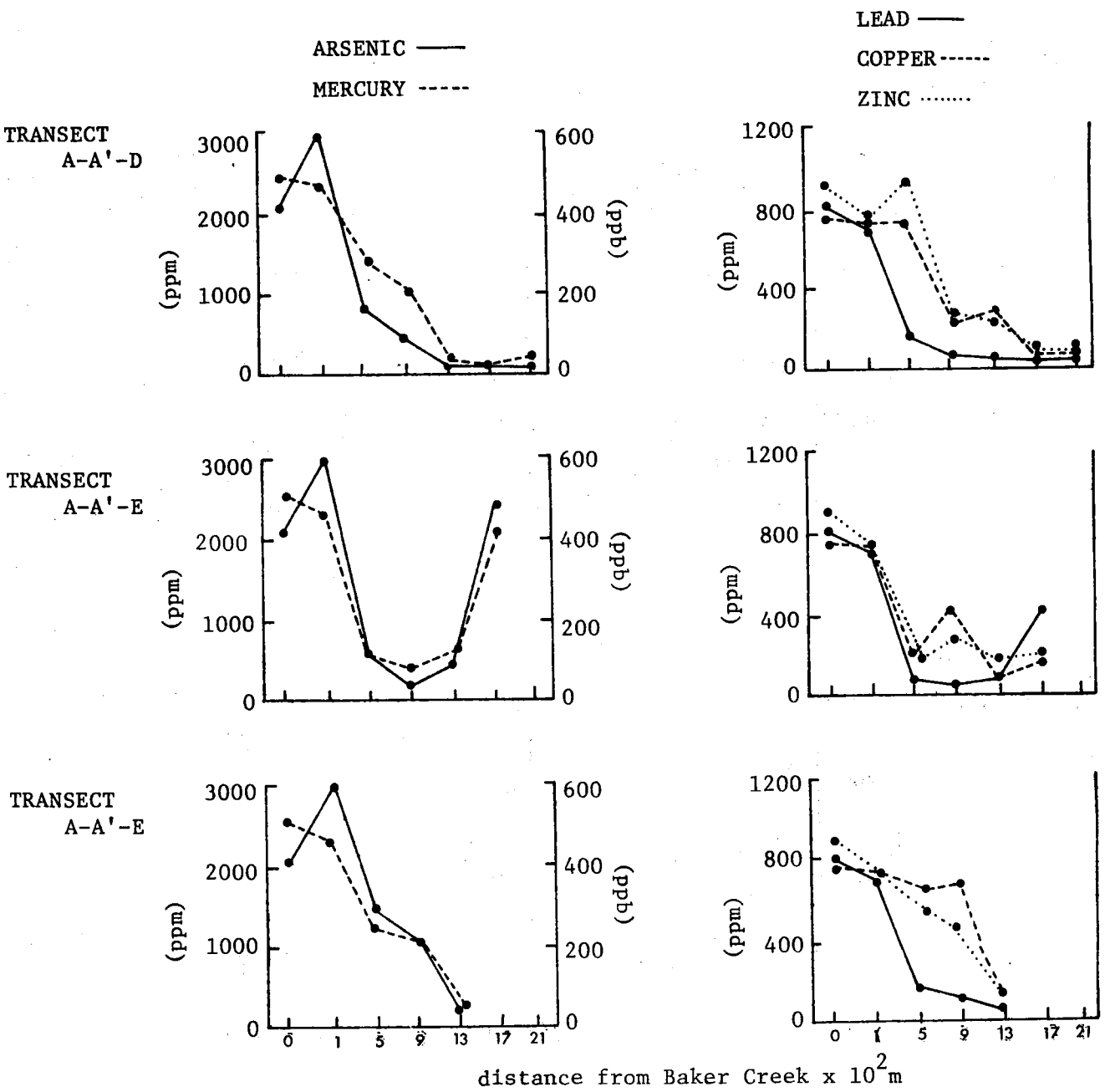

FIGURE 8 CONCENTRATION OF METALS IN THE SEDIMENTS OF YELLOWKNIFE BAY ALONG TRANSECTS A-B, A-A'-C, A-A'-D, A-A'-E AND A-F. All values are in ppm except those for mercury which are in ppb.

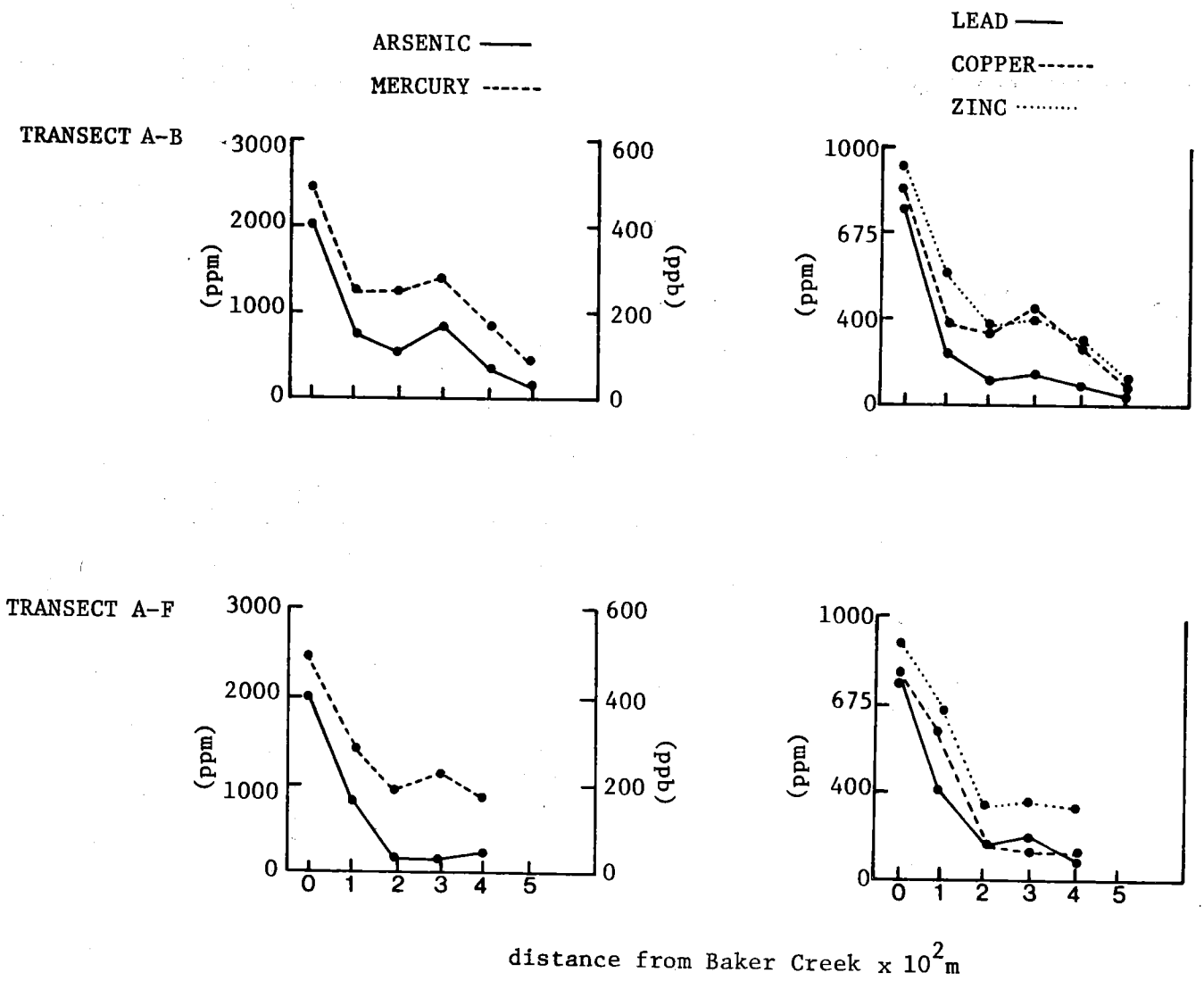

FIGURE 8 (CONTINUED).

stations a-j and areas 1-6, it is apparent that metal levels in the sediments tended to decrease as the distance from the point of discharge increased (Appendix III). For example, arsenic concentrations reached 450 ppm at station c and fell to 8 ppm at station i.

Arsenic in the water was recorded at a maximum level of 0.74 g/m^3 along the transects (Appendix IV), far in excess of the maximum permissable limit (0.05 g/m^3) recommended in the Canada Drinking Water Standards. Similarly, copper and iron were high on one occasion, reaching concentrations of up to 0.28 g/m^3. There was also a considerable amount of nutrient input from Baker Creek, with total phosphorus levels at the mouth reaching 0.19 g/m^3 (Appendix IV).

At stations e, f, h and j, most heavy metal concentrations in the water samples fell below detectable limits (Appendix V). However, a few high levels were seen, such as magnesium and zinc, where 8.4 and 0.3 g/m^3, respectively, were recorded. In addition, arsenic showed a distinct peak in June, reaching 0.4 g/m^3 at station e.

3.2 Biological Measurements

3.2.1 Baker Creek

The aquatic life in the upper reaches of Baker Creek was very abundant and diverse. For example, three species of fish - pike (*Esox lucius* L.), stickleback (*Pungitius pungitius* (L.)), and sculpins (*Cottus cognatus* Richardson) - were collected coincidentally with the water and invertebrate samples. Large numbers of algae were also found in the water (plankton), on rocks (epilithon), and on plant stems (epiphyton) (Figures 9-11). Although accurate density estimates were not made, invertebrate populations on the bottom frequently exceeded 5000 animals/m^2. The most common species were larval Simuliidae, Ephemeroptera, Plecoptera and Trichoptera. The drift of the stream included Crustacea and Rotifera with maximum population levels reaching 500 animals/m^3.

Below the mine, fish, crustaceans, insects and rotifers were never encountered. The benthic fauna consisted of a few

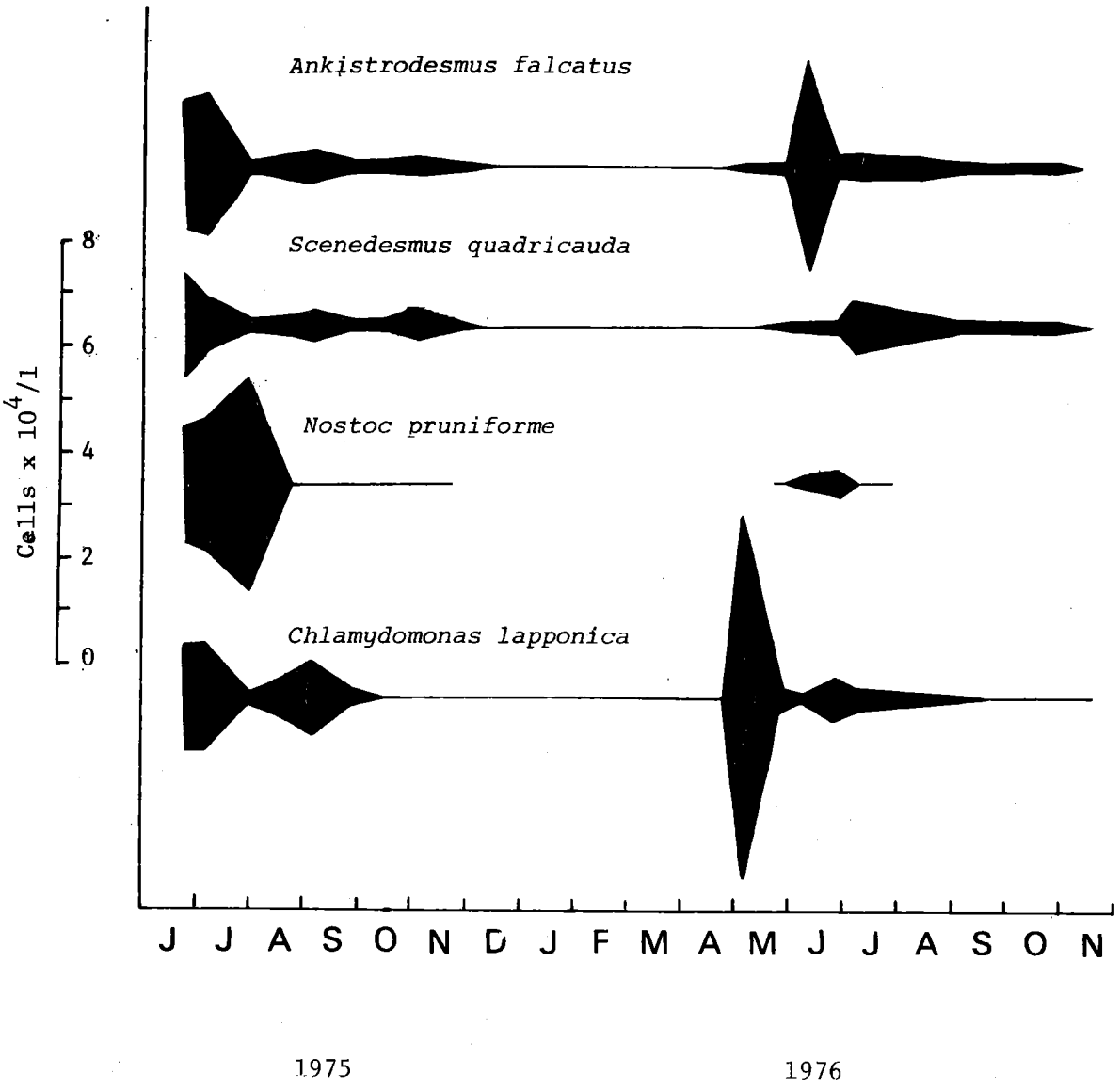

FIGURE 9 SEASONAL SUCCESSION OF PLANKTONIC ALGAL SPECIES IN THE UPPER REACHES OF BAKER CREEK.

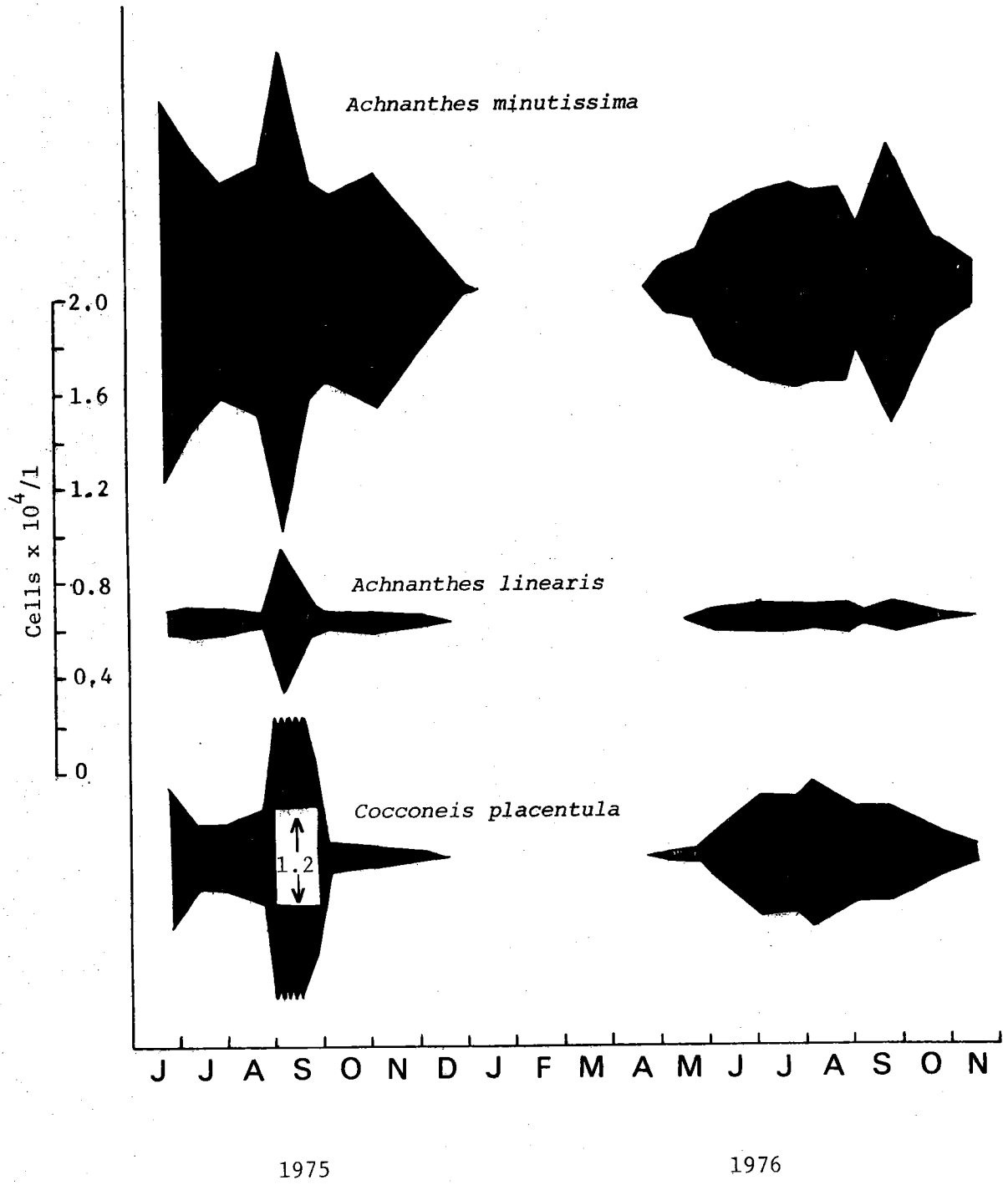

FIGURE 10 SEASONAL SUCCESSION OF EPILITHIC ALGAL SPECIES IN THE UPPER REACHES OF BAKER CREEK.

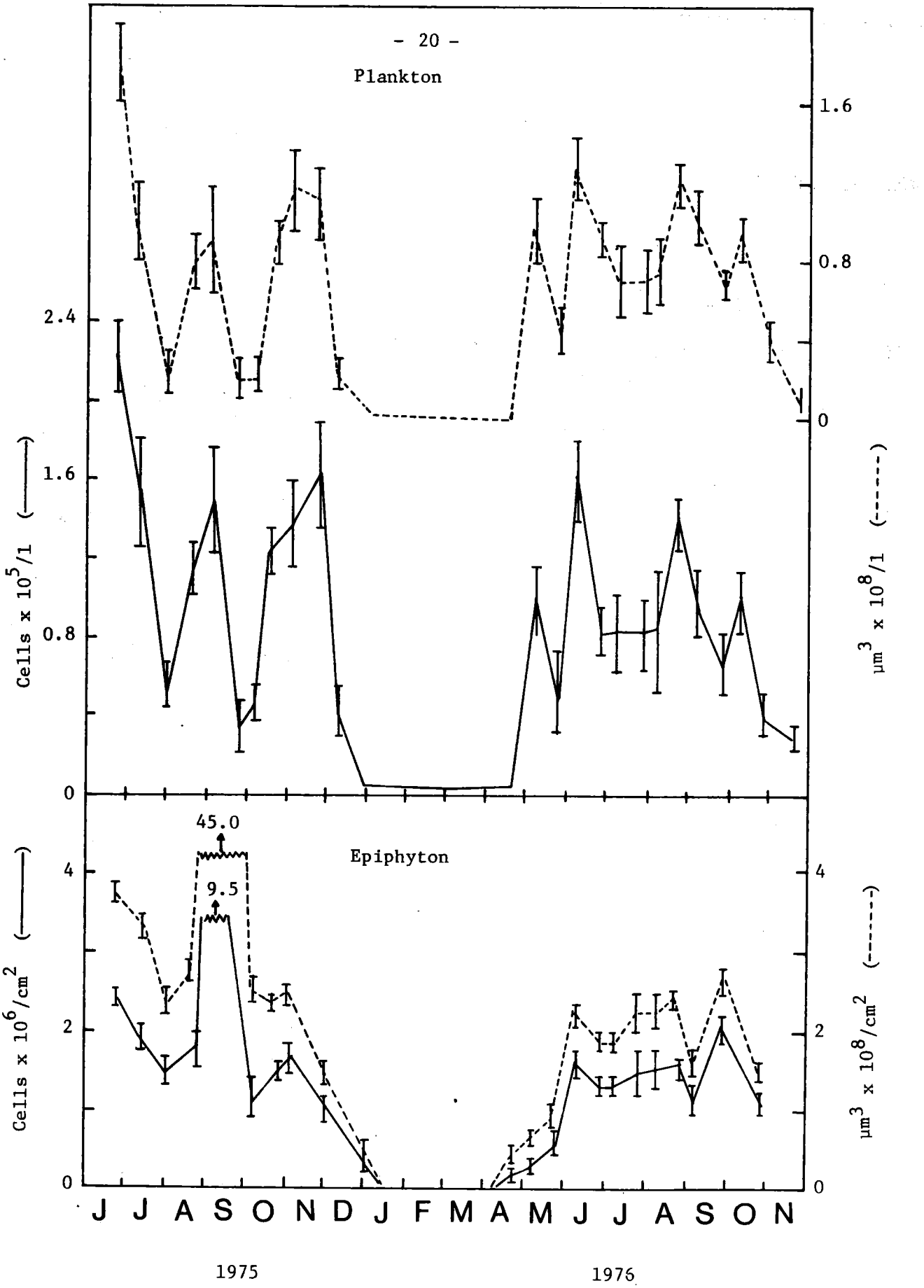

FIGURE 11 SEASONAL SUCCESSION OF PLANKTON AND EPIPHYTON IN THE UPPER REACHES OF BAKER CREEK. Vertical bar represents 95 % confidence limits.

(<100/m^2) Oligochaetes. While algae were usually absent, one species *(Chlamydomonas lapponica)* was recorded at low densities during July and August of 1975.

3.2.2 Yellowknife Bay

3.2.2.1 Zoobenthos

The density of benthic organisms was extremely low near the mouth of Baker Creek, averaging <200 animals/m^2 (Figure 12). Recovery of the populations began at a distance of 1000-1200 m from the mouth of Baker Creek. The predominant species within the contaminated zone were *Procladius denticulatus* Sublette, *Heterotrissocladius changi* Saether, and *Pontoporeia affinis*. Large numbers of invertebrates were recorded at stations e, f, i and j. Densities frequently exceeded 10,000 animals/m^2 during the winter, falling to <2000/m^2 in the summer (Figures 13-16). The most common species were generally similar to those outlined for the polluted area. Bottom sampling was also conducted in the area used for tailings disposal in Yellowknife Bay during the early part of the 1960's (Figure 17). No animals could be found in this area.

Based on the density of benthic organisms along the transects and at the collection stations, a well defined zone of influence can be delineated in Yellowknife and Back Bays (Figure 17). This zone, comprised of areas where densities are <400 animals/m^2, extends throughout almost the entire length of Back Bay.

It should be pointed out here that the delineation of the zone is based on the collections made during June, July and August 1976. Based on Figures 13-16, it is apparent that these collections were made at a period of low seasonal densities. It is therefore likely that the abundance of the biota within the zone of influence would, however, remain low compared to the non-impacted areas.

Multiple regression analysis was used to correlate invertebrate densities within the zone of influence to metal levels in the substrate. As indicated in Table 3, over 90% of the variability in invertebrate populations can be related to metal concentrations.

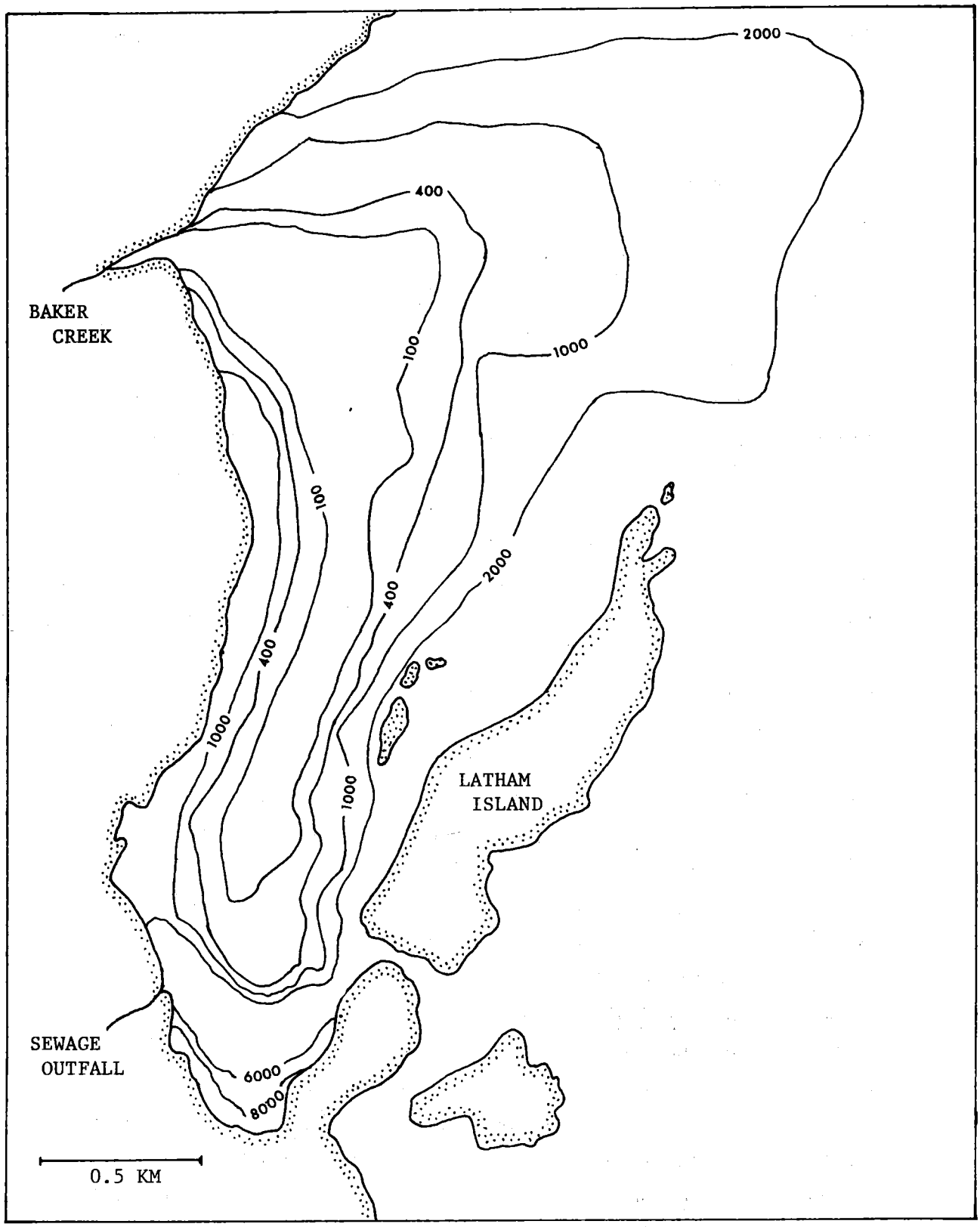

FIGURE 12 DENSITY OF ZOOBENTHOS IN BACK BAY. Numbers refer to animals/m^2. Samples taken during June, July and August 1976.

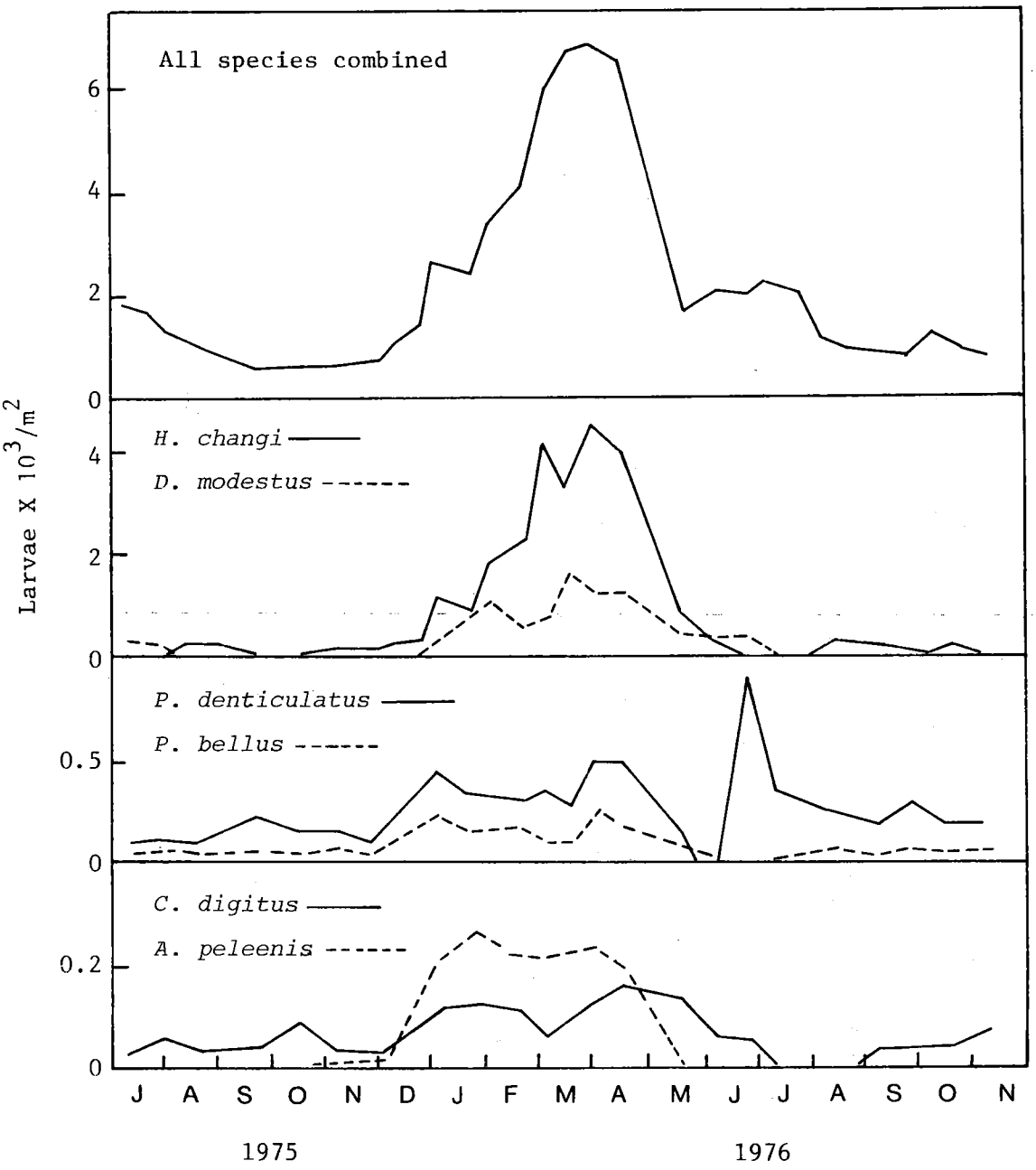

FIGURE 13 SEASONAL CHANGES IN THE DENSITY OF CHIRONOMIDS AT STATION e.

H. changi = Heterotrissocladius changi
D. modestus = Dicrotendipes modestus
P. denticulatus = Procladius denticulatus
P. bellus = Procladius bellus
C. digitus = Cryptochironomus digitus
A. peleenis = Ablabesmyia peleenis

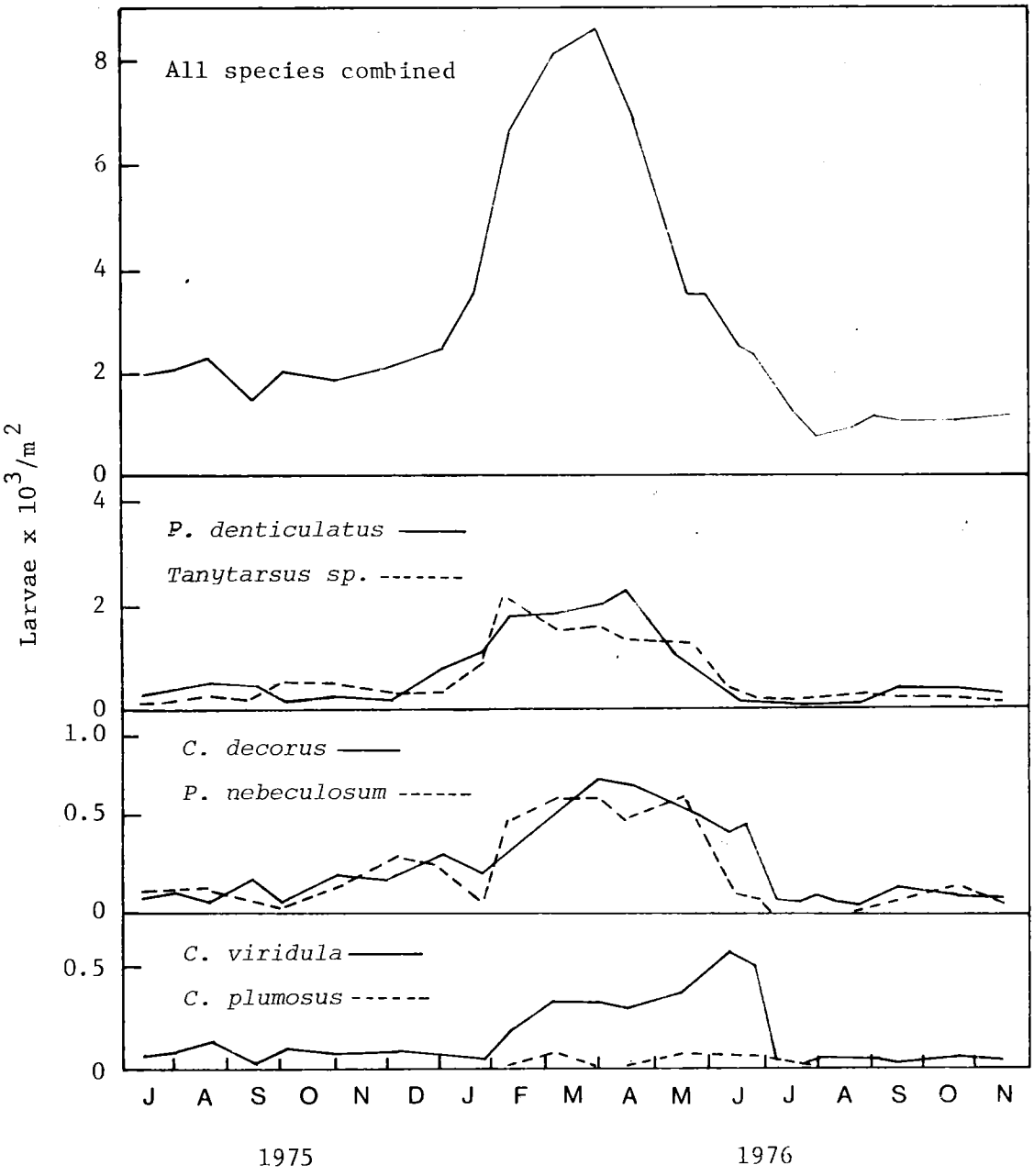

FIGURE 14 SEASONAL CHANGES IN THE DENSITY OF CHIRONOMIDS AT STATION f.

P. denticulatus = Procladius denticulatus
C. decorus = Chironomus decorus
P. nebeculosum = Polypedilum nebeculosum
C. viridula = Cryptochironomus viridula
C. plumosis = Chironomus plumosis

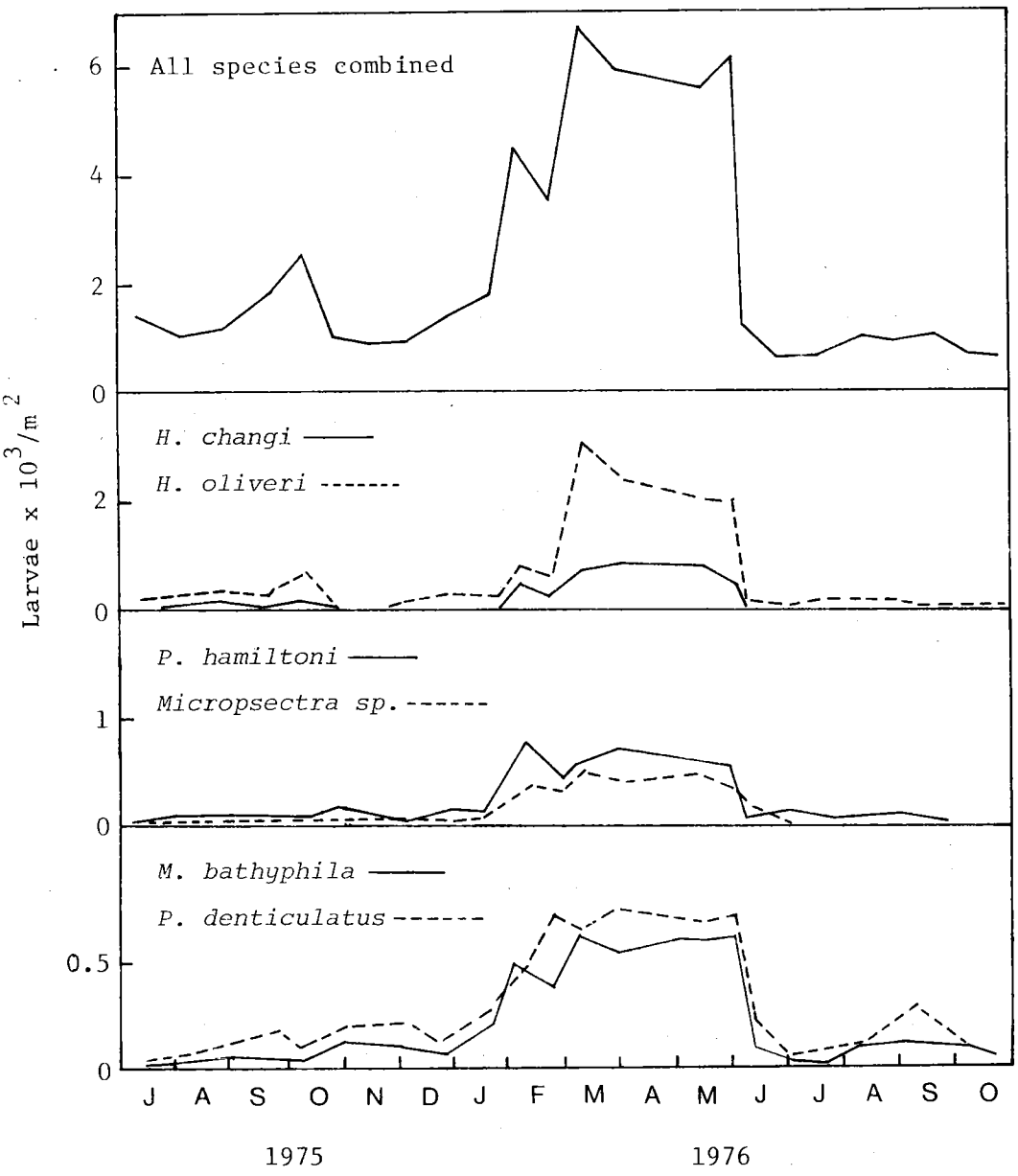

FIGURE 15 SEASONAL CHANGES IN THE DENSITY OF CHIRONOMIDS AT STATION j.

H. changi = Heterotrissocladius changi
H. oliveri = Heterotrissocladius oliveri
P. hamiltoni = Protanypus hamiltoni
M. bathyphila = Monodiamesa bathyphila
P. denticulatus = Procladius denticulatus

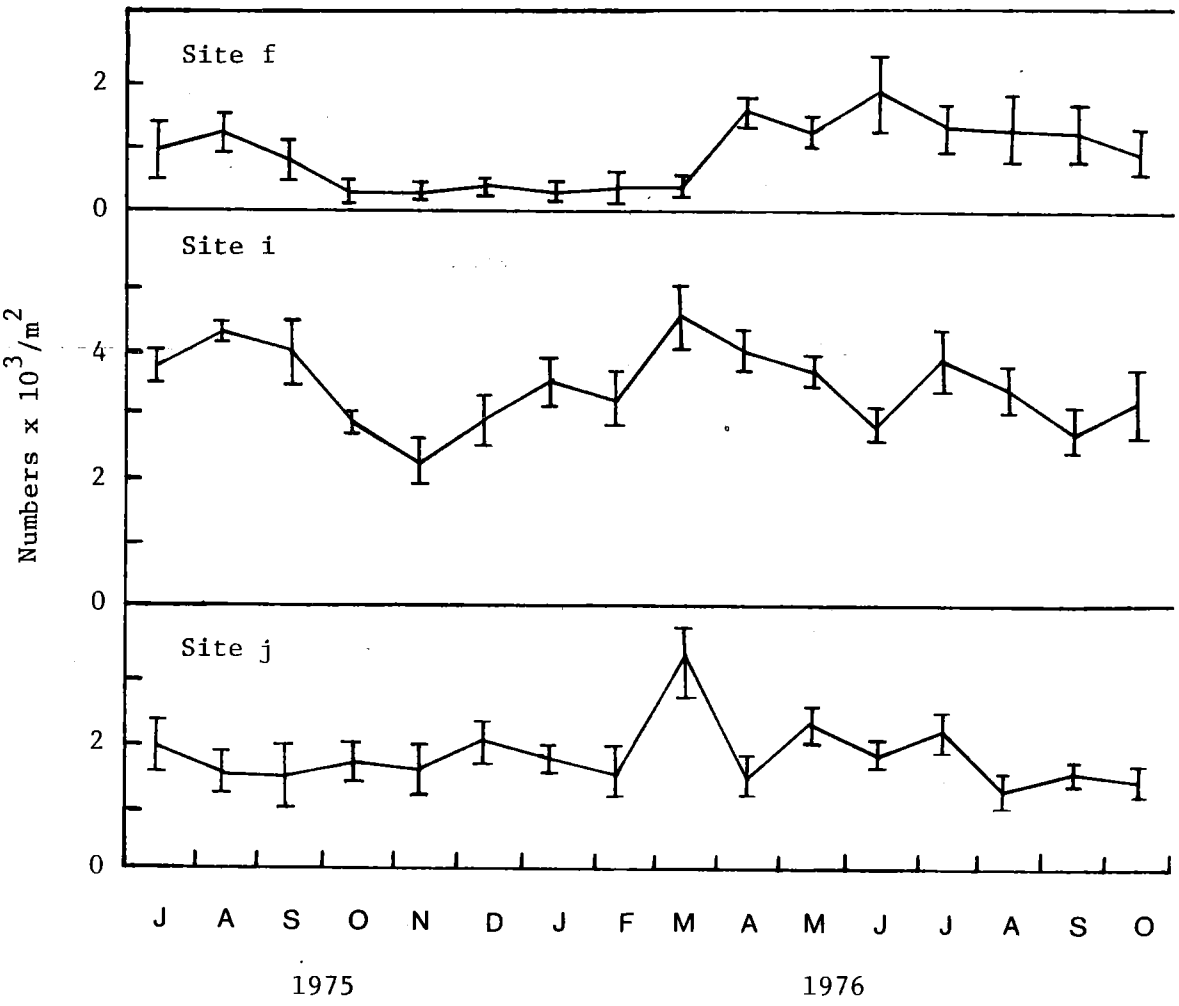

FIGURE 16 SEASONAL CHANGES IN THE DENSITY OF *Pontporeia affinis* AT STATIONS f, i, AND j.

TABLE 3

MULTIPLE REGRESSION ANALYSIS RELATING THE DENSITY OF BENTHIC ORGANISMS TO THE CONCENTRATION OF METALS IN THE SEDIMENTS OF YELLOWKNIFE BAY

METAL	RANK	r	MR^2
Zinc	1	-0.71	33.0
Arsenic	2	-0.46	63.2
Lead	3	-0.63	80.3
Mercury	4	-0.55	92.1
Copper	5	-0.64	94.5
Nickel	6	-0.60	95.6
Cadmium	7	-0.49	96.7

r = correlation coefficient

MR^2 = accumulated variation of the dependent variable accounted for by the step-wise entry of the independent variables. All values significant at P = 0.05

Therefore it is apparent that the contamination originating from the mine has had a direct and significant effect on the biota of the Bay. Furthermore, the zone of influence as illustrated in Figure 17, depicts the area of immediate contamination, given the highly significant correlation (P=0.05) between invertebrate densities and metal levels.

3.2.2.2 Zooplankton

The density of all species of zooplankton was generally identical along transects A-A'-C, A-A'-D and A-A'-E (Figure 18). However, levels were low at the mouth of Baker Creek and, to a lesser degree, at 400 m from the mouth. Prevalent species included the rotifers *Keratella cochlearis* Ahlstrom, *Kellicottia longispina* (Kellicott), *Synchaeta stylata* Weiz., the copepods *Cyclops bicuspidatus thomasi* Forbes, *Diaptomus ashlandi* Marsh, *Diaptomus sicilis* Forbes and the cladocerans *Holopedium gibberum* Zaddach and *Bosmina longirostris* (O.F. Muller) (Figures 19-21). The species composition of the zooplankton communities at stations e, f, i and j was usually identical to that found on the transects, though *Leptodora kindtii* (Focke) was occasionally recorded at j but nowhere else. The density of several species was significantly greater at station f than in the other areas particularly in the case of *Synchaeta stylata* (Figure 19).

3.2.2.3 Phytoplankton

Phytoplankton densities were also generally similar along transects A-A'-C, A-A'-D, and A-A'-E (Figure 22). The predominant species were *Asterionella formosa* Hass., *Diatoma tenue* Ag., *Melosira islandica* O.F. Mul., *Dinobryon* spp., *Scenedesmus quadricauda* (Turp.) Breb. (Figure 23). Algal populations at stations e, f, h and j were similar, with maximum densities of 7×10^3 cells/m^2 being reached in the summer. The species composition of the assemblages was generally comparable among the 4 stations (Figure 23, 24). However, *Scenedesmus* spp. were rare at station j.

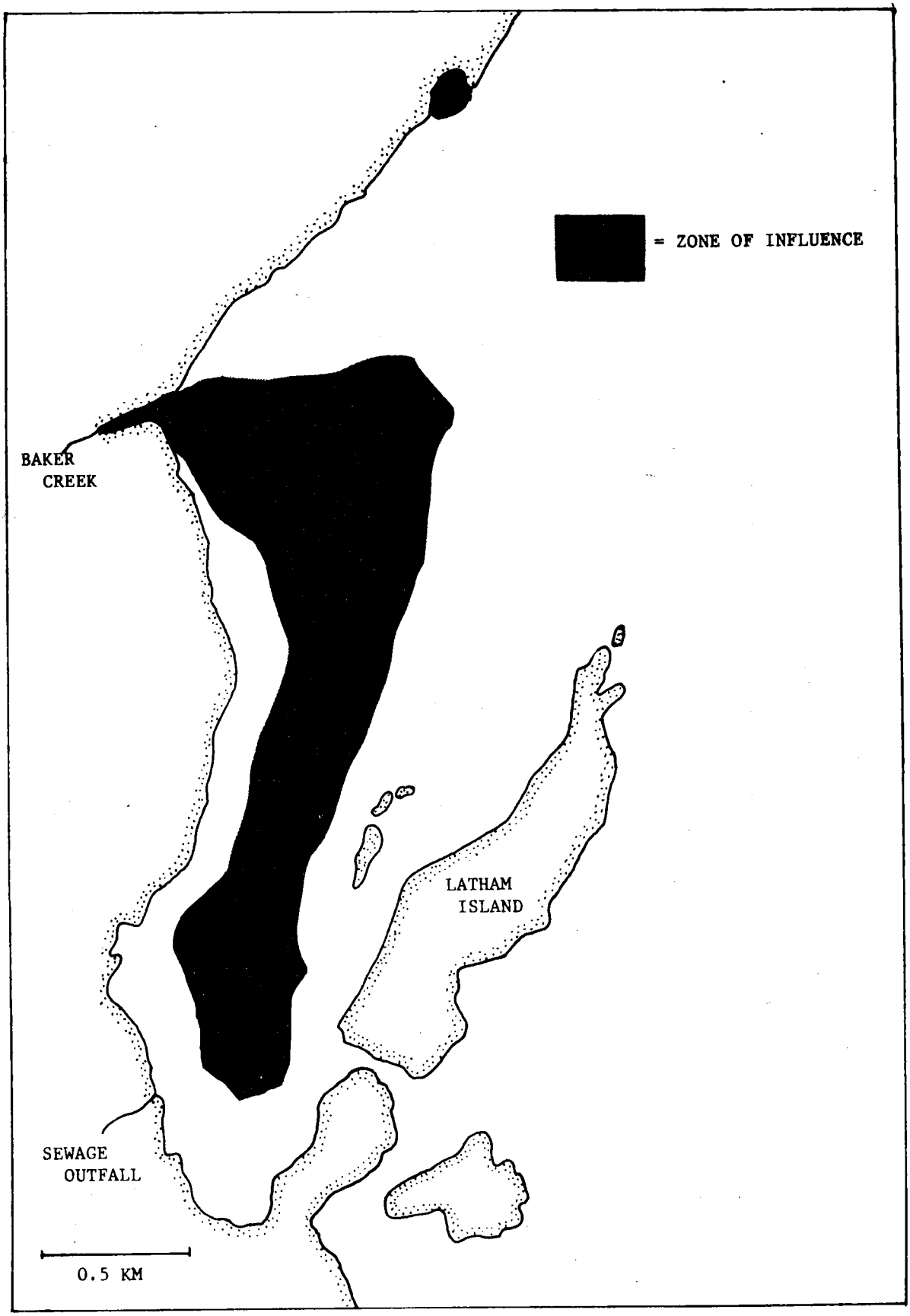

FIGURE 17 THE ZONE OF INFLUENCE CAUSED BY THE OPERATIONS OF GIANT YELLOWKNIFE MINES LTD. IN BACK BAY. Maximum summer zoobenthic densities were <400 animals/m^2 within the zone of influence.

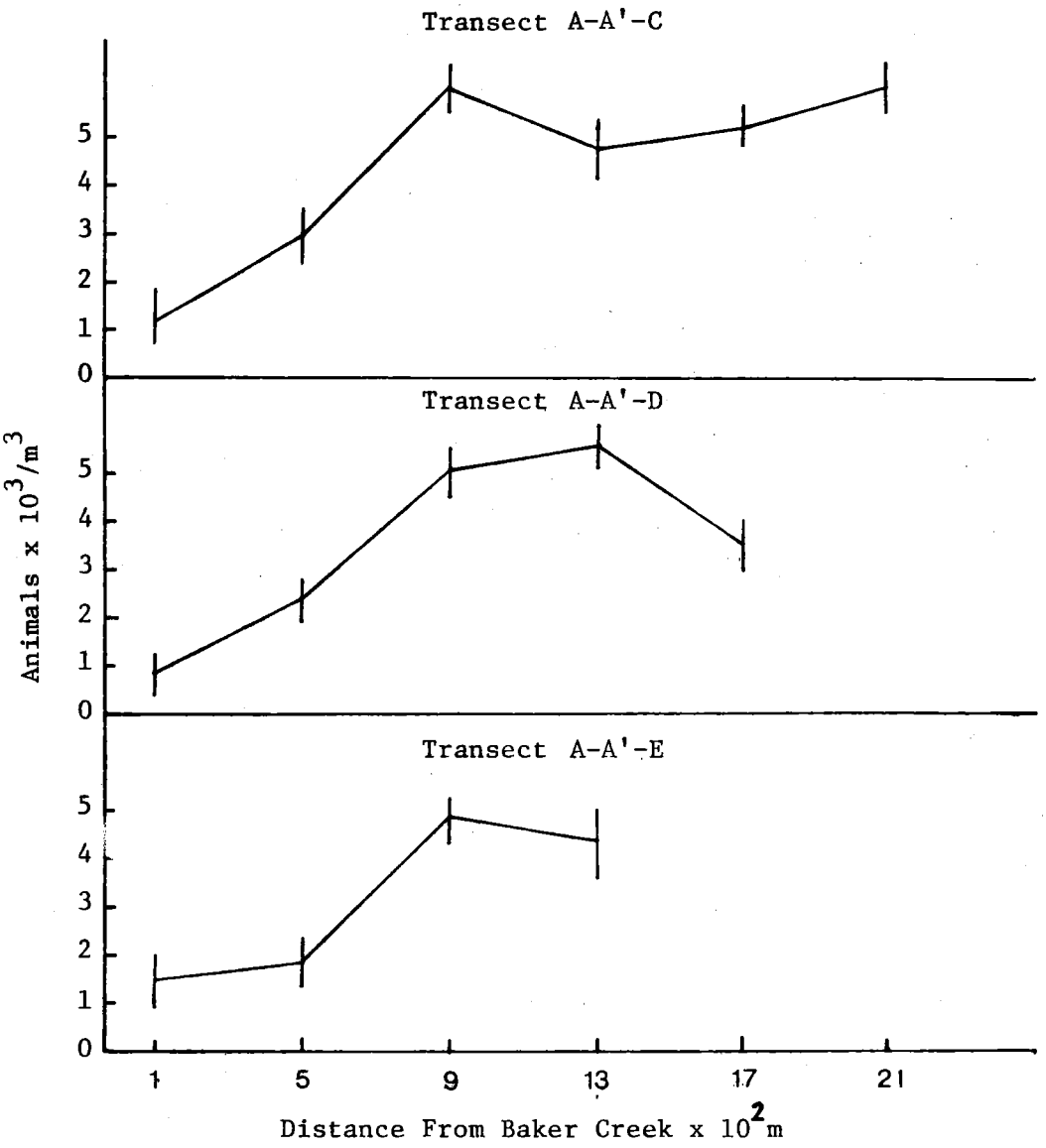

FIGURE 18 DENSITY OF ZOOPLANKTON ALONG TRANSECTS A-A'-C, A-A'-D, A-A'-E IN YELLOWKNIFE BAY. Vertical bar represents 95% confidence limits.

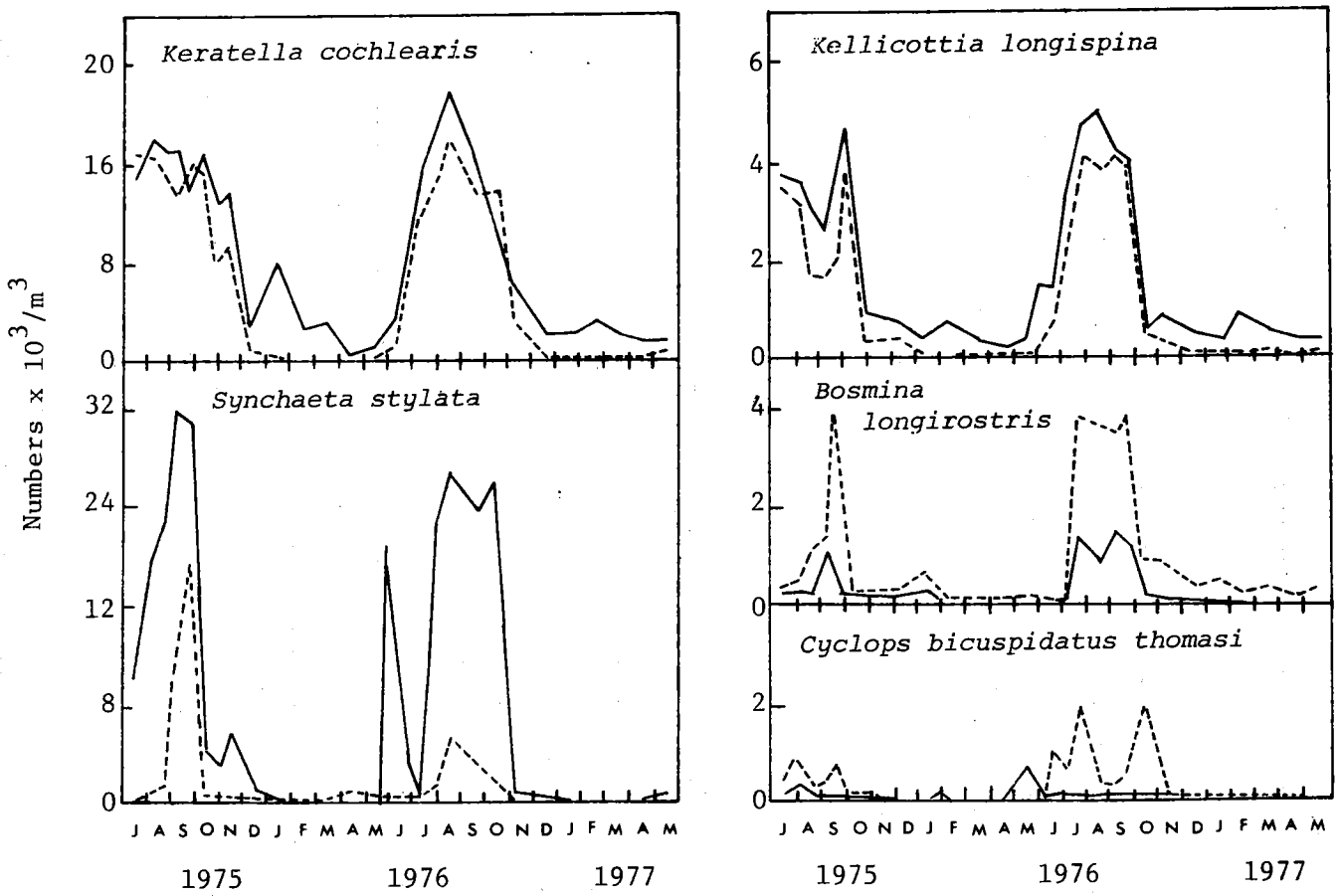

FIGURE 19 SEASONAL CHANGES IN THE DENSITY OF ZOOPLANKTON AT STATIONS e, i AND j (——) AND f (----).

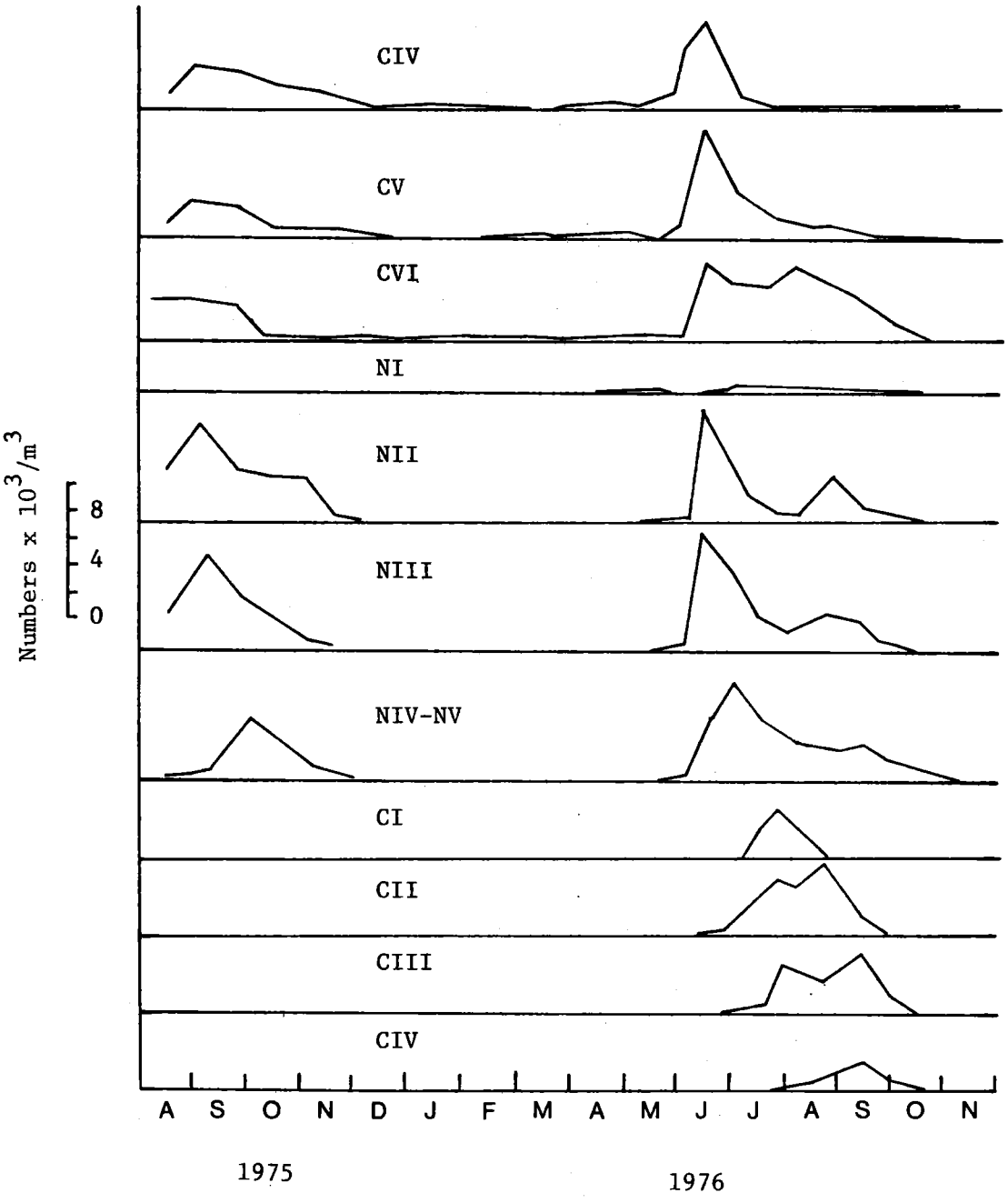

FIGURE 20 SEASONAL CHANGES IN THE DENSITY OF THE DIFFERENT DEVELOPMENTAL STAGES OF *Cyclops bicuspidatus thomasi* AT STATIONS e, f, i AND j. C refers to the copepodite stage, and N refers to the nauplian stage.

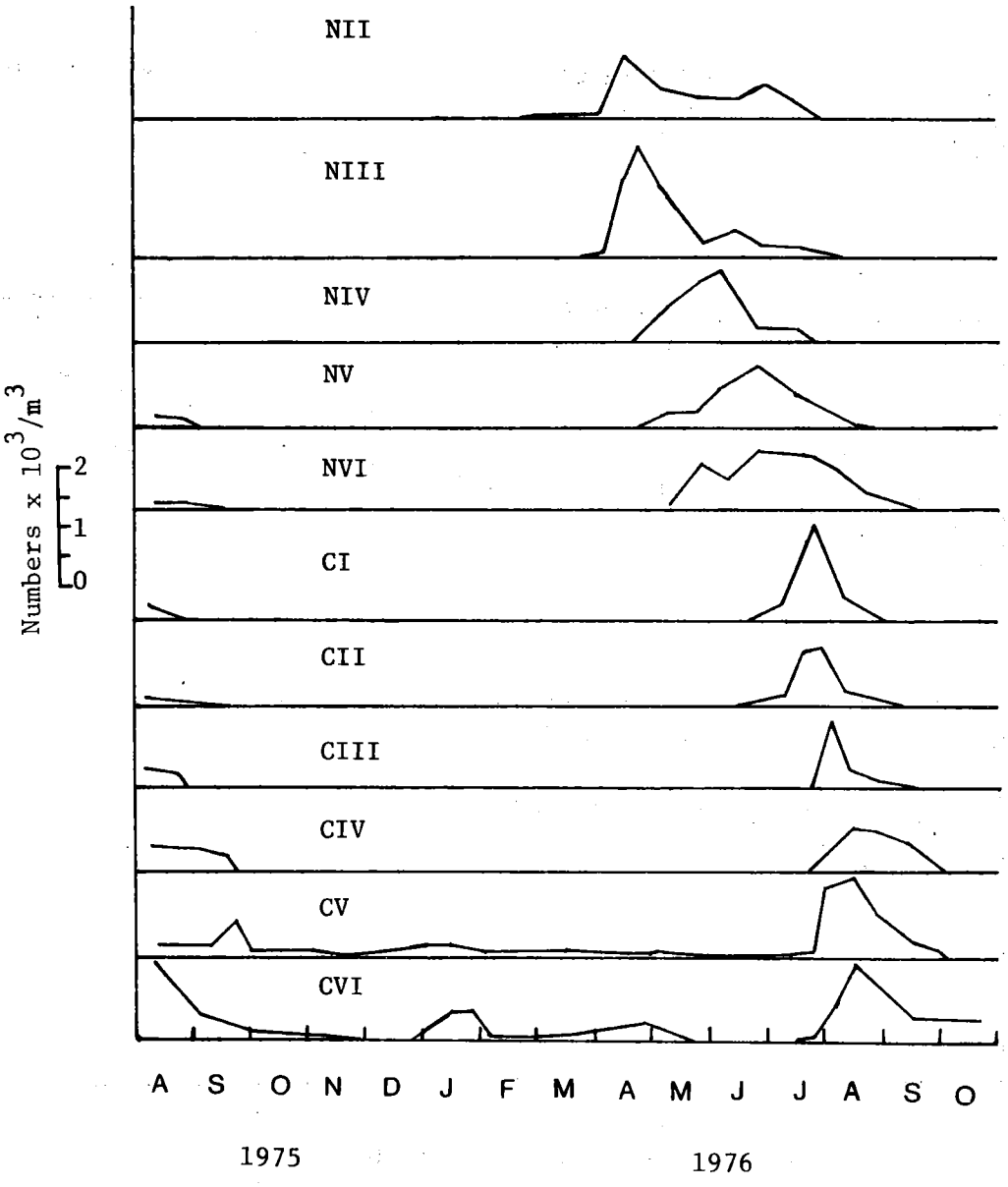

FIGURE 21 SEASONAL CHANGES IN THE DENSITY OF THE DIFFERENT DEVELOPMENT STAGES OF *Diaptomus ashlandi* AT STATIONS e, f, i AND j.C refers to the copepodite stage, and N refers to the nauplian stage.

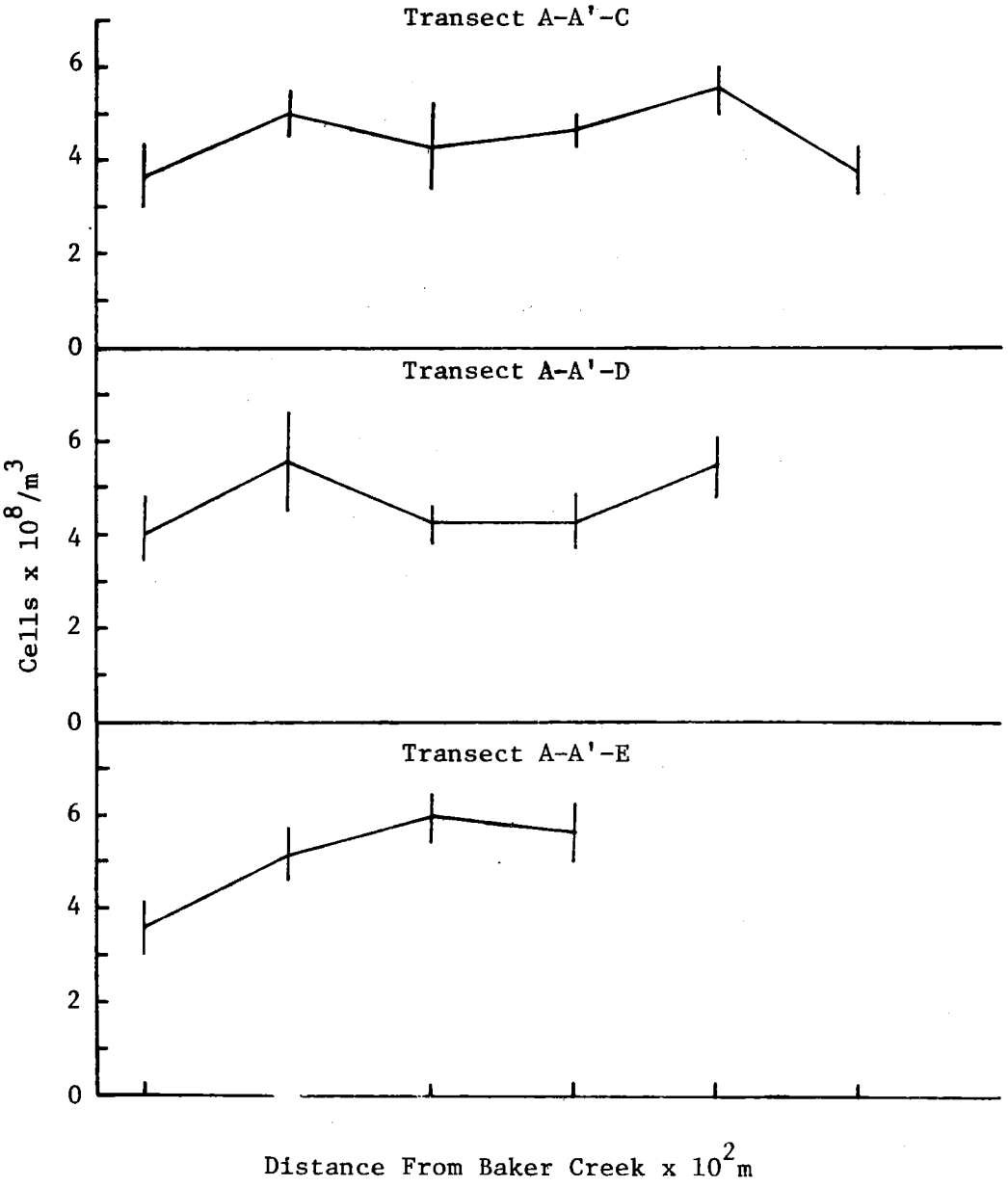

FIGURE 22 DENSITY OF PHYTOPLANKTON ALONG TRANSECTS A-A'-C, A-A'-D, A-A'-E. Vertical bar represents 95% confidence limits.

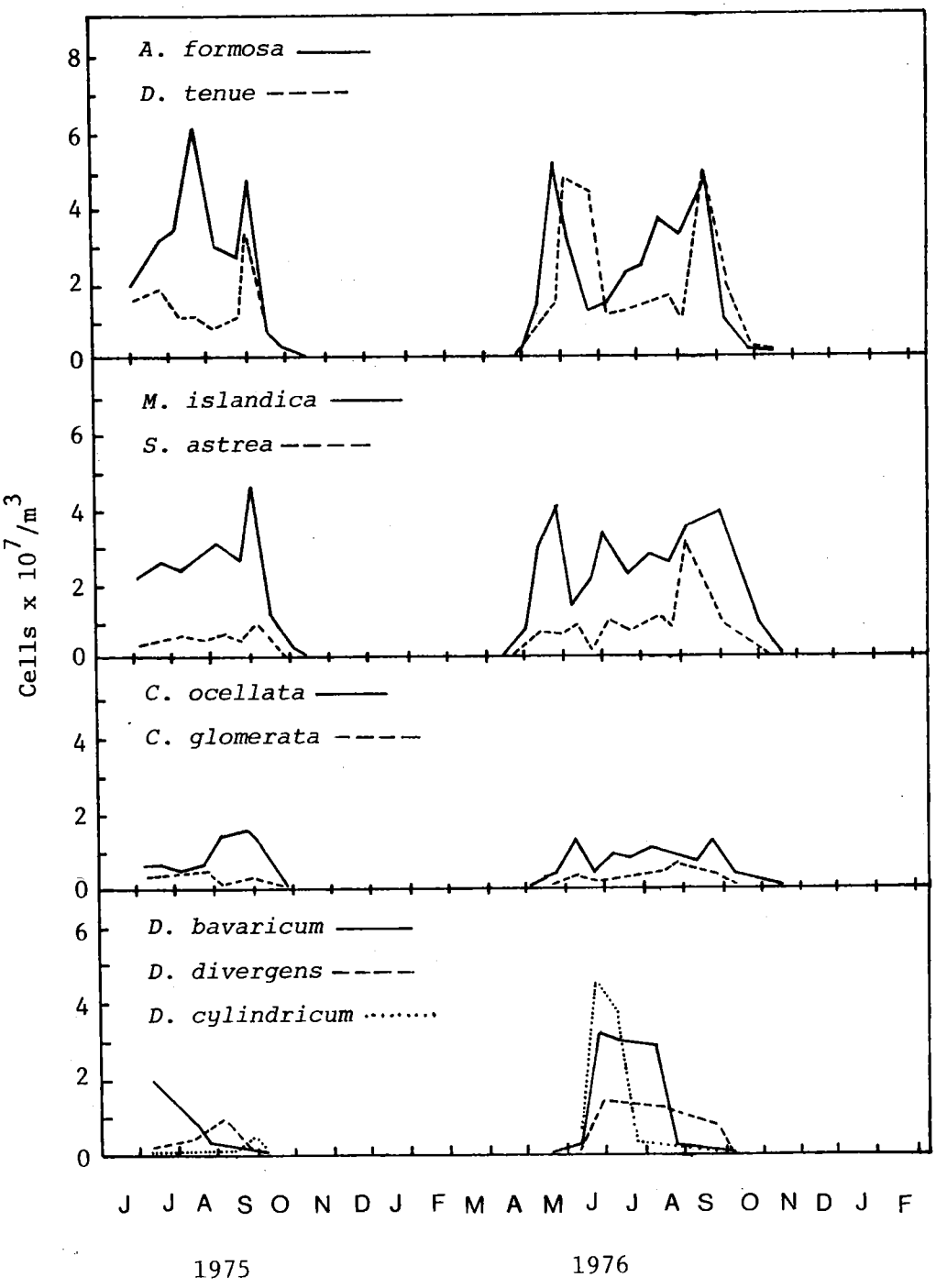

FIGURE 23 SEASONAL CHANGES IN THE DENSITY OF PLANKTONIC ALGAL SPECIES AT STATIONS e, f, i, AND j.

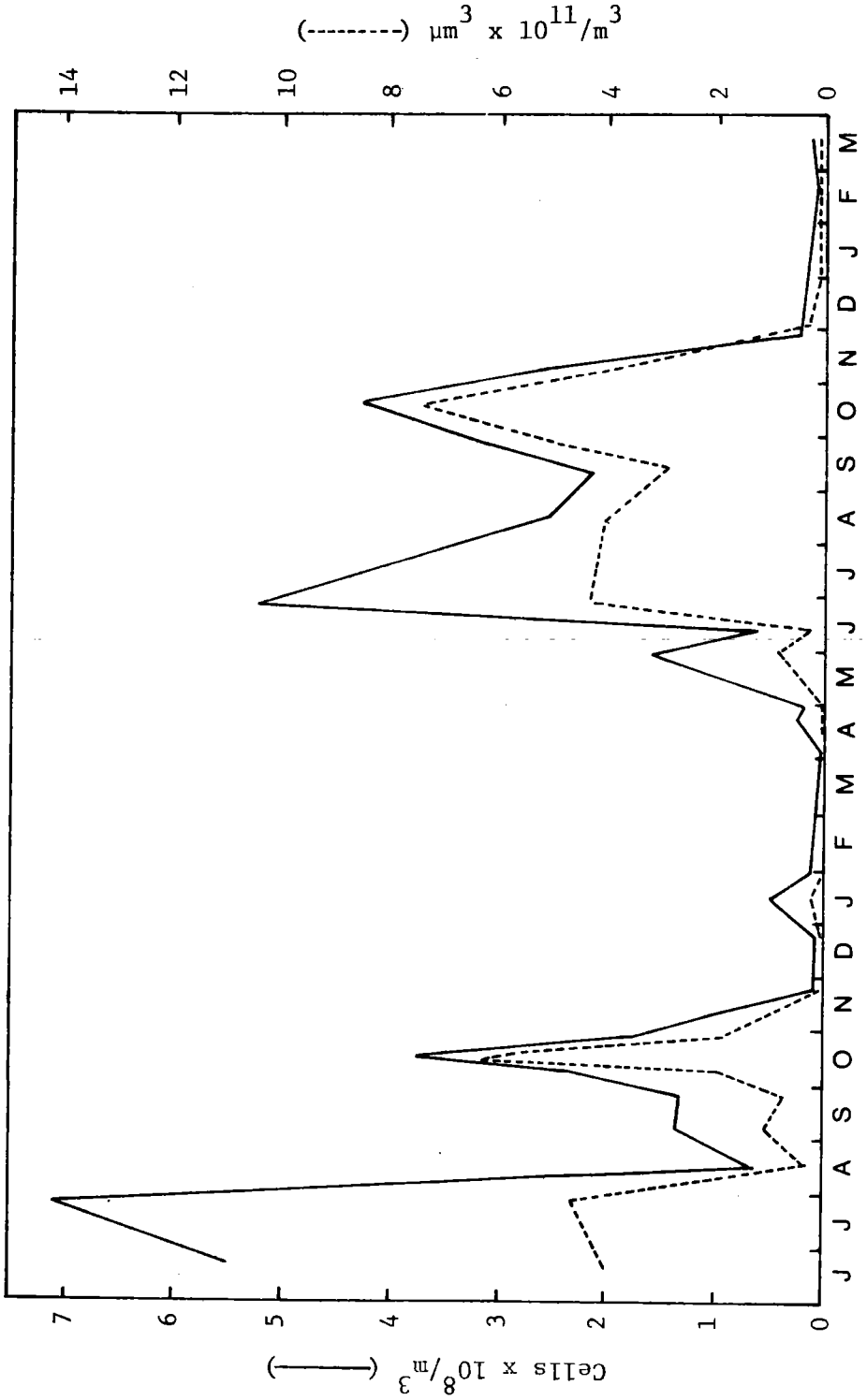

FIGURE 24 SEASONAL CHANGES IN THE DENSITY OF PHYTOPLANKTON AT STATIONS e, f, i, AND j.

4 FISH

The concentrations of all heavy metals (arsenic, copper, lead, zinc, cadmium, nickel, mercury) were low in northern pike and whitefish collected from Yellowknife Bay and Back Bay by personnel from the Fisheries and Marine Service during 1974 and 1975. The concentration of arsenic, for example, was always less than 0.4 ppb, while mercury was recorded at less than 0.2 ppm in all specimens (unpublished data).

5 GENERAL DISCUSSION

The operations of Giant Yellowknife Mines have clearly had a detrimental effect on a large part of Back Bay. The sediments of the bay are contaminated with arsenic and mercury up to a distance of at least 3 km from the mine. The water in Back Bay contained very large amounts of arsenic on at least 2 occasions, far above the maximum limit of 0.05 g/m^3 for potable water (1). The high concentrations of metals that are currently entering Yellowknife Bay from Baker Creek may result in an expansion of the zone of influence. Therefore, the quality of effluent from the mine must be greatly improved as soon as possible.

Although the multiple regression analysis showed that there were significant correlations between zoobenthos densities and the concentrations of metals in the sediments, it should be pointed out that other factors could have affected the invertebrate populations. For example, water depth, the organic content of the substrate, and substrate compactness could have influenced the populations. Furthermore, although there was a good correlation between invertebrate densities and metal levels within the zone of influence, there were several instances in which high concentrations of metals occurred outside of the zone (see for example, Figure 8). Therefore, while the response of the benthos to metal contamination depended to some degree on natural environmental conditions, the marked reduction in the density of the biota was also strongly related to the mining activities, as illustrated in Figure 17.

The fish in Yellowknife Bay and Back Bay are safe for human consumption despite the high level of metal contamination in the sediments. This is probably related to the fact that all species are free to move out of the contaminated zone of influence. Consequently, exposure to the heavy metals may be very brief. The marked reduction in the density of the bottom fauna in the bay, however, has reduced the food supply for bottom feeding fish such as lake whitefish, round whitefish and grayling. In addition, it is unlikely that the bottom fauna will recover while the effluent, with its high metal levels, continues to be deposited into the bay.

Based on the water quality characteristics of Baker Creek there can also be little doubt that a deleterious discharge is taking place into Yellowknife Bay. This discharge may be in contravention of Section 33 of the Fisheries Act. Furthermore, the results of bio-assay testing conducted by the Environmental Protection Service as part of its Monitoring and Surveillance survey at the mouth of Baker Creek indicated that there was always 100% mortality of rainbow trout within 96 hours (10).

It is not recommended that any restorative action be attempted on the most heavily impacted zones of Yellowknife Bay. Re-colonization is expected to be slow, the rate depending upon the burial or alteration of the contaminated sediments. However, it is expected that fish will move into Baker Creek when water quality improves, and major food organisms will once again inhabit Baker Creek.

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APPENDIX I

TABLE 1 PHYSICO-CHEMICAL CHARACTERISTICS OF WATER SAMPLES COLLECTED FROM BAKER CREEK UPSTREAM OF THE MILL. All values are in g/m^3 unless otherwise indicated. NA means analysis not done.

CHARACTERISTICS	DATE										
	11/12/74	13/01/75	17/02/75	25/04/75	28/05/75	18/09/75	21/10/75	18/12/75	13/09/76	12/05/77	06/06/77
Conductivity (µmho/cm)	117	126	150.3	121	81.1	138	146	161	167	108	98.2
Total alkalinity	45	40.1	49.9	35.3	27.6	47	46.7	54.4	39	34	33.1
Total hardness	57	55.0	64.7	51.9	36.3	64.6	60.6	73.2	54	66.4	47.5
Turbidity	0.2	1.5	2.1	2.2	1.4	2.0	2.2	3.5	3.5	5.8	5.5
Colour	5	25	30	65	30	20	20	10	20	40	20
Phosphorus (Total)	NA	NA	NA	NA	NA	0.048	NA	NA	NA	NA	NA
Chloride (Dissolved)	NA	NA	5.1	NA	NA	NA	NA	5.9	NA	NA	NA
Sulphate (Dissolved)	8.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silica (Reactive)	NA	NA	1.0	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic (Dissolved)	0.087	0.018	0.034	0.062	0.029	0.022	0.026	0.06	0.063	NA	0.026
Iron (Extractable)	0.13	0.13	0.19	0.34	0.115	0.35	0.027	0.20	0.22	0.20	0.04
Zinc (Extractable)	0.006	0.001	0.002	0.001	0.010	0.07	0.04	0.02	0.01	0.01	0.01
Copper (Extractable)	0.003	0.004	0.001	0.001	0.001	0.015	0.015	0.01	0.01	NA	0.01
Nickel (Extractable)	0.010	0.007	0.002	0.002	0.002	0.05	0.05	0.05	0.05	NA	0.05
Lead (Extractable)	NA	NA	NA	NA	NA	NA	NA	NA	0.05	0.05	NA
Calcium (Dissolved)	17	15.2	19.3	15.9	10.7	19.4	20.0	21.0	70	12.2	12.0
Potassium (Dissolved)	NA	NA	1.9	2.5	NA	NA	NA	NA	NA	NA	NA
Sodium (Dissolved)	NA	NA	3.8	2.8	NA	NA	NA	NA	NA	NA	NA
Cyanide (Total)	0.008	0.006	0.005	0.003	NA	0.005	0.005	0.007	0.005	0.005	0.005
Nitrogen (Dissolved)	NA	NA	NA	NA	NA	0.110	NA	NA	NA	NA	NA

APPENDIX I

TABLE 2 PHYSICO-CHEMICAL CHARACTERISTICS OF WATER SAMPLES COLLECTED FROM BAKER CREEK DOWNSTREAM OF THE MILL AT DISCHARGE TO YELLOWKNIFE BAY. All values are in g/m^3 unless otherwise indicated. NA means analysis not done.

CHARACTERISTICS	DATE								
	10/12/74	13/01/75	17/02/75	26/03/75	09/04/75	25/04/75	28/05/75	18/09/75	21/10/75
Conductivity (µmho/cm)	345	371	489.1	840	863.0	481	187	1600	1511
Total alkalinity	56	53.2	58.5	68.0	64.8	47.8	33.7	99	46.5
Total hardness	123	137	167.9	244	244.5	167	67.2	528	261
Turbidity	1.2	7.6	12	8.6	12	33	4.9	22	34
Colour	5	45	40	40	45	80	30	20	20
Phosphorus (Total)	NA	NA	NA	NA	NA	NA	NA	3.40	NA
Chloride (Dissolved)	NA	NA	89	NA	NA	NA	NA	NA	NA
Sulphate (Dissolved)	29	NA	NA	NA	NA	NA	NA	NA	NA
Silica (Reactive)	NA	NA	1.9	NA	NA	NA	NA	NA	NA
Arsenic (Dissolved)	0.50	0.400	0.17	0.30	0.41	3.00	0.85	5.0	NA
Iron (Extractable)	0.54	1.0	0.76	0.84	0.71	1.3	0.238	1.77	1.21
Zinc (Extractable)	0.014	0.074	0.031	0.030	0.012	0.390	0.015	0.05	0.03
Copper (Extractable)	0.090	0.091	0.035	0.031	0.020	4.1	0.624	1.08	3.85
Nickel (Extractable)	0.013	0.015	0.006	0.007	0.004	0.023	0.045	0.22	0.25
Lead (Extractable)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium (Dissolved)	41	37.4	51.9	77	79.0	57.3	22.6	166	76.3
Potassium (Dissolved)	NA	NA	2.9	NA	NA	8.5	NA	NA	NA
Sodium (Dissolved)	NA	NA	33	NA	NA	24.7	NA	NA	NA
Cyanide (Total)	0.12	0.15	0.57	0.050	0.050	6.1	NA	1.3	1.3
Nitrogen (Dissolved)	NA	NA	NA	NA	NA	NA	NA	6.00	NA
Residue (Nonfilterable)	NA	1	NA	1.0	68	17.5	NA	NA	45.3

APPENDIX I

TABLE 2 (Continued)

CHARACTERISTICS	DATE 18/12/75	17/02/76	03/05/76	08/07/76	13/09/76	12/05/77	06/06/77
Conductivity (µmho/cm)	1709	1309	234	446	1082	331	412
Total alkalinity	92.5	86.6	43.5	60	87	48.4	45.1
Total hardness	528	484	131	162	366	44	154
Turbidity	33	5.7	NA	NA	7.2	24	9.0
Colour	40	10	NA	10	20	50	20
Phosphorus (Total)	NA	NA	NA	NA	NA	NA	NA
Chloride (Dissolved)	402	NA	NA	61	NA	NA	NA
Sulphate (Dissolved)	NA	NA	NA	62.0	NA	NA	NA
Silica (Reactive)	NA	NA	NA	NA	NA	NA	NA
Arsenic (Dissolved)	0.07	2.06	0.40	2.1	9.1	1.0	1.74
Iron (Extractable)	0.89	0.75	0.99	NA	0.44	0.88	0.36
Zinc (Extractable)	0.05	0.10	0.09	0.32	0.02	0.04	0.01
Copper (Extractable)	1.9	0.22	0.65	0.77	1.35	0.37	1.8
Nickel (Extractable)	0.17	0.05	0.05	0.21	0.27	NA	0.14
Lead (Extractable)	NA	NA	0.05	0.05	0.05	0.05	NA
Calcium (Dissolved)	160	155	25.8	44.5	113	37.7	50.3
Potassium (Dissolved)	NA	NA	NA	NA	NA	NA	NA
Sodium (Dissolved)	NA	NA	NA	NA	NA	NA	NA
Cyanide (Total)	2.20	0.140	1.14	0.02	1.64	0.458	NA
Nitrogen (Dissolved)	NA	NA	NA	NA	NA	NA	NA
Residue (Nonfilterable)	NA	NA	57	2.4	NA	3.4	NA

APPENDIX II

TABLE 1 CONCENTRATION OF METALS IN THE SEDIMENTS OF YELLOWKNIFE BAY ALONG TRANSECTS A-B, A-C, A-D, A-E, AND A-F DURING JUNE, JULY, AND AUGUST, 1976. ND means not detectable.

METAL	STATION	1	2	3	4	5	6	7	8	9	10
	DEPTH (m)	3.5	4.5	7.5	10.5	5.0	5.0	4.5	8.0	9.5	8.0
As (ppm)		2,050	775	550	825	300	50	3,000	750	475	75
Hg (ppb)		496	246	249	280	177	81	459	300	228	42
Ni (ppm)		114	64	55	60	54	45	95	82	52	56
Cu (ppm)		783	331	298	360	231	77.4	729	721	210	283
Pb (ppm)		800	220	130	140	80	35	700	175	95	25
Zn (ppm)		913	517	312	340	243	138	762	935	320	264
Cd (ppm)		5	ND	ND	ND	ND	ND	ND	3	ND	ND
Co (ppm)		53	26	23	23	17	17	41	34	20	22
Fe (%)		6.50	4.08	4.05	4.34	3.79	3.79	5.91	5.22	4.21	4.05
Cr (ppm)		190	220	105	120	100	100	150	130	125	100
Mn (ppm)		678	618	941	1,200	837	837	704	711	600	784
Mg (%)		2.31	1.62	1.41	1.41	1.41	1.41	0.215	1.62	1.27	1.55
Al (%)		7.28	6.85	7.04	7.41	7.21	7.25	7.37	7.04	7.63	7.59
Ca (%)		2.04	0.920	0.932	0.921	0.906	1.01	2.05	1.05	1.29	0.921
Ti (ppm)		4,300	3,570	3,510	3,530	3,360	3,280	3,690	3,780	3,240	3,080
Na (%)		1.0	1.4	1.5	1.6	1.7	1.8	1.3	1.4	1.5	1.7
Ag (ppm)		12	ND	ND	ND	ND	ND	11	ND	ND	ND
Sr (ppm)		99.8	140	163	176	179	197	136	152	158	185
V (ppm)		221	142	130	137	117	98	203	173	168	127
Be (ppm)		1.9	1.8	2.1	2.1	2.2	2.4	2.0	2.0	2.2	2.3
Ba (ppm)		960	920	1,220	1,320	1,250	1,310	1,320	1,300	1,480	1,530
P (%)		0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.2

APPENDIX II

TABLE 1 (CONTINUED)

METAL	STATION DEPTH (m)	11 2.0	12 1.5	13 6.0	14 12.0	15 10.0	16 11.5	17 12.0	18 14.0	19 7.0	20 7.5
As (ppm)		28	12	575	185	425	2,400	1,450	1,100	20	325
Hg (ppb)		22	27	135	88	142	418	260	220	53	295
Ni (ppm)		42	38	56	64	48	50	68	71	42	78
Cu (ppm)		38.8	38.2	194	407	94.3	169	632	673	79.7	517
Pb (ppm)		15	15	70	40	60	440	190	130	35	340
Zn (ppm)		97.4	97.2	220	314	142	206	608	440	110	591
Cd (ppm)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Co (ppm)		14	15	23	22	18	23	20	20	16	33
Fe (%)		3.51	3.59	4.03	4.11	3.26	4.09	4.41	4.36	2.95	4.77
Cr (ppm)		75	95	125	95	105	150	120	135	100	130
Mn (ppm)		811	458	1,450	1,030	1,070	1,910	431	567	830	608
Mg (%)		1.21	1.21	1.21	1.21	1.27	1.48	1.34	1.34	1.14	1.95
Al (%)		7.81	7.66	7.32	7.85	6.68	7.00	7.71	7.70	7.32	6.78
Ca (%)		0.880	1.00	0.979	0.957	0.991	0.907	0.966	0.951	1.03	1.60
Ti (ppm)		3,290	3,180	3,230	3,230	3,230	3,370	3,420	3,440	3,080	3,610
Na (%)		1.7	1.8	1.8	1.7	1.8	1.6	1.6	1.6	1.9	1.3
Ag (ppm)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sr (ppm)		222	208	187	205	188	180	203	190	201	137
V (ppm)		94	106	117	129	103	125	146	142	97	170
Be (ppm)		2.7	2.7	2.3	2.5	2.5	2.5	2.3	2.3	2.5	1.9
Ba (ppm)		1,740	1,740	1,510	1,830	1,460	1,470	1,610	1,530	1,510	980
P (%)		0.1	0.1	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.1

TABLE 1 (CONTINUED)

METAL	STATION DEPTH (m)	21 7	22 6	23 3.5
As (ppm)		120	120	140
Hg (ppb)		191	228	169
Ni (ppm)		52	51	44
Cu (ppm)		135	121	110
Pb (ppm)		135	170	80
Zn (ppm)		268	274	233
Cd (ppm)		ND	ND	ND
Co (ppm)		27	29	21
Fe (%)		4.28	4.50	3.97
Cr (ppm)		135	130	150
Mn (ppm)		1,010	865	820
Mg (%)		1.41	2.05	2.23
Al (%)		6.96	7.00	6.24
Ca (%)		.994	1.48	2.95
Ti (ppm)		3,610	3,650	3,600
Na (%)		1.4	1.2	0.9
Ag (ppm)		ND	ND	ND
Sr (ppm)		145	123	87.3
V (ppm)		156	182	192
Be (ppm)		1.9	1.9	1.9
Ba (ppm)		930	1,050	1,000
P (%)		0.1	0.1	0.1

APPENDIX II

TABLE 2 CONCENTRATION OF METALS IN THE SEDIMENTS OF BACK BAY ALONG TRANSECT G–H DURING JUNE 1976. ND means not detectable.

METAL	STATION	24	25	26	27	28	29	30	31	32
	DEPTH (m)	12	9	8	6	3	2	2	2	2
As (ppm)		421	534	39	77	96	80	6	120	12
Hg (ppb)		328	234	169	212	478	234	22	93	19
Ni (ppm)		58	36	35	42	38	41	24	39	35
Cu (ppm)		417	150	69.3	135	247	268	27.1	194	32.9
Pb (ppm)		79	34	13	17	28	60	15	40	15
Zn (ppm)		438	175	118	171	171	193	64.5	149	85.8
Cd (ppm)		ND	ND	ND	ND	ND	ND	ND	ND	ND
Co (ppm)		20.9	17.8	14.1	18.1	13.5	14	6	13	10
Fe (%)		3.54	3.51	2.86	3.29	2.46	2.58	2.03	2.60	2.71
Cr (ppm)		92.6	75.7	75.5	83.4	69.4	100	90	100	350
Mn (ppm)		401	2580	448	509	358	342	300	340	337
Mg (%)		1.23	1.02	1.09	1.23	0.948	1.14	0.847	1.08	1.14
Al (%)		6.76	5.92	6.48	8.32	6.64	6.79	6.86	7.03	7.32
Ca (%)		0.858	0.822	0.977	1.22	1.36	1.15	1.15	1.16	1.02
Ti (ppm)		3080	2770	3080	3250	2620	3010	2610	2990	3190
Na (%)		1.24	1.26	1.53	1.73	1.93	1.9	2.2	2.1	1.9
Ag (ppm)		6.88	6.17	2.44	3.62	4.84	ND	ND	ND	ND
Sr (ppm)		152	145	164	201	183	195	211	196	198
V (ppm)		128	95.7	91.8	98.9	70.2	83	67	86	100
Be (ppm)		1.8	1.8	2.0	2.3	1.9	2.2	2.1	2.3	2.5
Ba (ppm)		890	880	898	1150	883	1150	1000	1170	1240
P (%)		0.097	0.102	0.082	0.078	0.080	0.1	0.1	0.1	0.1

APPENDIX III

TABLE 1 CONCENTRATION OF METALS IN THE SEDIMENTS OF YELLOWKNIFE BAY IN AREAS 1 - 6 (Figure 4) AND WOOL BAY. Values represent means ±95% confidence limits (range). Samples collected during 1974.

CHARACTERISTIC	AREA 1	2	3	4	5	6	WOOL BAY
Ni (ppm)	24.3 ± 3.4 (5 - 52)	45.1 ± 6.7 (27 - 68)	39.1 ± 6.1 (30 - 55)	39.3 ± 3.7 (31 - 46)	37.2 ± 5.4 (10 - 53)	40.1 ± 7.1 (13.9 - 57.3)	47.5 ± 2.8 (43 - 51)
Cu (ppm)	39.2 ± 11.6 (5 - 140)	131.5 ± 110.1 (26 - 743)	76.4 ± 37 (22 - 157)	62.6 ± 14.1 (37 - 108)	59.0 ± 21.1 (22 - 117)	43.8 ± 11.2 (11.0 - 76.0)	35.6 ± 39 (29 - 41)
Pb (ppm)	20.2 ± 4.4 (6 - 60)	36.7 ± 17.8 (14 - 100)	38.8 ± 1.4 (18 - 74)	22.9 ± 4.7 (15 - 38)	24.1 ± 5.4 (7 - 52)	24.0 ± 4.7 (6.4 - 37.2)	20.8 ± 1.9 (18 - 23)
Zn (ppm)	83.0 ± 16.7 (27 - 265)	178.4 ± 104 (63 - 658)	126.0 ± 33 (64 - 220)	94.2 ± 18.3 (62 - 154)	80.8 ± 16.1 (23 - 123)	98.0 ± 25.2 (26.7 - 162.0)	88.5 ± 8.0 (74 - 100)
Cd (ppm)	0.6 ± 0.1 (0.3 - 0.8)	1.6 ± 0.7 (0.8 - 3.3)	1.6 ± 0.8 (0.8 - 3.0)	- -	0.7 ± 0.1 (0.5 - 1.0)	0.9 ± 0.1 (0.4 - 1.3)	- -
Co (ppm)	9.9 ± 1.4 (5 - 24)	17.5 ± 2.7 (9 - 26)	16.1 ± 2.7 (12 - 24)	15.4 ± 1.3 (12 - 17)	15.0 ± 2.0 (4 - 20)	16.0 ± 2.3 (5.1 - 20.7)	23.2 ± 2.3 (16.1 - 30.4)
Fe (%)	2.0 ± 0.2 (1.5 - 3.4)	3.1 ± 0.4 (1.2 - 4.1)	2.4 ± 0.4 (1.5 - 3.3)	2.9 ± 0.4 (2.1 - 3.6)	2.7 ± 0.4 (0.6 - 4.0)	3.1 ± 0.5 (1.1 - 4.5)	3.5 ± 2.6 (3.0 - 4.0)
Cr (ppm)	55.5 ± 5.2 (28 - 88)	56.5 ± 5.3 (32 - 70)	42.9 ± 5.2 (34 - 56)	48.7 ± 6.6 (35 - 70)	60.4 ± 11.5 (32 - 115)	88.5 ± 19.5 (21.7 - 141.7)	84.0 ± 19.8 (50 - 105)
Mn (%)	3.1 ± 0.4 (1.5 - 7.6)	5.5 ± 2.1 (0.7 - 15.1)	4.6 ± 1.7 (2.1 - 7.7)	5.0 ± 1.0 (2.9 - 7.8)	4.7 ± 0.9 (1.0 - 8.8)	5.2 ± 1.7 (1.4 - 13.7)	5.4 ± 0.9 (4.3 - 6.8)

APPENDIX III

TABLE 2 CONCENTRATIONS OF METALS AT 0-5 cm, 5-10 cm, AND 10-15 cm DEPTHS IN THE SEDIMENTS OF YELLOWKNIFE BAY DURING SEPTEMBER, 1975. ND means not detectable.

METAL	STATION	a	a	a	b	b	b	c	c	c
	SEDIMENT DEPTH (cm)	0.5	5-10	10-15	0.5	5-10	10-15	0.5	5-10	10-15
	WATER DEPTH (m)	1.5	1.5	1.5	1.5	1.5	1.5	2.5	2.5	2.5
As (ppm)		325	28	1,250	120	14	14	450	80	16
Hg (ppb)		189	41	251	225	63	63	236	63	68
Ni (ppm)		51	49	35	66	43	40	52	38	41
Cu (ppm)		253	98.4	24.8	290	70.5	27.9	194	26.5	26.5
Pb (ppm)		155	25	160	150	25	25	140	20	15
Zn (ppm)		292	253	90.0	343	197	98.6	301	89.5	92.7
Cd (ppm)		ND	ND	ND	ND	ND	ND	ND	ND	ND
Co (ppm)		9	12	6	15	18	9	16	7	8
Fe (%)		3.92	4.10	2.79	4.66	3.83	3.35	4.05	3.20	3.00
Cr (ppm)		110	100	125	150	110	110	130	100	100
Mn (ppm)		616	679	441	1,040	804	565	560	526	434
Mg (%)		1.62	1.14	1.14	1.77	1.77	1.41	1.48	1.21	1.21
Al (%)		7.18	7.43	5.66	7.26	5.90	7.99	7.70	7.10	7.12
Ca (%)		0.941	1.71	0.955	0.860	1.42	1.13	1.30	1.09	1.08
Ti (ppm)		3,710	3,880	3,390	3,920	3,590	3,520	4,050	3,440	3,510
Na (%)		1.6	1.4	1.8	1.4	1.2	1.9	1.6	1.9	1.9
Ag (ppm)		ND	ND	ND	ND	ND	ND	ND	ND	ND
Sr (ppm)		176	165	182	162	128	228	168	201	195
V (ppm)		134	151	88	158	146	102	161	95	99
Be (ppm)		2.0	2.1	2.1	1.9	1.8	2.5	2.4	2.6	2.7
Ba (ppm)		1,060	1,090	850	1,150	1,080	1,560	1,370	1,290	1,310
P (%)		0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1

APPENDIX III

TABLE 2 (CONTINUED)

METAL	STATION	d	d	d	e	f	f	f	g	g
	SEDIMENT DEPTH (cm)	0-5	5-10	10-15	0-5	0-5	5-10	10-15	0-5	5-10
	WATER DEPTH (m)	19	19	19	14	8.5	8.5	8.5	6	6
As (ppm)		120	100	14	22	30	20	950	80	4
Hg (ppb)		175	102	41	24	79	86	160	87	67
Ni (ppm)		49	42	36	29	38	35	37	66	50
Cu (ppm)		196	47.6	23.8	28.9	68.9	29.4	30.6	753	68.4
Pb (ppm)		75	30	15	20	35	20	100	30	25
Zn (ppm)		237	121	80.9	64.0	115	85.3	90.8	352	156
Cd (ppm)		ND	ND	ND	ND	ND	ND	ND	ND	ND
Co (ppm)		15	11	7	5	6	6	11	23	17
Fe (%)		3.42	3.25	2.74	2.27	2.51	2.73	2.68	4.51	3.40
Cr (ppm)		120	100	105	80	90	100	130	105	105
Mn (ppm)		461	465	429	371	386	387	388	1,540	779
Mg (%)		1.14	1.27	1.08	0.811	1.02	1.14	1.27	1.27	1.27
Al (%)		6.49	7.54	7.07	6.50	6.36	6.13	6.13	6.76	5.85
Ca (%)		0.889	1.06	1.12	1.09	0.977	0.875	0.937	0.855	0.773
Ti (ppm)		3,590	3,640	3,360	2,690	3,210	3,400	3,550	3,560	3,380
Na (%)		1.7	1.9	2.0	2.2	2.1	1.9	1.9	1.5	1.5
Ag (ppm)		ND	ND	ND	ND	ND	ND	ND	ND	ND
Sr (ppm)		173	212	204	187	182	167	183	182	174
V (ppm)		121	105	86	62	88	97	99	136	110
Be (ppm)		2.3	2.6	2.6	2.2	2.3	2.5	2.5	2.4	2.3
Ba (ppm)		1,180	1,320	1,350	1,160	1,240	1,370	1,110	1,330	1,240
P (%)		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1

APPENDIX III

TABLE 2 (CONTINUED)

METAL	STATION	g	h	h	h	i	i	i	j	j	j
	SEDIMENT DEPTH (cm)	10-15	0-5	5-10	10-15	0-5	5-10	10-15	0-5	5-10	10-15
	WATER DEPTH (m)	6	19	19	17	21	21	21	39	39	39
As (ppm)		300	8	4	300	8	8	10	900	80	28
Hg (ppb)		149	149	55	124	58	58	34	274	44	29
Ni (ppm)		45	53	43	47	50	39	39	71	39	39
Cu (ppm)		32.4	173	32.9	30.6	114	25.9	25.9	537	29.7	27.1
Pb (ppm)		65	30	30	70	5	5	15	115	15	15
Zn (ppm)		107	217	108	104	212	89.5	89.5	521	99.9	98.4
Cd (ppm)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Co (ppm)		14	21	14	14	17	12	11	17	12	14
Fe (%)		3.63	4.33	3.77	3.68	3.92	3.20	3.31	4.22	3.62	3.53
Cr (ppm)		120	120	105	105	100	100	95	100	100	100
Mn (ppm)		709	2,340	610	595	2,010	765	802	2,010	765	802
Mg (%)		1.27	1.27	1.27	1.21	1.14	1.08	1.27	1.14	1.08	1.27
Al (%)		7.21	6.76	5.85	7.21	7.39	7.46	7.71	7.35	7.76	7.93
Ca (%)		0.954	0.855	0.773	0.954	0.994	1.10	1.09	0.901	1.00	1.01
Ti (ppm)		3,680	3,560	3,380	3,680	3,390	3,000	3,180	3,370	3,230	3,250
Na (%)		1.7	1.5	1.5	1.7	1.8	1.8	1.9	1.6	1.7	1.8
Ag (ppm)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sr (ppm)		205	206	216	194	195	209	216	190	219	216
V (ppm)		116	128	113	110	115	93	98	138	105	109
Be (ppm)		2.7	2.5	2.7	2.7	2.3	2.5	2.7	2.3	2.7	2.7
Ba (ppm)		1,430	1,690	1,730	1,450	1,520	1,500	1,620	1,490	1,600	1,680
P (%)		0.1	0.2	0.2	0.1	0.2	0.1	0.2	0.2	0.2	0.1

APPENDIX III

TABLE 3 CONCENTRATION OF METALS IN REPLICATE SAMPLES OF SEDIMENTS AT STATIONS e, f, h AND j IN YELLOWKNIFE BAY DURING JULY AND AUGUST 1976. ND means not detectable.

METAL	STATION	e	e	e	f	f	f	h	h	h	h	h	j
	DEPTH (m)	14	14	14	8.5	8.5	8.5	19	19	19	19	19	39
As (ppm)		48	30	126	61	53	74	92	157	279	160	209	27
Hg (ppb)		129	89	109	130	104	556	147	179	295	126	131	123
Ni (ppm)		37	37	37	42	26	43	39	40	41	36	36	47
Cu (ppm)		48.8	39.7	89.3	95.4	43.7	114	79.9	141	129	69.3	96.6	52.0
Pb (ppm)		25	ND	14	32	10	17	30	42	40	8	25	19
Zn (ppm)		119	101	136	161	77	148	150	203	192	117	152	150
Cd (ppm)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Co (ppm)		20.6	17.6	16.6	20.6	9.7	17.3	19.2	20.6	20.2	14.7	17.3	21.8
Fe (%)		3.49	3.65	3.47	3.29	2.18	3.48	3.58	3.64	3.83	3.53	3.45	5.32
Cr (ppm)		96.0	87.3	78.6	88.4	57.2	83.1	93.7	96.7	93.6	71.0	90.4	119
Mn (ppm)		1200	438	7200	562	558	637	775	671	1110	2680	874	2460
Mg (%)		1.22	1.33	1.16	1.09	0.790	1.21	1.16	1.15	1.11	0.979	1.06	1.27
Al (%)		7.80	8.36	7.20	6.64	6.28	8.28	7.44	7.40	6.88	6.52	6.56	8.64
Ca (%)		1.23	1.05	1.04	0.975	1.13	1.27	1.05	1.08	1.00	0.992	0.928	0.902
Ti (ppm)		3530	3570	3210	3000	2450	3350	3180	3250	3100	2750	3010	3890
Na (%)		1.68	1.47	1.42	1.45	1.80	1.89	1.38	1.49	1.33	1.33	1.28	0.788
Ag (ppm)		3.51	1.78	3.38	2.59	2.04	3.08	3.81	4.02	5.09	2.61	3.12	4.92
Sr (ppm)		202	192	173	171	169	207	184	191	175	164	168	182
V (ppm)		88.9	120	103	81.5	64.6	98.3	93.7	98.2	95.0	93.0	90.3	159
Be (ppm)		2.2	2.5	2.1	1.9	1.8	2.3	2.1	2.1	2.0	1.9	2.0	2.7
Ba (ppm)		886	1230	1030	785	818	1120	850	880	840	924	794	1160
P (%)		0.094	0.071	0.087	0.988	0.068	0.095	0.099	0.109	0.119	0.115	0.099	0.168

APPENDIX III

TABLE 3 (Continued)

METAL	STATION	j	j	j	j	j	j	j	j	j	j	j	j
	DEPTH (m)	39	39	39	39	39	39	39	39	39	39	39	39
As (ppm)		56	41	28	28	34	34	38	34	50	66	90	89
Hg (ppb)		102	128	118	119	129	88	97	146	225	177	120	124
Ni (ppm)		49	37	41	53	50	48	55	48	53	48	48	55
Cu (ppm)		54.2	37.2	51.1	59.0	49.4	51.2	64.5	60.2	65.2	62.4	53.6	59.5
Pb (ppm)		22	21	29	30	23	32	38	41	46	38	36	46
Zn (ppm)		149	113	140	165	143	151	177	159	174	171	150	172
Cd (ppm)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Co (ppm)		23.7	18.2	20.7	22.3	18.1	21.7	26.3	22.6	25.9	23.6	23.0	26.1
Fe (%)		4.92	4.52	4.48	4.48	5.12	4.56	5.28	4.60	4.76	4.56	4.40	4.92
Cr (ppm)		113	93.3	106	116	113	117	131	112	121	115	111	126
Mn (ppm)		5760	4200	838	646	1610	844	2370	1020	1530	709	659	966
Mg (%)		1.29	0.984	1.24	1.36	1.18	1.31	1.46	1.23	1.32	1.25	1.20	1.47
Al (%)		8.24	6.36	7.88	8.60	8.04	8.24	9.52	7.88	8.60	8.12	7.16	9.16
Ca (%)		0.925	0.718	0.862	0.870	0.877	0.838	0.968	0.775	0.842	0.815	0.782	0.954
Ti (ppm)		3690	3060	3560	3950	3740	3840	4210	3590	3780	3640	3650	4080
Na (%)		0.918	0.678	0.897	0.948	0.892	0.873	0.936	0.766	0.805	0.785	0.842	0.973
Ag (ppm)		3.60	4.49	2.29	3.81	2.16	2.84	4.58	3.29	3.00	3.19	3.30	3.97
Sr (ppm)		189	143	177	189	181	184	211	172	186	174	165	204
V (ppm)		139	118	130	147	149	150	166	147	160	149	139	156
Be (ppm)		2.5	2.1	2.4	2.7	2.5	2.6	2.9	2.4	2.6	2.5	2.4	2.8
Ba (ppm)		1220	956	1080	1170	1190	1200	1340	1140	1250	1160	1040	1290
P (%)		0.151	0.158	0.156	0.120	0.175	0.149	0.159	0.150	0.150	0.152	0.150	0.147

APPENDIX IV

TABLE 1 PHYSICO-CHEMICAL CHARACTERISTICS OF WATER SAMPLES COLLECTED FROM YELLOWKNIFE BAY ALONG TRANSECTS A-C, AND A-E ON JUNE 1, 1976. All values are in g/m^3 unless otherwise indicated. All samples collected at a depth of 0.5m. "NA" means analysis not done.

	TRANSECT A - E					TRANSECT A - F
CHARACTERISTIC / STATION	1	7	9	10	11	17
Conductivity (μmho/cm)	146	67	75	60	78	62
Total alkalinity	43	21	31	27	29	25
Total hardness	62	25	31	26	34	25
Nitrate (dissolved)	0.27	0.23	0.03	<0.01	<0.01	0.02
Nitrite (dissolved)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total phosphorous (dissolved)	0.19	0.05	0.03	0.02	0.03	0.03
Chloride (dissolved)	10.7	2.0	3.1	2.1	3.2	2.0
Sulfate (dissolved)	20	<5	<5	<5	6	<5
Silica (reactive)	0.4	0.4	0.6	1.3	0.8	0.5
Arsenic (dissolved)	0.03	0.74	0.05	<0.02	<0.02	<0.02
Magnesium (extractable)	4.45	2.10	2.70	2.30	3.05	2.30
Iron (extractable)	0.28	0.09	0.13	0.10	0.06	0.05
Manganese (extractable)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Mercury (ppb) (total)	NA	NA	NA	NA	NA	NA
Cobalt (extractable)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc (extractable)	0.051	0.014	<0.005	<0.005	<0.005	<0.005
Copper (extractable)	0.280	<0.015	<0.015	<0.015	<0.015	<0.015
Nickel (extractable)	0.03	<0.02	<0.02	<0.02	<0.02	<0.02
Molybdenum (extractable)	<0.02	<0.02	<0.02	0.08	<0.02	<0.02
Lead (extractable)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Calcium (dissolved)	17.0	7.2	9.4	9.1	10.5	7.6
Potassium (dissolved)	1.95	1.05	1.05	1.05	1.10	1.05
Sodium (dissolved)	7.20	3.20	4.0	3.3	4.35	3.6

APPENDIX V

TABLE 1 PHYSICO-CHEMICAL CHARACTERISTICS OF WATER SAMPLES COLLECTED FROM YELLOWKNIFE BAY DURING APRIL, MAY, JUNE, JULY, AUGUST, AND OCTOBER, 1976. All values are in g/m^3 unless otherwise indicated. NA means the analysis was not performed. All samples collected at a depth of 0.5m. "NA" means analysis not done.

CHARACTERISTIC	STATION DATE	e 17/05	e 28/05	e 09/06	e 23/06	e 08/07	e 26/07	e 05/08	e 18/08	e 06/10
Conductivity (μmho/cm)		50	60	55	90	90	93	76	105	95
Total alkalinity		21	25	26	40	37	43	41	41	43
Total hardness		20	23	NA	NA	NA	58	36	52	52
Nitrate (dissolved)		0.03	0.05	0.09	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nitrite (dissolved)		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Total phosphorous (dissolved)		0.03	0.02	0.01	0.01	0.2	0.02	0.01	0.03	< 0.01
Chloride (dissolved)		1.8	3.1	0.3	0.4	0.4	4.3	3.2	8.0	4.5
Sulfate (dissolved)		< 5	< 5	8	NA	NA	7	6	9	6
Silica (reactive)		0.4	0.4	0.24	0.57	0.62	0.9	0.7	0.7	0.7
Arsenic (dissolved)		< 0.002	< 0.002	0.06	0.4	NA	< 0.02	< 0.02	< 0.02	< 0.02
Magnesium (extractable)		1.70	2.20	2.0	3.3	3.4	4.4	3.4	3.9	4.5
Iron (extractable)		0.09	0.08	0.02	0.03	0.04	0.03	< 0.02	< 0.02	< 0.02
Manganese (extractable)		< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Mercury (ppb) (total)		NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt (extractable)		< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Zinc (extractable)		0.031	0.017	< 0.005	< 0.005	< 0.005	0.26	< 0.26	< 0.26	0.06
Copper (extractable)		0.025	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Nickel (extractable)		< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.03	< 0.03	< 0.03	< 0.03
Molybdenum (extractable)		< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Lead (extractable)		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.12	< 0.12
Calcium (dissolved)		6.8	10.3	6.5	14.0	14.8	14.0	11.4	14.1	13.1
Potassium (dissolved)		1.1	1.1	1.0	1.1	1.1	1.02	0.9	0.9	1.0
Sodium (dissolved)		3.5	3.35	3.5	4.7	5.6	5.0	4.7	5.0	4.9
Total carbon		NA	NA	12	14	15	18	14	16	16
Inorganic carbon		NA	NA	5	8	7	9	7	9	7
Organic carbon		NA	NA	7	6	8	9	7	7	9

TABLE 1 (CONTINUED)

CHARACTERISTIC	STATION DATE	f 17/05	f 28/05	f 09/06	f 23/06	f 08/07	f 26/07	f 05/08	f 18/08	f 06/10
Conductivity (µmho/cm)		50	70	60	85	85	88	95	98	93
Total alkalinity		21	27	27	39	47	39	43	39	42
Total hardness		25	31	NA	NA	NA	46	52	60	40
Nitrate (dissolved)		0.03	0.07	0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrite (dissolved)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total phosphorous (dissolved)		0.08	0.04	0.01	0.2	0.3	0.02	0.01	0.06	<0.06
Chloride (dissolved)		2.1	3.5	0.3	0.4	0.4	3.0	5.0	7.5	4.5
Sulfate (dissolved)		<5	5	NA	NA	8	6	11	9	6
Silica (reactive)		0.5	0.9	0.24	0.66	0.43	0.9	1.3	0.6	0.6
Arsenic (dissolved)		0.03	<0.02	<0.02	0.04	0.04	<0.04	<0.04	NA	<0.04
Magnesium (extractable)		1.85	2.50	2.0	3.3	3.2	3.6	5.2	NA	3.7
Iron (extractable)		0.08	0.10	0.02	0.03	0.08	0.03	0.05	NA	0.06
Manganese (extractable)		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	NA	<0.03
Mercury (ppb) (total)		NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt (extractable)		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	NA	<0.16
Zinc (extractable)		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.16	NA	<0.005
Copper (extractable)		<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	NA	<0.015
Nickel (extractable)		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	NA	<0.02
Molybdenum (extractable)		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	NA	<0.02
Lead (extractable)		0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	NA	<0.10
Calcium (dissolved)		5.5	9.2	7.0	14.0	14.0	11.5	17	NA	13.5
Potassium (dissolved)		1.05	1.10	1.0	1.1	1.1	0.9	1.0	NA	1.04
Sodium (dissolved)		3.25	3.80	3.8	4.7	4.6	4.7	56	NA	4.9
Total carbon		NA	NA	14	13	14	15	16	17	18
Inorganic carbon		NA	NA	7	7	7	8	9	8	7
Organic carbon		NA	NA	7	6	7	7	7	9	11

APPENDIX V

TABLE 1 (CONTINUED)

CHARACTERISTIC	STATION DATE	h 13/04	h 17/05	h 28/05	h 09/06	h 23/06	h 08/07	h 26/07	h 05/08	h 18/08
Conductivity (µmho/cm)		20	105	80	80	100	100	142	98	120
Total alkalinity		14	41	31	35	45	45	62	37	46
Total hardness		19	48	33	NA	NA	NA	84	52	68
Nitrate (dissolved)		0.10	0.13	0.07	<0.01	0.04	<0.01	<0.01	<0.01	<0.01
Nitrite (dissolved)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total phosphorous (dissolved)		0.03	0.03	0.03	0.01	0.01	0.01	<0.01	<0.01	0.04
Chloride (dissolved)		1.3	4.5	5.3	0.4	0.4	0.5	5.4	3.9	10.2
Sulfate (dissolved)		1.55	12	7	6	NA	NA	14	9	9
Silica (reactive)		0.2	1.9	1.0	0.33	0.66	0.80	1.8	1.1	0.9
Arsenic (dissolved)		<0.02	NA	0.02	0.03	0.03	<0.11	<0.11	<0.11	<0.11
Magnesium (extractable)		3.6	NA	2.90	2.5	3.4	3.8	5.1	4.4	5.8
Iron (extractable)		0.08	NA	0.08	<0.02	0.05	0.02	<0.02	<0.02	<0.05
Manganese (extractable)		<0.02	NA	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mercury (ppb) (total)		NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt (extractable)		<0.02	NA	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc (extractable)		0.023	NA	0.09	0.005	0.065	0.015	0.31	0.13	0.04
Copper (extractable)		0.015	NA	<0.015	<0.015	0.015	NA	<0.015	<0.015	<0.015
Nickel (extractable)		<0.02	NA	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	0.07
Molybdenum (extractable)		<0.02	NA	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Lead (extractable)		<0.10	NA	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Calcium (dissolved)		15.3	NA	11.9	10.5	18.2	18.5	19.4	17.5	16.2
Potassium (dissolved)		1.20	NA	1.10	1.0	1.1	1.1	1.0	1.0	1.0
Sodium (dissolved)		5.25	NA	4.25	4.6	5.2	5.7	6.5	5.1	5.6
Total carbon		NA	NA	NA	14	15	16	20	16	19
Inorganic carbon		NA	NA	NA	7	10	8	13	9	11
Organic carbon		NA	NA	NA	7	5	8	7	7	8

APPENDIX V

TABLE 1 (CONTINUED)

CHARACTERISTIC	STATION DATE	h 06/10	j 28/05	j 26/07	j 04/08	j 18/08	j 06/10
Conductivity (µmho/cm)		134	143	170	138	154	176
Total alkalinity		54	56	62	51	62	69
Total hardness		72	64	85	64	92	95
Nitrate (dissolved)		<0.01	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Nitrite (dissolved)		< 0.01	< 0.01	0.03	< 0.03	< 0.03	0.04
Total phosphorous (dissolved)		< 0.01	0.01	< 0.01	< 0.01	0.01	< 0.01
Chloride (dissolved)		6.2	1.1	6.3	5.8	7.2	7.1
Sulfate (dissolved)		2	16	19	16	15	18
Silica (reactive)		1.4	1.9	2.4	2.2	1.8	2.4
Arsenic (dissolved)		< 0.11	0.03	< 0.03	< 0.03	< 0.03	< 0.03
Magnesium (extractable)		5.7	4.9	5.8	6.3	5.5	8.4
Iron (extractable)		0.03	0.08	< 0.02	0.03	0.03	0.03
Manganese (extractable)		< 0.02	< 0.02	< 0.02	0.03	< 0.03	< 0.03
Mercury (ppb) (total)		NA	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Cobalt (extractable)		< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Zinc (extractable)		0.04	< 0.005	< 0.005	0.11	< 0.11	0.07
Copper (extractable)		< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Nickel (extractable)		< 0.07	< 0.02	< 0.02	0.04	< 0.04	< 0.04
Molybdenum (extractable)		< 0.02	0.04	< 0.04	< 0.04	< 0.04	< 0.04
Lead (extractable)		< 0.10	< 0.10	0.12	<0.1	< 0.1	< 0.1
Calcium (dissolved)		19.4	20.5	22.0	22.0	20.0	20.0
Potassium (dissolved)		1.0	1.20	1.0	1.0	1.0	1.0
Sodium (dissolved)		6.1	7.0	7.7	7.6	7.1	7.6
Total carbon		22	NA	NA	NA	NA	NA
Inorganic carbon		16	NA	NA	NA	NA	NA
Organic carbon		8	NA	NA	NA	NA	NA

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