ENVIRONMENTAL PROTECTION SERVICE
ENVIRONMENT CANADA
PACIFIC REGION

ENVIRONMENTAL STUDIES IN ALICE ARM AND HASTINGS ARM, BRITISH COLUMBIA

PART I: BASELINE STUDIES AMAX/KITSAULT MINE - SEDIMENT AND TISSUE TRACE METALS FROM TWO ABANDONED MINE SITES - B.C. MOLYBDENUM AND ANYOX, 1976 - 1980

REGIONAL PROGRAM REPORT 82 - 13

by

D. GOYETTE
P. CHRISTIE

NOVEMBER 1982

ABSTRACT

A series of studies has been undertaken in Alice Arm by the Environmental Protection Service from 1976 to the present. Studies involve sediment and tissue sampling for trace metals, transmissometer measurements and water column chemistry on the suspended particulate and bottom trawls and submersible observations for bottom conditions, turbidity and species distribution. Relative to the Amax/Kitsault mine, studies have been divided into baseline and initial production period and are being presented in a five part report series. The present report, Part I, contains baseline data on sediment and tissue trace metal data collected between 1976 and 1980 in the Alice Arm area prior to the opening of the Kitsault mine, along with tissue data from four control sites along the outer B.C. coast, collected in 1981.

Trace metal concentrations were significantly above the natural backgroud in marine sediment surrounding the abandoned B.C. Molybdenum operation (1967 - 1972) and the Anyox copper mine and smelter (1914 and 1936). Tissue trace metal data from selected species collected intertidally and by otter trawls are given to establish baseline tissue concentrations in preparation for monitoring effects from the new Kitsault mine which opened in April, 1981 and to determine evidence of metal uptake. Evidence of metal uptake in mussels (*Mytilus edulis*) and algae (*Fucus distichus*) was determined at the Anyox mine/smelter site. No evidence of metal uptake was observed in selected species of bivalves, shrimp, crab, sole and pollock taken in Alice Arm. Baseline tissue trace metal concentrations have been given for each species.

RÈSUMÈ

Depuis 1976, le Service de la protection de l'environnement a procédé à une série d'études sur le bras Alice. ces études ont consisté en la détection de métaux à l'état de traces dan des échantillons de sédiments et de tissue, en mesures à l'aide du transmissiomètre, en l'étude des propriétés chimiques des particules en suspension dans la collone d'eau, en prélèvements à l'aide du chalut de fond, en l'observation, à l'aide d'un submersible, de la vie dans les profondeurs, de la turbidité et de la répartition des espèces. Afin de mieu analyser les effets causés par la mine Amax/Kitsault sur l'environnement, on a étalé ces études sur deux périodes, une période de référence et une période correspondant à la production initiale. On a en outre divisé le rapport en cinqu partie séparées. Le présent rapport intitulé partie I, contient les données de base portant sur les métaux à l'état de traces relevés entre 1976 et 1980 dans les sédiments et les tissus dans le bras Alice, avant la mise en exploitation de la mine Kitsault, ainsi que les données recueillies en 1981 à la suite de l'analyse de tissus prélevés en quatre points échelonnés le long de la côte de la C.-B.

On a relevé des concentrations de métaux a l'état de traces nettement supérieures au milieu naturel normal, dans les sédiments marins situés à proximité, d'une part des installations B.C. Molybdenum (en opération entre 1967 et 1972), d'autre part de la mine de cuivre et de la fonderie d'Anyox (entre 1914 et 1936). Les données recueillies sur les métaux à l'état de traces, pour l'analyse d'échantillons de tissu de certaines espèces aquatiques prélevés dans la zone intertidale et dans les profondeurs, à l'aide de chaluts à double panneau, servent de données de base dans l'étude des effets causés par la mise en exploitation, à partir d'avril 1981, de la nouvelle mine Kitsault, et mettent en évidence la fixation des métaux. On a pu mettre en évidence la fixation de métaux dans les moules (Mytilus edulis) et les algues (Fucus distichus), à proximité de la mine/fonderie d'Anyox. Aucune fixation de métal n'a été observée dans les espèces choisies de mollusques bivalves, crevette, crabe, sole et colin prélevés dans le bras Alice. Pour chaque expèce, on a obtenu des données de base sur la concentration des métaux à l'etat de traces dans les tissus.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF APPENDICES

CONCLUSIONS

This segment of the study describes the trace metal concentrations found in marine sediment and tissue samples collected in the vicinity of two abandoned mining operations - B.C. Molybdenum (1967-1972) in Alice Arm and Anyox (1914-1936) in Hastings Arm. Comparisons are drawn with similar samples taken outside the tailings deposition area in Alice and Hastings Arms and tissue samples collected from other coastal areas.

Sediment

1. Waste disposal from both operations has altered the trace metal content of the surrounding marine sediment. Concentrations in the surface sediment at both sites remained significantly above the natural background levels a number of years after mine closure. In Alice Arm, although surface concentrations were lower than the deeper, older sediment, natural sediment deposition after closure of the B.C. Molybdenum operation in 1972 had not completely covered or diluted the sediments with elevated trace metals. Levels in the surface sediment near Anyox remained at a relatively high level through the continual supply of slag from shore deposits, 42 years after abandonment.

2. In Alice Arm sediments, metal concentrations showing the greatest increase were copper, lead, zinc, cadmium, silver and molybdenum. Near Anyox, copper, zinc and iron concentrations in the sediment were several orders of magnitude above those in Alice Arm. In cases where certain metals are not present in the tailings in significant quantity, eg. nickel and chromium, tailings deposits have lowered the sediment concentration.

3. Tailings deposits from the B.C. Molybdenum operation, based on 1980 surface sediment concentration, extend approximately 10 km seaward along the central trough of Alice Arm. Evidence of tailings deposition in the direction of the Kitsault and Illiance River estuary was also apparent.

Tissue

1. Tissue trace metal analysis of most species selected from Alice Arm failed to indicate conclusive evidence of metal uptake occurring under the present level of exposure to sediment trace metals. No major differences were observed, between samples from Alice Arm and those taken from Hastings Arm and several coastal control areas. Possible exceptions may be certain, species of bivalves, *Yoldia traciaeformis* and *Mytilus edulis*, which are less mobile and more directly exposed to contaminated sediment. Further sampling however, is required to confirm any definite trend in metal uptake.

2. Evidence of metal uptake was observed in mussel (*Mytilus edulis*) and alga (*Fucus distichus*) samples taken in the vicinity of Anyox. Copper and zinc concentrations in both species were substantially higher than other locations in Hastings Arm and Alice Arm. Two possible sources, particulates from slag shore deposits and dissolved metals from the mine drainage water exist at Anyox. The exact cause of metal uptake in these two species, presently is unknown.

1. INTRODUCTION

In June 1976, the Environmental Protection Service (EPS) began a series of investigations in Alice Arm, site of the B.C. Molybdenum mine near Kitsault, B.C., abandoned in 1972 and Hastings Arm, site of a copper mine and smelter at Anyox, abandoned in 1936. These were part of a number of investigations being carried out at various B.C. coastal mining operations, existing and abandoned, to determine the environmental effects of unconfined tailings disposal. (Goyette, 1975; Brothers, 1977; Goyette and Nelson, 1977). The area which is mineralized has been subject to a number of mining operations in the past. The primary purposes of studies in Alice Arm was to (1) obtain baseline data in response to a proposal to re-open the B.C. Molybdenum mine, (2) determine the residual effects from previous mine waste disposal, and (3) monitor any changes which take place after start-up of the Amax/Kitsault mine. Studies included sampling marine sediment and selected biota for trace metal distribution, benthic otter trawls for diversity and relative abundance of epibenthic invertebrates and fish, scuba and submersible observations using the Pisces IV for bottom conditions and species distribution, and water column measurements for light transmission, particulate concentration and trace metal content, along with post start-up oceanographic features such as temperature and salinity.

The present report is one of a number currently being prepared to document conditions prior to and following the re- opening of the B.C. Molybdenum mine in April, 1981, which is now under the name, Kitsault Mine. These reports have been separated into a baseline or pre start-up period and initial production period as follows:

ENVIRONMENTAL STUDIES IN ALICE ARM AND HASTINGS ARM, BRITISH COLUMBIA

Part I - Baseline Studies, Amax/Kitsault Mine - Sediment and Tissue Trace Metals from Two Abandoned Mine Sites - B.C. Molybdenum and Anyox. This report contains all sediment and tissue trace metal data collected in Alice Arm, prior to start-up of the Kitsault mine. Samples were also obtained from several

control sites along the outer B.C. coast, and data from the copper smelter site at Anyox in Hastings Arm.

Part II - Baseline Studies, Amax/Kitsault Mine - Transmissometry and Water Chemistry
This report contains transmissometer measurements (turbidity), along with results of total suspended particulate analysis for organic inorganic and trace metal concentrations of the natural suspended particulate in May and October 1980. Previously reported transmissometer data from June 1977 (Sullivan and Brothers, 1979) are also provided.

Part III - Initial Production Period, Amax/Kitsault Mine - Sediment and Tissue Trace Metals - 1981. This report contains sediment and tissue trace metal data from samples collected in May-June and October 1981, after start-up of the Amax/Kitsault mine.

Part IV - Initial Production Period, Amax/Kitsault Mine - Transmissometry and Water Chemistry - 1981 and 1982. This report contains transmissometer measurements, along with results of total suspended particulate analysis for organic, inorganic and trace metal concentrations in samples collected from Alice Arm in 1981 and 1982.

Part V - Baseline and Initial Production Period, Amax/Kitsault - Submersible Observations and Otter Trawls - 1980-1982. This report contains data on species abundance and distribution from 1980-1981 otter trawl surveys; along with observations of species distribution, bottom conditions and the tailings turbidity field taken from the submersible Pisces IV in July 1982. Reference is also made to submersible observations and otter trawl results, previously reported by Sullivan and Brothers (1979).

The present report is intended primarily to provide a baseline for future comparison with monitoring data collected during the operation of the Kitsault mine and to identify evidence if any, of metal uptake occurring in selected species exposed to marine tailings deposits from previous operations particularly those animals frequently used for human consumption. No attempt has been made in this study to determine the overall ecological impact of trace metals in receiving environment nor the effect on the individual organisms.

The method of tailings disposal employed at the Kitsault mine has drawn considerable public attention and is the subject of a review by a panel appointed by the Minister of Fisheries and Oceans. To facilitate this review all data gathered during this study has been presented and where possible summarized and compared to other sources. Detailed interpretation was not undertaken in order to provide the data within the required time frame for this review.

1.1 Study Area

The study area is located on the northern British Columbia coast approximately 144 km north of the city of Prince Rupert, B.C. (Figure 1). Alice Arm, site of the new Kitsualt mine is a glacially fed inlet about 18.5 km (10 nautical miles) in length and 1.4 km (0.8 nautical miles) in width, which along with Hastings Arm, forms a terminal branch of Observatory Inlet. Alice Arm is separated from Observatory Inlet by a complex of shallow sills near the entrance. The inner sill depth is approximately 42 metres (Figure 2). The maximum depth within Alice Arm is about 380 metres (1200 ft). Two main rivers, the Kitsault, the more dominant and glacial river, and the Illiance, flow into the head of Alice Arm (Figure 2). Two smaller creeks, Roundy Creek and Lime Creek, enter Alice Arm near the Kitsault townsite. The latter drains the mine operating area (Figure 2). Littlepage (1978) estimates the total annual discharge into Alice Arm to be $1.6 \times 10^9 m^3$ (1.3 million acre-feet).

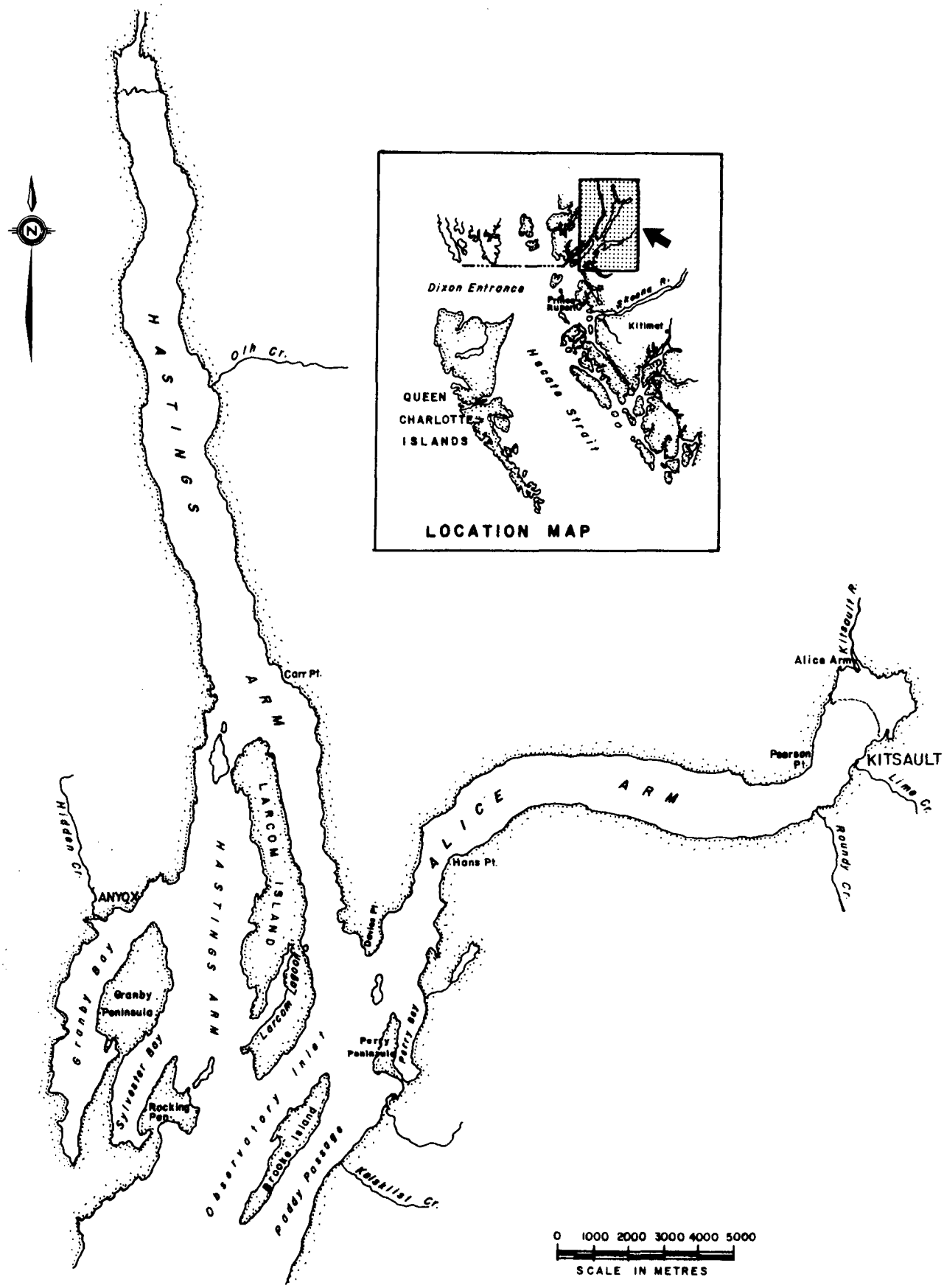

FIGURE 1 LOCATION MAP — ALICE ARM AND HASTINGS ARM

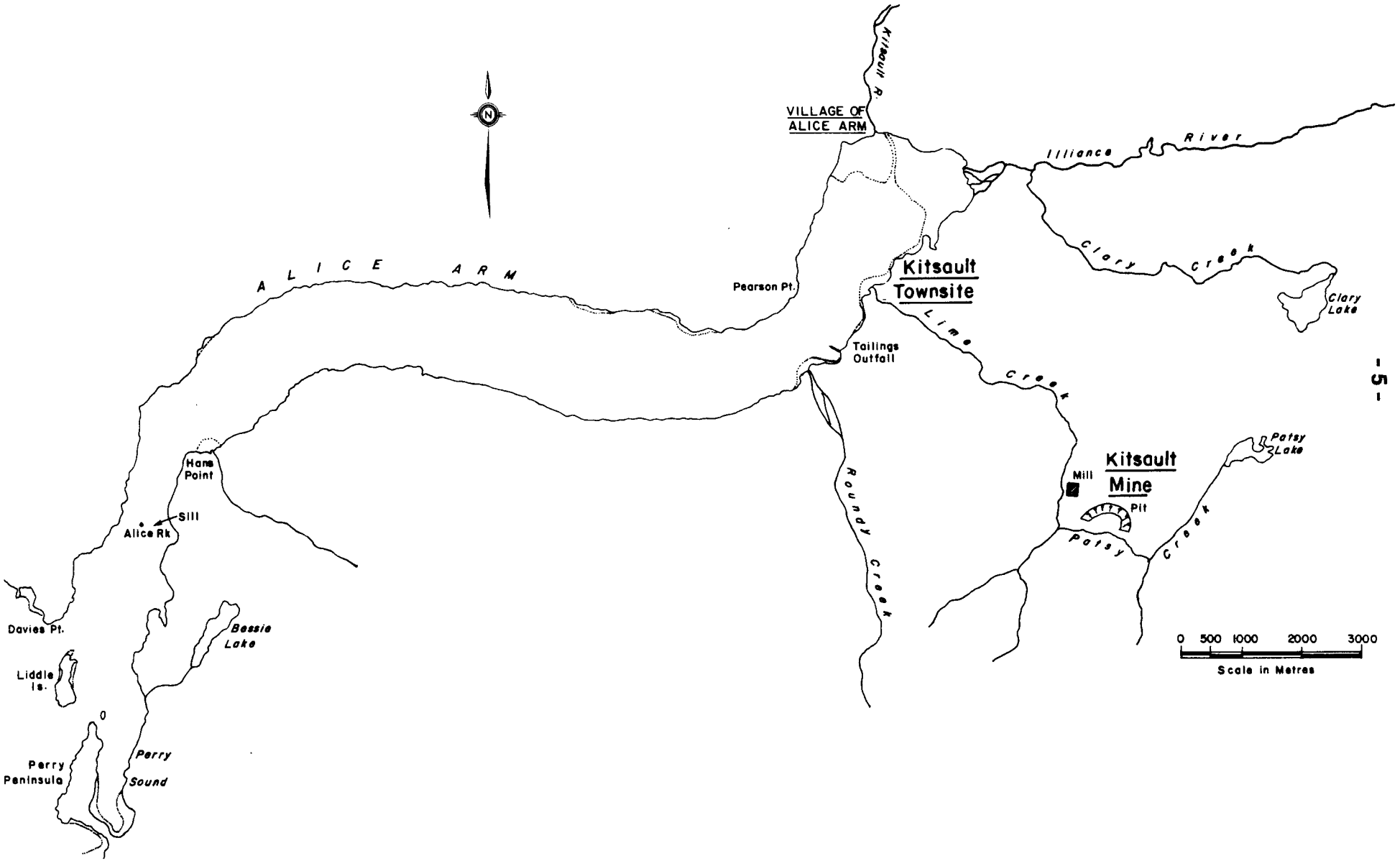

FIGURE 2 LOCATION MAP — ALICE ARM AND KITSAULT MINE DRAINAGE AREA

Hastings Arm is slightly longer (22.2 km or 12 nautical miles) and shallower (max. 307 m) than Alice Arm and within certain limits, can serve as a control inlet. Anyox, site of the abandoned copper smelter, is situated at the mouth of Hastings Arm in Granby Bay, near the junction with Alice Arm (Figure 1).

1.2 Previous Mining Operations

Over the years, the area around Alice Arm has been the site of numerous mining ventures. Littlepage (1978), reports that between 1911 and 1972 nine regional mines produced some 388,000 tons of copper, lead, molybdenum, gold and silver. The most recent mining venture has been the B.C. Molybdenum mine (1967 to 1972). The production rate averaged about 6,000 tons of ore per day, the bulk of which was discarded as tailings. Tailings from the mill, which was located approximately 5 kilometres inland, were discharged directly into Lime Creek (Figure 2) which flows into Alice Arm. Assuming a continuous operation of 330 days per year, this would represent a total of about 12 million tons discharged into Alice Arm during the six year life of the mine.

Anyox operated between 1914 and 1936 by Granby Consolidated Mining and Smelting Company. Martin (1933) reports that between 1924 and 1930, the daily tonnage through the concentrator ranged from 1,000 to 5,000 tons. The slag from the smelter was deposited on the shoreline of Granby Bay, portions of which still extend below low water. The slag pile occupies about 51 acres and represents several million tons. The tailings appear to have been impounded inland in a small tailings pond located behind the smelter adjacent to Hidden Creek.

Unlike B.C. Molybdenum (B.C. Res. Council, 1975), the ore body at Anyox appears to be readily susceptible to chemical and bacteriological oxidation. The British Columbia Research Council (1973) conducted studies to determine the feasibility of copper recovery through *in situ* leaching. Low pH (2.2 - 2.6), and relatively high iron (134 - 4770 mg/l), copper (2.6 - 294 mg/l), and zinc (2.9 - 73 mg/l) levels were found in Hidden Creek which drains the mine area and flows into Granby Bay (Figure 1). This factor is important when interpreting trace metal concentrations in tissue samples from the Anyox area.

Several smaller mines, noteably the Torbrit, Dolly Varden and Esperanza mines, operated in the Alice Arm area between 1911 and 1959 (Littlepage, 1978). Apart from construction of the Kitsualt mine and a brief helicopter logging operation, there has been no major industrial activity in the area since 1972 when B.C. Molybdenum ceased operation.

1.3 Kitsault Mine (Amax of Canada Ltd.)

The B.C. Molybdenum property was acquired by Amax of Canada Ltd. (formerly Climax Molybdenum Corporation) and production was resumed in April 1981. The designed production rate has been increased to about 12,000 tons of ore per day, twice the previous operation. Approximately 100 million tons will be processed over the 26 year life of the mine. The majority of the tonnage will be discharged directly into Alice Arm as tailings. However, steps may be taken to reduce cadmiun, lead and zinc which would lower the tailings volume slightly.

In contrast to the previous operation, tailings from the Kitsault mine are being piped to the foreshore of Alice Arm, where they are mixed with seawater and discharged near shore at a depth of 50 metres. The submerged outfall is located between Lime Creek and Roundy Creek (Figure 2), commonly referred to as Rocky Point.

The tailings effluent from the Kitsault mine comes under special Federal regulations which were promulgated in April, 1979, ie. Alice Arm Tailings Deposit Regulations (AATDR). These regulations set certain conditions on the effluent characteristics, behavior and deposition area of the tailings once discharged into Alice Arm (see Appendix 1).

2. MATERIALS AND METHODS

2.1 Survey Periods

Preliminary site inspections were carried out by EPS in June, 1976 aboard the fisheries patrol vessel "Kitimat II." Sediment samples were taken from the mouth of Lime Creek, from intertidal tailings deposits and from the head of Alice Arm. A sample of weathered tailings from the old tailings flume at the B.C. Molybdenum mine and several from the slag pile at Anyox were also collected (Figures 3 and 4). More extensive sampling was carried out in June 1977, October 1978 and May and October 1980 from the survey vessels "Parizeau" and "Vector".

Intertidal tissue samples (*Mytilus edulis* and *Fucus distichus*) were collected in June 1977, October 1978 and to a lesser extent in October 1980. In 1978, efforts concentrated on obtaining tissue samples from trawl catches, and sediment (cores and grabs) for trace metal analysis. Sediment sampling was carried out in conjunction with studies by Dr. J. Thompson, Institute of Ocean Sciences, who is currently investigating the interstitial or pore water chemistry of the Alice Arm tailings deposits and lead methylation. Additional sediment samples (surface only) were collected in May 1980, as well as tissue samples from trawl catches in May and October 1980.

In 1981, bottom trawls were carried out at four widely spaced areas along the B.C. Coast to obtain baseline tissue data on species commonly sampled from the trawl catches. These have been included to represent the normal or natural background levels for tissue trace metals. All locations were considered to be sufficiently removed from any industrial disturbances to serve as control sites.

2.2 Sediment

The June 1976 sediment samples collected from the intertidal zone were stored in "whirl pac" bags. Trace metal analysis was caried out by Dr. W. K. Fletcher (Department of Geology, University of British

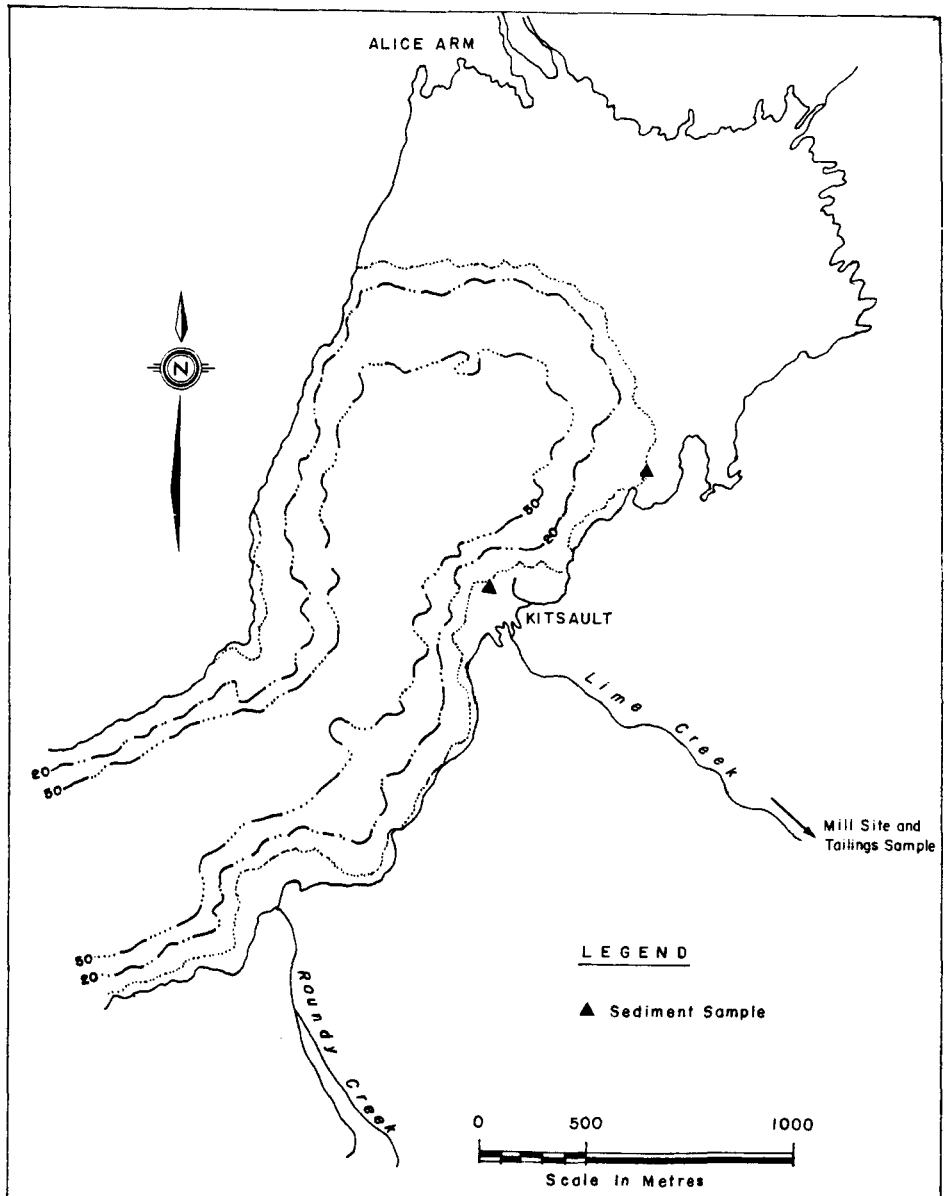

FIGURE 3 SAMPLING STATIONS IN ALICE ARM - June 1976

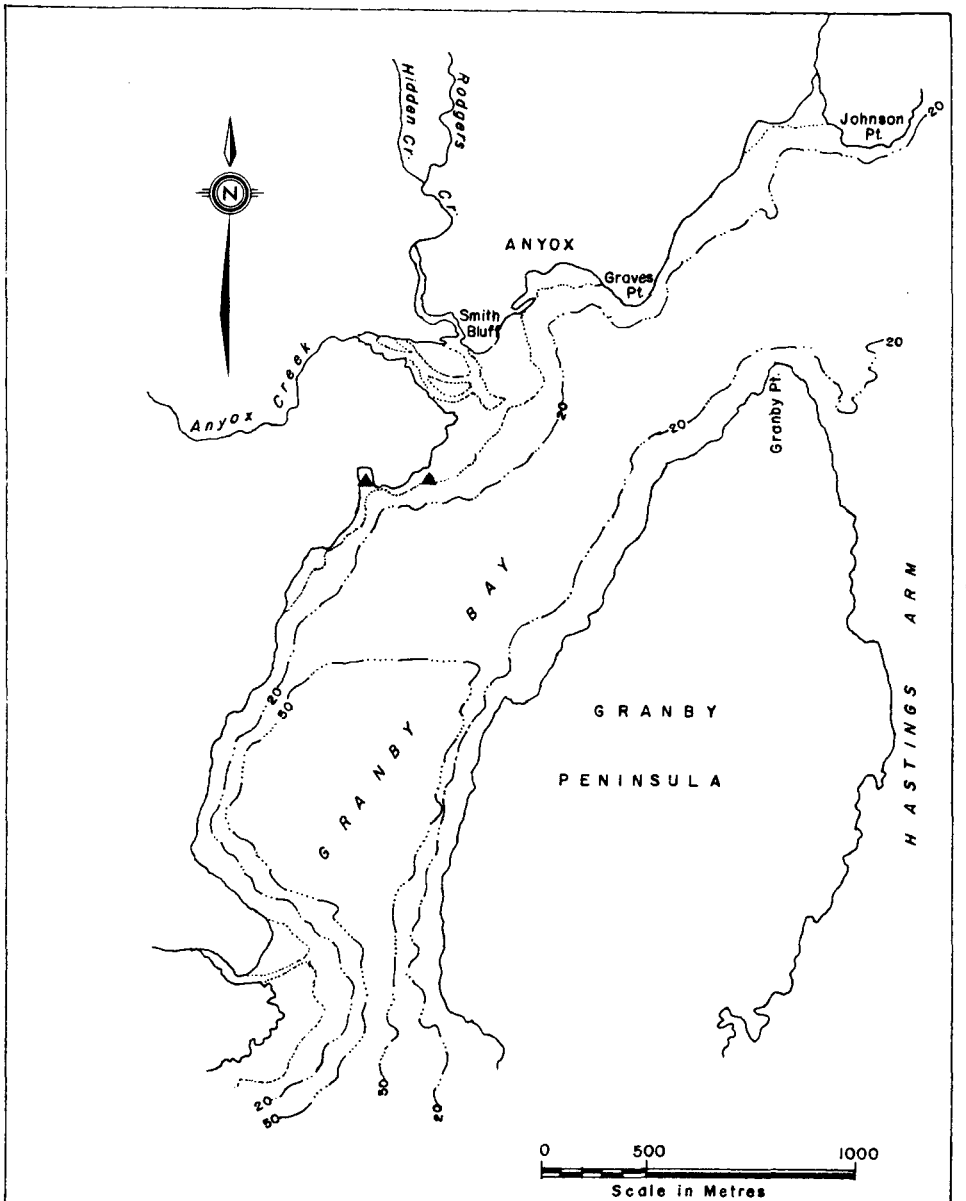

FIGURE 4 SEDIMENT SAMPLING STATIONS IN GRANBY BAY - June 1976

Columbia), as outlined in section 2.4. In October 1978, sediment samples were obtained from sixteen stations in Alice Arm, Hastings Arm and Granby Bay (Figure 5) using a Smith-McIntyre grab and an undisturbed box corer. Station coordinates and depths are given in Appendix 2A. Core samples were taken at centre channel and where possible, surface grabs were collected from north and south of each centreline core station. Sub-samples from the box core were extracted from the centre using a plexiglass tube and sections were taken at 0-2, 10-12, 20-22, 30-32, 40-42 and 50-52 cm intervals. Sub-samples were taken from the center portion of the Smith-McIntyre grab using a plastic trowel to avoid contamination. Samples were frozen immediately in "whirl pac" bags. Each sample was then freeze-dried at the Institute of Ocean Sciences, and later submitted to Dr. Fletcher's laboratory at U.B.C. for analysis. In some cases duplicate analysis was also conducted by the EPS Laboratory in West Vancouver.

In 1980, stored freeze-dried samples were selected from core stations A-1, A-5, A-10 and A-16 and submitted to Chemex Laboratories for U, Ra 226, Pb 210 and Th 230 analyses. Due to the cost of radioisotope analysis, samples were restricted to these four stations which were considered to adaquately reflect any contamination that may be associated with the B.C. Molybdenum operation. At Station A-1, a surface sample was selected for natural input coming from the head of Alice Arm. A core sample from Station A-5 represents known tailings deposits. Station A-10 was selected as Hans Creek is known to contain some uranium. An equivalent core from Station A-16 in Hastings Arm was chosen for analysis as a control site removed from any obvious mining effects. Results were to determine the need for futher analysis.

In May 1980 surface (0-6 cm) sediment samples were taken from 29 locations in Alice Arm and one at Anyox with a Smith-McIntyre grab (Figure 6). Station coordinates, depths and sample description are given in Appendix 2B. Attempts to obtain sediment from several stations were unsuccessful due to the coarseness of the bottom and the steep slope. Samples were frozen immediately in "whirl pac" bags for later analysis by the EPS Laboratory in West Vancouver.

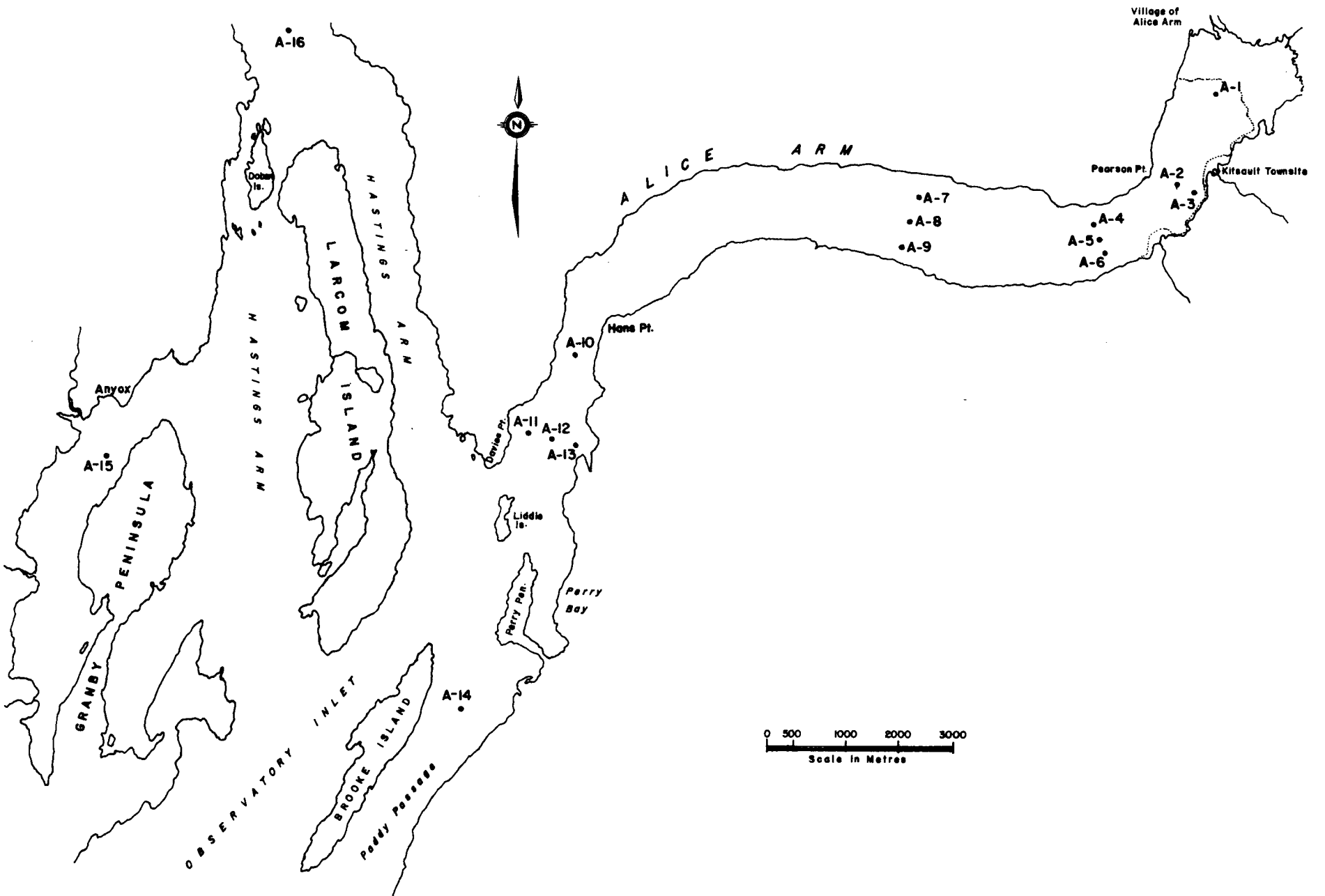

FIGURE 5 GRAB AND BOX CORE SEDIMENT STATIONS - ALICE ARM AND HASTINGS ARM - October 1978

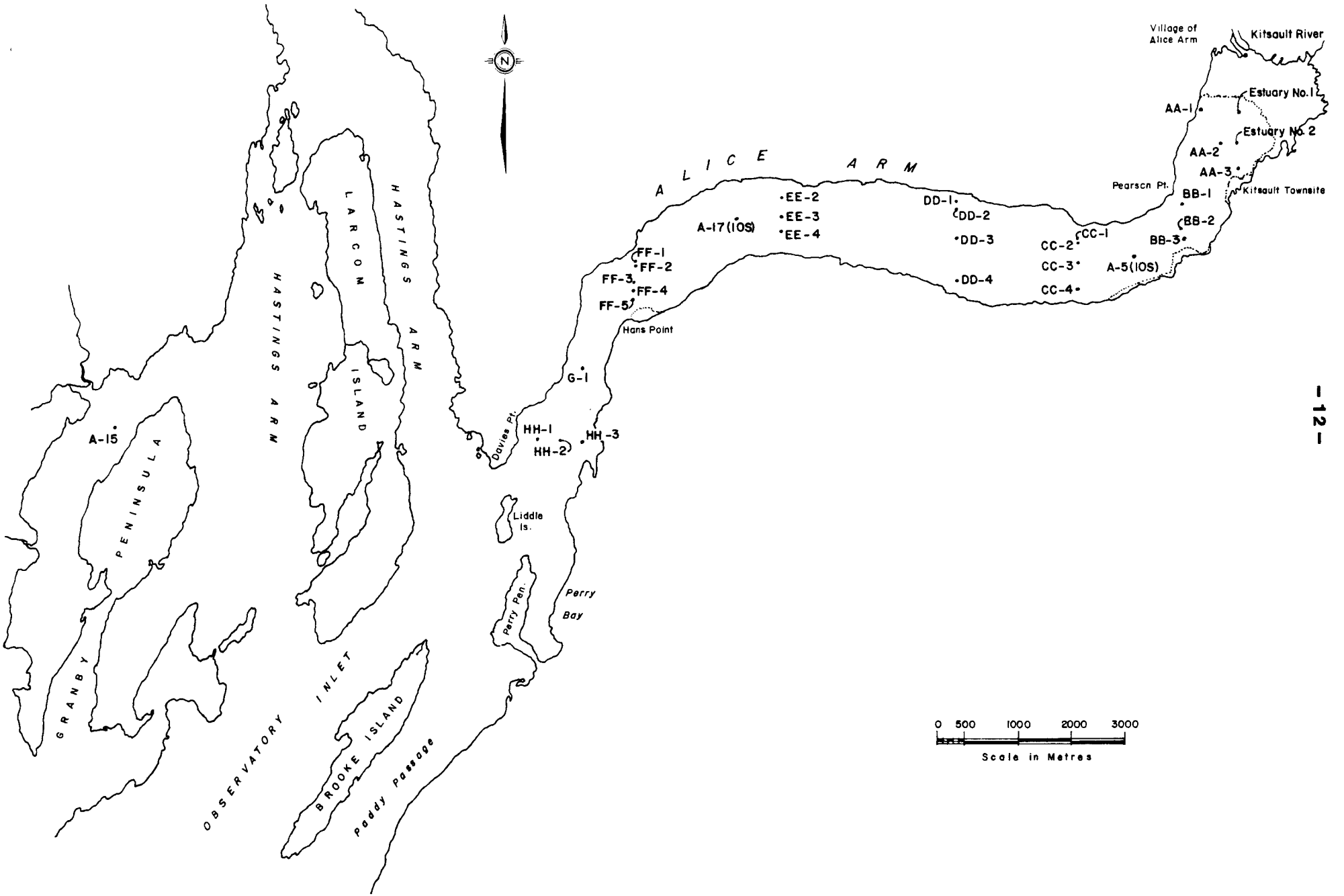

FIGURE 6 SEDIMENT SAMPLING STATIONS - ALICE ARM - May 1980

2.3 Biota

2.3.1 Trawl Samples. Samples of the more important commercial species were selected from otter trawl catches in Alice Arm and Hastings Arm in October 1978 and May and October 1980 for tissue trace metal analysis. Sampling locations are shown in Figure 7. Station information is given in Appendix 5A.

As indicated previously, additional trawl samples were taken from four widely spaced control areas along the coast to determine the natural concentration in epibenthic species commonly selected from the trawls. General locations are shown in Figure 8; specific trawl sites are shown in Figures 9 to 12. Coordinates are listed in Appendix 5A. The station off the entrance to Quatsino Sound, although part of the system used for tailings disposal from the Island Copper mine in Rupert Inlet, was beyond the area of tailings deposition (Goyette, unpubl. data) and considered to represent the natural coastal environment for that area.

The otter trawl consisted of a 3.8 cm mesh body, with a 5.8 metre throat. Each trawl was towed along the bottom with a 3 to 1 scope for a distance of approximately 0.8 km. The species selected were primarily pandalid shrimp (*Pandalus borealis*, *Pandalus hypsinotus*, *Pandalopsis dispar*); crangon shrimp (*Crangon communis*); the Brown King Crab (*Lithodes aequispina*); and pollock (*Theragra chalcogramma*) which generally represented the most dominant *montereyensis* species in the catch. The bivalve, (*Yoldia thraciaeformis/montereyensis*) and various species of sole, were sampled if present in the trawl catch. Samples were frozen in "whirl pac" bags and returned for analysis by the EPS West Vancouver Laboratory using the procedures outlined in Section 2.4.

Analysis of shrimp caught in 1978 was conducted on composite samples consisting of 2 to 20 individuals from each species (Appendix 6A) Pandalid shrimp were grouped into whole body and tail muscle only. Yoldia sp. were treated in the same manner, analyzed whole (minus shell) in groups of 20. Fish and other invertebrate species were treated individually. For fish, portions of the dorsal muscle were used. Crab samples consisted of leg, or claw muscle. The use of composite samples substantially reduces sampling logistics and analytical costs. However, this can limit statistical treatment of the data. In 1980 and 1981, individuals of each species were analyzed. Occasionally, insufficient tissue required using several animals in a composite sample. This was generally the case with Yoldia sp. For logistic reasons bivalve samples taken in 1978 were not purged prior to freezing aboard ship. Care was taken to remove any sediment adhering to the tissue by washing in distilled water prior to analysis. The 1980 and 1981 samples were purged for 24 hours in clean seawater before freezing aboard ship.

2.3.2 Intertidal Samples. In June 1977 and October 1978, mussel (Mytilus edulis), and rockweed (Fucus distichus) samples were collected from the intertidal zone (Figures 13 and 14). Station coordinates are given in Appendix 5B and 5C. Samples were frozen, in "whirl pac" bags and analyzed by the EPS Laboratory in West Vancouver according to procedures described in section 2.4. Samples were washed in distilled water before analysis. Mussels were submitted whole, minus byssal gland and threads. In October, 1978, the size range in each mussel sample was recorded and given in Appendix 6B.

2.4 Analytical Procedures.

2.4.1 Sediment Samples. Frozen sediment samples to be analyzed for trace metals were freeze-dried and sieved through an 80-mesh (2.5 phi)

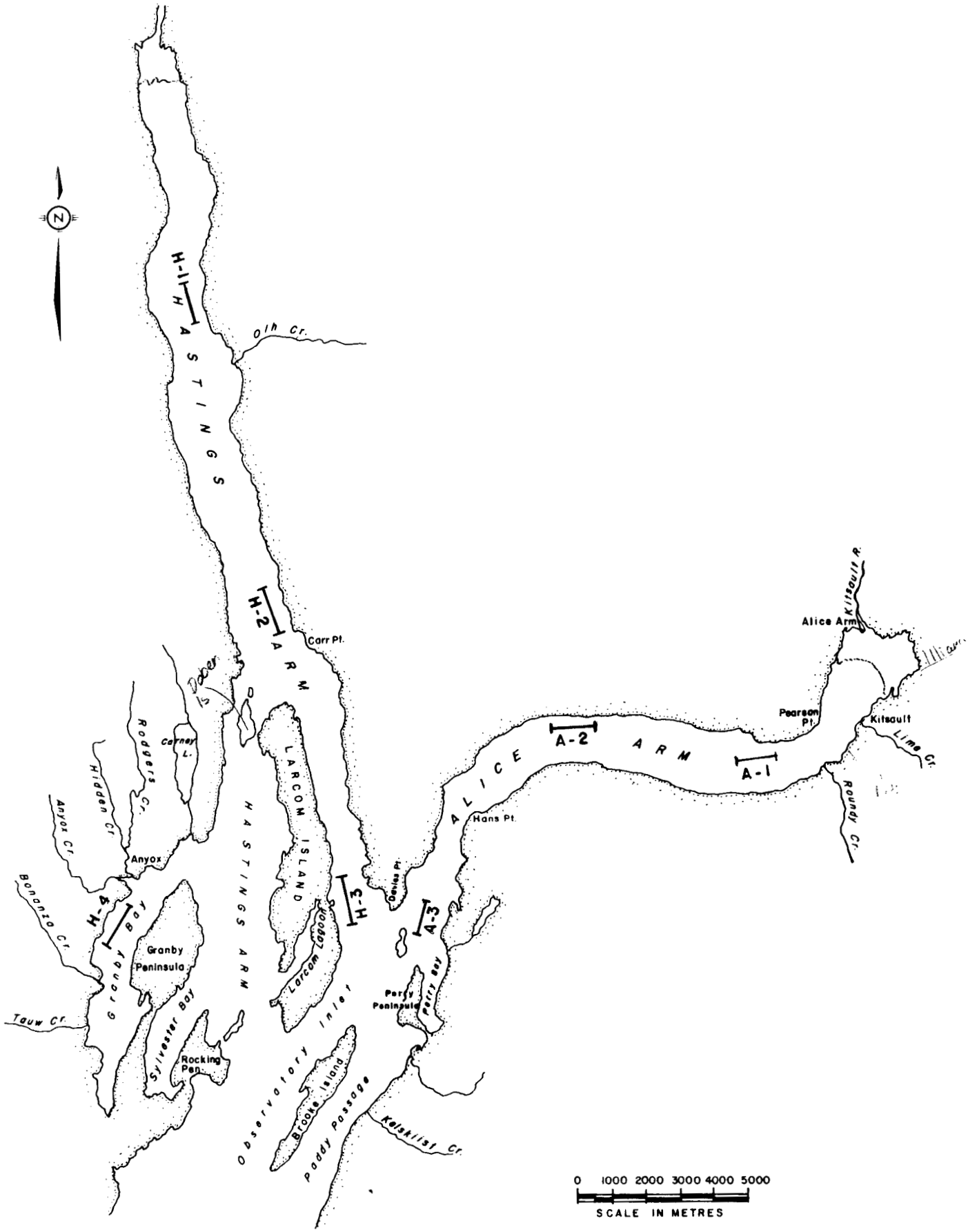

FIGURE 7 OTTER TRAWL STATIONS - ALICE ARM AND HASTINGS ARM - 1978, May 1980, October 1980

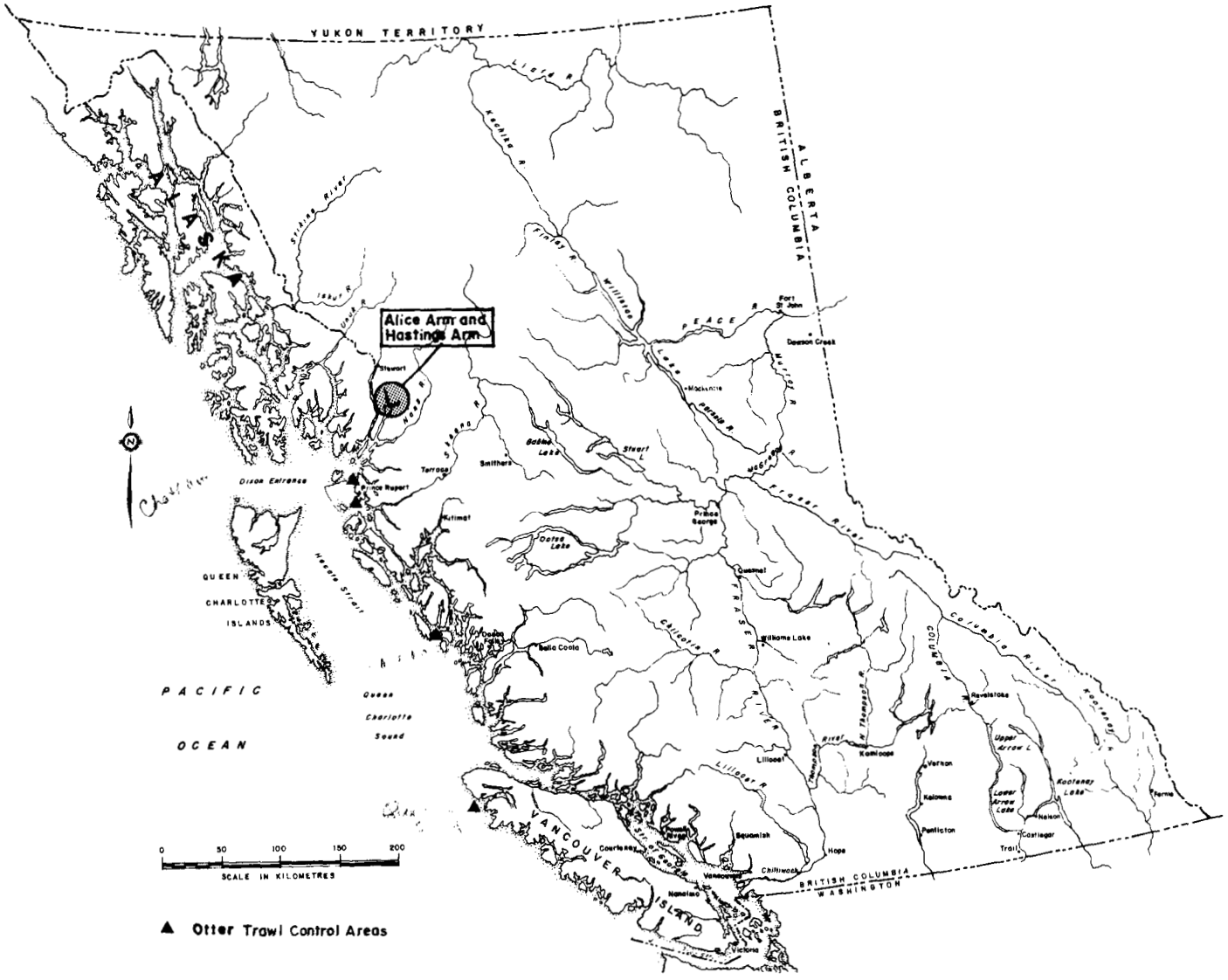

FIGURE 8 LOCATION MAP - OTTER TRAWL CONTROL AREAS, 1981

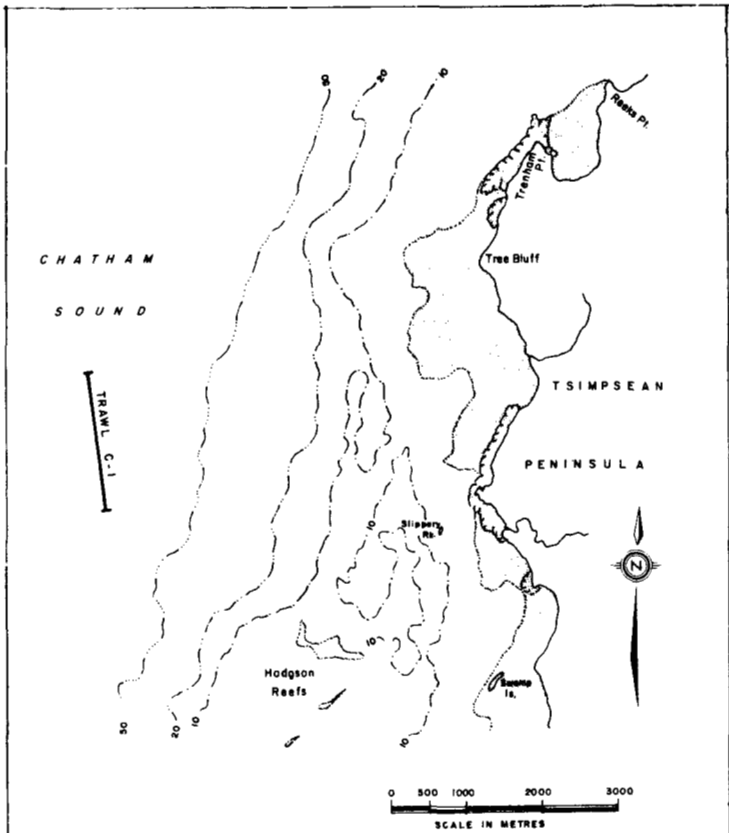

FIGURE 9 OTTER TRAWL STATION - CHATHAM SOUND - May, 1981

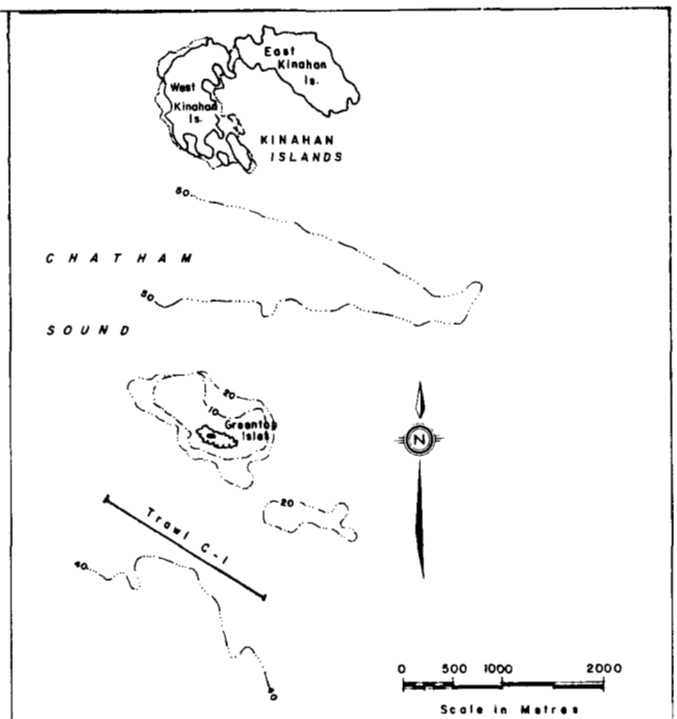

FIGURE 10 OTTER TRAWL STATION - CHATHAM SOUND - Oct. 1981

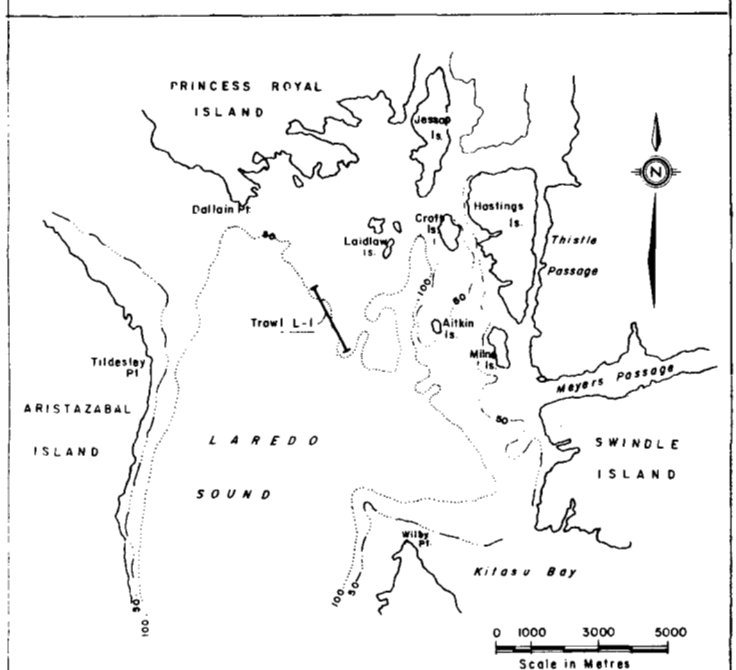

FIGURE 11 OTTER TRAWL STATION - LAREDO SOUND - Oct. 1981

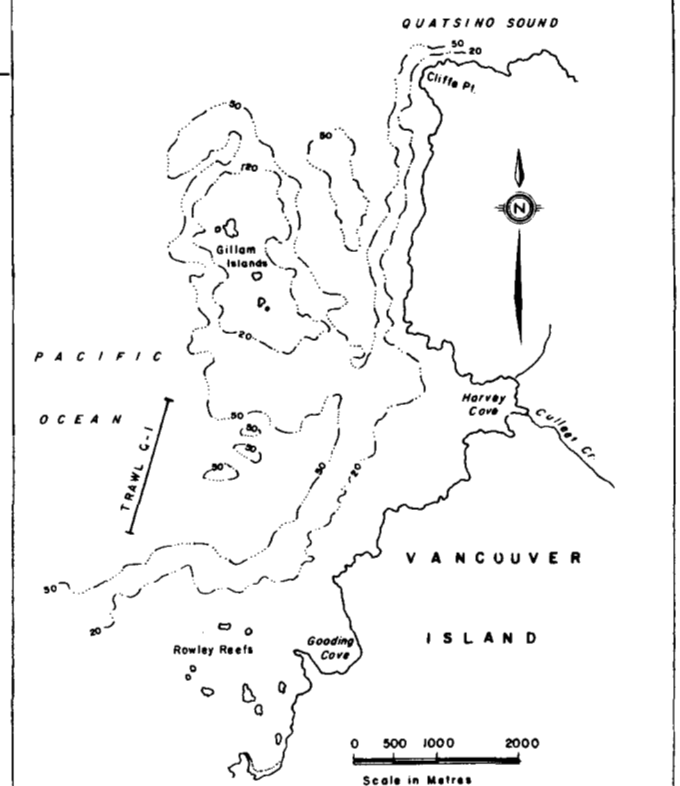

FIGURE 12 OTTER TRAWL STATION - QUATSINO SOUND - Sept. 1981

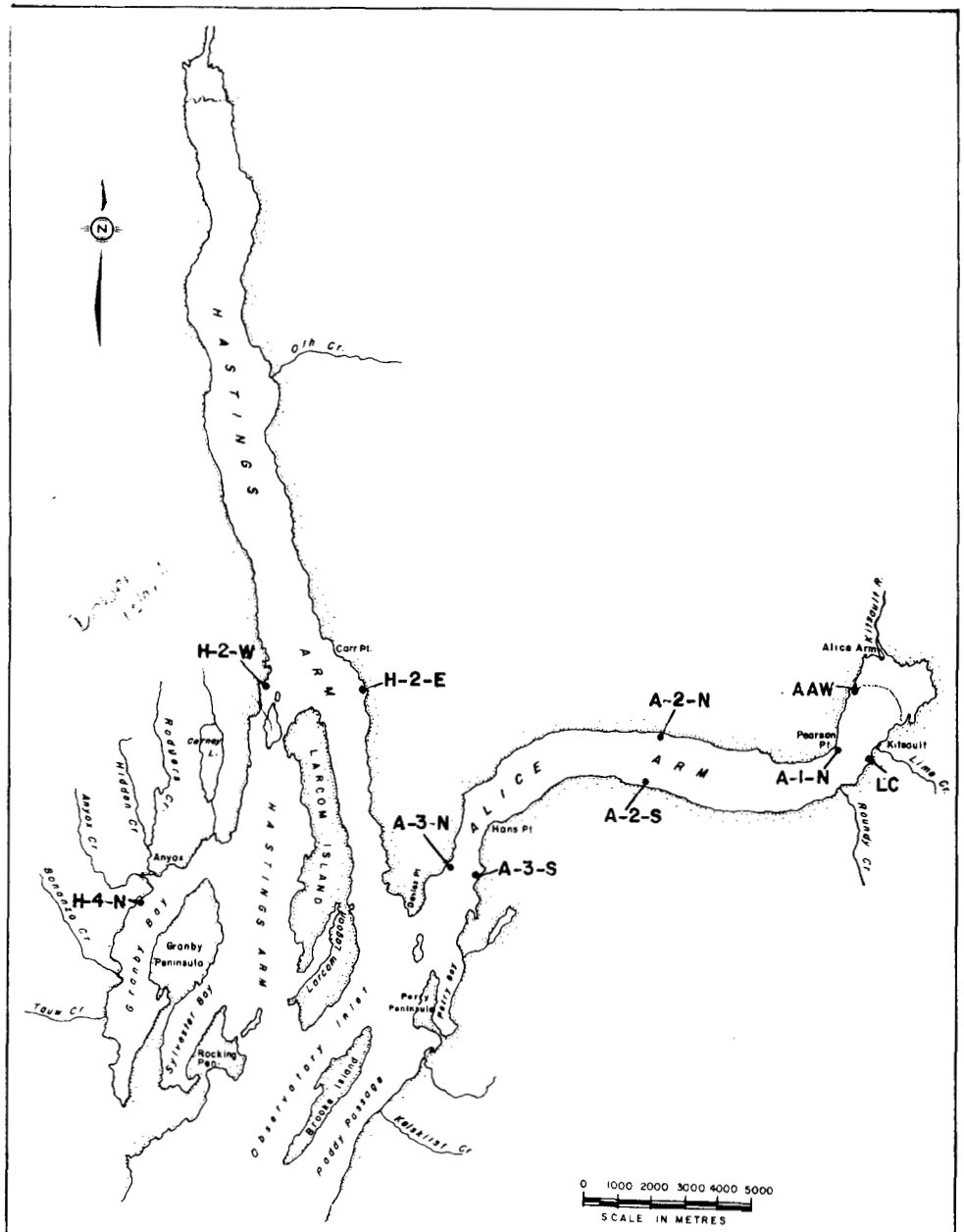

FIGURE 13 INTERTIDAL SAMPLING STATIONS - ALICE ARM AND HASTINGS ARM - 1977

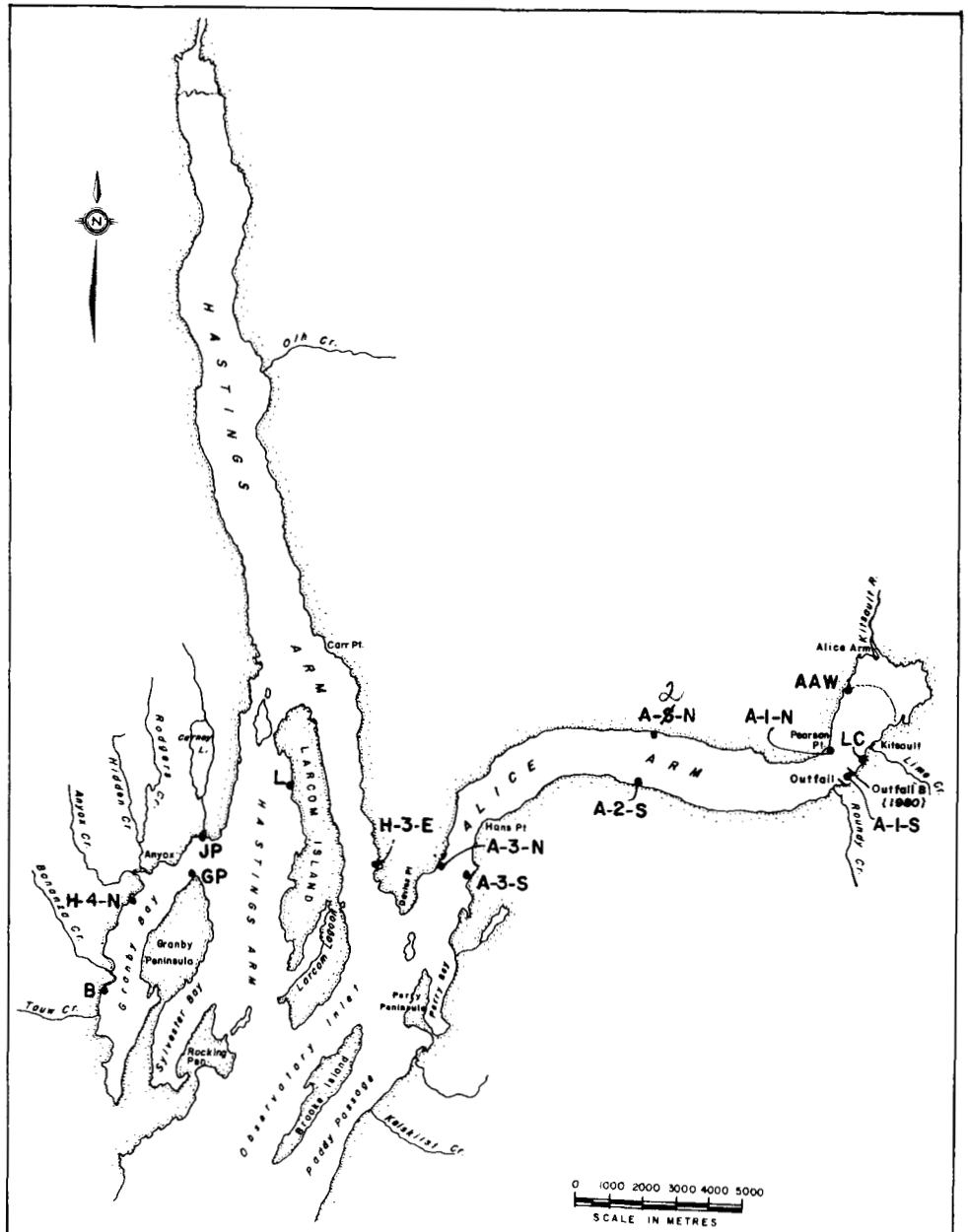

FIGURE 14 INTERTIDAL SAMPLING STATIONS - ALICE ARM AND HASTINGS ARM - 1978, 1980

nylon sieve. Portions of the minus 80-mesh fraction were forwarded to the laboratory of Dr. W. K. Fletcher (Department of Geology, University of British Columbia). They were then digested in a 4:1 nitric-perchloric acid mixture, evaporated to dryness over an air bath, taken up in 1.5 ml HCl and analyzed for cobalt (Co), copper (Cu), iron (Fe), manganese (Mn), Nickel (Ni), lead (Pb), silver (Ag), and zinc (Zn), with a Perkin Elmer 303 atomic absorption spectrophotometer (AAS). Background corrections were utilized in the determination of cadmium, nickel and lead. Analytical procedures at UBC are routinely checked against a standard rock sample. In 1978, samples of a National Bureau of Standards tailings standard certifying copper at 910 $\pm$10 ug/g were submitted to UBC along with the October sediment samples to determine the level of extraction by the UBC procedure. Samples collected in 1980 were analyzed in the EPS West Vancouver laboratory according to standard methods as outlined by Swingle and Davidson (1979). Results for the Standard Reference materials used by the West Vancouver laboratory are shown in Appendix 3A.

2.4.2 Biological Samples. Tissue samples were thawed, blended and freeze-dried. For analysis of metals other than mercury the organic material was oxidized in a low temperature asher. The remaining ash containing the metallic salts was dissolved in warm concentrated nitric acid. Samples done prior to October 8, 1978 were analyzed by a Jarrell Ash 850 AAS with background correction. Samples from October, 1978 and 1980, were analyzed by a Jerrell Ash Inductively Coupled Argon Plasma-Optical Emission Spectrometer (ICAP-OES).

For mercury analysis, the blended and freeze-dried samples were dissolved in a 4:1 sulfuric acid-water mixture. These solutions were further oxidized with 50 percent peroxide, heated, cooled, and diluted with a potassium permanganate. The resultant solutions were then analyzed by "cold vapour" AAS with background correction.

For the 1980 and 1981 samples, analysis was taken an additional step if necessary to lower the detection limit for lead and cadmium using the Jarrell Ash 850 AAS with FLA 100 graphite tube furnace. Detection limits in 1977 and 1978 ranged between 1.0 and 4.2 mg/kg for lead and 1.0 mg/kg for cadmium. Use of the graphite tube furnace lowered the detection for both elements to 0.05 mg/kg. All samples were analyzed at the West Vancouver Laboratory using analytical procedures described by Swingle and Davidson (1979).

Quality control checks are conducted routinely by the laboratory through daily batch control using calibration standards, analytical blanks, duplicate analysis of test samples and analysis of reference materials (NBS 1566 Oyster Tissue, NBS RM 50 Albacore tuna and NBS 1577 bovine liver) along with each batch. Longer term quality control is conducted through "blind audit" samples to check analyst performance and participation in interlaboratory studies with Fisheries and Oceans Freshwater Institute, Environment Canada's Centre for Inland Waters, US Geological Survey, International Atomic Energy Agency and others. Typical results obtained from Tissue Standard Reference Materials are given in Appendix 3B.

3. RESULTS AND DISCUSSION

3.1.1 Tailings Table 1 shows the total or acid extractable trace metal concentrations found in tailings samples from the abandoned mill site at the B.C. Molybdenum mine and slag from the Anyox smelter taken in June, 1976. In the absence of available records these results give some general indication of the metal content in the tailings during their operation. Analysis by UBC and West Vancouver laboratories were done on duplicate samples and show reasonably close agreement, with some variation in the lead and cadmium. Results from Hazen Research came from a separate sample taken at a later date.

Results from the analysis of both tailings solids and marine sediment depends, to a large extent, on the strength of the acid used and the total digestion time given to each sample by the laboratory. In most cases values approach the total metal content but, without more rigorous treatment, such as using hydrofloric acid, do not represent the absolute concentrations. As a consequence, results between laboratories can vary slightly depending upon their procedures. In addition, procedures used to obtain the total metal concentration in the solid fraction do not give a true indication of the amount that is biologically available. This would be considerably less and determined through a series of sequential digestions using weaker acids. Nonetheless, analysis of total metals gives a relative measure of the trace metals entering the receiving environment and provides the means of tracing tailings distribution. Compared to natural sediments from Hastings Arm and entrance to Alice Arm, noticeable features are the relatively high lead, zinc, cadmium, silver and iron content in the B.C. Molybdenum tailings and somewhat higher concentrations of copper, zinc and iron in the Anyox slag.

3.1.2 Sediment Analysis of intertidal samples taken at the head of Alice Arm, mouth of Lime Creek and near the slag pile at Anyox during preliminary studies in June 1976 are also shown in Table 1. The mean trace metal content found in core samples from 1978 and surface grabs in 1980 taken inside and outside the B.C. Molybdenum tailings deposits are

compared in Tables 2 and 3. The raw data are listed in Appendices 4A and 4B. For 1978 (Table 2), stations considered to be inside the B.C. Molybdenum deposits were determined from their overall metal content, since analysis for molybdenum was not done. For 1980 (Table 3), stations were grouped according to the molybdenum content, i.e. above and below the 18.5 mg/kg, detection limit. Stations at the head of Alice Arm, #1 (estuary); mouth of the Kitsault and Illiance rivers (Appendix 4B) and those well beyond any influence from the B.C. Molybdenum discharge molybdenum concentrations were below the detection limit.

Although the trace metal input into the receiving environment could be derived through analysis of the tailings effluent or the ore itself, the marine sediments give a closer picture of the trace metal distribution following exposure to a variety of environmental factors such as tidal sorting of the particles, dilution by natural deposition, differences in settling rates etc. Core samples provide an historical picture of fluctuations in metal content of the tailings solids and the ore body, as well as their horizontal and vertical distribution.

Mine waste from both the B.C. Molybdenum and Anyox operation has resulted in a noticeable increase in the metal content of the surrounding marine sediment for those metals which are present in the ore at concentrations higher than natural sources. For some which are below the natural concentrations, the reverse has occurred as in the case of nickel and chromium. Although in most cases the trace metal concentrations found in the surface sediments were lower than the underlying layers in 1978 they still remained above natural background levels six years after closure of the B.C. Molybdenum mine. At Anyox, 43 years after abondonment, surface concentrations in Granby Bay particularly Cu, Zn and Fe were substantially above the natural background and basically similar to those concentrations found throughout the core sample. This presumably has been the result of continual supply of slag from the shore deposits through erosion and wave action, along with somewhat lower natural sediment deposition since Granby Bay lacks the glacial runoff.

3.1.3 Tailing Distribution From 1978 data, the seaward extent of the B.C. Molybdenum deposits appeared to be somewhere between the north-south line of Station A-8 and Station A-10, near the base of the inner sill at the mouth of Alice Arm (Figure 5 and Appendix 4A). Unfortunately, in 1978 samples were not taken between Station A-8 and A-10, which were a 20-22 cm core depth appears to consist of almost entirely tailings from B.C. Molybdenum. Copper values found in the sample of weathered tailings taken in 1976 were similar to Station A-2 which is just off Lime Creek. Considerable distance apart. Station A-8 lies approximately 5.5 km from the point of discharge at Lime Creek. There was no evidence of tailings deposition outside the sill. At Station A-1 (76 metres), near the lower Kitsault River estuary, trace metal concentrations were near background levels, at least, to a core depth of 10-12 cm. Depths at stations A-7 to A-9, ranged between 225 and 360 metres. In May 1980 coverage by the surface grabs was more extensive and based on lead concentrations, the seaward leading edge of the B.C. Molybdenum surface deposits appeared to be in the vicinity of Station A-17, 10 km from the source at Lime Creek. (Figure 6 and Appendix 4B). For most metals surface concentrations were higher than natural background levels at Station #2 (estuary) (Figure 6) indicating some deposition had also occurred in the direction of the estuary. Depth at this station was 98 metres.

3.1.4 Comparison of the Major Trace Metals Table 4 presents a general comparison of the various sources of trace metals in the Alice Arm area, natural and mine derived. Figure 15, illustrates the general distribution pattern for copper, lead, zinc and cadmium thoughout Alice Arm from the 1978 core samples.

Copper

Copper concentrations in the natural sediments appear to range between 30 and 50 mg/kg, dry wt. (Appendix 4A and 4B, Stations A10-A13, HH). The copper content in sediment taken from the Alice Arm drainage basin is reported as 58 mg/kg (Table 4). Within the B.C. Molybdenum tailings deposits the average copper content, in the 1978 core samples,

TABLE 1: TRACE METAL CONCENTRATIONS FOUND IN INTERTIDAL SEDIMENT ALICE ARM AND ANYOX - JUNE 1976.

STATION	mg/kg, dry weight									
	Cu	Pb	Zn	Cd	Ni	Mn	Co	Ag	Fe (%)	Hg
Alice Arm										
B.C. Moly	[1]127.9	476.1	496.5	17.2	8.5	367.3	28.3	7.9	2.9	-
tailings	[2]130.0	560.0	520.0	16.0	-	-	-	-	4.1	0.077
(Mill site Tailings flume)										
Head of	[1]93.9	37.2	203.3	1.4	34.7	452.6	19.0	0.8	3.9	-
Alice Arm	[2]96.0	56.0	220.0	3.0	-	-	-	-	5.5	0.149
Lime Ck.	[1]80.7	356.5	487.1	13.8	9.3	463.8	13.3	5.4	2.2	-
(mouth)	[2]89.0	390.0	520.0	16.0	-	-	-	-	2.8	0.105
Anyox										
Slag pile	[1]3396	132	9649	1.1	6.7	557	224	4.5	25.5	-
	[2]3500	230	13000	3.0	-	-	-	-	39.0	0.043
	[3]3140	180	11800	5.0	38.0	-	-	6.0	50.9	-
South of	[1]52.9	9.0	147.1	0.0	57.2	690.1	17.4	0.4	3.4	-
slag pile	[2]60.0	33	150.0	3.0	-	-	-	-	5.0	0.081

[1] Analysis conducted by Dr. K. Fletcher, Department of Geology, U.B.C.

[2] Analysis conducted by Environmental Protection Service, West Vancouver Laboratory

[3] Analysis conducted by Hazen Research Inc., Colorado

TABLE 2: MEAN TRACE METAL CONCENTRATIONS FOUND IN CORE SAMPLES TAKEN INSIDE AND OUTSIDE THE AREA OF THE B.C. MOLYBDENUM TAILINGS DEPOSITS - OCTOBER 1978. (Analysis by UBC Dept. of Geology)

METAL (mg/kg, dry wt.)	INSIDE (A-2 to A-9)		OUTISDE (A-10 to A-14)	
	Complete Core	Surface Only	Complete Core	Surface Only
Copper (Cu.)				
Mean	75.0	68.4	50.7	44.5
Std. Dev.	15.0	4.9	14.4	4.4
n	17.0	8.0	13.0	5.0
Range	60.4-120.9	60.4-74.7	36.1-85.1	40.4-52.0
Lead (Pb.)				
Mean	93.4	68.6	19.0	22.0
Stn. Dev.	59.1	13.8	6.8	5.1
n	17.0	8.0	13.0	5.0
Range	54.0-263.0	54.0-84.0	9.0-30.0	18.0-30.0
Zinc (Zn.)				
Mean	241.7	190.3	114.9	114.4
Std. Dev.	65.4	15.2	12.8	11.3
n	17.0	8.0	13.0	5.0
Range	170.8-373.0	170.8-204.0	91.0-135.2	110.4-130.3
Cadmium (Cd.)				
Mean	13.6	7.1	1.9	1.8
Std. Dev.	10.4	2.9	0.6	0.7
n	17.0	8.0	13.0	5.0
Range	3.8-43.0	3.8-12.4	0.9-3.1	1.1-3.1
Iron (Fe) (%)				
Mean	3.2	3.4	2.6	2.7
Std. Dev.	0.3	0.06	0.2	0.2
n	17.0	8.0	13.0	5.0
Range	2.5-3.5	3.3-3.5	2.5-2.9	2.5-2.8
Nickel (Ni)				
Mean	32.6	35.9	43.0	42.4
Std. Dev.	7.6	2.7	3.7	3.7
n	17.0	8.0	13.0	5.0
Range	13.7-40.0	31.4-38.6	38.2-51.3	38.2-46.5

TABLE 2: (continued) MEAN TRACE METAL CONCENTRATIONS FOUND IN CORE SAMPLES TAKEN INSIDE AND OUTSIDE THE AREA OF THE B.C. MOLYBDENUM TAILINGS DEPOSITS - OCTOBER 1978. (Analysis by the UBC Dept. of Geology)

METAL (mg/kg, dry wt.)	INSIDE (A-2 to A-9)		OUTISDE (A-10 to A-14)	
	Complete Core	Surface Only	Complete Core	Surface Only
Manganese (Mn)				
Mean	1227.1	1788.6	453.5	1417.6
Std. Dev.	771.7	1266.1	32.8	1327.6
n	17.0	8.0	13.0	5.0
Range	684.5-4449.2	684.5-4449.2	405.0-3422.5	463.8-3422.5
Cobalt (Co)				
Mean	17.2	18.2	16.9	18.2
Std. Dev.	2.2	0.9	3.9	6.2
n	17.0	8.0	13.0	5.0
Range	12.0-19.0	17.0-19.0	14.0-29.0	14.0-29.0
Silver (Ag)				
Mean	1.5	1.0	0.3	0.4
Std. Dev.	0.8	0.2	0.1	0.2
n	17.0	8.0	13.0	5.0
Range	0.7-4.4	0.7-1.1	0.2-0.6	0.2-0.6

TABLE 3: MEAN CONCENTRATION AND SIGNIFICANCE OF TRACE METALS IN SURFACE SEDIMENT IN THE PRESENCE AND ABSENCE OF MOLYBDENUM - ALICE ARM, MAY 1980. (Analysis by EPS Lab. W.Van.)

Metal	Molybdenum (non-detected) (mg/kg, dry wt.)	Molybdenum[1] (detected) (mg/kg, dry wt.)	Significance[2] at 95% Confidence level
Copper (Cu.)			
Mean	44.42	74.88	increase
Std. Dev.	11.54	5.39	
n	38	16	
Range	29.4-73.2	62.0-83.3	
Lead (Pb.)			
Mean	66.94	140.70	increase
Stn. Dev.	23.13	22.99	
n	38	16	
Range	46.5-148.0	99.4-194.0	
Zinc (Zn.)			
Mean	126.07	223.66	increase
Std. Dev.	39.02	42.59	
n	38	16	
Range	87.2-234.0	179.0-360.0	
Cadium (Cd.)			
Mean	0.64	2.47	increase
Std. Dev.	0.18	1.55	
n	38	16	
Range	0.54-1.09	0.56-6.24	
Molybdenum (Mo.)			
Mean	L18.5	86.0	
Std. Dev.	-	37.76	
n	38	16	
Range	-	27.1-152.0	

1. Presence of molybdenum represents concentrations greater than the detection limit of 18.5 mg/kg, dry weight.

2. Statistical comparison of the means.

TABLE 3: (continued) MEAN CONCENTRATION AND SIGNIFICANCE OF TRACE METALS IN SURFACE SEDIMENT IN THE PRESENCE AND ABSENCE OF MOLYBDENUM - ALICE ARM MAY 1980. (Analysis by EPS Lab. W. Van.)

Metal	Molybdenum (non-detected) (mg/kg, dry wt.)	Molybdenum (detected) (mg/kg, dry wt.)	Significance[2] at 95% Confidence level
Mercury (Hg.)			
Mean	0.18	0.24	increase
Std. Dev.	0.08	0.08	
n	38	16	
Range	0.094-0.378	0.154-0.365	
Iron (Fe.)			
Mean (%)	3.91	4.18	increase
Std. Dev.	0.86	0.26	
n	38	16	
Range	2.94-7.29	3.64-4.63	
Chromium (Cr.)			
Mean	47.68	42.81	equal
Std. Dev.	12.11	9.21	
n	38	16	
Range	27.1-67.9	30.3-61.8	
Manganese (Mn.)			
Mean	985.63	1204.44	equal
Std. Dev.	481.87	380.06	
n	38	16	
Range	533-2310	689-2280	
Nickel			
Mean	36.84	40.03	equal
Std. Dev.	9.60	6.71	
n	38	16	
Range	19.2-61.2	31.5-52.6	
Aluminium			
Mean	21,273.95	25,387.50	increase
Std. Dev.	4,122.07	3,131.85	
n	38	16	
Range	17,000-30,900	20,000-29,500	

was 75 mg/kg. Analysis of the Kitsault ore body shows average copper levels within the range found in the natural sediment. The concentrations found in core samples from station A-2 in 1978 however, suggest that the copper content in the tailings during the B.C. Molybdenum operation, at times, approached or exceeded 100 mg/kg. Station A-2 (20-22 cm) in 1978 for example showed a maximum concentration of 121 mg/kg. Based on overall metal content, 20-22 cm core depth appears to consist of almost entirely undisturbed tailings from B.C. Molybdenum. Copper values found in the sample of weathered tailings taken in 1976 were similar to Station A-2 which is just off Lime Creek.

Near Anyox the average (0-22 cm) copper content in the sediment in 1978 was 650 mg/kg (Station A-15, Appendix A-5). This high value is not surprising as this source material contained from 3100 to 3500 mg/kg, Cu. In other industrial sites tested along the B.C. coast sediment copper concentrations for example, range anywhere from 69.5 to 190,000 mg/kg (Vancouver Harbour), 291 to 528 mg/kg (upper Howe Sound), 199 to 700 mg/kg (Rupert-Holberg Inlets) and up to 156 mg/kg (Victoria Harbour) (Garrett, 1981).

Lead

From the 1978 core samples, the natural background in Alice Arm ranged between 9.0 and 30.0 mg/kg, with an average of 19.0 mg/kg. Within the B.C. Molybdenum deposits lead concentrations were significantly higher ranging from 54 to 263 mg/kg, with an average of 93 mg/kg. Results obtained from the 1980 surface grabs suggest a somewhat higher natural background level (average of 67 mg/kg) and higher surface concentrations within the B.C. Molybdenum deposits (average of 141 mg/kg). The differences indicated may be a function of laboratory analysis or sampling procedure. Dobrocky Seatech (1981) report background concentrations ranging from less than 3 mg/kg to 35 mg/kg and surface sediment levels from 49 to 315 mg/kg in the contaminated areas. Sediment from the Alice Arm drainage basin averaged about 23 mg/kg (see Table 4). Around Anyox (Station A-15) lead concentrations in 1978 core samples ranged from 9.0 to 11.0 mg/kg. The equivalent station in 1980 showed surface sediment values

TABLE 4: COMPARISON OF NATURAL SEDIMENTS TRACE METAL CONTENT WITH THE KITSAULT AND ANYOX TAILINGS AND MARINE SEDIMENT - 1976-1980 in mg/kg, dry weight

LOCATION	DATE	Cu	Pb	Zn	Cd	As	Hg	Mo	Fe (%)	Ni	Mn	Ag	U	Ra
							Sediments - Natural Background							
Alice Arm Basin[1]	1978	58	23	176	-	29	0.134	7.9	3.8	40	1734	-	4.2	
Nass River Basin[1]	1978	44	10	122	-	13	0.088	2.5	3.5	51	1375	-	3.8	-
Head of Alice Arm	1976	94	37	203	1.4	-	0.149	-	3.9	35	453	0.8	-	-
Stn. A-1	1978	61	23	130	4.3	-	-	-	3.1	26	614	0.6	1.5	2.0
Estuary	1980	52	68	144	0.77	-	0.220	L18.5	4.8	24	935	-	-	-
		(44-59)	(52-92)	(96-201)	(L0.5-0.97)	-	(0.078-0.328)		(4.1-7.0)	(20-29)	(685-1155)	-	-	-
Outside Alice Arm Tailings Deposits														
Core Samples	1978	51	19	115	1.9	-	-	-	2.6	43	453	0.3	1.9	1.5
(A-10 to A-14)		(36-85)	(9-30)	(91-135)	(0.9-3.1)	-	-	-	(2.5-2.4)	(38-51)	(405-3422)	(0.2-0.6)	(1.5-3.0)	(1.1-1.9)
Surface Sediment	1980	44	67	126	0.64	-	0.130	L18.5	3.4	40	799	-		
		(29-73)	(46-148)	(87-234)	(0.54-1.09)	-	(L0.100-0.169)		(2.9-3.7)	(34-50)	(556-1440)	-	(1.8-2.4)	(1.3-1.9)
							Ore and Tailings Solids							
Kitsault Ore	1978	41	115	387	51	18	-	1093	2.9	8	409	2.0	2.3	-
BC Moly Tailings	1976	128	476	496	17	-	0.077	-	2.9	8	367	7.9	-	-
Anyox Slag	1976	3396	132	9649	1.1	-	0.043	-	2.5	7	557	4.5	-	-

[1] B.C. Department of Energy, Mines and Petroleum Resources (1978).

Continued...

TABLE 4: COMPARISON OF NATURAL SEDIMENTS TRACE METAL CONTENT WITH THE KITSAULT AND ANYOX TAILINGS AND MARINE SEDIMENT - 1976-1980 in mg/kg, dry weight

(Continued)

LOCATION	DATE	Cu	Pb	Zn	Cd	As	Hg	Mo	Fe (%)	Ni	Mn	Ag	U	Ra
							Marine Sediment (inside tailings deposition area)							
							Alice Arm							
Mouth of Lime Cr.	1976	81	356	487	14	-	0.105	-	2.2	9	463	5.4	-	-
Cores	1978	75	93	243	14	-	-	-	3.2	33	1227	1.5	1.4	1.1
		(60-121)	(54-263)	(171-373)	(3.8-43.0)	-	-	-	(2.5-3.5)	(14-40)	(684-4449)	(0.7-4.4)	(1.0-1.5)	(0.9-1.2)
Surface Sediment	1980	75	140	223	2.5	-	0.24	86	4.2	40	1204	-	-	-
		(51-83)	(86-191)	(144-358)	(L0.56-6.2)	-	(L0.98-0.36)	(L18.6-152)	(3.6-4.6)	(32-53)	(692-2300)	-	-	-
							Anyox							
Core A-15	1978	645	10	2208	27	-	-	-	12.6	23	358	0.88	-	-
		(624-660)	(9-11)	(2032-2386)	(24-29)	-	-	-	(11.1-13.4)	(21-25)	(339-370)	(0.81-0.92)	-	-
Surface Sed. A-15	1980	585	54	1785	6.8	-	0.782	-	11.7	23	516	-	-	-

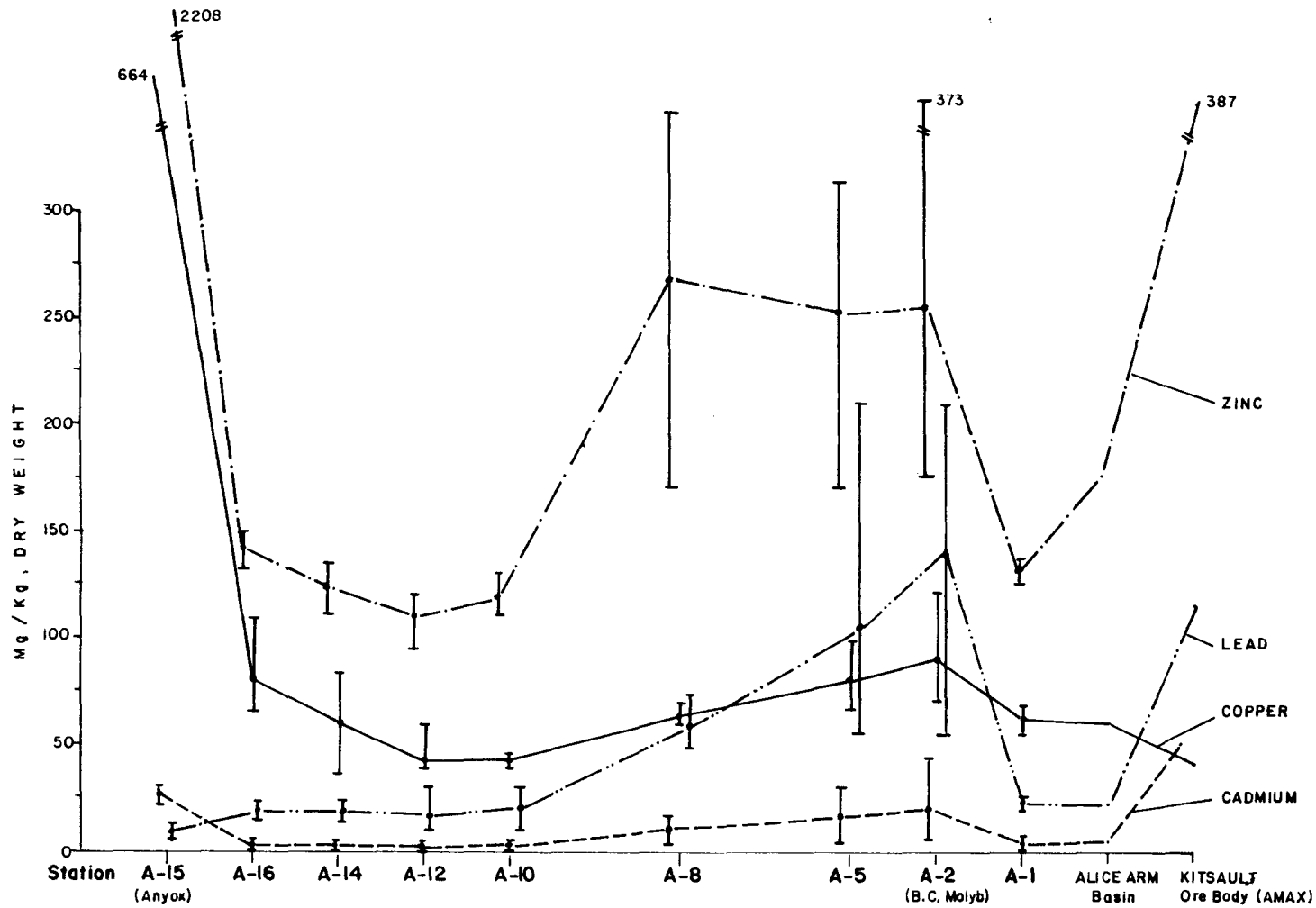

FIGURE 15 COPPER, LEAD, ZINC AND CADMIUM DISTRIBUTION IN ALICE ARM AND HASTINGS ARM - 1978 CORE SAMPLES

of approximately 54 mg/kg. Elsewhere along the B.C. coast concentrations between 20 and 100 mg/kg, are common and particularly around the Vancouver area, often greater than 100 mg/kg, and ranging from 160 to 1400 mg/kg (Garrett, 1981). In Victoria Harbour values range from 129 to 279 mg/kg (Goyette, unpublished).

Zinc

Based on the 1978 data the natural zinc levels in the Alice Arm area, appear to range between 91 and 135 mg/kg, dry wt. (x=115 mg/kg). Within the tailings deposits levels ranged from 170 to 373 mg/kg, (x=242 mg/kg). In 1980, the average surface concentration was 224 mg/kg. Zinc values reported in sediment from the Alice Arm drainage basin averaged 176 mg/kg (Table 4). Near Anyox, the zinc concentrations were substantially above background, ranging between 2000 and 2385 mg/kg (0 - 22 cm core depth). In other industrial areas along the B.C. coast values from 246 mg/kg, dry wt. (Victoria Harbour) to 9910 mg/kg (Vancouver Harbour) have been obtained (Garrett, 1981).

Cadmium

In 1978 concentrations found in sediment samples taken outside Alice Arm and away from the influence of Anyox suggest that the natural concentrations range between 1.0 and 2.0 mg/kg. Within the B.C. Molybdenum deposits in Alice Arm concentrations ranged between 3.8 and 43.0 mg/kg with an average in the core samples of 13.6 mg/kg. The latter value was similar to those found by both the UBC and EPS laboratories for the B.C. Molybdenum tailings (Table 1). In 1980 the concentrations overall, were lower. Surface concentrations outside the tailings deposition area were below the detection limit of 0.56 mg/kg and within the deposits averaged approximately 2.5 mg/kg. It is not known whether the lower values found in 1980 were the result of changes over time or due to analytical variation between the UBC (1978) and EPS (1980) laboratories. The latter is suspected since surface concentrations at Station A15 (Anyox) in 1980 were lower than the same location in 1978 by about 17.0 mg/kg. Cadmium levels in sediment from the Alice Arm drainage

basin have not been reported. Kitsault River sediment and samples from the nearby estuary in 1980 ranged between L0.54 mg/kg and 0.97 mg/kg. Analysis of the Kitsault ore body showed an average of 51 mg/kg (Table 4). Dobrocky Seatech (1981,) report cadmuim concentrations in Alice Arm of 1.5 to 11.2 mg/kg and 0.19 to 1.6 mg/kg, outside the area of tailing deposits. In the 1978 core samples from Anyox (Station A-15) concentrations were between 24 and 29 mg/kg. In other industralized areas along the B.C. coast values are generally lower than those reported for Alice Arm, ranging between 1 and 5 mg/kg. A few areas exceed this, such as Vancouver Harbour with up to 31 mg/kg (Garrett, 1981).

Radioisotope (U, Ra 226, Pb 210, Th 230)

Public concern has been expressed over the possible radium - 226 contamination from the new Kitsault mine. Analysis of four samples taken in 1978, one core from known B.C. Molybdenum deposits and one core from from Hastings Arm, as a control, along with two surface grabs in Alice Arm for additional background data showed no evidence of contamination. In fact, concentrations found the portion of the core sample considered to be almost entirely tailings from the B.C. Molybdenum operation (Station A-5, 20-22 cm), were lower than those reported in the Alice Arm and Nass River basin sediment and the core sample from Hastings Arm (Table 4).

Molybdenum

From an environmental standpoint molybdenum does not appear to represent any major concern. However, as it is a major element in the Kitsault ore body, molybdenum can provide a means of determining the distribution of the tailings in Alice Arm. The molybdenum content of the sediment, coupled with concentrations of the other major trace metals contained in the tailings, can be used to determine the tailings distribution long before any visual evidence is available. Analysis for molybdenum was not done on the 1978 core samples. However, in 1980, concentrations in surface sediments from Alice Arm ranged between 27.1 and 152.0 mg/kg, with an average of 86.0 mg/kg (Table 3). The presence of molybdenum was considered to define tailings distribution (Section 3.1.3).

Natural sediments outside this area were below the detection limit of 18.5 mg/kg. Dobrocky Seatech (1981) reports values of 5 to 32 mg/kg obtained outside the tailings deposition area and from 27 to 387 mg/kg, within the tailings area. Values reported from the Alice Arm drainage basin averaged 7.9 mg/kg (Table 4). Stations which were below the detection limit were generally considered outside the tailings deposits. Near the seaward fringe, eg. Stations EE and A-17, (Appendix 4-B), lead concentrations indicated some tailings present despite low molybdenum levels.

Nickel

Nickel is not a major element in the Kitsault ore but it is worth noting that, where tailings dominated the marine sediment, concentrations were lower than the natural sediment. Within the B.C. Molybdenum deposits nickel concentrations ranged between 13.7 and 40.0 mg/kg. Outside, values ranged between 38.2 and 51.3 mg/kg. This was also apparent in the 1980 surface samples for both nickel and chromium.

3.2 Biota

Increasing the trace metal content of the marine sediment poses a number of potentially harmful effects. Should certain metals leach from the solid phase into the surrounding water in sufficient quantity or be extracted, by the digestive system, following ingestion, lethal or sublethal toxicity could develop. Under certain circumstances metals can, without becoming acutely toxic to the individual, be sequestered or bioaccumulated in specific tissues, where if the organism is consumed, can result in the progressive accumulation through sucessive trophic levels in the food chain. This report considers only the effect of bioaccumulation with emphasis on tissues frequently used for human consumption. It does not address, to any great extent, changes in the total body burden nor effects on the individual organism. These aspects should be examined in the future. As indicated in the earlier sections, Alice Arm is a mineralized area and at least two previous operations have significantly increased the trace metal content (particularly Cu, Pb, Zn, Cd and Fe) of surrounding sediment in relation to the natural background. In Alice Arm

this represents a zone of some 8-10 km and at Anyox includes Granby Bay and approaches. This raises a number of questions in preparation for monitoring any impact that may occur from the new Kitsault mine. What are the natural tissue trace metal concentrations in Alice Arm in view of mineralization in the area? Do these differ significantly from other undisturbed areas and have the previous operations caused an increase in tissue concentrations in any given species? This information also provides a baseline on which to measure any changes resulting from the new Kitsault operation and the potential risk of metal uptake occurring in any particular species.

Table 5 presents a comparison of the mean trace metal concentrations found in tissue samples taken from Alice Arm and Hastings Arm between 1977 and 1980 and four coastal control sites sampled in 1981. The mean and standard deviation for each sampling period and station are given, by species, in Appendices 7 A-D and 8 A-D. Raw data are given in Appendicies 9 A-D and 10 A-D. Figures 16 to 21 present a series of histograms which show the mean trace metal (Cu, Pb, Zn, Cd and As) concentrations found in selected species.

Results are given in dry weight. Wet to dry ratios have been given for those wishing to convert to wet weight which is often used. In Appendices 9 and 10 all values below the laboratory detection limits are given as less than (L). For the purpose of the summary statistics given in Appendices 7 and 8 all less than values were taken to the next lower significant value and treated as a real number, eg. L0.5 mg/kg equals 0.49 mg/kg.

The highest tissue metal concentrations were found in mussels (*Mytilus edulis*) and alga (*Fucus distichus*) taken near Anyox in 1978 (Table 5, Figures 16 and 17). Copper and zinc concentrations in both species were substantially higher at all stations sampled near Anyox than in either Hastings Arm or Alice Arm. The exact source of copper and zinc is presently unknown. As mentioned earlier, the ore at Anyox is susceptible to bacteriological leaching. Contamination could orginate from mine drainage water which flows into Granby Bay, dissolution of metals contained in the slag which extends into the water or uptake

TABLE 5: COMPARISON OF MEAN TRACE METAL CONCENTRATIONS (mg/kg dry weight) IN TISSUES IN ALICE ARM (1977, 1978, 1980) AND CONTROL AREAS (1981)

SURVEY AND STATION		MEAN TRACE METAL CONCENTRATION (mg/kg)													
		WET/DRY RATIO	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
		Fucus distichus - Alga - Whole													
ALICE ARM															
AAW	+1977	*M(c)= .00	4.4	< 1.00	28.0	1.40	0	.00	.0	.00	150.0	.00	0	0
AAW	1978	M(c)= 6.00	8.6	< 4.23	67.1	3.76	16	< 7.14	.0	1.81	2000.0	.00	0	0
LC	1977	M(c)= .00	7.2	1.50	41.0	1.80	0	.00	.0	.00	220.0	.00	0	0
LC	1978	**M(c)= 6.35	5.3	< 4.39	51.1	2.90	26	< 7.32	.0	< .98	348.5	.00	0	0
Outfall B. Oct.	1980	M(2)= 4.57	6.5	2.50	36.2	2.50	30	.30	10.0	2.90	936.5	99.15	8880	560
A-1-N	1977	M(c)= .00	3.6	< 1.00	17.0	1.10	0	.00	.0	.00	120.0	.00	0	0
A-1-N	1978	M(c)= 7.10	5.9	< 4.31	30.6	2.49	19	< 7.19	.0	< .96	513.0	.00	0	0
A-1-S	1978	M(c)= 8.20	3.0	< 4.24	25.5	2.02	12	< 7.06	.0	< .94	205.0	.00	0	0
A-2-N	1977	M(c)= .00	5.3	< 1.00	24.0	2.10	0	.00	.0	.00	95.0	.00	0	0
A-2-N	1978	M(c)= 6.90	2.7	< 4.16	24.1	2.68	20	< 6.93	.0	< .92	115.0	.00	0	0
A-2-S	1977	M(c)= .00	7.4	< 1.00	23.0	1.80	0	.00	.0	.00	37.0	.00	0	0
A-2-S	1978	M(c)= 4.10	5.9	< 4.27	24.3	2.33	24	< 7.12	.0	< .95	183.0	.00	0	0
A-3-N	1977	M(c)= .00	4.6	< 1.00	14.0	1.70	0	.00	.0	.00	42.0	.00	0	0
A-3-N	1978	M(c)= 5.10	4.0	< 4.28	24.3	2.17	27	< 7.14	.0	1.38	889.0	.00	0	0
A-3-S	1977	M(c)= .00	3.8	< 1.00	13.0	1.20	0	.00	.0	.00	13.0	.00	0	0
A-3-S	1978	M(c)= 4.50	4.6	< 4.25	27.9	3.00	21	< 7.08	.0	< .97	682.0	.00	0	0

+ All zeros indicate no analysis.

++ Roman numerals indicate station trawl number.

* M(c)= mean of composite samples refer to Appendix 6A.

** M(n) n = number of individuals sampled.

< Indicates EPS laboratory detection limits.

Continued ...

TABLE 5: COMPARISON OF MEAN TRACE METAL CONCENTRATIONS (mg/kg dry weight) IN TISSUES IN ALICE ARM (1977, 1978, 1980) AND CONTROL AREAS (1981)

SURVEY AND STATION		MEAN TRACE METAL CONCENTRATION (mg/kg)												
		WET/DRY RATIO	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
		Fucus distichus - Alga - Whole (continued)												
HASTINGS ARM														
H-2-E	1977	M(c)= .00	10.0	< 1.00	31.0	2.10	0	.00	.0	.00	79.0	.00	0	0
H-2-W	1977	M(c)= .00	5.4	1.40	13.0	1.20	0	.00	.0	.00	57.0	.00	0	0
H-3-E	1978	M(c)= 6.10	6.3	< 4.11	28.8	4.20	24	< 6.84	.0	.94	290.0	.00	0	0
ANYOX														
H-4-N	1977	M(c)= .00	58.0	< 1.00	56.0	.57	0	.00	.0	.00	770.0	.00	0	0
H-4-N	1978	M(c)= 4.80	127.0	< 4.19	103.0	1.49	26	< 6.98	.0	1.26	594.0	.00	0	0
B	1978	M(c)= 5.50	66.9	4.33	131.0	2.50	18	< 7.22	.0	1.20	746.0	.00	0	0
GP	1978	M(c)= 5.70	70.1	< 4.22	80.8	1.29	19	< 7.03	.0	< .94	290.0	.00	0	0
L	1978	M(c)= 4.90	10.8	< 4.47	47.2	1.89	17	< 7.45	.0	< .99	379.0	.00	0	0
JP	1978	M(c)= 4.90	61.2	< 4.35	160.0	2.76	21	< 7.25	.0	< .97	641.0	.00	0	0
		Mytilus edulis - Bivalve - Whole Body												
ALICE ARM														
AAW	1977	M(c)= .00	8.9	2.60	110.0	4.80	0	.00	.0	.00	380.0	.00	0	0
AAW	1978	M(c)= 6.20	12.8	< 4.30	59.3	3.50	< 7	< 7.20	.0	1.91	1000.0	.00	0	0
LC	1977	M(c)= .00	11.0	5.00	130.0	6.60	0	.00	.0	.00	450.0	.00	0	0
LC	1978	M(c)= 6.30	12.9	7.81	107.0	5.86	9	< 7.30	.0	1.95	1100.0	.00	0	0

Continued ...

TABLE 5: COMPARISON OF MEAN TRACE METAL CONCENTRATIONS (mg/kg dry weight) IN TISSUES IN ALICE ARM (1977, 1978, 1980) AND CONTROL AREAS (1981)

SURVEY AND STATION		MEAN TRACE METAL CONCENTRATION (mg/kg)												
		WET/DRY RATIO	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
		Mytilus edulis - Bivalve - Whole Body (Continued)												
ALICE ARM														
LC (Purged)	1978	M(c)= 8.10	22.5	4.84	102.0	6.82	10	< 7.20	.0	1.74	662.0	.00	0	0
A-1-N	1977	M(c)= .00	9.6	2.10	100.0	6.50	0	.00	.0	.00	810.0	.00	0	0
A-1-N	1978	M(c)= 7.90	14.9	<4.30	101.0	7.40	9	< 7.20	.0	2.94	2220.0	.00	0	0
A-1-S	1978	M(c)= 7.70	18.3	5.60	107.0	5.90	12	< 7.30	.0	2.23	1010.0	.00	0	0
A-2-N	1977	M(c)= .00	13.0	2.10	110.0	6.90	0	.00	.0	.00	260.0	.00	0	0
A-2-N	1978	M(c)= 7.30	25.5	<4.35	93.0	6.82	10	< 7.25	.0	3.05	1400.0	.00	0	0
A-2-S	1977	M(c)= .00	10.0	1.10	99.0	6.00	0	.00	.0	.00	150.0	.00	0	0
A-2-S	1978	M(c)= 9.20	14.9	<4.30	101.0	7.42	9	< 7.20	.0	2.94	2200.0	.00	0	0
A-3-N	1978	M(c)= 6.60	11.6	<4.30	82.7	3.50	8	< 7.15	.0	1.61	789.5	.00	0	0
A-3-S	1978	M(c)= 6.20	12.0	<4.30	34.0	3.44	7	< 7.20	.0	1.76	726.0	.00	0	0
HASTINGS ARM														
H-2-E	1977	M(c)= .00	9.6	<1.00	87.0	4.50	0	.00	.0	.00	260.0	.00	0	0
H-2-W	1977	M(c)= .00	10.0	<1.00	89.0	5.80	0	.00	.0	.00	440.0	.00	0	0
H-3-E	1978	M(c)= 7.50	14.9	<4.35	80.7	4.34	8	< 7.30	.0	1.31	837.0	.00	0	0
ANYOX														
H-4-N	1977	M(c)= .00	27.0	<1.00	230.0	3.30	0	.00	.0	.00	430.0	.00	0	0
H-4-N	1978	M(c)= 8.50	243.0	7.20	462.0	8.36	11	< 7.20	.0	2.98	5910.0	.00	0	0
B	1978	M(c)= 8.40	53.3	<4.20	233.0	7.88	11	< 6.90	.0	2.73	1120.0	.00	0	0
GP	1978	M(c)= 7.30	120.0	<4.30	202.0	5.60	8	< 7.20	.0	1.21	699.0	.00	0	0
JP	1978	M(c)= 7.70	128.0	<4.20	264.0	7.46	8	< 7.00	.0	2.98	5910.0	.00	0	0
L	1978	M(c)= 6.80	23.9	<4.40	111.0	3.77	9	< 7.30	.0	2.33	1060.0	.00	0	0

Continued ...

TABLE 5: COMPARISON OF MEAN TRACE METAL CONCENTRATIONS (mg/kg dry weight) IN TISSUES IN ALICE ARM (1977, 1978, 1980) AND CONTROL AREAS (1981)

SURVEY AND STATION		MEAN TRACE METAL CONCENTRATION (mg/kg)												
		WET/DRY RATIO	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
		Crangon communis - Shrimp - Tail Only												
ALICE ARM														
A-1-I	Oct. 1978	M(c)= 4.86	70.0	< 4.40	51.3	.99	43	< 7.40	.0	1.82	124.0	.00	0	0
A-3-I	Oct. 1978	M(c)= 4.51	44.7	< 4.33	67.1	.79	41	< 7.20	.0	1.72	167.8	.00	0	0
CHATHAM SOUND														
C-1-I	Oct. 1981	M(10)= 4.09	59.1	.17	52.5	.63	44	3.49	3.9	.79	276.2	27.44	4332	149
LAREDO SOUND														
L-1-I	Oct. 1981	M(4)= 3.70	63.1	.10	70.1	4.03	32	< 1.45	< 6.4	.80	155.8	9.27	3728	84
		Crangon communis - Shrimp - Whole Body												
ALICE ARM														
A-3-I	Oct. 1978	M(c)= 4.08	55.9	< 4.40	72.4	1.05	31	< 7.33	.0	<.68	219.7	.00	0	0
CHATHAM SOUND														
C-1-I	May 1981	M(15)= 4.55	62.9	2.96	66.2	.55	31	.24	6.2	.89	381.3	6.88	3889	195
		Pandalopsis dispar - Sidestripe Shrimp - Muscle												
ALICE ARM														
A-1-I	Oct. 1978	M(c)= 4.79	29.2	< 4.23	48.6	1.03	55	< 7.07	.0	2.55	57.7	.00	0	0
A-1-I	Oct. 1980	M(15)= 4.44	16.3	.63	59.6	.29	49	.26	1.2	.70	120.8	8.59	1690	49
A-2-I	Oct. 1978	M(c)= 4.74	42.9	< 4.30	52.2	1.63	67	< 7.20	.0	1.22	46.7	.00	0	0
A-3-I	Oct. 1978	M(c)= 4.97	31.7	< 4.35	50.1	<.72	98	< 7.25	.0	1.46	36.2	.00	0	0
A-3-I	May 1980	M(1)= 4.16	48.1	.56	56.4	.39	98	< 7.17	.0	<.72	204.0	.00	0	0
A-3-I	Oct. 1980	M(15)= 4.37	15.4	.12	61.8	.13	80	< .22	1.1	.59	26.7	1.90	2015	14

Continued ...

TABLE 5: COMPARISON OF MEAN TRACE METAL CONCENTRATIONS (mg/kg dry weight) IN TISSUES IN ALICE ARM (1977, 1978, 1980) AND CONTROL AREAS (1981)

SURVEY AND STATION		MEAN TRACE METAL CONCENTRATION (mg/kg)												
	WET/DRY RATIO	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
	Mya arenaria - Bivalve - Whole Body												
ALICE ARM													
Perry Pen. Oct. 1980	M(12)= 8.17	21.5	1.46	108.6	1.01	7	0.71	11.8	1.71	795.7	26.59	4497	377
	Yoldia thraciaeformis/montereyensis - Bivalve - Whole Body												
ALICE ARM													
++ A-1-I Oct. 1978	M(c)= 6.38	292.0	60.00	682.0	13.40	57	< 7.30	.0	9.24	1200.0	.00	0	0
A-2-I Oct. 1978	M(c)= 8.23	435.0	9.14	681.0	17.70	47	< 6.86	.0	10.20	8590.0	.00	0	0
HASTINGS ARM													
H-2-1 Oct. 1978	M(c)= 7.88	328.0	< 4.40	788.0	19.30	47	< 7.30	.0	3.82	4690.0	.00	0	0
LAREDO SOUND													
L-1-I 1981	M(9)= 5.79	54.7	8.83	613.4	1.77	107	2.31	6.4	2.41	2026.7	17.04	4680	1068
QUATSINO SOUND													
Q-1-I 1981	M(1)= 4.96	23.2	.64	169.0	1.22	26	1.73	4.1	2.83	2570.0	23.20	3770	1220
	Lithodes aequispina - Brown King Crab - Muscle - Leg												
ALICE ARM													
A-1-I Oct. 1978	M(2)= 5.93	32.9	< 4.25	186.5	< .72	96	< 7.15	.0	1.11	10.3	.00	0	0
A-1-I May 1980	M(1)= 5.61	4.0	.12	17.9	< .05	49	< 7.02	.0	< .70	30.3	.00	0	0
A-1-I Oct. 1980	M(1)= 4.31	91.8	.05	215.0	.80	164	< .20	2.0	1.30	24.2	9.66	3940	12
A-2-I Oct. 1978	M(3)= 5.79	61.4	< 4.27	187.0	< .72	111	< 7.17	.0	1.26	12.4	.00	0	0
HASTINGS ARM													
H-2-1 Oct. 1978	M(1)= 6.93	85.3	4.24	189.0	< .71	104	< 7.10	.0	< .94	12.7	.00	0	0

Continued ...

TABLE 5: COMPARISON OF MEAN TRACE METAL CONCENTRATIONS (mg/kg dry weight) IN TISSUES IN ALICE ARM (1977, 1978, 1980) AND CONTROL AREAS (1981)

SURVEY AND STATION			MEAN TRACE METAL CONCENTRATION (mg/kg)											
		WET/DRY RATIO	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
		Pandalopsis dispar - Sidestripe Shrimp - Muscle (continued)												
HASTINGS ARM														
H-1-I	Oct. 1978	M(c)= 5.08	36.4	< 4.40	49.4	1.58	38	< 7.30	.0	1.78	44.9	.00	0	0
H-2-I	Oct. 1978	M(c)= 4.87	34.7	< 4.33	54.8	1.34	28	< 7.27	.0	1.19	91.5	.00	0	0
H-3-I	Oct. 1978	M(c)= 4.89	33.1	< 4.40	47.4	< .72	44	< 7.30	.0	< .96	29.0	.00	0	0
H-4-I	Oct. 1978	M(c)= 5.04	30.9	< 4.35	48.3	< .72	9	< 7.20	.0	.96	138.4	.00	0	0
CHATHAM SOUND														
C-1-I	Oct. 1981	M(15)= 4.53	16.9	< .05	46.0	.06	69	< 1.49	< 4.0	.84	22.2	.66	1801	12
LAREDO SOUND														
L-1-I	Oct. 1981	M(15)= 4.58	21.6	< .05	44.4	.09	43	< 1.46	< 3.9	< .73	16.0	.47	1849	11
QUATSINO SOUND														
Q-1-I	Sept. 1981	M(15)= 4.32	23.1	.06	47.8	.06	40	< 1.47	< 3.9	.78	19.4	.64	1644	12
		Pandalopsis dispar - Sidestripe Shrimp - Whole Body												
HASTINGS ARM														
H-1-I	Oct. 1978	M(c)= 4.63	96.4	< 4.20	657.5	34.40	23	< 7.00	.0	1.22	264.0	.00	0	0
H-2-I	Oct. 1978	M(c)= 4.44	95.0	< 4.35	81.0	3.58	25	< 7.20	.0	1.53	676.5	.00	0	0
LAREDO SOUND														
L-1-I	Oct. 1981	M(15)= 3.71	85.4	.09	53.7	2.20	29	< 1.48	4.3	1.05	140.4	4.10	3823	133

Continued...

TABLE 5: COMPARISON OF MEAN TRACE METAL CONCENTRATIONS (mg/kg dry weight) IN TISSUES IN ALICE ARM (1977, 1978, 1980) AND CONTROL AREAS (1981)

SURVEY AND STATION			MEAN TRACE METAL CONCENTRATION (mg/kg)												
		WET/DRY RATIO	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
		Pandalus borealis - Pink Shrimp - Muscle												
ALICE ARM														
A-1-I	Oct. 1978	M(c)= 4.82	33.6	< 4.33	50.3	< .73	57	< 7.23	.0	1.19	48.0	.00	0	0
A-1-I	Oct. 1980	M(30)= 4.32	15.5	.17	56.7	.18	70	< .21	1.4	.57	35.6	6.03	1650	15
A-2-I	Oct. 1978	M(c)= 4.84	49.6	< 4.30	57.3	.87	52	< 7.20	.0	.96	19.2	.00	0	0
A-3-I	Oct. 1978	M(c)= 4.63	21.0	< 4.20	47.1	< .69	96	< 6.90	.0	1.73	17.0	.00	0	0
A-3-I	Oct. 1980	M(15)= 4.40	13.0	.09	59.3	.17	99	.21	1.0	.66	22.3	5.91	1866	10
HASTINGS ARM														
H-2-I	Oct. 1978	M(c)= 5.00	34.2	< 4.50	49.8	<7.46	43	< 7.50	.0	< .99	46.8	.00	0	0
H-3-I	Oct. 1978	M(c)= 4.61	44.0	< 4.25	48.2	<7.13	48	< 7.10	.0	2.12	40.2	.00	0	0
H-4-I	Oct. 1978	M(c)= 5.01	49.8	< 4.25	57.2	< .71	20	< 7.15	.0	1.00	194.4	.00	0	0
H-4-I	May 1980	M(1)= 4.21	42.9	.59	54.2	.12	21	< 7.32	.0	< .73	70.5	.00	0	0
CHATHAM SOUND														
C-1-I	May 1981	M(8)= 4.43	27.4	.29	57.1	.29	75	.22	1.2	.91	200.3	3.32	2127	88
C-1-I	Oct. 1981	M(15)= 4.27	21.5	.09	52.6	.11	60	< 1.48	< 3.9	1.01	18.3	.98	1647	8
LAREDO SOUND														
L-1-I	Oct. 1981	M(15)= 4.27	21.2	.09	53.2	.10	38	< 1.46	5.5	1.90	31.9	1.09	1730	7
QUATSINO SOUND														
Q-1-I	Sept. 1981	M(15)= 4.21	20.7	.13	52.1	.07	65	1.47	3.9	.77	20.8	.88	1813	12

Continued ...

TABLE 5: COMPARISON OF MEAN TRACE METAL CONCENTRATIONS (mg/kg dry weight) IN TISSUES IN ALICE ARM (1977, 1978, 1980) AND CONTROL AREAS (1981)

SURVEY AND STATION		MEAN TRACE METAL CONCENTRATION (mg/kg)												
		WET/DRY RATIO	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
		Pandalus borealis - Pink Shrimp - Whole Body												
ALICE ARM														
A-1-I	Oct. 1978	M(c)= 4.89	102.7	5.03	60.8	2.81	24	< 7.30	.0	1.86	980.7	.00	0	0
A-2-I	Oct. 1978	M(c)= 4.98	108.0	< 4.30	82.4	3.95	28	< 7.20	.0	1.45	564.0	.00	0	0
HASTINGS ARM														
H-2-I	Oct. 1978	M(c)= 4.95	117.0	< 4.30	69.1	3.18	29	< 7.10	.0	2.02	670.0	.00	0	0
H-4-I	Oct. 1978	M(c)= 5.24	110.0	< 4.30	64.3	1.43	16	< 7.20	.0	1.38	901.0	.00	0	0
LAREDO SOUND														
L-1-I	Oct. 1981	M(15)= 3.60	95.1	.19	66.1	1.85	26	< 1.48	< 3.9	.92	99.7	3.60	2693	72
		Pandalus hypsinotus - Humpback Shrimp - Muscle												
ALICE ARM														
A-3-I	Oct. 1978	M(c)= 4.88	29.1	< 4.50	56.2	< .75	108	< 7.50	.0	1.59	14.3	.00	0	0
CHATHAM SOUND														
C-1-I	May 1981	M(3)= 4.59	112.3	.11	67.2	.17	50	< .30	2.0	.77	113.2	2.04	2390	46
		Pandalus hypsinotus - Humpback Shrimp - Whole Body												
ALICE ARM														
A-3-I	Oct. 1978	M(c)= 3.12	46.3	< 4.40	99.8	< .73	39	< 7.30	.0	< .97	88.2	.00	0	0

Continued ...

TABLE 5: COMPARISON OF MEAN TRACE METAL CONCENTRATIONS (mg/kg dry weight) IN TISSUES IN ALICE ARM (1977, 1978, 1980) AND CONTROL AREAS (1981)

SURVEY AND STATION			MEAN TRACE METAL CONCENTRATION (mg/kg)												
			WET/DRY RATIO	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
			Atheresthes stomias - Arrowtooth Flounder - Muscle												
ALICE ARM															
A-1-I	May	1980	M(2)= 5.04	4.5	.33	21.3	< .05	18	<7.17	.0	< .72	26.8	.00	0	0
CHATHAM SOUND															
C-1-I	May	1981	M(3)= 5.40	5.7	.70	21.1	< .05	25	.37	1.7	1.17	37.9	.75	1493	16
C-1-I	Oct.	1981	M(2)= 5.32	5.7	<.05	19.2	< .05	11	< 1.42	6.1	3.57	67.8	1.35	1645	21
LAREDO SOUND															
L-1-I	Oct.	1981	M(1)= 5.24	6.2	<.05	17.3	< .05	11	< 1.47	< 3.9	.80	31.7	.40	1620	21
QUATSINO SOUND															
Q-1-I	Sept.	1981	M(1)= 5.01	3.3	<.05	17.6	< .05	<7	< 1.41	< 3.81	.81	33.4	.14	1490	9
			Eopsetta jordani - Petrale Sole - Muscle												
LAREDO SOUND															
L-1-I	Oct.	1981	M(1)= 5.08	6.0	< .05	20.8	< .05	< 7	< 1.48	< 3.9	1.45	38.7	.51	1600	15
QUATSINO SOUND															
Q-1-I	Sept.	1981	M(3)= 5.18	3.8	< .05	16.5	< .05	76	< 1.47	< 3.9	1.15	29.4	.41	1417	9

Continued ...

TABLE 5: COMPARISON OF MEAN TRACE METAL CONCENTRATIONS (mg/kg dry weight) IN TISSUES IN ALICE ARM (1977, 1978, 1980) AND CONTROL AREAS (1981)

SURVEY AND STATION			MEAN TRACE METAL CONCENTRATION (mg/kg)												
			WET/DRY RATIO	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
			Atheresthes stomias - Arrowtooth Flounder - Muscle												
ALICE ARM															
A-1-I	May	1980	M(2)= 5.04	4.5	.33	21.3	< .05	18	< 7.17	.0	< .72	26.8	.00	0	0
CHATHAM SOUND															
C-1-I	May	1981	M(3)= 5.40	5.7	.70	21.1	< .05	25	.37	1.7	1.17	37.9	.75	1493	16
C-1-I	Oct.	1981	M(2)= 5.32	5.7	<.05	19.2	< .05	11	< 1.42	6.1	3.57	67.8	1.35	1645	21
LAREDO SOUND															
L-1-I	Oct.	1981	M(1)= 5.24	6.2	<.05	17.3	< .05	11	< 1.47	< 3.9	.80	31.7	.40	1620	21
QUATSINO SOUND															
Q-1-I	Sept.	1981	M(1)= 5.01	3.3	<.05	17.6	< .05	< 7	< 1.41	< 3.81	.81	33.4	.14	1490	9
			Eopsetta jordani - Petrale Sole - Muscle												
LAREDO SOUND															
L-1-I	Oct.	1981	M(1)= 5.08	6.0	<.05	20.8	< .05	< 7	< 1.48	< 3.9	1.45	38.7	.51	1600	15
QUATSINO SOUND															
Q-1-I	Sept.	1981	M(3)= 5.18	3.8	<.05	16.5	< .05	76	< 1.47	< 3.9	1.15	29.4	.41	1417	9

Continued ...

TABLE 5: COMPARISON OF MEAN TRACE METAL CONCENTRATIONS (mg/kg dry weight) IN TISSUES IN ALICE ARM (1977, 1978, 1980) AND CONTROL AREAS (1981)

SURVEY AND STATION			MEAN TRACE METAL CONCENTRATION (mg/kg)												
			WET/DRY RATIO	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
			Glypocephalus zachirus - Rex Sole - Muscle												
CHATHAM SOUND															
C-1-I	May	1981	M(7)= 5.32	6.7	.33	17.2	.17	59	< .20	2.3	.97	52.7	1.15	1339	26
QUATSINO SOUND															
Q-1-I	Sept.	1981	M(1)= 5.84	2.9	< .05	22.5	<.05	128	< 1.49	< 4.0	.79	98.8	2.01	1460	46
			Hippoglossoides elassodon - Flathead Sole - Muscle												
ALICE ARM															
A-1-I	Oct.	1978	M(1)= 4.74	4.2	< 4.40	23.6	<.73	19	< 7.30	.0	<.98	20.7	.00	0	0
A-1-I	May	1980	M(5)= 5.94	5.6	.41	19.8	.05	52	< 7.20	.0	<.72	12.3	.00	0	0
CHATHAM SOUND															
C-1-I	May	1981	M(7)= 5.55	5.0	.52	18.6	.22	29	.23	3.9	2.00	59.3	1.00	1283	30
			Microstomus pacificus - Dover Sole - Muscle												
ALICE ARM															
A-1-I	Oct.	1980	M(1)= 3.61	3.4	.18	15.4	< .05	126	< .20	< 1.0	.50	10.8	1.81	742	6
QUATSINO SOUND															
Q-1-I	Sept.	1981	M(1)= 5.41	10.4	< .05	20.4	< .05	195	<1.45	< 3.9	1.36	38.3	.58	1760	17

Continued ...

TABLE 5: COMPARISON OF MEAN TRACE METAL CONCENTRATIONS (mg/kg dry weight) IN TISSUES IN ALICE ARM (1977, 1978, 1980) AND CONTROL AREAS (1981)

SURVEY AND STATION			MEAN TRACE METAL CONCENTRATION (mg/kg)												
			WET/DRY RATIO	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
			Theragra chalcogramma - Walleye Pollock - Muscle												
ALICE ARM															
A-1-I	Oct.	1978	M(3)= 5.23	10.4	< 4.37	26.5	< .73	17	< 7.30	.0	1.07	75.8	.00	0	0
A-1-I	May	1980	M(2)= 5.06	6.1	.23	22.8	.14	20	< 7.23	.0	< .72	29.0	.00	0	0
A-2-I	Oct.	1978	M(2)= 5.18	6.0	< 4.10	25.3	< .68	21	< 6.90	.0	1.05	31.8	.00	0	0
A-3-I	Oct.	1978	M(3)= 4.87	6.5	< 4.30	38.7	< .72	15	< 7.20	.0	1.69	40.1	.00	0	0
HASTINGS SOUND															
H-3-I	Oct.	1978	M(2)= 5.21	6.6	< 4.25	24.4	< .70	31	< 7.05	.0	1.38	107.0	.00	0	0
H-4-I	Oct.	1978	M(1)= 5.08	17.3	< 4.30	59.3	< .72	< 7	< 7.20	.0	1.74	118.0	.00	0	0
CHATHAM SOUND															
C-1-I	May	1981	M(2)= 5.62	9.8	1.52	31.9	6.04	23	< .20	1.0	2.85	99.3	1.50	1540	3

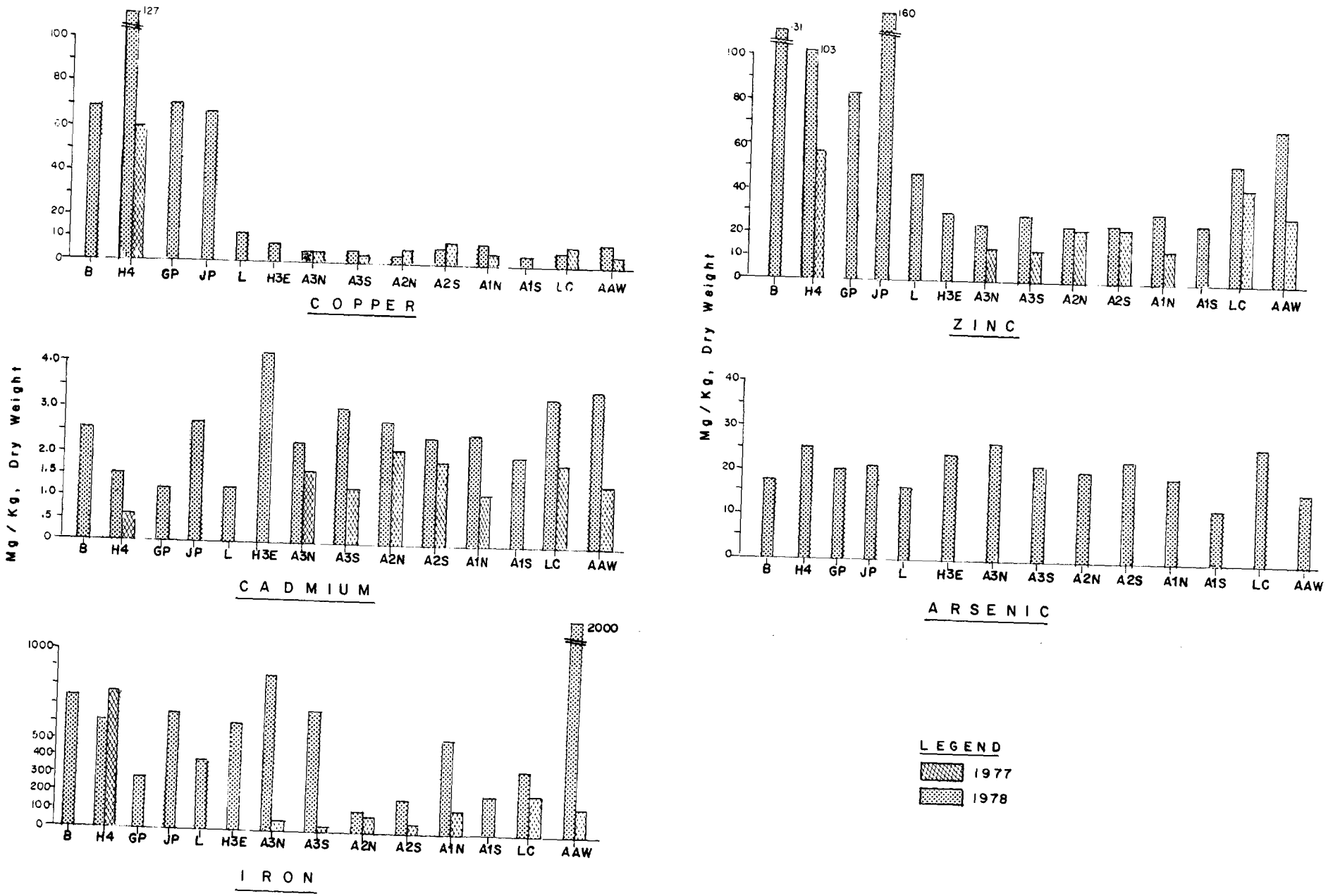

FIGURE 16 TISSUE TRACE METAL CONCENTRATIONS - *Fucus distichus* (Alga) in Mg/Kg, Dry Weight.

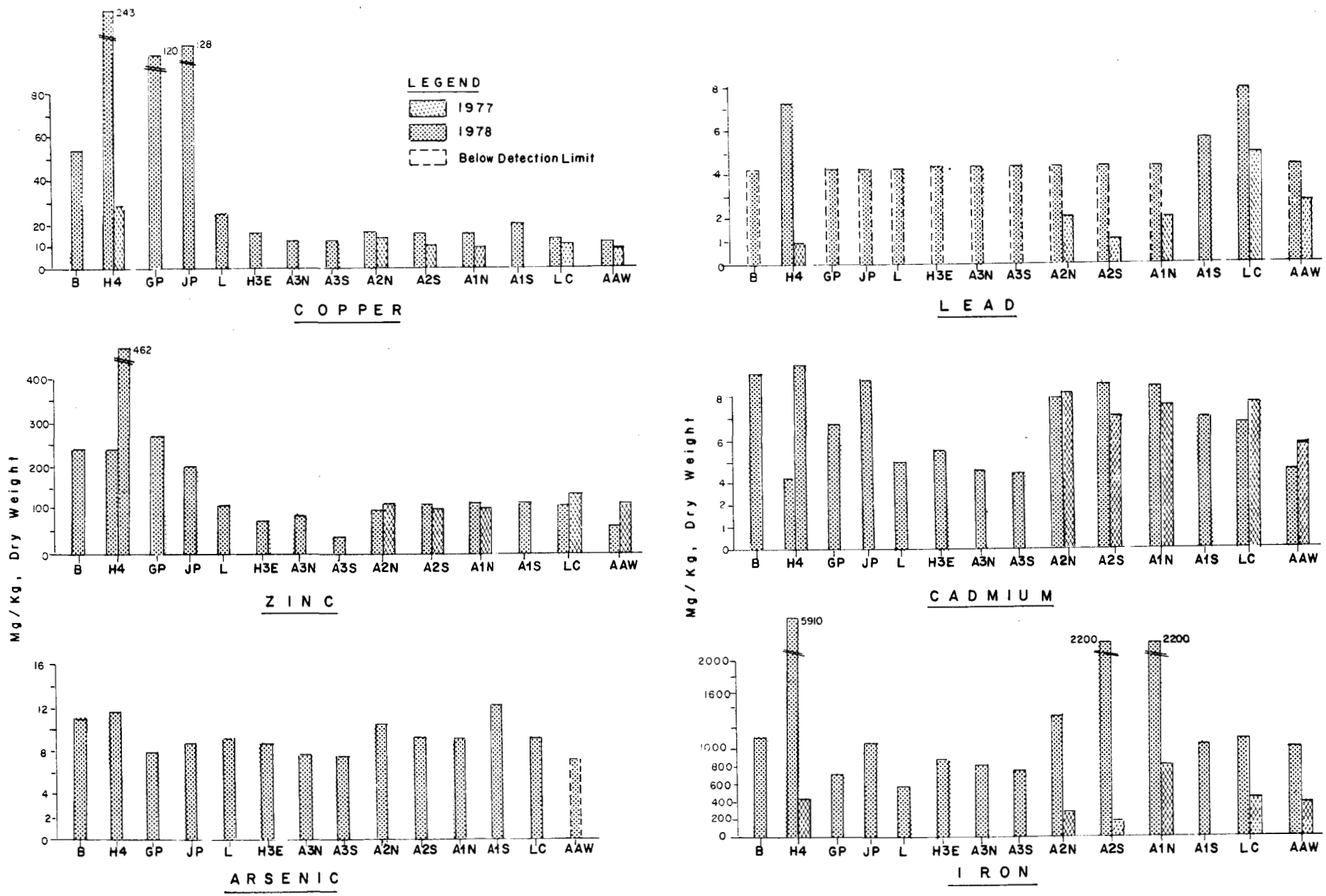

FIGURE 17 TISSUE TRACE METAL CONCENTRATIONS - Mytilus edulis (Mussels) in Mg/Kg, Dry Weight.

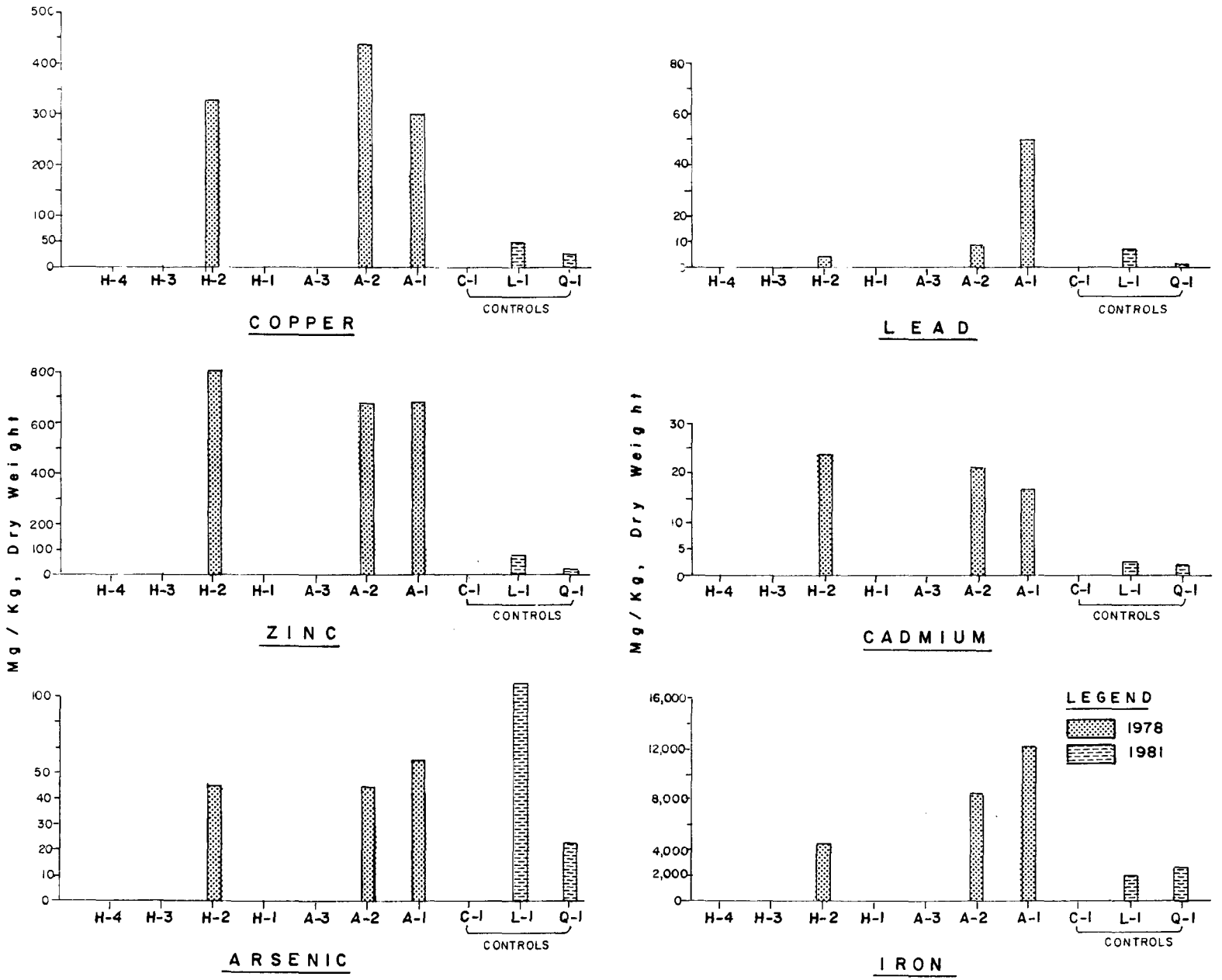

FIGURE 18 TISSUE TRACE METAL CONCENTRATIONS - *Yoldia thraciaeformis/montereyensis* (Bivalve in Mg /Kg, Dry Weight

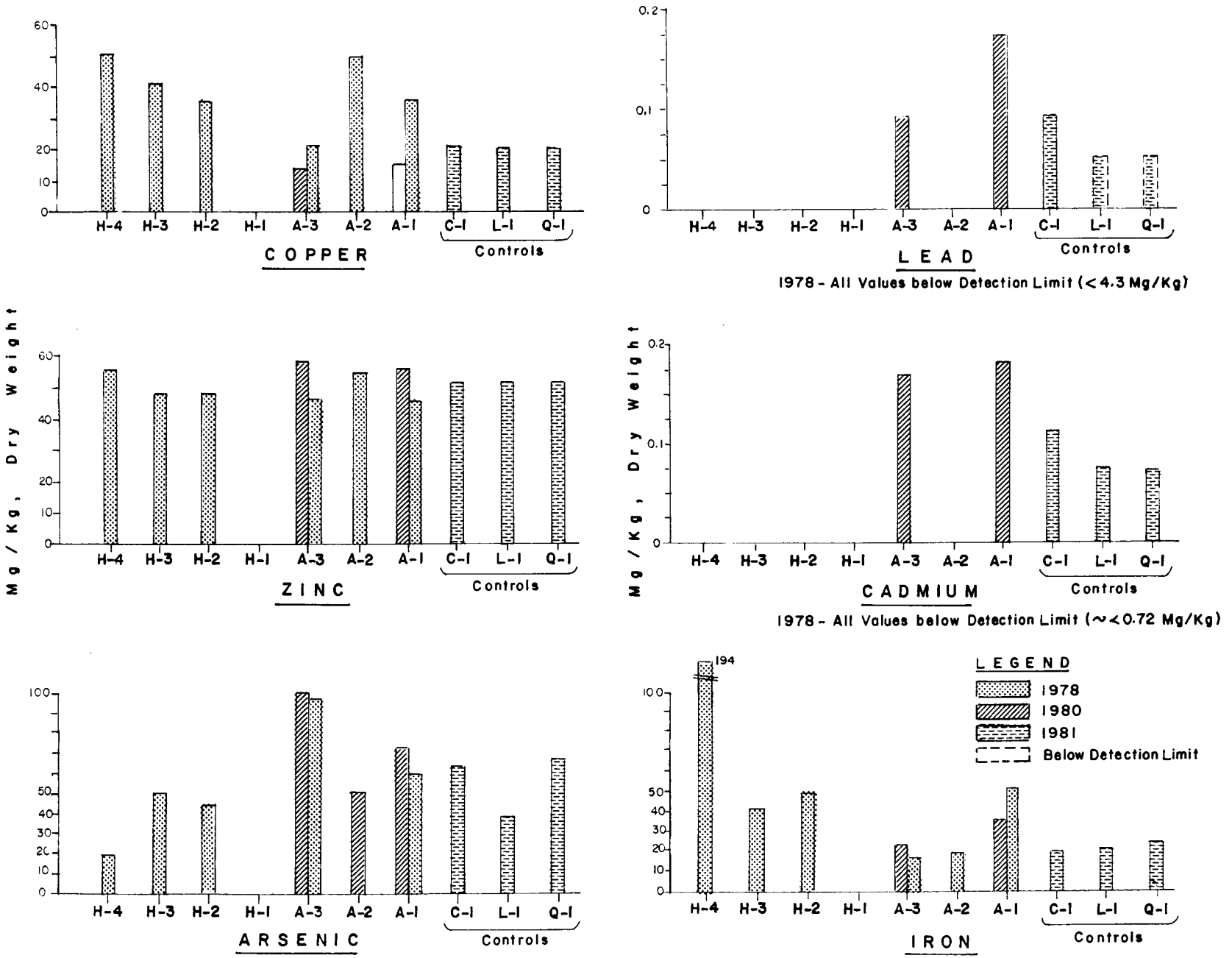

FIGURE 19 TISSUE TRACE METAL CONCENTRATIONS - Pandalus borealis (Pink Shrimp) in Mg/Kg, Dry Weight.

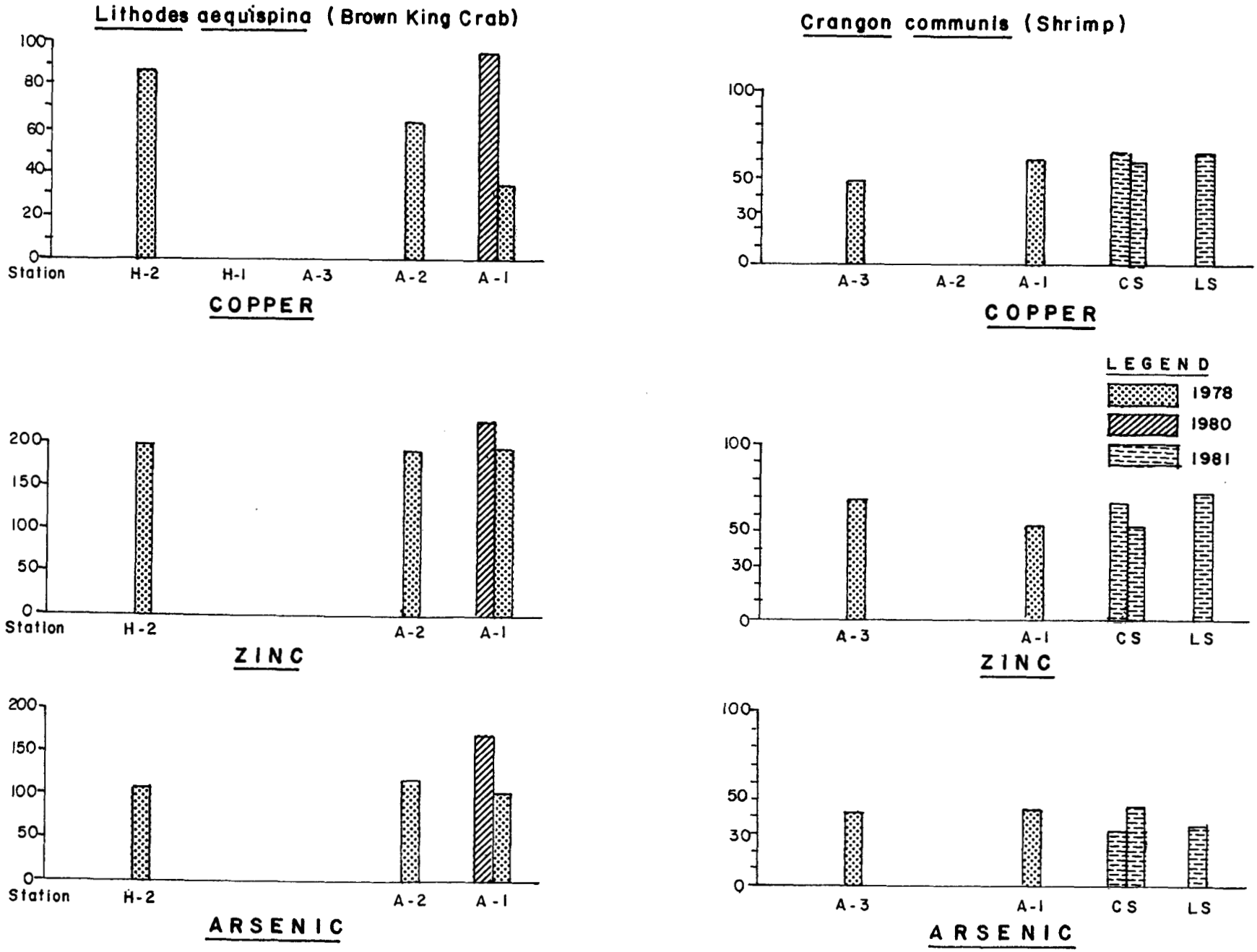

FIGURE 20 TISSUE TRACE METAL CONCENTRATIONS in Mg/Kg, Dry Weight

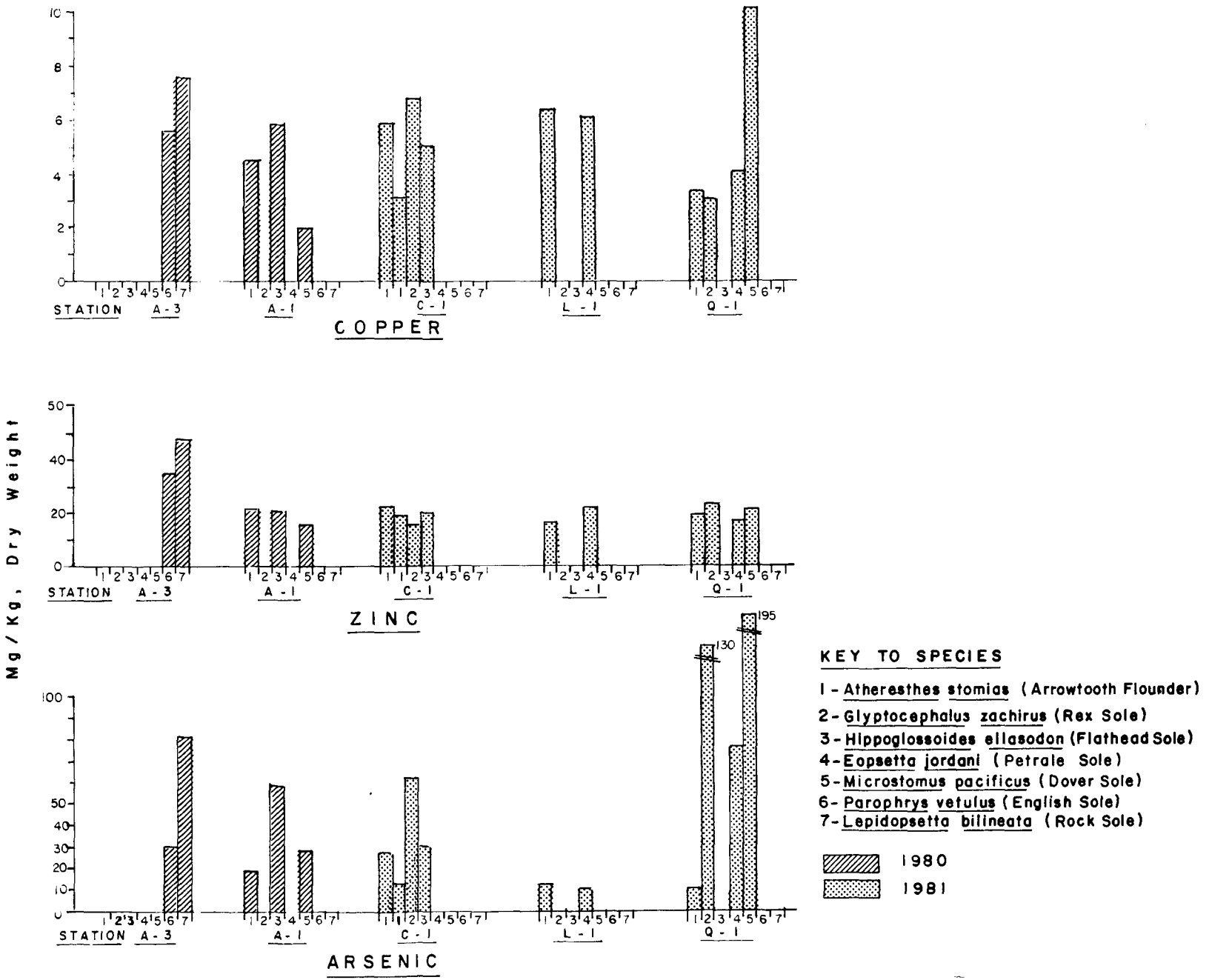

FIGURE 21 TISSUE TRACE METAL CONCENTRATIONS - SOLE (Mixed Species) in Mg / Kg, Dry Weight.

through ingestion of slag particles in the case of mussels. Elevated concentrations were found in Mytilus edulis from Station L-78 which is some distance from the slag pile. Seemingly the distance would be too far for the cause to be ingestion of slag particles although some have been observed floating around the edge of the pile during an incoming tide. Mussels from Alice Arm showed slightly higher lead, cadmium and iron levels in certain localized areas. The levels are not considered significant to represent a trend but should continue to be monitored during the Kitsault operation.

In the 1978 samples, lead and copper concentrations in Yoldia traciaeformis/montereyensis from Alice Arm (Trawl A-1) were higher than Hastings Arm (Table 5). With the exception of arsenic levels in Laredo Sound, all concentrations from both Alice Arm and Hastings Arm were well above those obtained from the control sites. The sample size from the Alice Arm area however, is too small for any definite conclusion. Any trends in this area will be apparent as more data is collected through monitoring programs currently underway. Analysis of shrimp muscle tissue in 1978 showed slightly higher copper levels off Anyox and Trawl A-2 (middle of Alice Arm) than Hastings Arm for the same period. Similarly in 1980, lead concentrations in samples from Alice Arm were slightly higher than outside (Trawl A-3). Trawl A-3 is at the entrance to Alice Arm and outside the tailings deposits from B.C. Molybdenum. These differences are slight and not considered sufficient to indicate any significant trend until additional monitoring data is available during the Kitsault operation. Zinc concentrations in tissue were similar both inside and outside Alice Arm, including Anyox, where sediment contains very high concentrations (over 1700 mg/kg). In shrimp muscle tissue, arsenic, which is not a major element in the B.C. Molybdenum ore, was higher outside Alice Arm (Trawl A-3) both in 1978 and 1980. The Brown king crab, Crangon shrimp and mixed species of sole showed no apparent differences between trawl sites. Sample size is limited and in the case of sole, it was difficult to obtain species common to all stations. It is apparent from the data on sole that differences can occur, naturally, between species (Figure 21).

3.2.1 Baseline Concentrations of the Major Trace Metal

This section compares results obtained during this study with other sources of information to establish "normal" baseline ranges for tissue trace metal concentrations in marine organisms sampled in Alice Arm. Firm baseline levels are important before any trends due to the Kitsault operation can be monitored effectively particularly, since Alice Arm has been subject to previous mining activity.

Table 6 presents a comparison of tissue data collected during this study and additional sources, on Alice Arm and other locations. All tissue data collected outside the Alice Arm sill (ie. Stations A-3, H-1 to H-3) have been included under Hastings Arm. Those collected inside (ie. A-1 and A-2), from the tailings deposits, have been grouped together under Alice Arm. Anyox samples have been treated separately. Data listed under Quatsino Sound (1978-79) have been taken from sample sites located beyond any direct effect from the Island Copper mine which discharges into the adjoining Rupert Inlet. It has been assumed that data collected in Alice Arm in 1980 represents pre-discharge baseline levels, although tests on water samples from Lime Creek in 1980 did show relatively high particulate metal concentrations compared to other freshwater sources (Part II, Hinder and Goyette, 1982). This may be due to run off from construction activity at the Kitsault mine which was underway during the survey.

Bivalves

Bivalves are relatively fixed in their location and being particulate feeders, can serve as useful indicators of metal uptake. Species selected for tissue analysis were mainly *Yoldia tranciaeformis/-montereyensis*, a subtidal form and *Mytilus edulis*, which occurs intertidally.

Analytical results can be biased by sediment particles and zooplankton in the gut and shell cavity, particularly in *Yoldia sp*. which lives in close contact with the sediment. This bias can be reduced by washing the tissue samples before analysis as was done in 1978 or preferably purging for 24 hours in clean seawater which was done with the 1980-81 samples. Caution however, should still be exercised when

TABLE 6: COMPARISON OF THE TISSUE TRACE METAL CONTENT FOUND IN BIOTA FROM ALICE ARM - 1977-1980, TO OTHER DATA SOURCES, AND LOCATIONS, IN mg/kg, dry weight

LOCATION	YEAR	Cu	Pb	Zn	Cd	As	Hg	Fe	Source
				Shrimp - Pandalus borealis - Pink Muscle Tissue					
Alice Arm	1978	38 (31-50)	L4.3	52 (48-57)	0.8 (L0.7-0.87)	55 (34-103)	0.13 (0.094-0.14)	40 (19-64)	
Alice Arm	1980	15 (11-23)	0.17 (L0.05-1.00)	57 (47-71)	0.18 (L0.05-0.50)	70 (40-124)	--		
* Hastings Arm	1978	40 (21-51)	L4.3	51 (47-51)	L0.69	48 (10-96)	0.12 (0.096-0.16)	89 (37-338)	
* Hastings Arm	1980	13 (9-19)	0.09 (L0.05-0.34)	59 (54-67)	0.17 (L0.05-0.30)	99 (59-191)	--		
Anyox	1978	50 (49-51)	L4.3	47	L0.71	20 (18-21)	0.10 (0.096-0.099)	194 (51-338)	
Anyox	1980	43	0.586	54	0.115	21	L0.179	70	
Alice Arm	1976	43 (42-45)	3.4 (2.6-4.3)	48 (47-50)	1.1 (1.06-1.11)	--	L0.11	--	2
* Hastings Arm	1976	41	4.3	58	0.9	--	L0.11	--	2
* Quatsino Sd.	1978	33 (31-39)	L4.3	55 (49-61)	L0.72	22 (15-34)	0.15 (0.137-0.176)	27 (15-52)	7
	1979	42 (31-57)	0.09 (L0.046-0.218)	61 (44-74)	0.12 (0.047-0.232)	19 (12-41)	0.13 (L0.093-0.226)	123 (38-291)	7
	1981	21 (12-31)	L0.05 (L0.050-1.3)	52 (49-60)	0.07 (L0.05-0.10)	65 (41-100)	--	21 (12-32)	
* Laredo Sd.	1981	21 (15-28)	L0.05 (L0.05-0.19)	53 (49-57)	0.07 (L0.05-0.15)	38 (28-49)	--	20 (9-50)	
* Chatham Sd.	1981	21 (18-29)	0.09 (L0.05-0.59)	53 (45-63)	0.11 (L0.05-0.49)	60 (53-76)	--	18 (9-32)	
Five Fingers	1981	30	L5.0	60	L2.5	--	--	--	6
Rupert Inlet	1980	40 (17-60)	3.0 (L1.0-7.0)	60 (46-85)	0.3 (L0.1-0.6)	17 (15-20)	0.10	--	9
Holberg Inlet	1980	38 (27-55)	L3.5 (L3.5-6.0)	55 (48-70)	0.4 (L0.3-0.8)	20 (11-32)	0.05 (0.05-0.10)	--	9
Alaska	1978	16 (8-34)	3.6 (2.5-8.0)	55 (45-84)	0.75 (0.40-1.3)	30 (5-88)	0.3 (0.20-0.55)	--	8

* = Control Areas

Continued...

TABLE 6: COMPARISON OF THE TISSUE TRACE METAL CONTENT FOUND IN BIOTA FROM ALICE ARM - 1977-1980, TO OTHER DATA SOURCES, AND LOCATIONS, IN mg/kg, dry weight (Continued)

LOCATION	YEAR	Cu	Pb	Zn	Cd	As	Hg	Fe	Source
				Shrimp - Pandalus borealis Whole Body					
Alice Arm	1977	94 (76-110)	L1.0	65 (57-42)	2.8 (2.4-3.2)	--	--	140 (44-200)	
Alice Arm	1978	104 (98-108)	L4.3	60	2.8 (2.7-3.9)	--	--	89 (81-98)	
* Hastings Arm	1977	93 (88-97)	L1.0	57 (54-60)	3.0 (2.4-3.7)	--	0.12 (0.099-0.14)	876 (564-1580)	
* Hastings Arm	1978	113 (110-117)	L4.3	67 (64-69)	2.3 (1.4-3.2)	--	0.11 (0.097-0.11)	785 (670-801)	7
Howe Sd.	1976	149 (87-260)	L1.0	77 (50-110)	1.1 (0.6-1.6)	--	0.46 (0.08-0.89)	808 (220-2500)	
* Laredo Sd.	1981	95 (70-144)	0.19 (L0.05-1.1)	66 (58-80)	1.85 (1.19-2.80)	25 (19-32)	--	100 (6.6-157)	
U.K.	1977	115	L1.0	125	L1.0	--	0.6	--	10
				Shrimp - Pandalopsis dispar - Sidestripe Muscle Tissue					
Alice Arm	1978	32 (28-43)	L4.3	49 (48-52)	1.2 (0.99-1.6)	57 (51-67)	0.16 (0.115-0.198)	55 (44-66)	
Alice Arm	1980	48	0.586	56	0.392	98	0.18	204	
Alice Arm	1980	16 (13-20)	0.58 (L0.05-3.00)	59 (53-58)	0.29 (0.14-0.60)	48 (39-60)	--		
* Hastings Arm	1978	34 (25-54)	L4.3	52 (47-61)	1.2 (L0.72-1.8)	44 (23-98)	0.12 (0.086-0.116)	67 (35-140)	
* Hastings Arm	1980	15 (9-18)	0.12 (L0.05-0.99)	62 (38-78)	0.13 (L0.05-0.20)	80 (46-122)	--		
Alice Arm	1980	--	--	--	--	48 (28-64)	--	--	4
* Quatsino Sd.	1978	41 (33-51)	L4.3	54 (48-60)	L0.71	28 (23-44)	0.16 (0.107-0.192)	19 (8-35)	7
	1979	37 (22-47)	L0.047 (L0.047-0.15)	50 (42-55)	0.11 (L0.047-0.166)	36 (21-56)	0.16 (L0.087-0.326)	147 (35-421)	7
	1981	23 (19-30)	L0.05	48 (43-54)	0.06 (L0.05-0.10)	40 (28-51)	--	19 (15-33)	

Continued...

TABLE 6: COMPARISON OF THE TISSUE TRACE METAL CONTENT FOUND IN BIOTA FROM ALICE ARM - 1977-1980, TO OTHER DATA SOURCES, AND LOCATIONS, IN mg/kg, dry weight (Continued)

LOCATION	YEAR	Cu	Pb	Zn	Cd	As	Hg	Fe	Source
				Shrimp - Pandalopsis dispar - (cont'd) Whole Body					
* Chatham Sd.	1981	17 (11-21)	L0.05	46 (43-55)	L0.05 (L0.05-0.10)	69 (48-108)	--	22 (10-61)	
* Laredo Sd.	1981	22 (15-29)	L0.05	47 (44-51)	L0.05 (L0.05-0.10)	43 (30-51)	--	16 (7-39)	
Alaska	1978	25 (12-45)	3.4 (2.2-8.0)	68 (43-104)	0.60 (0.15-1.1)	22 (11-41)	0.5 (0.1-1.4)		8
				Shrimp - Pandalopsis dispar Whole Body					
* Hastings Arm	1978	95 (92-99)	L4.2	81 (79-85)	3.6 (0.72-6.45)	24 (22-26)	0.1 (0.094-0.114)	533 (264-753)	
* Laredo Sd.	1981	85 (62-135)	0.09 (L0.05-0.45)	54 (45-71)	2.2 (1.37-3.62)	29 (22-35)	--	140 (60-266)	
				Shrimp - Crangon communis Whole Body					
* Hastings Arm	1978	45 (31-79)	L4.3	67 (53-83)	L0.70	41 (21-61)	0.13 (0.097-0.145)	168 (35-450)	
* Chatham Sd.	1981	59 (50-71)	0.17 (L0.05-1.0)	53 (45-63)	0.62 (0.42-0.82)	44 (38-60)	--	276 (228-435)	
* Laredo Sd.		63 (43-89)	0.10 (L0.05-0.25)	70 (61-82)	4.03 (3.3-5.4)	53 (27-36)	--	156 (81-198)	
				Crab - Chionoacetes bairdi - Tanner Muscle Tissue - Leg					
Alice Arm	1980	58	1.00	131	0.20	56	--	68	
* Hastings Arm	1980	54	1.00	116	0.20	111	--	26	

Continued...

TABLE 6: COMPARISON OF THE TISSUE TRACE METAL CONTENT FOUND IN BIOTA FROM ALICE ARM - 1977-1980, TO OTHER DATA SOURCES, AND LOCATIONS, IN mg/kg, dry weight (Continued)

LOCATION	YEAR	Cu	Pb	Zn	Cd	As	Hg	Fe	Source
				Crab - Lithodes aeguispina- Brown King Muscle Tissue - Leg					
Alice Arm	1978	50 (25-84)	L4.2	187 (179-194)	L0.7	104 (91-141)	L0.090	11 (9-12)	
Alice Arm	1980	--	0.117	--	L0.047	49	0.463	30	
Alice Arm	1980	92	L0.05	215	0.80	164	--	24	
* Hastings Arm	1977	24 (23-26)	L1.0	225 (220-230)	1.5 (1.2-1.9)	--	--	177 (35-320)	
* Hastings Arm	1978	85	L4.2	189	L0.7	104	L0.097	13	
Alice Arm	1977	148 (114-200)	1.8 (0.85-4.6)	218 (189-250)	L0.25 (L0.25-0.40)	--	L0.20	--	3
* Hastings Arm	1977	87 (71-108)	0.8 (0.49-0.98)	213 (211-232)	L0.25	--	L0.30	--	3
				Crab - Paralithodes camschatica - Alaskan King Muscle Tissue - Leg					
* Hastings Arm	1977	47	L1.0	200	L0.05	34	--	--	
Alaska	1978	55 (20-152)	3.6 (0.36-7.8)	360 (162-768)	1.3 (0.06-2.3)	29 (14-66)	0.5 (0.12-1.4)	--	8
				Crab - Cancer magister - Dungeness Muscle Tissue - Leg					
Alice Arm	1974	56 (50-63)	4.1 (L4.1-4.1)	233 (219-247)	L1.0	--	--	110 (105-115)	1
* Hastings Arm		76	3.8	270	L1.0	--	--	105	1
Alice Arm	1976	80 (51-102)	6.6 (5.0-10.6)	230 (257-443)	1.4 (0.76-2.2)	--	0.60 (0.30-1.3)	--	2
* Observatory In.	1976	47 (28-79)	4.2 (2.5-5.1)	219 (129-299)	0.6 (0.43-0.77)	--	0.12 (L0.05-0.21)	--	2
Alice Arm	1977	69 (58-81)	1.3 (L1.0-1.7)	217 (195-235)	L0.25	--	L0.20	--	3

Continued...

TABLE 6: COMPARISON OF THE TISSUE TRACE METAL CONTENT FOUND IN BIOTA FROM ALICE ARM - 1977-1980, TO OTHER DATA SOURCES, AND LOCATIONS, IN mg/kg, dry weight (Continued)

LOCATION	YEAR	Cu	Pb	Zn	Cd	As	Hg	Fe	Source
				Crab - Cancer magister - (cont'd.)					
Rupert In.	1978	69 (33-99)	L4.4	302 (286-314)	L0.73	37 (36-40)	0.6 (0.37-0.91)	58 (12-83)	7
Rupert In.	1979	48 (45-51)	L0.047	213 (203-237)	L0.05 (L0.05-0.05)	32 (21-49)	0.3 (0.16-0.45)	39 (26-52)	7
* Quatsino Sd.	1979	33 (31-36)	L0.046	238 (226-251)	L0.06	46 (36-57)	0.5 (0.35-0.51)	36 (26-46)	7
Rupert In.	1980	45 (32-65)	1.6 (1.0-2.0)	165 (135-190)	0.25 (L0.05-0.15)	28 (17-48)	0.2 (0.10-0.35)	--	9
* Quatsino Sd.		46 (27-55)	2.5 (2.0-3.0)	140 (105-175)	L0.05	34 (15-55)	0.15 (0.08-0.25)	--	9
Alaska	1978	22 (8-55)	2.8 (1.7-4.4)	273 (205-390)	0.49 (0.3-0.7)	28 (18-42)	0.25 (0.10-0.55)	--	8
Roberts Bank		72	1.2	228	(0.6-1.08)	--	--	--	6
Powell River			1.2	246	(0.6)	--	--	--	6
* Port Hardy		47	1.4	263	(0.36-3.0)	--	--	--	6
				Bivalve - Yoldia thraciaeformis Whole Body					
Alice Arm	1978	363 (292-435)	34.0 (9-60)	681 (681-682)	15.0 (13-18)	52 (47-57)	1.3 (1.1-57)	10295 (8590-12000)	
* Hastings Arm		328	L4.4	788	19.0	46	1.1	4560	
Alice Arm	1978	--	(14-79)	--	(2.4-12.6)	--	--		4
* Quatsino Sd.	1978	243	L4.3	219	1.86	40	0.647	3335	7
* Quatsino Sd.	1981	25	6.64	169	1.22	26	--	2570	7
* Laredo Sd.		55 (39-64)	8.8 (5.0-12)	613 (514-879)	1.77 (1.39-2.26)	107 (87-111)	2.3 (L2.3-2.7)	2027 (1500-2360)	
				Yoldia - scissurata					
* Quatsino Sd.	1981	60	0.8	111	1.04	41	--	2480	

Continued...

TABLE 6: COMPARISON OF THE TISSUE TRACE METAL CONTENT FOUND IN BIOTA FROM ALICE ARM - 1977-1980, TO OTHER DATA SOURCES, AND LOCATIONS, IN mg/kg, dry weight

LOCATION	YEAR	Cu	Pb	Zn	Cd	As	Hg	Fe	Source
				Bivalve - Mya arenaria Whole Body					
* Perry Pen	1980	21 (12-31)	1.5 (L0.05-2.00)	109 (76-164)	1.01 (0.70-1.60)	6.6 (4.0-11.0)	--	68	
				Bivalve - Mytilus edulis - Mussel Whole Body					
Alice Arm	1977	10 (9-13)	2.6 (1.1-5.0)	110 (99-130)	6.2 (4.8-6.9)	--	--	410 (150-810)	
	1978	18 (13-31)	L4.3 (L4.3-7.8)	95 (59-107)	6.3 (3.5-7.6)	9.5 (L7.2-12.0)	0.12 (L0.98-0.161)	1374 (662-2220)	
* Hastings Arm	1977	10	L1.0	88 (87-89)	5.1 (4.5-5.8)	--	--	350 (260-440)	
	1978	13 (9-15)	L4.3	72 (34-84)	3.8 (3.4-4.5)	7.9 (7.2-8.6)	(L0.088)	796 (726-1020)	
Anyox	1978	114 (24-128)	L4.3 L4.3-7.2	254 (14-462)	6.6 (3.8-8.4)	9.4 (7.9-11.5)	0.10 (L0.95-0.112)	3871 (565-5910)	
* Quatsino Sd.	1978	11 (7-15)	L3.8	208 (198-219)	3.9 (3.6-4.2)	11.5 (10.1-13.1)	0.17 (0.171-0.174)	207 (179-235)	7
	1979	13 (12-14)	--	233 (145-322)	5.2 (3.7-6.8)	1.27	--	--	7
* Quatsino Sd.	1980	9 (8-10)	4.5 (3.0-10.5)	120 (58-195)	3.6 (1.7-5.6)	--	0.17 (0.08-0.30)	--	9
U.K.	1977	7-9	3.0-6.7	97-105	L1.5-5.3	--	0.15-0.53	--	10
Greenland	1982		2-71	0.8-84	L0.1-2.1				5
Denmark			20-125	81-211	0.8-3.3				5
Sweden			34-202	52-361	0.6-7.6				5
Australia				19-60	0.2-0.6				5

Continued...

TABLE 6: COMPARISON OF THE TISSUE TRACE METAL CONTENT FOUND IN BIOTA FROM ALICE ARM - 1977-1980, TO OTHER DATA SOURCES, AND LOCATIONS, IN mg/kg, dry weight

LOCATION	YEAR	Cu	Pb	Zn	Cd	As	Hg	Fe	Source
				Algae - Fucus distichus rockweed					
Alice Arm	1977	4.5 (3.6-7.4)	L1.0 (L1.0-1.5)	27 (17-41)	1.6 (1.1-2.1)	--	--	124 (37-220)	
	1978	5.2 (2.7-8.6)	L4.2	39 (24-67)	2.7 (2.0-3.8)	20 (12-27)	L0.096	530 (115-2000)	
* Hastings Arm	1977	5.9 (3.8-10)	(L1.0-1.4)	18 (13-31)	1.5 (1.2-2.1)	--	--	48 (13-79)	
	1978	5.0 (4.0-6.3)	L4.2	27 (24-29)	3.1 (2.2-4.2)	24 (21-27)	L0.099	722 (594-889)	
Anyox	1977	58.0	L1.0	56	0.6	--	--	770	
	1978	67.2 (10.8-127)	L4.2	104 (47-160)	2.0 (1.3-2.8)	20 (17-26)	0.5 (L0.94-1.18)	530 (290-746)	
Alice Arm	1975	17.9 5.8-66	31 (5.2-178)	95 (28-427)	4.1 (2.1-13.0)	--	L0.10	--	2
* Hastings Arm	1975	17.8 (8.3-28)	7.3 (3.4-10.2)	35 (28-50)	2.8 (2.0-3.7)	--	--	--	2
Anyox	1975	110	10	80	2.3	--	L0.13	--	2
• Quatsino Sd.	1978	43.2	L4.2	29	4.4	31	L0.096	1900	• 7
	1979	10 (8-12)	--	87 (40-134)	3.2 (2.7-3.8)	35 (29-41)	L0.096	192 (70-315)	7
• Quatsino Sd.	1980	12 (7-18)	1.7 (1.0-2.5)	38 (24-53)	2.9 (1.6-4.1)	33 (27-41)	L0.01	--	9
				Algae - Fucus vesiculosus					
Arctic Bay	1976		2.1 ± 0.8	23.8 ± 9.7	1.7 ± 0.6	20.4 ± 4.1	0.02 ± 0.01		5
Strathcona Sd.	1976		2.1 ± 0.1	88.4 ± 3.3	0.6 ± 0.06	24.8 ± 2.2	0.02		5
Strathcona Sd.	1979		1.08 - 59.5	36 - 493	0.67 - 1.82	21.2-34.9	0.01-0.02		5

Continued...

TABLE 6: COMPARISON OF THE TISSUE TRACE METAL CONTENT FOUND IN BIOTA FROM ALICE ARM - 1977-1980, TO OTHER DATA SOURCES, AND LOCATIONS, IN mg/kg, dry weight (Continued)

LOCATION	YEAR	Cu	Pb	Zn	Cd	As	Hg	Fe	Source
Fish - Hippoglossoides elassodon - Flathead Sole									
Muscle Tissue									
Alice Arm	1978	4.2	L4.4	24	L0.7	19	0.194	21	
Alice Arm	1980	5.6 (4.5-6.7)	0.41 (0.21-0.87)	20 (18-22)	(L0.05-0.05)	52 (29-85)	0.41 (0.21-0.68)	12 (7-18)	
* Quatsino Sd.	1978	L4.7	L4.3	26	L0.7	25 (	0.557	13	7
* Quatsino Sd.	1979	5.3 (3.3-7.0)	L0.05	25 (20-33)	0.08 (L0.047-0.105)	23 (L7.1-48)	0.46 (0.224-0.904)	17 (13-24)	7
Fish - Atherethes stomias - Arrowtooth Flounder									
Alice Arm	1980	4.4 (4.1-4.9)	0.33 (L0.05-0.613)	21 (19-24)	L0.047	18 (13-23)	0.22 (L0.196-0.243)	27 (23-31)	
* Quatsino Sd.	1981	3.3	L0.05	18	L0.05	L7	--	33	
* Chatham Sd.	1981	5.7 (4.8-6.7)	L0.05	19 (18-20)	L0.05	11 (L7-16)	--	68 (55-91)	
* Laredo Sd.	1981	6.2	L0.05	17	L0.05	11	--	32	
Fish - Microstomus pacificus - Dover Sole									
Alice Arm	1980	3.4	0.18	15	L0.05	26		11	
Rupert In.	1978	0.69	L4.4	20	L0.71	25 (18-32)	0.12 (0.10-0.14)	15 (9-22)	7
* Quatsino Sd.		1.9	L4.2	23 (19-29)	L0.71	60 (27-95)	0.19 (0.17-0.25)	20 (8-25)	7
* Quatsino Sd.	1979	4.9	L0.048	14	L0.048	41	0.15	37	7
* Quatsino Sd.	1981	10.4	L0.05	20	--	--	--	38	
Pac Northwest	1978	1.0 (0.2-3.5)	2.4 (0.6-5.5)	17 (9-39)	0.5 (0.05-2.5)	42 (11-89)	0.53 (0.2-1.9)	--	8

Continued...

TABLE 6: COMPARISON OF THE TISSUE TRACE METAL CONTENT FOUND IN BIOTA FROM ALICE ARM - 1977-1980, TO OTHER DAA SOURCES, AND LOCATIONS, IN mg/kg, dry weight (Continued)

LOCATION	YEAR	Cu	Pb	Zn	Cd	As	Hg	Fe	Source
				Fish - Lipidopsetta bilineata- Rock Sole					
* Hastings Arm	1980	7.5	L0.05	46	0.10	80		13	
				Fish - Lyopsetta exilis - Slender Sole					
Rupert In.	1978	1.6 (1.5-1.9)	L4.2	18 (17-19)	L0.71	11 (7-16)	0.28 (0.169-0.396)	90 (70-110)	7
* Quatsino Sd.	1978	1.7 (L0.5-5.0)	L4.2	23 (18-26)	L0.71	16 (8-23)	0.41	17 (10-27)	7
Rupert In.	1979	5.7	L0.05	14	L0.05	16	0.187	33	7
* Quatsino Sd.	1979	3.7 (1.6-6.3)	L0.05	17 (13-21)	0.08 (L0.05-0.15)	25 (20-31)	0.41 (0.145-0.792)	27 (13-35)	7
Howe Sd.	1976	4.9	L1.0	27	0.57	--	--	32	7
				Fish - Glyptocephalus zachirus - Rex Sole					
Rupert In.	1978	0.6 (L0.5-0.7)	L4.3	17 (17-18)	L0.72	13 (9-18)	0.14 (L0.10-0.187)	21 (13-30)	7
Rupert In.	1979	4.3	L0.05	23	L0.05	12	L0.098	46	7
* Quatsino Sd.		2.8 (2.5-3.1)	L0.05	9 (4-15)	0.14 (L0.05-0.232)	45 (14-77)	0.23 (0.224-0.238)	19 (14-24)	7
* Quatsino Sd.	1981	2.9	L0.05	22	L0.05	128	--	99	
Howe Sd.	1976	3.8	L1.0	23	L0.05		--	22	7
Howe Sd.	1977	1.7 (0.99-2.7)	8.1 (5-13)	14	0.8 (0.49-1.3)	41 (10-87)	2.3 ().46-4.5)	--	7
Pac. Northwest	1978	0.64 (0.2-1.2)	2.3 (0.5-6.7)	18 (9-35)	0.4 (0.15-1.2)	45 (13-128)	0.14 (0.05-1.8)	--	8

Continued...

TABLE 6: COMPARISON OF THE TISSUE TRACE METAL CONTENT FOUND IN BIOTA FROM ALICE ARM - 1977-1980, TO OTHER DATA SOURCES, AND LOCATIONS, IN mg/kg, dry weight

(Continued)

LOCATION	YEAR	Cu	Pb	Zn	Cd	As	Hg	Fe	Source
				Fish - *Parophrys vetulus* - English Sole					
* Hastings Arm	1980	5.6 (1.3-16.6)	0.15 (L0.05-0.34)	33 (23-43)	L0.05	28 (12-71)			
Rupert In.	1978	1.2	L4.4	23	L0.7	7.2	0.115	22	7
Howe Sd.	1977	2.7 (0.93-11.7)	5.3 (4.6-9.5)	19 (15-25)	0.53 (0.46-0.95)	32 (10-81)	0.44 (0.08-1.6)	--	7
Pac. Northwest	1978	1.1 (0.5-2.1)	2.7 (1.0-6.2)	23 (12-31)	0.4 (0.05-1.8)	67 (17-225)	0.32 (0.1-2.2)	--	8
UK-Aberdeen	1978	0.9 (0.6-1.1)	L0.5	19 (16-21)	L0.1	--	--	--	10
				Fish - Theragra chalcogramma - Walleye Pollock					
Alice Arm	1978	8.6 (2.8-15.7)	L4.3	26 (18-36)	L0.71	19 (12-20)	0.22 (L0.152-0.354)	58 (18-400)	
Alice Arm	1980	6.1 (5.9-6.4)	0.22 (0.20-0.24)	23 (19-26)	0.14 (L0.05-0.23)	20 (18-22)	0.22 (L0.20-0.24)	29 (26-32) 21 (13-42)	
* Hastings Arm	1978	6.5 (4.4-9.1)	L4.3	33 (24-45)	L0.71	21 (13-42)	0.15 (0.110-0.198)	67 (29-144)	
Anyox	1978	17.3	L4.3	59	L0.72	(7.2)	0.113	118	
* Quatsino Sd.	1978	1.4 (1.2-1.6)	L4.2	26 (26-27)	L0.69 (L0.69)	15 (9-21)	0.48 (0.33-0.63)	13 (11-15)	7
Alaska	1978	1.9 (0.6-12)	2.5 (0.65-10.5)	24 (10-45)	0.4 (0.05-1.4)	12 (3-27)	1.0 (0.1-4.7)	--	10

Source

1. Dobrocky Seatech, (1974)
2. Dobrocky Seatech, (1976)
3. Dobrocky Seatech, (1977)
4. Dobrocky Seatech, (1981)
5. Fallis, (1982)
6. Garrett, (1982)
7. Goyette, (1982)
8. Hall, et al (1978)
9. Island Copper Mine (1982)
10. United Kingdom (1977)

interpreting results. Tissue concentrations exceeding background levels in the surrounding sediment, can with reasonable assurance, be taken as evidence of metal uptake.

Yoldia thraciaeformis/montereyensis

The small number of individual samples taken in Alice Arm and Hastings Arm, prior to opening of the Kitsault mine, does not permit a definite comparison between the two areas. In 1978 samples were obtained from two trawls in Alice Arm (A-1 and A-2) and one in Hastings Arm (H-2). Analysis was limited to a composite sample of 20 individuals from each site. Tissue concentration from these three locations were:

mg/kg, dry wt.					
Cu	Pb	Zn	Cd	As	Mo
292-435	L4.4-60.0	681-788	13.4-19.3	46.6-56.6	L6.9-L7.3

Copper, cadmium and to some extent, lead were higher than samples from Laredo Sound. Conversely, arsenic concentrations were higher in Laredo Sound. Results, based on nine individuals from Laredo Sound analyzed individually were as follows:

mg/kg, dry wt.					
Cu	Pb	Zn	Cd	As	Mo
54.7	8.83	613.4	1.77	106.9	2.31
(39.4-63.8)	(5.05-11.6)	(514-879)	(1.33-2.26)	(86.3-134.0)	(1.73-3.00)

As Laredo Sound is well removed from any industrial influence these samples should reflect the natural concentrations in Yoldia sp. Dobrocky Seatech (1981) reports mean concentrations for lead, cadmium, arsenic and molybdenum in Yoldia thraciaeformis from four stations in Alice Arm as 39.6, 6.97, 36.7 and 15.2 ppm, respectively.

Further sampling is needed to establish precise baseline concentrations for Yoldia sp. and to determine if purging techniques are adaquate to eliminate contamination from sediment adhering to the tissue.

Mytilus edulis

From the 1977-78 results, using stations removed from any direct effect from either Anyox or the B.C. Molybdenum tailings deposits the baseline concentrations for mussels range as follows:

mg/kg, dry wt.							
Cu	Pb	Zn	Cd	As	Mo	Hg	Fe
9-15	L1.0	30-90	3.0-5.0	L7.0-9.0	L7.2	L0.09-0.12	200-1000

Dobrocky Seatech (1981) found similar average values of 3.89 mg/kg for Cd and 9.23 mg/kg for As in some 76 samples taken throughout Alice Arm. Lead in most samples was below a detection limit of 2.5 mg/kg and for molybdenum, all samples were below the detection limit of 5.0 mg/kg. Table 5 shows basically similar values reported from the Quatsino Sound area and other locations.

Littlepage (1978) reports somewhat higher average metal levels in mussels from Alice Arm as follows:

mg/kg, dry wt.					
Cu	Pb	Zn	Cd	As	Mo
20.7±2.3	18.8±2.7	129±10.1	8.1±0.6	NS	ND

Alga

Fucus distichus

Using the 1977-78 data from stations outside the impact from either Anyox or B.C. Molybdenum the natural background levels in Fucus were generally within the range of:

mg/kg, dry wt.							
Cu	Pb	Zn	Cd	As	Mo	Hg	Fe
3.8-6.3	L1.0-1.5	13-31	1.2-4.2	21-27	L7.2	L0.099	13-889

Alice Arm samples in 1977 and 1978 ranged as follows:

mg/kg, dry wt.							
Cu	Pb	Zn	Cd	As	Mo	Hg	Fe
3.6-8.6	L1.0-1.5	17-67	1.1-3.8	12-27	L7.2	L0.096	37-2000

Littlepage (1978) reported averaged values in Fucus from Alice Arm as:

mg/kg, dry wt.

Cu	Pb	Zn	Cd	Mo
13.3±1.6	9.1±1.5	39.3±4.0	2.8±0.1	ND

Concentrations in Fucus from Quatsino Sound (Goyette, 1982) and elsewhere are shown in Table 6.

Crustaceans - Shrimp

One noticeable feature in the biota of Alice Arm is the dominance of crustaceans. The most numerous commercial species caught in the otter trawls were the pandalid shrimp, Pandalus borealis and Pandalopsis dispar. These were distributed throughout Hastings and Alice

Arms. Pandalus hypsinotus was only captured near the entrance to Alice Arm (A-3), possibly because of the shallower depth. In 1978 results were based on analysis of composite samples consisting of 10-20 individuals. In 1980 and 1981, up to 15 individuals per station were analyzed individually. Tissue samples consisted primarily of tail muscle but on occassion, whole animals were used. Analysis of whole animals usually resulted in higher levels of Cu, Cd and Fe.

Pandalus borealis

Using the 1978 and 1980 data from Alice Arm and the control sites the natural concentrations in shrimp muscle tissue generally ranged as follows:

mg/kg, dry wt.							
Cu	Pb	Zn	Cd	As	Mo	Hg	Fe
9-30	L0.05-0.6	45-70	L0.05-0.5	15-200	L0.2	0.09-0.2	9-50

Similar results were obtained for the sidestripe shrimp, Pandalopsis dispar.

It should be noted that the copper concentrations in the 1980 and 1981 samples from Alice Arm and the control sites were noticebly lower than previous samples. This was not apparent in the other metals and thought to be due to some sampling or laboratory artifact, specific to copper. A subsequent inter-laboratory tissue exchange program between the EPS laboratory, Dobrocky Seatech and an independent commercial lab., indicates that the lower 1980-81 values more closely reflect the true concentration.

Littlepage (1978) reports average trace metal levels in shrimp muscle tissue from Alice Arm as:

		mg/kg, dry wt.		
Cu	Pb	Zn	Cd	Mo
42.1±1.3	3.9±0.4	53.4±5.1	1.0±0.1	ND

Levels reported for Cd and As by Dobrocky Seatech (1981) averaged 0.32 mg/kg and 45.9 mg/kg, respectively for shrimp samples (52) collected in Alice Arm. Both lead and molybdenum were below the detection limit. (2.5 mg/kg and 5.0 mg/kg).

Tissue levels in shrimp (*P. borealis* and *P. dispar*) caught in Alaskan waters (NOAA, 1978) were slightly higher for lead and lower for arsenic (Table 6). Other metals are generally comparable to the baseline levels established for Alice Arm.

Crangon communis

Six samples (tail only) taken near the mouth of Alice Arm (Trawl A-3) in 1978 ranged as follows:

		mg/kg, dry wt.		
Cu	Pb	Zn	Cd	As
31.9-79.5	L4.2	10.5-83.6	L0.7-1.2	21-62

Concentrations in Chatham Sound and Laredo Sound ranged as follows:

		mg/kg, dry wt.		
Cu	Pb	Zn	Cd	As
43-89	L0.05-1.0	45-82	0.4-5.2	27-60

Crab

Lithodes aequispina - Brown king crab

The Brown king crab is distributed throughout Alice Arm and Hastings Arm. Although the total number of samples taken in 1978 and

1980 is somewhat restricted no appreciable differences between metal levels were found in the muscle samples in Alice Arm and Hastings Arm. Comparing the 1979 and 1980 results both Alice Arm and Hastings Arm the muscle tissue metal levels range as follows:

mg/kg, dry wt.							
Cu	Pb	Zn	Cd	As	Mo	Hg	Fe
25-92	L0.05-0.12	179-215	0.05-0.80	49-141	L0.2	L0.09-0.463	9-30

Littlepage (1978) reported average metal levels in six Brown king crab from Alice Arm as:

mg/kg, dry wt.				
Cu	Pb	Zn	Cd	Mo
147.9±11.3	1.8±0.6	216±6.7	0.3±0.03	1.2±0.13

The Alaskan king crab (*Paralithodes camschatica*) is present but from submersible observations and otter trawls seems to be largely confined to the entrance of Alice and Hastings arms. Levels for the Alaskan king crab (NOAA, 1978) have been reported as:

mg/kg, dry wt.							
Cu	Pb	Zn	Cd	As	Mo	Hg	Fe
20-152	0.36-78	162-768	0.06-2.3	14-66	-	0.12-1.4	-

One noteable feature is the natural copper and particularly, arsenic concentrations in king crab muscle tissue which are much higher than many other species.

Chionoecetes bairdi - Tanner crab

Tanner crabs were only sampled in 1980. Two samples, one from Alice Arm and one from Hastings Arm were as follows:

mg/kg, dry wt.					
Cu	Pb	Zn	Cd	As	Mo
57.9, 53.7	1.0,1.0	131.0,116.0	0.2,0.2	56.0,111.0	L0.2,L0.2

Littlepage (1979) reports averages in 6 Tanner crab from Alice Arm as:

mg/kg, dry wt.					
Cu	Pb	Zn	Cd	As	Mo
50.5±5.1	0.8±0.09	212.3±23.1	0.8±0.15	-	ND

Fish

Sole, Flounder

From trawl catches and submersible observations sole are most abundant near the head and entrance of Alice Arm. Unfortunately, the species caught in 1980 at the entrance to Alice Arm differed from those caught near the head and the total number of samples is too small to make definite statements regarding metal levels in the muscle tissue. A few general statements however, can be made. Copper levels in all species of sole were substantially below the levels found in most invertebrates. This would be expected since copper is a major component in the blood of many invertebrates eg. crustaceans. Lead concentrations are generally below a detection limit of 0.05 mg/kg, dry wt. Similarly, cadmium was generally below 0.05 mg/kg. Zinc, arsenic and iron were also below levels normally found in the invertebrate species.

Concentrations found in all species, Alice Arm and the control sites in Chatham, Laredo and Quatsino Sounds ranged as follows:

mg/kg, dry wt.							
Cu	Pb	Zn	Cd	As	Mo	Hg	Fe
1.3-17.0	L0.05-0.87	15-46	L0.05-0.1	L6.8-195	L1.4	0.22-0.68	11-99

Littlepage (1978) reported averages in 15 yellow fin sole (Limanda aspera) from Alice Arm as:

		mg/kg, dry wt.			
Cu	Pb	Zn	Cd	As	Mo
23.3±2.1	13.8±2.4	92.4±7.6	L0.9±2.0	-	ND

These values are higher than results obtained in this study however, yellow fin sole have not been captured during any of the trawl surveys to date.

Theragra chalcogramma - pollock

Muscle samples from Walleye pollock were collected in Alice Arm, Hastings Arm and a single sample from Anyox in 1978 and from Alice Arm in May, 1980. None were captured from the control areas sampled in 1981. There were no major differences between tissue samples from Alice Arm compared to those taken in Hastings Arm. The concentrations in both Alice and Hastings Arm 1978-1980 ranged as follows:

			mg/kg, dry wt.				
Cu	Pb	Zn	Cd	As	Mo	Hg	Fe
2.8-15.7	0.2-0.24	18-45	L0.05-0.23	12-42	L7.1	0.11-0.25	18-144

With the exception of a somewhat lower range in arsenic levels, tissue concentrations were basically similar to the sole. Table 6 shows metal levels found in pollock from Quatsino Sound and Alaskan waters.

3.2.2 Summary of Tissue Trace Metals

In relation to tissue metal levels found elsewhere in the Alice Arm area it is obvious that the mining/smelting operation at Anyox has had a marked impact on the copper and zinc levels in mussels (Mytilus edulis) and alga (Fucus distichus) tissue. Slight elevation in copper levels in shrimp muscle might also have occurred as a result of high copper bearing

waste from Anyox but further study is required. Whether the source of contamination originates from dissolved metals through bacteriological leaching, uptake from particulates or both has yet to be defined.

Although in some cases metal levels tended to be slightly higher in samples from upper Alice Arm (A-1 and A-2) there was no indication of any marked increase that could be directly attributed to the previous B.C. Molybdenum operation. Metal levels present in the surface sediments at the time these studies were undertaken in most cases would be substantially lower than expected during the operating stage of both the B.C. Molybdenum and the new Kitsault mine. Futher monitoring of tissue metal levels will be required to determine if significant metal uptake occurrs in the various species present in Alice Arm under operating condition.

It would appear from the tissue data collected during this study that the surrounding mineralization has not appreciably affected the natural tissue levels. On exception maybe the bivalve, *Yoldia sp.*, which contained much higher metal levels, in particular copper, zinc, and cadmium, in samples *from* both Alice Arm and Hastings Arm than those from the three coastal control areas. Additional study, however, would be neccesary to determine if this difference is real or due to analytical difficulties with metal bearing sediment adhering to the tissue samples or possibly, contamination coming from Anyox which may have affected tissue levels in samples from Hasting Arm.

The present study concentrated on the edible portion of selected species and does not address many other important species in the ecosystem, nor do the data address the effects of trace metal exposure on the organism itself, eg. metal uptake in specific body organs, effects on reproduction capacity, toxicity etc. The long term aspects of metal bioaccumulation also were not examined.

Evidence of metal uptake in *Mytilus edulis* at Anyox indicates that special attention should be paid to bivalves, particularly those exposed to tailings deposits from the Kitsault mine. Bioaccumulation experiments using filter and deposit feeding species would be worthwhile, with emphasis on determining the fate of ingested particulate trace metals.

REFERENCES

British Columbia Department of Energy, Mines, and Petroleum Resources, 1978. Regional Stream Sediment and Water. Accelerated Geochemical Survey. Report RGS-2-1978.

British Columbia Research Council, 1973. Effluent Discharge from a Proposed Leaching Operation at Anyox, Colby Mines Ltd., Project No. 1497.

British Columbia Research Council, 1975. Acid Production of Rock Samples, prepared for the Climax Molybdenum Corp., Project No. 10-1576.

Brothers, D., 1977. Marine Environmental Assessment of Tasu Sound, British Columbia, EPS Regional Program Report 78-12.

Dobrocky Seatech, 1974. Metal Content of Sediment, Fish and Shellfish Samples. Data report to J.L. Littlepage. 74-2.

Dobrocky Seatech, 1976. Heavy Metal Content of Sediments, Creek Water and Biological Materials. Data report to J.L. Littlepage, 75-2.

Dobrocky Seatech, 1977. Heavy Metal Content of Crabs Taken in Alice Arm and Hastings Arm, June, 1977 Data report to J.L. Littlepage 77-3.

Dobrocky Seatech, 1981, Metal Content of Marine Sediments and Marine Invertebrates Report 80-3, prepared for Amax of Canada Ltd.

Fallis, B.W., 1982. Trace Metals in Sediments and Biota from Strathcona Sound, NWT; Nanisivik Marine Monitoring Programme 1974 - 1979. Canadian Technical Report of Fisheries and Aquatic Sciences, No. 1982.

Garrett, C., 1981. Comparison of Heavy Metals in Alice Arm to Other Coastal Areas in B.C. EPS Internal Memorandum, June 25, 1981.

Goyette, D., 1975. Marine Tailings Disposal - Case Studies, Environmental Protection Service, presented at Mining Effluent Regulations/Guidelines and Effluent Treatment Seminar, Banff, Alberta, December, 1975.

Goyette, D. and Nelson, H., 1977. Marine Environmental Assessment of Mine Waste Disposal into Rupert Inlet, British Columbia. EPS Report PR-77-11.

Goyette, D., 1982. Tissue Trace Metals in Rupert Inlet Quatsino Sound, and Howe Sound. EPS unplublished data.

Hall, R.A., Zook, E.G. and G.M. Meaburn, 1978. National Marine Fisheries Service Survey of Trace Elements in the Fishery Resource. NOAA Technical Report NMFS SSRF-721.

Island Copper Mine, 1982. 1980 Annual Environmental Assessment Report. Utah Mines Ltd.

Littlepage, J.L., 1978. Oceanographic and Marine Biological Surveys. Alice Arm and Hastings Arm, B.C. 1974-1977, prepared for Climax Molybdenum Corporation of British Columbia Ltd., May, 1978.

Martin, W.H., 1933. Mud Deposits on Gill Nets in the Nass River District, B.C. In Contributions to Canadian Biology and Fisheries. Fish. Res. Bd. Can. Series A. Vol 7. Paper No. 23.

Sullivan D. and Brothers, D., 1979. Marine Evironmental Investigations of Alice and Hastings Arms, B.C. 1976-1978. EPS 1979-17.

Swingle, R.B. and Davidson, J.W., 1979. Environmental Laboratory Manual, Jan., 1979. Prepared by the Departments of Environment and Fisheries and Oceans.

United Kingdom, 1977. Monitoring the Marine Environment of the United Kingdom. Report of the Marine Pollution Monitoring Management Group., 1975-76., Pollution Report No. 2.

ACKNOWLEDGEMENTS

A study of this nature is not without the efforts of a great many people. Special thanks go to the Masters, officiers and crews of the CSS Vector and Parizeau and the Insitute of Ocean Sciences Ship's Division for their willing support and cooperation. Particular appreciation is extended to Capt. Sjoholm, whose presence on the Bridge of the Vector, upon his pending retirement, will be sorely missed. Appreciation is also extended to Dr. J. Thompson, Institute of Ocean Sciences for his help during the joint studies and to D. Brothers, D. DeMill, R. Hinder, H. Nelson and D. Sullivan for their assistance during the field surveys. The support given by L. Macleod in developing the computer programs and members of the West Vancouver Chemistry Lab., in particular J. Davidson, J. Pel, R. Leary and D. Yoshioka, for their patience with the numerous analyses, is gratefully acknowledged. The hardwork and forebearance of L. Pearson in the drafting and of F. Lund and P. Wakeman in the typing of this manuscript is greatly appreciated. The review and comments given by L. Harding, B. Kay and M. Pomeroy, in the preparation of this manuscript is appreciated. Thanks also go to the Management of EPS for their support in carring out this project.

APPENDIX 1

ALICE ARM TAILINGS DEPOSIT REGULATIONS (AATDR) - APRIL 10, 1979

Registration
SOR/79-345 10 April, 1979

FISHERIES ACT

Alice Arm Tailings Deposit Regulations

P.C. 1979-1112 4 April, 1979

His Excellency the Governor General in Council, on the recommendation of the Minister of Fisheries and the Environment, pursuant to subsections 33(12) and (13) and 33.1(3) of the Fisheries Act, is pleased hereby to make the annexed Regulations respecting the authorization to deposit deleterious substances in mill process effluent from the operation of the Kitsault Mine into the waters of Alice Arm, British Columbia.

REGULATIONS RESPECTING THE AUTHORIZATION TO DEPOSIT DELETERIOUS SUBSTANCES IN MILL PROCESS EFFLUENT FROM THE OPERATION OF THE KITSAULT MINE INTO THE WATERS OF ALICE ARM, BRITISH COLUMBIA

Short Title

1. These Regulations may be cited as the Alice Arm Tailings Deposit Regulations.

Interpretation

2. (1) In these Regulations,

"Act" means the *Fisheries Act*;

"Kitsault Mine" means the mine located within the aggregate of the areas, all situated in the Skeena Mining Division, Cassiar Land District, in the Province of British Columbia, to which Mineral Leases Numbers M 157 to M 191 inclusive (dated February 23, 1967 and issued by the Minister of Petroleum Resources of the Province of British Columbia) apply.

(2) In these Regulations, the following words and expressions, namely,

(*a*) "composite sample",
(*b*) "deposit",
(*c*) "final discharge point",
(*d*) "mill process effluent",
(*e*) "mine",
(*f*) "Minister", and
(*g*) "total suspended matter",

have the meanings assigned to those words and expressions in the *Metal Mining Liquid Effluent Regulations*.

[1]

Enregistrement
DORS/79-345 10 avril 1979

LOI SUR LES PÊCHERIES

Règlement sur les rejets de stériles dans le bras Alice

C.P. 1979-1112 4 avril 1979

Sur avis conforme du ministre des Pêches et de l'Environnement et en vertu des paragraphes 33(12) et (13) et 33.1(3) de la Loi sur les pêcheries, il plaît à Son Excellence le Gouverneur général en conseil d'établir le Règlement autorisant le rejet dans les eaux du bras Alice d'effluents des installations de préparation du minerai de la mine Kitsault, en Colombie-Britannique, et des substances nocives qu'ils contiennent, ci-après.

RÈGLEMENT AUTORISANT LE REJET DANS LES EAUX DU BRAS ALICE D'EFFLUENTS DES INSTALLATIONS DE PRÉPARATION DU MINERAI DE LA MINE KITSAULT, EN COLOMBIE-BRITANNIQUE, ET DES SUBSTANCES NOCIVES QU'ILS CONTIENNENT

Titre abrégé

1. Le présent règlement peut être cité sous le titre: *Règlement sur les rejets de stériles dans le bras Alice*.

Définitions

2. (1) Dans le présent règlement,

«Loi» désigne la *Loi sur les pêcheries*;

«mine Kitsault» désigne la mine située sur les concessions minières n^os^ M 157 à M 191 inclusivement, (datées du 23 février 1967 et émises par le ministre des Ressources pétrolières de la Colombie-Britannique), toutes situées dans la Division minière de Skeena du district de Cassiar, en Colombie-Britannique.

(2) Dans le présent règlement, les termes et expressions

a) «échantillon composite»,
b) «rejeter»,
c) «point de rejet final»,
d) «effluents des installations de préparation du minerai»,
e) «mine»,
f) «Ministre», et
g) «matière totale en suspension»

ont le sens qui leur est attribué dans le *Règlement sur les effluents liquides des mines de métaux*.

Application

3. (1) These Regulations apply to the deposit of mill process effluent emanating from the operation of the Kitsault Mine into the waters of Alice Arm, British Columbia.

(2) The *Metal Mining Liquid Effluent Regulations* do not apply to the deposit of mill process effluent emanating from the operation of the Kitsault Mine into the waters of Alice Arm, British Columbia.

Substances Prescribed as Deleterious Substances

4. For the purpose of paragraph (*c*) of the definition "deleterious substance" in subsection 33(11) of the Act, the following substances contained in mill process effluent from the operations or processes of the Kitsault Mine are hereby prescribed as deleterious substances:

(*a*) arsenic;
(*b*) copper;
(*c*) lead;
(*d*) nickel;
(*e*) zinc;
(*f*) total suspended matter;
(*g*) radium 226; and
(*h*) cadmium.

Authorization

5. Subject to the conditions set out in sections 6 to 10, the operator of the Kitsault Mine is hereby authorized to deposit into the waters of Alice Arm total suspended matter in any concentration contained in mill process effluent and the deleterious substances prescribed by paragraphs 4(*a*) to (*e*) and 4(*g*) and (*h*) contained in mill process effluent, if

(*a*) the deposit is made in such a manner that the solid portion of the tailings from the mill process effluent does not pass west of a north-south line at 129°39′45″ west longitude that runs through the vicinity of Hans Point, British Columbia; and

(*b*) the solid portion of the tailings from the mill process effluent is not deposited on

(i) the bed of any part of the estuaries of the Illiance River or the Kitsault River, or

(ii) the bed of Alice Arm at any place that is less than 100 m below mean sea level, except as provided in section 7.

De-aeration and Treatment

6. (1) The mill process effluent shall be de-aerated and otherwise treated prior to being deposited into the waters of Alice Arm to prevent solid tailings particles contained therein from moving upward from the final discharge point of any outfall structure.

(2) Except as provided in section 7, the deposit of mill process effluent shall be made in such a manner that solid tailings particles do not remain in suspension in the waters of Alice Arm above a depth of 100 m (mean sea level).

Application

3. (1) Le présent règlement s'applique au rejet dans le bras Alice d'effluents des installations de préparation du minerai de la mine Kitsault, en Colombie-Britannique.

(2) Le *Règlement sur les effluents liquides des mines de métaux* ne s'applique pas au rejet dans le bras Alice d'effluents des installations de préparation du minerai de la mine Kitsault, en Colombie-Britannique.

Substances déclarées nocives

4. Aux fins de l'alinéa *c*) de la définition de «substance nocive», au paragraphe 33(11) de la Loi, sont déclarées nocives les substances suivantes contenues dans les effluents des installations de préparation du minerai provenant des opérations ou des procédés de la mine Kitsault:

a) l'arsenic;
b) le cuivre;
c) le plomb;
d) le nickel;
e) le zinc;
f) les matières totales en suspension;
g) le radium 226; et
h) le cadmium.

Autorisation

5. Sous réserve des conditions visées aux articles 6 à 10, l'exploitant de la mine Kitsault est autorisé à rejeter les effluents des installations de préparation du minerai dans le bras Alice, peu importe leur concentration en matières totales en suspension, ainsi que les substances nocives prescrites aux alinéas 4*a*) à *e*) et 4*g*) et *h*)

a) si ces rejets sont effectués de manière que la fraction solide des stériles de ces effluents ne franchit pas vers l'ouest la ligne tracée dans le sens nord-sud à la longitude 129°39′45″O, dans le voisinage de la pointe Hans, en Colombie-Britannique; et

b) si cette fraction solide des stériles n'est pas rejetée

(i) sur le fond de l'estuaire des rivières Illiance ou Kitsault, ou

(ii) sur le fond du bras Alice partout où il est à moins de 100 m sous le niveau moyen de la mer, sauf dans les cas prévus à l'article 7.

Désaération et traitement

6. (1) Les effluents des installations de préparation du minerai doivent être désaérés ou autrement traités avant leur rejet dans le bras Alice, pour empêcher les particules solides de stériles qu'ils contiennent de remonter vers le point de rejet final des exutoires.

(2) Sauf dans les cas prévus à l'article 7, le rejet des effluents des installations de préparation du minerai doit se faire de manière que les particules solides de stériles ne restent pas en suspension dans le bras Alice à moins de 100 m sous le niveau moyen de la mer.

Outfall Structure

7. (1) Subject to the terms of an order of the Minister referred to in subsection (2), the final discharge point of any outfall structure for the deposit of mill process effluent from the Kitsault Mine shall be not less than 50 m below mean sea level.

(2) Where the Minister has evidence that the deposit of mill process effluent is not made in accordance with subparagraph 5(*b*)(ii) or subsection 6(2), the Minister may, by an order made under subsection 33.1(2) of the Act, require the operator of the Kitsault Mine to extend the final discharge point of any outfall structure to a depth between 50 and 100 m below mean sea level.

(3) Solid tailings particles may

(*a*) be deposited on that portion of the bed of Alice Arm in the vicinity of the final discharge point of the outfall structure where the bed is at a depth of less than 100 m but more than 50 m below mean sea level; and

(*b*) be suspended in the waters of Alice Arm in the vicinity of the final discharge point of the outfall structure where the water is less than 100 m deep but more than 50 m deep (mean sea level).

(4) Where the Minister has made an order referred to in subsection (2) that requires the final discharge point of any outfall structure to extend to a depth greater than 50 m below mean sea level, the reference to 50 m below mean sea level in paragraphs (3)(*a*) and (*b*) shall be deemed to be references to the depth specified in the order.

Solid Portion of Mill Process Effluent

8. The mill process effluent shall not be deposited into the waters of Alice Arm unless

(*a*) the solid portion of the mill process effluent originates from ore mined from the Kitsault Mine; and

(*b*) the solid portion of mill process effluent deposited since the date of the coming into force of these Regulations does not exceed in weight 100,000,000 t.

Liquid Portion of Mill Process Effluent

9. (1) The mill process effluent shall not be deposited into the waters of Alice Arm unless, before any dilution of the liquid portion of the mill process effluent after it leaves the mill,

(*a*) the liquid portion of the mill process effluent passes the acute lethality test for fish, described in the schedule, and

(*b*) the monthly arithmetic mean of the dissolved concentration of any deleterious substance prescribed by section 4 contained in the liquid portion of the mill process effluent, listed in column I of an item of the table to this section, is less than the concentration set out in column II of that item and the daily dissolved concentration of the substance monitored in accordance with subsection (2) is less than the concentration, set out in column III of that item,

using composite samples.

Exutoires

7. (1) Sous réserve des conditions de l'ordonnance du Ministre visée au paragraphe (2), le point de rejet final des exutoires pour le rejet des effluents des installations de préparation du minerai de la mine Kitsault doit être à au moins 50 m sous le niveau moyen de la mer.

(2) Lorsque le Ministre a la preuve que le rejet des effluents des installations de préparation du minerai ne se conforme pas au sous-alinéa 5*b*)(ii) ou au paragraphe 6(2), il peut, au moyen d'une ordonnance décrétée en vertu du paragraphe 33.1(2) de la Loi, exiger de l'exploitant de la mine Kitsault la relocalisation de tout point de rejet final de l'exutoire à une profondeur variant entre 50 et 100 m sous le niveau moyen de la mer.

(3) Les particules solides de stériles peuvent

a) être rejetées sur la partie du fond du bras Alice, dans le voisinage du point de rejet final de l'exutoire, si le fond se trouve à plus de 50 et à moins de 100 m sous le niveau moyen de la mer; et

b) rester en suspension dans le bras Alice, dans le voisinage du point de rejet final de l'exutoire, à une profondeur variant entre 50 et 100 m sous le niveau moyen de la mer.

(4) Lorsque le Ministre a rendu l'ordonnance visée au paragraphe (2) qui exige la relocalisation du point de rejet final de l'exutoire à une profondeur de plus de 50 m sous le niveau moyen de la mer, cette profondeur est censée viser la limite de 50 m paraissant aux alinéas (3)*a*) et *b*).

Fraction solide des effluents des installations de préparation du minerai

8. Les effluents des installations de préparation du minerai ne peuvent être rejetés dans le bras Alice que

a) si leur fraction solide provient de minerais extraits de la mine Kitsault; et

b) jusqu'à ce que leur fraction solide représente 100,000,000 t depuis la date d'entrée en vigueur du présent règlement.

Fraction liquide des effluents des installations de préparation du minerai

9. (1) Les effluents des installations de préparation du minerai peuvent être rejetés dans le bras Alice si des examens d'échantillons composites établissent que la fraction liquide de ces effluents, avant sa dilution à la sortie des installations

a) satisfait au contrôle de létalité aiguë pour les poissons, décrit en annexe; et

b) si les moyennes arithmétiques mensuelles de la concentration des substances visées à l'article 4, contenues dans cette fraction liquide et figurant au tableau du présent article sont moindres que celles visées à la colonne II, et si la concentration journalière dissoute des substances contrôlées conformément au paragraphe (2) est inférieure à celles visées à la colonne III.

(2) The daily dissolved concentration referred to in paragraph (1)(*b*) shall be monitored at the intervals and in the manner directed in writing by the Minister pursuant to subsection 33(14) of the Act.

TABLE

Item	Column I Substance	Column II Monthly Arithmetic Mean Concentration	Column III Daily Concentration
1.	arsenic	0.40 mg/ℓ	0.60 mg/ℓ
2.	copper	0.05 mg/ℓ	0.10 mg/ℓ
3.	lead	0.05 mg/ℓ	0.10 mg/ℓ
4.	nickel	0.20 mg/ℓ	0.4 mg/ℓ
5.	zinc	0.10 mg/ℓ	0.20 mg/ℓ
6.	radium 226	10.0 p Ci/ℓ	20.0 p Ci/ℓ
7.	cadmium	0.01 mg/ℓ	0.02 mg/ℓ

Recovery of Lead, Zinc, or Cadmium

10. Prior to and during the operation of the Kitsault Mine, the operator thereof shall, through research, work diligently toward the development of methods to recover and, if it is practical to do so, shall recover lead, zinc and cadmium from the tailings for sale as concentrates or for disposal on land as separate tailings.

SCHEDULE

THE MEASUREMENT OF ACUTE LETHALITY IN THE LIQUID PORTION OF MILL PROCESS EFFLUENT

1. (1) For the purposes of this schedule, the applicable portions of section 231 of the publication Standard Methods for the Examination of Water and Wastewater, 13th edition (1971), published jointly by the American Public Health Association, American Water Works Association and the Water Pollution Control Federation shall be used as a basis for this test procedure except as otherwise provided in this schedule.

(2) The bioassay sample shall be the liquid portion of a composite sample.

(3) When the bioassay sample is transported or stored, the sample shall be kept in filled, sealed containers excluding any air.

(4) The sample shall not be aerated during storage and shall not be held more than five days prior to the commencement of this test procedure.

(5) Rainbow trout (*Salmo gairdneri* Richardson) shall be used as the test species of fish.

(6) Only healthy stocks of fish acclimated to fresh water shall be used as test fish.

(2) La concentration journalière dissoute visée à l'alinéa (1)*b*) doit être contrôlée aux intervalles et de la manière ordonnés par écrit par le Ministre conformément au paragraphe 33(14) de la Loi.

TABLEAU

Article	Colonne I Substance	Colonne II Moyenne arithmétique mensuelle de la concentration	Colonne III Concentration journalière
1.	Arsenic	0.40 mg/ℓ	0.60 mg/ℓ
2.	Cuivre	0.05 mg/ℓ	0.10 mg/ℓ
3.	Plomb	0.05 mg/ℓ	0.10 mg/ℓ
4.	Nickel	0.02 mg/ℓ	0.04 mg/ℓ
5.	Zinc	0.10 mg/ℓ	0.20 mg/ℓ
6.	Radium 226	10.0 p Ci/ℓ	20.0 p Ci/ℓ
7.	Cadmium	0.01 mg/ℓ	0.02 mg/ℓ

Récupération du plomb, du zinc ou du cadmium

10. Avant et pendant l'exploitation de la mine Kitsault, l'exploitant doit diligemment entreprendre la recherche nécessaire à la mise au point de méthodes de récupération du plomb, du zinc et du cadmium à partir des stériles et, si possible, les appliquer, afin de vendre ces métaux sous forme de concentrés ou de les épandre séparément sur le sol, sous forme de stériles distincts.

ANNEXE

CONTRÔLE DE LA LÉTALITÉ AIGUË DE LA FRACTION LIQUIDE DES EFFLUENTS DES INSTALLATIONS DE PRÉPARATION DU MINERAI

1. (1) Aux fins de la présente annexe, les parties applicables de la section 231 du recueil «Standard Methods for the Examination of Water and Wastewater», 13e édition (1971), publiée conjointement par l'American Public Health Association, l'American Water Works Association et la Water Pollution Control Federation servant de fondement opératoire au présent contrôle, sous réserve des dispositions de la présente annexe.

(2) L'échantillon soumis au contrôle biologique doit être la fraction liquide d'un échantillon composite.

(3) L'échantillon soumis au contrôle biologique qui est transporté ou entreposé, doit être conservé dans des contenants hermétiques, remplis de manière à exclure toute trace d'air.

(4) L'échantillon ne doit pas entrer au contact de l'air pendant l'entreposage et ne doit pas être conservé plus de cinq jours avant le début des contrôles.

(5) L'espèce utilisée dans le contrôle doit être la truite arc-en-ciel (*Salmo gairdneri* Richardson).

(6) Seules des truites acclimatées à l'eau douce et en bonne santé doivent être utilisées pour le contrôle.

(7) Individual test fish shall weigh between 0.5 and 10 g and the length of the largest fish in a test vessel shall not be more than two times the length of the smallest fish in the same test vessel.

(8) A minimum of five test fish shall be exposed to a 100% concentration of the bioassay sample for a period of 96 hours and an equal number of control fish shall be exposed to control water during that period.

(9) The test is rendered invalid if more than 10% of the fish in the control water die.

(10) For every one g of fish, there shall be at least one ℓ of bioassay sample or control water for every 24 hours that the fish are exposed to the sample or control water.

(11) The water depth in any test vessel shall not be less than 15 cm.

(12) Immediately prior to the commencement of this test procedure, the pH of the bioassay sample shall be measured and if it is outside the pH range of 6.5 to 7.5, the pH shall be adjusted to 7.0 ± 0.5.

(13) If the dissolved oxygen concentration of the bioassay sample is less than 7 mg per litre, the sample shall be aerated, prior to the commencement of this procedure test, for not more than two hours at a rate of 5.0 to 7.5 cc of air per minute per litre.

(14) An aeration rate of 5.0 to 7.5 cc per minute per litre shall be applied to the bioassay sample and control water throughout the duration of the test.

(15) The temperature of the bioassay sample and the control water shall be 15 ± 1°C throughout the duration of the test.

(16) The total number of dead fish shall be counted after 96 hours or at the termination of the test and dead fish shall be removed at least once each day.

(17) If a sample of incoming water to the mine kills 10% or more of the fish placed in the sample during a 96 hour period when tested in accordance with the test procedure contained in this schedule, the bioassay sample is invalid.

2. A bioassay sample passes the acute lethality test if not more than 50% of the fish die when tested in accordance with the test procedure set out in section 1 of this schedule.

(7) Les poissons servant au contrôle doivent peser entre 0.5 et 10 g, et, dans un récipient donné, la longueur du plus gros poisson ne doit pas être plus du double de celle du plus petit poisson.

(8) Au moins cinq poissons doivent séjourner pendant 96 h dans l'échantillon soumis au contrôle biologique. Les témoins, en nombre égal, à ceux qui servent au contrôle, doivent rester dans le milieu témoin pendant le même nombre d'heures.

(9) Le contrôle est nul si plus de 10% des poissons témoins meurent.

(10) La proportion à observer est de 1ℓ d'échantillon soumis au contrôle biologique ou de 1ℓ de milieu témoin par gramme de poisson et par période de 24 h.

(11) La profondeur de l'eau dans les récipients utilisés doit être d'au moins 15 cm.

(12) On doit mesurer le pH de l'échantillon soumis au contrôle biologique immédiatement avant le début du contrôle. Si le pH est inférieur à 6.5 ou supérieur à 7.5, on doit l'ajuster à 7.0 avec un écart 0.5.

(13) Si la teneur en oxygène dissous dans l'échantillon soumis au contrôle biologique est inférieure à 7 mg/ℓ, cet échantillon doit être aéré, avant le début du contrôle, pendant une période ne dépassant pas 2 h, à raison de 5.0 à 7.5 cm^3/min/ℓ d'air.

(14) On doit aérer l'échantillon soumis au contrôle biologique et le milieu témoin à raison de 5.0 à 7.5 cm^3/min/ℓ pendant toute la durée du contrôle.

(15) On doit s'assurer que la température de l'échantillon soumis au contrôle biologique et du milieu témoin restent à 15 avec un écart de 1° C pendant toute la durée du contrôle.

(16) On doit noter le nombre total de poissons morts après 96 h, ou à la fin du contrôle. On doit retirer les poissons morts au moins une fois par jour.

(17) Si au moins 10% des poissons meurent dans un échantillon des eaux d'alimentation de la mine au cours d'un contrôle de 96 h, conforme à la présente méthode, on doit rejeter l'échantillon soumis au contrôle biologique.

2. L'échantillon soumis au contrôle biologique satisfait au contrôle de létalité aiguë réalisé selon l'article 1 de la présente annexe si la mortalité des poissons ne dépasse pas 50%.

QUEEN'S PRINTER FOR CANADA, OTTAWA, 1979 IMPRIMEUR DE LA REINE POUR LE CANADA, OTTAWA, 1979

APPENDIX 2

STATION COORDINATES

A - Core and Grab Stations - October 1978

B - Grab Stations - May 1980

APPENDIX 2A: COORDINATES AND DEPTHS
ALICE ARM, OCTOBER 1978

STATION	COORDINATE		DEPTH (metres)	SAMPLER
A-1	55°28.2'N	129°28.9'W	76	box core
A-2	27.3'	29.6'	112	box core
A-3	27.2'	29.3'	54	grab
A-4	26.9'	31.1'	135	grab
A-5	26.75'	31.0'	225	box core
A-6	26.6'	30.9'	162	grab
A-7	27.2'	34.2'	225	grab
A-8	26.95'	34.35'	360	box core
A-9	26.7'	34.5'	225	grab
A-10	25.6'	40.3'	202	box core
A-11	24.8'	41.1'	72	grab
A-12	24.75	40.7'	81	box core
A-13	24.7'	40.3'	59	grab
A-14	22.0'	42.4'	148	box core
A-15	24.6'	48.6'	58	box core
A-16	28.9'	45.4'	297	box core

APPENDIX 2B: STATION INFORMATION ON SMITH-MACINTYRE GRABS, MAY 1980

STATION	LATITUDE	LONGITUDE	DEPTH m	DEPTH fms	REMARKS
Upper Estuary					
Kitsault River	55°28.80'N	129°28.80'W	-	-	Samples obtained by hand from drying tidal flats in the upper intertidal zone, coarse sand, pebbles.
Lower Estuary					
Estuary #1	28.2'	28.9'	88	48	Coarse sand, thin surface layer of darker brown mud
Estuary #2	27.9'	28.96'	98	54	Light brown surface ooze over grey mud
Alice Arm-Head					
AA-1	28.22'	29.6'	85	46	Soft light brown surface layer, over dark grey mud
AA-2	27.9'	29.25'	104	57	Similar to A-1
AA-3	27.63'	28.95'	97	53	Similar to A-1
BB-1	27.25'	30.0'	79	43	Brown surface mud (=2cm) overlying hard packed grey mud
BB-2	27.05'	29.95'	159	87	Dark grey sediment
BB-3	26.94'	29.92'	63	34	Coarser texture than B-2, Pyrite particles
A-5(IOS)	26.75'	30.8'			Box core-light brown surface over grey
CC-1	26.95'	31.8'	86	47	Light brown surface layer overlying grey
CC-2	26.90'	31.8'	154	84	Light brown surface layer overlying grey
CC-3	26.69'	31.8'	278	152	Thin light brown surface layer over grey, fine texture
CC-4	26.43'	31.8'	135	74	Similar to C-3
Alice Arm-Middle					
DD-1	27.32'	33.95'			Bottom too steep
DD-2	27.28'	33.95'	110	60	Brown colored soft mud
DD-2(a)	27.25'	33.95'	110	60	Bottom of dredge sample-blue clay
DD-3	26.95'	33.95'	350	191	Fine mud, light brown surface layer over grey

APPENDIX 2B: STATION INFORMATION ON SMITH-MACINTYRE GRABS, MAY 1980
(Continued)

STATION	LATITUDE	LONGITUDE	DEPTH m	DEPTH fms	REMARKS
Alice Arm-Middle (continued)					
DD-4	55°26.52'N	12°33.95'	172	94	No sample-slope too steep
EE-2	27.35'	37.05'	93	51	Dark grey mud, trace of light brown on surface
EE-3.5	27.15'	37.05'	380	208	Off centre-greyish brown,soft mud throughout dredge
EE-4	26.92'	37.05'	137	75	Misfired, no sample
A-17(IOS)	27.1'	37.8'	383	209	Brown surface mud (=2cm) grey sediment beneath-15cm, box core sample
Alice Arm-Mouth					
FF-1	26.6'	39.58'	162	88	Light brown surface mud, dark grey beneath
FF-2	26.54'	39.58'	257	140	Light brown surface mud, dark grey beneath
FF-2			257	140	Replicate same
FF-3	26.4'	39.58'	280	153	Sand, light brown surface mud, rock
FF-4	26.3'	39.58'	124	68	Sand, rock
FF-5	26.22'	39.58'	52	28	River mouth, coarse sand, gravel
G-1	25.5'	40.34'	178	97	Similar in color & texture to H-1 & H-2
Alice Arm-Mouth					
HH-1a	24.75'	41.1'	83	45	Stations sampled twice to determine variability between grabs. Fine light brown surface mud over dark grey
HH-1b			86	47	
HH-2a	24.75'	39.8'	86	47	Similar to HH-1
HH-2b			86	47	Similar to HH-1
HH-3a	24.75'	40.3'	71	39	Similar color pattern to H-1 & H-2, but slightly coarser texture
Anyox					
A-15	24.6	48.6'	58	32	Coarse sand (slag), pyrite present

APPENDIX 3

STANDARD REFERENCE MATERIAL

A - Sediment

B - Tissue

Appendix 3

Sediment Standard Reference Materials - EPS Laboratory Results

For - Cd, Cu, Pb, Zn (6 month period).

BCSS-1 Marine Sediment[1]

	Certified Value (Mg/g)	Lab. Serv. Value (Mg/g)	% Variation	No. of values	Deviation from Certified Value	% Deviation from Certified Value
Cd	0.25 ± .04	0.5		11	-	-
Cu	18.5 ± 2.7	17.5 ± 1.9	11%	11	- 1	- 5.4 %
Pb	22.7 ± 3.4	20.4 ± 2.0	10%	11	- 2.3	- 10 %
Zn	119 ± 12	102 ± 4	4%	11	- 17	- 14 %

MESS - 1 Marine Sediment [1]

Cd	0.59 ± .10	.72 ± .12	17%	6*	+ 1.3	+ 22%
Cu	25.1 ± 3.8	26.1 ± 3.1	12%	12	+ 1	+ 3.9%
Pb	34.0 ± 6.1	38.7 ± 2.3	8%	12	- 5.3	- 16%
Zn	191 ± 17	174 ± 7	4%	12	- 17	- 8.9%

NBS - 1645 River Sediment[1]

Cd	10.2 ± 1.5	8.0 ± 2.1	26%	11	- 2.2	- 22%
Cu	109 ± 19	120 ± 12	10%	12	+ 11	+ 10%
Pb	714 ± 28	636 ± 51	8%	12	- 78	- 11%
Zn	1720 ± 169	1670 ± 96	8%	12	- 50	- 2.9%

* Detection Limit lowered - only 6 values for new limit.

Note: 1. Certified values are total. Lab. Serv. values are strong acid leach and should be within or less than certified range.

2. The quantity of element leached depends on the geochemistry and the sample will vary from sample to sample.

[1] BCSS-1 and MESS 1 obtained from the National Research Council of Canada, Division of Chemistry, Marine Analytical Chemistry Standards Program.

[2] 1645 River Sediment obtained from U.S. Department of Commerce, National Bureau of Standards.

APPENDIX 3B: TISSUE STANDARD REFERENCE MATERIALS - EPS LABORATORY RESULTS

Elements	NBS 1577 - Bovine Liver (1978-1982 Data)		NBS 1566 - Oyster Tissue (1979-1982 Data)	
(ICAP)	Certified (ug/g dry)	Found	Certified (ug/g dry)	Found
As	0.053 ± 0.01	L 2.	13.4 ± 1.9	12.1 ± 1.3
Cd	0.27 ± 0.04	0.31 ± 0.05	3.5 ± 0.4	3.6 ± 0.3
Cr	0.65 ± 0.73	0.60 ± 0.14	0.65 ± 0.27	0.79 ± 0.15
Mn	10.3 ± 1.0	9.59 ± 0.31	17.5 ± 1.2	16.3 + 1.2
Mo	3.1 ± 0.5	3.48 ± 0.16	(L0.2)	0.2 ± 0.1
Cu	193 ± 10	195 ± 10	63.0 ± 3.5	65.5 ± 4.1
Zn	130 ± 10	137 ± 6	852 ± 14	857 ± 46
Fe	270 ± 20	255 ± 8	195 ± 34	162 ± 9
Mg	587 ± 20 (605)	590 ± 29	0.128 ± 0.009	0.118 ± 0.00
(Graphite Furnace)				
Pb	0.34 ± 0.08	0.43 ± 0.02	0.48 ± 0.04	0.45 ± 0.03

APPENDIX 4

SEDIMENT TRACE METAL DATA

A - 1978 Core and Grab Samples

B - 1980 Grab Samples

APPENDIX 4A: TRACE METAL CONCENTRATIONS FOUND IN CORE AND GRABS SAMPLES - ALICE ARM, OCTOBER 1978

STATION	CORE DEPTH (cm)	TRACE METALS - mg/kg, dry weight Cu	Pb	Zn	Cd	Fe (%)	Ni	Mn	Co	Ag	U	(pCi/gm) Ra 226	Pb 210	Th 230
A-1	0-2	55.25	22.0	124.70	3.18	3.12	28.44	766.05	16.00	0.53	1.5	1.5	2	0.7
Head Alice Arm	10-12	68.27	24.00	137.53	5.39	3.13	25.34	462.03	16.00	0.71				
A-2	0-2	69.33	54.00	175.28	6.65	3.39	33.91	1163.64	19.00	0.88				
Lime Creek	10-12	80.00	110.00	220.22	13.87	3.35	25.74	831.66	18.00	1.26				
Centre Channel	20-22	120.89	263.00	373.03	43.02	2.99	13.66	684.49	18.00	3.12				
A-3	0-6	74.67	84.00	204.04	12.44	3.35	37.25	684.49	19.00	1.20				
Lime Creek														
A-4	0-6	73.60	82.00	202.25	10.05	3.39	31.45	917.22	19.00	1.05				
Pearson Point North Shore														
A-5	0-2	65.78	55.00	170.79	4.80	3.35	35.55	2156.15	17.00	0.90	1.0	1.2	2	0.5
Pearson Point-	10-12	73.60	82.00	204.04	9.01	3.35	37.03	684.49	16.00	1.00	1.5	1.1	2	0.7
Centre Channel	20-22	97.78	210.00	314.61	30.12	2.46	20.75	684.49	12.00	2.12	1.5	1.2	1	0.8
	30-32	85.33	137.00	301.12	26.48	2.46	20.98	708.45	12.00	1.39	1.5	1.2	L1	0.6
	40-42	79.29	54.00	269.66	14.29	3.35	35.47	845.35	16.00	1.49	1.5	0.9	3	0.7
A-6	0-6	72.18	86.00	197.75	7.76	3.35	33.59	1078.07	17.00	1.09				
Roundy Creek														
A-7	0-6	65.07	63.00	204.04	5.50	3.48	38.61	1191.02	18.00	1.12				
Alice Arm- North Shore														
A-8	0-2	60.44	55.00	170.79	3.76	3.35	38.58	4449.20	18.00	0.69				
Alice Arm-	10-12	69.33	73.00	238.00	10.74	3.13	36.07	2053.48	18.00	1.46				
Centre	20-22	61.51	61.00	319.10	12.48	3.44	40.05	2737.97	19.00	3.04				
	30-32	61.51	49.00	346.07	15.49	3.30	36.51	1813.90	18.00	4.43				
A-9	0-6	66.49	70.00	197.75	5.75	3.26	38.63	2669.52	19.00	1.07				
Alice Arm-South														
A-10	0-2	44.44	30.00	130.34	3.07	2.90	46.50	3422.46	29.00	0.63	1.5	1.7	3	0.5
Alice Arm-	10-12	40.18	10.00	106.07	2.15	2.63	51.28	455.19	17.00	0.29				
Base of sill														
A-11	0-6	43.34	24.00	110.44	1.55	2.54	38.20	467.28	15.00	0.29				
Outside sill- North Shore														
A-12	0-2	40.45	18.00	101.60	1.52	2.54	40.35	588.43	14.00	0.29				
Outside sill-	10-12	45.15	30.00	121.92	2.84	2.63	41.86	449.97	14.00	0.52				
Centre	20-22	58.87	12.00	106.02	1.40	2.45	42.11	425.74	15.00	0.35				
	30-32	39.73	9.00	91.00	1.93	2.45	43.95	404.98	15.00	0.00				

APPENDIX 4A: TRACE METAL CONCENTRATIONS FOUND IN CORE AND GRABS SAMPLES - ALICE ARM, OCTOBER 1978
(Continued)

STATION	CORE DEPTH (cm)	TRACE METALS - mg/kg, dry weight Cu	Pb	Zn	Cd	Fe (%)	Ni	Mn	Co	Ag	U	(pCi/gm) Ra 226	Pb 210	Th 230
A-13 Outside sill-East Shore	0-6	42.26	20.00	108.67	1.77	2.54	40.69	463.82	15.00	0.44				
A-14 Pass	0-2	52.01	18.00	121.04	1.12	2.81	46.24	2146.02	18.00	0.18				
	10-12	59.59	21.00	123.69	0.87	2.85	46.09	501.89	17.00	0.15				
	20-22	74.04	24.00	135.17	2.06	2.85	40.15	498.43	17.00	0.45				
	30-32	83.07	17.00	128.11	1.52	2.85	39.22	443.05	17.00	0.30				
	40-42	36.12	14.00	110.44	1.48	2.90	42.40	449.97	17.00	0.25				
A-15 Anyox	0-2	624.83	11.00	2032.02	23.97	11.14	21.08	363.44	100.00	0.92				
	10-12	660.95	10.00	2208.72	27.52	13.15	23.18	339.21	140.00	0.81				
	20-22	650.11	9.00	2385.42	29.40	13.37	22.94	370.36	140.00	0.92				
A-16 Hastings Arm Carr Point	0-2	65.01	19.00	135.17	3.85	3.07	33.36	2942.13	17.00	0.39	1.5	1.6	3	0.6
	10-12	74.04	22.00	145.78	4.14	3.30	37.11	1540.29	19.00	0.45	2.0	1.3	4	0.8
	20-22	75.85	23.00	150.19	2.26	3.34	35.01	1903.73	19.00	0.40	2.0	1.7	4	1.1
	30-32	83.07	20.00	148.43	3.51	3.39	36.52	1938.34	20.00	0.38	1.5	1.9	2	0.9
	40-42	74.04	15.00	132.52	2.98	3.25	33.99	1055.71	18.00	0.24	3.0	1.1	2	1.0
	50-52	108.35	17.00	145.78	2.76	3.34	35.13	1730.67	20.00	0.39				
NBS Copper Mill Tailings-Certified (910±10, Cu)		830.7	3.6	28.7	0.0	1.8	23.2	79.6	29	0.03				

APPENDIX 4B: SEDIMENT TRACE METAL CONCENTRATIONS IN SURFACE GRABS - ALICE ARM, MAY 1980

STATION	DEPTH (m)	Mo	Cu	Pb	Zn	Cd	Fe(%)	Ni	Mn	Cr	Ti	V	Hg	Al	Si
		mg/kg, dry weight													
Kitsault River		L18.3	43.9	52.5	96.5	L0.54	4.43	20.4	685	27.6	990	122.0	0.195	19350	2640
Illiance River		L18.5	52.2	60.1	201.0	0.83	6.97	29.4	1155	33.4	975	183.5	0.179	20400	3285
Illiance Point		L18.4	45.4	92.0	164.0	L0.54	4.29	19.9	1095	27.8	1019	112.0	0.078	20200	2890
#1 (estuary)	88	L18.6	58.0	68.1	129.0	0.97	4.03	26.6	872	29.0	1025	100.4	0.322	21300	2760
#1 (estuary)	88	L18.5	58.7	68.8	132.5	0.97	4.06	26.3	869	29.2	1014	98.8	0.328	21200	3130
#2 (estuary)	98	75.1	75.6	125.5	203.5	2.31	4.32	33.9	1120	35.6	991	114.5	0.296	26150	2220
AA-1	85	31.5	74.9	100.7	180.0	1.28	4.59	34.7	1125	35.1	985	118.5	0.304	27150	3235
AA-2	104	65.6	70.0	139.5	221.5	3.74	4.23	32.6	1195	33.5	1010	104.5	0.288	23800	2845
AA-2	104	92.3	78.1	149.5	255.5	3.12	4.27	33.3	1120	32.9	1035	98.3	0.322	22600	2620
AA-3	97	151.5	75.8	191.5	268.0	6.24	3.68	31.6	877	30.4	1040	87.4	0.328	20750	3230
BB-1	79	49.6	75.2	179.5	358.0	4.46	4.12	33.9	1180	33.7	1150	98.7	0.365	21200	2860
BB-2	159	137.0	80.6	128.0	222.5	3.53	4.17	50.3	969	45.6	1165	111.5	0.166	25900	2855
BB-3	63	115.5	62.2	120.5	221.5	3.70	3.65	47.4	692	58.8	1200	95.2	0.119	20000	2485
A-5(IOS)	225	112.5	70.3	130.5	212.5	1.85	4.37	44.0	1840	47.8	1011	114.5	0.253	27400	3370
A-5(IOS)	225	120.0	74.3	158.5	231.0	L0.56	3.99	35.4	1040	37.7	1035	96.4	0.328	22350	2665
CC-1	86	88.0	81.0	147.0	204.5	1.34	4.22	40.5	1120	41.4	1175	123.0	0.163	27500	2320
CC-2	154	104.5	82.4	141.0	207.5	1.80	4.23	41.4	1260	41.4	1140	115.5	0.155	26450	3020
CC-3	278	105.0	79.5	145.5	209.0	2.19	4.16	42.5	1595	44.4	1165	119.0	0.169	27150	2550
CC-4	135	61.3	80.6	151.5	208.0	1.62	4.05	39.7	953	45.0	1140	118.5	0.238	28950	2330
DD-2	110	28.4	67.9	120.0	189.5	0.62	4.57	51.9	1110	61.2	1185	122.5	0.154	28700	3000
DD-2a	110	L19.1	73.9	170.0	268.0	1.67	4.44	43.1	999	49.8	1185	120.0	0.267	27900	2615
DD-3	350	38.4	70.7	122.5	186.0	1.11	4.32	47.4	2280	53.4	1170	127.5	0.177	28900	2545
EE-2	93	L18.6	73.0	145.5	230.5	1.09	4.31	48.3	960	60.4	1240	125.0	0.243	30450	2830
EE-3.5	380	L18.7	60.4	89.1	164.0	0.68	4.30	50.5	2300	61.1	1160	118.0	L0.098	27500	2805
A-17(IOS)	383	L18.7	51.4	86.4	144.5	0.59	4.09	46.7	1995	61.3	996	105.0	0.184	26450	2675
FF-1	162	L18.5	44.6	64.7	123.5	L0.56	3.65	49.9	715	66.8	1120	96.0	L0.147	23050	2455
FF-2	257	L18.5	36.3	55.4	99.7	L0.56	3.73	41.9	1225	53.8	1065	84.3	0.168	19700	2425
FF-2	257	L18.4	34.4	56.1	107.0	L0.56	3.78	42.0	1055	56.3	1150	88.4	L0.100	20550	2440
FF-3	280	L18.3	31.5	47.7	87.4	L0.55	3.53	38.8	1440	50.3	1040	79.4	0.126	18050	1935
G-1	178	L18.3	39.6	60.8	106.5	0.55	3.45	41.8	656	53.9	1060	80.4	0.168	20200	2155
HH-1a	83	L18.5	39.9	56.8	108.5	L0.56	3.47	41.3	650	52.1	1065	78.0	0.130	19950	2565
HH-2a	86	L18.5	37.2	52.1	104.0	L0.56	3.50	40.4	624	40.6	1110	76.1	0.126	19150	2160
HH-3a	71	L18.6	29.7	47.0	93.2	L0.56	3.03	33.9	566	46.7	1100	67.8	L0.094	17000	2300
HH-1b	86	L18.2	40.0	60.3	107.5	L0.55	3.50	41.0	676	52.7	1050	79.8	0.126	20500	2215
HH-2b	86	L18.6	33.5	53.4	98.9	L0.56	2.94	35.7	556	51.2	1160	74.0	L0.098	18850	2235
HH-3b	66	L18.6	34.7	55.0	97.1	L0.56	3.31	39.0	630	49.7	1070	74.3	0.139	19000	2000
A-15	58	L18.4	595.0	53.8	1725.0	6.83	11.7	23.0	516	41.0	1055	106.5	0.782	28400	3630

APPENDIX 5

TISSUE SAMPLING STATION COORDINATES

A - Otter Trawls - 1978 through 1981

B - Intertidal Stations - 1977

C - Intertidal Stations - 1978

APPENDIX: 5A OTTER TRAWL COORDINATES AND DEPTHS, ALICE ARM AND HASTINGS ARM, CHATHAM SOUND, LAREDO SOUND AND QUATSINO SOUND, 1978 THROUGH 1981.

TRAWL NO.	DATE	DEPTH (metres)		LATITUDE	LONGITUDE
A-1	1978, May & October 1980	start:	235	55°26.72'N	129°31.95'W
		finish:	182	55°26.83'N	129°30.33'W
A-2	1978	start:	355	55°27.10'N	129°36.86'W
		finish:	362	55°27.00'N	129°35.05'W
A-3	1978, May & October 1980	start:	55	55°25.11'N	129°40.58'W
		finish:	91	55°24.09'N	129°41.08'W
H-1	1978	start:	265	55°33.82'N	129°47.68'W
		finish:	247	55°34.82'N	129°47.78'W
H-2	1978	start:	307	55°28.91'N	129°45.49'W
		finish:	293	55°29.91'N	129°45.89'W
H-3	1978	start:	172	55°24.04'N	129°42.72'W
		finish:	168	55°25.02'N	129°42.99'W
H-4	1978, May 1980	start:	115	55°23.88'N	129°49.55'W
		finish:	59	55°24.65'N	129°48.52'W
C-1	May 1981	start:	117	54°24.14'N	130°33.70'W
		finish:	124	54°25.09'N	130°33.92'W
C-1	October 1981	start:	81	54°10.30'N	130°25.55'W
		finish:	88	54° 9.79'N	130°24.03'W
L-1	October 1981	start:	180	52°37.50'N	128°51.31'W
		finish:	165	52°36.43'N	128°50.45'W
O-1	September 1981	start:	128	50°25.80'N	127°58.71'W
		finish:	128	50°24.84'N	127°59.14'W

APPENDIX: 5B INTERTIDAL SAMPLING STATION COORDINATES - ALICE ARM AND HASTINGS ARM - 1977.

STATION	SPECIES	LATITUDE	LONGITUDE
AAW	*Mytilus edulis*, *Fucus distichus*	55° 28.19'N	129° 29.58'W
LC	"	55° 27.20'N	129° 29.09'W
A-1-N	"	55° 27.35'N	129° 30.09'W
A-2-N	"	55° 27.47'N	129° 34.64'W
A-2-S	"	55° 26.70'N	129° 35.67'W
A-3-N	*Fucus distichus*	55° 25.31'N	129° 40.82'W
A-3-S	"	55° 25.06'N	129° 40.05'W
H-2-E	*Mytilus edulis*, *Fucus distichus*	55° 28.42'N	129° 43.70'W
H-2-W	"	55° 28.34'N	129° 45.95'W
H-4-N	"	55° 24.53'N	129° 49.50'W

APPENDIX: 5C INTERTIDAL SAMPLING STATION COORDINATES - ALICE ARM AND HASTINGS ARM - 1978.

STATION	SPECIES	LATITUDE	LONGITUDE
A-1-S	*Mytilus edulis*, *Fucus sp.*	55° 26.92'N	129° 29.48'W
A-1-N	"	55° 27.35'N	129° 30.09'W
AAW	"	55° 28.19'N	129° 29.58'W
LC	"	55° 27.20'N	129° 29.09'W
A-2-S	"	55° 26.70'N	129° 35.67'W
A-2-N	"	55° 27.47'N	129° 34.64'W
A-3-S	"	55° 25.06'N	129° 40.05'W
A-3-N	"	55° 25.31'N	129° 40.82'W
H-3-E	"	55° 25.19'N	129° 42.55'W
H-4-N	"	55° 24.53'N	129° 49.50'W
R	"	55° 23.15'N	129° 50.21'W
GP	"	55° 25.00'N	129° 47.59'W
JP	"	55° 25.64'N	129° 47.42'W
L	"	55° 26.12'N	129° 44.82'W

APPENDIX 6

TISSUE SAMPLE DESCRIPTION - 1978

A - Trawl Samples - October 1978

B - Intertidal Samples - October 1978

APPENDIX 6A: DESCRIPTION OF COMPOSITE TISSSUE SAMPLES TAKEN FROM OTTER TRAWL CATCH ALICE ARM AND HASTINGS ARM, OCTOBER 1978

SAMPLE NO.	STATION	TISSUE	NUMBER OF INDIVIDUALS IN COMPOSITE
Pandalus borealis - pink shrimp			
15	A-1	muscle	20 (small)
53		muscle	20 (small)
61		muscle	2
16		whole	2
48		whole	2
62		whole	2
59	A-2	muscle	2
26	A-3	muscle	1 (large)
13	H-2	muscle	20 (small)
14		whole	2
51	H-3	muscle	20 (small)
52		muscle	20 (small)
56	H-4	muscle	20 (small)
57		muscle	20 (small)
Pandalopsis dispar - sidestripe shrimp			
39	A-1	muscle	10
40		muscle	10
42		muscle	10
37	A-2	muscle	7
38	A-3	muscle	10
43	H-1	muscle	10
45		muscle	5
44		whole	20
7	H-2	muscle	10
8		muscle	10
9		muscle	10
54		muscle	20
11		whole	10
12		whole	10
49	H-3	muscle	2
63	H-4	muscle	20
64		muscle	20
Pandalus hypsinotus - humpback shrimp			
17	H-4	muscle	7
46		whole	1
Crangon communis - shrimp			
65	A-1	muscle	20
66	A-3	muscle	20
67		muscle	20
1		muscle	10
2		muscle	10
3		muscle	10
4		muscle	10
5		whole	10
6		whole	10
68		whole	2
Lithodes aequispina - brown king crab			
32	A-1	leg muscle	1
35		leg muscle	1
31	A-2	leg muscle	1
34		leg muscle	1
36		leg muscle	1
33	H-2	leg muscle	1
Yoldia thraciaeformis - bivalve			
69	A-2	whole	20
70		whole	20
71	H-2	whole	20
Theragra chalcogramma - Pollock			
21	A-1	whole muscle	1
25		muscle/skin	1
27		muscle/skin	1
24	A-2	muscle/skin	1
29		muscle/skin	1
20	A-3	whole muscle	1
30		whole muscle	1
50		whole muscle	1
22	H-3	muscle/skin	1
23		muscle/skin	1
28		muscle/skin	1
19	H-4	whole muscle	4
Hippoglossides elassodon - flathead sole			
18	A-1	muscle/skin	1

APPENDIX 6B: SAMPLE DESCRIPTION AND SIZE RANGE
Mytilus edulis, OCTOBER 1978

SAMPLE NO.	STATION	NUMBER OF INDIVIDUALS PER SAMPLE	SIZE RANGE (mm)
3	A-1-S-78	18	46-69
5	A-1-N-78	20	36-69
14	AAW-78	30	32-40
	Lime Creek - 78		
18	purged	20	56-80
2	non-purged	17	49-66
9	A-2-S-78	20	40-51
4	A-2-N-78	20	39-58
15		24	39-56
8	A-3-S-78	20	49-59
10	A-3-N-78	20	47-60
16		20	44-62
13	H-3-E-78	20	49-66
11		19	42-69
17	H-4-N-78	30	32-54
1	B-78	20	46-58
7	GP-78	20	41-51
6	JP-78	20	41-51
12	L-78	20	45-76

APPENDIX 7

MEAN TISSUE TRACE METAL CONCENTRATIONS (mg/kg, dry weight) BY SPECIES ALICE ARM, 1977-1980

A - June 1977
B - October 1978
C - May 1980
D - October 1980

APPENDIX: 7A MEAN TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight) BY SPECIES, ALICE ARM AND HASTINGS ARM, JUNE 1977.

Station	Stat	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
						ALGAE - FUCUS DISTICHUS				- WHOLE				
A-1-N		+ .00	3.6	1.00	17.0	1.10	0	.00	.0	.00	120.0	.00	0	0
A-2-N		.00	5.3	1.00	24.0	2.10	0	.00	.0	.00	95.0	.00	0	0
A-2-S		.00	7.4	1.00	23.0	1.80	0	.00	.0	.00	37.0	.00	0	0
A-3-N		.00	4.6	1.00	14.0	1.70	0	.00	.0	.00	42.0	.00	0	0
A-3-S		.00	3.8	1.00	13.0	1.20	0	.00	.0	.00	13.0	.00	0	0
AAW		.00	4.4	1.00	28.0	1.40	0	.00	.0	.00	150.0	.00	0	0
H-2-E		.00	10.0	1.00	31.0	2.10	0	.00	.0	.00	79.0	.00	0	0
H-2-W		.00	5.4	1.40	13.0	1.20	0	.00	.0	.00	57.0	.00	0	0
H-4-N		.00	58.0	1.00	56.0	.57	0	.00	.0	.00	770.0	.00	0	0
LC		.00	7.2	1.50	41.0	1.80	0	.00	.0	.00	220.0	.00	0	0
						BIVALVE - MYTILUS EDULIS				- WHOLE BODY				
A-1-N		.00	9.6	2.10	100.0	6.50	0	.00	.0	.00	810.0	.00	0	0
A-2-N		.00	13.0	2.10	110.0	6.90	0	.00	.0	.00	260.0	.00	0	0
A-2-S		.00	10.0	1.10	99.0	6.00	0	.00	.0	.00	150.0	.00	0	0
AAW		.00	8.9	2.60	110.0	4.80	0	.00	.0	.00	380.0	.00	0	0
H-2-E		.00	9.6	1.00	87.0	4.50	0	.00	.0	.00	260.0	.00	0	0
H-2-W		.00	10.0	1.00	89.0	5.80	0	.00	.0	.00	440.0	.00	0	0
H-4-N		.00	27.0	1.00	230.0	3.30	0	.00	.0	.00	430.0	.00	0	0
LC		.00	11.0	5.00	130.0	6.60	0	.00	.0	.00	450.0	.00	0	0

+ All zeros indicate no analysis.

Trace Metal Values Derived from Composite Samples.

APPENDIX: 7B MEAN TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight) BY SPECIES, ALICE ARM AND HASTINGS ARM, OCTOBER 1978.

Station	Stat	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
						BIVALVE - Y.THRACIAEFORMIS/MONTEREYENSIS - WHOLE BODY								
+ A-1-I		6.38	292.0	60.00	682.0	13.40	57	7.30	* .0	9.24	12000.0	.00	0	0
A-2-I		8.23	435.0	9.14	681.0	17.70	47	6.86	.0	10.20	8590.0	.00	0	0
H-2-I		7.88	328.0	4.40	788.0	19.30	47	7.30	.0	3.82	4690.0	.00	0	0
						Brownring CRAB - LITHODES AEQUISPINA				- MUSCLE-LEG				
A-1-I	++ M(2)	5.93	32.9	4.25	186.5	.72	96	7.15	.0	1.11	10.3	.00	0	0
	S.D.	.08	11.0	.07	10.6	.01	6	.07	.0	.13	1.6	.00	0	0
	Max	5.99	40.7	4.30	194.0	.73	100	7.20	.0	1.21	11.4	.00	0	0
	Min	5.88	25.1	4.20	179.0	.71	91	7.10	.0	1.02	9.1	.00	0	0
A-2-I	M(3)	5.79	61.4	4.27	187.0	.72	111	7.17	.0	1.26	12.4	.00	0	0
	S.D.	.37	21.5	.12	6.2	.01	26	.12	.0	.22	1.0	.00	0	0
	Max	6.13	83.7	4.40	194.0	.73	141	7.30	.0	1.46	13.3	.00	0	0
	Min	5.39	40.7	4.20	182.0	.71	91	7.10	.0	1.02	11.4	.00	0	0
H-2-I		6.93	85.3	4.24	189.0	.71	104	7.10	.0	.94	12.7	.00	0	0
						SHRIMP - CRANGON COMMUNIS				- TAIL ONLY				
A-1-I		4.86	70.0	4.40	51.3	.99	43	7.40	.0	1.82	124.0	.00	0	0
A-3-I	M(6)	4.51	44.7	4.33	67.1	.79	41	7.20	.0	1.72	167.7	.00	0	0
	S.D.	.49	17.6	.12	10.5	.18	16	.17	.0	.99	164.1	.00	0	0
	Max	5.45	79.5	4.50	83.6	1.16	62	7.40	.0	3.43	450.0	.00	0	0
	Min	4.10	31.9	4.20	52.7	.70	21	7.00	.0	.93	35.5	.00	0	0
						SHRIMP - CRANGON COMMUNIS				- WHOLE BODY				
A-3-I	M(3)	4.08	55.9	4.40	72.4	1.05	31	7.33	.0	.68	219.7	.00	0	0
	S.D.	.10	16.8	.10	18.5	.37	12	.15	.0	.50	85.7	.00	0	0
	Max	4.18	75.1	4.50	92.3	1.45	41	7.50	.0	.98	316.0	.00	0	0
	Min	3.99	43.6	4.30	55.6	.73	19	7.20	.0	.10	152.0	.00	0	0
						SHRIMP - PANDALOPSIS DISPAR				- MUSCLE				
A-1-I	M(3)	4.79	29.2	4.23	48.6	1.03	55	7.07	.0	2.55	57.7	.00	0	0
	S.D.	.05	1.0	.15	.5	.06	4	.21	.0	.90	12.3	.00	0	0
	Max	4.85	30.1	4.40	49.0	1.10	58	7.30	.0	3.32	66.5	.00	0	0
	Min	4.75	28.2	4.10	48.1	.99	51	6.90	.0	1.56	43.7	.00	0	0
A-2-I		4.74	42.9	4.30	52.2	1.63	67	7.20	.0	1.22	46.7	.00	0	0
A-3-I	M(2)	4.97	31.7	4.35	50.1	.72	98	7.25	.0	1.46	36.2	.00	0	0
	S.D.	.27	.4	.07	1.3	.01	1	.07	.0	.69	1.5	.00	0	0
	Max	5.16	32.0	4.40	51.0	.73	99	7.30	.0	1.95	37.2	.00	0	0
	Min	4.78	31.5	4.30	49.2	.72	98	7.20	.0	.97	35.1	.00	0	0

Continued ...

APPENDIX: 7B MEAN TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight) BY SPECIES, ALICE ARM AND HASTINGS ARM, OCTOBER 1978.

Station	Stat	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
H-1-I	M(2)	5.08	36.4	4.40	49.4	1.58	38	7.30	.0	1.78	44.9	.00	0	0
	S.D.	.02	.5	.14	.2	.26	1	.14	.0	1.12	14.4	.00	0	0
	Max	5.10	36.7	4.50	49.5	1.76	38	7.40	.0	2.57	55.0	.00	0	0
	Min	5.07	36.0	4.30	49.2	1.39	37	7.20	.0	.99	34.7	.00	0	0
H-2-I	M(6)	4.87	34.7	4.33	54.8	1.34	28	7.27	.0	1.19	91.5	.00	0	0
	S.D.	.28	11.2	.10	3.8	.19	5	.16	.0	.54	40.1	.00	0	0
	Max	5.12	54.1	4.50	61.5	1.50	33	7.50	.0	2.30	140.0	.00	0	0
	Min	4.48	24.9	4.20	51.0	1.02	23	7.10	.0	.95	44.3	.00	0	0
H-3-I		4.89	33.1	4.40	47.4	.72	44	7.30	.0	.96	29.0	.00	0	0
H-4-I	M(2)	5.04	30.9	4.35	48.3	.72	9	7.20	.0	.96	138.4	.00	0	0
	S.D.	.05	4.7	.07	1.6	.01	0	.14	.0	.02	146.5	.00	0	0
	Max	5.07	34.2	4.40	49.4	.73	9	7.30	.0	.98	242.0	.00	0	0
	Min	5.00	27.6	4.30	47.2	.71	9	7.10	.0	.95	34.8	.00	0	0
					SHRIMP - PANDALOPSIS DISPAR					- WHOLE BODY				
H-1-I		4.63	96.4	4.20	657.5	34.40	23	7.00	.0	1.22	264.0	.00	0	0
H-2-I	M(2)	4.44	95.0	4.35	81.0	3.58	25	7.20	.0	1.53	676.5	.00	0	0
	S.D.	.04	4.2	.07	2.8	4.05	1	.14	.0	.45	116.7	.00	0	0
	Max	4.47	98.0	4.40	83.0	6.45	26	7.30	.0	1.85	759.0	.00	0	0
	Min	4.41	92.0	4.30	79.0	.72	24	7.10	.0	1.22	594.0	.00	0	0
					SHRIMP - PANDALUS BOREALIS					- MUSCLE				
A-1-I	M(3)	4.82	33.6	4.33	50.3	.73	57	7.23	.0	1.19	48.0	.00	0	0
	S.D.	.15	2.8	.06	2.6	.01	40	.06	.0	.36	22.3	.00	0	0
	Max	4.94	36.6	4.40	53.0	.73	103	7.30	.0	1.61	64.1	.00	0	0
	Min	4.65	31.0	4.30	47.8	.72	34	7.20	.0	.97	22.5	.00	0	0
A-2-I		4.84	49.6	4.30	57.3	.87	52	7.20	.0	.96	19.2	.00	0	0
A-3-I		4.63	21.0	4.20	47.1	.69	96	6.90	.0	1.73	17.0	.00	0	0
H-2-I		5.00	34.2	4.50	49.8	7.46	43	7.50	.0	.99	46.8	.00	0	0
H-3-I	M(2)	4.61	44.0	4.25	48.2	7.13	48	7.10	.0	2.12	40.2	.00	0	0
	S.D.	.01	9.8	.07	1.9	.06	10	.14	.0	1.66	4.1	.00	0	0
	Max	4.61	51.0	4.30	49.5	7.18	55	7.20	.0	3.30	43.1	.00	0	0
	Min	4.60	37.1	4.20	46.8	7.09	41	7.00	.0	.95	37.3	.00	0	0
H-4-I	M(2)	5.01	49.8	4.25	57.2	.71	20	7.15	.0	1.00	194.4	.00	0	0
	S.D.	.01	1.3	.07	.4	.01	2	.13	.0	.04	203.1	.00	0	0
	Max	5.02	50.7	4.30	57.4	.72	21	7.24	.0	1.03	338.0	.00	0	0
	Min	5.00	48.9	4.20	56.9	.71	18	7.06	.0	.97	50.8	.00	0	0

Continued ...

APPENDIX: 7B MEAN TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight) BY SPECIES, ALICE ARM AND HASTINGS ARM, OCTOBER 1978.

Station	Stat	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					SHRIMP - PANDALUS BOREALIS					- WHOLE BODY				
A-1-I	M(3)	4.89	102.7	5.03	60.8	2.81	24	7.30	.0	1.86	980.7	.00	0	0
	S.D.	.56	4.4	1.19	3.6	.07	2	.10	.0	.24	529.0	.00	0	0
	Max	5.50	107.0	6.40	63.2	2.86	26	7.40	.0	2.01	1580.0	.00	0	0
	Min	4.41	98.2	4.30	56.7	2.73	22	7.20	.0	1.58	579.0	.00	0	0
A-2-I		4.98	108.0	4.30	82.4	3.95	28	7.20	.0	1.45	564.0	.00	0	0
H-2-I		4.95	117.0	4.30	69.1	3.18	29	7.10	.0	2.02	670.0	.00	0	0
H-4-I		5.24	110.0	4.30	64.3	1.43	16	7.20	.0	1.38	901.0	.00	0	0
					SHRIMP - PANDALUS HYPSINOTUS					- MUSCLE				
A-3-I		4.88	29.1	4.50	56.2	.75	108	7.50	.0	1.59	14.3	.00	0	0
					SHRIMP - PANDALUS HYPSINOTUS					- WHOLE BODY				
A-3-I		3.12	46.3	4.40	99.8	.73	39	7.30	.0	.97	88.2	.00	0	0
					FISH - HIPPOGLOSSOIDES ELASSODON					- MUSCLE				
A-1-I		4.74	4.2	4.40	23.6	.73	19	7.30	.0	.98	20.7	.00	0	0
					FISH - THERAGRA CHALCOGRAMMA					- MUSCLE				
A-1-I	M(3)	5.23	10.4	4.37	26.5	.73	17	7.30	.0	1.07	75.8	.00	0	0
	S.D.	.26	4.9	.06	9.1	.01	5	.10	.0	.17	56.9	.00	0	0
	Max	5.52	15.7	4.40	36.4	.74	23	7.40	.0	1.26	140.0	.00	0	0
	Min	5.00	6.0	4.30	18.5	.72	14	7.20	.0	.96	31.5	.00	0	0
A-2-I	M(2)	5.18	6.0	4.10	25.3	.68	21	6.90	.0	1.05	31.8	.00	0	0
	S.D.	.01	4.5	.00	.5	.01	13	.00	.0	.21	19.2	.00	0	0
	Max	5.18	9.1	4.10	25.6	.69	30	6.90	.0	1.20	45.4	.00	0	0
	Min	5.17	2.8	4.10	24.9	.68	12	6.90	.0	.91	18.2	.00	0	0
A-3-I	M(3)	4.87	6.5	4.30	38.7	.72	15	7.20	.0	1.69	40.1	.00	0	0
	S.D.	.10	2.4	.10	5.2	.02	4	.20	.0	.57	10.4	.00	0	0
	Max	4.98	9.1	4.40	44.7	.74	19	7.40	.0	2.33	50.1	.00	0	0
	Min	4.79	4.4	4.20	35.2	.70	12	7.00	.0	1.26	29.4	.00	0	0
H-3-I	M(2)	5.21	6.6	4.25	24.4	.70	31	7.05	.0	1.38	107.0	.00	0	0
	S.D.	.09	.1	.07	.1	.01	16	.07	.0	.22	52.3	.00	0	0
	Max	5.27	6.6	4.30	24.5	.71	42	7.10	.0	1.53	144.0	.00	0	0
	Min	5.14	6.5	4.20	24.4	.70	19	7.00	.0	1.22	70.1	.00	0	0
H-4-I		5.08	17.3	4.30	59.3	.72	7	7.20	.0	1.74	118.0	.00	0	0

Continued ...

APPENDIX:7B MEAN TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight) BY SPECIES, ALICE ARM AND HASTINGS ARM, OCTOBER 1978.

Station	Stat	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
						BIVALVE - MYTILUS EDULIS Blue Mussel				- WHOLE BODY				
A-1-N		7.90	14.9	4.30	101.0	7.40	9	7.20	.0	2.94	2220.0	.00	0	0
A-1-S		7.70	18.3	5.60	107.0	5.90	12	7.30	.0	2.23	1010.0	.00	0	0
A-2-N	M(2)	7.30	25.5	4.35	93.0	6.82	10	7.25	.0	3.05	1400.0	.00	0	0
	S.D.	.42	7.9	.07	4.2	1.17	1	.07	.0	.78	14.1	.00	0	0
	Max	7.60	31.1	4.40	95.9	7.64	11	7.30	.0	3.60	1410.0	.00	0	0
	Min	7.00	19.9	4.30	90.0	5.99	10	7.20	.0	2.49	1390.0	.00	0	0
A-2-S		9.20	14.9	4.30	101.0	7.42	9	7.20	.0	2.94	2200.0	.00	0	0
A-3-N	M(2)	6.60	11.6	4.30	82.7	3.50	8	7.15	.0	1.61	789.5	.00	0	0
	S.D.	.85	3.7	.00	.6	.21	.0	.07	.0	.06	326.0	.00	0	0
	Max	7.20	14.2	4.30	83.2	3.65	8	7.20	.0	1.65	1020.0	.00	0	0
	Min	6.00	9.0	4.30	82.3	3.35	8	7.10	.0	1.57	559.0	.00	0	0
A-3-S		6.20	12.0	4.30	34.0	3.44	7	7.20	.0	1.76	726.0	.00	0	0
AAW		6.20	12.8	4.30	59.3	3.50	7	7.20	.0	1.91	1000.0	.00	0	0
B		8.40	53.3	4.20	233.0	7.88	11	6.90	.0	2.73	1120.0	.00	0	0
GP		7.30	120.0	4.30	202.0	5.60	8	7.20	.0	1.21	699.0	.00	0	0
H-3-E	M(2)	7.50	14.9	4.35	80.7	4.34	8	7.30	.0	1.31	837.0	.00	0	0
	S.D.	.71	.8	.07	5.3	.18	0	.14	.0	.30	134.4	.00	0	0
	Max	8.00	15.5	4.40	84.5	4.47	9	7.40	.0	1.52	932.0	.00	0	0
	Min	7.00	14.4	4.30	77.0	4.21	8	7.20	.0	1.10	742.0	.00	0	0
H-4-N		8.50	243.0	7.20	462.0	8.36	11	7.20	.0	2.98	5910.0	.00	0	0
JP		7.70	128.0	4.20	264.0	7.46	8	7.00	.0	2.33	1060.0	.00	0	0
L		6.80	23.9	4.40	111.0	3.77	9	7.30	.0	1.41	565.0	.00	0	0
LC NOT PUR		6.30	12.9	7.81	107.0	5.86	9	7.30	.0	1.95	1100.0	.00	0	0
LC PURGED		8.10	22.5	4.84	102.0	6.82	10	7.20	.0	1.74	662.0	.00	0	0

Continued ...

APPENDIX: 7B MEAN TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight) BY SPECIES, ALICE ARM AND HASTINGS ARM, OCTOBER 1978.

Station	Stat	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
						ALGAE - FUCUS DISTICHUS				- WHOLE				
A-1-N		7.10	5.9	4.31	30.6	2.49	19	7.19	.0	.96	513.0	.00	0	0
A-1-S		8.20	3.0	4.24	25.5	2.02	12	7.06	.0	.94	205.0	.00	0	0
A-2-N		6.90	2.7	4.16	24.1	2.68	20	6.93	.0	.92	115.0	.00	0	0
A-2-S		4.10	5.9	4.27	24.3	2.33	24	7.12	.0	.95	183.0	.00	0	0
A-3-N		5.10	4.0	4.28	24.3	2.17	27	7.14	.0	1.38	889.0	.00	0	0
A-3-S		4.50	4.6	4.25	27.9	3.00	21	7.08	.0	.97	682.0	.00	0	0
AAW		6.00	8.6	4.23	67.1	3.76	16	7.14	.0	1.81	2000.0	.00	0	0
B		5.50	66.9	4.33	131.0	2.50	18	7.22	.0	1.20	746.0	.00	0	0
GP		5.70	70.1	4.22	80.8	1.29	19	7.03	.0	.94	290.0	.00	0	0
H-3-E		6.10	6.3	4.11	28.8	4.20	24	6.84	.0	1.26	594.0	.00	0	0
H-4-N		4.80	127.0	4.19	103.0	1.49	26	6.98	.0	1.26	594.0	.00	0	0
JP		4.90	61.2	4.35	160.0	2.76	21	7.25	.0	.97	641.0	.00	0	0
L		4.90	10.8	4.47	47.2	1.89	17	7.45	.0	.99	379.0	.00	0	0
LC	M(2)	6.35	5.3	4.39	51.1	2.90	26	7.32	.0	.98	348.5	.00	0	0
	S.D.	.78	1.0	.01	6.6	.40	2	.01	.0	.00	13.4	.00	0	0
	Max	6.90	6.0	4.40	55.7	3.18	27	7.33	.0	.98	358.0	.00	0	0
	Min	5.80	4.6	4.39	46.4	2.61	24	7.31	.0	.98	339.0	.00	0	0

\+ Roman numerals indicate station trawl number.

++ M(n) Mean of n number of individuals sampled.

* All zeros indicate no analysis.

Trace metal values derived from composite samples.

APPENDIX: 7C MEAN TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight) BY SPECIES, ALICE ARM AND HASTINGS ARM, MAY 1980.

Station	Stat	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					CRAB - LITHODES AEQUISPINA					- MUSCLE-LEG				
+ A-1-I		5.61	4.0	.12	17.9	.05	49	7.02	* .0	.70	30.3	.00	0	0
					SHRIMP - EUALUS SUCKLEYI					- WHOLE BODY				
A-1-I		4.21	69.4	2.79	71.8	3.16	27	7.18	.0	.72	1020.0	.00	0	0
					SHRIMP - PANDALOPSIS DISPAR					- MUSCLE				
A-3-I		4.16	48.1	.56	56.4	.39	98	7.17	.0	.72	204.0	.00	0	0
					SHRIMP - PANDALUS BOREALIS					- MUSCLE				
H-4-I		4.21	42.9	.59	54.2	.12	21	7.32	.0	.73	70.5	.00	0	0
					FISH - ATHERESTHES STOMIAS					- MUSCLE				
A-1-I	++ M(2)	5.04	4.5	.33	21.3	.05	18	7.17	.0	.72	26.8	.00	0	0
	S.D.	.09	.6	.40	4.0	.00	7	.13	.0	.01	5.4	.00	0	0
	Max	5.10	4.9	.61	24.1	.05	23	7.26	.0	.73	30.6	.00	0	0
	Min	4.97	4.1	.05	18.5	.05	13	7.08	.0	.71	23.0	.00	0	0
					FISH - HIPPOGLOSSOIDES ELASSODON					- MUSCLE				
A-1-I	M(5)	5.94	5.6	.41	19.8	.05	52	7.20	.0	.72	12.3	.00	0	0
	S.D.	.27	.9	.27	1.7	.00	22	.15	.0	.02	5.0	.00	0	0
	Max	6.37	6.7	.87	21.6	.05	86	7.46	.0	.75	18.3	.00	0	0
	Min	5.68	4.6	.21	17.6	.05	29	7.10	.0	.71	6.7	.00	0	0
					FISH - THERAGRA CHALCOGRAMMA					- LIVER				
A-1-I	M(2)	1.00	9.5	.78	19.0	.35	2	1.47	.0	.14	18.1	.00	0	0
	S.D.	.00	1.6	.01	1.8	.11	0	.01	.0	.01	4.9	.00	0	0
	Max	1.00	10.7	.79	20.3	.43	2	1.48	.0	.15	21.5	.00	0	0
	Min	1.00	8.4	.78	17.7	.27	2	1.47	.0	.14	14.6	.00	0	0
					FISH - THERAGRA CHALCOGRAMMA					- MUSCLE				
A-1-I	M(2)	5.06	6.1	.23	22.8	.14	20	7.23	.0	.72	29.0	.00	0	0
	S.D.	.06	.4	.02	4.8	.13	3	.12	.0	.01	3.7	.00	0	0
	Max	5.10	6.4	.24	26.2	.23	22	7.32	.0	.73	31.6	.00	0	0
	Min	5.01	5.9	.21	19.4	.05	18	7.15	.0	.72	26.3	.00	0	0

\+ Roman numerals indicate station trawl number.

++ M(n) Mean of n number of individuals sampled.

* All zeros indicate no analysis.

APPENDIX: 7D MEAN TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight) BY SPECIES, ALICE ARM AND HASTINGS ARM, OCTOBER 1980.

Station	Stat	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
						ALGAE - FUCUS DISTICHUS				- WHOLE				
OUTFALL B	M(2)+	4.57	6.5	2.50	36.2	2.50	30	.30	10.0	2.90	936.5	99.15	8880	560
	S.D.	.01	.9	.71	15.7	.28	4	.00	.0	1.13	627.2	13.93	1301	358
	Max	4.57	7.1	3.00	47.3	2.70	32	.30	10.0	3.70	1380.0	109.00	9800	813
	Min	4.56	5.8	2.00	25.1	2.30	27	.30	10.0	2.10	493.0	89.30	7960	307
						BIVALVE - MYA ARENARIA				- WHOLE BODY				
PERRY PEN.	M(12)	8.17	21.5	1.46	108.6	1.01	7	.71	11.8	1.71	795.7	26.59	4497	377
	S.D.	1.78	5.8	.65	26.1	.31	2	.22	10.1	1.47	442.7	12.45	852	294
	Max	12.61	31.4	2.00	164.0	1.60	11	1.10	39.0	5.50	1640.0	48.40	6190	1040
	Min	6.47	12.3	.05	76.1	.70	4	.40	3.9	.09	316.0	6.30	3220	130
						CRAB - CHIONOECETES BAIRDI				- MUSCLE-LEG				
++A-1-I		4.66	57.9	1.00	131.0	.20	56	.20	2.0	.50	67.9	26.10	2410	23
A-3-I		5.77	53.7	1.00	116.0	.20	111	.20	4.0	.50	25.9	2.36	6080	13
						CRAB - LITHODES AEQUISPINA				- MUSCLE-LEG				
A-1-I		4.31	91.8	.05	215.0	.80	164	.20	2.0	1.30	24.2	9.66	3940	12
						SHRIMP - PANDALOPSIS DISPAR				- MUSCLE				
A-1-I	M(15)	4.44	16.3	.63	59.6	.29	49	.26	1.2	.70	120.8	8.59	1619	49
	S.D.	.13	2.1	.85	4.2	.12	6	.18	.6	.19	229.8	11.59	201	90
	Max	4.66	20.4	3.00	66.5	.60	60	.90	3.0	1.30	942.0	49.60	2220	372
	Min	4.23	13.1	.05	53.3	.10	39	.20	.9	.60	26.5	2.92	1390	11
A-3-I	M(15)	4.37	15.4	.12	61.8	.13	80	.22	1.1	.59	26.7	1.90	2015	14
	S.D.	.29	2.6	.24	8.3	.06	24	.04	.3	.14	14.1	.67	250	6
	Max	4.79	18.3	1.00	77.6	.20	122	.30	2.0	.90	47.0	3.25	2400	22
	Min	3.87	8.7	.05	38.2	.05	46	.20	.9	.40	11.0	1.10	1410	7
						SHRIMP - PANDALUS BOREALIS				- MUSCLE				
A-1-I	M(30)	4.32	15.5	.17	56.7	.18	70	.21	1.4	.57	35.6	6.03	1651	15
	S.D.	.46	3.0	.20	5.6	.11	19	.03	1.9	.11	32.3	4.92	251	14
	Max	4.87	22.8	1.00	71.3	.50	124	.30	11.0	.80	160.0	18.00	2050	71
	Min	2.05	10.7	.05	47.2	.05	40	.20	.9	.30	7.9	1.07	1280	4
A-3-I	M(15)	4.40	13.0	.09	59.3	.17	99	.21	1.0	.66	22.3	5.91	1866	10
	S.D.	.25	2.6	.09	3.8	.08	34	.03	.0	.15	8.6	3.96	141	4
	Max	4.86	18.6	.34	67.1	.30	191	.30	1.0	1.10	39.4	14.00	2170	18
	Min	3.98	9.0	.05	54.3	.05	59	.20	.9	.50	12.8	2.12	1620	6

Continued ...

APPENDIX: 7D MEAN TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight) BY SPECIES, ALICE ARM AND HASTINGS ARM, OCTOBER 1980.

Station	Stat	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					FISH - LEPIDOPSETTA BILINEATA					- MUSCLE				
A-3-I		5.27	7.5	.05	46.5	.10	80	.20	1.0	1.00	12.6	2.66	1150	4
					FISH - MICROSTOMUS PACIFICUS					- MUSCLE				
A-1-I		3.61	3.4	.18	15.4	.05	126	.20	1.0	.50	10.8	1.81	742	6
					FISH - PAROPHRYS VETULUS					- MUSCLE				
A-3-I	M(6)	4.61	5.6	.15	33.1	.05	28	.20	2.0	.65	24.1	2.37	1232	9
	S.D.	.16	5.6	.11	7.2	.00	23	.00	2.4	.16	9.6	1.21	61	6
	Max	4.79	16.6	.34	42.8	.05	71	.20	7.0	.90	39.2	4.17	1320	20
	Min	4.41	1.3	.05	23.5	.05	12	.20	1.0	.40	16.1	.91	1160	5

\+ M(n) Mean of n number of individuals sampled.

++ Roman numerals indicate station trawl number.

APPENDIX 8

MEAN TISSUE TRACE METAL CONCENTRATIONS (mg/kg, dry weight) BY SPECIES

A - Chatham Sound - May 1981
B - Chatham Sound - October 1981
C - Laredo Sound - October 1981
D - Quatsino Sound - September 1981

APPENDIX: 8A MEAN TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight) BY SPECIES, CHATHAM SOUND, MAY 1981.

Station	Stat	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
						SHRIMP - ARGIS ALASKENSIS				- MUSCLE				
+ C-1-I	* M(9)	4.28	59.1	2.22	62.7	.50	25	.74	11.4	1.09	216.0	5.55	3454	120
	S.D.	.38	29.5	.67	4.5	.15	4	.37	1.0	.25	87.4	1.98	315	42
	Max	4.78	135.0	4.00	70.9	.80	32	1.50	14.0	1.50	350.0	8.64	3770	184
	Min	3.79	36.1	2.00	56.5	.30	19	.40	11.0	.70	99.3	3.08	2930	65
						SHRIMP - CRANGON COMMUNIS				- WHOLE BODY				
C-1-I	M(15)	4.55	62.9	2.96	66.2	.55	31	.24	6.2	.89	381.3	6.88	3889	195
	S.D.	.22	25.9	1.22	13.4	.25	7	.05	5.2	.23	202.8	2.99	484	80
	Max	4.92	145.0	6.00	96.5	1.10	41	.30	14.0	1.30	876.0	15.60	4560	344
	Min	4.14	38.0	1.00	51.3	.20	21	.20	.9	.60	124.0	3.53	2840	70
						SHRIMP - PANDALUS BOREALIS				- MUSCLE				
C-1-I	M(8)	4.43	27.4	.29	57.1	.29	75	.22	1.2	.91	200.3	3.32	2127	88
	S.D.	.25	7.1	.69	3.7	.11	19	.05	.5	.57	200.5	2.71	297	87
	Max	4.91	39.3	2.00	62.8	.50	104	.30	2.0	2.20	612.0	8.97	2560	269
	Min	4.15	18.0	.05	50.7	.20	46	.20	1.0	.40	19.0	.32	1690	10
						SHRIMP - PANDALUS HYPSINOTUS				- MUSCLE				
C-1-I	M(3)	4.59	112.3	.11	67.2	.17	50	.30	2.0	.77	113.2	2.04	2390	46
	S.D.	.32	72.6	.05	5.2	.12	19	.00	.0	.15	54.0	.72	62	25
	Max	4.91	196.0	.17	73.0	.30	71	.30	2.0	.90	174.0	2.87	2460	75
	Min	4.27	67.4	.07	63.0	.10	35	.30	2.0	.60	70.7	1.61	2340	30
						FISH - ATHERESTHES STOMIAS				- MUSCLE				
C-1-I	M(3)	5.40	5.7	.70	21.1	.05	25	.37	1.7	1.17	37.9	.75	1493	16
	S.D.	.12	3.3	1.13	3.9	.00	11	.29	1.2	.35	12.9	.21	67	3
	Max	5.51	9.3	2.00	25.0	.05	35	.70	3.0	1.50	52.7	.99	1550	20
	Min	5.28	2.9	.05	17.2	.05	14	.20	1.0	.80	29.1	.60	1420	14
						FISH - GLYPTOCEPHALUS ZACHIRUS				- MUSCLE				
C-1-I	M(7)	5.32	6.7	.33	17.2	.17	59	.20	2.3	.97	52.7	1.15	1339	26
	S.D.	.32	10.2	.46	3.9	.19	12	.00	2.6	.15	19.4	.57	125	9
	Max	5.86	29.8	1.00	24.9	.50	70	.20	8.0	1.10	80.1	2.38	1520	38
	Min	5.04	1.9	.05	12.5	.05	37	.20	1.0	.70	31.8	.71	1200	14
						FISH - HIPPOGLOSSOIDES ELASSODON				- MUSCLE				
C-1-I	M(7)	5.55	5.0	.52	18.6	.22	29	.23	3.9	2.00	59.3	1.00	1283	30
	S.D.	.56	1.8	.73	2.4	.39	16	.05	3.4	1.64	22.1	.26	113	18
	Max	6.27	8.1	2.00	22.5	1.10	50	.30	9.0	5.40	106.0	1.42	1390	67
	Min	4.84	2.5	.05	16.0	.05	8	.20	1.0	.80	43.3	.69	1070	14

Continued ...

APPENDIX: 8A MEAN TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight) BY SPECIES, CHATHAM SOUND, MAY 1981.

Station	Stat	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
						FISH - THERAGRA CHALCOGRAMMA				- MUSCLE				
C-1-I	M(2)	5.62	9.8	1.52	31.9	6.04	23	.20	1.0	2.85	99.3	1.50	1540	31
	S.D.	.21	4.5	2.09	14.4	8.43	18	.00	.0	1.91	83.1	.99	127	23
	Max	5.76	13.0	3.00	42.1	12.00	36	.20	1.0	4.20	158.0	2.20	1630	47
	Min	5.47	6.6	.05	21.7	.08	11	.20	1.0	1.50	40.5	.80	1450	15

\+ Roman numbers indicate station trawl number.

* M(n) Mean of n number of individuals.

APPENDIX: 8B MEAN TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight) BY SPECIES, CHATHAM SOUND, OCTOBER 1981.

Station	Stat	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					SHRIMP - CRANGON COMMUNIS					- TAIL ONLY				
+ C-1-I	* M(10)	4.09	59.1	.17	52.5	.63	44	3.49	3.9	.79	276.2	27.44	4332	149
	S.D.	.17	7.4	.30	6.5	.14	6	2.35	.2	.09	62.6	11.66	239	33
	Max	4.36	72.3	1.00	63.1	.82	60	8.77	4.3	.96	425.0	55.30	4690	224
	Min	3.80	49.8	.05	45.3	.43	38	1.38	3.7	.71	225.0	17.10	3850	104
					SHRIMP - PANDALOPSIS DISPAR					- MUSCLE				
C-1-I	M(15)	4.53	16.9	.05	46.0	.06	69	1.49	4.0	.84	22.2	.66	1801	12
	S.D.	.11	2.5	.01	3.2	.02	16	.01	.0	.28	15.5	.39	204	8
	Max	4.73	20.8	.05	55.3	.10	108	1.50	4.0	1.79	60.8	1.65	2110	29
	Min	4.36	10.7	.01	43.0	.05	49	1.46	3.9	.73	10.4	.20	1530	6
					SHRIMP - PANDALUS BOREALIS					- MUSCLE				
C-1-I	M(15)	4.27	21.5	.09	52.6	.11	60	1.48	3.9	1.01	18.3	.98	1647	8
	S.D.	.11	3.4	.14	4.5	.11	7	.05	.1	.88	7.1	.25	89	3
	Max	4.59	29.2	.59	62.7	.49	76	1.62	4.3	4.17	31.8	1.35	1840	16
	Min	4.17	17.8	.05	45.5	.05	52	1.41	3.8	.70	8.4	.46	1510	5
					FISH - ATHERESTHES STOMIAS					- MUSCLE				
C-1-I	M(2)	5.32	5.7	.05	19.2	.05	11	1.42	6.1	3.57	67.8	1.35	1645	21
	S.D.	.05	1.3	.00	1.8	.00	6	.06	3.4	3.50	18.5	.86	35	2
	Max	5.35	6.7	.05	20.5	.05	16	1.46	8.4	6.04	80.9	1.96	1670	22
	Min	5.28	4.8	.05	18.0	.05	7	1.38	3.7	1.09	54.8	.75	1620	19

\+ Roman numerals indicate station trawl number.

* M(n) Mean of n number of individuals.

APPENDIX: 8C MEAN TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight) BY SPECIES, LAREDO SOUND, OCTOBER 1981.

Station	Stat	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
						BIVALVE - Y.THRACIAEFORMIS/MONTEREYENSIS - WHOLE BODY								
+L-1-I	*M(9)	5.79	54.7	8.83	613.4	1.77	107	2.31	6.4	2.41	2026.7	17.04	4680	1068
	S.D.	.41	7.7	2.22	126.4	.26	17	.37	1.3	.19	298.5	3.85	718	196
	Max	6.37	63.8	11.60	879.0	2.26	134	3.00	8.0	2.62	2360.0	21.70	5760	1370
	Min	5.05	39.4	5.05	514.0	1.39	87	1.73	4.4	2.06	1500.0	11.30	3780	721
						SHRIMP - CRANGON COMMUNIS				- TAIL ONLY				
L-1-I	M(4)	3.70	63.1	.10	70.1	4.03	32	1.45	6.4	.80	155.8	9.27	3728	84
	S.D.	.27	19.3	.10	9.4	.95	4	.04	3.9	.09	53.4	1.30	146	32
	Max	3.97	89.4	.25	82.5	5.43	36	1.48	12.1	.92	198.0	11.20	3890	113
	Min	3.39	42.9	.05	60.7	3.31	27	1.39	3.9	.72	81.0	8.35	3540	45
						SHRIMP - PANDALOPSIS DISPAR				- MUSCLE				
L-1-I	M(15)	4.58	21.6	.05	44.4	.09	43	1.46	3.9	.73	16.0	.47	1849	11
	S.D.	.12	3.5	.00	11.1	.04	6	.04	.1	.02	7.8	.15	198	4
	Max	4.72	29.2	.05	51.5	.15	51	1.50	4.0	.75	39.0	.70	2100	18
	Min	4.32	15.4	.05	5.0	.05	30	1.39	3.7	.69	6.7	.29	1440	5
						SHRIMP - PANDALOPSIS DISPAR				- WHOLE BODY				
L-1-I	M(15)	3.71	85.4	.09	53.7	2.20	29	1.48	4.3	1.05	140.4	4.10	3823	133
	S.D.	1.13	18.0	.10	7.8	.75	4	.02	1.4	.61	67.0	1.13	688	68
	Max	4.53	125.0	.45	71.4	3.62	35	1.50	9.3	3.16	266.0	6.51	4590	276
	Min	1.00	62.0	.05	45.3	1.37	22	1.41	3.3	.74	59.7	2.65	2060	56
						SHRIMP - PANDALUS BOREALIS				- MUSCLE				
L-1-I	M(15)	4.27	21.2	.09	53.2	.10	38	1.46	5.5	1.90	31.9	1.09	1730	7
	S.D.	.09	3.5	.12	2.8	.12	6	.04	5.8	2.87	48.5	1.32	127	2
	Max	4.42	28.0	.50	56.9	.50	49	1.50	26.5	11.30	203.0	5.72	1920	13
	Min	4.11	14.7	.05	49.1	.05	28	1.35	3.6	.00	8.8	.39	1520	5
						SHRIMP - PANDALUS BOREALIS				- WHOLE BODY				
L-1-I	M(15)	3.60	95.1	.19	66.1	1.85	26	1.48	3.9	.92	99.7	3.60	2693	72
	S.D.	.21	21.7	.27	5.9	.47	3	.02	.0	.45	31.0	.77	157	32
	Max	3.98	144.0	1.10	79.9	2.80	32	1.50	4.0	2.47	157.0	5.13	3090	139
	Min	3.21	68.1	.05	58.3	1.19	19	1.43	3.9	.73	65.7	2.50	2430	41
						FISH - ATHERESTHES STOMIAS				- MUSCLE				
L-1-I		5.24	6.2	.05	17.3	.05	11	1.47	3.9	.80	31.7	.40	1620	21

Continued ...

APPENDIX: 8C MEAN TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight) BY SPECIES, LAREDO SOUND, OCTOBER 1981.

Station	Stat	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					FISH - EOPSETTA JORDANI					- MUSCLE				
L-1-I		5.08	6.0	.05	20.8	.05	7	1.48	3.9	1.45	38.7	.51	1600	15

\+ Roman numerals indicate station trawl number.

* M(n) Mean of n number of individuals sampled.

APPENDIX: 8D MEAN TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight) BY SPECIES, QUATSINO SOUND, SEPTEMBER 1981.

Station	Stat	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
						BIVALVE - Y.THRACIAEFORMIS/MONTEREYENSIS - WHOLE BODY								
+ Q-1-I		4.96	23.2	.64	169.0	1.22	26	1.73	4.1	2.83	2570.0	23.20	3770	1220
						BIVALVE - YOLDIA SCISSURATA - WHOLE BODY								
Q-1-I		4.91	60.3	.80	111.0	1.04	41	1.34	4.0	2.99	2480.0	36.10	3880	1170
						SHRIMP - PANDALOPSIS DISPAR - MUSCLE								
Q-1-I	* M(15)	4.32	23.1	.06	47.8	.06	40	1.47	3.9	.78	19.4	.64	1644	12
	S.D.	.14	2.7	.05	3.0	.02	9	.02	.2	.10	5.9	.15	127	4
	Max	4.56	29.7	.25	53.9	.10	51	1.49	4.0	1.03	33.1	.91	1860	21
	Min	4.08	19.4	.05	42.6	.05	23	1.40	3.3	.72	13.0	.40	1420	7
						SHRIMP - PANDALUS BOREALIS - MUSCLE								
Q-1-I	M(15)	4.21	20.7	.13	52.1	.07	65	1.47	3.9	.77	20.8	.88	1813	12
	S.D.	.08	5.1	.32	4.0	.03	20	.03	.1	.13	6.5	.26	124	4
	Max	4.33	30.6	1.30	60.0	.10	105	1.50	4.0	1.25	31.7	1.56	2020	20
	Min	4.03	12.4	.05	46.8	.05	41	1.38	3.7	.69	11.7	.46	1630	7
						FISH - ANOPLOPOMA FIMBRIA - MUSCLE								
Q-1-I		4.97	5.5	.00	24.6	.05	7	1.41	3.7	1.10	56.8	.72	1650	20
						FISH - ATHERESTHES STOMIAS - MUSCLE								
Q-1-I		5.01	3.3	.05	17.6	.05	7	1.41	3.8	.81	33.4	.14	1490	9
						FISH - EOPSETTA JORDANI - MUSCLE								
Q-1-I	M(3)	5.18	3.8	.05	16.5	.05	76	1.47	3.9	1.15	29.4	.41	1417	9
	S.D.	.23	2.2	.00	.2	.00	26	.03	.1	.59	4.8	.07	21	2
	Max	5.42	6.3	.05	16.7	.05	102	1.50	4.0	1.83	34.2	.46	1440	11
	Min	4.97	2.5	.05	16.4	.05	50	1.44	3.8	.73	24.7	.33	1400	8
						FISH - GLYPTOCEPHALUS ZACHIRUS - MUSCLE								
Q-1-I		5.84	2.9	.05	22.5	.05	128	1.49	4.0	.79	98.8	2.01	1460	46
						FISH - MICROSTOMUS PACIFICUS - MUSCLE								
Q-1-I		5.41	10.4	.05	20.4	.05	195	1.45	3.9	1.36	38.3	.58	1760	17

\+ Roman numerals indicate station trawl number.

* M(n) Mean of n number of individuals sampled.

APPENDIX 9

TISSUE DATA - ALICE ARM
1977 - 1980

APPENDIX

A - Intertidal Samples - June 1977

B - Intertidal and Trawl Samples - October 1978

C - Trawl Samples - May 1980

D - Trawl Samples - October 1980

APPENDIX: 9A TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), ALICE ARM AND HASTINGS ARM, JUNE 1977.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					ALGAE - FUCUS DISTICHUS				- WHOLE				
A-1-N	+ .00	3.6	* <1.00	17.0	1.10	0	.00	.0	.00	120.0	.00	0	0
A-2-N	.00	5.3	<1.00	24.0	2.10	0	.00	.0	.00	95.0	.00	0	0
A-2-S	.00	7.4	<1.00	23.0	1.80	0	.00	.0	.00	37.0	.00	0	0
A-3-N	.00	4.6	<1.00	14.0	1.70	0	.00	.0	.00	42.0	.00	0	0
A-3-S	.00	3.8	<1.00	13.0	1.20	0	.00	.0	.00	13.0	.00	0	0
AAW	.00	4.4	<1.00	28.0	1.40	0	.00	.0	.00	150.0	.00	0	0
H-2-E	.00	10.0	<1.00	31.0	2.10	0	.00	.0	.00	79.0	.00	0	0
H-2-W	.00	5.4	1.40	13.0	1.20	0	.00	.0	.00	57.0	.00	0	0
H-4-N	.00	58.0	<1.00	56.0	.57	0	.00	.0	.00	770.0	.00	0	0
LC	.00	7.2	1.50	41.0	1.80	0	.00	.0	.00	220.0	.00	0	0
					BIVALVE - MYTILUS EDULIS				- WHOLE BODY				
A-1-N	.00	9.6	2.10	100.0	6.50	0	.00	.0	.00	810.0	.00	0	0
A-2-N	.00	13.0	2.10	110.0	6.90	0	.00	.0	.00	260.0	.00	0	0
A-2-S	.00	10.0	1.10	99.0	6.00	0	.00	.0	.00	150.0	.00	0	0
AAW	.00	8.9	2.60	110.0	4.80	0	.00	.0	.00	380.0	.00	0	0
H-2-E	.00	9.6	<1.00	87.0	4.50	0	.00	.0	.00	260.0	.00	0	0
H-2-W	.00	10.0	<1.00	89.0	5.80	0	.00	.0	.00	440.0	.00	0	0
H-4-N	.00	27.0	<1.00	230.0	3.30	0	.00	.0	.00	430.0	.00	0	0
LC	.00	11.0	5.00	130.0	6.60	0	.00	.0	.00	450.0	.00	0	0

\+ All zeros indicate no analysis.

*< Indicates EPS Laboratory detection limits.

Trace metal values derived from composite samples.

APPENDIX: 9B TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), ALICE ARM AND HASTINGS ARM, OCTOBER 1978.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					BIVALVE - Y.THRACIAEFORMIS/MONTEREYENSIS - WHOLE BODY								
+ A-1-I	6.38	292.0	60.00	682.0	13.40	57	* <7.30	++ .0	9.24	12000.0	.00	0	0
A-2-I	8.23	435.0	9.14	681.0	17.70	47	<6.86	.0	10.20	8590.0	.00	0	0
H-2-I	7.88	328.0	<4.40	788.0	19.30	47	<7.30	.0	3.82	4690.0	.00	0	0
					CRAB - LITHODES AEQUISPINA				- MUSCLE-LEG				
A-1-I	5.88	25.1	<4.30	179.0	<.73	100	<7.20	.0	1.21	9.1	.00	0	0
	5.99	40.7	<4.20	194.0	<.71	91	<7.10	.0	1.02	11.4	.00	0	0
A-2-I	6.13	59.8	<4.20	182.0	<.71	101	<7.10	.0	1.46	13.3	.00	0	0
	5.84	40.7	<4.20	194.0	<.71	91	<7.10	.0	1.02	11.4	.00	0	0
	5.39	83.7	<4.40	185.0	<.73	141	<7.30	.0	1.31	12.5	.00	0	0
H-2-I	6.93	85.3	<4.24	189.0	<.71	104	<7.10	.0	<.94	12.7	.00	0	0
					SHRIMP - CRANGON COMMUNIS				- TAIL ONLY				
A-1-I	4.86	70.0	<4.40	51.3	.99	43	<7.40	.0	1.82	124.0	.00	0	0
A-3-I	4.36	31.9	<4.40	70.3	<.73	25	<7.32	.0	<.98	48.1	.00	0	0
	4.31	32.8	<4.20	83.6	<.70	21	<7.00	.0	1.35	112.0	.00	0	0
	4.57	40.0	<4.30	59.4	<.73	62	<7.20	.0	3.43	35.5	.00	0	0
	5.45	40.7	<4.50	68.5	<.74	57	<7.40	.0	2.38	80.9	.00	0	0
	4.25	43.1	<4.20	52.7	<.70	42	<7.00	.0	<.93	280.0	.00	0	0
	4.10	79.5	<4.40	67.9	1.16	38	<7.30	.0	1.26	450.0	.00	0	0
					SHRIMP - CRANGON COMMUNIS				- WHOLE BODY				
A-3-I	4.07	75.1	<4.30	69.3	<.96	33	<7.20	.0	<.96	316.0	.00	0	0
	4.18	43.6	<4.40	55.6	<.73	41	<7.30	.0	<.98	152.0	.00	0	0
	3.99	49.0	<4.50	92.3	1.45	19	<7.50	.0	<.10	191.0	.00	0	0
					SHRIMP - PANDALOPSIS DISPAR				- MUSCLE				
A-1-I	4.77	30.1	<4.10	48.6	1.10	51	<6.90	.0	1.56	43.7	.00	0	0
	4.85	29.3	<4.20	48.1	1.01	54	<7.00	.0	2.78	66.5	.00	0	0
	4.75	28.2	<4.40	49.0	.99	59	<7.30	.0	3.32	63.0	.00	0	0
A-2-I	4.74	42.9	<4.30	52.2	1.63	67	<7.20	.0	1.22	46.7	.00	0	0
A-3-I	4.78	32.0	<4.30	49.2	<.72	99	<7.20	.0	<.97	35.1	.00	0	0
	5.16	31.5	<4.40	51.0	<.73	98	<7.30	.0	1.95	37.2	.00	0	0
H-1-I	5.07	36.7	<4.30	49.2	1.76	37	<7.20	.0	.99	34.7	.00	0	0
	5.10	36.0	<4.50	49.5	1.39	38	<7.40	.0	2.57	55.0	.00	0	0

Continued ...

APPENDIX: 9B TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), ALICE ARM AND HASTINGS ARM, OCTOBER 1978.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
H-2-I	4.97	25.5	<4.30	53.5	1.48	32	<7.20	.0	2.30	46.9	.00	0	0
	5.00	24.9	<4.50	53.0	1.50	34	<7.50	.0	<1.00	107.0	.00	0	0
	4.48	28.8	<4.40	61.5	1.02	25	<7.30	.0	<.97	126.0	.00	0	0
	4.54	34.7	<4.30	57.1	1.38	25	<7.10	.0	<.95	140.0	.00	0	0
	5.08	40.3	<4.30	52.7	1.18	33	<7.40	.0	<.99	44.3	.00	0	0
	5.12	54.1	<4.20	51.0	1.46	23	<7.10	.0	.95	84.7	.00	0	0
H-3-I	4.89	33.1	<4.40	47.4	<.72	44	<7.30	.0	<.96	29.0	.00	0	0
H-4-I	5.00	27.6	<4.30	49.4	<.71	9	<7.10	.0	<.95	34.8	.00	0	0
	5.07	34.2	<4.40	47.2	<.73	9	<7.30	.0	.98	242.0	.00	0	0
					SHRIMP - PANDALOPSIS DISPAR				- WHOLE BODY				
H-1-I	4.63	96.4	<4.20	657.5	34.40	23	<7.00	.0	1.22	264.0	.00	0	0
H-2-I	4.41	92.0	<4.40	79.0	.72	26	<7.30	.0	1.22	594.0	.00	0	0
	4.47	98.0	<4.30	83.0	6.45	24	<7.10	.0	1.85	759.0	.00	0	0
					SHRIMP - PANDALUS BOREALIS				- MUSCLE				
A-1-I	4.88	31.0	<4.30	53.0	<.72	34	<7.20	.0	1.61	57.4	.00	0	0
	4.65	33.3	<4.30	50.0	.73	103	<7.20	.0	.99	22.5	.00	0	0
	4.94	36.6	<4.40	47.8	<.73	35	<7.30	.0	.97	64.1	.00	0	0
A-2-I	4.84	49.6	<4.30	57.3	.87	52	<7.20	.0	<.96	19.2	.00	0	0
A-3-I	4.63	21.0	<4.20	47.1	<.69	96	<6.90	.0	1.73	17.0	.00	0	0
H-2-I	5.00	34.2	<4.50	49.8	<7.46	43	<7.50	.0	<.99	46.8	.00	0	0
H-3-I	4.61	37.1	<4.30	49.5	<7.18	55	<7.20	.0	3.30	37.3	.00	0	0
	4.60	51.0	<4.20	46.8	<7.09	41	<7.00	.0	<.95	43.1	.00	0	0
H-4-I	5.02	48.9	<4.20	56.9	<.71	21	<7.06	.0	1.03	50.8	.00	0	0
	5.00	50.7	<4.30	57.4	<.72	18	<7.24	.0	.97	338.0	.00	0	0
					SHRIMP - PANDALUS BOREALIS				- WHOLE BODY				
A-1-I	5.50	107.0	<4.40	62.6	2.86	24	<7.40	.0	1.58	783.0	.00	0	0
	4.41	98.2	<4.30	63.2	2.83	22	<7.20	.0	2.01	1580.0	.00	0	0
	4.75	103.0	6.40	56.7	2.73	26	<7.30	.0	1.98	579.0	.00	0	0
A-2-I	4.98	108.0	<4.30	82.4	3.95	28	<7.20	.0	1.45	564.0	.00	0	0
H-2-I	4.95	117.0	<4.30	69.1	3.18	29	<7.10	.0	2.02	670.0	.00	0	0
H-4-I	5.24	110.0	<4.30	64.3	1.43	16	<7.20	.0	1.38	901.0	.00	0	0

Continued ...

APPENDIX: 9B TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), ALICE ARM AND HASTINGS ARM, OCTOBER 1978.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					SHRIMP - PANDALUS HYPSINOTUS				- MUSCLE				
A-3-I	4.88	29.1	<4.50	56.2	<.75	108	<7.50	.0	1.59	14.3	.00	0	0
					SHRIMP - PANDALUS HYPSINOTUS				- WHOLE BODY				
A-3-I	3.12	46.3	<4.40	99.8	<.73	39	<7.30	.0	<.97	88.2	.00	0	0
					FISH - HIPPOGLOSSOIDES ELASSODON				- MUSCLE				
A-1-I	4.74	4.2	<4.40	23.6	<.73	19	<7.30	.0	<.98	20.7	.00	0	0
					FISH - THERAGRA CHALCOGRAMMA				- MUSCLE				
A-1-I	5.00	9.6	<4.40	36.4	<.74	15	<7.40	.0	<.99	140.0	.00	0	0
	5.52	15.7	4.40	24.6	<.73	14	<7.30	.0	1.26	55.9	.00	0	0
	5.18	6.0	<4.30	18.5	<.72	23	<7.20	.0	<.96	31.5	.00	0	0
A-2-I	5.17	2.8	<4.10	25.6	<.69	30	<6.90	.0	1.20	18.2	.00	0	0
	5.18	9.1	<4.10	24.9	<.68	12	<6.90	.0	<.91	45.4	.00	0	0
A-3-I	4.79	4.4	<4.20	36.1	<.70	12	<7.00	.0	2.33	29.4	.00	0	0
	4.98	6.1	<4.30	35.2	<.72	19	<7.20	.0	1.26	40.7	.00	0	0
	4.84	9.1	<4.40	44.7	<.74	13	<7.40	.0	1.47	50.1	.00	0	0
H-3-I	5.14	6.6	<4.30	24.5	<.71	42	<7.10	.0	1.53	70.1	.00	0	0
	5.27	6.5	<4.20	24.4	<.70	19	<7.00	.0	1.22	144.0	.00	0	0
H-4-I	5.08	17.3	<4.30	59.3	<.72	<7	<7.20	.0	1.74	118.0	.00	0	0

Continued ...

APPENDIX: 9B TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), ALICE ARM AND HASTINGS ARM, OCTOBER 1978.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					BIVALVE - MYTILUS EDULIS				- WHOLE BODY				
A-1-N	7.90	14.9	<4.30	101.0	7.40	9	<7.20	.0	2.94	2220.0	.00	0	0
A-1-S	7.70	18.3	5.60	107.0	5.90	12	<7.30	.0	2.23	1010.0	.00	0	0
A-2-N	7.60	31.1	<4.40	90.0	7.64	11	<7.30	.0	3.60	1410.0	.00	0	0
	7.00	19.9	<4.30	95.9	5.99	10	<7.20	.0	2.49	1390.0	.00	0	0
A-2-S	9.20	14.9	<4.30	101.0	7.42	9	<7.20	.0	2.94	2200.0	.00	0	0
A-3-N	6.00	9.0	<4.30	82.3	3.35	8	<7.20	.0	1.65	559.0	.00	0	0
	7.20	14.2	<4.30	83.2	3.65	8	<7.10	.0	1.57	1020.0	.00	0	0
A-3-S	6.20	12.0	<4.30	34.0	3.44	7	<7.20	.0	1.76	726.0	.00	0	0
AAW	6.20	12.8	<4.30	59.3	3.50	<7	<7.20	.0	1.91	1000.0	.00	0	0
B	8.40	53.3	<4.20	233.0	7.88	11	<6.90	.0	2.73	1120.0	.00	0	0
GP	7.30	120.0	<4.30	202.0	5.60	8	<7.20	.0	1.21	699.0	.00	0	0
H-3-E	8.00	15.5	<4.40	84.5	4.47	8	<7.40	.0	1.52	932.0	.00	0	0
	7.00	14.4	<4.30	77.0	4.21	9	<7.20	.0	1.10	742.0	.00	0	0
H-4-N	8.50	243.0	7.20	462.0	8.36	12	<7.20	.0	2.98	5910.0	.00	0	0
JP	7.70	128.0	<4.20	264.0	7.46	8	<7.00	.0	2.33	1060.0	.00	0	0
L	6.80	23.9	<4.40	111.0	3.77	9	<7.30	.0	1.41	565.0	.00	0	0
LC NOT PUR	6.30	12.9	7.81	107.0	5.86	9	<7.30	.0	1.95	1100.0	.00	0	0
LC PURGED	8.10	22.5	4.84	102.0	6.82	10	<7.20	.0	1.74	662.0	.00	0	0

Continued ...

APPENDIX: 9B TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), ALICE ARM AND HASTINGS ARM, OCTOBER 1978.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					ALGAE - FUCUS DISTICHUS				- WHOLE				
A-1-N	7.10	5.9	<4.31	30.6	2.49	19	<7.19	.0	<.96	513.0	.00	0	0
A-1-S	8.20	3.0	<4.24	25.5	2.02	12	<7.06	.0	<.94	205.0	.00	0	0
A-2-N	6.90	2.7	<4.16	24.1	2.68	20	<6.93	.0	<.92	115.0	.00	0	0
A-2-S	4.10	5.9	<4.27	24.3	2.33	24	<7.12	.0	<.95	183.0	.00	0	0
A-3-N	5.10	4.0	<4.28	24.3	2.17	27	<7.14	.0	1.38	889.0	.00	0	0
A-3-S	4.50	4.6	<4.25	27.9	3.00	21	<7.08	.0	<.97	682.0	.00	0	0
AAW	6.00	8.6	<4.23	67.1	3.76	16	<7.14	.0	1.81	2000.0	.00	0	0
B	5.50	66.9	4.33	131.0	2.50	18	<7.22	.0	1.20	746.0	.00	0	0
GP	5.70	70.1	<4.22	80.8	1.29	19	<7.03	.0	<.94	290.0	.00	0	0
H-3-E	6.10	6.3	<4.11	28.8	4.20	24	<6.84	.0	1.26	594.0	.00	0	0
H-4-N	4.80	127.0	<4.19	103.0	1.49	26	<6.98	.0	1.26	594.0	.00	0	0
JP	4.90	61.2	<4.35	160.0	2.76	21	<7.25	.0	<.97	641.0	.00	0	0
L	4.90	10.8	<4.47	47.2	1.89	17	<7.45	.0	<.99	379.0	.00	0	0
LC	5.80	6.0	<4.40	55.7	3.18	27	<7.33	.0	<.98	358.0	.00	0	0
	6.90	4.6	<4.39	46.4	2.61	24	<7.31	.0	<.98	339.0	.00	0	0

\+ Roman numerals indicate station trawl number.

++ All zeros indicate no analysis.

*< Indicates EPS laboratory detection limits.

Trace metal values derived from composite samples. Refer to Appendix 6A.

APPENDIX: 9C TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), ALICE ARM AND HASTINGS ARM, MAY 1980.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					CRAB - LITHODES AEQUISPINA				- MUSCLE-LEG				
* A-1-I	5.61	4.0	.12	17.9	+ <.05	49	<7.02	++ .0	<.70	30.3	.00	0	0
					SHRIMP - EUALUS SUCKLEYI				- WHOLE BODY				
A-1-I	4.21	69.4	2.79	71.8	3.16	27	<7.18	.0	<.72	1020.0	.00	0	0
					SHRIMP - PANDALOPSIS DISPAR				- MUSCLE				
A-3-I	4.16	48.1	.56	56.4	.39	98	<7.17	.0	<.72	204.0	.00	0	0
					SHRIMP - PANDALUS BOREALIS				- MUSCLE				
H-4-I	4.21	42.9	.59	54.2	.12	21	<7.32	.0	<.73	70.5	.00	0	0
					FISH - ATHERESTHES STOMIAS				- MUSCLE				
A-1-I	4.97	4.9	.61	24.1	<.05	23	<7.08	.0	<.71	30.6	.00	0	0
	5.10	4.1	<.05	18.5	<.05	13	<7.26	.0	<.73	23.0	.00	0	0
					FISH - HIPPOGLOSSOIDES ELASSODON				- MUSCLE				
A-1-I	5.68	4.6	.21	17.6	.05	38	<7.12	.0	<.71	18.3	.00	0	0
	6.37	6.2	.43	21.6	<.05	86	<7.16	.0	<.72	8.7	.00	0	0
	6.00	6.7	.87	21.4	<.05	54	<7.10	.0	<.71	16.8	.00	0	0
	5.73	5.8	.30	18.6	<.05	29	<7.17	.0	<.72	6.7	.00	0	0
	5.93	4.8	.25	19.9	<.05	56	<7.46	.0	<.75	11.1	.00	0	0
					FISH - THERAGRA CHALCOGRAMMA				- LIVER				
A-1-I	1.00	8.4	<.79	20.3	.43	2	<1.48	.0	<.14	21.5	.00	0	0
	1.00	10.7	<.78	17.7	.27	2	<1.47	.0	<.15	14.6	.00	0	0
					FISH - THERAGRA CHALCOGRAMMA				- MUSCLE				
A-1-I	5.10	6.4	.24	19.4	<.05	22	<7.15	.0	<.72	31.6	.00	0	0
	5.01	5.9	.21	26.2	.23	18	<7.32	.0	<.73	26.3	.00	0	0

* Roman numberals indicate station trawl number.

+< Indicates EPS laboratory detection limits.

++ All zeros indicate no analysis.

APPENDIX: 9D TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), ALICE ARM AND HASTINGS ARM, OCTOBER 1980.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
A-3-I	4.68	18.0	<.05	77.6	.20	122	<.20	2.0	.60	15.9	1.21	2250	9
	4.13	16.0	<.05	61.9	.08	120	<.20	<1.0	.50	13.8	1.10	2180	8
	4.66	17.5	<.05	57.9	.08	59	<.20	<1.0	.50	38.6	1.84	1940	18
	4.28	14.9	<.05	58.9	.05	97	<.20	<1.0	.50	11.2	1.45	1700	7
	4.79	17.2	<.05	63.6	.20	89	<.20	<1.0	.60	16.8	2.24	2220	12
	4.47	18.3	<.05	63.0	.20	94	<.20	<1.0	.60	11.0	1.30	2010	7
	4.46	13.4	<.05	60.6	.07	97	<.20	<1.0	.60	47.0	2.95	1900	22
	3.87	14.6	.08	61.8	.08	80	<.20	<1.0	.40	28.4	1.60	2150	13
	4.57	18.1	<.05	59.8	.10	89	<.20	<1.0	.60	12.6	1.23	2000	8
	4.53	16.2	<.05	64.7	.10	79	<.20	<1.0	.80	28.8	2.16	2270	16
	4.31	14.7	<.05	69.9	.20	53	<.30	<1.0	.90	43.9	2.41	2400	20
	4.01	8.7	.08	38.2	.20	46	<.20	<1.0	.40	25.2	1.70	1410	14
	3.89	12.2	<1.00	62.0	.10	69	<.30	<1.0	.60	46.7	2.58	1900	21
	4.56	16.9	<.05	67.9	.20	64	<.30	<1.0	.50	15.1	1.55	2020	9
	4.41	14.7	<.05	59.1	.15	46	<.20	<.9	.70	45.2	3.25	1870	20
					SHRIMP - PANDALUS BOREALIS				- MUSCLE				
A-1-I	4.87	11.0	<.05	58.3	.20	46	<.20	<1.0	.60	13.8	2.08	1780	6
	4.19	13.0	<.05	59.7	.20	59	<.20	<1.0	.50	14.6	2.37	1800	7
	4.32	13.7	<.05	59.6	.20	73	<.20	<1.0	.60	11.6	3.70	2030	7
	4.35	12.4	<.05	58.6	.50	69	<.30	<1.0	.60	10.1	2.77	1810	5
	4.19	15.1	<.05	63.0	.20	63	<.20	<1.0	.60	37.2	4.94	2020	17
	4.42	16.5	1.00	65.7	.20	95	<.20	11.0	.80	33.1	2.74	1840	9
	4.30	16.9	<.05	57.4	.20	77	.20	<1.0	.60	7.9	1.55	1880	5
	4.29	11.2	.08	51.5	.30	83	<.20	1.0	.80	12.3	1.07	1910	5
	4.52	17.0	.22	60.1	.50	65	<.20	1.0	.60	20.9	2.08	1820	6
	4.63	10.7	.17	60.7	.18	55	<.20	3.1	.60	21.3	1.67	2020	4
	4.42	11.8	.08	56.4	.10	50	<.20	<1.0	.30	12.8	2.50	1740	5
	4.39	14.8	.08	55.8	.20	124	<.30	2.0	.60	13.0	3.00	1830	6
	4.35	11.2	<.05	53.8	.20	58	<.20	<1.0	.40	8.7	2.67	1640	4
	4.39	12.8	<.05	71.3	.20	90	<.20	<1.0	.60	12.2	1.54	1950	4
	4.46	17.4	.41	59.3	.17	110	<.20	1.3	.60	19.8	1.88	2050	5
	4.33	15.4	.10	55.1	<.05	64	<.20	<1.0	.50	41.7	5.51	1330	15
	4.25	16.7	.18	60.3	.10	70	<.20	<1.0	.60	67.4	15.30	1390	25
	4.68	14.1	.10	54.3	.20	78	<.20	<1.0	.70	26.6	7.30	1450	14
	4.09	18.8	.08	62.2	.20	85	<.30	<1.0	.70	32.6	6.69	1340	15
	4.31	16.0	.18	60.0	.20	65	<.20	<1.0	.60	84.0	11.40	1430	32
	4.53	17.3	.12	58.3	.14	53	<.20	<.9	.50	66.9	9.58	1590	28
	4.32	16.7	.12	58.3	.20	58	<.20	<1.0	.40	35.0	10.30	1410	13
	4.34	15.5	.10	47.8	.06	60	<.20	<1.0	.60	42.3	6.81	1400	20
	4.85	15.8	<.05	48.9	.20	80	<.20	<1.0	.50	26.3	3.45	1490	13
	4.33	18.1	.17	47.8	.09	80	<.20	<.9	.60	24.5	17.60	1460	11
	4.46	16.2	.06	47.2	.06	80	<.30	<1.0	.50	17.5	4.27	1340	10
	4.43	17.3	.24	52.9	.08	60	<.20	<1.0	.50	62.7	8.86	1470	26
	4.34	22.8	.38	58.4	.08	52	<.20	<1.0	.50	160.0	18.00	1630	71
	4.28	17.7	.20	51.2	<.05	56	<.20	<1.0	.50	47.8	5.88	1280	22
	2.05	22.4	.50	48.5	.06	40	<.20	<1.0	.50	84.1	13.30	1390	33

Continued ...

APPENDIX: 9D TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), ALICE ARM AND HASTINGS ARM, OCTOBER 1980.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					ALGAE - FUCUS DISTICHUS				- WHOLE				
OUTFALL B	4.57	7.1	2.00	47.3	2.70	32	.30	10.0	2.10	493.0	89.30	9800	307
	4.56	5.8	3.00	25.1	2.30	27	.30	10.0	3.70	1380.0	109.00	7960	813
					BIVALVE - MYA ARENARIA				- WHOLE BODY				
PERRY PEN.	7.71	22.2	+<.05	114.0	1.60	4	.50	19.0	.70	316.0	36.00	4440	142
	7.73	17.5	2.00	110.0	.90	8	.90	12.0	1.20	827.0	15.00	4060	239
	7.65	21.4	2.00	128.0	.90	4	.80	39.0	3.00	1480.0	46.80	4290	789
	7.83	22.2	2.00	97.6	.70	6	.40	19.0	3.00	1320.0	48.40	4530	686
	10.75	12.9	2.00	112.0	.90	5	.80	12.0	5.50	1640.0	27.70	5720	1040
	6.47	31.4	2.00	76.1	1.40	9	1.10	6.0	1.10	604.0	20.70	3220	225
	12.61	12.3	1.00	105.0	1.50	11	1.00	9.0	1.40	702.0	23.80	6190	283
	8.33	20.6	1.50	77.1	.80	6	.60	7.0	.90	365.0	6.30	3980	130
	7.05	19.0	1.00	138.0	.90	7	.50	4.0	1.30	550.0	32.50	5420	237
	8.18	24.3	1.00	77.9	1.01	6	.70	3.9	.09	645.0	20.70	4090	278
	6.92	25.0	1.00	104.0	.70	6	.50	7.0	.80	421.0	19.60	4050	161
	6.78	29.5	2.00	164.0	.80	7	.70	4.0	1.50	678.0	21.60	3980	315
					CRAB - CHIONOECETES BAIRDI				- MUSCLE-LEG				
++ A-1-I	4.66	57.9	1.00	131.0	.20	56	<.20	2.0	.50	67.9	26.10	2410	23
A-3-I	5.77	53.7	1.00	116.0	.20	111	<.20	4.0	.50	25.9	2.36	6080	13
					CRAB - LITHODES AEQUISPINA				- MUSCLE-LEG				
A-1-I	4.31	91.8	.05	215.0	.80	164	<.20	2.0	1.30	24.2	9.66	3940	12
					SHRIMP - PANDALOPSIS DISPAR				- MUSCLE				
A-1-I	4.54	15.4	.14	66.5	.40	43	<.20	<1.0	.60	40.2	4.85	1610	19
	4.45	17.1	.24	63.7	.60	49	<.20	<1.0	.60	48.5	4.61	1670	23
	4.30	13.9	.18	54.9	.20	49	<.20	<1.0	.80	112.0	6.05	1500	49
	4.66	20.4	1.00	58.5	.40	57	<.20	<1.0	.80	41.3	3.72	1390	27
	4.49	15.5	.19	59.9	.10	47	<.20	<.9	.60	96.5	6.18	1660	38
	4.38	14.4	.14	55.8	.30	52	<.20	<1.0	.60	61.0	5.65	1660	15
	4.50	13.1	.05	53.3	.20	60	.20	<1.0	.60	28.3	3.07	1450	11
	4.34	17.6	.80	54.3	.20	43	.30	<1.0	.60	26.5	2.92	1430	11
	4.45	17.3	.10	57.0	.23	46	<.20	.9	.60	45.1	3.85	1480	18
	4.53	14.0	.05	58.5	.30	56	<.20	<1.0	.60	27.0	4.96	1700	12
	4.60	16.5	1.00	65.4	.30	44	<.20	2.0	.60	62.5	8.51	1750	24
	4.28	17.1	.20	58.0	.20	50	<.20	3.0	.70	60.0	5.39	1510	27
	4.54	15.6	3.00	63.5	.40	39	.90	1.0	1.30	942.0	49.60	2220	372
	4.35	16.1	.30	59.8	.30	52	<.20	<1.0	.80	153.0	12.40	1710	59
	4.23	20.2	2.00	64.2	.20	41	.30	1.0	.70	68.4	7.16	1540	27

Continued ...

APPENDIX: 9D TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), ALICE ARM AND HASTINGS ARM, OCTOBER 1980.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
A-3-I	4.86	11.2	.34	60.8	.10	94	<.20	1.0	.70	23.8	3.65	2170	11
	4.29	12.9	<.05	60.8	.10	111	<.20	<1.0	.60	28.3	7.54	1960	9
	4.14	18.6	<.05	62.8	<.05	105	<.20	<1.0	.50	14.7	2.55	1950	6
	4.66	13.9	.24	59.3	.20	93	<.20	1.0	1.10	20.9	4.48	1830	9
	4.50	10.8	<.05	58.3	.10	89	<.30	<1.0	.60	19.6	9.23	1970	10
	4.02	13.3	<.05	56.7	<.10	76	<.20	<1.0	.70	39.4	9.09	1790	15
	4.67	10.3	<.05	55.5	.30	112	<.20	<1.0	.70	16.1	2.12	1860	7
	4.21	9.0	<.05	54.3	.20	74	<.20	<1.0	.70	18.1	14.00	1750	8
	4.44	17.6	<.05	64.6	.20	156	<.20	<1.0	.60	12.8	3.20	1930	7
	4.27	14.1	<.05	55.3	.30	90	<.20	1.0	.70	33.2	6.44	1770	14
	4.61	13.1	<.05	62.4	.20	93	<.20	<1.0	.70	35.2	2.71	2050	18
	4.52	14.4	<.05	54.3	.20	65	<.20	<1.0	.50	13.8	13.20	1710	6
	4.38	12.8	.08	67.1	.10	80	<.20	1.0	.70	18.3	5.99	1850	10
	3.98	11.3	<.05	58.2	.23	59	<.20	<.9	.60	13.1	2.15	1620	7
	4.44	11.9	.12	58.5	.15	191	<.20	<.9	.50	27.5	2.32	1780	14
FISH - LEPIDOPSETTA BILINEATA - MUSCLE													
A-3-I	5.27	7.5	<.05	46.5	.10	80	<.20	1.0	1.00	12.6	2.66	1150	4
FISH - MICROSTOMUS PACIFICUS - MUSCLE													
A-1-I	3.61	3.4	.18	15.4	<.05	126	<.20	<1.0	.50	10.8	1.81	742	6
FISH - PAROPHRYS VETULUS - MUSCLE													
A-3-I	4.66	3.0	.18	38.1	<.05	15	<.20	7.0	.60	20.2	2.30	1170	20
	4.79	2.7	.34	35.0	<.05	38	<.20	<1.0	.60	39.2	3.27	1320	8
	4.42	16.6	.06	26.7	<.05	14	<.20	<1.0	.70	17.7	2.26	1160	5
	4.41	5.1	.20	42.8	<.05	71	<.20	<1.0	.90	33.0	4.17	1260	10
	4.70	1.3	<.05	23.5	<.05	12	<.20	<1.0	.40	18.5	1.30	1260	6
	4.65	4.8	.06	32.7	<.05	21	<.20	<1.0	.70	16.1	.91	1220	5

+< Indicates EPS laboratory detection limits.

++ Roman numerals indicate station trawl number.

APPENDIX 10

TISSUE DATA - GEOGRAPHICAL CONTROL SITES, 1981

A - Trawl Samples - Chatham Sound - May 1981
B - Trawl Samples - Chatham Sound - October 1981
C - Trawl Samples - Laredo Sound - October 1981
D - Trawl Samples - Quatsino Sound - September 1981

APPENDIX:10A TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), CHATHAM SOUND, MAY 1981.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					SHRIMP - ARGIS ALASKENSIS				- MUSCLE				
+C-1-I	4.43	50.7	2.00	63.5	.60	26	.50	11.0	1.00	238.0	4.02	3110	133
	4.17	51.0	2.00	63.5	.50	25	.50	11.0	1.10	350.0	7.06	3750	184
	3.79	41.8	2.00	62.1	.40	21	.80	11.0	.90	140.0	8.64	3570	73
	4.19	36.1	2.00	56.7	.40	20	.60	11.0	1.20	99.3	4.19	3690	65
	4.78	53.1	2.00	70.9	.60	26	.40	11.0	1.00	198.0	4.33	3130	137
	4.62	135.0	4.00	65.9	.80	32	1.20	12.0	1.40	299.0	6.03	3490	154
	4.77	62.2	2.00	64.6	.50	30	.70	11.0	.70	171.0	3.08	2930	101
	3.89	57.0	2.00	56.5	.40	23	.50	11.0	1.50	308.0	8.06	3770	154
	3.92	45.3	2.00	60.9	.30	19	1.50	14.0	1.00	141.0	4.50	3650	82
					SHRIMP - CRANGON COMMUNIS				- WHOLE BODY				
C-1-I	4.92	83.9	2.00	52.5	.50	28	.30	<1.0	1.00	515.0	7.91	4300	281
	4.48	50.2	3.00	51.3	.80	32	.30	2.0	1.20	489.0	8.24	3760	262
	4.73	41.4	2.80	59.2	.40	21	++<.20	1.7	.80	433.0	8.10	3500	191
	4.14	65.7	2.00	57.8	.50	25	<.30	2.0	.80	442.0	6.45	4390	207
	4.69	73.0	3.00	52.2	.40	38	<.20	<1.0	.60	238.0	5.44	4120	150
	4.79	145.0	1.60	60.3	1.01	40	<.20	<.9	.60	150.0	3.53	3650	80
	4.34	55.5	2.00	72.4	.70	38	<.30	12.0	1.30	301.0	5.70	2840	148
	4.60	38.0	1.00	80.3	.40	25	<.20	3.0	.70	307.0	6.24	3660	154
	4.88	49.8	3.00	58.3	.60	41	<.20	1.0	1.10	241.0	5.01	4190	172
	4.40	53.6	3.00	84.3	.40	34	<.20	11.0	.70	258.0	5.75	3700	173
	4.36	43.4	6.00	73.2	.20	31	<.20	11.0	.90	259.0	4.93	4110	181
	4.52	50.0	4.00	72.8	1.10	39	<.20	11.0	1.10	876.0	15.60	4420	344
	4.44	65.1	4.00	96.5	.30	21	<.30	11.0	.80	401.0	6.47	3170	178
	4.58	64.7	4.00	65.9	.40	21	<.20	11.0	1.10	686.0	10.10	4560	332
	4.44	64.3	3.00	55.6	.50	30	<.30	14.0	.60	124.0	3.69	3960	70
					SHRIMP - PANDALUS BOREALIS				- MUSCLE				
C-1-I	4.21	21.7	<.05	50.7	.20	83	<.20	<1.0	.60	55.8	1.58	1920	25
	4.66	31.9	<.05	58.5	.30	59	.30	2.0	.70	55.2	1.76	1690	26
	4.53	30.9	<.05	57.2	.30	70	<.20	<1.0	.40	71.5	1.93	1870	27
	4.33	29.4	<.05	56.7	.40	78	<.20	1.0	.70	19.0	.32	2290	10
	4.30	39.3	<.05	60.8	.50	104	<.20	<1.0	.90	338.0	4.97	2050	136
	4.37	27.8	<.05	55.2	.20	93	<.20	<1.0	1.20	612.0	8.97	2210	269
	4.15	20.4	<.05	62.8	.20	66	<.20	<1.0	.60	235.0	3.89	2560	117
	4.91	18.0	<2.00	54.9	.20	46	<.30	2.0	2.20	216.0	3.12	2430	96
					SHRIMP - PANDALUS HYPSINOTUS				- MUSCLE				
C-1-I	4.27	73.5	.17	63.0	.10	43	<.30	2.0	.60	70.7	1.61	2340	30
	4.91	196.0	.07	65.6	.10	71	<.30	2.0	.90	174.0	2.87	2370	75
	4.59	67.4	.09	73.0	.30	35	<.30	2.0	.80	94.9	1.64	2460	33

Continued ...

APPENDIX: 10A TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), CHATHAM SOUND , MAY 1981.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					FISH - ATHERESTHES STOMIAS				- MUSCLE				
C-1-I	5.51	2.9	<.05	17.2	<.05	14	<.20	3.0	.80	29.1	.65	1510	14
	5.28	9.3	<.05	25.0	<.05	26	.20	1.0	1.20	31.9	.60	1420	15
	5.40	4.8	2.00	21.1	<.05	35	.70	1.0	1.50	52.7	.99	1550	20
					FISH - GLYPTOCEPHALUS ZACHIRUS				- MUSCLE				
C-1-I	5.10	2.1	1.00	16.8	.40	62	<.20	2.0	.90	46.4	2.38	1360	27
	5.06	1.9	<.05	12.5	<.05	66	<.20	1.0	.90	35.3	.75	1200	21
	5.04	29.8	.12	15.7	.50	66	<.20	2.0	1.00	48.6	.94	1230	25
	5.18	4.4	1.00	14.6	<.10	70	<.20	8.0	1.10	31.8	.90	1220	14
	5.64	3.4	<.05	24.9	<.05	50	<.20	1.0	1.10	80.1	1.22	1450	37
	5.36	3.1	<.05	18.2	<.05	37	<.20	<1.0	1.10	48.0	.71	1390	18
	5.86	2.2	<.05	17.5	<.05	61	<.20	<1.0	.70	78.8	1.15	1520	38
					FISH - HIPPOGLOSSOIDES ELASSODON				- MUSCLE				
C-1-I	5.39	4.9	1.00	17.0	.10	48	.20	6.0	5.40	49.8	1.14	1190	14
	5.22	5.8	2.00	22.5	.09	19	<.20	2.0	2.80	106.0	1.42	1320	67
	5.13	8.1	.09	16.0	.10	38	<.20	7.0	1.60	56.1	.88	1320	32
	4.84	5.7	.17	19.6	1.10	50	<.20	9.0	1.00	47.1	.69	1070	22
	6.25	4.1	.17	20.4	<.05	21	.30	1.0	1.40	45.4	1.06	1340	19
	5.77	4.1	<.05	16.4	<.05	22	.30	<1.0	1.00	43.3	.72	1350	22
	6.27	2.5	.16	18.5	<.05	8	<.20	<1.0	.80	67.2	1.07	1390	33
					FISH - THERAGRA CHALCOGRAMMA				- MUSCLE				
C-1-I	5.47	6.6	<.05	21.7	12.00	36	<.20	1.0	1.50	40.5	.80	1450	15
	5.76	13.0	3.00	42.1	.08	11	<.20	1.0	4.20	158.0	2.20	1630	47

\+ Roman numerals indicate station trawl number.

++< Indicates EPS laboratory detection limits.

APPENDIX:10B TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), CHATHAM SOUND, OCTOBER 1981.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					SHRIMP - CRANGON COMMUNIS				- TAIL ONLY				
+C-1-I	3.95	57.8	.10	48.3	.54	41	8.77	<3.9	.81	347.0	22.50	4690	161
	3.80	63.0	++<.05	58.2	.80	44	4.81	<3.8	<.72	225.0	34.20	3850	104
	4.04	49.8	<.05	46.4	.43	44	2.44	<3.9	<.73	228.0	20.20	4170	138
	4.32	50.0	<.05	48.6	.82	40	<1.40	4.1	.71	260.0	20.30	4160	154
	4.36	51.2	<.05	45.3	.50	41	<1.40	<3.9	<.73	259.0	17.10	4550	157
	3.99	62.7	1.00	47.6	.50	40	4.43	<4.0	<.75	244.0	36.60	4390	111
	4.10	72.3	.24	63.1	.68	46	4.22	3.9	<.73	277.0	25.30	4340	165
	4.10	56.2	<.05	61.8	.65	38	<1.38	<3.7	.91	425.0	55.30	4340	224
	4.01	65.0	.10	52.5	.57	45	4.40	<4.0	.96	248.0	19.60	4290	139
	4.25	63.4	<.05	53.6	.77	60	<1.63	<4.3	<.81	249.0	23.30	4540	136
					SHRIMP - PANDALOPSIS DISPAR				- MUSCLE				
C-1-I	4.60	17.4	<.05	43.1	<.05	69	<1.50	<4.0	.79	12.3	.20	1970	7
	4.38	20.8	<.05	45.6	.10	49	<1.46	<3.9	<.73	14.2	.99	1630	7
	4.70	19.1	<.05	44.6	.10	70	<1.48	<3.9	<.74	16.6	.54	1630	8
	4.36	18.6	<.05	46.7	<.05	64	<1.50	<4.0	.76	10.4	.68	1530	7
	4.45	18.8	<.05	45.8	<.05	60	<1.49	<4.0	<.75	16.7	.61	1740	8
	4.47	18.7	<.05	47.6	<.05	70	<1.49	<4.0	<.75	11.4	.36	1630	7
	4.65	14.8	<.05	45.0	<.05	56	<1.49	<4.0	<.75	30.4	.68	2110	18
	4.51	16.2	<.05	55.3	<.05	77	<1.49	<4.0	<.75	60.8	1.65	1810	24
	4.73	17.4	<.05	44.3	<.05	68	<1.50	<4.0	<.75	21.2	.32	2110	13
	4.49	15.7	<.05	44.0	<.05	65	<1.49	<4.0	<.74	51.6	1.03	1880	29
	4.58	15.9	<.05	43.6	<.05	97	<1.50	<4.0	<.75	15.3	.42	1600	7
	4.48	14.7	<.05	43.0	.05	50	<1.48	<3.9	1.15	10.6	.41	2040	6
	4.47	18.7	<.05	46.7	.05	55	<1.48	<3.9	1.79	15.0	1.01	1540	25
	4.52	10.7	<.05	44.7	.05	72	<1.49	<4.0	<.74	13.4	.23	1960	7
	4.55	15.6	<.01	50.0	<.05	108	<1.47	<3.9	<.74	33.6	.80	1830	15
					SHRIMP - PANDALUS BOREALIS				- MUSCLE				
C-1-I	4.41	17.8	<.05	50.8	.15	53	<1.49	<4.0	<.75	31.8	1.22	1550	16
	4.32	18.4	<.05	49.3	.15	59	<1.49	<4.0	.87	16.3	1.35	1600	9
	4.59	20.9	<.05	58.3	.15	65	<1.47	<3.9	.74	11.9	.84	1790	<5
	4.20	29.2	<.05	62.7	<.05	70	<1.47	<3.9	.74	15.0	1.06	1580	8
	4.35	23.2	<.05	51.4	<.05	63	<1.48	<3.9	1.10	14.8	.82	1730	7
	4.21	18.4	.59	52.5	<.05	58	<1.62	<4.3	<.81	8.4	.46	1610	<5
	4.31	19.8	<.05	47.9	.05	71	<1.49	<4.0	4.17	30.5	1.32	1840	9
	4.20	25.4	<.05	54.3	<.05	54	<1.45	<3.9	.76	12.3	.84	1660	6
	4.17	24.5	<.05	56.0	.14	57	<1.45	<3.9	.73	16.2	1.02	1700	9
	4.31	20.1	<.05	48.1	<.05	52	<1.47	<3.9	<.73	25.7	1.10	1640	10
	4.18	25.1	.10	56.2	.49	76	<1.46	<3.9	<.73	14.7	.82	1680	7
	4.17	21.7	<.05	52.1	.09	54	<1.41	<3.8	<.70	21.6	1.08	1620	9
	4.23	18.3	<.05	53.5	<.05	63	<1.49	<4.0	<.74	19.6	1.20	1600	10
	4.22	18.4	.10	50.1	.15	53	<1.46	<3.9	.87	24.3	.91	1600	8
	4.22	21.4	<.05	45.5	<.05	55	<1.44	<3.8	<.72	11.9	.64	1510	7

Continued ...

APPENDIX: 10B TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), CHATHAM SOUND, OCTOBER 1981.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					FISH - ATHERESTHES STOMIAS				- MUSCLE				
C-1-I	5.28	4.8	<.05	18.0	<.05	<7	<1.38	<3.7	1.09	54.8	.75	1620	22
	5.35	6.7	<.05	20.5	<.05	16	<1.46	8.4	6.04	80.9	1.96	1670	19

\+ Roman numerals indicate station trawl number.

++< Indicates EPS laboratory detection limits.

APPENDIX: 10C TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), LAREDO SOUND, OCTOBER 1981.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
						BIVALVE - Y.THRACIAEFORMIS/MONTEREYENSIS - WHOLE BODY							
+L-1-I	5.89	63.8	11.60	541.0	1.99	111	2.13	7.2	2.62	2260.0	21.30	4880	1180
	5.05	60.6	5.05	566.0	1.59	87	2.32	6.9	2.42	2310.0	21.70	5200	1370
	5.93	61.4	5.93	533.0	1.72	105	++<2.27	8.0	2.38	1800.0	14.60	4370	1020
	6.01	49.1	9.51	590.0	1.82	134	2.68	6.8	2.55	1500.0	11.30	4150	721
	5.78	51.9	7.60	514.0	1.39	107	1.73	4.9	2.06	1860.0	13.00	4080	947
	5.29	60.5	11.00	526.0	1.60	133	2.00	4.4	2.16	1860.0	20.10	3780	972
	5.66	39.4	9.49	879.0	1.89	95	2.27	5.0	2.43	1980.0	14.10	4260	971
	6.17	51.7	9.07	772.0	2.26	103	2.35	6.6	2.53	2360.0	18.40	5640	1170
	6.37	54.2	10.20	600.0	1.63	88	<3.00	<8.0	2.51	2310.0	18.90	5760	1260
						SHRIMP - CRANGON COMMUNIS			- TAIL ONLY				
L-1-I	3.56	89.4	<.05	71.3	3.31	33	<1.39	<5.7	.72	190.0	11.20	3890	72
	3.39	59.4	<.05	82.5	3.72	35	<1.47	<3.9	.78	81.0	8.69	3540	45
	3.97	42.9	.05	60.7	3.65	27	<1.46	<12.1	.92	198.0	8.35	3770	113
	3.86	60.8	.25	65.7	5.43	36	<1.48	<3.9	.76	154.0	8.84	3710	107
						SHRIMP - PANDALOPSIS DISPAR			- MUSCLE				
L-1-I	4.46	22.6	<.05	48.4	<.05	48	<1.50	<4.0	<.75	19.2	.68	1890	12
	4.65	18.3	<.05	47.9	<.05	42	<1.48	<3.9	<.74	12.8	.29	2090	10
	4.66	29.2	<.05	51.5	.10	48	<1.49	<4.0	<.74	22.6	.70	2020	17
	4.71	20.3	<.05	44.7	.15	42	<1.47	<3.9	<.74	21.1	.57	1580	18
	4.72	22.7	<.05	49.3	<.05	42	<1.41	<3.8	<.70	11.6	.63	1890	8
	4.67	22.0	<.05	46.4	<.05	43	<1.49	<4.0	<.74	12.6	.29	1840	8
	4.72	15.4	<.05	44.6	.10	30	<1.49	<4.0	<.75	6.7	.29	1440	<5
	4.62	18.1	<.05	48.7	.10	44	<1.43	<3.8	<.72	18.9	.39	2060	12
	4.61	21.9	<.05	48.6	<.05	40	<1.39	<3.7	<.69	39.0	.67	1880	18
	4.42	28.5	<.05	45.8	<.05	30	<1.49	<4.0	<.74	12.2	.48	1580	8
	4.56	21.7	<.05	5.0	.09	51	<1.41	<3.7	<.70	16.1	.53	1990	11
	4.51	19.4	<.05	48.0	<.05	42	<1.45	<3.9	<.73	10.8	.42	2100	11
	4.56	21.3	<.05	47.4	.10	45	<1.48	<3.9	<.74	13.5	.29	1770	8
	4.49	21.1	<.05	45.8	.15	48	<1.49	<4.0	<.74	13.4	.47	1870	9
	4.32	21.5	<.05	44.3	.15	45	<1.46	<3.9	<.73	8.9	.41	1740	8
						SHRIMP - PANDALOPSIS DISPAR			- WHOLE BODY				
L-1-I	3.70	90.0	<.05	60.5	2.72	27	<1.50	<4.0	.86	73.0	3.98	2840	75
	1.00	87.2	<.05	46.8	2.28	28	<1.49	9.3	.82	133.0	2.88	3750	101
	1.00	118.0	<.05	71.4	3.31	35	<1.50	<4.0	.90	143.0	3.74	3720	155
	4.03	72.6	.10	45.3	1.74	31	<1.49	<4.0	1.04	266.0	6.51	4500	276
	4.01	78.3	<.05	45.6	1.80	26	<1.50	<4.0	.82	72.9	2.65	3740	78
	3.67	93.4	<.05	54.7	3.62	31	<1.49	<4.0	<.75	72.1	3.14	3340	73
	4.18	125.0	<.05	55.9	3.61	34	<1.46	<3.9	3.16	255.0	6.32	4100	251
	3.99	68.6	<.05	67.2	1.80	34	<1.41	<3.8	.77	59.7	3.13	2060	56
	4.18	80.4	.10	45.5	1.83	27	<1.48	<3.9	.79	166.0	4.03	4380	171
	4.18	99.6	.45	48.9	1.64	27	<1.49	<4.0	1.09	150.0	4.04	4330	161

Continued ...

APPENDIX: 10C TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), LAREDO SOUND, OCTOBER 1981.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
L-1-I	continued...												
	4.53	78.2	.05	53.0	1.88	33	<1.49	<4.0	.87	167.0	4.36	4590	136
	4.41	62.0	<.05	54.1	1.92	28	<1.48	<3.9	1.43	113.0	3.87	3660	93
	4.19	65.5	<.05	48.0	1.37	22	<1.46	<3.9	.74	86.9	4.00	4110	70
	4.50	86.0	.10	55.7	1.58	32	<1.47	<3.3	.94	230.0	5.23	4520	191
	4.12	76.4	<.05	53.1	1.91	22	<1.49	<4.0	<.74	118.0	3.63	3710	105
					SHRIMP - PANDALUS BOREALIS				- MUSCLE				
L-1-I	4.34	22.2	<.05	56.4	<.05	41	<1.47	<3.9	<.73	26.7	.60	1830	5
	4.15	22.8	.19	52.7	<.05	36	<1.45	<3.9	.78	13.1	.76	1650	5
	4.30	19.0	<.05	49.8	<.05	28	<1.48	5.9	11.30	49.8	1.52	1770	6
	4.36	28.0	<.05	55.7	<.05	37	<1.49	26.5	.00	203.0	5.72	1920	10
	4.25	23.7	<.05	53.9	<.05	42	<1.47	<3.9	.78	13.8	.90	1760	8
	4.23	20.5	<.05	56.8	.09	40	<1.41	<3.8	<.70	9.6	.39	1870	7
	4.23	22.2	<.05	49.6	.10	38	<1.50	<4.0	<.75	17.2	.47	1640	8
	4.39	20.1	<.05	54.2	<.05	49	<1.49	<4.0	2.12	26.0	1.08	1750	13
	4.24	14.7	<.05	54.8	<.05	36	<1.38	<3.7	1.09	19.2	.52	1650	<5
	4.20	19.8	<.05	56.9	.10	28	<1.49	<4.0	<.74	14.9	1.15	1880	10
	4.11	19.9	<.50	49.1	<.05	44	<1.35	<3.6	<.68	13.6	.75	1520	7
	4.42	27.3	<.05	53.6	<.05	45	<1.49	<4.0	1.99	23.6	.45	1750	9
	4.21	20.0	<.05	50.7	<.50	32	<1.45	<3.9	5.22	28.5	.89	1610	6
	4.34	22.0	<.05	54.5	.14	36	<1.44	<3.8	.93	10.9	.72	1830	<5
	4.30	16.2	.05	50.0	.15	38	<1.49	<4.0	<.74	8.8	.44	1520	6
					SHRIMP - PANDALUS BOREALIS				- WHOLE BODY				
L-1-I	3.61	98.2	1.10	68.5	2.48	19	<1.49	<4.0	.81	146.0	5.06	2700	120
	3.71	121.0	.35	72.7	1.62	27	<1.49	<4.0	<.75	120.0	3.73	2430	95
	3.44	68.1	<.05	63.6	1.76	25	<1.49	<4.0	<.75	70.1	2.93	2500	41
	3.71	75.1	.24	65.9	1.28	26	<1.45	<3.9	<.73	68.3	3.36	2620	42
	3.21	73.9	.15	59.9	1.65	31	<1.50	<4.0	<.99	149.0	4.30	2830	139
	3.98	81.2	.05	65.8	2.16	24	<1.49	<4.0	<.74	69.8	3.30	2750	48
	3.58	70.1	.05	62.6	1.81	23	<1.48	<4.0	<.75	73.1	3.15	2740	49
	3.92	99.3	.05	59.3	2.02	32	<1.49	<3.9	1.24	102.0	3.45	3090	73
	3.31	78.8	.15	63.7	1.30	22	<1.46	<3.9	.75	105.0	4.33	2510	86
	3.63	99.0	.30	74.0	2.80	28	<1.50	<4.0	2.47	81.5	3.06	2640	50
	3.66	102.0	<.05	66.1	1.73	26	<1.43	<4.0	.75	103.0	3.21	2700	59
	3.66	122.0	.05	58.3	1.19	24	<1.49	<3.9	<.75	65.7	2.50	2780	44
	3.64	91.3	<.05	63.6	1.94	26	<1.46	<3.9	<.73	98.1	3.46	2650	65
	3.66	144.0	.10	79.9	2.46	26	<1.48	<3.9	<.81	157.0	5.13	2770	120
	3.34	103.0	<.05	67.3	1.48	26	<1.46	<3.9	<.75	86.3	3.10	2680	51
					FISH - ATHERESTHES STOMIAS				- MUSCLE				
L-1-I	5.24	6.2	<.05	17.3	<.05	11	<1.47	<3.9	.80	31.7	.40	1620	21

Continued ...

APPENDIX:10C TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), LAREDO SOUND, OCTOBER 1981.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					FISH - EOPSETTA JORDANI				- MUSCLE				
L-1-I	5.08	6.0	<.05	20.8	<.05	<7	<1.48	<3.9	1.45	38.7	.51	1600	16

+ Roman numerals indicate station trawl number.

++< Indicates EPS laboratory detection limits.

APPENDIX:10D TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), QUATSINO SOUND, SEPTEMBER 1981.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					BIVALVE - Y.THRACIAEFORMIS/MONTEREYENSIS - WHOLE BODY								
+ Q-1-I	4.96	23.2	.64	169.0	1.22	26	1.73	4.1	2.83	2570.0	23.20	3770	1220
					BIVALVE - YOLDIA SCISSURATA - WHOLE BODY								
Q-1-I	4.91	60.3	.80	111.0	1.04	41	++<1.34	4.0	2.99	2480.0	36.10	3880	1170
					SHRIMP - PANDALOPSIS DISPAR - MUSCLE								
Q-1-I	4.41	23.4	<.05	48.4	<.05	42	<1.48	<3.9	<.74	17.2	.75	1830	11
	4.56	21.0	<.05	52.0	<.05	49	<1.49	<4.0	.80	13.0	.91	1860	10
	4.47	19.6	<.05	49.5	<.05	49	<1.46	<3.9	<.73	13.8	.40	1830	9
	4.27	23.9	<.05	49.7	<.05	51	<1.49	<4.0	.98	28.6	.66	1630	20
	4.27	24.6	<.05	49.8	.05	47	<1.44	<3.8	<.72	15.0	.56	1660	10
	4.23	24.9	<.05	47.2	.05	42	<1.49	<4.0	.84	20.0	.59	1570	12
	4.22	23.3	<.05	48.1	.10	28	<1.47	<3.9	<.73	33.1	.88	1530	21
	4.27	23.7	.25	48.8	.05	50	<1.47	<3.3	<.74	17.8	.46	1580	11
	4.18	26.1	<.05	46.7	<.05	35	<1.48	<3.9	<.74	15.4	.71	1640	10
	4.27	29.7	<.05	53.9	.10	50	<1.48	<3.9	<.74	20.4	.72	1570	13
	4.54	20.7	<.05	45.6	.05	36	<1.46	<3.9	<.73	26.1	.59	1710	16
	4.35	19.4	<.05	45.6	.05	40	<1.49	<4.0	<.74	17.1	.62	1490	12
	4.08	21.7	<.05	42.6	<.05	23	<1.46	<3.9	<.73	17.7	.76	1420	8
	4.28	20.7	<.05	45.0	<.05	33	<1.48	<3.9	<.74	22.6	.47	1690	14
	4.43	24.3	<.05	44.3	<.05	28	<1.40	<3.7	1.03	13.4	.51	1650	7
					SHRIMP - PANDALUS BOREALIS - MUSCLE								
Q-1-I	4.23	21.1	<.05	49.3	<.05	43	<1.45	<3.9	<.73	18.4	.96	1630	11
	4.33	14.5	<.05	49.0	.10	65	<1.49	<4.0	<.75	14.6	.53	1760	10
	4.16	22.2	<.05	53.3	<.05	62	<1.48	<3.9	<.74	21.3	1.56	1830	14
	4.09	24.1	<.05	55.0	.10	41	<1.50	<4.0	<.75	24.3	.96	1800	14
	4.19	17.6	.05	48.4	.10	105	<1.45	<3.9	<.73	15.6	.91	1640	8
	4.17	20.1	<.05	48.7	<.05	57	<1.49	<4.0	.76	11.7	.70	1680	7
	4.23	12.4	<.05	46.8	<.05	60	<1.38	<3.7	<.69	31.3	1.04	1680	20
	4.27	20.2	<.05	50.8	<.05	67	<1.49	<4.0	<.75	13.1	.72	1760	8
	4.20	23.9	<.05	53.9	.05	87	<1.47	<3.9	<.74	24.4	.77	1890	14
	4.18	16.9	<.05	49.7	.10	79	<1.49	<4.0	1.25	27.7	1.00	1850	14
	4.25	14.5	<.05	49.9	.05	100	<1.48	<3.9	<.74	15.4	.46	1880	9
	4.03	25.1	<.05	51.5	<.05	43	<1.49	<4.0	<.74	15.2	1.01	1820	9
	4.32	19.3	<.05	56.3	.10	70	<1.49	<4.0	<.75	22.0	.96	1930	15
	4.23	27.6	<.05	58.9	.05	42	<1.45	<3.9	<.73	25.6	.75	2020	18
	4.27	30.6	1.30	60.0	.10	59	<1.50	<4.0	<.75	31.7	.83	2020	14
					FISH - ANOPLOPOMA FIMBRIA - MUSCLE								
Q-1-I	4.97	5.5	.00	24.6	<.05	<7	<1.41	<3.7	1.10	56.8	.72	1650	20

Continued ...

APPENDIX:10D TISSUE TRACE METAL CONCENTRATIONS (mg/kg dry weight), QUATSINO SOUND, SEPTEMBER 1981.

Station	Wet/Dry	Cu	Pb	Zn	Cd	As	Mo	Ni	Cr	Fe	Mn	Mg	Al
					FISH - ATHERESTHES STOMIAS				- MUSCLE				
Q-1-I	5.01	3.4	<.05	17.6	<.05	<7	<1.41	<3.8	.81	33.4	.14	1490	9
					FISH - EOPSETTA JORDANI				- MUSCLE				
Q-1-I	5.42	6.3	<.05	16.7	<.05	50	<1.50	<4.0	1.83	29.2	.46	1400	8
	4.97	2.5	<.05	16.4	<.05	102	<1.46	<3.9	<.73	24.7	.33	1410	9
	5.14	2.6	<.05	16.5	<.05	76	<1.44	<3.8	.89	34.2	.44	1440	11
					FISH - GLYPTOCEPHALUS ZACHIRUS				- MUSCLE				
Q-1-I	5.84	2.9	<.05	22.5	<.05	128	<1.49	<4.0	.79	98.8	2.01	1460	46
					FISH - MICROSTOMUS PACIFICUS				- MUSCLE				
Q-1-I	5.41	10.4	<.05	20.4	<.05	195	<1.45	<3.9	1.36	38.3	.58	1760	17

\+ Roman numerals indicate station trawl number.

++< Indicates EPS laboratory detection limits.