Benthic Studies in Alice Arm and Hastings Arm, B.C. in Relation to Mine Tailings Dispersal

R.D. Kathman[1], R.O. Brinkhurst[2], R.E. Woods[1], and D.C. Jeffries[3]

[1]E.V.S. Consultants; Marine Technology Centre;
Sidney, B.C. V8L 3S1

[2]Institute of Ocean Sciences;
Department of Fisheries and Oceans;
Sidney, B.C. V8L 4B2

[3]Quantum Research; Vancouver B.C. V6S 2G3

1983

Canadian Technical Report of Hydrography and Ocean Sciences No. 22

Fisheries and Oceans
Pêches et Océans

Canada

Canadian Technical Report of Hydrography and Ocean Sciences

These reports contain scientific and technical information of a type that represents a contribution to existing knowledge but which is not normally found in the primary literature. The subject matter is generally related to programs and interests of the Ocean Science and Surveys (OSS) sector of the Department of Fisheries and Oceans.

Technical Reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report will be abstracted in Aquatic Sciences and Fisheries Abstracts. Reports are also listed in the Department's annual index to scientific and technical publications.

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

Regional and headquarters establishments of Ocean Science and Surveys ceased publication of their various report series as of December 1981. A complete listing of these publications and the last number issued under each title are published in the *Canadian Journal of Fisheries and Aquatic Sciences*, Volume 38: Index to Publications 1981. The current series began with Report Number 1 in January 1982.

Rapport technique canadien sur l'hydrographie et les sciences océaniques

Ces rapports contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles mais que l'on ne trouve pas normalement dans les revues scientifiques. Le sujet est généralement rattaché aux programmes et intérêts du service des Sciences et Levés océaniques (SLO) du ministère des Pêches et des Océans.

Les rapports techniques peuvent être considérés comme des publications à part entière. Le titre exact figure au-dessus du résumé du chaque rapport. Les résumés des rapports seront publiés dans la revue Résumés des sciences aquatiques et halieutiques et les titres figureront dans l'index annuel des publications scientifiques et techniques du Ministère.

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

Les établissements des Sciences et Levés océaniques dans les régions et à l'administration centrale ont cessé de publier leurs diverses séries de rapports depuis décembre 1981. Vous trouverez dans l'index des publications du volume 38 du *Journal canadien des sciences halieutiques et aquatiques*, la liste de ces publications ainsi que le dernier numéro paru dans chaque catégorie. La nouvelle série a commencé avec la publication du Rapport n° 1 en janvier 1982.

ADDENDUM

After the manuscript was in press, a number of incorrect or outdated familial or generic assignments were discovered. The following classification and specific names, recognized by Austin (1983), should replace those presented in Appendices G, H, and I.

Porifera
Hexactinellida
Lyssacinosa
Rosellidae

Coelenterata
Anthozoa
Pennatulacea
Virgulariidae
Virgularia cf. *tuberculata* Marshal

Platyhelminthes
Turbellaria
Polycladida

Nemertea
Anopla
Palaeonemertea

Heteronemertea
Lineidae
? *Cerebratulus*
Micrura alaskensis? Coe

Enopla
Hoplonemertea

Nematoda

Sipunculoidea
Golfingiidae
Golfingia sp.

Echiuroidea

Annelida
Oligochaeta
Tubificida
Tubificidae
Limnodriloides sp.
L. victoriensis Brinkhurst and Baker

Polychaeta
(Errantiate)
Polynoidae
? Eunoe
Gattyana treadwelli? Pettibone

Sigalionidae
Pholoe minuta (Fabricius)

Phyllodocidae
Eteone (Mysta) sp.
E. columbiensis Kravitz and Jones
Phyllodoce groenlandica Oersted

Pilargidae
Ancistrosyllis sp.
A. groenlandica McIntosh

Syllidae
Exogone sp. 1
Exogone sp. 2
E. gemmifera Pagenstecher
Eusyllis cf. blomstrandi Malmgren
Syllis sp.
S. alternata Moore

Nephtyidae
Aglaophamus malmgreni (Theel)
Nephtys cornuta cornuta Berkley and Berkley
N. punctata Hartman

Sphaerodoridae
Sphaerodoropsis sphaerulifer (Moore)

Goniadidae
Goniada annulata Moore
Glycinde armigera Moore

Lumbrineridae
Lumbrineris sp.
L. luti Berkley and Berkley
Paraninoe simpla (Moore)

Dorvilleidae
Schistomeringos sp.

Hesionidae
Gyptis brevipalpa (Hartmann-Schroder)

(Sedentariate)
Orbiniidae
Leitoscoloplos pugettensis (Pettibone)

Paraonidae
Aricidea suecica Eliason
A. lopezi lopezi Berkley and Berkley
Cirrophorus branchiatus Ehlers
Levinsenia gracilis (Tauber)

Trochochaetidae
Trochochaeta multisetosa (Oersted)

Chaetopteridae
Spiochaetopterus costarum (Claparede)

Spionidae
Polydora sp.
Pseudopolydora kempi? (Southern)
Prionospio sp.
P. cirrifera Wiren
P. steenstrupi Malmgren
Spiophanes sp.
S. kroyeri Grube

Cirratulidae
Chaetozone setosa Malmgren
Caulleriella hamata (Hartman)
C. cf. hamata (Hartman)

Cossuridae
Cossura soyeri Laubier

Flabelligeridae
Brada sp.
B. villosa (Rathke)
Pherusa sp.

Opheliidae
Ophelina breviata (Ehlers)

Sternaspidae
Sternaspis scutata (Renier)

Capitellidae
Capitella capitata (Fabricius)
Decamastus sp.
Heteromastus sp.
H. filobranchus? Berkley and Berkley
Mediomastus sp.

Maldanidae
Maldane glebifex Grube
Rhodine sp.

Oweniidae
Myriochele oculata Zachs
Owenia fusiformis Chiaje

Amphictenidae
Pectinaria sp.
P. moorei Annenkova

Terebellidae
Artacama conifera Moore
Pista cristata (Muller)
Polycirrus sp.

Trichobranchidae
Terebellides sp.
Terebellides stroemi Sars

Ampharetidae
Amage anops (Johnson)
Amphicteis sp.
A. cf. *scaphobranchiata* Moore
Anobothrus gracilis (Malmgren)
Sosanopsis cf. *hesslei* Banse

Sabellidae
Euchone sp.
Jasmineira pacifica Annenkova

UID Polychaeta

Arthropoda
Crustacea
Cumacea
Nannastacidae
Campylaspis ?*papillata* Lomakina

Leuconidae
Eudorella sp.
Leucon sp.

Tanaidacea
Leptognathiidae
Leptognathia sp.

Amphipoda
Corophiidae
Corophium acherusicum Costa

Lysianassidae
Cyclocaris challengeri Stebbing
Koroga megalops Holmes
Orchomene obtusa (Sars)
Pachynus barnardi Hurley

Phoxocephalidae
Paraphoxus oculatus Sars

Oedicerotidae
Bathymedon pumilis Barnard
Monoculodes cf. emarginatus Barnard

Eusiridae
?Rhachotropis sp.

Hyperiidae
Hyperia medusarum (Muller)
Parathemisto sp.
P. pacifica Stebbing

Mysidacea
Mysidae
Pseudomma truncatum S.I. Smith

Decapoda

Mollusca
Aplacophora

Gastropoda
Pyramidellida
Pyramidellidae
Turbonilla sp.

Cephalaspidea
Cylichnidae
Cylichna altonsa

Gastropteridae
Gastropteron pacificum? Bergh

Thecosomata
Limacinidae
Limacina sp.

Neogastropoda
Nucellidae

Buccinidae
Buccinum sp.

Mesogastropoda
Vitrinellidae
?*Vitrinella* sp.

Scaphopoda
Dentaliida
Dentaliidae
Rhabdus rectius Carpenter

Gadilida
Siphonodentaliidae
Polyschides californicus (Pilsbry and Sharp)

Bivalvia
Veneroida
Tellinidae
Macoma sp.
M. carlottensis Whiteaves
M. eliminata Dunnill and Coan
M. cf. *nasuta* (Conrad)

Cooperellidae
Cooperella sp.

Veneridae
Transenella tantilla (Gould)

Ungulinidae
Diplodonta orbella Gould

Hiatellidae
Hiatella arctica (Linnaeus)

Nuculoidae
Nuculanidae
Nuculana minuta Fabricius

Nuculidae
Nucula tenuis (Montagu)

Yoldiidae
Yoldia amygdalea Valenciennes
Y. beringiana Dall
Y. martyria Dall
Y. myalis (Couthouy)

Echinodermata
Asteroidea
Paxillosida
Goniopectinidae
Ctenodiscus crispatus Retzius

Ophiuroidea
Ophiurida
Ophiuridae
Ophiura sp.
O. leptoctenia H.L. Clark
O. sarsi Lutken

Holothuroidea
Apodida
Chiridotidae
Chiridota albatrossi Ohshima

Molpadida
Molpadiidae
Molpadia intermedia (Ludwig)

Hemichordata
Enteropneusta

Austin, W.C. 1983. An annotated checklist of marine invertebrates in the cold temperate Northeast Pacific. Khoyatan Marine Laboratory, Cowichan Bay, B.C. 621 pp.

Kathman, R.D., R.O. Brinkhurst, R.E. Woods, and D.C. Jeffries. 1983. Benthic studies in Alice Arm and Hastings Arm, B.C. in relation to mine tailings dispersal. Can. Tech. Rep. Hydrogr. Ocean Sci. 22: vii + 30 p.

Canadian Technical Report of
Hydrography and Ocean Sciences
No. 22
1983

BENTHIC STUDIES IN ALICE ARM AND HASTINGS ARM, B.C. IN RELATION TO MINE TAILINGS DISPERSAL

by

R.D. Kathman[1], R.O. Brinkhurst[2], R.E. Woods[1], and D.C. Jeffries[3]

[1]E.V.S. Consultants; Marine Technology Centre; Sidney, B.C. V8L 3S1

[2]Institute of Ocean Sciences; Department of Fisheries and Oceans; Sidney, B.C. V8L 4B2

[3]Quantum Research; Vancouver B.C. V6S 2G3

Institute of Ocean Sciences
Department of Fisheries and Oceans
Sidney, B.C. V8L 4B2

Cat. No. Fs 97-18/22E ISSN 0711-6764

Correct citation for this publication:

Kathman, R.D., R.O. Brinkhurst, R.E. Woods, and D.C. Jeffries. 1983. Benthic studies in Alice Arm and Hastings Arm, B.C. in relation to mine tailings dispersal. Can. Tech. Rep. Hydrogr. Ocean Sci. 22: vii + 30 p.

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Kathman, R.D., R.O. Brinkhurst, R.E. Woods, and D.C. Jeffries. 1983. Benthic studies in Alice Arm and Hastings Arm, B.C. in relation to mine tailings dispersal. Can. Tech. Rep. Hydrogr. Ocean Sci. 22, 1-30.

Identification of benthic invertebrates was performed on samples collected in Alice Arm and Hastings Arm, British Columbia, in October 1982 to determine distribution of settled mine tailings and the effect on the benthos. Taxonomic and hierarchical analyses of these organisms indicated that mine tailings were affecting the benthic composition and density in the middle to lower section (towards the sill) of Alice Arm. Sediment data from other sources support these findings.

Key words: benthic invertebrates, mine tailings, sedimentation, fjords.

RÉSUMÉ

Kathman, R.D., R.O. Brinkhurst, R.E. Woods, and D.C. Jeffries. 1983. Benthic studies in Alice Arm and Hastings Arm, B.C. in relation to mine tailings dispersal. Can. Tech. Rep. Hydrogr. Ocean Sci. 22, 1-30.

L'identification d'invertèbrés benthiques a été faite à partir d'échantillons recueillis dans le bras Alice et le bras Hastings (Colombie-Britannique) en octobre 1982 pour déterminer la distribution de stériles miniers déposés et l'effet sur le benthos. L'analyse taxonomique de ces organismes et de leur hiérarchie montre que les stériles miniers ont une incidence sur la composition et la densité du benthos à partir du milieu jusqu'à la partie inférieure (vers le seuil) du bras Alice. Les données sur les sédiments provenant d'autres sources appuient ces conclusions.

Mots-cles: invertébrés benthiques, stériles miniers, sédimentation, fjords.

ACKNOWLEDGEMENTS

E.V.S. Consultants would like to thank all the people who contributed to this project. Verifications of organisms were done by the following: Dr. Craig Staude - Amphipoda; Dr. Frank Bernard - Mollusca; Mr. Eugene Ruff -Polychaeta; Mr. Steve Stricker - Nemertea; and Dr. William Austin -Echinodermata and minor phyla. Mr. Jean Coustalin performed the initial taxonomic identifications. Several scientists provided additional information; we would especially like to thank Drs. Jeff Thompson and Rob Macdonald, and Mr. Darcy Goyette for their input. E.V.S. Consultants personnel included Dr. Peter Chapman, who reviewed the manuscript and added valuable comments; Mss. Marla Mees and Sarah Irwin, who prepared the report; Ms. Connie Priestley, who assisted with data and draft report preparation; and Mr. Paul Wheeler, who deserves special thanks for coordination and production of the report. Mss. Deedee Kathman and Roberta Woods were the Principal Investigators. Cluster analysis was done by Mr. Duncan Jeffries of Quantum Research. Dr. Ralph Brinkhurst assisted with report preparation.

SUMMARY

Benthic invertebrate samples were collected during October 1982 in Alice Arm and Hastings Arm, British Columbia. Composition, density and distribution of the benthos were analyzed in relation to the distribution of settled mine tailings in Alice Arm as determined by corresponding studies.

Transects CC and DD in Alice Arm had very few species, indicating severe stress at these locations, particularly in the north and middle stations at CC and the middle station at DD. Transect EE had more species, although the deep middle station along this transect had reduced numbers, comparable to Transect DD. This indicates that mine tailings are probably beginning to affect the lower section of Alice Arm, and have progressed to the deep middle section of EE. Independent sedimentation data and sediment analyses from other sources agree with these findings.

North and south stations on Transect EE had similar numbers of species and individuals as the stations in Hastings Arm. However, the qualitative taxonomic composition of the fauna was quite different. Greater varieties and abundances of nemerteans, polychaetes, gastropods, scaphopods, bivalves and echinoderms occurred in Hastings Arm, while nematodes, amphipods and holothuroids were more diverse and abundant at the north and south stations at EE. These differences were probably not related to the effects of tailings but rather to differences in physical, chemical, and biological factors between the two fjords.

Station FF nearest the sill in Alice Arm was dissimilar in composition and density from all other stations sampled and could not be used for comparisons. A heavy sediment load from Hans Creek which settled at Station FF, as well as large amounts of wood fibers in the substrate, contributed to the uniqueness of benthic invertebrates at this station.

INTRODUCTION

The study of the effect of mine tailings deposition on marine benthic invertebrates in Alice Arm was carried out to indicate the extent and degree of dispersion of tailings along the deeper part of Alice Arm. This study formed one component of an overall study being conducted by the Canadian federal government into the effects of Kitsault mine tailings deposition on the Alice Arm aquatic ecosystem. Other concurrent surveys include zooplankton composition and distribution, sedimentation rates, trace metal concentrations in sediments, and hydrographical data collections.

Tailings discharge into Alice Arm began in April 1981 and ceased with the temporary shut-down of the mill in November 1982. During that period approximately four million tons of process effluent were discharged into Alice Arm (R. Hinder, pers. comm.). A variety of fauna may be affected by these tailings due to toxicity of heavy metal concentrations, increased turbidity limiting light penetration and primary production, and smothering of infaunal organisms.

Samples were collected from a series of transects in Alice Arm at increasing distances from the discharge site, and from adjacent Hastings Arm, an area unaffected by tailings discharge. Benthic invertebrates were sorted from the sediment and the infauna identified. The benthic infaunal data were used to assess possible effects, including extent and severity, of tailings deposition on benthic communities.

TERMS OF REFERENCE

The overall objective of this study was to determine composition, density and distribution of the benthic invertebrate faund in relation to mine tailings distribution in Alice Arm, British Columbia. Specific objectives were:

1. Sort and identify benthic macroinvertebrates retained by a 1.0 mm mesh screen in samples collected from Alice Arm and Hastings Arm, British Columbia.

2. Count benthic invertebrates retained by a 0.25 mm mesh screen in samples collected from Alice Arm and Hastings Arm, British Columbia.

3. Verify all identified material from 1. above.

4. Perform statistical analyses on identification data from 1., allowing comparisons among stations and between the two basins.

5. Prepare a data report incorporating the above and other pertinent information with data on the distribution of infaunal benthic invertebrates in relation to settled mine tailings in Alice Arm.

METHODS

SAMPLING

Sampling in Alice Arm and Hastings Arm, British Columbia (Fig. 1), was conducted by Dobrocky Seatech Ltd. in October 1982. Two replicates were taken at each station with the exception of Station EEM on predetermined transect lines (Fig. 2), using a 0.1 m^2 Smith-McIntyre grab. Each sample was sieved through a 1.0 mm screen and preserved with seven percent formalin with phloxine B, an histological stain used to facilitate sorting. Residues from each 1.0 mm sieving were then screened at 0.25 mm and the contents preserved as previously described. Samples were transferred to the E.V.S. Consultants Taxonomy Centre on 12 and 18 November. Pertinent information recorded during the field survey is presented in Appendix A.

SORTING AND QUALITY CONTROL

Upon receipt of the above samples by the E.V.S. Consultants Taxonomy Centre, each 1.0 mm-sieved sample was washed through a 1.0 mm sieve to remove formalin. Aliquots of each sample were examined using a Wild M3 or M5A stereomicroscope until the entire sample was sorted and all organisms removed. Organisms were counted and placed into separate containers filled with alcohol according to the following major taxonomic groups: Amphipoda, Other Crustacea, Polychaeta, Oligochaeta, Mollusca, Nematoda, and Others. Pertinent information for each sample was recorded using the format shown in Appendix B. Sample residues were represerved with seven percent formalin.

Each 0.25 mm-sieved sample was washed through a 0.25 mm sieve to remove formalin and examined as above. Organisms were counted according to major taxonomic groups (for example, Foraminifera, Nematoda, Polychaeta, Ostracoda, Harpacticoida). Only the Oligochaeta were removed, preserved in ethanol and given to the Scientific Authority. A separate information sheet was compiled for each sample using the format shown in Appendix C. Residues were re-preserved with seven percent formalin for possible future analyses.

To ensure quality control of sorting, thirty-two percent (10 samples) of the 1.0 mm residue samples were independently resorted following the procedure outlined above. If additional organisms were found, they were placed in the appropriately labelled vial and information on the sorting sheets was changed accordingly. A separate sheet for each quality control check was completed, in the format shown in Appendix D.

Quality control data for sorting of 1.0 mm screened samples are provided in Table 1. Percent error ranged from 0 to 4.2, well within the requisite limits for accuracy of sorting benthic invertebrate samples.

IDENTIFICATION AND VERIFICATION

All organisms were identified to the lowest possible taxonomic level consistent with the presently-available literature. Identifications were accomplished using either a Wild M5A stereomicroscope or a Leitz Laborlux compound microscope. A list of the taxonomic references used for identifications and verifications is provided.

Fig. 1. Map showing general location of study area.

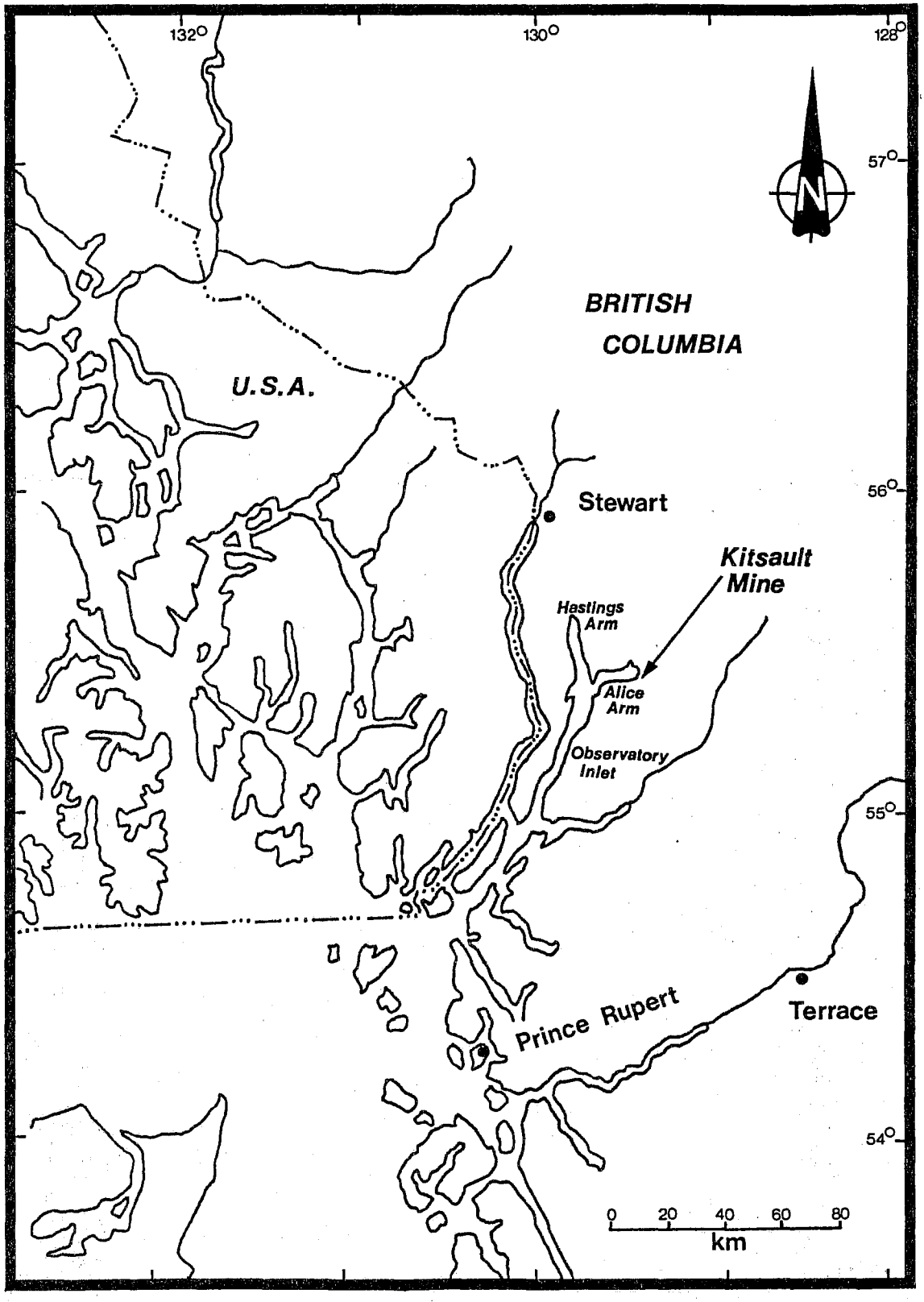


Fig. 2. Station locations in Alice Arm and Hastings Arm, British Columbia.

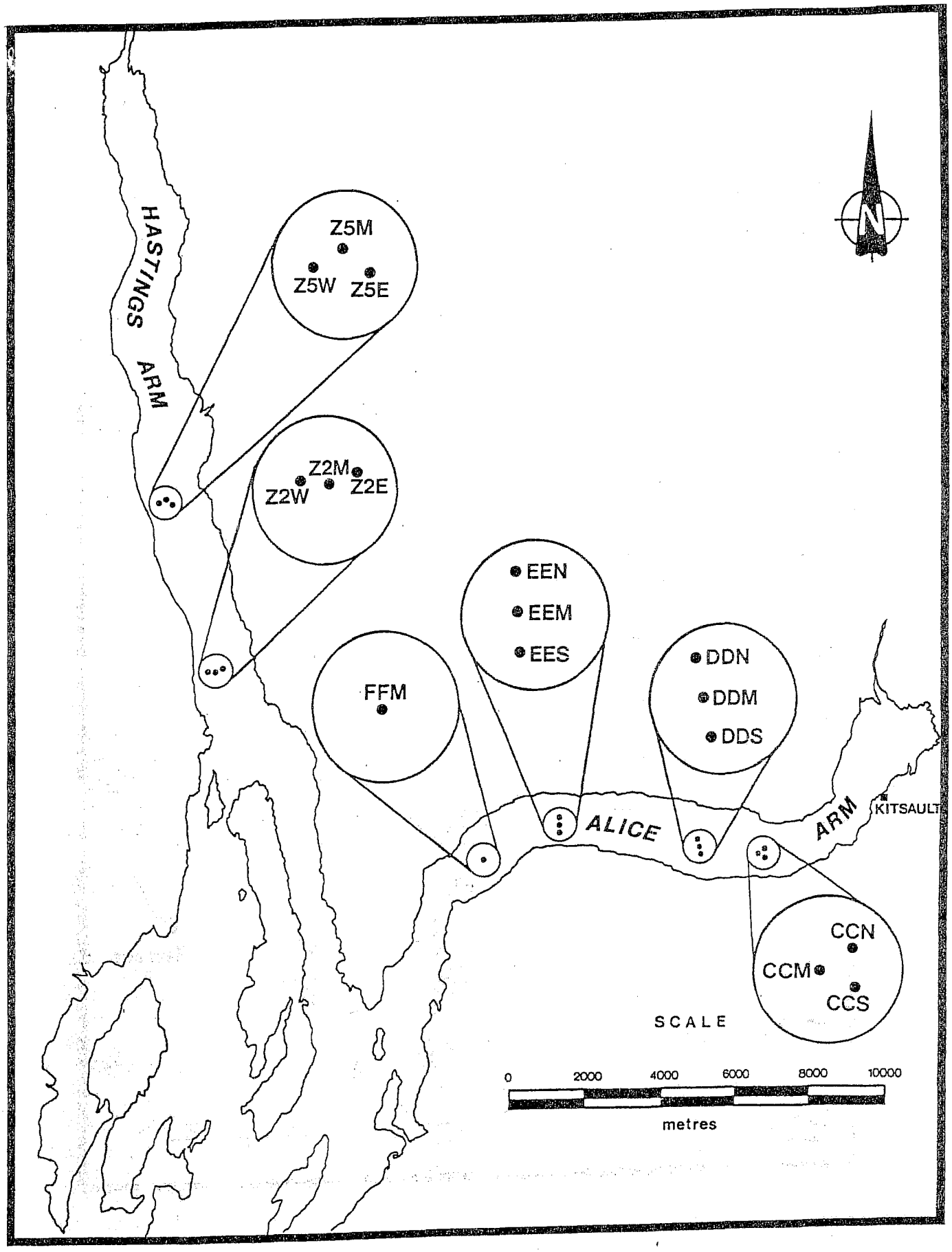


TABLE 1. Quality control (QC) for sorting benthic invertebrates from sediments sieved through a 1.0 mm screen.

Sample identification	Total number of individuals during sorting	Total number of individuals after QC	Percent error for sample
CCN-A	2	2	0
CCM-B	5	5	0
CCS-A	74	77	3.9
DDN-B	57	59	1.7
DDM-A	3	3	0
EEN-A	332	333	0.3
EEM-A	104	104	0
Z2W-B	114	119	4.2
Z5E-A	100	101	1.0
Z5W-B	208	210	1.0

Representative samples of organisms identified to the generic or specific level were sent to recognized taxonomic experts (approved by the Scientific Authority) for verification. If the original identification was incorrect, all samples of that genus or species were re-examined to ensure accuracy. In addition, all samples identified to the familial level were sent to experts for possible identification to a lower taxonomic unit. All necessary changes were incorporated into the original identification sheets and vial labels.

A representative sample of each genus/species was separated from the entire collection and presented to the Scientific Authority as a reference set for future use. The identity of all reference material was further verified by appropriate taxonomic experts.

HIERARCHICAL ANALYSIS

Two-way cluster (hierarchical) analysis was performed on the data using the cluster analysis program "*CGROUP", allowing comparison among species and among stations. This program also allowed comparison among species and between Alice Arm and Hastings Arm. The program uses the grouping algorithm as described by Ward (1963) and follows recognized and accepted techniques for analysis of benthic data. Replicate samples for each station were averaged in order to produce an appropriate data base for use in the cluster analysis. This also simplified the problem associated with the single sample for Station EEM. Data were also entered individually and are therefore on file and readily accessible for possible future analyses.

OTHER RELATED STUDIES

Other agencies and individuals were contacted to identify pertinent past and current studies in Alice Arm and in other areas impacted by mine tailings (for example, Rupert Inlet). Respondents included Drs. D. Mackas, R. Macdonald, and J. Thompson and Mr. D. Stucchi (Institute of Ocean Sciences), Drs. J.-McInerney and D. Ellis (University of Victoria), Dr. S. Calvert (University of British Columbia), Dr. J. Patterson (Amax of Canada Ltd.), Mr. D. Goyette (Environmental Protection Service), and Mr. W. Drinnan (Dobrocky Seatech Ltd.). A partial listing of studies and reports is given in Appendix E. However, given the terms of reference for this study, a comprehensive review of all pertinent information was not possible.

RESULTS

BENTHIC INVERTEBRATES - 0.25 mm SIEVE SAMPLES

The results of simple scanning of the invertebrates retained by a 0.25 mm sieve are presented in Appendices F-1 through F-4. They are summarized for all taxa in Table 2. These samples were initially retained to ascertain if differences in benthic distribution and density in relation to tailings dispersal would be observed between these and the 1.0 mm sieved samples. Although the 1.0 mm sieved samples only accounted for approximately 23 percent of the total benthic invertebrates collected in Alice Arm and Hastings Arm, similar patterns between each set of samples among stations and transects can be observed. For example, for both sieve sizes fewer numbers of organisms were collected at the middle stations on Transects DD and EE than at the north and south stations, and the north and middle stations on Transect CC had fewer individuals than the south station.

Nematodes (which are not readily identifiable) comprised 70 percent of the small organisms found in Alice Arm. If the contribution of these organisms to overall numbers in samples of both sieve sizes is discounted, the patterns of similarity become apparent (see Table 2). The data indicate that benthic samples screened with 1.0 mm mesh will provide enough information to accurately assess trends and patterns in benthic composition and distribution.

BENTHIC INVERTEBRATES - 1.0 mm SIEVE SAMPLES

A listing of all benthic invertebrates collected during this study is given in Appendix G. The number of organisms for each sample and the mean number of organisms for each station in Alice Arm and Hastings Arm are presented in Appendices H and I, respectively. The cluster analysis performed on these data clearly differentiates three groups of stations: Group 1 - Alice Arm not including Station FFM; Group 2 - Hastings Arm; and Group 3 - Station FFM in Alice Arm (see Figure 3). These groupings are based on the species, numbers of taxa and numbers of individuals collected. Three subgroups can be differentiated in Group 1. Stations CCN, DDM and CCM are very similar, having a very poor benthic infaunal composition. Visual observations made from **Pisces IV** and trace metal analyses of sediments in cores verify a more northern circulation of tailings at Transect CC (D. Goyette, pers. comm.). The next subgroup (1.2) comprises the remaining stations in Transects CC and DD which are also quite severely affected by tailings deposition. Stations on Transect EE join stations on CC and DD at Step 6 in the clustering. EEM is the most divergent station on Transect EE and most similar to stations on Transects CC and DD. Figure 4 illustrates a tentative horizontal display of the cluster analysis, showing the similarity among stations in relation to tailings distribution. All species collected at Station EEM were also found at EEN and EES, although approximately one-third as many individuals and one-half as many taxa occurred at EEM. This substantial decrease is indicated by the dashed lined in Figure 4. Sedimentation data substantiate settled tailings occurring at Transect EE as shown in Figure 5 (R. Macdonald, pers. comm.). Trace metal analyses indicate that surface sediments in 1981 at Station EEM contain much higher concentrations than at either EEN or EES, and are comparable to concentrations at Stations CCM and DDM (Goyette and Christie, 1982).

TABLE 2. Comparison of the results of 0.25 mm and 1.0 mm sieve screening of the same benthic sediment samples. All results are given in numbers per m^2 and are the mean of two samples (except EEM).

	0.25 mm			1.0 mm		
	No. of Individ. per Stat.	No. of Individ. per Trans.	No. of Individ. per Inlet	No. of Individ. per Stat.	No. of Individ. per Trans.	No. of Individ. per Inlet
CCN	675			20		
CCM	230	3,260		30	715	
CCS	2,355			665		
DDN	3,565			520		
DDM	775	7,235	31,200	25	1,630	9,950
DDS	2,895			1,085		
EEN	11,140			3,125		
EEM	1,755	20,705		1,040	7,605	
EES	7,810			3,440		
FFM*	64,380			12,565		
Z2E	11,725			1,835		
Z2M	6,415	22,455		1,255	5,175	
Z2W	4,315			2,085		
			56,355			10,305
Z5E	14,830			1,310		
Z5M	8,715	33,900		2,075	5,130	
Z5W	10,355			1,745		

*Station FFM considered a separate and distinct area.

Fig. 3. Cluster analysis station groupings.

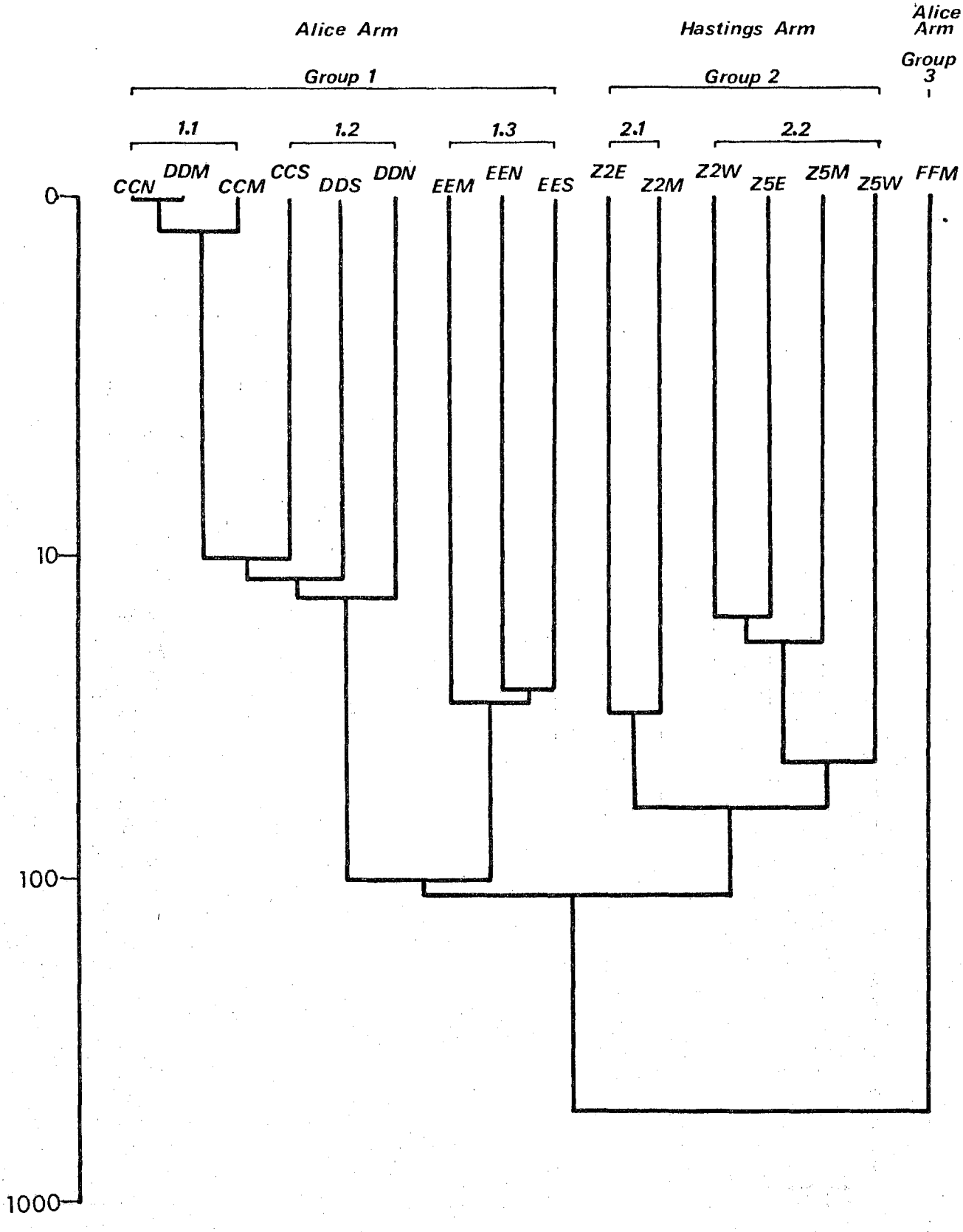


Fig. 4. Tentative horizontal display of cluster analysis of station groupings derived from data in Fig. 3.

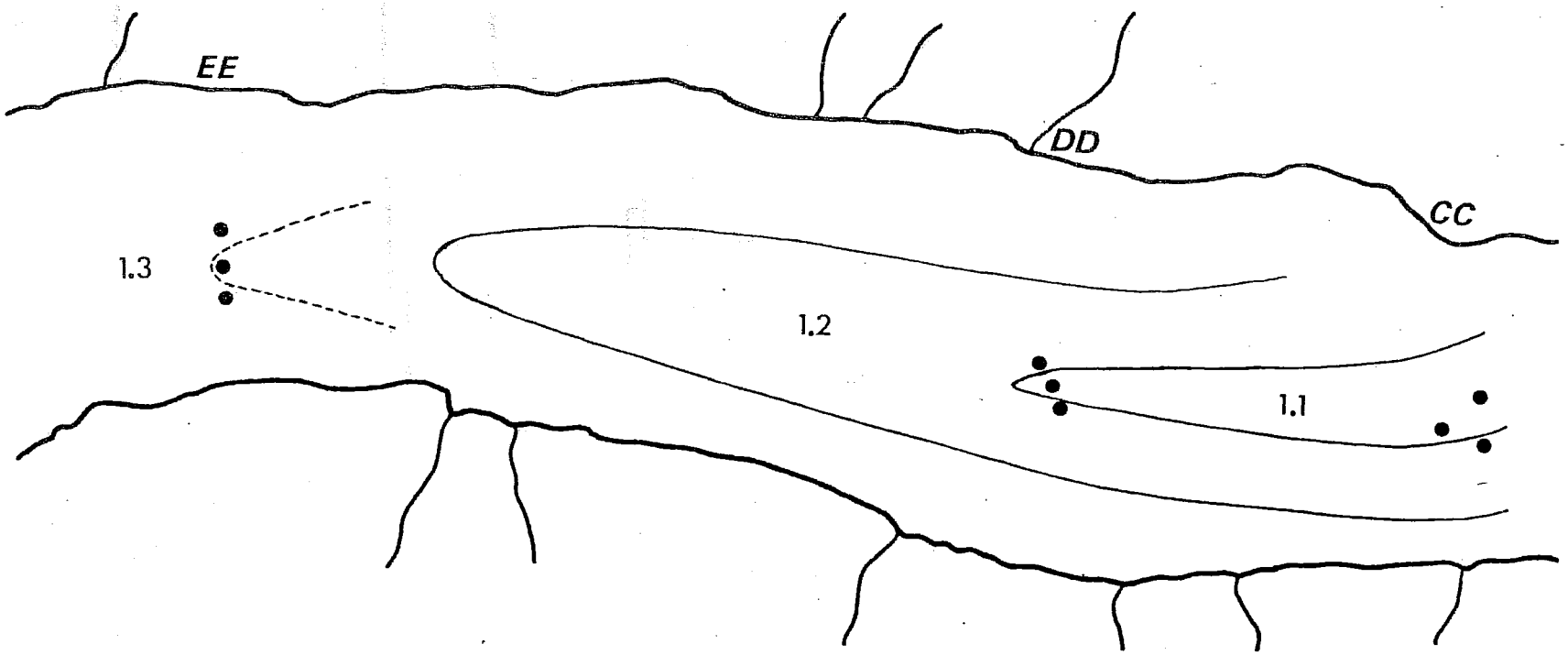
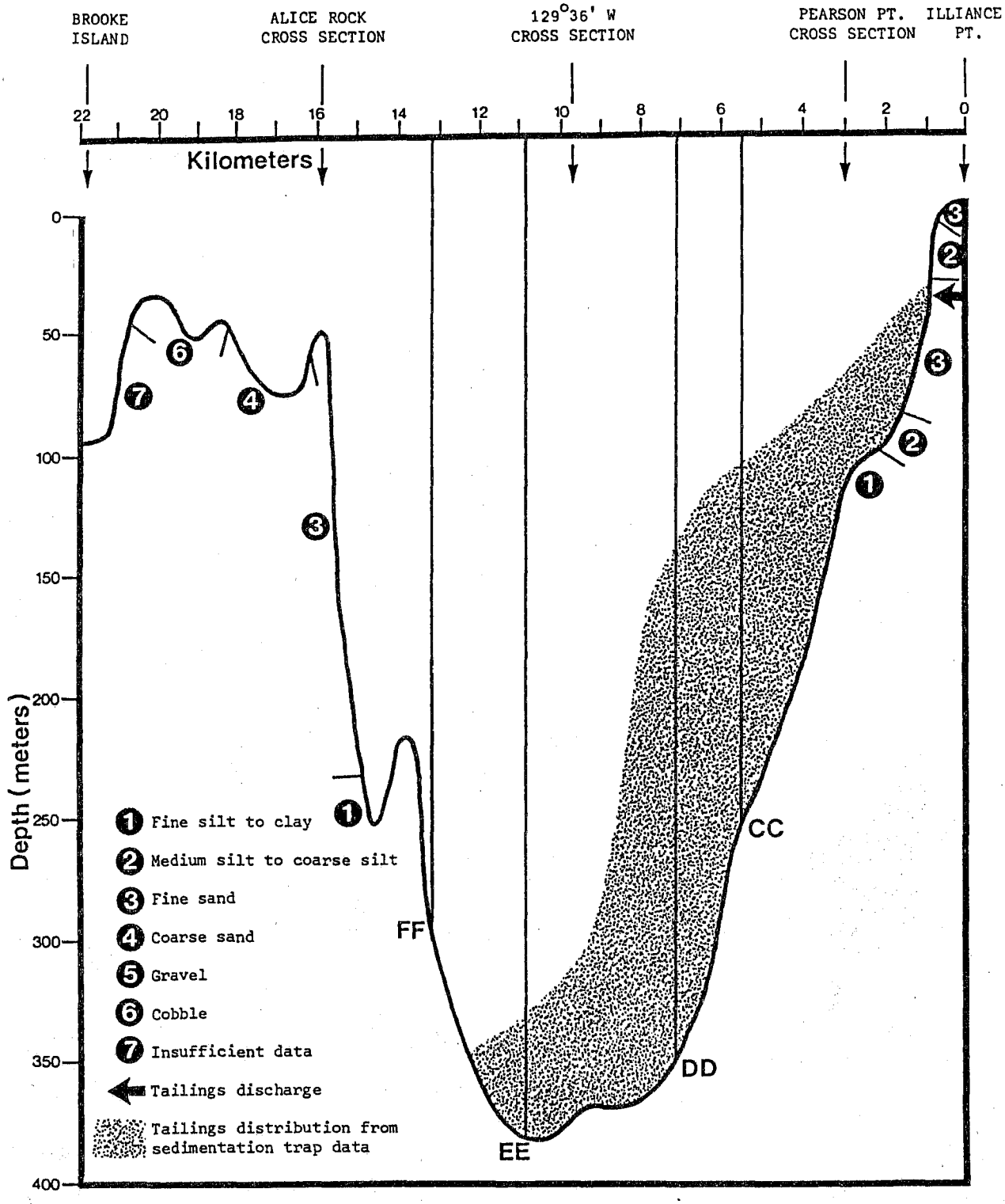


Fig. 5. Longitudinal section of Alice Arm showing generalized sediment distribution, sampling locations, and tailings distribution. Data from R.W. Macdonald and J.L. Littlepage.



While the cluster analysis delineates two subgroups of stations (2.1 and 2.2) within Hastings Arm, we feel the degree of dissimilarity is not a significant factor for comparison with Alice Arm. Group 2 stations are clearly differentiated from Group 1 stations at Step 14. Speciation and density of the benthos as seen in Table 3 and Appendices H and I are also distinct between the two inlets.

Station FFM in Alice Arm forms Group 3, which is widely divergent from all other stations. This station contained higher numbers of individuals and numbers of taxa than all other stations combined in either Alice Arm or Hastings Arm (Table 3). At least twice as many endemic taxa (organisms restricted to a particular station in this study) were found at this station compared to each other transect.

The number of individuals found in the northern and middle samples at CC, and the middle samples at DD and EE in Alice Arm were an order of magnitude lower than the number of individuals found in the equivalent southern samples at CC, and the equivalent northern and southern samples at DD and EE, as shown below.

Transect	CC			DD			EE		
Station	N	M	S	N	M	S	N	M	S
Number of individuals per m^2	20	30	670	520	25	1,085	3,125	1,040	3,440

Polychaetes were the most abundant organisms at Transects CC, DD and FF, while polychaetes and molluscs were equally abundant at EE in Alice Arm (Table 3). Nephtys cornuta cornuta, Levinsenia gracilis, Spiophanes sp. and Myriochele oculata were the overall dominant polychaetes. Transenella tantilla and Diplodonta orbella were the most abundant bivalves. The fauna at Transects CC and DD, with the exception of five nemerteans at Station DDN, consisted of only four major groups: polychaetes, crustaceans, molluscs and echinoderms.

Polychaetes were the most abundant organisms in Hastings Arm, represented by large numbers of N. cornuta cornuta, Aricidea lopezi lopezi, L. gracilis, Chaetozone setosa, Cossura soyeri and Cirratulidae (Table 3). The bivalves T. tantilla, D. orbella and Nucula tenuis, and ophiuroids were also common.

TABLE 3. Summary of benthic invertebrate composition and density for Alice Arm and Hastings Arm.

Mean number of individuals per m^2	Regions				
	Alice Arm			Hastings Arm	Alice Arm
	CC	DD	EE	Z2 + Z5	FF
All individuals	238	543	2,843	1,718	12,565
Polychaeta spp.	216	112	922	1,213	11,170
Mollusca spp.	8	73	1,648	306	335
Crustacea spp.	7	12	86	59	90
Total number of taxa per transect					
All taxa	27	25	52	69	93
Polychaeta spp.	18	12	22	35	61
Mollusca spp.	3	5	15	14	11
Crustacea spp.	3	6	9	12	7
Endemic taxa*	0	4	8	14	29
Endemic Polychaeta spp.	0	0	1	4	16
Endemic Mollusca spp.	0	0	2	4	4
Endemic Crustacea spp.	0	3	4	2	3
No. of samples	6	6	5	12	2

*Species limited to a transect in this study.

DISCUSSION

Visual examination of the data indicates a depressed number and variety of benthic infaunal species at all stations on Transects CC and DD in Alice Arm. Field observations (S. Byers, pers. comm.) suggest that deposits of mine tailings were present in the sample sediments from these stations. Data on the present areal distribution of mine tailings (Fig. 5; R. Macdonald, pers. comm.) indicate that both these transects are affected by settled tailings deposits. Cluster analysis of station groupings (Fig. 3) agrees with grain size distribution and trace metal concentrations (Goyette and Christie, 1982) and light transmission properties (D. Stucchi, pers. comm.). Suppressed benthic fauna at CCN and CCM, but slightly elevated benthic populations at CCS coincide with the initial northerly tailings plume track from Kitsault (D. Goyette, pers. comm. and D. Stucci, pers. comm.). These tailings appear to be settling in the deep middle stations at Transects DD and EE, as shown in Figure 4 and evidenced by the reduced numbers of species and individuals at DDM and EEM. Equally high trace metal concentrations at CCN, CCM, DDM and EEM (Goyette and Christie, 1982) suggest that tailings have progressed down the inlet at least to EEM, but have not spread to the north or south sides of the channel in this area.

The benthic fauna at Station FFM was distinct from all other stations in both Alice Arm and Hastings Arm. Cluster analysis, visual observation and benthic composition indicate that this station is not representative of other areas in the inlet. This station is directly affected by Hans Creek with highly variable sediment and associated organic loadings. In October 1982, during the period of sample collection, large sediment inputs (three or four times average transport) were collected at this station location in sedimentation traps at subsurface and near-bottom locations (R. Macdonald, pers. comm.). The substrate also differed from that at other Alice Arm stations, with large amounts of wood fiber observed in the sediment during field sampling (S. Byers, pers. comm.). This station is also located close to the sill at the mouth of Alice Arm, which may produce different circulation patterns, making available more niches and more nutrients. Natural variability in this area would be expected to be high. Consequently, this station may not provide useful information related to effects of mine tailings dispersal in Alice Arm.

Faunal composition and density in Hastings Arm appeared to be distinct from that in Alice Arm, as evidenced in the cluster analysis (Fig. 3). The faunal density and diversity is similar between Hastings Arm Transects Z2 and Z5, and Alice Arm Stations EEN and EES, (Table 3; Appendices H and I). (The major difference between EEN and EES compared to Hastings Arm is the large number of the bivalves Transenella tantilla and Nucula tenuis found at EEN and EES.) Hastings Arm thus serves as a useful reference area for comparison of "normal" benthic composition, even though it differs in detail from Alice Arm. Although the two fjords are physically distinct and direct comparisons cannot be made between the benthic fauna, Hastings Arm serves as an important reference inlet on which to compare species groupings and diversity.

Changes in infaunal composition and density can be observed between the data from a 1977 benthic study and the 1982 data set. The mean numbers of taxa and mean numbers of individuals at Transect CC in Alice Arm (identified as Station G9.5 in 1977) have decreased substantially in the 1982 samples, as indicated below.

	Transect CC		
	1977	1982	Percent reduction
Mean number of taxa per sample	23	11	52
Mean number of individuals per m^2	483	238	51

This decrease is even more noticeable if only CCN and CCM (1982) data, in which the mean number of taxa was four and the mean number of individuals was 25, are compared with the 1977 data. Station CCS, however, was similar to G9.5 (23 vs. 23 taxa; 665 vs. 483 individuals, respectively), suggesting that the north and middle stations have been dramatically affected by mine tailings.

Further comparisons between the 1977 and 1982 sampling data for Alice Arm are complicated by the fact that station locations differed. For instance, although the 1982 Transect EE was located in the same general area as the 1977 Station F15, the latter was approximately 20 m deeper and located farther from the tailings discharge. However, comparison of the two data sets indicated substantial differences not totally attributable to location. Of 18 species of polychaetes collected in 1977 and 23 species in 1982, only seven were common to both collections. The 1977 samples showed no clear dominance by particular organisms, while the 1982 benthos was dominated by the bivalve Transenella tantilla (38 percent) and the polychaete Nephtys cornuta cornuta (17 percent).

A number of factors in addition to increased mine tailings dispersal could be responsible for the marked differences between 1977 and 1982 collections. Sampling in 1977 took place during June whereas 1982 samples were collected in October and seasonal differences may be a factor. In addition, 1977 samples were not collected in the same locations as 1982 samples. The closest match between the two collection periods is provided by Transect CC (=Station G9.5) with only minor differences in location (latitude varied less than one minute and longitude less than 15 seconds), but the sampling records indicate that 1977 collection depths were greater than those recorded in 1982 by an average of over 24 meters. Other factors such as natural variability may also be implicated.

Overall, many species of polychaetes collected in 1977 were not found in 1982. But the most abundant sedentary polychaete found in 1982, Levinsenia gracilis, was not collected at all in 1977, indicating that both elimination and addition of species have occurred in Alice Arm. Of the 23 species of polychaetes identified in 1977 and the 28 species identified in 1982, only five were common to both sampling periods.

Previous sampling closer to the Alice Arm sill (Station I 17.5 in 1977) indicated that Station FFM was not representative of other areas during the October sampling. Taxa were approximately threefold higher and numbers of individuals tenfold higher in 1982 when the three sample average in 1977 is compared with the two sample average in 1982. Reasons for variabilities have been discussed previously.

Transects Z2 and Z5 in Hastings Arm were sampled in both 1982 and 1977, allowing comparisons to be made among numbers of taxa, numbers of individuals and species. Numbers of taxa and numbers of individuals were lower in 1977 than in 1982 as shown below.

Year	1977		1982	
Transect	Z2	Z5	Z2	Z5
Mean number of taxa per sample	15	15	36	37
Mean number of individuals per m^2	320	227	1725	1710

These changes in faunal composition and density are apparently typical of temporal changes observed in other fjords. For example, numerous studies related to tailings discharge from Island Copper Mine in Rupert Inlet indicate annual shifts in benthic composition and density (D. Ellis, pers. comm.). No individual taxon was clearly dominant in 1977, but polychaetes were dominant at both transects in 1982 (71 percent), followed by molluscs (18 percent). Nephtys cornuta cornuta, L. gracilis, A. lopezi lopezi and Cirratulidae were dominant polychaetes, and T. tantilla and N. tenuis were the dominant bivalve molluscs.

The 1982 data set indicated that benthic infaunal composition and density in Hastings Arm are representative of northern fjords. Undisturbed stations in Alice Arm (EEN, EES) have similar benthic density and diversity as stations in Hastings Arm, making the latter useful as a reference location for comparisons. The data for Alice Arm indicated that mine tailings in Alice Arm are progressing westward down the inlet and settling in the deepest part of the trough. Elimination of most benthic invertebrates at Transects CC and DD and a large decrease at Station EEM coincides with sedimentation data on tailings distribution and trace metal concentrations of sediments. The present benthic infaunal data set also provides a basis for future comparisons to evaluate possible faunal changes and to relate these changes to substrate disturbances such as tailings sedimentation.

RECOMMENDATIONS

1. An annual or biennial benthic program should be implemented to monitor the density and distribution of benthic invertebrates in relation to settled mine tailings in Alice Arm. This should include stations in both Alice Arm and Hastings Arm.

2. Additional transects should be established between DD and EE, and EE and FF to provide more detailed information on the dispersal of mine tailings and the effect on benthos.

3. Benthic sampling should be done prior to commencement of mill operations after a period of recovery has taken place, followed by sampling a sufficient time after operation to pinpoint and determine specific effects caused by tailings discharge.

TAXONOMIC REFERENCES AND REFERENCES CITED

Anonymous. Key to Pacific Northwest sea cucumbers. Mar. Sci. Soc. Pac. N.W.

Arwidsson, I. 1907. Studien uber die skandinavischen und Arktischen Maldaniden nebst Zusammenstellung der Ubrigen bisher bekannten Arten dieser Familie. Zoll. Jahrb. Suppl. 9: 1-308.

Austin, W.C. 1970. Preliminary list of marine invertebrates of the Barkley Sound region. Bamfield Marine Sta. Rpt. 3(5): 1-125.

Austin, W.C. and M.P. Haylock. 1973. British Columbia marine faunistic survey report: ophiuroids from the northeast Pacific. Fish. Res. Bd. Can. Tech. Rep. 426. 33 pp.

Banse, K. 1963. Polychaetous annelids from Puget Sound and the San Juan Archipelago, Washington. Proc. Biol. Soc. Wash. 76: 197-208.

_____. 1970. The small species of Euchone Malmgren (Sabellidae, Polychaeta). Proc. Biol. Soc. Wash. 83(35): 387-408.

_____. 1972. On some species of Phyllodocidae, Syllidae, Nephtyidae, Goniadidae, Apistobranchidae, and Spionidae (Polychaeta) from the northeast Pacific Ocean. Pac. Sci. 26: 191-222.

_____. 1972. Redescription of some species of Chone Kroyer and Euchone Malmgren, and three new species. Fish. Bull. 70(2): 459-495.

_____. 1979. Ampharetidae (Polychaeta) from British Columbia and Washington. Can. J. Zool. 57(8): 1543-1552.

_____. 1980. Terebellidae (Polychaeta) from the northeast Pacific Ocean. Can. J. Fish. Aquat. Sci. 37(1): 20-40.

Banse, K. and K.D. Hobson. 1968. Benthic polychaetes from Puget Sound, Washington, with remarks on four other species. Proc. U.S. Nat. Mus. 125: 1-53.

Banse, K., K.D. Hobson and F.H. Nichols. 1968. Annotated list of polychaetes. Appendix II, p. 521-548. In U. Liez, ed. A quantitative study of benthic infauna in Puget Sound, Washington, USA, in 1963-1964. Fiskeridir. Skr. Ser. Havunders.

Banse, K. and K.D. Hobson. 1974. Benthic errantiate polychaetes of British Columbia and Washington. Bull. Fish. Res. Bd. Can. 185: 1-111.

Barnard, J.L. 1954. Marine Amphipoda of Oregon. Oregon St. Coll. Monogr. Studies in Zool. 8. 103 pp.

Barnard, J.L. 1960. Amphipod family Phoxocephalidae in the eastern Pacific Ocean, with analyses of other species and notes for a revision of the family. Allan Hancock Exped. 18: 175-375.

_____. 1962. Benthic marine Amphipoda of southern California: family Oedicerotidae. Pac. Nat. 3: 349-371.

Berkeley, C. 1966. Records of some species of Polychaeta new to British Columbia and of extensions in distributions of some others. Can. J. Zool. 44: 839-849.

_____. 1967. A checklist of Polychaeta recorded from British Columbia since 1923, with references to name changes, descriptions, and synonymies. I. Errantia. Can. J. Zool. 45: 1049-1059.

_____. 1968. A checklist of Polychaeta recorded from British Columbia since 1923, with references to name changes, descriptions, and synonymies. II. Sedentaria. Can. J. Zool. 46: 557-567.

_____. 1972. Further records of Polychaeta new to British Columbia with comments on some others. Can. J. Zool. 50: 451-456.

Berkeley, E. 1923. Polychaetous annelids from the Nanaimo district. Part I. Syllidae to Sigalionidae. Contr. Can. Biol. 1: 203-218.

_____. 1924. Polychaetous annelids from the Nanaimo district. Part 2. Phyllodocidae to Nereidae. Contr. Can. Biol. 2: 285-293.

_____. 1927. Polychaetous annelids from the Nanaimo district. Part 3. Leodicidae to Spionidae. Contr. Can. Biol. 3: 407-422.

_____. 1929. Polychaetous annelids from the Nanaimo district. Part 4. Chaetopteridae to Maldanidae. Contr. Can. Biol. 6: 305-316.

_____. 1930. Polychaetous annelids from the Nanaimo district. Part 5. Ammocharidae to Myzostomidae, with an appendix on some forms from the Strait of Georgia and the west coast of Vancouver Island. Contr. Can. Biol. 6: 65-77.

Berkeley, E. and C. Berkeley. 1932. On a collection of littoral Polychaeta from the west coast of Vancouver Island. Contr. Can. Biol. 7: 309-318.

_____. 1936. Notes on Polychaeta from the coast of western Canada. I. Spionidae. Ann. Mag. Nat. Hist., ser. 10, vol. 18: 468-477.

_____. 1938. Notes on Polychaeta from the coast of western Canada. 2. Syllidae. Ann. Mag. Nat. Hist., ser. 11, vol. 1: 33-49.

_____. 1942. North Pacific polychaeta, chiefly from the west coast of Vancouver Island, Alaska, and Bering Sea. Can. J. Res. 20(D): 183-208.

Berkeley, E. and C. Berkeley. 1945. Notes on Polychaeta from the coast of western Canada. 3. Further notes on Syllidae and some observations on other Polychaeta Errantia. Ann. Mag. Nat. Hist., ser. 11, vol. 12: 316-335.

_____. 1948. Annelida. Polychaeta Errantia. Canadian Pacific Fauna, Fish. Res. Bd. Can. 9b(1): 1-100.

_____. 1950. Notes on polychaeta from the coast of western Canada. Part 4. Polychaeta Sedentaria. Ann. Mag. Nat. Hist. ser. 12, Vol. 3: 50-69.

_____. 1952. Annelida. Polychaeta Sedentaria. Canadian Pacific Fauna, Fish. Res. Bd. Can. 9b(2): 1-139.

_____. 1954. Additions to the polychaete fauna of Canada, with comments on some older records. J. Fish. Res. Bd. Can. 11: 454-471.

_____. 1956. Notes on polychaeta from the east coast of Vancouver Island and from adjacent waters, with a description of a new species of Aricidea. J. Fish. Res. Bd. Can. 13: 541-546.

_____. 1962. Polychaeta from British Columbia, with a note on some western Canadian arctic forms. Can. J. Zool. 40: 571-577.

Blake, J.A. 1971. Revisions of the genus Polydora from the east coast of North America (Polychaeta: Spionidae). Smithsonian Contr. Zool. 75: 1-32.

_____. 1975. The larval development of Polychaeta from the northern California coast. III. Eighteen species of Errantia. Ophelia 14: 23-84.

Blake, J.A. and D. Dean. 1973. Polychaetous annelids collected by the R/V HERO from Baffin Island, Davis Strait, and west Greenland in 1968. Bull. S. Calif. Acad. Sci. 72(1): 31-39.

Blake, J.A. and K.H. Woodwick. Reproduction and larval development of Pseudopolydora paucibranchiata (Okuda) and Pseudopolydora kempi (Southern) (Polychaeta: Spionidae). Biol. Bull. 148(4): 109-127.

Bowman, T.E. 1960. The pelagic amphipod genus Parathemisto (Hyperiidea: Hyperiidae) in the north Pacific and adjacent Arctic Ocean. Proc. U.S. Nat. Mus. 112: 343-392.

Bush, K.J. 1904. Tubicolous annelids of the tribes Sabellides and Serpulides from the Pacific Ocean. Harriman Alaska Exped. 12: 169-355.

Chamberlin, R.V. 1919. Pacific coast Polychaeta collected by Alexander Agassiz. Bull. Mus. Comp. Zool. Harvard 63: 251-276.

_____. 1919. The annelid Polychaeta. Mem. Mus. Com. Zool. Harvard 48: 1-514.

Clark, R.B. and M.L. Jones. 1955. Two new Nephtys (Annelida, Polychaeta) from San Francisco Bay. J. Wash. Acad. Sci. 45: 143-146.

Coan, E.V. 1971. The Northwest American Tellinidae. The Veliger 14: Supplement.

_____. 1973. The Northwest American Donacidae. The Veliger 16: 130-139.

Correa, D.D. 1964. Nemerteans (Rhynchocoelia) from California and Oregon. Calif. Accl. Sci. Proc. 31: 515-558.

Day, J.H. 1964. A review of the family Ampharetidae (Polychaeta). Ann. S. African Mus. 48(4): 97-120.

_____. 1967. A monograph on the Polychaeta of southern Africa. Brit. Mus. Nat. Hist. Publ. 656: 1-878.

DeLaubenfels, M.W. 1953. Sponges of the Alaskan Arctic. Smith. Misc. Coll. 121: 1-22.

_____. 1961. Porifera of Friday Harbor and vicinity. Pac. Sci. 15: 192-202.

Dunnill, R.M. and D.V. Ellis. 1969. Recent species of the genus Macoma (Pelecypoda) in British Columbia. Nat. Mus. Can. Nat. Hist. 45: 1-34.

Eliason, A. 1920. Biologisch-faunistische Untersuchungen aus dem Oresund. Polychaeta. Lunds Univ. Arsskr., Avd. 2 16(6): 1-103.

Fauchald, K. 1963. Nephtyidae (Polychaeta) from Norwegian waters. Sarsia 13: 1-32.

_____. 1968. Nephtyidae (Polychaeta) from the Bay of Nha Trang. NAGA Report 4(3): 7-33.

_____. 1970. Polychaetous annelids of the families Eunicidae, Lumbrineridae, Iphitimidae, Arabellidae, Lysaretidae and Dorvilleidae from western Mexico. Allan Hancock Monogr. Mar. Biol. 5: 1-335.

_____. 1972. Benthic polychaetous annelids from deep water off western Mexico and adjacent areas in the eastern Pacific Ocean. Allan Hancock Monogr. Mar. Biol. 7: 1-575.

_____. 1974. Sphaerodoridae (Polychaeta: Errantia) from world-wide areas. J. Nat. Hist. 8: 257-289.

_____. 1975. A commentary on Hartman's Atlas of Polychaetes. In J.Q. Word, ed. Invertebrates of southern California. Southern California Coastal Water Research Project.

_____. 1977. The polychaete worms: Definitions and keys to the orders, families and genera. Nat. Hist. Mus. Los Angeles County, Science Ser. 28: 1-190.

Fauvel, P. 1923. Polychetes Errantes. Faune de France 5: 1-488.

_____. 1927. Polychetes Sedentaires. Addenda aux Errantes, Archiannelides, Myzostomaires. Faune de France 16: 1-494.

Foster, N.M. 1971. Spionidae (Polychaeta) of the Gulf of Mexico and Caribbean Sea. Studies on the fauna of Curacao and other Caribbean Islands 36(129): 1-183.

Furlong, M., V. Pill and E.H. Robinson. 1970. Starfish, methods of preserving and guides to identification. Ellison Ind., Edmonds, Wash. 104 pp.

Gavin, A.M. and V.I. Macdonald. 1977. Annotated bibliography of the Polychaeta of the Pacific Northwest. Contractor Report Series 77-6. Institute of Ocean Sciences, Patricia Bay, Sidney, B.C. 125 pp.

Gitay, A. 1969. A contribution to the revision of Spiochaetopterus (Chaetopteridae, Polychaeta). Sarsia 37: 9-20.

Griffith, L.M. 1967. The intertidal univalves of British Columbia. B.C. Prov. Mus. Handbook No. 26. 101 pp.

Grube, A.E. 1860. Beschreibung neuer oder wenig bekannter Anneliden. Zahlreiche Gattungen. Arch. Naturgesch. Berlin 26: 71-118.

Hartley, J.P. 1981. The family Paraonidae (Polychaeta) in British waters: a new species and new records with a key to species. J. Mar. Biol. Ass. U.K. 61: 133-149.

Hartman, O. 1936. A review of the Phyllodocidae (Annelida, Polychaeta) of the coast of California, with descriptions of nine new species. Univ. Calif. Publ. Zool. 41: 117-132.

_____. 1938. Descriptions of new species and new generic records of polychaetous annelids from California of the families Glyceridae, Eunicidae, Stauronereidae and Opheliidae. Univ. Calif. Publ. Zool. 43: 93-112.

_____. 1938. Review of the annelid worms of the family Nephtyidae from the northeast Pacific, with descriptions of five new species. Proc. U.S. Nat. Mus. 85: 143-158.

_____. 1939. Polychaetous annelids. Pt. 1. Aphroditidae to Pisionidae. Allan Hancock Pac. Exped. 7: 1-156.

_____. 1940. Polychaetous annelids. Pt. 2. Chrysopetalidae to Goniadidae. Allan Hancock Pac. Exped. 7: 173-287.

_____. 1941. Some contributions to the biology and life history of Spionidae from California. Allan Hancock Pac. Exped. 7: 289-324.

_____. 1941. Polychaetous annelids. 4. Pectinariidae, with a review of all species from the western hemisphere. Allan Hancock Pac. Exped. 7: 325-345.

Hartman, O. 1944. Polychaetous annelids. 6. Paraonidae, Magelonidae, Longosomidae, Ctenodrilidae and Sabellariidae. Allan Hancock Pac. Exped. 10(2): 311-389.

_____. 1947. Polychaetous annelids. 7. Capitellidae. Allan Hancock Pac. Exped. 10(4): 391-481.

_____. 1948. The polychaetous annelids of Alaska. Pac. Sci. 8(1): 1-58.

_____. 1950. Polychaetous annelids. Goniadidae, Glyceridae, Nephtyidae. Allan Hancock Pac. Exped. 15(1): 1-181.

_____. 1951. Literature of the polychaetous annelids. Vol. I, Bibliography. Los Angeles, California. 290 pp.

_____. 1955. Endemism in the north Pacific Ocean, with emphasis on the distribution of marine annelids, and descriptions of new or little known species. Pages 39-60 In Essays in natural science in honor of Captain Allan Hancock. Univ. S. Calif., Los Angeles.

_____. 1957. Orbiniidae, Apistobranchidae, Paraonidae and Longosomidae. Allan Hancock Pac. Exped. 15: 211-393.

_____. 1959. Catalogue of the polychaetous annelids of the world. I. Allan Hancock Found. Publ., Occas. Paper 23: 1-353.

_____. 1959. Catalogue of the polychaetous annelids of the world. II. Allan Hancock Found. Publ., Occas. Paper 23: 355-628.

_____. 1961. Polychaetous annelids from California. Allan Hancock Pac. Exped. 25: 1-226.

_____. 1965. Catalogue of the polychaetous annelids of the world. Supplement 1960-1965 and index. Allan Hancock Found. Publ., Occas. Paper 23: 1-197.

_____. 1968. Atlas of the errantiate polychaetous annelids from California. Allan Hancock Foundation. Univ. of S. Calif., Los Angeles. 828 pp.

_____. 1969. Atlas of the sedentariate polychaetous annelids from California. Allan Hancock Foundation. Univ. of S. Calif., Los Angeles. 812 pp.

Hartman, O. and D.J. Reish. 1950. The marine annelids of Oregon. Oregon State Monogr. Stud. Zool. 6: 1-64.

Hartmann-Schroder, G. 1971. Annelida, Borstenwurmer, Polychaeta. Tierwelt Deutschlands 58: 1-594.

Hessle, C. 1917. Zur Kenntnis der Terebellomorphen Polychaeten. Zool. Bidrag. Fran. Uppsala 5: 39-248.

Hillger, K.A. and D.J. Reish. 1970. The effect of temperature on the setal characteristics in Polynoidae. Bull. S. Calif. Acad. Sci. 69: 87-99.

Hobson, K.D. 1972. Two new species and two new records of the family Paraonidae (Annelida, Polychaeta) from the northeastern Pacific Ocean. Proc. Biol. Soc. Wash. 85(48): 549-556.

_____. 1974. Orbiniella nuda new species (Orbiniidae) and nine new records of other sedentariate polychaetous annelids from Washington and British Columbia. Can. J. Zool. 52: 69-75.

_____. 1976. Notes on benthic sedentariate Polychaeta (Annelida) from British Columbia and Washington. Syesis 9: 135-142.

Hobson, K.D. and K. Banse. 1981. Sedentariate and archiannelid polychaetes of British Columbia and Washington. Can. Bull. Fish. Aquat. Sci. 209: 1-144.

Holleman, J.J. 1972. Marine turbellarians of the Pacific coast. Proc. Biol. Soc. Wash. 85: 405-412.

Holmquist, C. 1967. Turbellaria of northern Alaska and northwestern Canada. Int. Rev. Ges. Hydrobiol. 52: 123-139.

Imajima, M. 1966.The Syllidae (polychaetous annelids) from Japan. I. Exogoninae. Publ. Seto Mar. Biol. Lab. 13: 385-404.

_____. 1966. The Syllidae (polychaetous annelids) from Japan. III. Eusyllinae. Publ. Seto Mar. Biol. Lab. 14: 85-111.

_____. 1966. The Syllidae (polychaetous annelids) from Japan. VI. Distribution and literature. Publ. Seto Mar. Biol. Lab. 14: 351-368.

Imajima, M. and O. Hartman. 1964. The polychaetous annelids of Japan. Allan Hancock Found. Publ., Occas. Paper 26: 1-452.

Imajima, M. and M. Higuchi. 1975. Lumbrineridae of polychaetous annelids from Japan, with descriptions of six new species. Bull. Nat. Sci. Mus. ser. A 1(1): 5-37.

Imajima, M. and Y. Shiraki. 1982. Maldanidae (Annelida: Polychaeta) from Japan. (Part 1). Bull. Nat. Sci. Mus. Ser. A 8(1): 7-46.

_____. 1982. Maldanidae (Annelida: Polychaeta) from Japan. (Part 2). Bull. Nat. Sci. Mus. Ser. A 8(2): 47-88.

Johnson, H.P. 1897. A preliminary account of the marine annelids of the Pacific coast, with descriptions of new species. Euphrosynidae, Amphinomidae, Polmyridae, Polynoidae and Sigalionidae. Proc. Calif. Acad. Sci. Zool. 1: 153-190.

_____. 1901. The Polychaeta of the Puget Sound region. Proc. Boston Soc. Nat. Hist. 29: 381-437.

Jumars, P.A. 1974. A generic revision of the Dovilleidae (Polychaeta) with six new species from the deep north Pacific. Zool. J. Linn. Soc. London 54: 101-135.

Kozloff, E.N. 1976. Keys to the marine invertebrates of Puget Sound, the San Juan Archipelago, and adjacent regions. Univ. Wash. Press, Seattle. 226 pp.

Kravitz, M.J. and H.R. Jones. 1979. Systematics and ecology of benthic Phyllodocidae (Annelida: Polychaeta) off the Columbia River, USA. Bull. S. Calif. Acad. Sci. 78(1): 1-19.

Laubier, L. 1961. Podarkeopsis galangaui n.g., n.sp., Hesionide des vases coteres de Banyuls-sur-mer. Vie et Milieu 12: 211-217.

Lasubier, L. 1964. Decouverte du genre Cossura (Polychete, Cossuridae) en Mediterranee: Cossura soyeri sp.n. Vie et Milieu 14: 833-842.

Levenstein, R.Y. 1977. A new genus and species of Polychaeta (Family Lumbrineridae) from the deep-water trenches of the North Pacific. Pages 189-198 In D.J. Reish and K. Fauchald, eds. Essays on polychaetous annelids in memory of Dr. Olga Hartman. Univ. S. Calif., Los Angeles, California.

Light, W.J. 1978. Spionidae (Polychaeta, Annelida). The Boxwood Press, Pacific Grove, California. 211 pp.

McCauley, J.E. and A.G. Carey. 1967. Echinoidea of Oregon. J. Fish. Res. Bd. Can. 24: 1385-1401.

McIntosh, W.C. 1879. On the Annelida obtained during the cruise of H.M.S. **Valorous** to Davis Strait in 1875. Trans. Linn. Soc. London n.s. 1: 499-511.

Melville, R.V. 1979. Opinion 1139 Paraonis Grube, 1873 (Polychaeta, Paraonidae): Designation of a type species under the plenary powers. Bull. Zool. Nomen. 36: 114-118.

Mills, E.L. 1962. Amphipod crustaceans of the Pacific coast of Canada. II. Family Oedicerotidae. Nat. Mus. Can. Nat. Hist. Papers 15: 1-21.

Moore, J.P. 1905. New species of polychaetes from the north Pacific, chiefly from Alaskan waters. Proc. Acad. Nat. Sci. Phila. 57: 525-554.

_____. 1905. New species of Ampharetidae and Terebellidae from the North Pacific. Proc. Acad. Nat. Sci. Phila. 57: 846-860.

_____. 1906. Additional new species of Polychaeta from the north Pacific. Proc. Acad. Nat. Sci. Phila. 58: 217-260.

_____. 1908. Some polychaetous annelids of the northern Pacific coast of North America. Proc. Acad. Nat. Sci. Phila. 60: 321-364.

_____. 1909. Polychaetous annelids from Monterey Bay and San Diego, California. Proc. Acad. Nat. Sci. Phila. 61: 235-295.

Moore, J.P. 1909. The polychaetous annelids dredged by the USS Albatross off the coast of southern California in 1904. I. Syllidae, Sphaerodoridae, Hesionidae and Phyllodocidae. Proc. Acad. Nat. Sci. Phila. 61: 321-351.

_____. 1910. The polychaetous annelids dredged by the USS Albatross off the coast of southern California in 1904. Polynoidae, Aphroditidae and Sigalionidae. Proc. Acad. Nat. Sci. Phila. 62: 328-402.

_____. 1911. The polychaetous annelids dredged by the USS Albatross off the coast of southern California in 1904. Euphrosynidae to Goniadidae. Proc. Acad. Nat. Sci. Phila. 63: 234-318.

_____. 1923. The polychaetous annelids dredged by the USS Albatross off the coast of southern California in 1904. 4. Spionidae to Sabellariidae. Proc. Acad. Nat. Sci. Phila. 61: 321-351.

_____. 1910. The polychaetous annelids dredged by the USS Albatross off the coast of southern California in 1904. Polynoidae, Aphroditidae and Sigalionidae. Proc. Acad. Nat. Sci. Phila. 62: 328-402.

_____. 1911. The polychaetous annelids dredged by the USS Albatross off the coast of southern California in 1904. Euphrosynidae to Goniadidae. Proc. Acad. Nat. Sci. Phila. 63: 234-318.

_____. 1923. The polychaetous annelids dredged by the USS Albatross off the coast of southern California in 1904. 4. Spionidae to Sabellariidae. Proc. Acad. Nat. Sci. Phila. 75: 179-259.

Moore, J.P. and K.J. Bush. 1904. Sabellidae and Serpulidae from Japan with descriptions of new species of Spirorbis. Proc. Acad. Nat. Sci. Phila. 56: 157-179.

Myers, B.L. 1975. Key to the genera of Cumacea from Southern California with some descriptions. S. Calif. Coastal Wat. Res. Proj., El Segundo.

Pearson, T.H. 1970. Litocorsa stremma a new genus and species of pilargid (Polychaeta: Annelida) from the west coast of Scotland, with notes on two other pilargid species. J. Nat. Hist. 4: 69-77.

Pettibone, M.H. 1948. Two new species of polychaete worms of the family Polynoidae from Puget Sound and San Juan Archipelago. J. Wash. Acad. Sci. 38: 412-414.

_____. 1949. Polychaetous annelids of the Polynoidae from the northeastern Pacific, with a description of a new species. Am. Mus. Novit. 1414: 1-6.

_____. 1953. Some scale-bearing polychaetes of Puget Sound and adjacent waters. Univ. Wash. Press, Seattle. 89 pp.

_____. 1954. Marine polychaete worms from Point Barrow, Alaska, with additional records from the north Atlantic and north Pacific. Proc. U.S. Nat. Mus. 103: 203-356.

Pettibone, M.H. 1956. Marine polychaete worms from Labrador. Proc. U.S. Nat. Mus. 105: 531-584.

_____. 1961. New species of polychaete worms from the Atlantic Ocean, with a revision of the Dorvilleidae. Proc. Biol. Soc. Wash. 74: 167-186.

_____. 1962. New species of polychaete worms (Spionidae: Spiophanes) from the east and west coast of North America. Proc. Biol. Soc. Wash. 75: 77-88.

_____. 1963. Marine polychaete worms of the New England region. I. Aphroditidae through Trochochaetidae. Bull. U.S. Nat. Mus. 227(1): 1-356.

_____. 1966. Revision of the Pilargidae (Annelida: Polychaeta), including descriptions of new species, and redescription of the pelagic Podarmus ploa Chamberlin (Polynoidae). Proc. U.S. Nat. Mus. 118(3525): 155-208.

_____. 1967. Contribution to the polychaete family Trochochaetidae Pettibone. Smithsonian Cont. Zool. 230: 1-21.

_____. 1967. Type specimens of polychaetes described by Edith and Cyril Berkeley (1923-1964). Proc. U.S. Nat. Mus. 119(3553): 1-23.

Quayle, D.B. 1960. The intertidal bivalves of British Columbia. B.C. Prov. Mus. Handbook. 104 pp.

Reish, D.J. 1965. Benthic polychaetous annelids from the Bering, Chukchi and Beaufort Seas. Proc. U.S. Nat. Mus. 117(3511): 131-158.

Smith, R.I. and J.T. Carlton. 1980. Light's manual: intertidal invertebrates of the central California coast. Univ. Calif. Press, Berkeley. 717 pp.

Soderstrom, A. 1920. Studien uber die Polychaetenfamilie Spionidae. Uppsala. 286 pp.

Stop-Bowitz, C. 1948. Les Flabelligeriens Norvegiens. Bergens Museum Arbok 1946/1947, Naturvitskapelig rekke, nr. 2, Bergen. 59 pp.

_____. 1948. Sur les polychaetes arctiques, des Families des Glyceriens, des Opheliens, des Scalibregmiens et des Flabelligeriens. Tromso Mus. Archefter 66(2): 1-58.

Strelzov, V. Polychaetous annelids of the family Paraonidae Cerruti, 1909 (Polychaeta, Sedentaria). Akad. Nauk SSSR, Leningrad. 170 pp. (translated 1979).

Theel, H.J. 1879. Les Annelides polychetes des Mers de la Nouvelle-Zemble. Svensk. Akad. Handl. 16(3): 3-75.

Treadwell, A.L. 1914. Polychaetous annelids of the Pacific coast in the collection of the zoological museum of the University of California. Univ. Calif. Publ. Zool. 13: 175-234.

_____. 1921. Report on the annelids of Puget Sound, Fiji and Samoa. Yearbk. Carnegie Inst. Wash. 19: 199-200.

_____. 1922. Polychaetous annelids collected at Friday Harbor, State of Washington, in February and March, 1920. Carnegie Inst. Publ. 312: 171-181.

Ushakov, P.V. 1955. Polychaetous annelids of the Far Eastern Seas of the USSR. Akad. Nauk SSSR, Keys to the fauna of the SSSR 56: 1-433. (translated 1965).

_____. 1972. Polychaeta 1. Polychaetes of the suborder Phyllodociformia of the polar basin and the northwestern part of the Pacific. Akad. Nauk SSSR, Zool. Inst., Fauna of the SSSR, n.s. 102: 1-271. (translated 1974).

Ward, J.H. 1963. Hierarchical grouping to optimize an objective function. J. Amer. Stat. Ass. 58: 236-244.

Warren, L.M. 1976. A review of the genus Capitella (Polychaeta, Capitellidae). J. Zool. London 180: 195-209.

Webster, H.E. and J.E. Benedict. 1887. The Annelida Chaetopoda from Eastport, Maine. Rep. U.S. Comm. Fish. Wash. 1881: 707-755.

Wiren, A. 1883. Chaetopoda fran Sibiriska Ishafvet och Berings Haf insamlade under Vega-Expeditionen 1878-79. Vega-Exped. Vetensk. Iagtt. 2: 383-428.

APPENDIX A

AUXILIARY INFORMATION TAKEN DURING SAMPLE ACQUISITION

Date (October 1982)	Station*	Avg. Depth (m)	North latitude West longitude
23	CCN	264.5	55°26'40" 129°31'42"
26	CCM	277.5	55°26'36" 129°31'53"
26	CCS	256.0	55°26'33' 129°31'44"
25	DDN	349.5	55°26'48" 129°33'37"
26	DDM	351.0	55°26'44" 129°33'35"
26	DDS	356.0	55°26'41" 129°33'31"
25	EEN	370.0	55°27'12" 129°37'00"
25	EEM**	373.0	55°27'06" 129°37'00"
25	EES	369.0	55°27'00" 129°37'00"
26	FFM	303.0	55°26'30" 129°39'03"
24	Z2E	296.0	55°29'19" 129°45'37"
24	Z2M	296.0	55°29'17" 129°45'50"
24	Z2W	296.0	55°29'14" 129°45'57"
24	Z5E	294.0	55°31'41" 129°46'53"
24	Z5M	295.0	55°31'41" 129°47'02"
24	Z5W	295.0	55°31'38" 129°47'12"

* Stations CCN to FFM are located in Alice Arm; Z2E to Z5W are located in Hastings Arm.

** One sample taken at EEM; two samples at all other stations.

APPENDIX B

INFORMATION SHEET USED DURING SORTING OF 1.0 mm-SIEVED SAMPLES

Sample identification _____

Date of Collection _____ Sieve Size _____

Sorted by _____ Date sorted _____ No. Hours _____

TAXA	NO. OF INDIVIDUALS
Amphipoda	_____
Other Crustacea	_____
Polychaeta	_____
Oligochaeta	_____
Molluska	_____
Nematoda	_____
Others	_____

Substrate description (by percent) _____

_____

Observations/comments _____

_____

_____

APPENDIX C

INFORMATION SHEET USED DURING SORTING OF 0.25 mm-SIEVED SAMPLES

Sample identification _____

Date of Collection _____ Sieve Size _____

Sorted by _____ Date sorted _____ No. Hours _____

Phylum	Class/Order	No. of Individuals

Substrate description (by percent) _____

_____

Observations/comments _____

_____

_____

APPENDIX D

INFORMATION SHEET USED DURING QUALITY CONTROL OF 1.0 mm SAMPLES

Sample identification _____

Date of Collection _____ Sieve Size _____

Sorted by _____ Date sorted _____ No. Hours _____

QC'd by _____ Date QC'd _____ No. Hours _____

Organism	Number of indiv. for taxon found during QC	No. indiv. for taxon originally found	Percent error for taxon	Total no. of individuals in sample	Percent error for sample

Total number individuals missed _____

Percent error for total sample _____

APPENDIX E

PERTINENT STUDIES AND REPORTS

PARTIAL LISTING

Amax of Canada Ltd. 1981. Kitsault mine effluent monitoring program, Int. Rep. prep. for Environ. Canada, EPS. 105 pp.

Anderson, E. and D. Mackas. Short-term effects of tailings from the Amax Kitsault Mine on the survival, respiration, feeding and swimming behaviour of marine zooplankton. (In preparation)

Anderson, E. and D. Mackas. Zooplankton community structure in Alice Arm, Hastings Arm and Observatory Inlet, August 1981 and June 1982, with reference to the discharge of tailings from the Amax Kitsault Mine. (In preparation)

Goyette, D. and P. Christie. 1982. Environmental studies in Alice Arm and Hastings Arm, British Columbia. III. Initial production period - Amax/Kitsault Mine - Sediment and tissue trace metals, May - June and October 1981. Reg. Prog. Rep. 82-14, EPS, Pacific Region.

Littlepage, J.L. 1978. Oceanographic and marine biological surveys, Alice Arm and Hastings Arm, British Columbia, 1974-1977. Rep. prep. for Climax Molybdenum Corp. 78 pp.

Losher A. Geochemistry of recent sediments and tailings in Alice and Hastings Arms and Observatory Inlet, B.C. M.Sc. Thesis, Univ. British Columbia. (Expected completion date 1984)

Macdonald, R.W. Sediment transport and sedimentation processes in Alice Arm.*

Nicoll, M. and D.J. Stucci. 1982. Alice Arm 1981 CTD data access guide. Can. Contract. Rep. Hydrogr. Ocean Sci. 5: 76 pp.

O'Connell, G.W. and S.C. Byers. 1978. Oceanographic and marine biological surveys in Alice Arm and Hastings Arm, B.C. Data Rep. 77-4, Species and sediment composition of the benthos in Alice Arm and Hastings Arm, B.C. Prep. for J.L. Littlepage. 122 pp.

Retech Ltd. Sedimentation of mine tailings in a marine environment.*

Stucchi, D. Analysis of the Crash Program data (1981 CTD data set).*

Thompson, J.A.J. Heavy metal analyses of sediments and interstitial water from cores taken in Alice Arm and surrounding environs.*

*General title or description of ongoing study.

APPENDIX F-1

DENSITY AND DISTRIBUTION OF BENTHIC INVERTEBRATES
FOR EACH SAMPLE (0.25 mm screen) FROM ALICE ARM.
ALL RESULTS ARE GIVEN IN NUMBERS PER M^2.

	CCN		CCM		CCS		DDN		DDM		DDS		EEN		EEM		EES		FFM	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B*	A	B	A	B
Coelenterata																				
Hydroidea																				
Platyhelminthes																				
Turbellaria																				
Nemertea	10						10				10	10	40				20		160	
Nematoda	240	10		150	940	1570	4060	640	40	900	170	1780	8260	8320	1450		1180	1870	50480	51080
Annelida																				
Oligochaeta																				
Polychaeta	120		70	50	850	1100	260	870		140	650	840	2230	1320	560		4730	6040	14640	10160
Arthropoda																				
Crustacea																				
Cumacea					10															
Tanaidacea													10		10					
Amphipoda																		10	120	160
Isopoda							80	10	10				130	90	70		60	40	40	160
Ostracoda	20		10	20	50	40	10												40	
Harpacticoida	10				10	20	250	20	40	60	220	60	710	510	790		60	590	160	120
Insecta							40	10	10	30	20	40	10		20		40	20	80	400
Collembola	10																			
Acarina							10							10					40	
Mollusca																				
Aplacophora							10													
Gastropoda	770	70		110	60	30	410	10	120	110	30	100	170	20	280		10	20	160	
Pelecypoda	80	10	20	20	10	10	320	110	50	40		390	280	90	290		510	390	440	280
Echinodermata																				
Ophiuroidea			10		10						140	1330	80		40		20	10		
Tardigrada																				40

* No Sample taken.

APPENDIX F-2

DENSITY AND DISTRIBUTION OF BENTHIC INVERTEBRATES FOR EACH STATION (0.25 mm screen) FROM ALICE ARM. ALL RESULTS ARE GIVEN IN NUMBERS PER M^2.

	CCN	CCM	CCS	DDN	DDM	DDS	EEN	EEM	EES	FFM
Coelenterata										
Hydroidea										
Platyhelminthes										
Turbellaria										
Nemertea	5			5		10	20		10	80
Nematoda	125	75	1255	2350	470	975	8290	725	1525	50780
Annelida										
Oligochaeta										
Polychaeta	60	60	975	565	70	745	1775	280	5385	12400
Arthropoda										
Crustacea										
Cumacea			5				5	5		
Tanaidacea									5	140
Amphipoda				45	5		110	35	50	100
Isopoda				5						20
Ostracoda	10	15	45	135	50	140	610	395	325	140
Harpacticoida	5		15	25	20	30	5	10	30	240
Insecta										
Collembola	5									
Acarina				5			5			20
Mollusca										
Aplacophora				5						
Gastropoda	420	55	45	210	115	65	95	140	15	80
Pelecypoda	45	20	10	215	45	195	185	145	450	360
Echinodermata										
Ophiuroidea		5	5			735	40	20	15	
Tardigrada										20

APPENDIX F-3

DENSITY AND DISTRIBUTION OF BENTHIC INVERTEBRATES FOR EACH SAMPLE (0.25 mm screen) FROM HASTINGS ARM. ALL RESULTS ARE GIVEN IN NUMBERS PER M^2.

	Z2E		Z2M		Z2W		Z5E		Z5M		Z5W	
	A	B	A	B	A	B	A	B	A	B	A	B
Coelenterata												
Hydroidea	20									50		
Platyhelminthes												
Turbellaria												
Nemertea	30			10	30		160	10	30	10	180	
Nematoda	2900		330	680	960	230	2720	1290	1230	4910	1720	310
Annelida												
Oligochaeta			10									
Polychaeta	10020	8840	5880	5010	4580	2260	13090	11470	9750	410	12100	5720
Arthropoda												
Crustacea												
Cumacea		10	70	50	10		180	70	50	200	220	
Tanaidacea			40		10		10	10	20			
Amphipoda		10	20			10		20	10	50		30
Isopoda												
Ostracoda	110	60	10	10	10	10	40	70	20	10	40	30
Harpacticoida	280	120	50	10	170	30	130	60	40	350	200	20
Insecta												
Collembola												
Acarina	10											
Mollusca												
Aplacophora	10							10			10	
Gastropoda	150	70	20	30	30	20	30	20		90	10	10
Pelecypoda	420	390	290	310	230	40	130	140	30	140	40	40
Echinodermata												
Ophiuroidea									10	20	10	20
Tardigrada												

APPENDIX F-4

DENSITY AND DISTRIBUTION OF BENTHIC INVERTEBRATES FOR EACH STATION (0.25 mm screen) FROM HASTINGS ARM. ALL RESULTS ARE GIVEN IN NUMBERS PER M^2.

	Z2E	Z2M	Z2W	Z5E	Z5M	Z5W
Coelenterata						
Hydroidea	10				25	
Platyhelminthes						
Turbellaria						
Nemertea	15	5	15	85	20	90
Nematoda	1450	505	595	2005	3070	1015
Annelida						
Oligochaeta		5				
Polychaeta	9430	5445	3420	12280	5080	8910
Arthropoda						
Crustacea						
Cumacea	5	60	5	125	125	110
Tanaidacea		20	5	10	10	
Amphipoda	5	10	5	10	30	15
Isopoda						
Ostracoda	85	10	10	55	15	35
Harpacticoida	200	30	100	95	195	110
Insecta						
Collembola						
Acarina	5					
Mollusca						
Aplacophora	5			5		5
Gastropoda	110	25	25	25	45	10
Pelecypoda	405	300	135	135	85	40
Echinodermata						
Ophiuroidea					15	15
Tardigrada						

APPENDIX G

LIST OF ALL TAXA FOUND IN ALICE ARM AND HASTINGS ARM

Porifera
Hexactinellida
Rosellidae

Coelenterata
Pennatulacea
Virgulariidae
Virgularia cf. *tuberculata* Marshal

Platyhelminthes
Turbellaria
Polycladida

Nemertea
Anopla
Paleonemertea

Heteronemertea
Lineidae
? *Cerebratulus*
Micrura alaskensis? Coe

Enopla
Hoplonemertea

Nematoda

Sipunculida
Golfingiidae
Golfingia sp.

Echiura

Annelida
Oligochaeta
Tubificida
Tubificidae
Limnodriloides sp.
L. victoriensis Brinkhurst and Baker

Polychaeta
(Errantiate)
Polynoidae
? *Eunoe*
Gattyana treadwelli? Pettibone

Sigalionidae
Pholoe minuta (Fabricius)

Phyllodocidae
Eteone (Mysta) sp.
E. columbiensis Kravitz and Jones
Phyllodoce groenlandica Oersted

Pilargidae
Ancistrosyllis sp.
A. groenlandica McIntosh

Syllidae
Exogone sp. 1
Exogone sp. 2
E. gemmifera Pagenstecher
Eusyllis cf. blomstrandi Malmgren
Syllis sp.
S. alternata Moore

Nephtyidae
Aglaophamus malmgreni (Theel)
Nephtys cornuta cornuta Berkley and Berkley
N. punctata Hartman

Sphaerodoridae
Sphaerodoropsis sphaerulifer (Moore)

Goniadidae
Goniada annulata Moore
Glycinde armigera Moore

Lumbrineridae
Lumbrineris sp.
L. luti Berkley and Berkley
Paraninoe simpla (Moore)

Dorvilleidae
Schistomeringos sp.

Hesionidae
Gyptis brevipalpa (Hartmann-Schroder)

(Sedentariate)
Orbiniidae
Leitoscoloplos pugettensis (Pettibone)

Paraonidae
Aricidea suecica Eliason
A. lopezi lopezi Berkley and Berkley
Cirrophorus branchiatus Ehlers
Levinsenia gracilis (Tauber)

Trochochaetidae
Trochochaeta multisetosa (Oersted)

Chaetopteridae
Spiochaetopterus costarum (Claparede)

Spionidae
Polydora sp.
Pseudopolydora kempi? (Southern)
Prionospio sp.
P. cirrifera Wiren
P. steenstrupi Malmgren
Spiophanes sp.
S. kroyeri Grube

Cirratulidae
Chaetozone setosa Malmgren
Caulleriella hamata (Hartman)
C. cf. *hamata* (Hartman)

Cossuridae
Cossura soyeri Laubier

Flabelligeridae
Brada sp.
B. villosa (Rathke)
Pherusa sp.

Opheliidae
Ophelina breviata (Ehlers)

Sternaspidae
Sternaspis scutata (Renier)

Capitellidae
Capitella capitata (Fabricius)
Decamastus sp.
Heteromastus sp.
H. filobranchus? Berkley and Berkley
Mediomastus sp.

Maldanidae
Maldane glebifex Grube
Rhodine sp.

Oweniidae
Myriochele oculata Zachs
Owenia fusiformis Chiaje

Amphictenidae
Pectinaria sp.
P. moorei Annenkova

Terebellidae
Artacama conifera Moore
Pista cristata (Muller)
Polycirrus sp.

Trichobranchidae
Terebellides sp.
Terebellides stroemi Sars

Ampharetidae
Amage anops (Johnson)
Amphicteis sp.
A. cf. scaphobranchiata Moore
Anobothrus gracilis (Malmgren)
Sosanopsis cf. hesslei Banse

Sabellidae
Euchone sp.
Jasmineira pacifica Annenkova

UID Polychaeta

Arthropoda
Crustacea
Cumacea
Campylaspis ? papillata Lomakina
Eudorella sp.
Leucon sp.

Tanaidacea
Leptognathia sp.

Amphipoda
Corophiidae
Corophium acherusicum Costa

Lysianassidae
Cyphocaris challengeri Stebbing
Koroga megalops Holmes
Orchomene obtusa (Sars)
Pachynus barnardi Hurley

Phoxocephalidae
Paraphoxus oculatus (Sars)

Oedicerotidae
Bathymedon pumilis Barnard
Monoculodes cf. emarginatus Barnard

Eusiridae
?Rhacotropis sp.

Hyperiidae
Hyperia sedusarum Muller
Parathemisto sp.
P. pacificus Stebbing

Mysidacea
Mysidae
Pseudomma truncatum S.I. Smith

Decapoda

Mollusca
Aplacophora

Gastropoda
Pyramidellida
Pyramidellidae
Turbonilla sp.

Cephalospidea
Cylichna altonsa
Gastropteron pacificum? Bergh

Thecosomata
Limacina sp.

Neogastropoda
Thaididae

Buccinidae
Buccinum sp.

Megogastropoda
Vitrinellidae
?Vitrinella sp.

Scaphopoda
Dentaloida
Dentaliidae
Dentalium rectius Carpenter

Siphonodentaloida
Cadulidae
Cadulus californicus (Pilsbury and Sharp)

Bivalvia
Heterodonta
Tellinidae
Macoma sp.
M. carlottensis Whiteaves
M. elimata Dunnill and Coan
M. cf. nasuta (Conrad)

Cooperellidae
Cooperella sp.

Veneridae
Transenella tantilla (Gould)

Ungulidae
Diplodonta orbella Gould

Hiatellidae
Hiatella arctica (Linnaeus)
Nuculana minuta Fabricius
Nucula tenuis (Montagu)
Yoldia amydalea Valenciennes
Y. beringiana Dall
Y. martyria Dall
Y. myalis (Couthouy)

Echinodermata
Asteroidea
Paxilloridea
Goniopectinidae
Ctenodiscus crispatus Retzius

Ophiuroidea
Ophiurida
Ophiolepididae
Ophiura sp.
O. leptoctenia H.L. Clark
O. sarsi Lutken

Holothuroidea
Apodida
Chirodotidae
Chirodota albatrossi Ohshima

Molpadida
Molpadiidae
Molpadia intermedia (Ludwig)

Hemichordata
Enteropneusta

APPENDIX H

DENSITY AND DISTRIBUTION FOR BENTHIC INVERTEBRATES (1.0 mm screen) FROM ALICE ARM. ALL RESULTS ARE GIVEN IN NUMBERS PER M^2.

	CCN			CCM			CCS			DDN			DDM			DDS			EEN			EEM	EES			FFM		
	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	A	B	$\bar{X}$	A	B	$\bar{X}$
Porifera																												
Hexactinellida																												
Rosellidae																			10		5							
Coelenterata																												
Pennatulacea																												
Virgulariidae																												
Virgularia cf. tuberculata																												
Platyhelminthes																												
Turbellaria																												
Polycladida																												
Nemertea																												
Anopla																												
Paleonemertea																							10	20	15		60	30
Heteronemertea																												
Lineidae																			10		5							
? Cerebratulus																										90	50	70
Micrura alaskensis?																											10	5
Enopla																											10	5
Hoplonemertea										10		5																
Nematoda																			10		5		10		5	240	270	255
Sipunculida																												
Golfingiidae																												
Golfingia sp.																										10	10	10
Echiura																										20	30	25
Annelida																												
Oligochaeta																												
Tubificida																												
Tubificidae																												
Limnodriloides sp.																										10		5
L. victoriensis																										10		5
Polychaeta																												
(Errantiate)																												
Polynoidae																												
? Eunoe																												
Gattyana treadwelli?							20		10											10	5					90	50	70

	CCN			CCM			CCS			DDN			DDM			DDS			EEN			EEM	EES			FFM		
	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	A	B	$\bar{X}$	A	B	$\bar{X}$
Sigalionidae																												
Pholoe minuta																			10		5			10	5	80	140	110
Phyllodocidae																												
Eteone (Mysta) sp.																											10	5
E. columbiensis																										30	40	35
Phyllodoce groenlandica																										70	30	50
Pilargidae																												
Ancistrosyllis sp.											10	5																
A. groenlandica																			20		10	10						
Syllidae																												
Exogone sp. 1																										30	20	25
Exogone sp. 2																											20	10
E. gemmifera																							10		5	20		10
Eusyllis cf. blomstrandi																											20	10
Syllis sp.																											10	5
S. alternata																										20	40	30
Nephtyidae																												
Aglaophamus malmgreni							10		5								10	5										
Nephtys cornuta cornuta										130	70	100	10		5	90	20	55	650	440	545	330	430	690	560	80	530	305
N. punctata							10	10	10											10	5	20					10	5
Sphaerodoridae																												
Sphaerodoropsis sphaerulifer																										10		5
Goniadidae																												
Goniada annulata							10	10	10	30	20	25														50	20	35
Glycinde armigera																	10	5								10		5
Lumbrineridae																												
Lumbrineris sp.							10		5														10		5			
L. luti																			10	20	15			20	10		20	10
Paraninoe simpla							20		10								20	10				10		30	15	410	460	435
Dorvilleidae																												
Schistomeringos sp.																											10	5
Hesionidae																												
Gyptis brevipalpa																			30	40	35	20	10	20	15	100	30	65
(Sedentoriate)																												
Orbiniidae																												
Leitoscoloplos pugettensis																										70	10	40

	CCN			CCM			CCS			DDN			DDM			DDS			EEN			EEM	EES			FFM		
	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	A	B	$\bar{X}$	A	B	$\bar{X}$
Paraonidae																												
Aricidea suecica																											60	30
A. lopezi lopezi							20	10	15	50	20	35				10		5	30	50	40	30	130	70	100		10	5
Cirrophorus branchiatus								10	5		10	5							30		15			10	5	10	70	40
Levinsenia gracilis				20	10		420	370	395	40	40	40	10	10	10	40		20	270	180	225	110	60	130	95	1160	2290	1725
Trochochaetidae																												
Trochochaeta multisetosa																												
Chaetopteridae																												
Spiochaetopterus costarum																												
Spionidae																												
Polydora sp.																										10		5
Pseudopolydora kempi?								10	5																	10		5
Prionospio sp.																											40	20
P. cirrifera										30		15							40	10	25	10	40	20	30	130	10	70
P. steenstrupi																										340	10	175
Spiophanes sp.																										1740	2140	1940
S. kroyeri																												
Cirratulidae							20	20	20		30	15				10		5	10		5			40	20	30	30	30
Chaetozone setosa																			40	60	50		30	140	85	10	20	15
Caulleriella hamata																				10	5					10		5
C. cf. hamata																								10	5			
Cossuridae																												
Cossura soyeri								10	5																	30		15
Flabelligeridae																												
Brada sp.																											10	5
B. villosa																			10		5					10		5
Pherusa sp.																										80	10	45
Opheliidae																												
Ophelina breviata																										30	30	30
Sternaspidae																												
Sternaspis scutata																										10		5
Capitellidae																												
Capitella capitata																										290		145
Decamastus sp.				10	5																					10		5
Heteromastus sp.																										470	620	545
H. filobranchus?																											30	15
Mediomastus sp.				10	5		20		10										20	10	15	10	40		20	590	1310	950
Maldanidae								10	5																	260	560	410
Maldane glebifex							90		45																	80	60	70
Rhodine sp.																										20		10

	CCN			CCM			CCS			DDN			DDM			DDS			EEN			EEM	EES			FFM		
	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	A	B	$\bar{X}$	A	B	$\bar{X}$
Oweniidae																												
Myriochele oculata							100	50	75	20	20	20								20	10	10	40	10	25	2450	2980	2715
Owenia fusiformis								10	5																	50	10	30
Amphictenidae																												
Pectinaria sp.																							10		5			
P. moorei																										520	70	295
Terebellidae																												
Artacama conifera																										10		5
Pista cristata																										20		10
Polycirrus sp.																										50		25
Trochobranchidae																												
Terebellides sp.																										50		25
T. stroemi																										140	50	95
Ampharetidae																												
Amage anops																										230	50	140
Amphicteis sp.																											10	5
A. cf. scaphobranchiata							10		5																	100		50
Anobothrus gracilis																										20	50	35
Sosanopsis cf. hesslei																										30		15
Sabellidae																										90	60	75
Euchone sp.																										20		10
Jasmineira pacifica																												
UID Polychaeta																								10	5			
Arthropoda																												
Crustacea																												
Cumacea																												
Campylaspis ? papillata																											20	10
Eudorella sp.										10		5		10	5								50	30	40	20	10	15
Leucon sp.																10	5											
Tanaidacea																											20	10
Leptognathia sp.																												
Amphipoda																												
Corophiidae																												
Corophium acherusicum																										10		5
Lysianassidae																						10						
Cyphocaris challengeri																								10	5			
Koroga megalops		10	5					10	5				10		5									10	5			
Orchomene obtusa											10	5																
Pachynus barnardi																												
Phoxocephalidae																												
Paraphoxus oculatus							10		5																	50		25

	CCN			CCM			CCS			DDN			DDM			DDS			EEN			EEM			EES			FFM		
	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A			A	B	$\bar{X}$	A	B	$\bar{X}$
Oedicerotidae										10		5								10	5	10							10	5
Bathymedon pumilis																			40	80	60	10			20	80	50		30	15
Monoculodes cf. emarginatus																										10	5			
Eusiridae																														
?Rhacotropis sp.											10	5																		
Hyperiidae																			20		10	10							10	5
Hyperia sedusarum																														
Parathemisto sp.																										20	10			
P. pacificus																				10	5									
Mysidacea	10		5																											
Mysidae																														
Pseudomma truncatum																														
Decapoda																														
Mollusca																														
Aplacophora										10		5							50	10	30	10						90	70	80
Gastropoda																														
Pyramidellida																														
Pyramidellidae																														
Turbonilla sp.																														
Cephalospidea																														
Cylichna altonsa																														
Gastropteron pacificum?											10	5							50	10	30				30	30	30	60	20	40
Thecosomata																												10		5
Limacina sp.	10		5																10		5									
Neogastropoda																														
Thaididae																												10		5
Buccinidae																														
Buccinum sp.																													10	5
Megogastropoda																														
Vitrinellidae																														
?Vitrinella																			10		5							20	10	15
Scaphopoda																														
Dentaloida																														
Dentaliidae																														
Dentalium rectius																														
Siphonodentaloida																														
Cadulidae																														
Cadulus californicus																														

	CCN			CCM			CCS			DDN			DDM			DDS			EEN			EEM	EES			FFM		
	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	A	B	$\bar{X}$	A	B	$\bar{X}$
Bivalvia																												
Heterodonta																												
Tellinidae																								60	30		80	40
Macoma sp.																										30		15
M. carlottensis																												
M. climata																										110		55
M. cf. nasuta																												
Cooperellidae																												
Cooperella sp.																						30	60		30			
Veneridae																										10		5
Transenella tantilla		10	5	10		5				30	170	100							800	1280	1040	140	1420	1700	1560			
Ungulidae																												
Diplodonta orbella										50	150	100							330	140	235	60	180	90	135	50	30	40
Hiatellidae																												
Hiatella arctica																											10	5
Nuculana minuta																							20		10			
Nucula tenuis					10	5					10	5					10	5	520	280	400	140	310	350	330			
Yoldia amydalea																			10		5							
Y. beringiana																						10	10	50	30			
Y. martyria																			10		5		10		5			
Y. myalis																			10		5					30	20	25
Echinodermata																												
Asteroidea																												
Paxilloridea																												
Goniopectinidae																												
Ctenodiscus crispatus										30	10	20											10		5	20		10
Ophiuroidea																												
Ophiurida							10		5							530	1410	970	100	100	100		20	70	45	130	310	220
Ophiolepididae																												
Ophiura sp.																			100		50							
O. leptoctenia																										10		5
O. sarsi																												
Holothuroidea																												
Apodida																												
Chirodotidae																												
Chirodota albatrossi							10		5										70	130	100	50	100	70	85	110	240	175
Molpadida																												
Molpadiidae																												
Molpadia intermedia								10	5											10	5					10		5
Hemichordata																												
Enteropneusta																												

* Sample not taken.

APPENDIX I

DENSITY AND DISTRIBUTION FOR BENTHIC INVERTEBRATES (1.0 mm screen) FROM HASTINGS ARM.
ALL RESULTS ARE GIVEN IN NUMBERS PER M^2.

	Z2E			Z2M			Z2W			Z5E			Z5M			Z5W		
	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$
Porifera																		
Hexactinellida																		
Rosellidae																		
Coelenterata																		
Pennatulacea																		
Virgulariidae																		
Virgularia cf. tuberculata		20	10														10	5
Platyhelminthes																		
Turbellaria																		
Polycladida								10	5									
Nemertea	10		5	20		10	60	20	40	10	20	15	20	30	25		30	15
Anopla																		
Paleonemertea													20		10		20	10
Heteronemertea		10	5	10		5				10		5						
Lineidae																		
? Cerebratulus																		
Micrura alaskensis?																		
Enopla																		
Hoplonemertea																		
Nematoda							10		5									
Sipunculida																		
Golfingiidae																		
Golfingia sp.																		
Echiura																		
Annelida																		
Oligochaeta																		
Tubificida																		
Tubificidae																		
Limnodriloides sp.																		
L. victoriensis																		
Polychaeta																		
(Errantiate)																		
Polynoidae																		
? Eunoe		10	5								20	10	10		5			
Gattyana treadwelli?				10		5												

	Z2E			Z2M			Z2W			Z5E			Z5M			Z5W		
	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$
Sigalionidae																		
Pholoe minuta		10	5															
Phyllodocidae																		
Eteone (Mysta) sp.																		
E. columbiensis																		
Phyllodoce groenlandica																		
Pilargidae																		
Ancistrosyllis sp.																		
A. groenlandica		10	5															
Syllidae																		
Exogone sp. 1																		
Exogone sp. 2																		
E. gemmifera																		
Eusyllis cf. blomstrandi																		
Syllis sp.																		
S. alternata																		
Nephtyidae																		
Aglaophamus malmgreni	30	30	30	10		5	20	30	25					10	5	10		5
Nephtys cornuta cornuta	570	200	385	180	200	190	520	190	355	140	210	175	420	400	410	300	400	350
N. punctata					20	10				20		10						
Sphaerodoridae																		
Sphaerodoropsis sphaerulifer																		
Goniadidae																		
Goniada annulata	10	30	20	20	20	20	20	40	30	20	30	25	40	30	35		30	15
Glycinde armigera							10		5							20	10	15
Lumbrineridae																		
Lumbrineris sp.					10	5	10		5		20	10				30	20	25
L. luti													20		10		10	5
Paraninoe simpla	20	10	15										10		5			
Dorvilleidae																		
Schistomeringos sp.																		
Hesionidae																		
Gyptis brevipalpa		30	15	20	50	35	50	30	40	20	70	45	100	80	90	100	110	105
(Sedentariate)																		
Orbiniidae																		
Leitoscoloplos pugettensis							10		5				10		5			

	Z2E			Z2M			Z2W			Z5E			Z5M			Z5W		
	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$
Paraonidae																		
Aricidea suecica	30		15								30	15						
A. lopezi lopezi	120	40	80	80	50	65	250	80	165	70	130	100	200	290	245	110	340	225
Cirrophorus branchiatus	30		15					10	5									
Levinsenia gracilis	270	140	205	120	60	90	210	180	195	160	210	185	430	460	445	270	320	295
Trochochaetidae																		
Trochochaeta multisetosa													10		5			
Chaetopteridae																		
Spiochaetopterus costarum														10	5			
Spionidae																		
Polydora sp.																		
Pseudopolydora kempi?																		
Prionospio sp.								10	5									
P. cirrifera	100		50	10	10	10	60	10	35					20	10	20		10
P. steenstrupi	20	30	25	30		15		20	10	20	40	30	10	20	15		10	5
Spiophanes sp.								10	5	20		10						
S. kroyeri	20		10	30		15	10		5	10	10	10					10	5
Cirratulidae	410	180	295	80	220	150	460	100	280	10	70	40	110	140	125			
Chaetozone setosa	310	70	190	20	50	35	340	50	195		60	30	50	50	50	40	100	70
Caulleriella hamata																		
C. cf. hamata																		
Cossuridae																		
Cossura soyeri	220	20	120	10	30	20	380	20	200	10		5	30	40	35	10	60	35
Flabelligeridae																		
Brada sp.																		
B. villosa							20		10									
Pherusa sp.																		
Opheliidae																		
Ophelina breviata																		
Sternaspidae																		
Sternaspis scutata	20		10		10	5	10	10	10		10	5						
Capitellidae																		
Capitella capitata																		
Decamastus sp.																		
Heteromastus sp.																		
H. filobranchus?	10		5				20		10									
Mediomastus sp.							10	10	10				10		5			
Maldanidae																		
Maldane glebifex																		
Rhodine sp.																		

	Z2E			Z2M			Z2W			Z5E			Z5M			Z5W		
	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$
Oweniidae																		
Myriochele oculata										10	10	10		10	5			
Owenia fusiformis																		
Amphictenidae																		
Pectinaria sp.																		
P. moorei		30	15	10		5				10		5	10	10	10		10	5
Terebellidae																		
Artacama conifera																		
Pista cristata																		
Polycirrus sp.																		
Trochobranchidae																		
Terebellides sp.																		
T. stroemi	10		5															
Ampharetidae																		
Amage anops				10		5												
Amphicteis sp.																		
A. cf. scaphobranchiata																		
Anobothrus gracilis																		
Sosanopsis cf. hesslei																		
Sabellidae																		
Euchone sp.																		
Jasmineira pacifica																		
UID Polychaeta																		
Arthropoda																		
Crustacea																		
Cumacea																		
Campylaspis ? papillata																		
Eudorella sp.	10		5	50	50	50	30		15	100	90	95	70	50	60	80	20	50
Leucon sp.																		
Tanaidacea																		
Leptognathia sp.							10		5								10	5
Amphipoda																		
Corophiidae																		
Corophium acherusicum																		
Lysianassidae																		
Cyphocaris challengeri																	10	5
Koroga megalops																		
Orchomene obtusa																		
Pachynus barnardi													10		5			
Phoxocephalidae																		
Paraphoxus oculatus																		

	Z2E			Z2M			Z2W			Z5E			Z5M			Z5W		
	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$
Oedicerotidae																		
Bathymedon pumilis	20		10							20		10	10		5	10	10	10
Monoculodes cf. emarginatus					10	5							10		5		10	5
Eusiridae																		
?Rhacotropis sp.																		
Hyperiidae																		
Hyperia sedusarum																		
Parathemisto sp.																		
P. pacificus								10	5							10		5
Mysidacea																		
Mysidae																		
Pseudomma truncatum																		
Decapoda																		
Mollusca																		
Aplacophora																		
																	10	5
Gastropoda																		
Pyramidellida																		
Pyramidellidae																		
Turbonilla sp.																	10	5
Cephalospidea																		
Cylichna altonsa	10		5	40	50	45	20	60	40	20	70	45	50	100	75	70	30	50
Gastropteron pacificum?																		
Thecosomata																		
Limacina sp.													10		5			
Neogastropoda																		
Thaididae																		
Buccinidae																		
Buccinum sp.																		
Megogastropoda																		
Vitrinellidae																		
?Vitrinella																		
Scaphopoda																		
Dentaloida																		
Dentaliidae																		
Dentalium rectius		10	5		10	5					10	5	10	20	15	20	10	15
Siphonodentaloida																		
Cadulidae																		
Cadulus californicus	10		5											10	5			

	Z2E			Z2M			Z2W			Z5E			Z5M			Z5W		
	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$	A	B	$\bar{X}$
Bivalvia																		
Heterodonta																		
Tellinidae																		
Macoma sp.																10		5
M. carlottensis	30	20	25															
M. climata																	10	5
M. cf. nasuta																		
Cooperellidae																		
Cooperella sp.				70	80	75	70	60	65	10	10	10						
Veneridae																		
Transenella tantilla	50	30	40	80	80	80	140	120	130	170	120	145	20	190	105	40	10	25
Ungulidae																		
Diplodonta orbella	30	60	45	60	70	65		50	25	30	10	20	40	60	50	50	40	45
Hiatellidae																		
Hiatella arctica																		
Nuculana minuta																		
Nucula tenuis	50	90	70	100	190	145	120		60	10	40	25	20	20	20	10		5
Yoldia amydalea	10		5				40	30	35									
Y. beringiana	30	40	35	20	40	30				30	90	60	40	20	30	30		15
Y. martyria		10	5													10		5
Y. myalis																		
Echinodermata																		
Asteroidea																		
Paxilloridea																		
Goniopectinidae							20		10									
Ctenodiscus crispatus	10		5	20		10				10	20	15		10	5			
Ophiuroidea				40		20												
Ophiurida	40		20		20	10	20		10	20	180	100	30	150	90	100	350	225
Ophiolepididae																		
Ophiura sp.										50	10	30		70	35			
O. leptoctenia							10		5		10	5				10	20	15
O. sarsi																10		5
Holothuroidea																		
Apodida																		
Chirodotidae																		
Chirodota albatrossi	20	10	15		30	15	20	20	20					10	5		20	10
Molpadida																		
Molpadiidae																		
Molpadia intermedia								10	5	10		5				10	10	10
Hemichordata																		
Enteropneusta														10	5			