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Environmental Surveillance Of Kitimat Arm, British Columbia.

Surveillance Report
EPS 5-PR-77-7

Pacific Region
May, 1977

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ENVIRONMENTAL SURVEILLANCE
OF
KITIMAT ARM, BRITISH COLUMBIA

by

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Environmental Protection Service
Pacific Region

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May, 1977

ABSTRACT

A survey of the marine environment in Kitimat Arm, British Columbia, was undertaken by the Marine Studies Group of the Environmental Protection Service in 1975. The purpose of the work was to obtain basic chemical and biological information on the watercolumn and sediments in order to determine possible environmental impacts attributable to existing industrial discharges and activities in the area. The parameters examined included watercolumn temperature, salinity, dissolved oxygen and trace metals; sediment size characteristics, trace metals in the sediments and benthic infaunal species composition. In addition, two submersible dives were completed with the Pisces IV in order to obtain qualitative information with respect to submarine topography and macro pelagic and benthic fauna inhabiting the area.

The results of this work indicated that the watercolumn of Kitimat Arm was typical of a relatively deep marine inlet with a significant freshwater input at its head. There was no evidence of a significant build-up of trace metals in the marine sediments that could be attributed to anthropogenic inputs.

The Pisces IV dives revealed that the floor of the inlet 1.7 miles from the head had been disturbed to a considerable degree by submarine mud slides. The dive across the delta front revealed a steep slope of approximately 35 degrees which appeared to have undergone considerable slumping. In both locations benthic infaunal and epifaunal communities were sparse probably due to the instability of the substrate. Evidence of dumped dredgeate was found at the northwest end of the dive track.

RÉSUMÉ

Le groupe des études marines du Service de la protection de l'environnement a exploré le milieu marin à Kitimat Arm (Colombie-Britannique) en 1975. Le but de cette reconnaissance était d'obtenir des renseignements chimiques et biologiques sur la masse d'eau verticale et les sédiments afin d'estimer les effets écologiques éventuels des décharges et activités industrielles de la region. On a contrôlé la température, la salinité, la concentration en oxygène dissous et la teneur oligométallique de la masse d'eau verticale, ainsi que les caractéristiques granulaires des sédiments, leur contenu oligométallique et la composition de l'endofaune benthique. En outre, deux plognées effectuées par le <u>Pisces IV</u>, ont donné des renseignements qualitatifs sur la topographic sous-marine ainsi que sur la faune macropélagique et benthique de la région.

Les résultats de ces travaux ont montré que la masse d'eau verticale de Kitimat Arm est typique d'um bras de mer assez profond qu'alimente one source imprtante d'eau douce. On n'a pas découvert, dans les sédiments marins, d'accumulations oligométalliques imputables aux activités de l'homme. Les plongées du <u>Pisces IV</u> ont révélé que le fond avait été fortement bouleversé par des éboulements boueux sous-marins à 1.7 mille de l'embouchure. Par ailleurs, le long du talus du delta, une pente abrupte d'environ 35 degrés semblait avoir connu de graves effondrements. Aux deux endroits, les communautés endofauniques et épifauniques étaient rares, probablement à cause de l'instabilité du subtrat. On a trouvé des traces de déchets de dragage à l'extrémité nord-ouest du sillage de plongée.

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SUMMARY

1. The waters of Kitimat Arm exhibited temperature, salinity and dissolved oxygen characteristics typical of a British Columbia inlet with a substantial freshwater input at its head. The water column was highly stratified with respect to temperature and salinity. Dissolved oxygen values were high at all depths with the lowest oxygen value of 5.0 mg/l (52% saturation) recorded at a depth of 50 meters. Concentrations of metals in the water column appeared typical of background levels for the area.

2. Analysis of the 80 mesh sediment fraction revealed a slight increase in the concentration of aluminum in the sediments adjacent to the dock where alumina is unloaded. The other data for trace metals in the sediments revealed no trends or elevated values.

3. Concentrations of benthic infaunal organisms were low throughout the area sampled with populations being exceptionally sparse in areas where submarine mud slides had occurred. Polychaetes and bivalves were the prominent taxa in all grab samples collected.

4. The Pisces dives revealed that a considerable area of the floor of the inlet had been affected by a series of submarine mud slides and delta slumping. The benthic infaunal and epifaunal communities were found to be quite sparse on both dives due to the instability of the substrate. It was felt that the tendency towards submarine slides should be an important factor when considering development-related construction projects in this area.

1 INTRODUCTION

A study of existing environmental conditions in Kitimat Arm was undertaken in June of 1975 by the Marine Studies Group of the Environmental Protection Service. The objectives of this study were to examine oceanographic parameters including temperature, salinity, dissolved oxygen and trace metal concentrations; sediment characteristics, including sediment size, trace metal concentrations, and benthic biota. This work was accomplished with a view to updating and broadening the existing environmental data base for this area. In the fall of 1976 two Pisces dives were completed in the area in order to further augment the previous work undertaken.

Kitimat is located approximately 715 kilometres northwest of Vancouver on the British Columbia mainland coast (Bell and Kallman, 1976). The town is located at the head of a deep marine fjord known as Kitimat Arm on an estuary and delta system created by the inflow of the Kitimat River (Figure 1). Kitimat Arm is an extension of the Squally Channel, Whale Channel, Douglas Channel system, which is contiguous with the Pacific Ocean via Hecate Strait.

The Kitimat River and its main tributaries drain a region of the Kitimat Ranges encompassing an area of approximately 2000 square km. The river, at its mouth, has an average annual flow of 134 cubic meters per second (cms), thus providing a major freshwater input into the head of the inlet. The river delta (Figure 2), comprised mainly of coarse sediments (sand and gravel), is less than 3 km wide and extends southward for approximately 1.5 km. Beyond the delta front, the estuary deepens rapidly to a maximum depth of 220 metres within the grid sampled during the present survey.

Two major industrial complexes are located along the Kitimat estuary. These are Alcan Smelters and Chemicals Ltd. and Eurocan Pulp and Paper Co. Ltd. These two industries are the economic backbone of

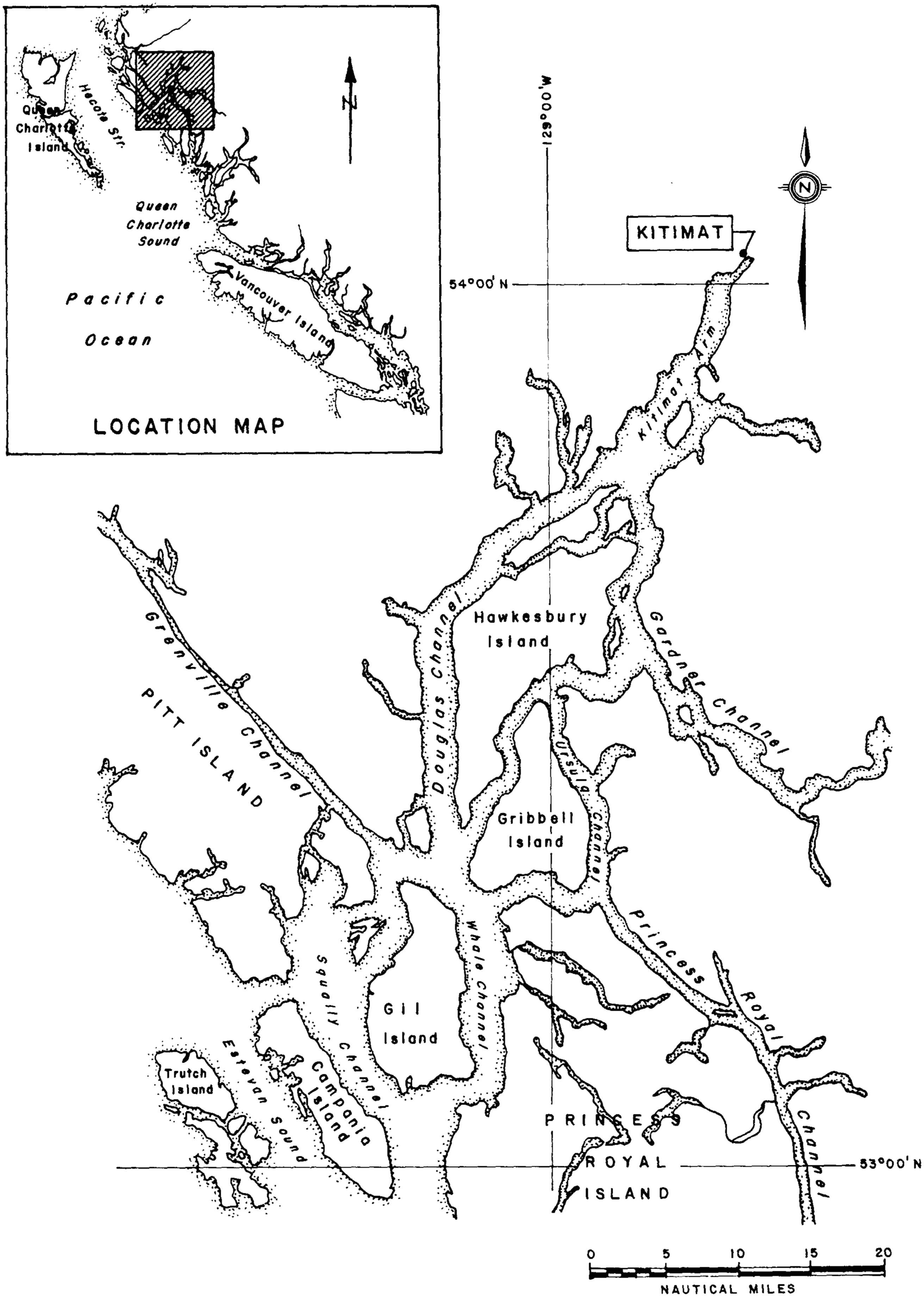

FIGURE 1 KITIMAT ARM AND CONTIGUOUS WATERS

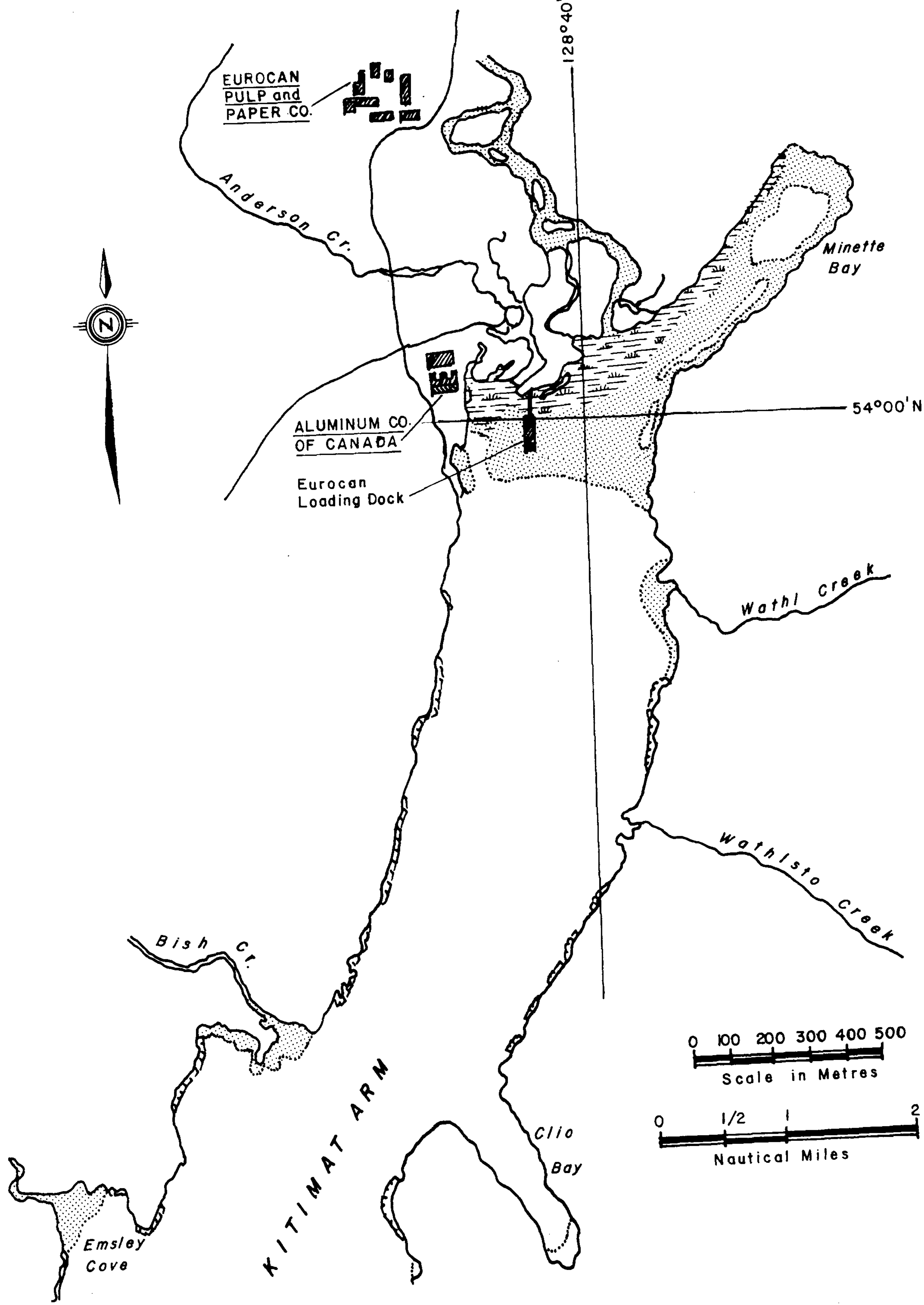

FIGURE 2 STUDY AREA

the community as well as being the major sources of pollution. The Alcan smelter was constructed between 1951 and 1954 and presently has a total annual production capacity of 296 tons. The major pollutants originating from this complex include fluorides, aluminum and alumina dust.

The other major industrial pollution source considered was the Eurocan Pulp and Paper Co. Ltd. pulp mill. This mill is located on the Kitimat River approximately 4 km. upstream from the delta front (Figure 2). It is equipped with secondary effluent treatment facilities which appear to have succeeded in reducing environmental damage from this source. Treated effluent is discharged to the Kitimat River, after passing through a series of clarifiers and aerated bio-basins.

Primary treated sewage from the Corporation of Kitimat is also discharged into the Kitimat River at a site in close proximity to but on the opposite bank from the Eurocan discharge.

Two development proposals are presently being considered for the Kitimat area. One of these is a steel mill proposed by a consortium including Japanese interests. Both Kitimat and Prince George have been suggested as possible sites for this development. Also, Kitimat has been proposed as an off-loading terminal for oil brought down from Alaska via tankers and destined for the mid-western United States via a pipeline proposed by Trans Mountain Pipe Line Co. Ltd.

2 METHODS AND MATERIALS

The major portion of the environmental assessment of Kitimat Arm was carried out during the period June 23 to 28, 1975. Prevailing weather conditions were generally poor with frequent rain showers, winds (particularly in the afternoons), and maximum daytime temperatures of approximately 15°C. Two dives were made aboard the Pisces IV submersible in October, 1976.

2.1 Physical Oceanographic Sampling

The oceanographic stations sampled are illustrated in Figure 3 as are the depths at each site. Station locations were established by means of horizontal sextant angles subsequently plotted with a Douglas protractor. All oceanographic sampling was conducted on a rising tide, commencing at Station K-6, in order to minimize the effects of tidal flushing. Water samples were collected using Nansen bottles equipped with paired, protected, reversing thermometers.

Temperatures were read and recorded as soon as possible after bottle recovery. Temperatures observed at the surface were later back-calculated to the temperature at depth using equations outlined in Sverdrup et al (1946).

Dissolved oxygen levels were measured using the azide modification of the Winkler method (Davidson et al, 1974). Salinity values were obtained using a refractometer calibrated by hydrometric and electro-conductivity techniques. The percent saturation of oxygen in the water column was calculated from the above parameters using the equation of Gameson and Robertson (1955).

All calculations were performed on the Hewlett-Packard computer available at the Pacific Environment Institute.

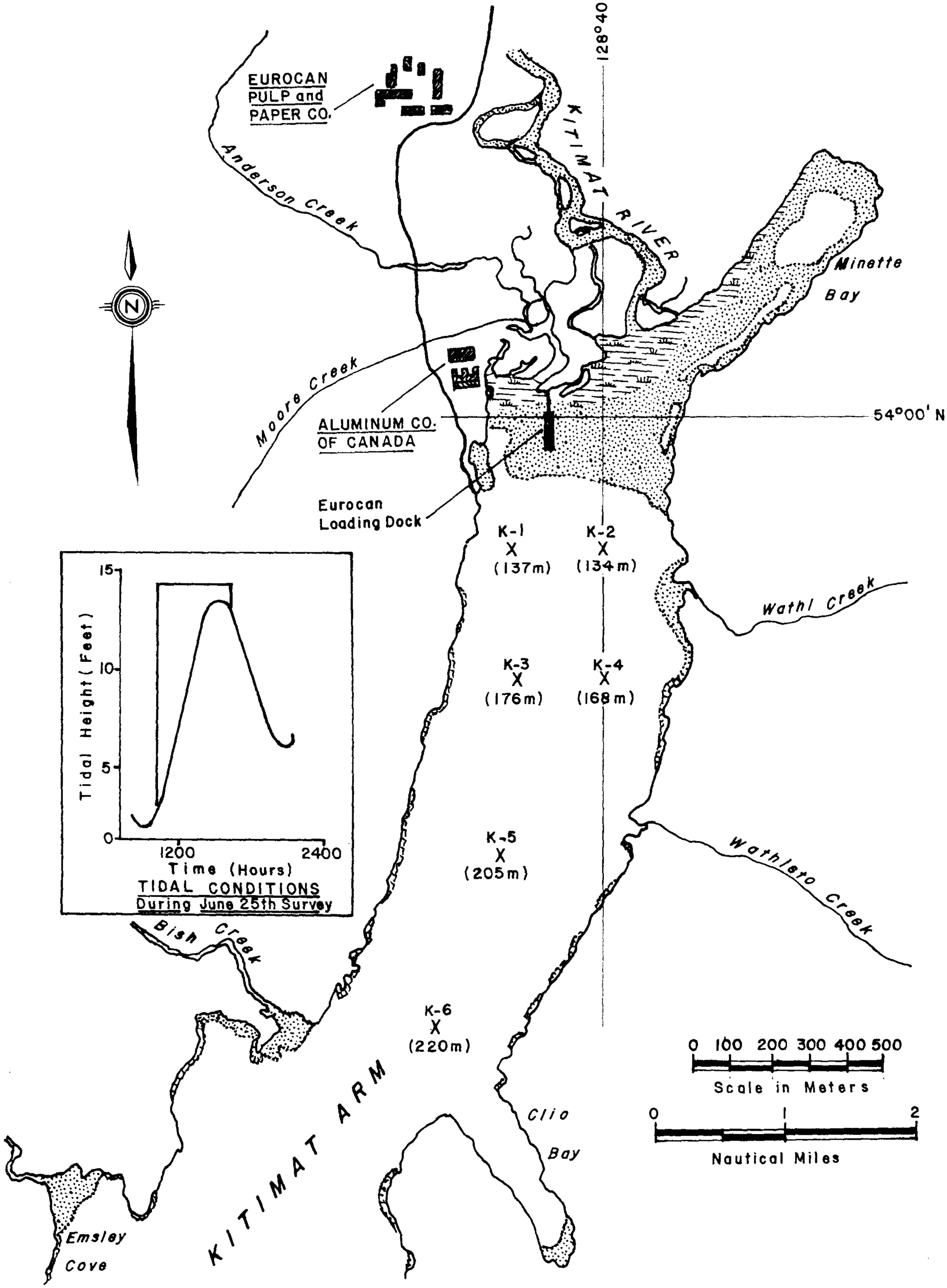

FIGURE 3 OCEANOGRAPHIC STATIONS - JUNE 25, 1975

Water samples were also collected from the surface and bottom depths at each station for analysis for trace metal concentrations. These samples were acidified to a pH of less than 1.5 by the addition of nitric acid and stored in this manner until analyzed.

2.2 Benthic Sampling

Fourteen benthic stations were sampled in order to determine concentrations of trace metals in the sediments and the composition of the benthic biota present (Figure 4). The samples were collected with a Ponar grab which sampled a surface area of 0.092 square metres. Upon collection of the sample, a small sub-sample was retained for metal analysis. These samples were stored in a frozen state. The remainder of the grab sample was washed through a 0.5 mm screen. The material retained on the screen was preserved in isopropyl alcohol and later sorted and identified. The organisms thus obtained were then identified to as low a taxon as was practically possible.

2.3 Laboratory Methods

All sediment samples for trace element analysis were air-dried under cover, disaggregated, and sieved through an 80-mesh nylon sieve (2.5 phi). The fine fractions were forwarded to Dr. W.K. Fletcher (University of British Columbia) where they were digested in a 4:1 nitric-perchloric acid mixture, evaporated to dryness over an air-bath, taken up in 1.5 M HCl, and analyzed for cobalt (Co), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb), zinc (Zn), silver (Ag), and cadmium (Cd) with a Perkin-Elmer 303 atomic absorption spectrophotometer. Background corrections were used for the determination of Co, Ni, and Pb concentrations.

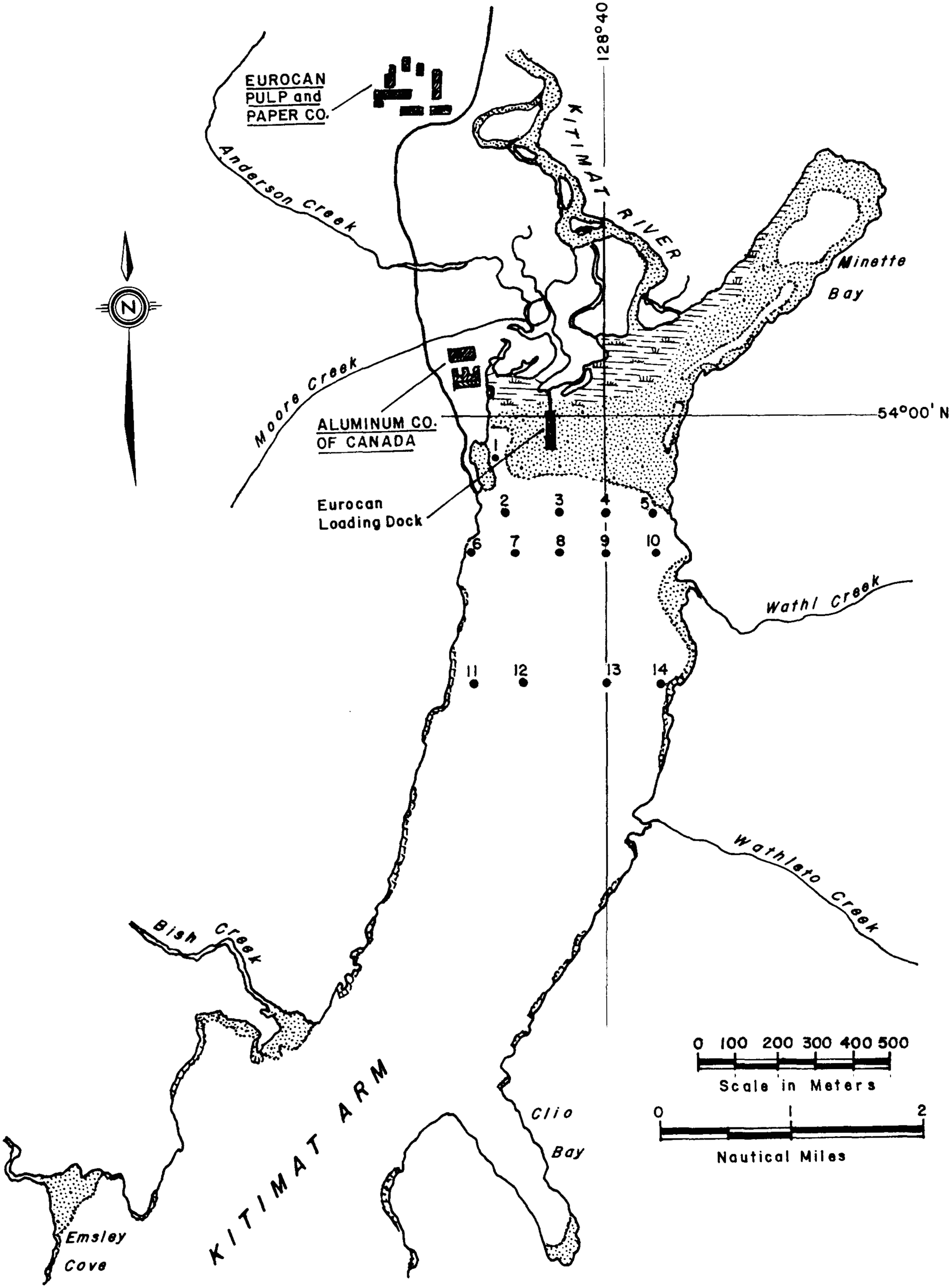

FIGURE 4 BENTHIC STATIONS - JUNE 24, 1975

Analysis of the sediment samples for aluminum was conducted by the Environmental Protection Service Laboratory, as follows:

> 0.25 - 0.35 gm of dried and sieved sediment was placed into an acid-washed Teflon bomb. This was acidified with 3 mls of concentrated nitric acid and 3 mls of concentrated hydroflouric acid. The bomb was closed and heated to 110°C for 1.5 hrs. The sample was then cooled and transferred in deionized water to a 50 ml plastic beaker containing 2.8 gm of boric acid. This was then transferred to a 100 ml volumetric flask and volumized. Final measurement was made with a Jarrell-Ash atomic absorption spectrophotometer and compared with commercial atomic absorption standards.

Sediment samples for grain-size analysis were oven-dried, disaggregated and weighed. The sample was then wet-sieved through a series of 3 screens ranging in mesh size from 500 to 62.5 microns; the portion of the sample remaining on each screen after the wet-sieving was oven-dried and weighed to determine its ratio to the total amount sieved. The amount of material passing through all of the screens was back-calculated from the weight of the entire sample. All fractions were then expressed as percentages of the total.

All water samples for trace element analysis were tested for the chelation/solvent extractable portions of Cu, Pb, Fe, Cd, and mercury (Hg) using a Jarrell-Ash Atomic Absorption Spectrophotometer.

2.4 Pisces Dives

Two Pisces dives were conducted in Kitimat Arm during October of 1976 on the tracks indicated in Figure 5. The main purpose of these dives was to evaluate areas of Kitimat Arm as potential sites for the ocean disposal of various construction-related materials; however, it was felt that the information obtained through this work should be incorporated into this report as it was directly relevant to our previous survey of the area.

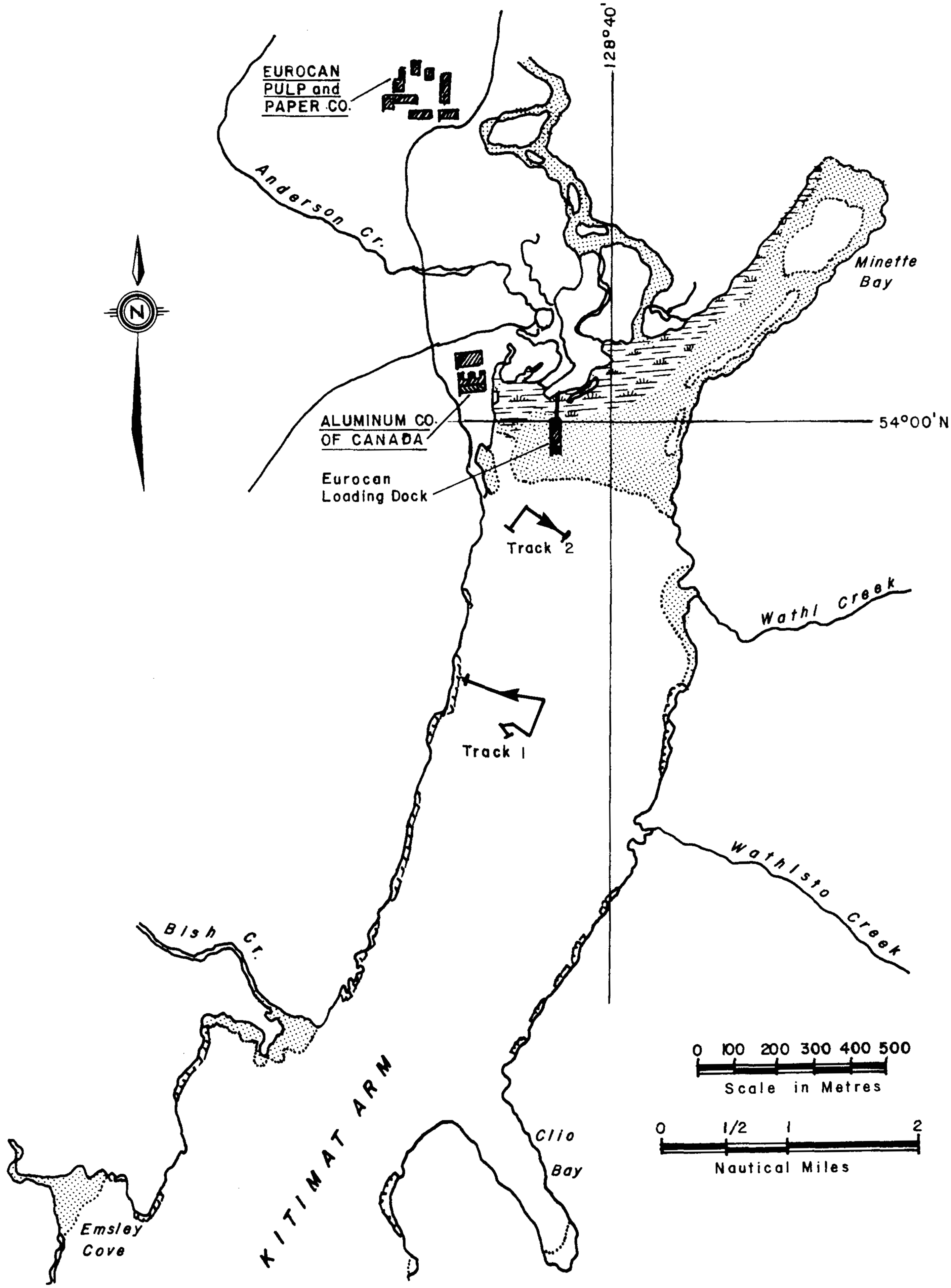

FIGURE 5 PISCES IV - DIVE TRACKS

The dives were recorded by means of still photography using a 70 mm Hydroproducts underwater camera mounted on the front of the Pisces and a 16 mm Bolex movie camera operated from within the boat itself by one of the observers. Biological observations and species identifications were made as well.

3 RESULTS AND DISCUSSION

3.1 Physical Oceanography

The results obtained from the physical oceanographic sampling are contained in Appendix I and depicted graphically in Figures 7 to 10 utilizing the data collected from the stations indicated in Figure 6.

Kitimat Arm may be described as a typical British Columbia fjord. It is characterized by a steep drop-off from the delta front and has no apparent sill at its entrance. A slight sill to the Douglas Channel system from Hecate Strait through Caamano Sound is, however, present.

The results obtained from this survey correspond with those reported in previous investigations (Goyette, 1971; Waldichuk et al, 1972). The watercolumn was found to be highly stratified with respect to the three parameters investigated, i.e., temperature, salinity, and dissolved oxygen. A surface layer of relatively fresh, warm, highly oxygenated water stemming from the Kitimat River was found to exist throughout the area sampled. It has been stated by Waldichuk (in Bell and Kallman, 1976) that the fresh water from the Kitimat River fans out over the entire inlet with no apparent jet stream. Therefore, the watercolumn profiles obtained in this survey may be assumed to be indicative of conditions throughout the inlet to the down inlet extent of the sampling.

The temperatures obtained in the surface waters were of the order of 12°C. A thermocline was apparent at approximately the 5 meter depth below which the temperature dropped more slowly from approximately 8.0°C at 10 metres to 6.6°C in the bottom water.

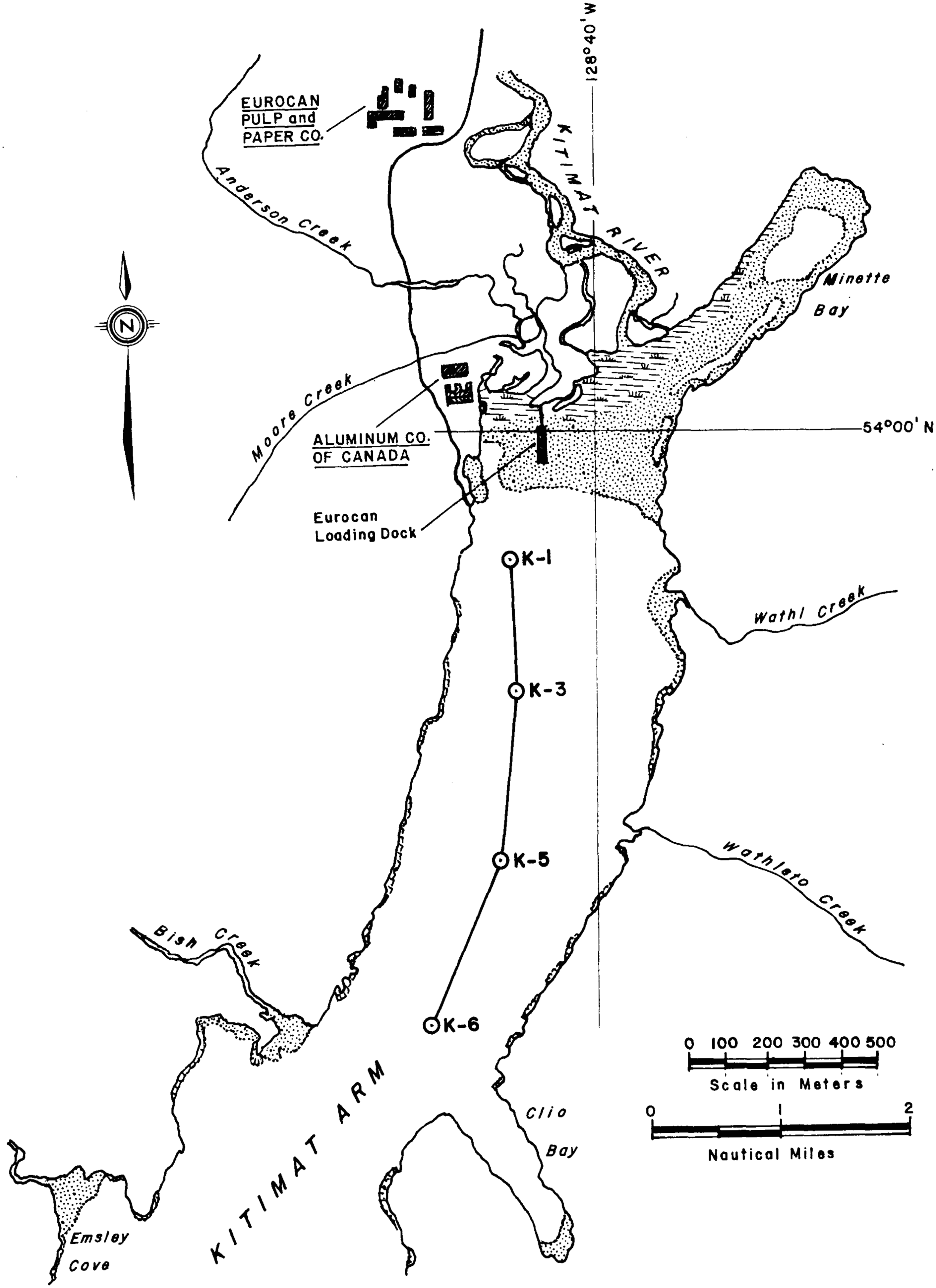

FIGURE 6 SALINITY - TEMPERATURE - DISSOLVED OXYGEN
PROFILE TRACK - JUNE 25, 1975

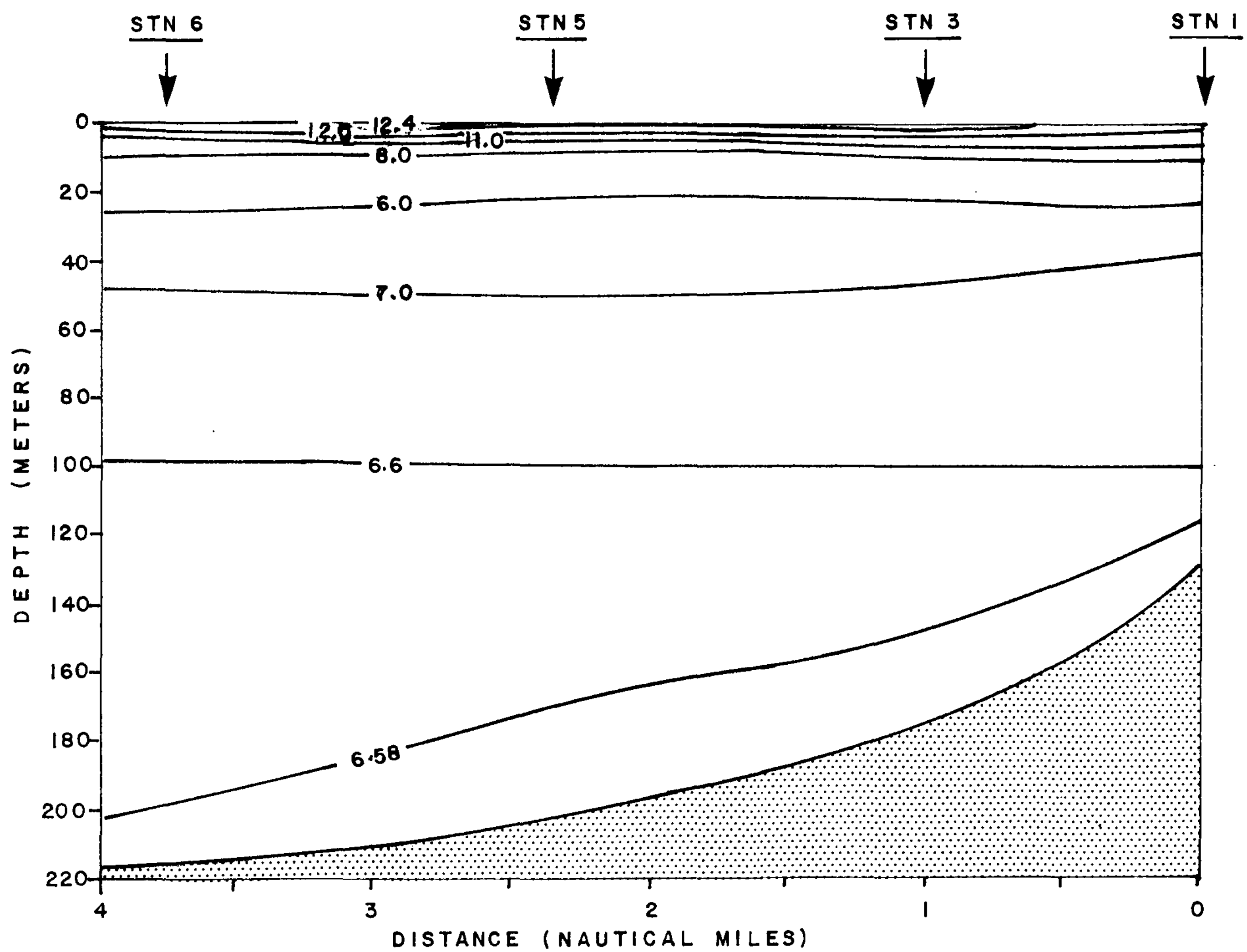

FIGURE 7 KITIMAT ARM - TEMPERATURE (°C) - June 25, 1975

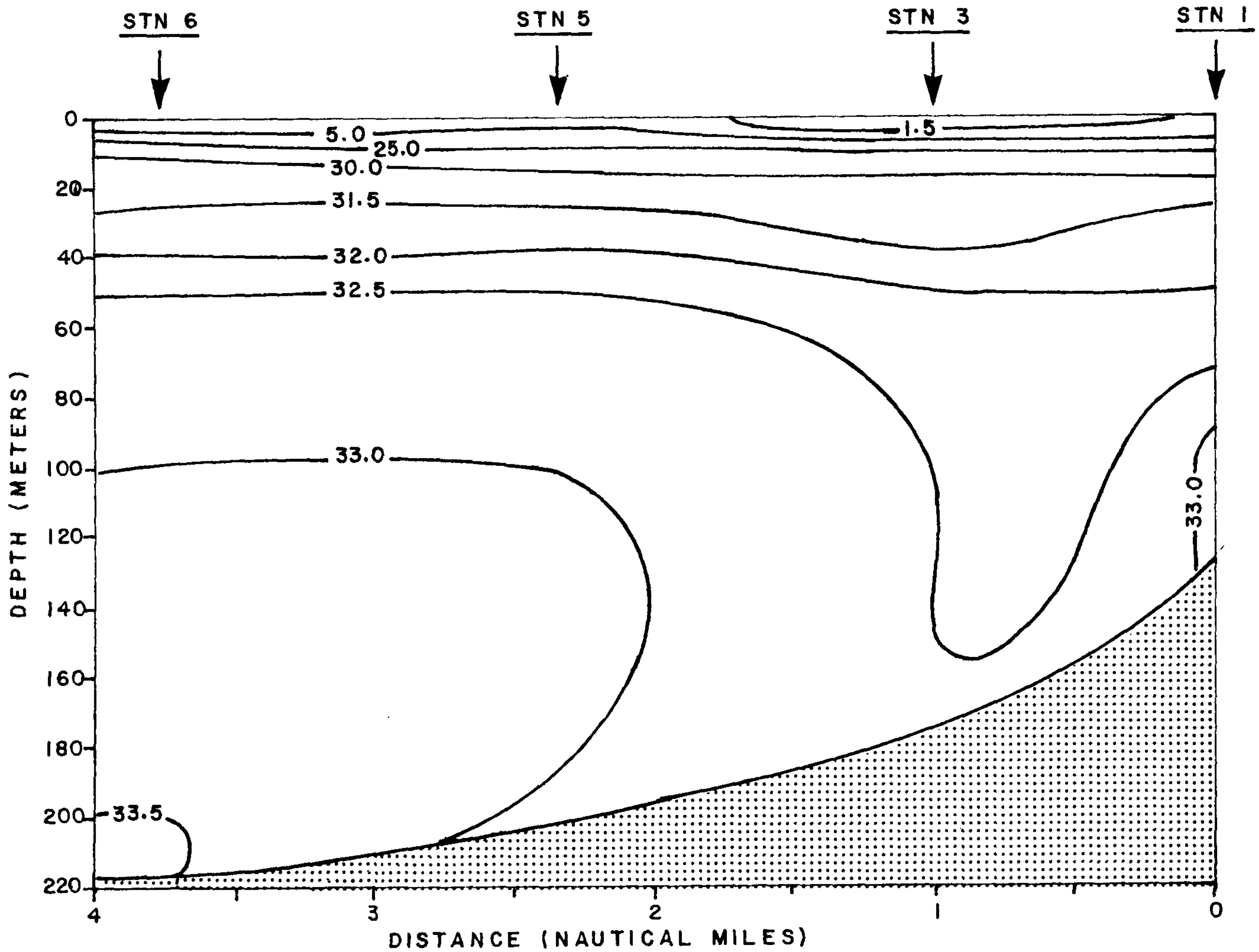

FIGURE 8 KITIMAT ARM - SALINITY (‰) - June 25, 1975

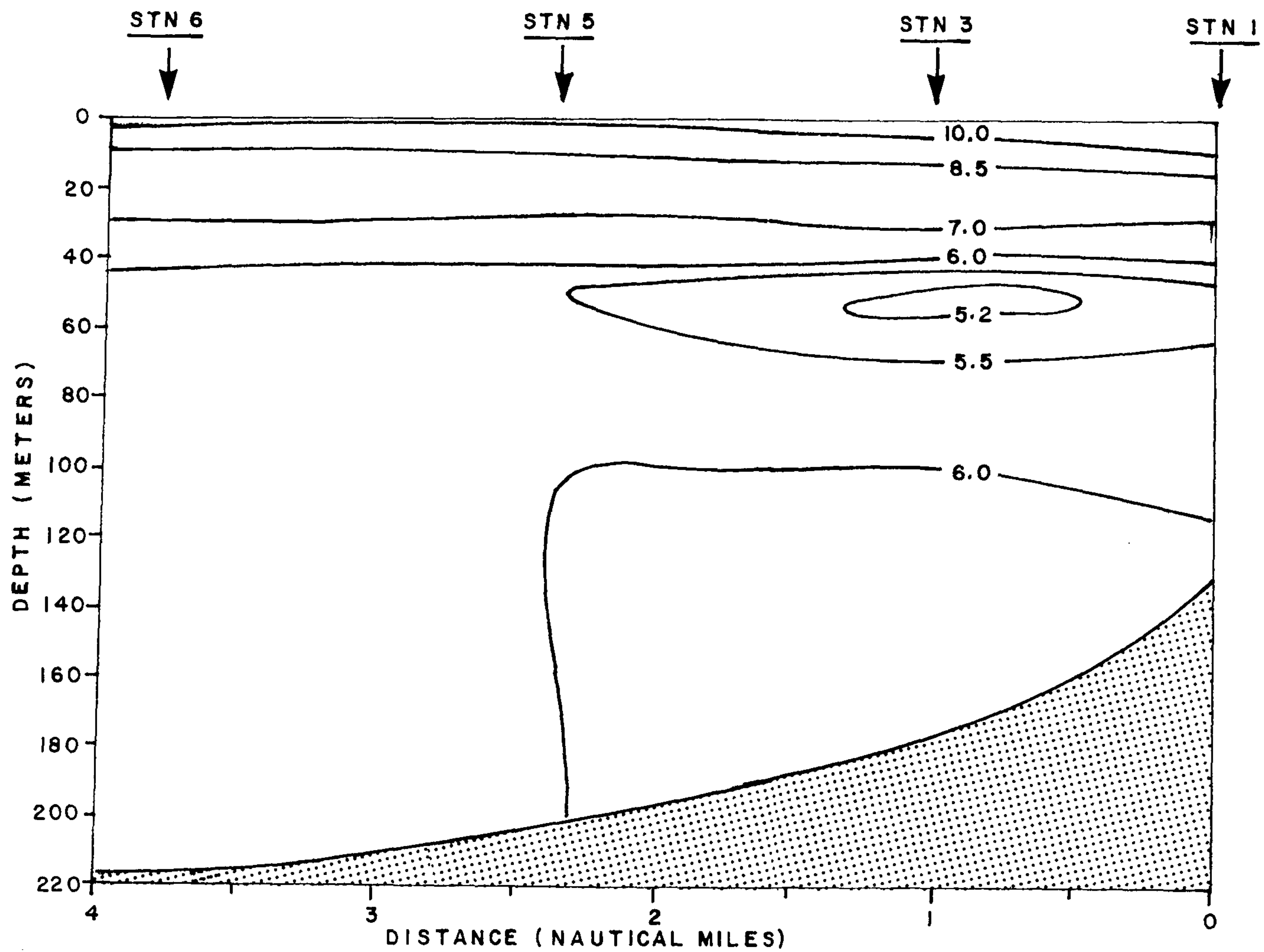

FIGURE 9 KITIMAT ARM - DISSOLVED OXYGEN (mg/ℓ) - June 25, 1975

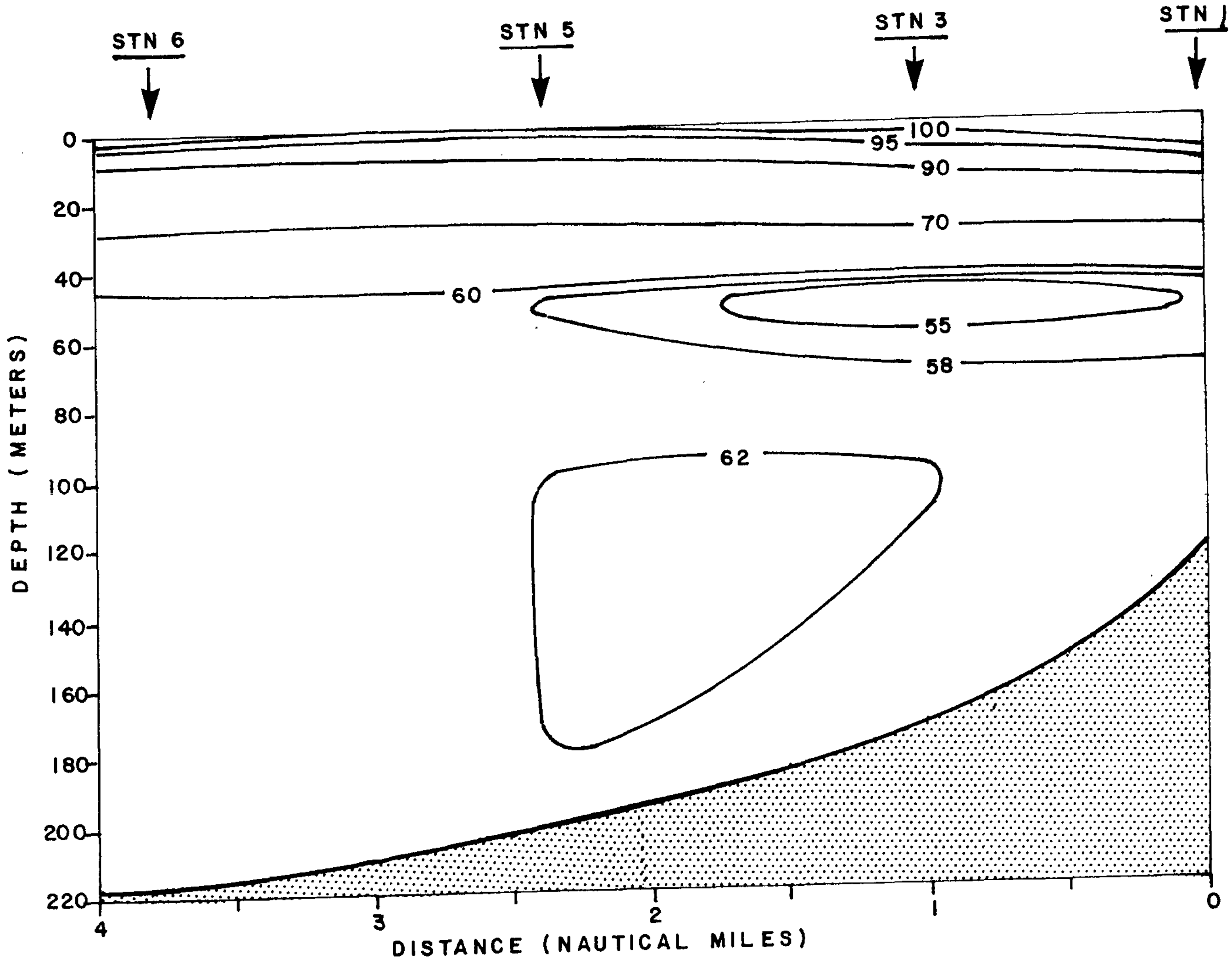

FIGURE 10 KITIMAT ARM OXYGEN SATURATION (%) - June 25, 1975

A halocline was apparent at approximately the same depth as the thermocline. Surface salinities were quite low (1.5 $^{o}/oo$ at K-3) in the vicinity of the Kitimat River. At approximately 10 metres the salinity was 10.0 $^{o}/oo$ and below this salinity increased slowly to 33.5$^{o}/oo$. in the bottom water at Station K-6. The high salinities in the bottom water are a reflection of the Pacific Ocean origin of that water.

Dissolved oxygen concentrations were high, with the lowest value obtained being 5.1 mg/l at a depth of 50 m at Station K-3. Waldichuk (in Bell and Kallman, 1976) has stated that due to entrainment of bottom water by fresh water input from the Kitimat River and good tidal flushing made possible by the absence of a sill at the mouth of the inlet, the deep water in Kitimat Arm should be replaced regularly. The high dissolved oxygen values obtained are a reflection of that assumption.

3.2 Trace Metal Analysis (Watercolumn)

The results obtained from the analysis of the water samples collected for trace metals are contained in Appendix II. As may be seen from examination of this table, both lead and cadmium were at concentrations below the detection levels of the instruments and methods available at the Environmental Protection Service Laboratory. The other metals (i.e., copper, iron, and mercury) were at levels which were detectable but all were low.

The water samples were not analysed for aluminum as the methods available at the laboratory are not considered reliable by that establishment. Therefore, aluminum concentrations should be investigated when an improved method for analysis becomes available.

3.3 Benthic Survey

3.3.1 Sediment Metal Analysis. The results of the metal analyses carried out on the less than 80-mesh fraction of the sediment samples are contained in Appendix III. The values for metal concentrations in the sediments were not unusually high and no significant distribution pattern was apparent. The value obtained for aluminum at Station 1, off the alumina loading facilities, was slightly higher (82 mg/l) compared with the highest values obtained elsewhere (77 mg/l at Stations 2 and 14).

Fluoride determinations were attempted but our lack of confidence in the results obtained discouraged us from reporting them at this time.

3.3.2 Particle Size Analysis. The results of the wet sieve particle size analysis are summarized in Appendix IV. Most of the sediments in Kitimat Arm were predominantly silt (≤62.5 microns). Stations 6 and 7 on the west side of Kitimat Arm differed from this trend in being of a more sandy nature. The sediment at Station 6 was 97.0% sand (>500 microns), while at Station 7 it was 40.0% medium sand (250 to 500 microns).

3.3.3 Benthic Fauna. The results obtained from the sorting and identification of the benthic fauna collected are contained in Appendix V. It may be seen from this table that benthic organisms were sparse. Exlcuding the protozoan Globigerina sp. which was reasonably abundant at a few stations the only invertebrate group which was consistently represented was the genus Macoma. The specific representation, although low in abundance, contained the types of animals which would be expected on the type of substrate present, with polychaetes being the most numerous and diversely represented group. From the data obtained no trends in diversity of benthic populations attributable to industrial development were apparent. The low faunal representation at Stations 6 and 7 may be related to the presence of a sandy substrate in that area as indicated by the grain-size analysis (Appendix IV). This area may also be an area of intense geological flux stemming from submarine slides which would inhibit the establishment of benthic populations. However, it is difficult to draw concrete conclusions without a number of replicate samples, especially when faunal representation is so low.

3.3.4 Pisces Dives. Species lists compiled for both Pisces dives are contained in Appendix VI.

The first Pisces dive, made along the track indicated in Figure 5 at a mean depth of 180 meters, revealed a bottom highly disrupted by submarine mudslides. Initially the bottom was quite normal being reasonably flat and possessing a benthic faunal population which although not exceptionally dense was, however, uniformly distributed and apparently stable.The organisms represented here included the burrowing anemone (*Pachycerianthus* sp.) a few thin white seapens, the pink shrimp (*Pandalus borealis*), and eelpouts (Zoarcidae).

After covering a short distance, however, the plane of the sediments began to undulate in the manner of rolling hills and then became quite broken with large piles of mud and blue clay dominating (Plates 1 & 2). The disrupted topography appeared to have been the result of submarine mudslides such as the one which resulted in a tidal wave which destroyed the Northland Navigation Company dock in 1974. The sparse benthic macrofauna present (anemones, shrimp, eelpouts) in this area appeared to be randomly distributed over the rugged terrain. These conditions prevailed through the remainder of the dive on the actual bottom of the inlet.

Plate 1 Photograph showing disruption of the bottom of Kitimat Arm by submarine slides. Mound is approximately five feet in height.

Plate 2 Photograph showing the disruption of the bottom of Kitimat Arm and the underlying blue clay nature of the sediment.

The mounds and piles of mud decreased in incidence as the slope on the west side of the inlet was climbed. This slope for most of its length was comprised of mud and was quite steep (35°), and is probably a major factor contributing to the high incidence of submarine slides. Benthic fauna became more abundant as the slope was ascended and was quite abundant on a short rock face encountered on the ascent. This, therefore, explains the deceptively long species list in (Appendix VI).

The second dive aboard Pisces was conducted closer to the delta front of the Kitimat River. The bottom here was also generally rugged, apparently the result of active sedimentation and slumping processes. It also appeared as though some dumping of dredge material from various construction projects in Kitimat had occurred here. Life was sparse with the dominant forms being the pink shrimp (Pandalus borealis), eelpouts (Zoarcidae), and sole (Pleuronectidae). There was a conspicuous absence of both infaunal and epifaunal Actinarians along this track.

The observations made in these dives confirmed implications of the grab sample program, that the benthic fauna was of a low density. This is probably due to the constant state of flux which the substrate appears to be in. The fact that the sides of the inlet appear to be subject to slumping should be a consideration when plans are being formulated for future construction and industrial development. It was generally felt that the bottom of the inlet would be suitable for the disposal of dredge material as the benthic fauna is at such a low density.

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ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance of R.A.W. Hoos and W.N. Holman for their participation in the planning and completion of the field work and R.A.W. Hoos for reviewing the paper.

APPENDICES

APPENDIX I KITIMAT ARM - WATER QUALITY DATA
June 25, 1975

Station	Depth (m)	Temperature (°C)	Salinity °/oo	Dissolved Oxygen (mg/1)	% Saturation O_2
K-1	0	11.99	1.5	10.5	101
	2	11.89	2.0	10.7	103
	5	11.50	2.0	10.7	102
	10	8.43	27.5	9.3	97
	25	6.08	31.5	7.1	71
	50	7.11	32.0	5.4	56
	100	6.60	33.0	6.1	63
	125	6.56	33.0	5.9	61
K-2	0	11.58	1.5	10.5	100
	2	11.42	1.5	10.3	98
	5	12.10	5.5	10.1	100
	10	8.01	29.0	9.5	99
	25	6.08	31.0	7.5	76
	50	7.06	32.0	5.0	52
	100	6.60	32.5	6.0	62
	125	6.58	32.5	5.8	60
K-3	0	11.47	2.0	10.3	99
	2	12.30	4.5	10.2	101
	5	10.40	20.0	9.1	94
	10	7.71	30.0	8.8	92
	25	6.03	31.5	7.5	76
	50	7.07	32.5	5.1	53
	100	6.56	33.0	6.0	62
	150	6.54	33.0	5.9	61

APPENDIX I KITIMAT ARM - WATER QUALITY DATA (Continued)
June 25, 1975

Station	Depth (m)	Temperature (°C)	Salinity °/oo	Dissolved Oxygen (mg/1)	% Saturation O_2
K-4	0	10.91	2.5	10.3	98
	2	10.58	3.5	10.2	97
	5	11.74	13.0	9.5	98
	10	7.77	30.0	8.9	93
	25	6.04	31.5	7.1	72
	50	7.12	32.0	5.4	46
	100	6.64		8.4	79
K-5	0	10.57	2.0	10.1	95
	2	12.43	4.0	9.5	94
	5	11.93	12.5	9.1	94
	10	7.95	29.0	8.6	90
	25	6.08	31.5	7.1	72
	50	6.97	32.5	5.55	58
	100	6.60	33.0	6.0	62
	175	6.56	33.0	6.0	62
K-6	0	11.53	2.0	10.3	99
	2	12.91	4.5	10.1	101
	5	9.33	25.5	8.75	92
	10	7.65	30.0	8.5	88
	25	6.02	31.5	7.2	73
	50	7.09	32.5	5.7	60
	100	6.61	33.0	5.7	59
	200	6.58	33.5	5.7	59

APPENDIX II WATER COLUMN - HEAVY METAL CONCENTRATIONS

Station	Depth (meters)	Cu mg/l	Pb mg/l	Fe mg/l	Cd mg/l	Hg µg/l
1	0	0.04	<0.02	0.25	<0.01	0.4
	125	0.07	<0.02	0.05	<0.01	0.4
2	0	0.04	<0.02	0.24	<0.01	0.3
	125	0.05	<0.02	0.06	<0.01	0.3
3	0	0.01	<0.02	0.23	<0.01	0.3
	150	0.09	<0.02	0.03	<0.01	0.3
4	0	0.02	<0.02	0.25	<0.01	0.3
	150	0.02	<0.02	<0.03	<0.01	0.4
5	0	0.05	<0.02	0.25	<0.01	0.2
	175	0.05	<0.02	<0.03	<0.01	0.3
6	0	0.02	<0.02	0.23	<0.01	0.3
	200	0.05	<0.02	0.04	<0.01	0.5

APPENDIX III KITIMAT ARM - SEDIMENT DATA
June 24, 1975

Metal Analysis of the Minus 80-mesh Fractions

Station	Co µg/g	Cu µg/g	Fe %	Mn µg/g	Ni µg/g	Pb µg/g	Zn µg/g	Ag µg/g	Cd µg/g
Ditch Outfall	0.0	8.9	0.0	5.4	18.2	16.9	15.0	0.0	0.0
1	11.5	38.0	2.4	304.2	27.6	3.7	60.4	0.0	0.0
2	11.9	39.8	2.4	308.1	25.7	0.0	61.3	0.0	0.0
3	10.0	32.0	2.4	300.4	20.6	0.0	50.4	0.0	0.0
4	10.5	40.1	2.6	315.8	25.8	0.0	64.9	0.0	0.0
5	10.6	33.4	2.4	277.3	21.6	0.0	51.4	0.0	0.0
6	8.2	26.6	2.2	269.6	18.1	0.0	55.0	0.0	0.0
7	9.1	30.2	2.2	250.3	20.0	0.0	50.4	0.0	0.0
8	12.6	44.4	2.8	358.1	28.4	0.0	69.4	0.0	0.0
9	8.0	26.6	2.3	254.2	20.5	0.0	48.6	0.0	0.0
10	10.6	32.3	2.4	292.7	23.4	0.0	54.1	0.0	0.0
11	11.9	49.7	3.2	408.2	31.6	0.0	77.5	0.0	0.0
12	11.9	31.0	2.1	291.3	21.0	0.0	52.1	0.0	0.0
13	11.7	27.4	1.9	240.8	18.1	0.0	45.2	0.0	0.0
14	13.6	45.4	2.8	372.8	28.1	0.0	69.5	0.0	0.0
Means of Stations 1 - 14	10.9	35.5	2.4	303.1	23.6	3.7	57.9		

APPENDIX IV KITIMAT ARM - SEDIMENT DATA

June 24, 1975

Particle Size Analysis

Station	% Sand >0.5 mm	% Medium Sand 0.25-0.5mm	% Fine Sand 0.0625-0.25mm	% Silt <0.0625mm
1	1.2	4.2	34.5	60.1
2	0.4	0.2	16.4	83.0
3	0.6	3.5	17.2	78.7
4	0.1	0.2	16.6	83.1
5	1.8	9.4	35.0	53.8
6	97.0	0.8	1.8	0.4
7	3.7	40.0	2.0	54.3
8	1.5	0.2	11.7	86.6
9	0.6	2.5	56.0	40.9
10	0.8	1.0	35.1	63.1
11	0.1	0.2	2.2	97.5
12	0.1	0.1	24.5	75.3
13	0.3	4.1	54.0	41.6
14	0.1	0.4	3.8	95.7

APPENDIX V

Kitimat Arm - June 24th, 1975

Benthic Survey Invertebrate Inventory

			Stations 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Protozoa	Foraminifera	Globigerina	≈240	43		151	1	1	5			≈800		3	17	≈600
		unidentified foram		5		2		92	43	7	9	35			4	
Nemertea			1							2						
Annelida	Polychaeta	Oweniidae	1													
		Nephtydae	2	11		2	6			3			1		1	
		Maldanidae	2			1				2						2
		Terebellidae	2													1
		Orbiniidae	1			3				5	3				2	
		Polynoidae	1													1
		Lumbrineridae			2	2				2		4	2	1	2	3
		Opheliidae			5	1	37				9				4	2
		Paraonidae				1										
		Sternaspidae								1			1			
		Nereidae								1						
		Ampharetidae														1
		Others				6				1	5	6			1	
Mollusca	Bivalvia	*Macoma* sp.	20		5	29	35			6	14	13	2		2	22
		Nucula sp.										1				
		Nuculana sp.	3													
	Gastropoda	*Acteocina* sp.	3													
Arthropoda	Crustacea	Amphipoda				2					1	1			1	
		Cumacea														2
Echinodermata	Echinoidea	*Brisaster* sp.											2			
Total no. of organisms (excluding protozoa)			36	11	12	47	78	0	0	23	32	25	8	1	13	34
Total no. of taxa represented			11	3	3	11	4	2	2	10	6	7	5	2	9	9
Total no. organisms/m^2 (excluding protozoa)			391	120	130	511	848	0	0	250	348	272	87	11	141	370

APPENDIX VI PISCES IV DIVE SPECIES LISTS

SPECIES LIST TRACT #1

PORIFERA HEXACTINELLIDAE

CNIDARIA - ANTHOZOA - Pachycerianthus sp.

- Small Thin seapen

MOLLUSCA - CEPHALOPODA - Unidentified squid

Rossia pacifica

Octopus sp.

Bivalvia - Chlamys sp.

Gastropoda - Neptunea sp.

Fusitriton sp.

Polinices pallida

POLYCHAETA - SABELLIDAE

CRUSTACEA - Munida quadraspina

Crangonidae

Pandalus borealis

P. platyceros

P. hypsinotus

P. stenolepis

P. montagni tridens

P. borealis

Pagurus sp.

Brachyura - unidentified

ECHINODERMATA - HOLOTHUROIDEA - Parastichopus californicus

Psolus sp.

Chirodota sp.

ECHINOIDEA - Strongylocentrotus droebachiensis

BRACHIOPODA - Terebratula sp.

PISCES - Ophiodon elongatus

Lycodes sp.

Zoarcidae

Stichaeidae

Cottidae

APPENDIX VI (Continued)

SPECIES LIST TRACT #2

MOLLUSCA - GASTROPADA - Neptunea sp.

CRUSTACEA - *Pandalus borealis*

P. platyceros

P. hypsinotus

Brachyura

CHORDATA - PICSES - *Hydrolagos colliei*

Raja sp.

Zoarcidae

Gadidae

Pleuronectidae