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Sublittoral Macro-infauna of St. Croix Estuary

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St. Andrews, N.B., EOG 2XO

December 1977

Fisheries & Marine Service Manuscript Report No. 1462

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Fisheries and Marine Service
Manuscript Report 1462

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SUBLITTORAL MACRO-INFAUNA OF ST. CROIX ESTUARY

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This is the sixth Manuscript Report in this series from the Biological Station, St. Andrews, N.B.

Cat. no. Fs 97-4/1462 ISSN 0701-7618

ABSTRACT

Wildish, D. J., A. J. Wilson, and H. M. Akagi. 1977. Sublittoral macro-infauna of St. Croix estuary. Fish. Mar. Serv. MS Rep. 1462, 14 p.

Taxonomic data for seven sublittoral, benthic stations in the St. Croix estuary worked during August/September, 1974 are presented.

Species diversity is high: at least 60 species are present at the seven stations worked. Species diversity was higher in the detritus feeding communities of the seaward, fjord-like section of the system, than in the estuarine section. In the more landward, estuarine section the fauna are primarily suspension feeding.

Densities ranged from 56 to 1,208,479 individuals per m^2; wet biomasses from 0.9 to 274.4 g/m^2.

Key words: St. Croix estuarine benthos, species diversity, density, biomass

RESUME

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Les auteurs présentent les données taxonomiques qu'ils ont recueillies en sept stations benthiques et infralittorales, dans l'estuaire de la Sainte-Croix, en août et en septembre 1974.

La richesse de la faune y est considérable: au moins 60 espèces ont été recensées aux sept stations. Les détritivores étaient plus variés dans la zone en forme de fjord, en direction du large, que dans l'estuaire. Dans la partie de l'estuaire proche de la terre, c'est la faune suspensivore qui dominait.

La densité de la population a varié entre 56 et 1 208 479 organismes/m^2, et la biomasse (poids frais), entre 0,9 et 274,4 g/m^2.

INTRODUCTION

The benthic macrofauna and sediment data reported here were obtained as part of a study including a survey of chemical and physical characteristics of the St. Croix estuary (Kristmanson and Wildish, in preparation). The overall purpose of the study was to ascertain the mixing characteristics of the system as well as to determine the nature of sediments and the density and biomass of the constituent macrofauna. It is thought that such data will be of future value in the multiple-use resource management of the estuary.

Previous work on the hydrography of the St. Croix estuary is reported by Craige (1916) and Ketchum and Keen (1953). Tidal exchange ratios range from 0.905 to 0.300 and there is a retention time of fresh water in the estuary of 8 days. The large freshwater flow from the St. Croix River induces a general counter-clockwise circulation within Passamaquoddy Bay (Ketchum and Keen 1953). No previous work on sublittoral benthic ecology is available. A recent investigation of heavy metals in water, biota, and sediment indicates elevated levels in some compartments (Fink et al. 1977) of the St. Croix River and estuary.

MATERIALS AND METHODS

Designated sampling stations in the St. Croix estuary are shown in Table 1. Time constraints allowed only ten of these stations to be worked, of which three proved to be unsuitable for sampling with the Smith-McIntyre grab.

The limits of the system considered are from a line joining Joe's Point and Liberty Point as the seaward limit (Fig. 1) and at the falls 200 m above the International Bridge joining Calais, U.S.A., and St. Stephen, Canada. Coordinates for the stations were taken from the U.S. Dept. of Commerce, N.O.A.A., chart "Calais to W. Quoddy Head". The marine end of the ecosystem which is fjord-like, except only 35-m maximum depth, extends from the seaward limit to a line from Todd's Point to Devil's Head. The estuary proper extends 11,613 m at the centre-channel line from this point to the estuarine limit and compares with an estimated distance of 11,887 m for the fjord section.

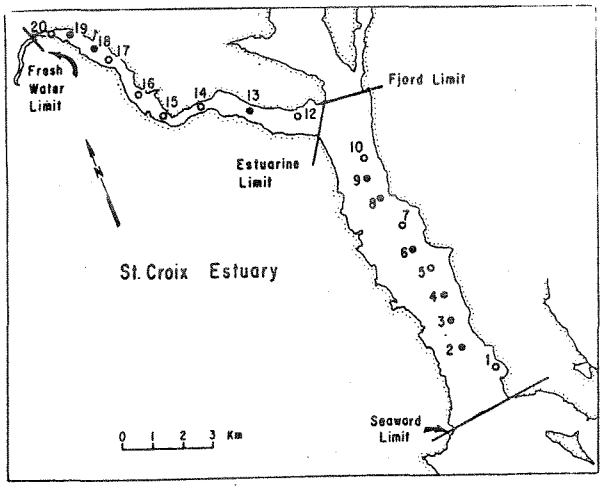

Fig. 1. Map showing topography and sampling stations in the St. Croix estuary. The open circles indicate stations sampled for macro-benthos in 1974.

MACROFAUNAL SAMPLING

Samples were taken with a 0.1 m^2 Smith-McIntyre grab having a 16-cm effective digging depth. Sampling dates were:

August 27, 1974 for stations 20, 17, 16, 15, and 14
August 28, 1974 for stations 10, 12
September 9, 1974 for stations 7, 5, and 1.

Attempts were made to obtain 10 replicates at each station. However, at stations 15 and 16 adequate samples could not be taken because the bottom was covered with wood chips of sizes >2 mm which precluded quantitative sampling. In addition, satisfactory quantitative samples could not be taken at station 7 because the substrate was hard.

Individual samples were passed through a series of sieves (5.0, 2.5, and 1.0 mm^2) with a jet of sea water and the sieve contents collected on a black plastic garbage bag. The samples were further sorted in the laboratory, involving removal of inorganic material, and a preliminary taxonomic diagnosis made by untrained personnel (rapid sort method). All animals were then placed in 5% formalin in sea water and sent to the Canadian Oceanographic Identification Centre, Ottawa, for taxonomic diagnosis and wet weighing. The data are given in C.O.I.C. Rep. No. 131, Reference 0408. Species (S), numbers of individuals (N), and wet weight biomass, inclusive of shell (B) were determined.

SEDIMENT SAMPLING

Sediment subsamples (200-500 g) were taken from two of the grabs in each of the replicate series at each station. Sorting characteristics and organic carbon content were determined as previously (Akagi and Wildish 1975).

RESULTS

TAXONOMY

A complete list of the species identified during this work is shown in Table 2.

Comparison of the rapid sort data (see Appendix 1) with that of C.O.I.C. for the same samples (Appendix 2) indicates that the former method is unsatisfactory for determining the correct number of species which are generally underestimated. Numbers of individuals, however, are correctly estimated except at station 14 where the discrepancy is explained by the large number of very small mussels included by C.O.I.C.

Further analysis is based on the S times N matrix of Appendix 2 or S times B matrix of Appendix 3.

ECOLOGICAL ANALYSIS

Dominant species (Table 3) may be arranged in two groups corresponding to the estuarine and fjord-like sections of the system. In the estuarine section a primarily suspension-feeding association dominated by *Mytilus* is present; in the fjord-like section the macrofauna dominants are primarily surface deposit feeders or detritus swallowers. Station 10 is an intermediate station with significant biomasses of suspension feeders (e.g. *Mytilus* and *Mya*) as well as detritus swallowers (*Yoldia* and *Nepthys*).

A total of 47 identified species (Table 1) were found for the seven stations (70 replicates). In addition, 13 other taxa identified only to genus or higher group, which were certainly members of different species, were found. Six taxa (see Table 1, Temporary numbers 2, 4, 7, 11, 20, and 21), treated in this analysis as new species, were doubtful as such. They were identified only to genus or higher taxa because of damage, etc., yet the list contained one or more species of the same taxa.

Species diversity calculated as the α value of Fisher et al. (1943) and twice its standard error (Table 4) indicates a decline in diversity in the estuarine section of the system from station 12 landwards to station 20. The species equilibrium number, S_{max}, calculated from the S versus S/N filtering for all replicate samples at each station also shows this trend. The maximum S_{max} value of 55 species is found in the fjord-like section of the St. Croix at station 5.

The density and biomass (Table 5) are low only at stations 12 and 20. The very high number of individuals at station 14 is mainly composed of large numbers of newly settled mussels.

SEDIMENTS

The proportion of three major size fractions in dried sediment is shown in Table 6. The most landward stations (20 to 17) are predominantly hard: rocks grading to sand at station 17. At station 16 and 15 large beds of coarse wood particles (>2 mm) and fibres are present. There is a sorting gradient of wood particles from 15 to 12 with the particle size becoming progressively smaller (Table 7). Smaller particles are also found high on the shore at station 15. This observation is supported by tidal current measurements here (Kristmanson and Wildish, in preparation).

Station 12 has a predominantly silt/clay sediment which is relatively well sorted (Table 7) and has a prominent sulphide layer near the surface. Station 10 is quite similar, but lacks the sulphide layer to within a few cm of the surface. At station 7 the bottom is stoney and shallower due to outcropping rock ledges. All the stations seaward of this with soft bottoms consist of mixtures of >2 mm particles, sand, and silt/clay, the latter of which is poorly sorted. They are in relatively deep water (≈30 m at low water).

DISCUSSION

The most notable feature of this work is the obvious evidence of past industrial activity in the form of wood particles from saw mills in the sediments, the sorting action of the tidal currents on these particles, particularly where they pass through the "Narrows" near station 15, and the development of a specialized fauna consisting of *Gammarus oceanicus* and *Balanus* sp. which live in association with the wood particles.

Fishery statistics (Perley 1852; Anon. 1924; Kendall 1935; and Murchie 1947) indicate that the St. Croix was, prior to 1825, a productive Atlantic salmon river, although in 1977 no migratory run was present. Tentative plans have been made to reinstate a migratory salmon run in the St. Croix, one requirement for which is a clean, well oxygenated estuary. Dissolved oxygen levels in the St. Croix estuary (Kristmanson and Wildish, in preparation) are adequate to allow salmonid migration, but levels are lowest in the most landward few kilometres (stations 17 to 20). The benthic data presented here also support the view that environmental quality in the estuary is poorest just below the twin towns of St. Stephen and Calais. Obviously effluents entering here would need to be strictly controlled to maintain adequate water quality for salmon migration.

The benthic data presented here also provide a baseline against which future man-made changes, both negative and positive, can be assessed.

ACKNOWLEDGMENTS

We thank Captain and crew of the *PANDALUS II* for help in sampling and Brenda McCullough for typing the manuscript. D. W. McLeese, R. Peterson, B. T. Hargrave and D. Peer critically read the manuscript.

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Table 1. List of stations in the St. Croix estuary showing Milne estuarine penetration fraction (distance from mouth divided by total distance) calculated for the single system and the fjord and estuarine sections separately.

Station	Coordinates	Distance (m)	Estuarine penetration fraction	
			Single	Double system
1	45°05.0'N 67°06.0'W	1331	.06	.12 FJORD
2	45°05.2'N 67°06.2'W	2163	.10	.20
3	45°06.0'N 67°06.4'W	2996	.14	.28
4	45°06.4'N 67°06.6'W	3827	.18	.36
5	45°07.0'N 67°07.0'W	4860	.22	.44
6	45°07.4'N 67°07.4'W	5492	.26	.52
7	45°07.8'N 67°07.7'W	6241	.29	.58
8	45°08.3'N 67°08.2'W	7323	.34	.68
9	45°08.7'N 67°08.7'W	8155	.38	.76
10	45°09.0'N 67°09.3'W	8903	.42	.84
11	45°10.2'N 67°09.0'W	10817	.46	.92
12	45°09.9'N 67°10.3'W	11483	.54	.08 ESTUARY
13	45°10.0'N 67°11.7'W	13148	.62	.22
14	45°10.1'N 67°12.9'W	14811	.69	.38
15	45°09.9'N 67°13.8'W	16226	.76	.52
16	45°10.3'N 67°14.6'W	17474	.82	.64
17	45°10.9'N 67°15.3'W	19055	.89	.78
18	45°11.2'N 67°15.6'W	19638	.92	.84
19	45°11.4'N 67°16.1'W	20387	.95	.90
20	45°11.5'N 67°16.6'W	20885	.98	.96
			1.00	1.00 FALLS

Table 2. Species list for 7 stations in St. Croix estuary.

018 *Lunatia pallida* (Broderip & Sowerby, 1829)
027 *Cylichna alba* (Brown, 1827)
031 *Nucella lapillus* (L. 1758)
100 *Nucula proxima* Say, 1822
103 *Yoldia sapotilla* (Gould, 1841)
104 *Mytilus edulis* Linne, 1758
106 *Musculus niger* (Gray, 1824)
108 *Crenella glandula* (Totten, 1834)
111 *Astarte undata* Gould, 1841
112 *Astarte crenata subaequilatera* Sowerby, 1854
113 *Artica islandica* (Linne, 1767)
114 *Cyclocardia borealis* (Conrad, 1831)
115 *Thyasira flexuosa* (Montagu, 1803)
116 *Cerastoderma pinnulatum* (Conrad, 1831)
117 *Macoma balthica* (L., 1758)
118 *Mya arenaria* Linne, 1758
120 *Lyonsia hyalina* Conrad, 1831
123 *Musculus discors* var. *laevigata* Gray, 1824
203 *Nephtys incisa* Malmgren, 1865
212 *Ophioglycera gigantea* Verrill, 1855
215 *Nephtys* sp.
218 *Aphrodita hastata* Moore, 1905
222 *Nereis diversicolor* O. F. Muller, 1771
223 *Nereis* sp.*
262 *Eteone longa* (Fabricius, 1780)
265 *Eteone* sp.*
269 *Goniada maculata* Oersted, 1843
274 *Praxillella praetermissa* (Malmgren, 1866)
281 *Ninoe nigripes* Verrill, 1873
282 *Lumbrineris fragilis* (O. F. Muller, 1776)
287 *Maldane sarsi* Malmgren, 1865
347 *Pista maculata* (Dalyell, 1853)
351 *Pherusa affinis* (Leidy, 1855)
356 *Chone infundibuliformis* (Kroyer, 1856)
357 *Sternaspis scutata* (Renier, 1807)
359 *Brada granosa* Stimpson, 1854
430 *Balanus crenatus* Bruguiere 1789
451 *Crangon septemspinosa* Say, 1818
503 *Unciola irrorata* Say, 1818
504 *Gammarus oceanicus* Sergestrale 1947
505 *Casco bigelowi* (Blake 1929)
508 *Leptocheirus pinguis* (Stimpson, 1853)
514 *Gammarus lawrencianus* Bousfield, 1956
515 *Ampelisca macrocephala* Lilljeborg, 1852
581 *Diastylis quadrispinosa* Sars, 1871
801 *Phascolion strombi* (Montagu, 1804)

Temporary Numbers

1 *Periploma* sp.
2 Maldanidae
3 *Praxillella* sp.
4 Ampharetidae
5 *Colus* sp.
6 *Drilonereis* sp.
7 Owenidae
8 *Thracia septentrionalis*
9 Nemeretea
10 *Mysis* sp.
11 Polychaeta
12 *Chaetoderma* sp.
13 *Rhodine* sp.
14 *Ampharete* sp.
15 *Oenopota* sp.
16 *Bostrichobranchus pilularis*
17 *Oenopota bicarinata*
18 *Harmothoe* sp.
20 *Gammarus* sp.
21 Polynoidae

*In MS No. 1398 these numbers are suppressed. Three-digit numbers in Table 2 can be used to indicate taxonomic grouping by reference to Tech. Rep. No. 450.

Table 3. Species dominance estimates based on ten samples of 0.1 m^2 per station. Numbers refer to species as in Table 2.

Station	$N/m^2 > 5$	$B/m^2 > 1.0$ g
1	114, 115,103,103,282,281	114,113,282,103,1
5	115,103,503,13,112,269,282,111,215,114,281	113,112,114,111,212,103
10	114,104,118,103,215,274	114,118,104,212,103,215
12	17,15,027	-
14	104,504,430,20	104,018,430
17	104,118,117,223	118,104,117,114,223
20	223,117	-

Table 4. Species diversity data in St. Croix estuary.

Station	S/m^2	$\alpha \pm$ % S.E.		S_{max}
1	28	9.5	12	42
5	33	13.0	14	55
10	24	7.5	12	33
12	17	8.0	22	34
14	12	-	-	-
17	14	2.5	12	19
20	3	1.0	40	-

Table 5. Density (N/m^2) and wet biomass (g/m^2) of macrofauna in the St. Croix estuary based on 10 replicates per station.

Station	Density (N/m^2)	Biomass (g/m^2)
1	207	218.20
5	137	64.75
10	200	197.77
12	56	3.06
14	1,208,479	220.40
17	682	274.40
20	17	0.91

Table 6. Percentage of size fractions in sublittoral sediments from the St. Croix estuary. Numbers in brackets refer to the grab subsampled for sediment analysis.

Station	%>2 mm	% sand	% silt/clay
1(1)	22.5	36.7	40.8
1(10)	22.5	30.3	47.2
5(1)	13.6	35.6	50.8
7(1)	20.1	72.3	7.6
7(10)	15.2	57.3	27.5
10(1)	2.7	10.6	86.7
10(10)	1.6	17.1	81.3
12(2)	0.2	6.9	92.9
12(4)	0.8	9.0	90.2
14(6)	30.2	25.2	44.6
14(10)	3.8	8.5	85.7
15	28.7(wood particles)	61.3	0
16			
16	Wood particles		
17(1)	6.7	56.8	36.5
17(10)	12.8	70.8	16.4
20(2)	73.6	16.6	9.8
20(10)	78.4	15.9	5.7

Table 7. Sorting characteristics and organic carbon content of St. Croix estuary sediments.

Station	MdØ	QDØ	SkqØ	Organic carbon, dry weight basis % Walkley Black	Organic carbon, dry weight basis % volatile solids
1(1)	5.80	3.16	-0.46	2.76	7.30
1(10)	6.20	2.86	-0.58	3.27	6.25
5(1)	6.75	3.02	-1.12	2.55	6.44
7(1)	1.95	1.18	-0.11	0.54	2.32
7(10)	2.75	2.79	+1.33	0.53	5.23
10(1)	8.40	1.12	-0.69	3.79	10.37
10(10)	7.40	2.01	-0.26	2.03	5.92
12(2)	7.60	1.28	-0.25	4.95	14.15
12(4)	7.50	1.81	-0.24	2.47	14.08
14(6)	6.80	2.52	-0.77	26.52	56.04
14(10)	7.40	1.21	-0.16	2.98	8.23
15	(-0.80)	Wood particles			
16					
16		Wood particles			
17(1)	2.23	3.08	+1.59	3.42	6.97
17(10)	1.17	1.06	+0.53	1.03	3.96
20(2)	2.00	2.97	+1.39	1.82	8.38
20(10)	0.90	2.63	+1.80	2.13	7.47

Appendix 1. Comparison of rapid sort and COIC identification methods.

Station	Rapid sort S	Rapid sort N	COIC S	COIC N	Station	Rapid sort S	Rapid sort N	COIC S	COIC N
1	7	28	7	22	14	2	11	2	10
	9	48	9	38		5	1,252	4	1,205,221
	11	91	18	67		5	1,284	5	1,205,255
	13	113	20	87		6	1,375	7	1,205,353
	13	137	20	103		7	2,002	7	1,205,965
	13	164	24	123		9	3,000	10	1,206,923
	13	179	25	137		9	3,127	10	1,207,160
	14	206	27	168		10	3,697	10	1,207,778
	15	246	27	192		11	3,783	10	1,208,180
	15	261	28	207		11	4,066	12	1,208,479
5	6	12	5	9	17	4	116	6	118
	11	41	15	30		4	165	6	168
	12	64	19	44		7	183	12	184
	12	102	22	63		7	192	12	193
	13	120	25	79		8	401	12	408
	15	138	27	89		8	445	13	452
	15	158	29	99		8	474	14	483
	16	181	32	116		8	527	14	537
	16	197	33	133		8	580	14	586
	16	202	33	137		9	684	14	682
10	7	22	7	20	20	1	1	1	1
	9	39	11	35		4	6	2	5
	11	49	12	52		5	9	2	8
	12	65	14	69		5	12	2	11
	12	85	17	90		5	13	3	12
	12	99	18	104		5	14	3	13
	13	178	21	179		5	14	3	13
	14	188	22	187		5	14	3	13
	15	201	23	198		5	16	3	15
	15	203	24	200		5	18	3	17
12	3	8	5	9					
	3	11	6	12					
	5	16	8	17					
	6	22	10	23					
	7	30	12	29					
	7	34	13	33					
	9	41	14	39					
	10	47	16	44					
	10	57	17	54					
	10	60	17	56					

Appendix 2. S x N matrix for stations in St. Croix estuary Aug.-Sept. 1974.

Station 1

S	1	2	3	4	5	6	7	8	9	10
018		1								
100	1									
103	5	2	3	1		1	1	1	3	1
108	4	2		1		2	1	3	3	
111			1							
112							1			
113				1						
114	2	9	6	7	11	4	11	15	9	12
115	8	1	4	4	1	6		8	5	
123	1									
215				1				1		
281			4	1		1			1	
282	1		4	2	2	1		1	1	
347			1							
357								1		
505			1	1						
515			1							
801										1
1		1		1					1	1
2			1		1	1			1	
3			1							
4			1		1					
5			1							
6						1				
7						1				
8						1				
9						1				
10								1		

Station 5

018					1					
103	4	2			1	2	1	2	1	
106		1				1				
108			1	1			1			
111	1		1	1	1		2		1	
112		3		2	1			2	1	1
113								1		
114		1	1						3	
115				8				5	1	
116	2			1				1		
212		1								
215		1	2	1				1	1	
218						1				
223			1							
269		6		1				1	1	
281			2		1			1		1
282	1	1			2	1			3	
287								1		
351		1				1				
356					1	2	1			
357							1			
359									2	
503		1	3		6		1			
508						1				
581				1						
1			1							
2	1	1	1	1						
4					1			1		
11		1								
12		1	1							
13				2	1	1	2		3	2
14							1			
15								1		

Appendix 2 (cont'd)

S	1	2	3	4	5	6	7	8	9	10
Station 10										
018	1									
103	4	3	4			3		1	4	
104							39			
108									1	
112				1						
114	11	6	12	11	9	7		6	4	1
115		2		1		1				
118							35			
203										1
212						1			1	
215		2		2	4	2			1	
223							1			
274		1			5					
282			1							
357	1									
359	1									
505					1					
508	1									
801	1									
2				1						
4					1					
12		1		1						
13								1		
16					1					
Station 12										
027				1		1	2	1		
100							1			
103								1		
106				1				1		
118									1	
120					1	1	1			
215		1			2				1	
223			1							
274									1	
281	2		1							1
282							1			
508			1							
801						1				
9	1									
11	1					1				
15	2	2			1	1	1			4	1
17	3		2		1	2		2		4	1
Station 14										
018					1		2			
031							1			
104	3	1,205,212	31		94	604	949	230	586	396	294
118											2
223											1
265			1								
430		1	1					3	22	4	1
451							3				1
504	7	7	1		2	8	2		10	2	
514							1				
18		1									
20					1			4			

Appendix 2 (cont'd)

°S	1	2	3	4	5	6	7	8	9	10
Station 17										
103			4							
104	19	31		2	148	5	1	20	22	53
108			1							
114			5							
117	29	5			15	5	6	7	6	4
118	66	14		7	50	33	23	27	20	38
223	2				2				1	1
262	1									
282			3							
4			1							
11							1			
12			2							
20						1				
21	1									
Station 20										
117	1	2				1				2
222					1					
223		2	3	3					2	

Appendix 3. S x Biomass for stations in St. Croix estuary Aug.-Sept. 1974.

S	1	2	3	4	5	6	7	8	9	10
Station 1										
018		0.38								
100	0.02									
103	0.85	0.40	0.37	0.04		0.18	0.16	0.09	0.26	0.10
108	0.16	0.20		0.14		0.05	0.06	0.14	0.17	
111			0.19							
112							0.05			
113				35.38						
114	3.18	16.85	12.67	12.38	20.51	7.96	21.07	25.96	22.30	28.84
115	0.08	0.01	0.06	0.10	0.02	0.02		0.14	0.07	
123	0.37									
215				0.37				0.11		
281			0.06	0.02		0.06				
282	0.02		0.48	1.37	1.35	0.14		0.01	0.17	
347			0							
357								0.01		
505			0.03	0.01						
515			0.02							
801										0
1		0.05		0.12					0.06	1.09
2			0.16		0.06	0			0.01	
3			0							
4			0.01		0					
5			0.30							
6						0.01				
7						0				
8						0.07				
9						0.02				
10								0.03		
Station 5										
018					0.39					
103	0.31	0.19			0.10	0.17	0.12	0.19	0.08	
106		0.21				0.26				
108			0.10	0.05			0.21			
111	3.40		2.57	0.15	0.15		0.14		0.08	
112		8.06		4.60	0.07			0.26	0.04	0.03
113								25.24		
114		2.53	2.57						6.53	
115				0.08				0.06	0.01	
116	0.05			0.02				0.02		
212		1.48								
215		0.01	0.14	0.15				0.33	0.19	
218						0.30				
223		0								
269		0.14		0.01	0.02			0.05		
281			0		0			0.01		0

Appendix 3 (cont'd)

S	1	2	3	4	5	6	7	8	9	10
282	0.06	0.23			0.18	0.14			0.01	
287								0.01		
351		0.03				0.04				
356					0.02	0.10	0.10			
357							0.10			
359									0.28	
503		0.01	0.06		0.12		0.02			
505			0.04	0.06			0.04			
508						0.05				
581				0.01						
1			0.31							
2	0.03	0.15	0.07	0						
4					0.01			0.01		
11		0.01								
12		0.02	0.02							
13				0.12	0.01	0	0.18		0.05	0.06
14							0.01			
15								0.11		
Station 10										
018	0.22									
103	0.45	0.35	0.67			0.31		0.14	0.50	
104							8.98			
108									0.20	
112				0.13						
114	22.09	13.39	25.53	25.44	19.75	10.93		15.16	9.93	2.44
115		0.02		0.01		0.01				
118							30.55			
203										0.48
212						4.06			3.58	
215		0.67		0.25	0.71	0.15			0.04	
223							0.29			
274		0.01			0.05					
282			0.55							
357	0.01									
359	0.12									
505					0.01					
508	0.04									
801	0.01									
2										
4				0.01	0.01					
12		0.11		0.02						
13								0.04		
16					0.05					
Station 12										
027				0.02		0.03	0.05	0.03		
100							0.05			
103								0.02		
106				0.06				0.20		

Appendix 3 (cont'd)

S	1	2	3	4	5	6	7	8	9	10
118									0.05	
120					0.02	0.02	0.02			
215		0.09		0.37				0.16		
223			0.66							
274								0.05		
281	0.02		0.01						0.01	
282						0.05				
508			0.04							
801					0.02					
9	0									
11	0				0.04					
15	0.07	0.06		0.04	0.03	0.04			0.15	0.04
17	0.09		0.11	0.02	0.03		0.10		0.16	0.02
Station 14										
018				0.15		4.39				
031						0.44				
104	0.11		3.50	8.17	56.50	16.30	11.79	49.20	28.80	36.30
118										0.21
223										0.05
265			0.01							
430		0.10	0				0.16	2.58	0.02	0
451						0.16				0.73
504	0.11	0.09	0.01	0.01	0.11	0.01		0.11	0.01	
514						0				
18		0.03								
20				0			0.04			
Station 17										
103			0.42							
104	4.43	9.38		0.21	29.50	1.11	0.06	3.89	6.26	8.74
108			0.12							
114			10.69							
117	5.79	1.36			2.64	0.72	1.79	0.60	0.73	0.46
118	72.20	7.11		1.42	26.40	1 .50	15.70	12.40	13.90	19.50
223	0.05				0.42				0.03	1.14
262	0.07									
282			0.58							
4			0.01							
11							0			
12			0.06							
20						0				
21	0.01									
Station 20										
117	0.08	0.15				0.04				0.18
222					0.22					
223		0.05	0.05	0.10					0.04	