SECTION B

DISTRIBUTION AND ABUNDANCE OF JUVENILE SALMONIDS IN THE MORICE AND BULKLEY RIVERS DURING LATE OCTOBER/EARLY NOVEMBER 1981

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1.0 INTRODUCTION

This study was conducted during late October - early November 1981 to supplement data collected in 1979 describing the abundance and relative distribution of juvenile salmonids in the Morice/Bulkley Rivers. Emphasis was placed on sampling side channel habitat in Reach 2 and main channel sites in Reaches 1 through 6.

Earlier studies of the distribution and abundance of juvenile salmonids in the Morice River during 1979 identified Reach 2 as important rearing habitat for juvenile salmonids prior to overwintering (Section A). During 1979, coho salmon juveniles showed a strong year-round preference for side channels offering low velocities and instream cover such as debris and vegetation. Chinook salmon juveniles were distributed throughout main and side channel habitats by the fall and early winter of 1979. Steelhead trout fry and parr showed similar utilization of side and main channel locations, suggesting a widespread distribution in the various channel types throughout the year. More recent studies (1981-1982) have indicated that low winter flows play a significant role in limiting production of juvenile salmonids in side channel habitats of the upper Morice River (Section C). Since a high percentage of adult steelhead trout and coho and chinook salmon returning to the Morice River overwinter in freshwater as juveniles (Whately et al. 1978; Shepherd 1979), an understanding of the year to year variations in relative distribution of juvenile salmonids utilizing main and side channel habitats is important to assess the potential effects of the proposed Kemano Completion flow regime on juvenile salmonid rearing within the system (Volume 19).

2.0 METHODS

Totals of 13 main channel and 6 large side channel sites in the Morice/Bulkley Rivers from Morice Lake to Smithers (Reaches 1 to 6) were sampled during late October/early November 1981 (Figure 2.1). In addition, 4 small side channels in Reach 2 were sampled in a concurrent study (Section C) and the results of that study are included here.

Smith-Root Type VII electrofishers were used to sample fish abundance at each site and population sizes were estimated using the multiple pass removal method (DeLury 1951). To minimize fish movement out of the sampling area and to determine the area sampled, a 30m x 2.5m beach seine with 6mm mesh was attached to steel rods and positioned in a semi-circle from the shore. In small side channels, stop nets at each end of the sampling site prevented fish from moving out of the area. All fish captured were enumerated by species and life stage and fork length was measured to the nearest millimeter. Habitat characteristics including type (riffle, pool, run, flat, back eddy), and area (m^2) of hydraulic unit sampled, type and abundance of cover, substrate composition, and water temperature were recorded at each sampling site.

Main channel and large side channel population estimates were doubled at each site to account for both shoreline margins and expressed as fish per length of stream margin. Population estimates from small side channels were not doubled since it was assumed fish populations could utilize the entire width of the channel. Since extensive sampling of fish populations in side channel habitats was restricted to Reach 2 in this study, population estimates in side channels of other reaches were calculated based on main:side channel catch ratios from those reaches in September 1979 (Section A). For example, if coho salmon juveniles in Reach 3 had a main channel to side channel catch ratio of 1:3 in 1979, then the Reach 3 main channel catch from this study was multiplied by 3 to give the side channel coho population estimate. This extrapolation is a rough estimate and should be considered accordingly.

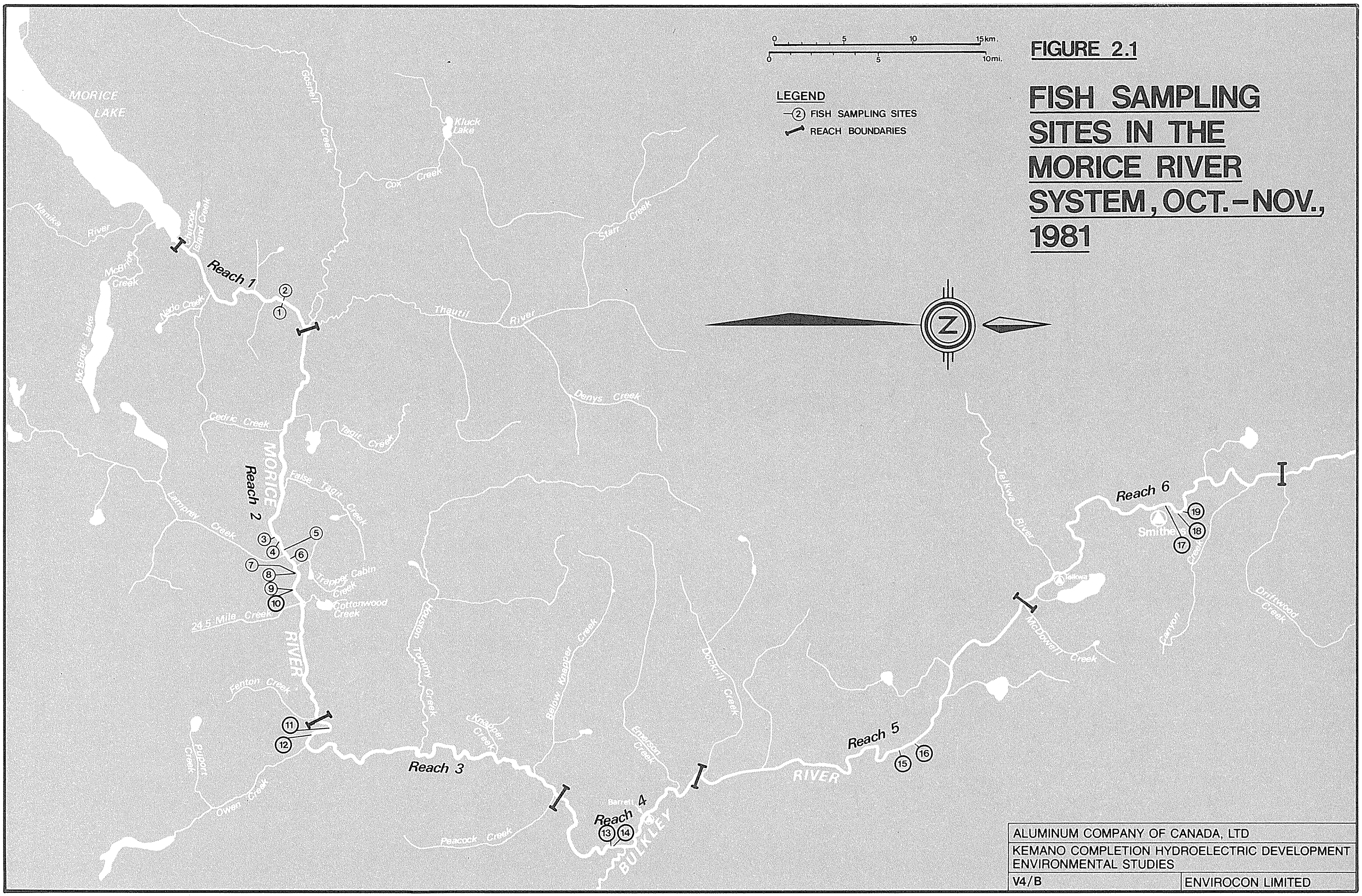

FIGURE 2.1

FISH SAMPLING SITES IN THE MORICE RIVER SYSTEM, OCT.-NOV., 1981

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3.0 RESULTS

Of a total of 1,352 juvenile fish captured in the Morice/Bulkley Rivers during late October - early November 1981, coho salmon juveniles (0+ and 1+) comprised 39.9% (539) (Table 3.1). Steelhead trout fry (0+) and parr (1+ and greater) comprised 23.6% (319) and 5.5% (75) of the total, respectively (Table 3.1). Juvenile chinook salmon (0+) represented 11.4% (154), and prickly sculpins, Rocky Mountain whitefish, Dolly Varden char, longnose dace and Pacific lamprey comprised the remaining 19.6% (265). Generally, steelhead trout and chinook salmon juveniles were slightly smaller in November 1981 than during a similar period in 1979, while coho salmon juveniles (0+) were of a similar size (Appendix B2).

Steelhead trout fry were in highest densities in Reaches 5, 4 and 2 (Table 3.2). Weighting these data to reach length indicated that fry were most abundant in side channel and main channels of Reach 2 in the upper Morice River and in the main channel of Reaches 4 and 5 in the lower Morice/Bulkley Rivers (Table 3.3). Margin areas of both shorelines with gravel/cobble substrate were most frequently utilized by steelhead trout fry. Steelhead trout fry were probably also utilizing side channel habitats in Reaches 3, 4 and 5 although these areas were not sampled. Extrapolation from 1979 main:side channel catch ratios indicated that Reach 1 side channels were probably used extensively by steelhead fry (Table 3.3; see also Appendix B1, Table B1.2). Comparison of total catches corrected for channel length indicated that approximately 71% of the steelhead trout fry reared in Reaches 2 and 5 (Table 3.3).

Steelhead trout parr were in greatest densities and most abundant in main channels of Reach 5 in the lower Morice/Bulkley Rivers and in the main and side channels of Reach 2 in the upper Morice River (Tables 3.2 and 3.3). Areas with coarse substrate and abundant cover in the form of log debris were most often utilized. Comparison of total catches corrected for channel length indicated that Reaches 2 and 5 accounted for the majority (71%) of steelhead trout parr (Table 3.3; Appendix B1, Table B1.3). More recent studies conducted in the Morice River main channel indicated that steelhead trout parr catches increased progressively from the upper river to the lower river, and that areas of the main channel offering gravel/cobble substrate and overhanging vegetation or log debris were most often used (Section F).

Coho salmon juveniles were in highest densities and most abundant in main and side channels of Reach 2 in the upper Morice River (Tables 3.2 and 3.3). Side channel areas offering deep pools, gravel-cobble substrate and abundant log debris or overhanging vegetation were heavily utilized by coho juveniles. Main channel areas most often

TABLE 3.1
Summary of Electrofishing Catches in Reaches 1 - 6 of the Morice/Bulkley Rivers During Late October - Early November 1981

Species			
Common Name	Scientific Name	Numbers Captured	Percent of Total Species Captured
Steelhead trout fry	Salmo gairdneri	319	23.6
Steelhead trout parr	Salmo gairdneri	75	5.5
Coho Salmon	Oncorhynchus kisutch	539	39.9
Chinook Salmon	Oncorhynchus tshawytscha	154	11.4
Dolly Varden char	Salvelinus malma	1	0.1
Rocky Mountain whitefish	Prosopium williamsoni	108	8.0
Longnose dace	Rhinichthys cataractae	13	1.0
Prickly sculpin	Cottus asper	3	0.2
Pacific lamprey	Lampetra tridentata	140	10.3
		1,352	100

TABLE 3.2
Densities of Juvenile Salmonids in Reaches 1 - 6 of the Morice/Bulkley Rivers During Late October - Early November 1981[1]

Reach	Channel Type[2]	Shoreline Margin Sampled (m)	Area Sampled (m^2)	Density (Fish/km) Steelhead Trout Fry	Steelhead Trout Parr	Coho Salmon Fry	Chinook Salmon Fry
1	M	32	97	187	0	187	0
2	M	64	291	1219	562	1594	2125
	LS	66	404	1030	91	1485	424
	SS[3]	1305	15000	814	231	1397	213
3	M	24	78	833	83	0	417
4	M	27	91	2148	296	148	1333
5	M	27	142	3481	593	74	1704
6	M	20	95	600	100	0	400
	LS	34	56	59	176	0	647

1 Based on population estimates doubled to include both margins for mainstem and large side channel sites

2 M = Main Channel
LS = Large Side Channels
SS = Small Side Channels

3 From Section C. Population estimates were extrapolated from the area sampled to the total area sectioned off by fences in all study side channels. Population estimates were then converted to fish/km based on shoreline distance between fences in all study side channels. Note: Shoreline margin and area sampled are **total** distance and area between fences and not that sampled

TABLE 3.3
Abundance of Juvenile Salmonids in Reaches 1 - 6 of the Morice/Bulkley Rivers During Late October - Early November 1981[1]

		Population Estimate (in 1,000's) Weighted to Channel Length							
		Steelhead				Coho		Chinook	
		Fry		Parr					
Reach	Channel Type	Numbers	%	Numbers	%	Numbers	%	Numbers	%
1	Main	2.9	6.7	0	6.1	2.9	5.2	0	6.1
	Side	23.6		5.3		16.8		14.4	
2	Main	41.2	39.6	19.0	44.8	53.9	62.2	71.8	47.2
	Side	115.9		20.2		181.1		40.0	
3	Main	23.2	6.6	2.3	3.8	0	2.1	11.6	5.2
	Side	3.2		1.1		8.0		0.7	
4	Main	38.9	11.1	5.4	11.7	2.7	8.1	24.1	10.2
	Side	5.2		4.9		28.1		0	
5	Main	121.8	31.2	20.8	26.5	2.6	6.9	59.6	25.3
	Side	1.8		2.5		23.4		0.4	
6	Main	18.7	4.7	3.1	7.1	0	15.5	12.5	6.0
	Side	0		3.1		58.6		1.8	

1 See Appendix B1, Tables B1.2 - B1.6 for calculations

used by coho salmon juveniles were those with low velocities and abundant log debris cover. More recent studies have indicated that pond areas adjacent to the main river in Reach 2 are also used extensively for rearing by coho juveniles (Section D). Extrapolation from 1979 main:side channel catch ratios to 1981 catches suggests that side channels of all reaches provide important rearing habitat for coho juveniles. Comparison of total catches corrected for channel length indicated that Reach 2 accounted for the majority (62%) of coho salmon juvenile rearing (Table 3.3; Appendix B1, Table B1.4).

Chinook salmon juveniles were in highest densities in the main channels of Reaches 2, 4 and 5 (Table 3.2). Margin areas of the mainstem offering large cobble/boulder substrate at the base of runs or pools were most often used by chinook salmon fry. Based on 1979 main:side channel catch ratios, side channels of Reach 1 likely provide rearing habitat for chinook juveniles. Catches weighted to reach length indicated that chinook salmon fry were most abundant in the main channel of Reaches 2 and 5 and side channels of Reach 2 (Table 3.3). Comparison of total catches corrected for channel length indicated that Reach 2 accounted for approximately 47% of the chinook salmon rearing, while Reaches 4, 5 and 6 of the lower Morice/Bulkley Rivers together comprised approximately 42% of the total (Table 3.3; Appendix B1, Table B1.5).

4.0 DISCUSSION

Sampling efficiency during 1981 was increased by using stop nets to minimize the movement of fish out of the sampling area and by using the multiple-pass removal method of electrofishing in both main and side channel habitat. Sampling during 1981 was concentrated in main channel habitat in Reaches 1 to 6 and side channels of Reach 2, whereas 1979 sampling effort was more uniform throughout the various channels of all reaches. Although sampling effort was concentrated in different areas during 1979 and 1981, the importance of Reach 2 in the upper river for juvenile salmonid rearing prior to overwintering is readily apparent.

Most steelhead trout fry rearing occurred in the upper Morice River (Reaches 1-3) during 1979 and 1981 (Figure 4.1). Reach 2, which contains approximately 126 km of side channel habitat, accounted for a greater percentage of steelhead trout fry rearing than any other reach during both years of sampling. Both main and side channel habitats in Reach 2 were important for fry rearing. The main channel of Reach 5 in the lower Morice/Bulkley Rivers was also important for steelhead trout fry rearing during 1981 (Appendix B1, Table B1.2). Although side channel habitat in most reaches was not sampled during 1981, the concentration of steelhead trout fry rearing in the multi-channelled Reach 2 for both years indicates the importance of side channel habitat for steelhead fry rearing.

Steelhead trout parr were more evenly distributed throughout the Morice/Bulkley Rivers. However, as with steelhead fry, Reach 2 was utilized more extensively by parr than any other reach during both years of sampling (Figure 4.1). Main and side channels were important areas for steelhead parr rearing during 1979. In 1981, main channel areas had a higher abundance of steelhead than side channels. Although the area sampled in 1981 was small, this apparent shift of parr rearing into main channel habitat during 1981 may reflect a higher main channel sampling efficiency rather than a change in parr rearing habitat.

Most juvenile coho salmon rearing occurred in the approximately 126 km of side channels in Reach 2 of the upper Morice River during both years of sampling (Figure 4.1). Although side channel habitat in other reaches was not sampled (except Reach 6) during 1981, extrapolation from 1979 main channel to side channel catch ratios suggests that side channel habitat in other reaches could account for considerable additional coho rearing (Appendix B1, Table B1.4).

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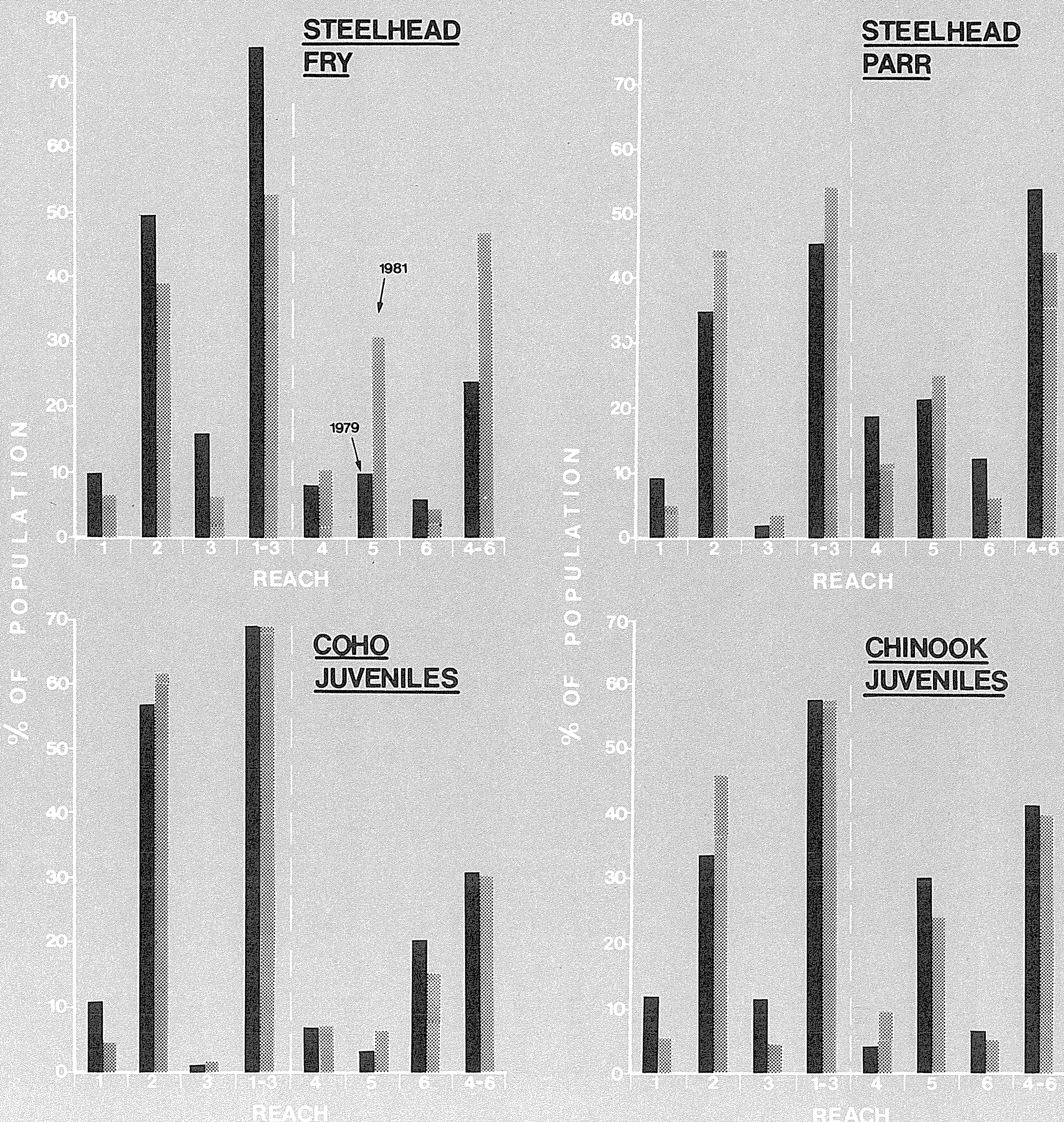
FIGURE 4.1: COMPARISON OF JUVENILE SALMONID DISTRIBUTION IN THE MORICE/BULKLEY RIVERS, LATE SEPT./NOV., 1979 AND OCT., 1981



Chinook salmon juveniles were distributed throughout the Morice and Bulkley Rivers during both years of study (Figure 4.1). As with steelhead trout fry and parr, and coho salmon juveniles, Reach 2 accounted for the majority of chinook juveniles compared to the other reaches. Main channel habitat was utilized more than side channel habitat during 1981. The main channel of Reach 5 in the lower Morice/Bulkley Rivers also provided important rearing habitat for chinook juveniles.

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APPENDIX B1

Catches, Population Estimates and Distribution of Juvenile Steelhead Trout, and Coho and Chinook Salmon in the Morice/Bulkley Rivers, October - November 1981

TABLE BI.I
Summary of Population Estimates Within Area Sampled with Multiple-Pass Removal Electrofishing from the Morice/Bulkley Rivers During October-November 1981

Reach	Channel[1] Type	Margin Sampled (m)	Area Sampled (m^2)	Steelhead Trout Fry	Steelhead Trout Parr	Coho	Chinook
1	M	32	97	3	0	3	0
2	M	64	291	39	18	51	68
	LS	66	404	34	3	49	14
	SS[2]	513	3,715	198	50	1,086	59
3	M	24	78	10	1	0	5
4	M	27	91	29	4	2	18
5	M	27	142	47	8	1	23
6	M	20	95	6	1	0	4
	LS	34	56	1	3	0	11

1 M = Main Channel
LS = Large Side Channel
SS = Small Side Channel

2 From Section C. Population estimates are for the enclosed sampling sites only

TABLE BI.2
Numbers Captured, Population Estimates and Distribution of Steelhead Trout Fry in Reaches 1 - 6 of the Morice/Bulkley Rivers During October - November 1981

Reach	Habitat[1] Type	Margin Sampled (M)	Numbers Captured	Population Estimate	Population Estimate (x2)	Fish Per km	Channel Length (km)	Population Estimate[2] Per Channel Length	Weighted Distribution (%) for All Channels
1	M	32	3	3	6	187	15.4	2880	6.7
	S	0	-	-		2,314**	10.2	23,603	
2	M	64	36	39	78	1,219	33.8	41,202	39.6
	LS	66	32	34	68	1,030 (922)	125.7	115,895	
	SS	1,305*	168	1,063*	1,063	814			
3	M	24	10	10	20	833	27.8	23,157	6.6
	S	0	-	-	-	599**	5.3	3,175	
4	M	27	20	29	58	2,148	18.1	38,879	11.1
	S	0	-	-	-	277**	18.6	5,152	
5	M	27	44	47	94	3,481	35.0	121,835	31.2
	S	0	-	-	-	148**	12.2	1,806	
6	M	20	5	6	12	600	31.2	18,720	4.7
	LS	34	1	1	2	0**	25.9	0	
							Total	396,304	

1 M = Main Channel
LS = Large Side Channel
SS = Small Side Channel
S = Side Channels (combined large and small)

Note: Small side channel fish populations are assumed to use the entire channel width, therefore population estimates were not doubled

2 Population estimates are not accurate to the nearest fish

* Extrapolated to include the entire channel length between fence traps for side channels A, B and D. Side channel C population estimates were extrapolated between the upstream and downstream sample sites

** Extrapolated based on 1979 mainstem: side channel fish population ratios

TABLE BI.3

Numbers Captured, Population Estimates and Distribution of Steelhead Trout Parr in Reaches 1-6 of the Morice/Bulkley Rivers During October-November 1981

Reach	Habitat Type[1]	Margin Sampled (M)	Numbers Captured	Population Estimate	Population Estimate (x2)	Fish Per km	Channel Length (km)	Population Estimate[2] Per Channel Length	Weighted Distribution (%) for All Channels
1	M	32	0	0	0	0	15.4	0	6.1
	S	0	-	-	-	523**	10.2	5,335	
2	M	64	10	18	36	562	33.8	18,996	44.8
	LS	66	2	3	6	91 (161)	125.7	20,238	
	SS	1,305*	45	302*	302	231			
3	M	24	1	1	2	83	27.8	2,307	3.8
	S	0	-	-	-	201**	5.3	1,065	
4	M	27	4	4	8	296	18.1	5,358	11.7
	S	0	-	-	-	261**	18.6	4,855	
5	M	27	8	8	16	593	35.0	20,755	26.5
	S	0	-	-	-	201**	12.2	2,452	
6	M	20	1	1	2	100	31.2	3,120	7.1
	LS	34	3	3	6	121**	25.9	3,134	
							Total	87,615	

1 M = Main Channel
LS = Large Side Channel
SS = Small Side Channel
S = Side Channels (combined large and small)

Note: Small side channel fish populations are assumed to use the entire channel width, therefore population estimates were not doubled

2 Population estimates are not accurate to the nearest fish

* Extrapolated to include the entire channel length between fence traps for side channels A, B and D. Side channel C population estimates were extrapolated between the upstream and downstream sample sites

** Extrapolated based on 1979 mainstem: side channel fish population ratios

TABLE B1.4
Numbers Captured, Population Estimates and Distribution of Coho Salmon Juveniles in Reaches 1 - 6 of the Morice/Bulkley Rivers During October - November 1981

Reach	Habitat Type[1]	Margin Sampled (M)	Numbers Captured	Population Estimate	Population Estimate (x2)	Fish Per km	Channel Length (km)	Population Estimate[2] Per Channel Length	Weighted Distribution (%) for All Channels
1	M	32	2	3	6	187	15.4	2,880	5.2
	S	0	-	-	-	1,643**	10.2	16,759	
2	M	64	39	51	102	1,594	33.8	53,877	62.2
	LS	66	36	49	98	1,485 (1441)	125.7	181,134	
	SS	1,305*	460	1,823*	1,823	1,397			
3	M	24	0	0	0	0	27.8	0	2.1
	S	0	-	-	-	1,513**	5.3	8,019	
4	M	27	2	2	4	148	18.1	2,679	8.1
	S	0	-	-	-	1,513**	18.6	28,142	
5	M	27	1	1	2	74	35.0	2,590	6.9
	S	0	-	-	-	1,917**	12.2	23,387	
6	M	20	0	0	0	0	31.2	0	15.5
	LS	34	0	0	0	2,262**	25.9	58,586	
							Total	378,053	

1 M = Main Channel
LS = Large Side Channel
SS = Small Side Channel
S = Side Channels (combined large and small)

Note: Small side channel fish populations are assumed to use the entire channel width, therefore population estimates were not doubled.

2 Population estimates are not accurate to the nearest fish

* Extrapolated to include the entire channel length between fence traps for side channels A, B and D. Side channel C population estimates were extrapolated between the upstream and downstream sample sites

** Extrapolated based on 1979 mainstem: side channel fish population ratios

TABLE BI.5
Numbers Captured, Population Estimates and Distribution of Chinook Salmon Juveniles in Reaches 1-6 of the Morice/Bulkley Rivers During October-November 1981

Reach	Habitat Type[1]	Margin Sampled (M)	Numbers Captured	Population Estimate	Population Estimate (x2)	Fish Per km	Channel Length (km)	Population Estimate[2] Per Channel Length	Weighted Distribution (%) for All Channels
1	M	32	0	0	0	0	15.4	0	6.1
	S	0	-	-	-	1,412**	10.2	14,402	
2	M	64	39	68	136	2,125	33.8	71,825	47.2
	LS	66	12	14	28	424 (318)	125.7	39,973	
	SS	1,305*	52	320*	320	213			
3	M	24	5	5	10	417	27.8	11,593	5.2
	S	0	-	-	-	140**	5.3	742	
4	M	27	18	18	36	1,333	18.1	24,127	10.2
	S	0	-	-	-	0**	18.6	0	
5	M	27	12	23	46	1,704	35.0	59,640	25.3
	S	0	-	-	-	35**	12.2	427	
6	M	20	4	4	8	400	31.2	12,480	6.0
	S	34	11	12	24	70**	25.9	1,813	
							Total	237,022	

1 M = Main Channel
LS = Large Side Channel
SS = Small Side Channel
S = Side Channels (combined large and small)

Note: Small side channel fish populations are assumed to use the entire channel width, therefore population estimates were not doubled.

2 Population estimates are not accurate to the nearest fish

* Extrapolated to include the entire channel length between fence traps for side channels A, B and D. Side channel C population estimates were extrapolated between the upstream and downstream sample sites

** Extrapolated based on 1979 mainstem: side channel fish population ratios

TABLE B1.6
Summary of Multiple-Pass Electrofishing in the Morice/Bulkley Rivers During October - November 1981

Date	Reach	Site	Channel[1] Type	Area Sampled (m²)	Length Sampled (m)	Habitat Type	Water Temp. (C°)	Pass No.	Steelhead Fry n	Steelhead Fry mean length (mm)	Steelhead Fry Range	Steelhead Parr n	Steelhead Parr mean length (mm)	Steelhead Parr Range	Coho Salmon n	Coho Salmon mean length (mm)	Coho Salmon Range	Chinook Salmon n	Chinook Salmon mean length (mm)	Chinook Salmon Range
Nov. 3/81	1	1	M	68.6	12.5	Flat	6.5	1	2	-	49, 53	0	-	-	1	-	68	0	-	-
								2	0	-	-	0	-	-	1	-	66	0	-	-
								3	0	-	-	0	-	-	0	-	-	0	-	-
	1	2	M	28.6	19.6	Pool	6.0	1	1	-	41	0	-	-	0	-	-	0	-	-
								2	0	-	-	0	-	-	0	-	-	0	-	-
								3	0	-	-	0	-	-	0	-	-	0	-	-
Oct. 27/81	2	3	M	105.3	18.5	Run/Flat	5.5	1	12	40.7	36-51	0	-	-	0	-	-	12	63.2	56-67
								2	3	40.3	36-43	0	-	-	0	-	-	5	61.6	58-65
								3	0	-	-	0	-	-	0	-	-	2	-	56, 62
	2	4	M	92.0	18.3	Run	5.5	1	0	-	-	3	76.7	71-84	9	71.8	61-89	2	-	68, 82
								2	4	54.5	49-58	2	-	102, 103	8	64.5	53-73	4	71.7	71-73
								3	4	44.2	38-48	0	-	-	3	67.3	55-74	2	-	78, 78
	2	5	S	114.2	17.5	Run	5.0	1	7	49.7	46-54	0	-	-	0	-	-	0	-	-
								2	4	45.0	40-51	0	-	-	0	-	-	0	-	-
								3	0	-	-	0	-	-	0	-	-	1	-	68
	2	6	S	179.4	17.5	Pool	-	1	4	44.7	40-50	1	-	84	15	57.4	50-72	6	68.5	65-72
								2	0	-	-	1	-	85	13	62.5	51-75	2	-	70, 78
								3	0	-	-	0	-	-	6	60.3	46-70	1	-	73
Oct. 28/81	2	7	S	45.3	15.8	Run	-	1	3	42.7	39-45	0	-	-	1	-	50	0	-	-
								2	1	-	40	0	-	-	0	-	-	0	-	-
								3	0	-	-	0	-	-	0	-	-	0	-	-

(Continued)

TABLE B1.6 (Continued)

Date	Reach	Site	Channel[1] Type	Area Sampled (m²)	Length Sampled (m)	Habitat Type (C°)	Water Temp.	Pass No.	Steelhead Fry n	Steelhead Fry mean length (mm)	Steelhead Fry Range	Steelhead Parr n	Steelhead Parr mean length (mm)	Steelhead Parr Range	Coho Salmon n	Coho Salmon mean length (mm)	Coho Salmon Range	Chinook Salmon n	Chinook Salmon mean length (mm)	Chinook Salmon Range
Oct. 28/81	2	8	S	64.9	14.9	Run	8.5	1	8	42.6	37-46	0	-	-	1	-	55	1	-	58
								2	4	40.2	32-49	0	-	-	0	-	-	2	-	63, 79
								3	1	-	42	0	-	-	0	-	-	0	-	1
	2	9	M	58.8	13.2	Pool	7.5	1	4	47.7	45-52	1	-	82	10	63.3	52-92	1	-	75
								2	1	-	47	2	-	93, 123	6	64.5	52-73	5	69.2	64-79
								3	1	-	44	2	-	81, 84	3	61.7	57-69	4	77.2	72-84
Oct. 29/81	2	10	M	62.3	14.0	Run	6.5	1	6	40.3	36-45	0	-	-	0	-	-	1	-	61
								2	1	-	49	0	-	-	0	-	-	1	-	57
								3	0	-	-	0	-	-	0	-	-	0	-	-
	3	11	M	31.4	14.6	Pool	-	1	1	-	48	1	-	89	0	-	-	0	-	-
								2	1	-	62	0	-	-	0	-	-	0	-	-
								3	2	-	39, 43	0	-	-	0	-	-	0	-	-
Oct. 30/81	3	12	M	46.5	9.5	Pool	-	1	5	46	40-54	1	-	75	0	-		3	73.7	69-77
								2	0	-	-	0	-	-	0	-	-	1	-	67
								3	1	-	51	0	-	-	0	-	-	0	-	-
								4	0	-	-	0	-	-	0	-	-	1	-	71
Oct. 29/81	4	13	M	44.8	13.4	Run	-	1	8	43.6	39-55	3	86.7	80-93	2	-	-	2	-	69, 71
								2	5	44.8	35-52	1	-	73	0	-	-	0	-	-
								3	2	-	40, 41	0	-	-	0	-	-	0	-	-
Oct. 30/81	4	14	M	46.2	13.2	Run	6.0	1	1	-	42	0	-	-	0	-	-	12	71.2	64-81
								2	3	49.3	43-56	0	-	-	0	-	-	2	-	66, 81
								3	1	-	49	0	-	-	0	-	-	2	-	70, 71

(Continued)

TABLE B1.6 (Continued)

									Species Captured											
									Steelhead											
									Fry			Parr			Coho Salmon			Chinook Salmon		
Date	Reach	Site	Channel Type[1]	Area Sampled (m^2)	Length Sampled (m)	Habitat Type	Water Temp. (C°)	Pass No.	n	mean length (mm)	Range	n	mean length (mm)	Range	n	mean length (mm)	Range	n	mean length (mm)	Range
Oct. 31/81	5	15	M	59.3	12.3	Run	6.0	1	8	39.1	40-57	2	-	82, 85	1	-	66	2	-	71, 71
								2	5	44.6	41-50	0	-	-	0	-	-	2	-	63, 71
								3	0	-	-	0	-	-	0	-		2	-	63, 68
	5	16	M	82.3	14.3	Run	-	1	21	41.8	35-54	5	88.6	73-99	0	-	-	3	58.7	54-66
								2	8	39.6	35-48	1	-	77	0	-	-	2	-	64, 71
								3	2	-	40, 41	0	-	-	0	-	-	1	-	64
Nov. 2/81	6	17	S	52.9	16.3	Run	-	1	1	-	58	2	-	87, 155	0	-	-	0	-	-
								2	0	-	-	1	-	109	0	-	-	0	-	-
								3	0	-	-	0	-	-	0	-	-	0	-	-
	6	18	S	41.8	17.3	Run	-	1	0	-	-	0	-	-	0	-	-	7	69.1	59-79
								2	0	-	-	0	-	-	0	-	-	2	-	74, 77
								3	0	-	-	0	-	-	0	-	-	2	-	65, 83
	6	19	M	55.8	19.5	Pool	-	1	3	43.7	38-50	0	-	-	0	-	-	4	69.5	67-74
								2	1	-	45	1	-	74	0	-	-	0	-	-
								3	1	-	43	0	-	-	0	-	-	0	-	-

1 M = Main channel
S = Side channel

APPENDIX B2

Summary of Mean Fork Lengths of Juvenile
Steelhead Trout, and Coho and Chinook Salmon
Captured in the Morice/Bulkley Rivers
During November 1979 and 1981

TABLE B2.1
Summary of Mean Fork Lengths of Juvenile Salmonids Captured in the Morice/Bulkley Rivers During November 1979 and 1981

Species	Year	Sample Size	Mean Fork Length (mm)	Standard Deviation (mm)
Steelhead Trout Fry (0+)	1979	52	50.0	8.9
	1981	100	44.9	5.8
Steelhead Trout Parr (1+)	1979	58	95.2	-
	1981	29	90.2	17.1
Coho Salmon Fry (0+)	1979	55	60.9	8.5
	1981	74	61.2	7.4
Chinook Salmon Juveniles (0+ and 1+)	1979	54	73.8	7.6
	1981	98	68.6	6.9

SECTION C

JUVENILE SALMONID OVERWINTER SURVIVAL IN SELECTED SIDE CHANNELS OF THE MORICE RIVER DURING 1981-1982

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1.0 INTRODUCTION

Most studies of the relationship between discharge and juvenile salmonid rearing have stressed the importance of low summer flows in limiting fish populations (Burns 1971; Shepherd 1979). Observations during field studies conducted on the Morice River in 1979 suggest that low winter flows might be a major factor limiting juvenile salmonid (chinook and coho salmon, and steelhead trout) production (Section A). As flows decline during the late fall-early winter period in the Morice system, side channels become isolated from the mainstem flows. Fish must either move out of these channels or be confined to side channel habitats which may dewater or freeze as flows decline during the winter. Stranded juveniles were found dead in dried channels in April 1979 and in frozen side channel pools in November 1979 (Section A). Mason (1974) has also suggested that winter habitat availability and winter mortality can limit the production of coho smolts in coastal streams.

A program of field studies undertaken jointly by Envirocon Limited and the Department of Fisheries and Oceans was conducted in the late fall 1981 and the early spring 1982 to determine:

(1) the importance of side channel habitats to juvenile salmonid rearing during the late fall period;

(2) whether juvenile salmonids migrate from side channel locations as flows decline during late fall; and

(3) overwinter survival of juvenile salmonids in representative side channel habitats under winter low flow conditions.

2.0 STUDY AREA DESCRIPTION

The study area included four side channels in Reach 2 of the Morice River from just upstream of Lamprey Creek to Fenton Creek (Figure 2.1). Side channels were selected to represent a range of conditions with respect to flow and cover type and abundance. Side channel selection was also governed by winter access and suitability for constructing and maintaining upstream and downstream fences on the channels. Site suitability for sampling by electrofishing was another consideration.

Side Channel A, located approximately 1.0 km upstream of Lamprey Creek, was the smallest flowing channel examined, with 2,200 m^2 of wetted area in October 1981 (Figure 2.2, Table 2.1). This channel is characterized by primarily riffle and pool hydraulic units with substrate comprising mainly gravel. Channel banks were unstable, with little overhanging vegetation, although log jams and some undercut bank area provided cover for rearing juvenile salmonids. By early April 1982, flows had ceased in Side Channel A and only three isolated pools totalling 20 m^2 (1% of October area) of wetted area remained (Table 2.1, Figure 2.2).

Side Channel B, situated parallel to Side Channel A, was the largest channel studied, with 8,600 m^2 of wetted area in October 1981 (Figure 2.2, Table 2.1). Hydraulic units were generally riffle and pool with some run and flat areas. Substrate was mainly gravel and cobble. Channel banks were stable, with little overhanging vegetation, although some log debris and cobble provided cover. By early April 1982, only seven isolated pools totalling 300 m^2 (3% of October area) of wetted area remained (Table 2.1, Figure 2.2).

Side Channel C, located approximately 5 km downstream of Lamprey Creek, had no flow but had 1,250 m^2 of isolated pools in October 1981 (Table 2.1, Figure 2.3). Pools generally had an abundance of overhanging vegetation and moderate log debris cover. Leaf litter also provided abundant cover for rearing juvenile salmonids. Substrate was predominantly gravel. By early April 1982, wetted area within the isolated pools had been reduced by 88% to 150 m^2 (Figure 2.1). Groundwater input was suspected to be sustaining the water level in the lower pool of this side channel.

Side Channel D, located approximately 5 km upstream of Fenton Creek, was the second largest channel examined, comprising 3,300 m^2 of wetted area in October 1981 (Figure 2.4, Table 2.1). Hydraulic units were characterized by numerous riffle/pool combinations with few runs. Substrate was primarily gravel, with log debris and boulders providing the majority of cover for juvenile salmonids. By early April 1982,

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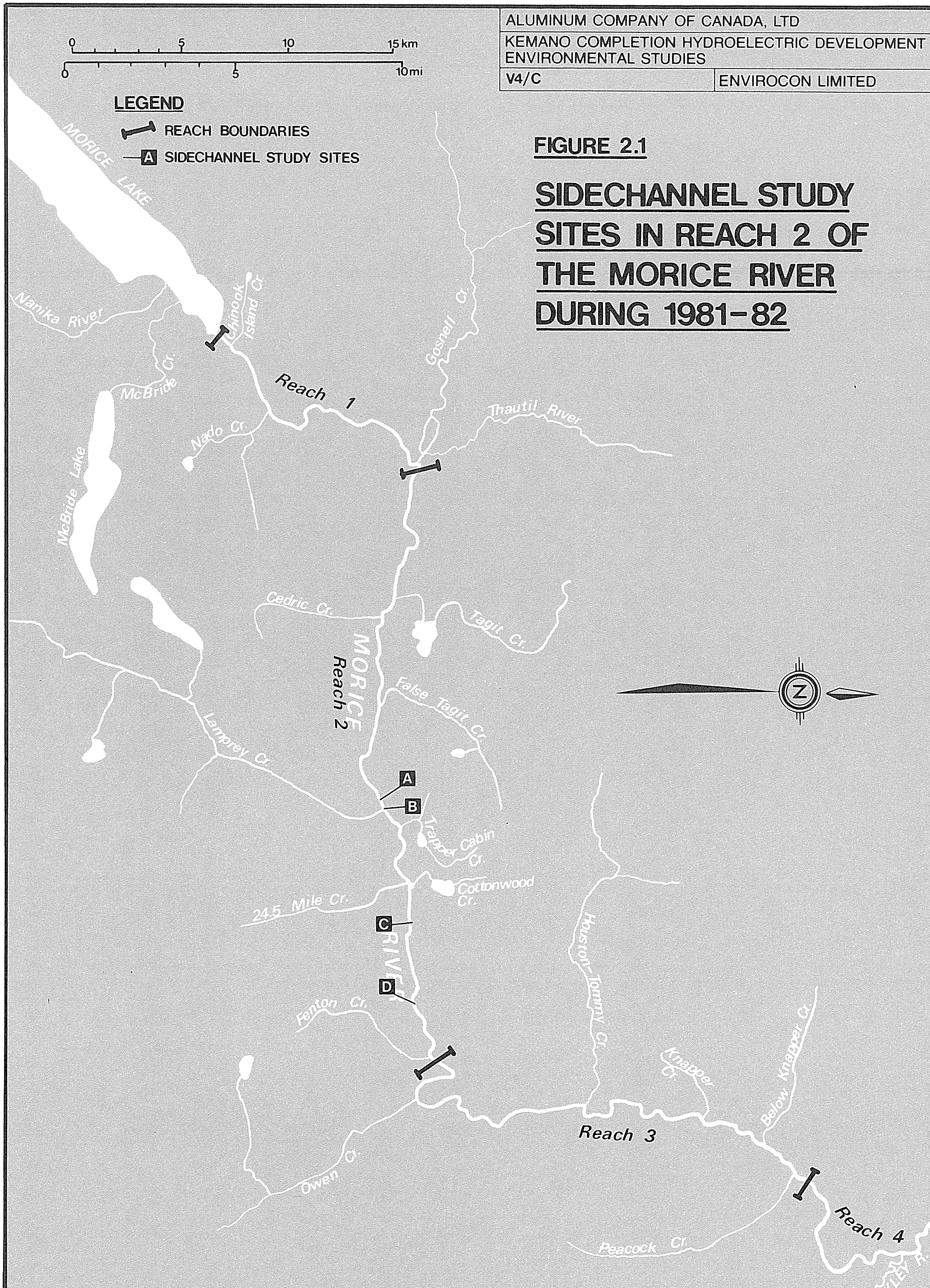
FIGURE 2.1

SIDECHANNEL STUDY SITES IN REACH 2 OF THE MORICE RIVER DURING 1981-82



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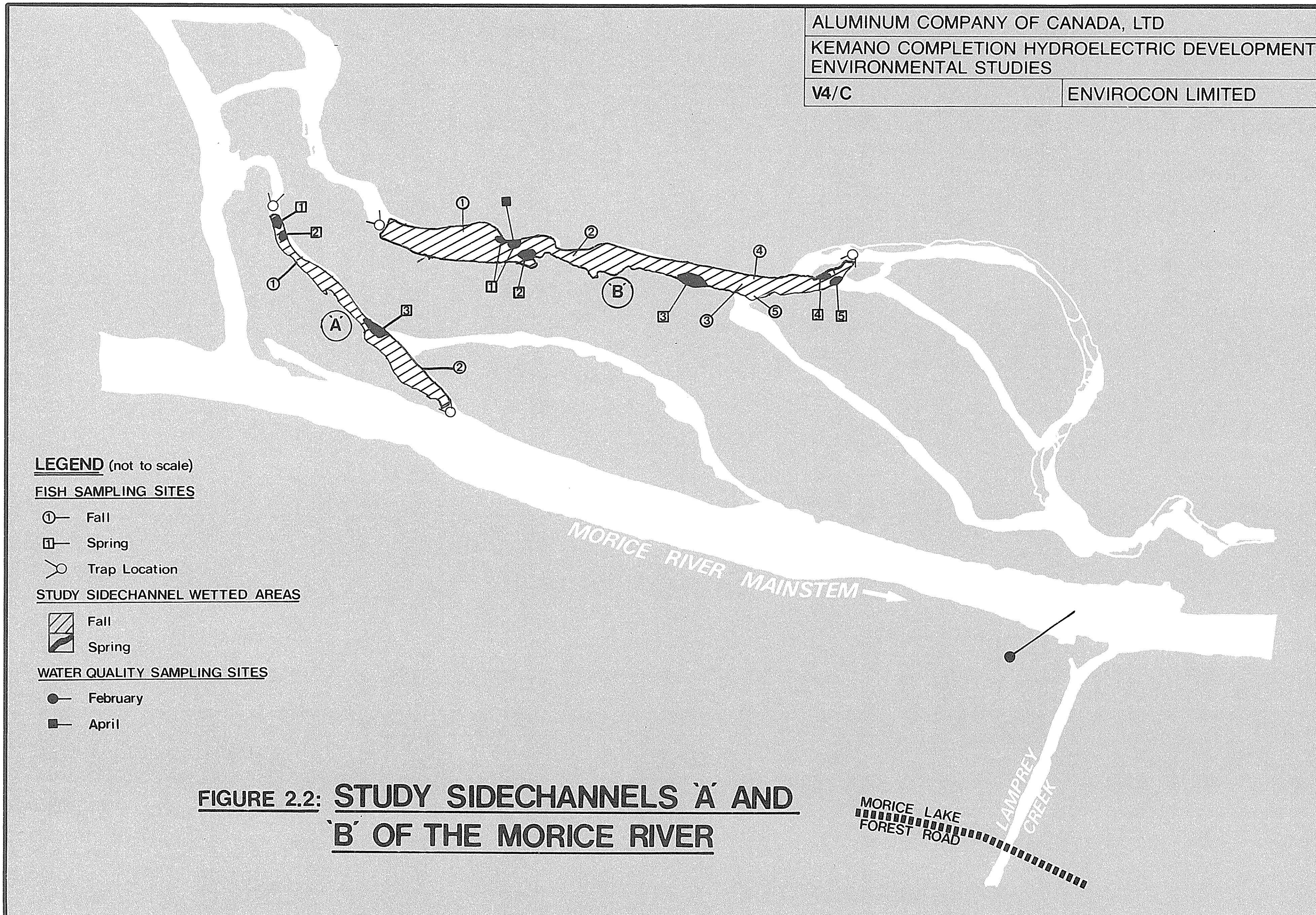

FIGURE 2.2: STUDY SIDECHANNELS 'A' AND 'B' OF THE MORICE RIVER

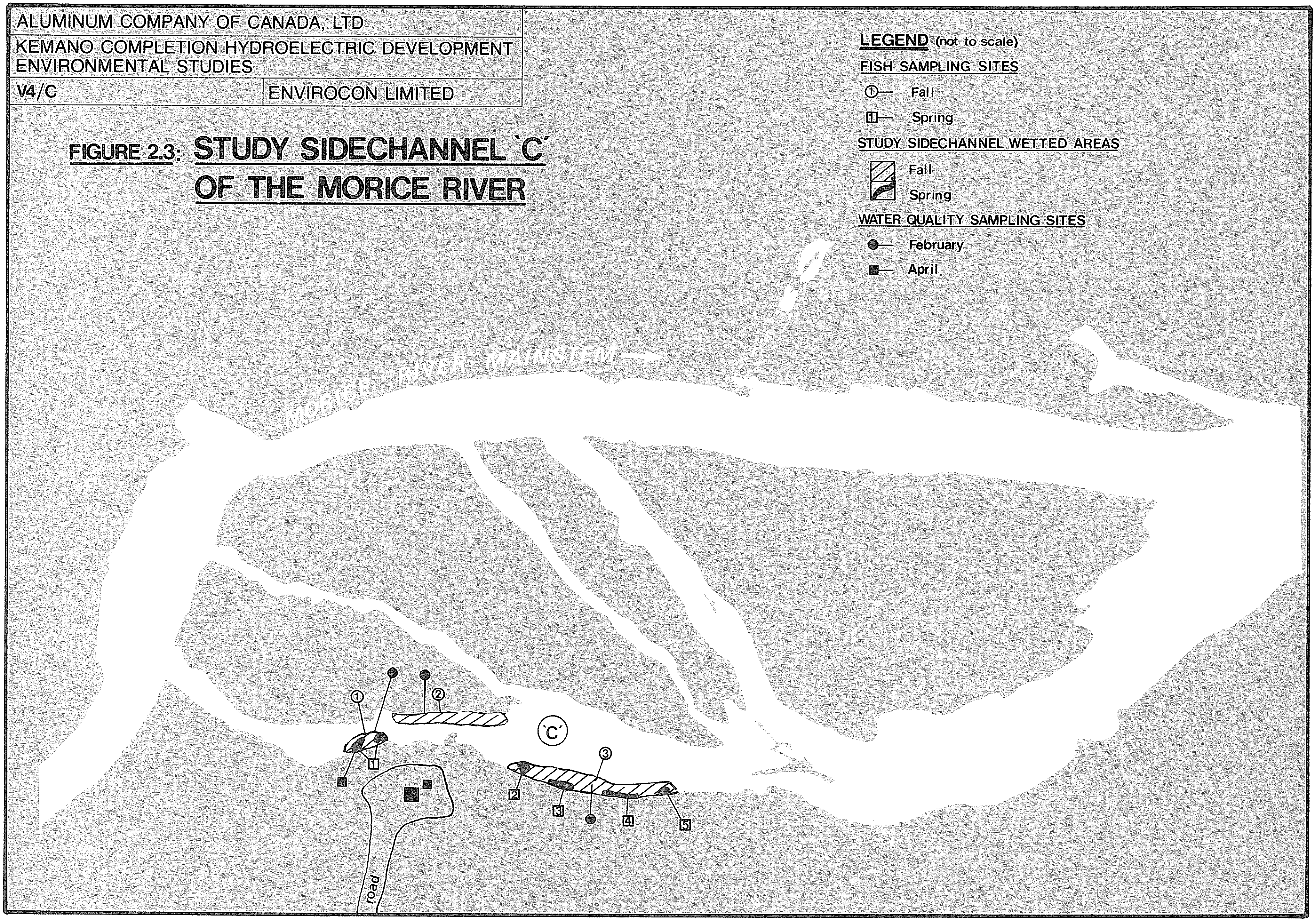

FIGURE 2.3: STUDY SIDECHANNEL 'C' OF THE MORICE RIVER

FIGURE 2.4

STUDY SIDECHANNEL 'D' OF THE MORICE RIVER

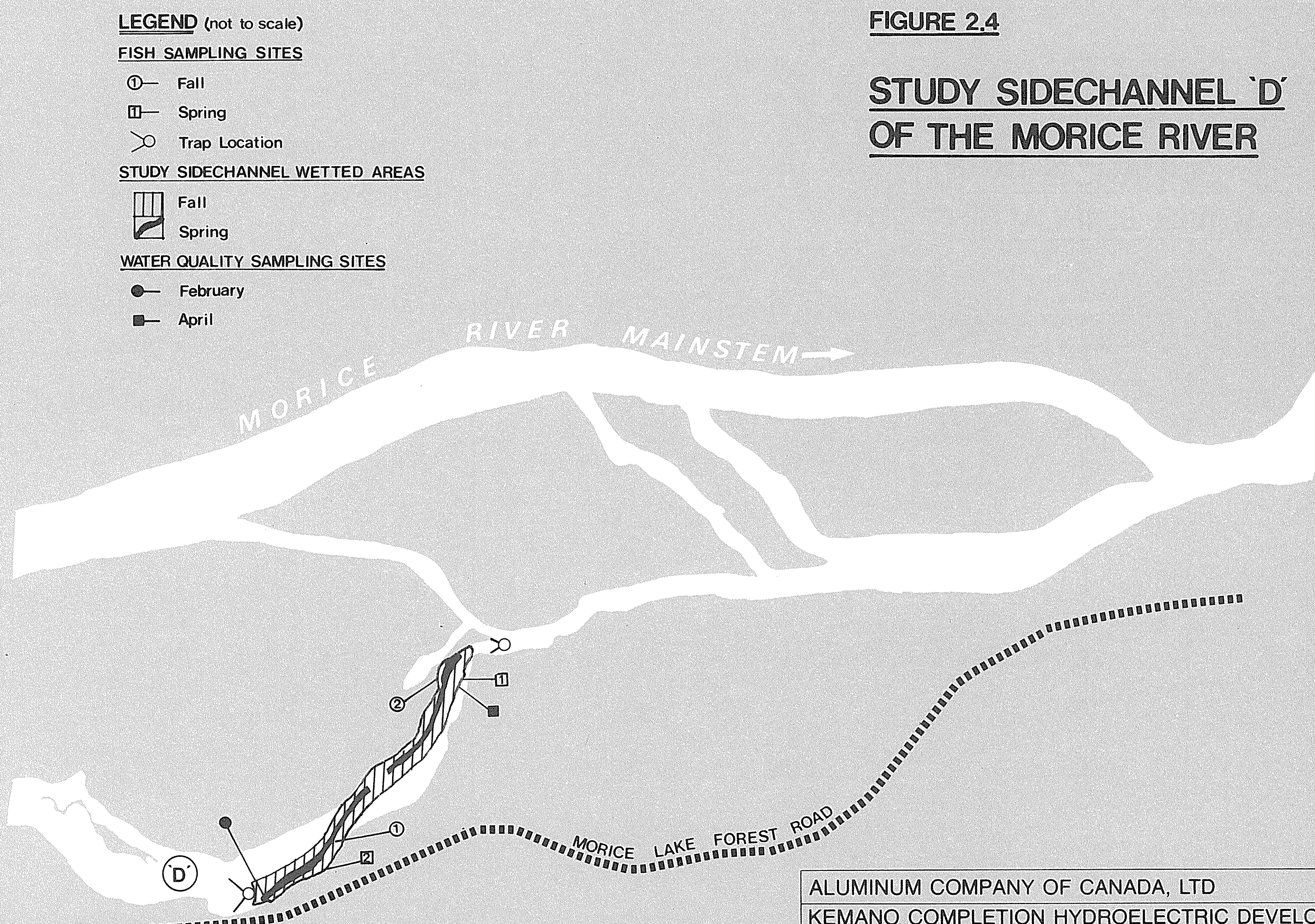

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TABLE 2.1
Physical Characteristics of Selected Side Channels in Reach 2 of the Morice River During October 1981 and April 1982

Characteristics	Selected Side Channels							
	A		B		C		D	
	October	April	October	April	October	April	October	April
Wetted Area (m^2)	2,200	20	8,600	300	1,250	150	3,300	1,500
Maximum Depth (m)	1.3	.3	1.4	.8	1.5	.3	1.4	1.0
Percent Area <0.75 m deep	80	100	90	100	70	100	75	85
Percent Area >1.0 m deep	5	0	5	0	15	0	10	5
Predominant Sub-strate	gravel	gravel	gravel-cobble	gravel-cobble	gravel	gravel	gravel-cobble	gravel-cobble
Cover:								
% log debris	10	20	1-5	5	10	10	5	5
% over stream vegetation	1-5	0	10	0	20-30	0	10	0
% instream vegetation	1-5	0	5	5	5	0	5	0
% cobble-boulder	1-5	0	10	0	-	0	15	1-5

Side Channel D was still flowing and wetted area had been reduced by 55% to 1,500 m^2 (Figure 2.1). Groundwater input to the top end of Side Channel D maintained some flow in this side channel throughout the winter.

3.0 METHODS

Population estimates of overwintering juvenile salmonids were calculated for all four side channels in early winter (1981) and in the following spring (1982) before flows resumed in these channels. Representative sections (12-93% of the total wetted area between fence traps) within each side channel were electrofished utilizing either the multiple-pass removal method or the mark-recapture method of estimating population sizes for each species and life stage. In shallow areas with little cover the multiple-pass removal method was used, while in deeper areas with an abundance of log debris or ice cover the mark-recapture method was used. Stop nets were employed in both methods to minimize the movement of fish out of the sample area.

Estimates of population sizes were calculated from electrofishing results (multiple-pass removal method) using Brataen's (1969) modification of DeLury's (1951) method (discussed in Ricker 1975). Confidence intervals (95%) for population estimates were calculated using a modification of DeLury's method (Appendix C1).

The Chapman (1951) modification of the Peterson method (cited in Ricker 1975) was used to calculate population sizes from the mark-recapture results. Confidence intervals (95%) for each estimate were calculated as described by Robson and Reiger (1971).

To determine the net movement of juvenile salmonids in and out of side channels during the late fall-early winter period and to correct side channel population estimates, upstream/downstream traps equipped with live boxes were placed at the inlet and outlet of Channels A, B and D (Plate 1). Wood frame fences covered with 6 mm wire mesh were angled from shore to lead fish into traps. Side Channel C did not require traps since it comprised a series of isolated pools and was totally separated from the mainstem Morice River flow throughout the study period.

Traps were operated continuously and checked daily from October 23 to December 9, 1981 and from May 3 to May 15, 1982. All fish captured were enumerated by species and life stage, and fork length was measured to the nearest mm. After December 9 and prior to May 3, flows were inadequate (based on visual observations and examination of WSC flow records) to permit fish to move in and out of the channels.

Staff gauges were installed in Channels A, B and D to determine stage. Minimum-maximum thermometers were installed in each side channel and water temperatures recorded daily during the period of trap operation to provide additional information on the physical environment during the fall-winter period.

To determine changes in water quality in side channel and mainstem habitats, water samples were collected on February 11 from Side Channels C and D and the mainstem Morice River, and on April 6 from Side Channels B, C and D and the mainstem Morice River (Figure 2.1). Samples were packed in ice and shipped within 48 hours to Chemex Laboratories in North Vancouver for subsequent determination of metals, nutrients, pH, alkalinity and conductivity. Dissolved oxygen measurements were taken at the time of water sampling using a YSI model 54A oxygen meter. Dissolved oxygen measurements were also taken during late March - early April at selected isolated pool habitats.

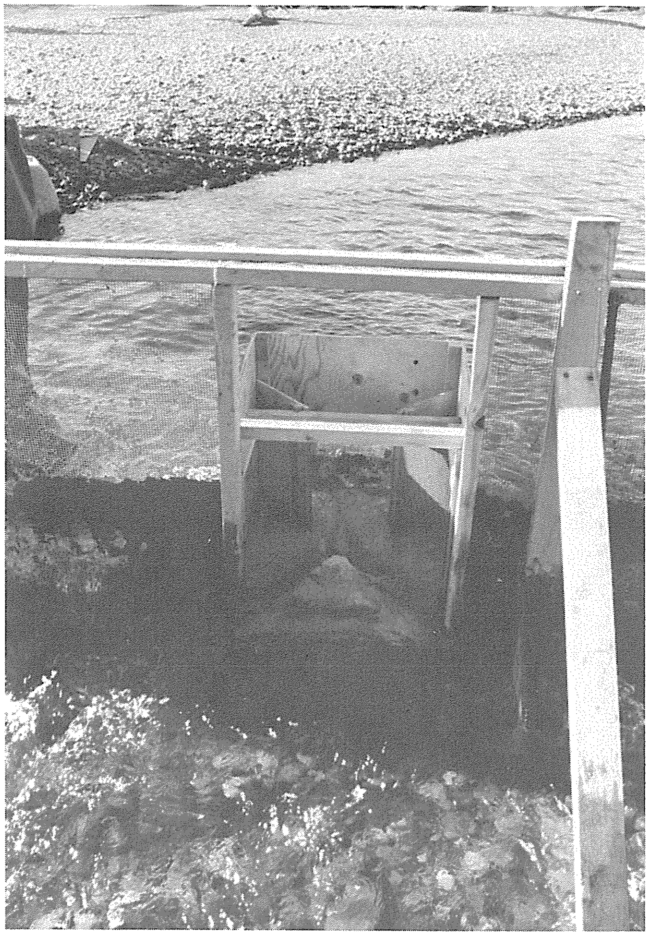
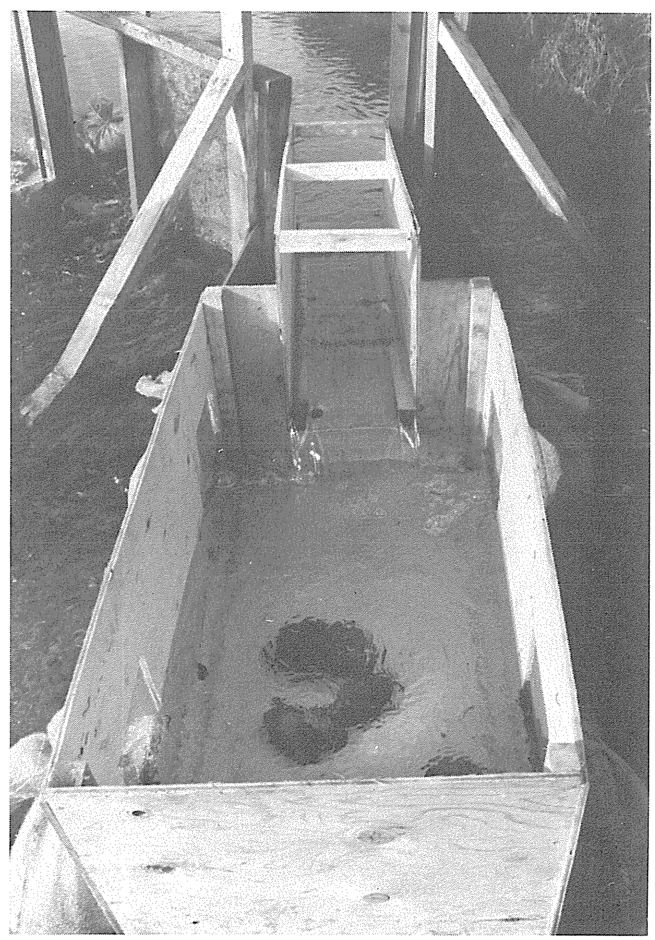


Plate I: Fence traps equipped with live boxes in study side channels of the Morice River during October, 1981.

Upstream trap



Downstream trap

4.0 RESULTS

4.1 Movement In and Out of Side Channels

Of a total of 359 juvenile salmonids captured moving in and out of study side channels from late October - early December, 1981, chinook salmon juveniles were the only species to show substantial net movement. A total of 62 chinook juveniles, comprising approximately 16% of the estimated chinook population in the four side channels studied, moved out of the side channels into the main channel Morice River prior to freeze-up (Table 4.1; Appendix C2). Flows through side channels during that period were generally declining with water temperatures decreasing from approximately 8.0 to 0.5^{o}C.

Some unrecorded movement of juvenile fish out of Side Channels B and D may also have occurred during mid-November and February. During a small fall freshet from November 11-13, some flow around fences in Side Channels B and D (Plate 2) allowed unrecorded movement of fish in and out of these side channels. No obvious trends in fish movement during this period were apparent from catches in those traps still operational, except for an increase in chinook salmon outmigration from Side Channel B on November 13, the first day trapping resumed. A total of 13 juvenile chinook salmon, comprising 3% of the estimated fall side channel chinook populations, left Side Channel B on that day, suggesting that other fish may have left Side Channels B and D during the previous 48 hours when traps were not operational.

As well, during a February reconnaissance of the study area, seepage flow into Side Channel D created a flowing channel around the downstream fence, allowing access to the mainstem Morice River. The potential for outmigration of fish populations during mid-winter from Side Channel D may have contributed to reduced population estimates by early spring, suggesting that overwinter survival for all species was higher than estimated for this channel.

4.2 Population Estimates and Overwinter Survival

Of a total 3,505 juvenile salmonids estimated in the study side channels in the fall, coho salmon comprised 51.9% (1,820), while steelhead fry and parr were 30.3% (1,062) and 8.6% (301), respectively (Table 4.2; Appendices C3 and C4). Chinook salmon represented the remaining 9.2% (323). Rocky Mountain whitefish, longnose dace, Pacific lamprey, Dolly Varden char and prickly sculpin comprised less than 10% of the total catch and were not included in population estimates. Side Channel C,

TABLE 4.1
Summary of Net Change in Fish Movements from Selected Side Channels of the Morice River During October - December 1981

	Fish Species							
					Steelhead Trout			
	Chinook Fry		Coho Fry		Fry		Parr	
Side Channel	Pop. Size	Net Change	Pop. Size	Net Change	Pop. Size	Net Change	Pop. Size	Net Change
A	27	-13	200	-10	124	+1	19	-2
B	278	-34	278	-7	515	-4	180	-1
C	1	0	987	0	18	0	3	0
D	78	-15	358	+14	403	+5	101	+1
Total	384	-62	1823	-3	1060	+2	303	-2

Plate 2: Study side channel D showing the additional channel (arrow) created during mid-November, 1981 flow increases.

TABLE 4.2
Population Estimates of Juvenile Salmonids in Selected Side Channels of the Morice River in October 1981

Species	Side Channel A		Side Channel B		Side Channel C		Side Channel D		All Channels	
	Number	% of Total in all Side Channels	Number	% of Total in all Side Channels	Number	% of Total in all Side Channels	Number	% of Total in all Side Channels	Number	% of Total Fish
Steelhead - fry	125	11.8	511	48.1	18	1.7	408	38.4	1,062	30.3
- parr	17	5.6	179	59.5	3	1.0	102	33.9	301	8.6
Coho	190	10.4	271	14.9	987	54.2	372	20.4	1,820	51.9
Chinook	14	4.3	244	75.8	1	0.3	63	19.6	323	9.2
All Species	346	9.9	1,205	34.4	1,009	28.8	945	27.0	3,505	100

characterized by isolated pool habitat, contained 54% of the total coho population overwintering in side channel habitats. Side Channel B, the largest of all side channels examined, comprised 48% and 59% of the steelhead fry and parr overwintering populations, respectively (Table 4.2). It also supported the majority (76%) of the overwintering chinook population in the four side channels.

As mainstem flows declined from October to May and side channels became isolated from Morice River inflow, total wetted area within side channels was reduced by 87% from 15,000 m^2 in November to 1,900 m^2 in April (Table 4.3; Figure 2.1). Side Channels A and B had the greatest reduction in total wetted area with only 1% and 3% of the wetted area remaining by the following spring, respectively. During the period of flow decline, overall fish densities increased from an average 0.23 fish/m^2 in October to 0.80 fish/m^2 in April. Side Channels A and C had the highest overall densities during April for all species combined with 5.7 fish/m^2 and 3.1 fish/m^2, respectively (Table 4.3).

Of the total 3,505 juvenile salmonids estimated in the four side channels during the fall, only 43% (1,520) survived to early May when flows through side channels resumed (Table 4.3; Appendices C3 and C4). Side Channel B had only 3% of the wetted area remaining by early spring and the lowest overall fish survival (30%). The 33% and 46% estimates of survival of juvenile salmonids in Side Channels A and C, respectively, may be high because deep pools in areas of extensive log debris made sampling difficult during the fall period when higher flows prevailed. By early May, pool areas were much shallower, allowing more efficient sampling of fish populations. Side Channel D had 45% of the wetted area remaining by early spring and the highest overall fish survival (61%). Steelhead trout parr and fry had the lowest survival of 23% and 30%, respectively, while chinook salmon juveniles had the highest overwinter survival of 61% (Table 4.3). Coho salmon survival averaged 52%.

4.3 Water Quality

Water quality in study side channels of the Morice River during February and April 1982 was generally within accepted limits set for fish culture (Sigma 1979) (Appendix C5, Table C5.2). Higher levels of several water quality values in Side Channel D, notably conductivity, hardness and dissolved solids, may be indicative of groundwater input.

Dissolved oxygen content in study side channels ranged from 0.7 to 11.2 ppm in February to March samples.

TABLE 4.3
Summary of Change in Wetted Area, Fish Densities and Juvenile Salmonid Overwinter Survival Estimates in Selected Side Channels of the Morice River During 1981-82[1]

Location	Steelhead Fry	Steelhead Parr	Coho	Chinook	All Species	Approximate Total Wetted Area[2] (m^2)	Density ($fish/m^2$)
	Numbers of Fish						
Side Channel A							
October	125	17	190	14	346	2,200	0.2
April	20	4	75	15	114	20	5.7
% Survival	**16**	**23**	**39**	**N/A**	**33**	**1%**	
Side Channel B							
October	511	179	271	244	1,205	8,600	0.1
April	54	7	178	123	362	300	1.2
% Survival	**11**	**4**	**66**	**50**	**30**	**3%**	
Side Channel C							
October	18	3	987	1	1,009	1,200	0.8
April	64	1	402	1	468	150	3.1
% Survival	N/A	**33**	**41**	**100**	**46**	**12%**	
Side Channel D							
October	408	102	372	63	945	3,300	0.3
April	178	56	286	59	576	1,500	0.4
% Survival	**44**	**55**	**77**	**94**	**61**	**45%**	
All Channels Combined							
October	1,062	301	1,820	322	3,505	15,000	0.23
April	316	68	941	198	1,520	1,900	0.80
% Survival	**30**	**23**	**52**	**61**	**43**	**13%**	

1 Fall population estimates have been corrected for movements in and out of the study side channels.

2 % of wetted area remaining over winter

Davis (1975) developed dissolved oxygen criteria for freshwater salmonids based on the average incipient oxygen response level of a fish community to the effects of low oxygen. Protection Level A, 7.75 ppm, is one standard deviation above the mean and represents "ideal conditions" ensuring a high degree of safety for freshwater salmonids. Protection Level B, 6.00 ppm, represents the oxygen level where the average member of a given salmonid community starts to exhibit signs of oxygen distress, and some proportion of the population is at risk if this level is sustained beyond a few hours. Protection Level C, 4.25 ppm, is one standard deviation below the mean and is the level at which a large proportion of the salmonid population may be severely affected by low oxygen if this level is sustained beyond a very few hours.

The dissolved oxygen levels (5.5-6.9 ppm) recorded in isolated pools of Side Channel C during February (Appendix C5, Table C5.1) are below Protection Level A and may have caused some stress to overwintering fish populations although no mortalities were observed. Dissolved oxygen levels in Side Channel D in February were 9.0 ppm, well above Protection Level A (7.75 ppm), and likely provided good conditions for overwintering fish. By early April, dissolved oxygen levels were low in Side Channels A and B, with the lowest recorded values (0.7 to 5.7 ppm) observed in Side Channel B. All but one of these measurements were below Protection Level C (4.25 ppm) and likely contributed to the overwinter loss of more than 100 fish in two of the three largest pools remaining in Side Channel B (Appendix C5, Table C5.1). However, oxygen levels in isolated pool #1 of Side Channel A were approximately 3 ppm and although juvenile fish appeared to be stressed, mortalities were not observed. Oxygen levels in Side Channels C and D were relatively high in April (6.6-11.2 ppm) with no observed fish mortalities (Appendix C5).

5.0 DISCUSSION

Results from the seven weeks that the traps were maintained indicate that when the data were combined for all the channels, there was a less than 1% change in steelhead fry or parr numbers, no net change in coho salmon numbers, and an outmigration of approximately 20% of the estimated chinook population. These results suggest that most juvenile salmonids do not leave these side channels with decreasing flow and water temperatures during the late fall and early winter, but remain in the vicinity of rearing areas utilized during late October.

Bjornn and Morrill (1972) suggest that in Idaho streams during the fall the number of migrating trout and salmon probably reflects the availability of suitable winter cover. This suggests that Morice River side channel locations in the late fall period probably provide adequate cover for juvenile salmonids. However, as flows decline in late winter, fish would not have the choice to leave side channels because most side channels are isolated from the mainstem river by this time.

Juvenile salmonid overwinter survival in side channels in Reach 2 of the Morice River suggests that those channels with groundwater inflow had the least reduction in wetted area through the winter period and the highest overwinter survival of juvenile fish populations. The higher overwinter survival of coho and chinook salmon compared to steelhead trout fry may be a reflection of coho and chinook juveniles' preference for deep pool habitats with log debris cover during the fall. These areas are less subject to freezing and dewatering during the winter period, and the abundant log debris provides cover during the early spring when predation from birds may occur. The shallower riffle areas occupied by steelhead trout fry are more subject to freezing and dewatering, and the lack of available cover at these sites may expose fry to greater predation during the early spring. Reasons for the poor steelhead parr survival in this study are not clear as these fish tended to occupy similar habitats to those of chinook salmon during the fall.

Observations at the study channels, particularly during late March and April, indicated that stranding and freezing of juvenile fish, low dissolved oxygen levels and predation on juvenile fish by birds contributed to overwinter fish losses in the side channels.

Stranding of juveniles in isolated pools which subsequently dewatered in the spring occurred in all side channels except Side Channel D, which had the least reduction in wetted area of all channels. Observations during March and April suggested that groundwater from adjacent slopes was seeping into the upper end of Side Channel D and the lower end of Side Channel C. During initial site selection, groundwater seepage was not identified since this input was masked by far greater flows from the mainstem Morice River. Overwinter survival of juvenile salmonids was higher in these two channels than in Side Channels A and B which did not have any groundwater input. Side Channels A and B also had the greatest reductions in wetted areas with consequent higher numbers of stranded fish.

During clear cold periods in early winter and spring, shallow pools not covered with ice and insulated by snow can freeze to the bottom with resulting fish mortalities. Widespread incidences of this were observed in November 1979 throughout side channels in the Morice and Nanika Rivers (Section A). However, during the 1981-82 study period, freezing did not appear to be a significant mortality factor.

Oxygen levels during late winter in some isolated pools of Side Channels A and B were below 4.16 ppm (Protection Level C, Davis 1975), the level at which a large proportion of a given salmonid population may be severely affected. This may have been responsible for some winter losses of juvenile fish populations. Upon removal of 15 cm of ice cover from two of the three pools remaining in Side Channel B, all fish were decomposed, suggesting that mortalities had occurred earlier in the winter. Benthic invertebrate fauna and lamprey ammocoetes in these pools had moved out of the bottom silts and were very active, apparently under stress. Depressed winter oxygen levels beneath ice cover have been found in two Yukon rivers and attributed in part to respiration of aquatic and benthic flora and fauna and reduction of the reaeration rate by ice cover (Albright et al. 1980; Schreier et al. 1980). The two pools in Side Channel B with winter kill had substantial accumulations of leaf litter, and oxygen concentrations in the pools probably decreased both as a result of bacterial decomposition and respiration of juvenile fish. This, in conjunction with little or no exchange of the water in the pools and the prevention of reaeration by ice cover, probably led to the low oxygen levels resulting in fish mortalities.

Juvenile fish in other isolated pools of Side Channels A and B survived, but they were darker in colour and more agitated in their movements than fish in areas with higher oxygen levels, suggesting that they were stressed. Fish captured in these areas during spring population sampling were sensitive to handling. Davis (1975) reports that, for a variety of species, dissolved oxygen concentrations below 5 ppm have deleterious effects on swimming ability, respiration, circulatory dynamics, metabolism and behaviour, and that in some cases the threshold response level was above 5 ppm. Schreier et al. (1980) suggest that natural oxygen concentrations below 5 ppm in the late winter are a widespread phenomenon in northern environments.

Winter kill does not occur every year in these pools. Side Channel B was sampled in late April 1979, and over 120 juveniles were captured, with no evidence of winter mortalities. One explanation for this difference may be the occurrence of a fall freshet capable of moving leaf litter out of these side channels which occurred prior to the winter in 1978 but not in 1981. This would have reduced oxygen consumption and severe depletion would not have occurred.

Oxygen concentrations in Side Channels C and D exceeded 6 and 10 ppm dissolved oxygen during the March-April period, suggesting that oxygen depletion was not a problem for overwintering fish in these two channels. These channels had more seepage inflows during the winter resulting in open water areas and thus higher oxygen levels.

Predation on juvenile fish, particularly by birds, may also have contributed to overwinter losses of fish populations in side channels. An isolated pool of Side Channel A was sampled shortly after the ice had melted (April 12, 1982) and again on April 28 before flows had connected the pool to the mainstem river. During this period, fish populations decreased from 159 to 59 fish in this pool. The large reduction in fish numbers was probably the result of bird or small mammal predation since oxygen levels (6-7 ppm) were not in the lethal range and there were no apparent mortalities in the initial sampling. The maximum depth in this pool was 15 cm and available cover was sparse. The most likely predators were mergansers, since over 50 were observed on a 25 km section of the Morice River during this period. Elson (1962) found that, under suitable conditions, mergansers can take a heavy toll of juvenile fish populations.

6.0 SUMMARY

Of a total 359 juvenile salmonids captured moving in and out of study side channels from late October - early December 1981, chinook salmon were the only species to show a substantial net movement. A net total of 62 chinook juveniles, comprising approximately 16% of the estimated chinook population in the four side channels, moved into the main channel Morice River prior to freeze-up.

Of a total 3,505 juvenile salmonids estimated in the four side channels during the fall, coho salmon comprised 52% (1,820), while steelhead trout fry and parr were 30% (1,062) and 9% (301) of the total, respectively. Chinook salmon represented the remaining 9% (323). As flows declined during the early winter period and side channels became isolated from the main channel flow, total wetted area within side channels was reduced by 87% from 15,000 m^2 to 1,900 m^2. Only 43% (1,520) of the juvenile fish overwintering in side channel habitats survived to early May when flows through side channels resumed. Side Channels A and B, which had only 1% and 3% of the total area remaining wetted by early May, had the lowest overall survivals of 33% and 30%, respectively. Side Channels C and D, which had groundwater inflow and had 12% and 45% of the total area remaining wetted by early May, had the highest overwinter survivals of 46% and 61%, respectively.

Steelhead trout parr and fry had the lowest overall survival of 23% and 30%, respectively, while chinook salmon juveniles had the highest overwinter survival of 61%. Chinook and coho salmon survival averaged 61 and 52%, respectively. The generally higher overwinter survival of chinook and coho salmon may result from a tendency to occupy deep pool habitats with log debris cover, rather than the shallow riffle areas with less cover occupied by steelhead fry during the fall.

Observations at the side channels, particularly during late March and April, indicated that stranding and freezing, low dissolved oxygen levels and bird predation on juvenile fish were some of the observed mortality factors affecting the survival of overwintering fish populations. The low percent overwinter survival of steelhead trout fry and parr and coho salmon juveniles would imply that low winter flows play a major role in limiting juvenile salmonid production in the Morice River.

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APPENDIX C I

Method of Calculating 95% Confidence Intervals for Population Estimates from Multiple-Pass Electrofishing Results

Electrofishing results from the multiple-pass removal method were utilized to calculate population size based on a variation of Delury's (1951) method.

In Delury's (1951) method, the population estimate is taken as the intercept of the regression line with the x-axis (c(t)), and the confidence limits of this estimate are the roots of a quadratic equation. This technique causes difficulties when the determinant of the quadratic equation is negative.

If the assumption of constant catchability is not met, the fit of the regression line to the data will be poor. This can result in a high value of P. If the absolute value of P is greater than that of the slope, the confidence intervals cannot be evaluated. This is because the evaluation of Equation I would give a positive (rising) slope and would therefore not intercept the x axis, meaning there would be no upper bound to the population estimate confidence interval.

To circumvent this problem a different technique was used. The intercepts of the confidence limits of the slope of the regression line with the x-axis (c(t)) were used to give the confidence limits of the population estimate. The confidence limits of the slope were calculated as follows:

$$\text{conf. Int} = \text{Slope} \pm P$$

where

$$P = t_{\alpha/2}\,\text{S.D.}\sqrt{\frac{N}{N\left(\sum_{i=1}^{N} c(t)\right)^2 - \left(\sum_{i=1}^{N} c(t)\right)^2}} \qquad \text{(Equation I)}$$

and where $t_{\alpha/2}$ is the tabulated t-value of the $1-\alpha$ confidence level with N-2 degrees of freedom. N is the number of passes and S.D. is the standard deviation from the regression.

If the lower bound of the population estimate confidence interval was less than the total catch, then the lower bound was adjusted to equal the total catch.

APPENDIX C2

Daily Fish Migrations in Morice River
Side Channels, October to December 1981

TABLE C2.1
Daily Fish Migrations in Side Channel A, 1981

Date		Staff Gauge (cm)	Water Temp. (°C)	Species Capture: Steelhead Trout, Fry: In	Out	Net Change	Steelhead Trout, Parr: In	Out	Net Change	Coho Salmon: In	Out	Net Change	Chinook Salmon: In	Out	Net Change	Rocky Mountain Whitefish: In	Out	Net Change	Total Species Net Change
October	24	-	8.0	1		+1	1		+1		1	-1				2		+2	+3
	25	-	8.0							1	1	0		1	-1	1	1	0	-1
	26	-	7.5					1	-1					1	-1	2		+2	0
	27	-	5.0				2	1	+1				1	1	0	2	3	-1	0
	28	-	7.0	1	1	0													0
	29	37.5	7.0					1	-1		1	-1							-2
	30	36.0	-					1	-1					1	-1		2	-2	-4
	31	42.5	6.5								1	-1							-1
November	01	42.5	5.0											4	-4				-4
	02	-	4.0											2	-2				-2
	03	45.5	4.5		1	-1							4	3	+1	1	1	0	0
	04	-	-											1	-1		2	-2	-3
	05	42.7	5.0								1	-1		1	-1	2	2	0	-2
	06	42.5	5.0								2	-2							-2
	07	42.5	4.0							2	3	-1	1	3	-2	1	1	0	-3
	08	43.0	5.5								1	-1	1	1	0	1	1	0	-1
	09	46.5	4.5							1		+1				1	1	0	+1
	10	48.5	5.0	1		+1	1		+1				1		+1				+3
	11	50.7	5.0					1	-1		1	-1		3	-3	2		+2	-3
	12	-	-																
	13	63.0	4.0											1	-1				-1
	14	61.3	4.0																
	15	63.0	-							1		+1	1		+1				+2
	16	53.0	4.5																
	17	54.0	4.0										1		+1	1		+1	+2
	18	60.5	4.0																
	19	55.0	4.0																
	20	55.5	4.0								3	-3							-3
	21	53.3	4.0										1		+1				+1

(Continued)

TABLE C2.1 (Continued)

Date	Staff Gauge (cm)	Water Temp. (°C)	Species Capture: Steelhead Trout: Fry In	Out	Net Change	Parr In	Out	Net Change	Coho Salmon In	Out	Net Change	Chinook Salmon In	Out	Net Change	Rocky Mountain Whitefish In	Out	Net Change	Total Species Net Change
November 22	-																	
23	52.0	4.0																
24	54.8	3.5																
25	-																	
26	54.0	5.0																
27	-																	
28	-																	
29	38.7	3.0																
30	36.0	2.0							1		+1				6		+6	+7
December 01	37.3	2.5							3		+3				1		+1	+4
02	38.7	2.5								1	-1	1		+1	1		+1	+1
03	33.3	2.0											1	-1				-1
04	33.0																	
05	33.5	2.0								1	-1							-1
06	32.5	2.0													2		+2	+2
07	-	1.0							1		+1				1	1	0	+1
08	-																	
09	-	0.5					1	-1		3	-3		1	-1				-5
Total			3	2	+1	4	6	-2	10	20	-10	12	25	-13	27	15	+12	-13

TABLE C2.2
Daily Fish Migrations in Side Channel B, 1981

			Species Capture															
			Steelhead Trout						Coho Salmon			Chinook Salmon			Rocky Mountain Whitefish			Total Species Net Change
			Fry			Parr												
Date	Staff Gauge (cm)	Water Temp. (°C)	In	Out	Net Change	In	Out	Net Change	In	Out	Net Change	In	Out	Net Change	In	Out	Net Change	
October 23	-	7.0													1		+1	+1
24	-	8.0																
25	-	6.5								3	-3							-3
27	-	5.5		1	-1													-1
28	-	7.0																
29	-	7.0																
30	-	-																
31	51.5	6.0																
November 01	51.5	5.0																
02	-	4.0																
03	52.0	5.0											4	-4				-4
04	51.0	5.0		1	-1					1	-1		4	-4				-5
05	51.0	4.5											2	-2		1	-1	-3
06	51.5	5.0								1	-1							
07	51.5	3.5								1	-1		1	-1				-2
08	51.5	4.0																
09	52.0	4.5																
10	54.5	5.0											1	-1				-1
11	55.5	5.0																
12	-	-																
13	62.5	4.0										3	13	-10				-10
14	61.3	4.0										2		+2				+2
15	63.0	-										5		+5				+5
16	63.0	4.5																
17	62.0	4.0										1	1	0				0
18	61.0	4.0										1		+1				+1
19	59.5	4.0										2		+2				+2
20	61.0	4.0										2	2	0				0
21	60.0	4.0										1	1	0				0

(Continued)

TABLE C2.2 (Continued)

Date	Staff Gauge (cm)	Water Temp. (°C)	Steelhead Trout – Fry – In	Steelhead Trout – Fry – Out	Steelhead Trout – Fry – Net Change	Steelhead Trout – Parr – In	Steelhead Trout – Parr – Out	Steelhead Trout – Parr – Net Change	Coho Salmon – In	Coho Salmon – Out	Coho Salmon – Net Change	Chinook Salmon – In	Chinook Salmon – Out	Chinook Salmon – Net Change	Rocky Mountain Whitefish – In	Rocky Mountain Whitefish – Out	Rocky Mountain Whitefish – Net Change	Total Species Net Change
November 22	-	-																
23	56.0	3.0																
24	49.7	3.5																
25	-	-																
26	-	-																
27	-	-																
28	-	-																
29	51.0	3.0																
30	48.0	2.0																
December 01	49.5	3.0														1	-1	-1
02	50.0	2.0											1	-1		1	-1	-2
03	47.2	2.0																
04	48.0	1.5		1	-1		1	-1					1	-1				-3
05	47.5	2.5										1	12	-11				-11
06	46.5	2.0								1	-1		6	-6				-7
07	44.5	1.0		1	-1								3	-3				-4
08	-	-																
09	44.5	0.5																
Total			**0**	**4**	**-4**	**0**	**1**	**-1**	**0**	**7**	**-7**	**18**	**52**	**-34**	**1**	**3**	**-2**	**-46**

TABLE C2.3
Daily Fish Migrations in Side Channel D, 1981

				Species Capture															
				Steelhead Trout						Coho Salmon			Chinook Salmon			Rocky Mountain Whitefish			Total Species Net Change
				Fry			Parr												
Date		Staff Gauge (cm)	Water Temp. (°C)	In	Out	Net Change	In	Out	Net Change	In	Out	Net Change	In	Out	Net Change	In	Out	Net Change	
October	24	-	6.0																
	25	-	6.0																
	26	-	-																
	27	-	4.5											1	-1	1		+1	0
	28	25.5	4.5								3	-3		2	-2		2	-2	-7
	29	25.0	5.0		1	-1					14	-14		3	-3				-18
	30	24.5	-								1	-1	1	4	-3	2	1	+1	-3
	31	26.2	4.0							1		+1	1	1	0				+1
November	01	27.0	4.0							1	2	-1	2	7	-5				-6
	02	27.5	3.0	1		+1				3		+3	1		+1				+5
	03	27.5	4.0											3	-3	1		+1	-2
	04	27.0	3.0							1	3	-2		1	-1				-3
	05	26.5	3.0								1	-1		1	-1				-2
	06	27.0	3.5	1		+1					1	-1	2	1	+1				+1
	07	27.2	2.5																
	08	26.8	3.0										1		+1				+1
	09	27.5	3.0								1	-1							-1
	10	29.0	3.5										2		+2				+2
	11	29.7	4.0										1		+1				+1
	12	39.0	3.5														1	-1	-1
	13	42.0	3.0										1		+1				+1
	14	43.0	4.0																
	15	42.0	4.0																
	16	41.5	4.0																
	17	38.5	4.0													1		+1	+1
	18	37.0	4.0																
	19	35.3	3.0																

(Continued)

TABLE C2.3 (Continued)

			Species Capture															
			Steelhead Trout												Rocky Mountain Whitefish			Total Species
			Fry			Parr			Coho Salmon			Chinook Salmon						
Date		Staff Gauge (cm)	Water Temp. (°C)	In	Out	Net Change	In	Out	Net Change	In	Out	Net Change	In	Out	Net Change	In	Out	Net Change	Net Change
November	20	35.5	3.5														3	-3	-3
	21	38.5	-																
	22	32.0	3.5													3		+3	+3
	23	30.0	4.0																
	24	28.8	3.0														1	-1	-1
	25	27.5	2.0																
	26	27.5	0.5																
	27	-	-																
	28	24.5	-											1	-1				-1
	29	24.2	1.0													1		+1	+1
	30	23.0	1.0											1	-1				-1
Dec.	01	22.5	1.5																
	02	23.8	1.0													1		+1	+1
	03	22.1	1.0													1		+1	+1
	04	23.0	1.0														2	-2	-2
	05	-	1.0							24	1	+23	1		+1	6		+6	+30
	06	22.0	3.0	3	1	+2	1		+1	1		+1							+4
	07	21.8	1.0	2		+2				10	1	+9				2		+2	+13
	08	-	0.0							1		+1		2	-2	1		+1	0
	09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Total				**7**	**2**	**+5**	**1**		**+1**	**42**	**28**	**+14**	**13**	**28**	**-15**	**20**	**10**	**+10**	**+15**

APPENDIX C3

Multiple-Pass and Mark-Recapture Electrofishing in Morice River Side Channels in October 1981 and April 1982

TABLE C3.1
Multiple-Pass and Mark-Recapture Electrofishing from Side Channel A of the Morice River During the Fall 1981 and Spring 1982

Date	Site	Area Sampled (m^2)	Habitat Type	Water Temp. (C^o)	Electro-fishing Tech-nique[1]	Pass No.	Species Captured: Steelhead Trout: Fry: n	Fry: $\bar{x}$ length (mm)	Fry: Range	Parr: n	Parr: $\bar{x}$ length (mm)	Parr: Range	Coho Salmon: n	Coho: $\bar{x}$ length (mm)	Coho: Range	Chinook Salmon: n	Chinook: $\bar{x}$ length (mm)	Chinook: Range
Oct. 26/81	1	497	Run/Riffle Pool	8.0	MP	1	5	46.2	37-57	3	87.3	84-90	17	59.1	52-75	4	65.6	58-73
						2	5	40.8	38-45	0	-	-	11	54.0	43-71	2	-	57, 69
						3	3	38.7	35-45	0	-	-	2	-	55, 85	0	-	-
Oct. 25/81	2	318	Run	8.0	MP	1	14	40.8	35-51	3	96.0	69-135	15	56.9	50-61	3	65.3	55-82
						2	3	40.0	39-41	0	-	-	4	58.2	48-75	0	-	-
						3	6	42.2	37-45	1	-	82.0	11	57.4	40-78	1	-	59
April 12/82	3	-	Isolated Pool	9.0	MP	1	15	47.2	39-57	21	101.9	71-168	50	66.2	56-100	9	63.0	54-73
						2	6	43.2	38-50	5	95.4	74-145	18	58.6	45-94	8	68.1	62-76
						3	7	47.7	41-60	3	87.7	85-91	8	59.1	41-91	1	-	64
April 28/82	3	10.5	Isolated Pool	-	MP	1	6	51.2	44-56	2	-	71, 93	28	56.7	46-74	7	64.1	57-73
						2	3	41.3	40-43	0	-	-	7	56.8	45-74	3	63.7	59-70
						3	1	-	42	0	-	-	2	-	44, 49	0	-	-
April 12/82	1	8.0	Isolated Pool	5.0	MR	1	7	44.1	38-51	2	-	83, 84	14	57.1	49-75	2	-	60, 64
						2	5	42.6	39-50	0	0	-	7	55.0	46-74	1	-	75
April 12/82	2	2.0	Isolated Pool	-	MR	1	1	-	45	0	-	-	0	-	-	0	-	-
						2	-	-	-	-	-	-	-	-	-	-	-	-

1 MR = Mark-Recapture
MP = Multiple-Pass

TABLE C3.2
Multiple-Pass and Mark-Recapture Electrofishing from Side Channel B of the Morice River During the Fall 1981 and Spring 1982

							Species Captured											
							Steelhead Trout						Coho Salmon			Chinook Salmon		
							Fry			Parr								
Date	Site	Area Sampled (m^2)	Habitat Type	Water Temp. (C^o)	Electro-fishing Technique[1]	Pass No.	n	$\bar{x}$ length (mm)	Range	n	$\bar{x}$ length (mm)	Range	n	$\bar{x}$ length (mm)	Range	n	$\bar{x}$ length (mm)	Range
Oct. 26/81	1	87.8	Pool	5.5	MP	1	12	43.7	33-65	0	-	-	2	-	55, 59	2	-	67, 71
						2	2	-	38, 44	1	-	69	3	53.0	48-56	0	-	-
						3	1	-	47	0	-	-	1	-	58	0	-	-
	2	461.2	Run	5.5	MP	1	13	44.7	39-54	8	87.2	74-92	9	58.0	49-74	17	68.0	59-81
						2	6	42.2	36-48	9	89.4	70-116	6	62.5	55-88	9	70.7	62-79
						3	3	44.3	37-49	0	-	-	6	61.3	48-70	3	62.0	60-65
	3	146.0	Flat	5.5	MP	1	1	-	41	0	-	-	0	-	-	0	-	-
						2	2	-	44, 46	0	-	-	0	-	-	0	-	-
						3	2	-	36, 44	0	-	-	0	-	-	0	-	-
						4	1	-	41	0	-	-	0	-	-	0	-	-
	4	236.7	Riffle	5.5	MP	1	7	40.0	34-46	0	-	-	0	-	-	0	-	-
						2	3	40.7	-	0	-	-	0	-	-	0	-	-
						3	0	-	-	0	-	-	0	-	-	0	-	-
	5	123.5	Pool	5.5	MP	1	8	42.4	38-48	0	-	-	0	-	-	2	-	67, 70
						2	1	-	44	0	-	-	0	-	-	0	-	-
						3	0	-	-	1	-	92	0	-	-	0	-	-
April 12/82	1	1.9	Isolated Pool	7.0	MP	1	4	47.5	44-51	0	-	-	3	66.3	65-69	0	-	-
						2	0	-	-	0	-	-	1	-	58	1	-	73
						3	0	-	-	0	-	-	0	-	-	0	-	-
	2	51.7	Isolated Pool	4.0	MP	1	3	44.7	40-51	1	-	96	1	-	53	0	-	-
						2	0	-	-	0	-	-	1	-	78	0	-	-
						3	0	-	-	0	-	-	0	-	-	0	-	-
	4	6.6	Isolated Pool	3.0	MP	1	32	47.6	38-65	2	-	78, 83	19	58.2	38-85	5	65.2	58-72
						2	2	-	42, 51	1	-	80	3	68.7	61-76	2	-	61, 71
						3	1	-	49	1	-	84	1	-	49	0	-	-

(Continued)

TABLE C3.2 (Continued)

Date	Site	Area Sampled (m^2)	Habitat Type	Water Temp. (C^o)	Electro-fishing Technique[1]	Pass No.	Steelhead Trout – Fry n	Steelhead Trout – Fry $\bar{x}$ length (mm)	Steelhead Trout – Fry Range	Steelhead Trout – Parr n	Steelhead Trout – Parr $\bar{x}$ length (mm)	Steelhead Trout – Parr Range	Coho Salmon n	Coho Salmon $\bar{x}$ length (mm)	Coho Salmon Range	Chinook Salmon n	Chinook Salmon $\bar{x}$ length (mm)	Chinook Salmon Range
	5	4.0	Isolated Pool	6.5	MP	1	2	-	42, 43	1	-	77	5	57.0	46-78	1	-	69
						2	0	-	-	0	-	-	4	38.2	43-51	0	-	-
						3	0	-	-	0	-	-	2	-	58, 68	1	-	69
April 28/82	3	200	Pool	-	MR	1	3	38.7	36-41	0	-	-	14	59.5	43-74	20	68.1	59-80
						2	6	41.0	37-45	1	-	145	29	62.9	49-78	9	72.4	59-86

1 MR = Mark-Recapture
MP = Multiple-Pass

TABLE C3.3
Multiple-Pass and Mark-Recapture Electrofishing from Side Channel C of the Morice River During the Fall 1981 and Spring 1982

Date	Site	Area Sampled (m^2)	Habitat Type	Water Temp. (C°)	Electro-fishing Tech-nique[1]	Pass No.	Species Captured: Steelhead Trout – Fry: n	Fry: $\bar{x}$ length (mm)	Fry: Range	Parr: n	Parr: $\bar{x}$ length (mm)	Parr: Range	Coho Salmon: n	Coho: $\bar{x}$ length (mm)	Coho: Range	Chinook Salmon: n	Chinook: $\bar{x}$ length (mm)	Chinook: Range
Oct. 24/81	1	225.0	Isolated Pool	-	MP	1	5	51.8	45-61	1	-	88	46	72.8	52-95	1	-	65
						2	1	-	53	0	-	-	32	-	-	0	-	-
						3	1	-	50	0	-	-	9	-	-	0	-	-
	2	410.9	Isolated Pool	-	MP	1	5	56.8	53-62	1	-	80	57	74.5	55-104	0	-	-
						2	0	-	-	1	-	104	25	69.5	51-85	0	-	-
						3	0	-	-	0	-	-	22	-	0	-	-	
Oct. 24/81	3	519.6	Isolated Pool	-	MR	1	5	46.8	45-50	0	-	-	71	67.0	49-97	0	-	-
						2	0	-	-	0	-	-	53	-	-	0	-	-
April 16/82	1	39.6	Isolated Pool	2.5	MR	1	7	50.6	45-56	1	-	82	47	67.7	48-106	0	-	-
						2	5	53.4	45-64	0	-	-	49	69.4	52-100	0	-	-
	1	34.0	Isolated Pool	-	MR	1	1	-	54	0	-	-	10	78.7	69-92	1	-	62
						2	0	-	-	0	-	-	16	77.1	56-90	0	-	-
	2	1.4	Isolated Pool	-	MR	1	4	56.7	52-63	0	-	-	3	72.7	68-78	1	-	72
						2	-	-	-	-	-	-	-	-	-	-	-	-
	3	15.0	Isolated Pool	4.0	MR	1	8	51.9	43-59	0	-	-	55	60.2	49-79	0	-	-
						2	12	50.6	40-58	0	-	-	57	59.6	47-79	0	-	-
	4	61.1	Isolated Pool	-	MR	1	0	-	-	0	-	-	51	70.6	52-98	0	-	-
						2	0	-	-	0	-	-	46	66.1	54-100	0	-	-
	5	13.2	Isolated Pool	-	MR	1	1	-	49	0	-	-	6	70.2	62-90	0	-	-
						2	0	-	-	0	-	-	7	69.7	53-90	0	-	-

1 MR = Mark-Recapture
MP = Multiple-Pass

TABLE C3.4
Multiple-Pass and Mark-Recapture Electrofishing from Side Channel D of the Morice River During the Fall 1981 and Spring 1982

							Species Captured											
							Steelhead Trout											
							Fry			Parr			Coho Salmon			Chinook Salmon		
Date	Site	Area Sampled (m^2)	Habitat Type	Water Temp. (C^o)	Electro-fishing Technique[1]	Pass No.	n	$\bar{x}$ length (mm)	Range	n	$\bar{x}$ length (mm)	Range	n	$\bar{x}$ length (mm)	Range	n	$\bar{x}$ length (mm)	Range
Oct. 25/81	1	365.4	Pool/Riffle	6.0	MP	1	14	48.5	40-63	6	78.8	73-87	23	61.2	53-74	2	-	60, 63
						2	10	46.2	37-65	3	71.0	67-78	11	61.3	55-68	4	66.7	63-74
						3	5	46.8	41-51	1	-	75	8	61.1	50-68	1	-	62
	2	212.8	Run	6.0	MP	1	12	46.5	38-65	3	76.5	68-91	12	65.8	58-83	1	-	59
						2	6	46.5	39-55	2	-	73, 82	1	-	62	0	-	-
						3	6	45.8	42-49	1	-	84	3	62.7	62-63	0	-	-
April 13/82	2	719.0	Pool	6.0	MR	1	43	46.7	33-65	13	79.3	71-130	16	66.1	36-88	5	66.0	61-72
						2	28	48.7	36-64	6	96.2	74-129	12	61.0	35-79	9	59.8	40-67
April 26/82	1	313.0	Pool	-	MR	1	6	44.0	41-51	11	85.1	67-141	53	62.2	51-80	9	69.6	63-76
						2	8	49.6	40-63	8	90.1	75-149	32	60.1	51-70	4	65.7	62-71

MR = Mark-Recapture
MP = Multiple-Pass

APPENDIX C4

Population Estimates for Juvenile Salmonids in Morice River Side Channels for October 1981 and April 1982

TABLE C4.1
Side Channel A Population Estimates for October 1981 and April 1982

Fish Species	Life Stage	Year of Study	Total[1] Species Captured	Initial Population Estimate for Area Sampled	95% Confidence Intervals	Total Area Sampled (m^2)	Total Wetted Area (m^2)	Correction Factor	Corrected Population Estimate for Total Wetted Area	Net Species Change	Corrected Population Estimate for Species Migration	Percent Over-Winter Survival
Steelhead Trout	Fry	Fall 1981	36	46	-	815	2,200	2.7	124	+1	125	16.0
		Spring 1982	20	10		1	20	1	20	0	20	
				10 (MR)								
	Parr	Fall 1981	7	7	-	815	2,200	2.7	19	-2	17	23.5
		Spring 1982	4	2	2-2	1	20	1	4	0	4	
				2 (MR)								
Coho Salmon	Juvenile	Fall 1981	60	74	-	815	2,200	2.7	200	-10	190	39.5
		Spring 1982	56	38	36-40	1	20	1	75	0	75	
				37 (MR)								
Chinook Salmon	Juvenile	Fall 1981	10	10	10-14[2]	815	2,200	2.7	27	-13	14	N/A
		Spring 1982	13	10	-	1	20	1	15	0	15	
				5 (MR)								
Total Species	All Juvenile Life Stages	Fall 1981	113	137	-	815	2,200	2.7	370	-24	346	32.9
		Spring 1982	94	114	-	1	20	1	114	0	114	

1 Includes marks from previous catch in mark-recapture technique (MR)

2 90% Confidence Interval

TABLE C4.2
Side Channel B Population Estimates for October 1981 and April 1982

Fish Species	Life Stage	Year of Study	Total[1] Species Captured	Initial Population Estimate for Area Sampled	95% Confidence Intervals	Total Area Sampled (m^2)	Total Wetted Area (m^2)	Correction Factor	Corrected Population Estimate for Total Wetted Area	Net Species Change	Corrected Population Estimate for Species Migration	Percent Over-Winter Survival
Steelhead Trout	Fry	Fall 1981	62	63	62-66	1,100	8,600	8.18	515	-4	511	10.6
		Spring 1982	53	43	43-50	300	300	1	54		54	
				11 (MR)								
	Parr	Fall 1981	19	22	-	1,100	8,600	8.18	180	-1	179	3.9
		Spring 1982	7	7	-	300	300	1	7		7	
Coho Salmon	Juvenile	Fall 1981	27	34	-	1,100	8,600	8.18	278	-7	271	65.7
		Spring 1982	83	34	34-35	300	300	1	178		178	
				144 (MR)								
Chinook Salmon	Juvenile	Fall 1981	33	34	33-39	1,100	8,600	8.18	278	-34	244	50.4
		Spring 1982	39	10	-	300	300	1	123		123	
				113 (MR)								
Total Species	All Juvenile Life Stages	Fall 1981	141	153	-	1,100	8,600	8.18	1,251	-46	1,205	30.0
		Spring 1982	182	362	-	300	300	1	362		362	

1 Includes marks from previous catch in mark-recapture technique (MR)

TABLE C4.3
Side Channel C Population Estimates for October 1981 and April 1982

Fish Species	Life Stage	Year of Study	Total[1] Species Captured	Initial Population Estimate for Area Sampled	95% Confidence Intervals	Total Area Sampled (m^2)	Total Wetted Area (m^2)	Correction Factor	Corrected Population Estimate for Total Wetted Area	Net Species Change	Corrected Population Estimate for Species Migration	Percent Over-Winter Survival
Steelhead Trout	Fry	Fall 1981	17	5 (MR)								
				12	-	1,200	1,250	1.08	18	0	18	N/A
		Spring 1982	38 (MR)	64	20-108	150	150	1	64		64	
	Parr	Fall 1981	3	3	-	1,200	1,250	1.08	3	0	3	33.3
		Spring 1982	1 (MR)	1	-	150	150	1	1		1	
Coho Salmon	Juvenile	Fall 1981	124	685 (MR)	189-1181							
			191	229	220-240	1,200	1,250	1.08	987	0	987	40.7
		Spring 1982	347 (MR)	402	349-455	150	150	1	402		402	
Chinook Salmon	Juvenile	Fall 1981	1	1	-	1,200	1,250	1.08	1	0	1	100.0
		Spring 1982	21 (MR)	1	-	150	150	1	1		1	
Total Species	All Juvenile Life Stages	Fall 1981	336	935	-	1,200	1,250	1.08	1,010	0	1,010	46.3
		Spring 1982	388	468	-	150	150	1	468		468	

1 Includes marks from previous catch in mark-recapture technique (MR)

TABLE C4.4
Side Channel D Population Estimates for October 1981 and April 1982

Fish Species	Life Stage	Year of Study	Total[1] Species Captured	Initial Population Estimate for Area Sampled	95% Confidence Intervals	Total Area Sampled (m^2)	Total Wetted Area (m^2)	Correction Factor	Corrected Population Estimate for Total Wetted Area	Net Species Change	Corrected Population Estimate for Species Migration	Percent Over-Winter Survival
Steelhead Trout	Fry	Fall 1981	53	72	57-119[2]	600	3,300	5.6	403	+5	408	43.6
		Spring 1982	85 (MR)	127	81-173	1,050	1,500	1.4	178		178	
	Parr	Fall 1981	16	18	-	600	3,300	5.6	101	+1	102	54.9
		Spring 1982	38 (MR)	40	28-52	1,050	1,500	1.4	56		56	
Coho Salmon	Juvenile	Fall 1981	58	64	-	600	3,300	5.6	358	+14	372	77.0
		Spring 1982	113 (MR)	203	126-280	1,050	1,500	1.4	286		286	
Chinook Salmon	Juvenile	Fall 1981	8	14	-	600	3,300	5.6	78	-15	63	93.7
		Spring 1982	27 (MR)	42	15-69	1,050	1,500	1.4	59		59	
Total Species	All Juvenile Life Stages	Fall 1981	135	168	-	600	3,300	5.6	941	+5	945	60.9
		Spring 1982	263	412	-	1,050	1,500	1.4	579		576	

1 Includes marks from previous catch in mark-recapture technique (MR)

2 90% Confidence Interval

APPENDIX C5

Dissolved Oxygen Content and Water Quality in
Morice River Main and Side Channels During Winter 1982

TABLE C5.1
Dissolved Oxygen Measurements in Side Channels of the Morice River During 1982

Date	Side Channel	Location[1]	Dissolved Oxygen (ppm)	Water Temp. (°C)	Comments
Feb. 11/82	C	Pool 1	6.9	1.0	
Feb. 11/82		Pool 2	6.9	1.0	
Feb. 11/82		Pool 3	5.5	2.0	
Feb. 11/82	D	Upper Fence	9.0	1.0	
April 4/82	A	Pool 1	3.0	2.0	
April 4/82		Pool 3	6.0	3.0	
April 6/82		Pool 3	6.7	4.0	
April 6/82	B	Pool 1	4.0	1.0	Ice cover
April 4/82		Pool 2	0.7	2.5	15 cm ice, 100+ dead fish
April 4/82		Downstream of Pool 2	3.8	5.5	Open water
April 4/82		Downstream of Pool 2	5.7	6.0	Open water
April 4/82		Downstream of Pool 2	2.6	9.0	18 fish dead 2 alive
April 4/82		Pool 3	2.5	2.5	
April 4/82		Pool 4	3.8	1.5	
April 4/82		Pool 5	4.1	4.0	
March 23/82	C	Pool 1	6.6	-	Ice cover
April 6/82		Pool 1	7.2	1.0	Ice cover
March 23/82		Pool 2	8.6	4.5	Seepage
April 6/82		Pool 2	8.0	1.0	Seepage
March 23/82		Pool 3	6.9	4.0	Seepage
April 6/82		Pool 3	7.2	3.0	Seepage
March 23/82	D	Upper fence	10.7	-	Open
March 23/82		Staff gauge	11.2	-	Ice cover
April 4/82	Mainstem	Lamprey Creek	7.8	3.0	

1 Refer to Section C, Figure 2.1

TABLE C5.2
Water Quality of the Mainstem and Side Channels of the Morice River, February 11, 1982

Parameter	Mainstem	Mainstem	Side Channel D	Side Channel D
pH (rel. units)	7.30	7.30	7.30	7.30
Nitrate/Nitrite (mg/l)	0.08	0.08	0.04	0.04
Ammonia (mg/l)	0.14	0.14	0.14	0.18
Kjeldahl Nitrogen (mg/l)	0.54	0.40	0.70	0.70
Tot. Organic Carbon (mg/l)	1	1	1	1
Sulphate (mg/l)	2.00	-	4.00	-
Total Iron (mg/l)	0.160	-	0.110	0.090

Parameter	Side Channel C			
	Pool 1	Pool 1	Pool 1	Pool 1
pH (rel. units)	7.20	7.10	7.20	7.30
Nitrate/Nitrite (mg/l)	0.11	0.11	0.12	0.12
Ammonia (mg/l)	0.04	0.01	<0.01	<0.01
Kjeldahl Nitrogen (mg/l)	1.60	1.40	0.30	0.40
Tot. Organic Carbon (mg/l)	2	2	1	1
Sulphate (mg/l)	-	-	-	-
Total Iron (mg/l)	-	-	-	-

TABLE C5.2 (Continued)

Parameter	Side Channel C Pool 2	Pool 2	Pool 2	Pool 2
pH (rel. units)	7.40	7.30	7.30	7.30
Nitrate/Nitrite (mg/l)	0.09	0.09	0.08	0.07
Ammonia (mg/l)	<0.01	<0.01	<0.01	<0.01
Kjeldahl Nitrogen (mg/l)	0.34	0.24	0.26	0.24
Tot. Organic Carbon (mg/l)	<1	<1	<1	<1
Sulphate (mg/l)	2.00	6.00	-	-
Total Iron (mg/l)	0.180	0.240	-	-

Parameter	Side Channel C Pool 3	Pool 3	Pool 3	Pool 3
pH (rel. units)	7.00	7.00	7.10	7.20
Nitrate/Nitrite (mg/l)	0.09	0.10	0.10	0.08
Ammonia (mg/l)	<0.01	<0.01	<0.01	<0.01
Kjeldahl Nitrogen (mg/l)	0.40	0.35	0.98	0.76
Tot. Organic Carbon (mg/l)	1	1	1	1
Sulphate (mg/l)	-	8.00	-	-
Total Iron (mg/l)	0.120	0.110	-	-

TABLE C5.3
Water Quality of the Mainstem and Side Channels of the Morice River, April 6, 1982[1]

Parameter	Mainstem	Side Channel B Pool 1	Side Channel C Pool 1	Side Channel D Pool 1
pH (rel. units)	6.65	6.75	6.45	6.50
Conductivity (umhos/cm)	50	80	45	150
Hardness (mg/l $CaCO_3$)	24.0	38.5	21.5	68.5
Alkalinity (mg/l)	21.0	35.0	19.0	69.0
Chloride (mg/l)	<0.1	<0.1	<0.1	<0.1
Dissolved Solids (mg/l)	13	37	21	67
Suspended Solids (mg/l)	<1	<1	<1	<1
Sulphate (mg/l)	<2.00	2.00	3.00	4.50
Turbidity (NTU)	0.45	1.05	0.50	0.40
Total Calcium (mg/l)	7.6	12.0	7.0	20.0
Total Magnesium (mg/l)	1.6	1.4	1.2	2.6
Total Potassium (mg/l)	0.52	0.64	0.52	0.76
Total Sodium (mg/l)	1.45	1.65	1.30	5.40
Nitrate/Nitrite (mg/l)	0.06	0.08	0.04	0.04
Ammonia (mg/l)	<0.02	0.05	<0.02	<0.02
Total SiO_2 (mg/l)	4.3	7.3	4.3	7.0
Total PO_4 (mg/l)	0.010	0.020	0.015	0.015
Total Cadmium (mg/l)	<0.001	<0.001	<0.001	<0.001
Total Chromium (mg/l)	<0.025	<0.025	<0.025	<0.025
Total Copper (mg/l)	0.001	<0.001	0.001	<0.001
Diss. Iron (mg/l)	0.040	0.140	0.060	0.020
Total Iron (mg/l)	0.100	0.350	0.200	0.090
Total Lead (mg/l)	0.004	0.003	0.006	0.008
Total Mercury (mg/l)	0.0003	0.0002	0.0003	0.0002
Total Zinc (mg/l)	0.006	0.004	0.006	0.080

1 Data for each location are means of 2 samples

SECTION D

MOVEMENTS OF JUVENILE COHO SALMON FROM A POND AREA ADJACENT TO THE MORICE RIVER DURING 1982

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LIST OF FIGURES

1.0 INTRODUCTION

Studies conducted on the Morice River in 1979 indicated that ponds adjacent to the main river channel provided rearing areas for significant numbers of juvenile coho salmon (Section A). Minnow trap catches at two pond sites were approximately 10 times greater than in adjacent main river sites, and it was estimated that up to 20 such pond areas may be used by juvenile coho salmon in Reach 2 of the Morice River alone.

Pond and slough areas adjacent to streams provide important overwinter habitat for coho salmon in coastal B.C. (Bustard and Narver 1975; Tschaplinski and Hartman 1983) and Washington State rivers (Peterson 1980; Cederholm and Scarlett 1981). It is thought that movements into these coastal pond areas is in response to rising streamflows in the main river, and that fish entering the ponds avoid high freshet flows characteristic of coastal streams during the winter. The use of ponds adjacent to interior rivers, such as the Morice River, which typically have low winter flows has not been reported previously.

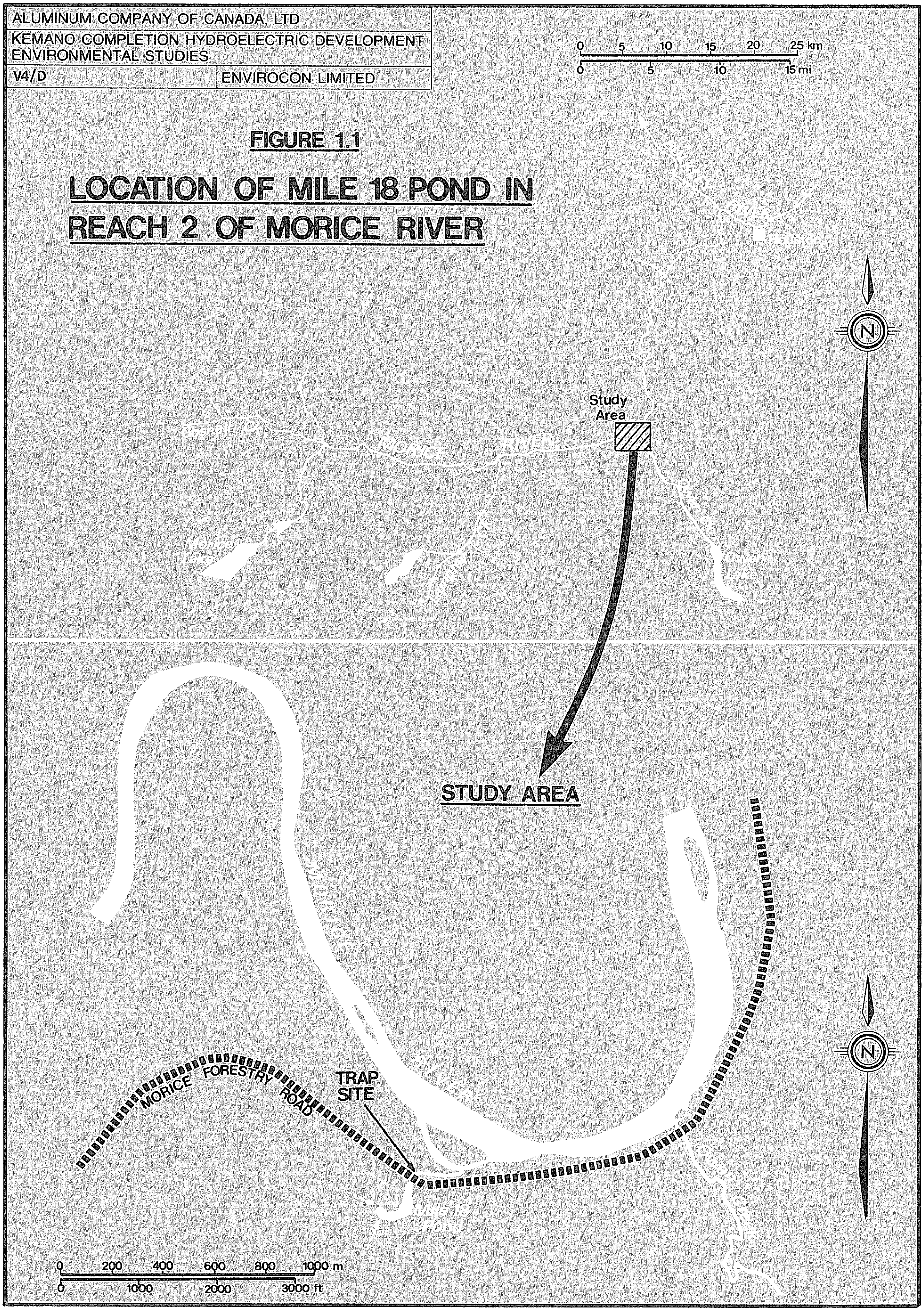
The objective of this study was to determine the timing and extent of coho salmon smolt movements to and from a pond site on the Morice River.

Mile 18 Pond is located just upstream of Owen Creek in an old river channel adjacent to the Morice River (Figure 1.1). The pond has a surface area of 0.5 ha, a maximum depth of 1 m and a mean depth of 0.6 m. The pond has abundant aquatic vegetation around its margin and is covered with ice and snow from November to May. The pond is located above the high water level of the Morice River and is connected to a side channel of the main river by a small stream 250 m long. Flows in this outlet stream do not exceed 0.1 m^3/sec during spring snow melt, and are very low from early July onward through the summer. Pockets of open water and a slight flow during the winter suggest that the pond area is influenced by groundwater input from adjacent slopes. There is no spawning potential in the inlet or outlet streams to Mile 18 Pond; all fish present migrate from the Morice River.

2.0 METHODS

Upstream and downstream traps were installed in the outlet tributary of Mile 18 Pond on May 14, 1982, three days after ice had disappeared from the pond surface. The fence material was 6 mm mesh.

The traps were checked every 2-3 days until fish movements started, after which time they were checked daily. After June 20th, when fish movements had virtually stopped, they were examined less frequently. Flows were too low in the outlet creek during July and August to permit fish movement. Flows in the creek were adequate for fish movements during several rainy periods in September and October, and traps were checked periodically during these periods until freeze-up in early November. All coho salmon smolts were measured and scales were removed from 67 fish for aging by the Department of Fisheries and Oceans. All other juvenile fish moving upstream and downstream were measured except on days when large numbers were moving; on those days a subsample was measured. After June 4, adipose fins were clipped on upstream fish to determine if these were the same juveniles that were subsequently captured in downstream traps. Water temperature and water height (at a staff gauge) were recorded during each visit to the trap site.


ALUMINUM COMPANY OF CANADA, LTD
KEMANO COMPLETION HYDROELECTRIC DEVELOPMENT ENVIRONMENTAL STUDIES
V4/D
ENVIROCON LIMITED
FIGURE 1.1
LOCATION OF MILE 18 POND IN REACH 2 OF MORICE RIVER
0 5 10 15 20 25 km
0 5 10 15 mi
BULKLEY RIVER
Houston
Study Area
Gosnell Ck
MORICE RIVER
Owen Ck
Morice Lake
Lamprey Ck
Owen Lake
N
STUDY AREA
MORICE RIVER
MORICE FORESTRY ROAD
TRAP SITE
Mile 18 Pond
Owen Creek
0 200 400 600 800 1000 m
0 1000 2000 3000 ft

3.0 RESULTS

A total of 285 coho salmon smolts was captured in the downstream trap during a 35-day period between May 26 and June 29, inclusive (Figure 3.1). Water temperatures were 6°C at the start of downstream migration and were 20°C near the end (Figure 3.2). Of the 67 smolts aged, 52 (78%) were age 1+ and 15 (22%) were age 2+. Smolts were large, averaging 110 mm fork length (range: 72 to 145 mm) (Figure 3.3). Smolts captured during the first 16 days averaged more than 20 mm longer than those captured in the last 19 days (118 mm compared to 97 mm fork length). Peterson (1980) reported that larger coho smolts migrated before their smaller cohorts. Smolts from Mile 18 Pond were nearly 30 mm longer, on average, than smolts captured in the Morice River during mid-May, 1982.

Juvenile coho salmon were moving into Mile 18 Pond during the same period as smolt migration downstream. The migrants were comprised of age 0+ and age 1+ fish; most were yearlings. A total of 657 juvenile coho was captured in the upstream trap with peak numbers in the first week of June (Figure 3.1), a period of rapidly rising flows in the mainstem Morice River (Figure 3.2). Many newly-emerged coho salmon fry, which were less than 45 mm fork length, could move freely through the fence screening and were observed upstream of the traps. Since these fish were not counted, the total number of upstream migrants in 1982 is not known. A total of 92 downstream migrants which were not smolts were captured during the same period (Figure 3.1). After June 4, the adipose fin of upstream migrants was clipped, and 30 of 70 fish captured in downstream traps after this date had marks, indicating that at least some fish which had moved upstream subsequently moved back downstream. Water temperature in the Morice River was 5°C at the beginning of the immigration into the pond tributary where the temperature was 6°C and rising quickly at this time (Figure 3.2). Only five juvenile coho downstream migrants (non-smolts) were captured during the September and October period. These fish were larger than the May-June downstream migrants and averaged 105 mm in fork length. No juvenile coho were captured in the upstream trap after the end of June.

A total of 18 newly-emerged chinook salmon fry was captured in the downstream trap and 11 were captured in the upstream trap. Since these fry could freely move through the fence screening, the total number of these fish moving could not be determined. No chinook salmon smolts were captured, suggesting that chinook salmon fry do not remain in Mile 18 Pond. A single Dolly Varden char moved upstream in early June and downstream the following day.

4.0 DISCUSSION

Coho salmon smolt migration out of and juvenile coho immigration into Mile 18 Pond was restricted to a short period in May and June immediately after ice break-up on the pond. No movement occurred during July and August and a very small number of juveniles left the pond during September and October. Little migration occurred into Mile 18 Pond when water temperatures were less than 5°C. This is similar to findings in a Washington study (Cederholm and Scarlett 1981) where immigration slowed noticeably when main river temperatures fell below 6°C. It is highly doubtful that any movements occurred from November through April due to very low flows and cold water temperatures.

The timing of movements, particularly the immigration into the pond, is very different from that reported in coastal pond and slough systems (Cederholm and Scarlett 1981; Tschaplinski and Hartman 1983). Coho immigration in these coastal areas typically occurs from September to January, coinciding with freshets resulting from winter rains. The immigration of coho into Mile 18 Pond coincided with rapidly rising early summer flows in the Morice River, suggesting that these juveniles were also avoiding freshet conditions in the mainstem river. High flows resulting from spring snowmelt typically occur from mid-May through July in the Morice River. Similarly, flows in the outlet of Mile 18 Pond are the highest during May and June, when juveniles would have continuous access to the pond from the main river. The pond provides productive summer rearing habitat while the main river is in freshet, as well as a stable winter refuge not subject to dewatering or subsurface ice conditions which may be encountered in many channels of the Morice River.

The rearing of 285 coho salmon smolts in Mile 18 Pond is significant, particularly since there are many similar pond environments throughout the Morice River and its tributaries. The large size of smolts produced in the pond suggests that it is a productive habitat for juvenile coho growth.

It is not known whether this 0.5 ha pond is at capacity for smolt production. The only data for comparison are from coastal Washington ponds (Peterson 1980). Coho salmon smolt migration from two ponds (1.3 and 0.8 ha) was 1,500 and 3,000, respectively. The author suspected that pond morphometry was the major difference between these two ponds, and he stressed the importance of deep water (greater than 1 m) areas to provide refuge from predation. These figures suggest that, with increased natural recruitment or artificial stocking, more smolt production may be possible in Mile 18 Pond. However, substantial differences in the length of growing season and the basic

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FIGURE 3.1

MOVEMENT OF JUVENILE COHO THROUGH TRAPS LOCATED AT THE OUTLET OF MILE 18 POND

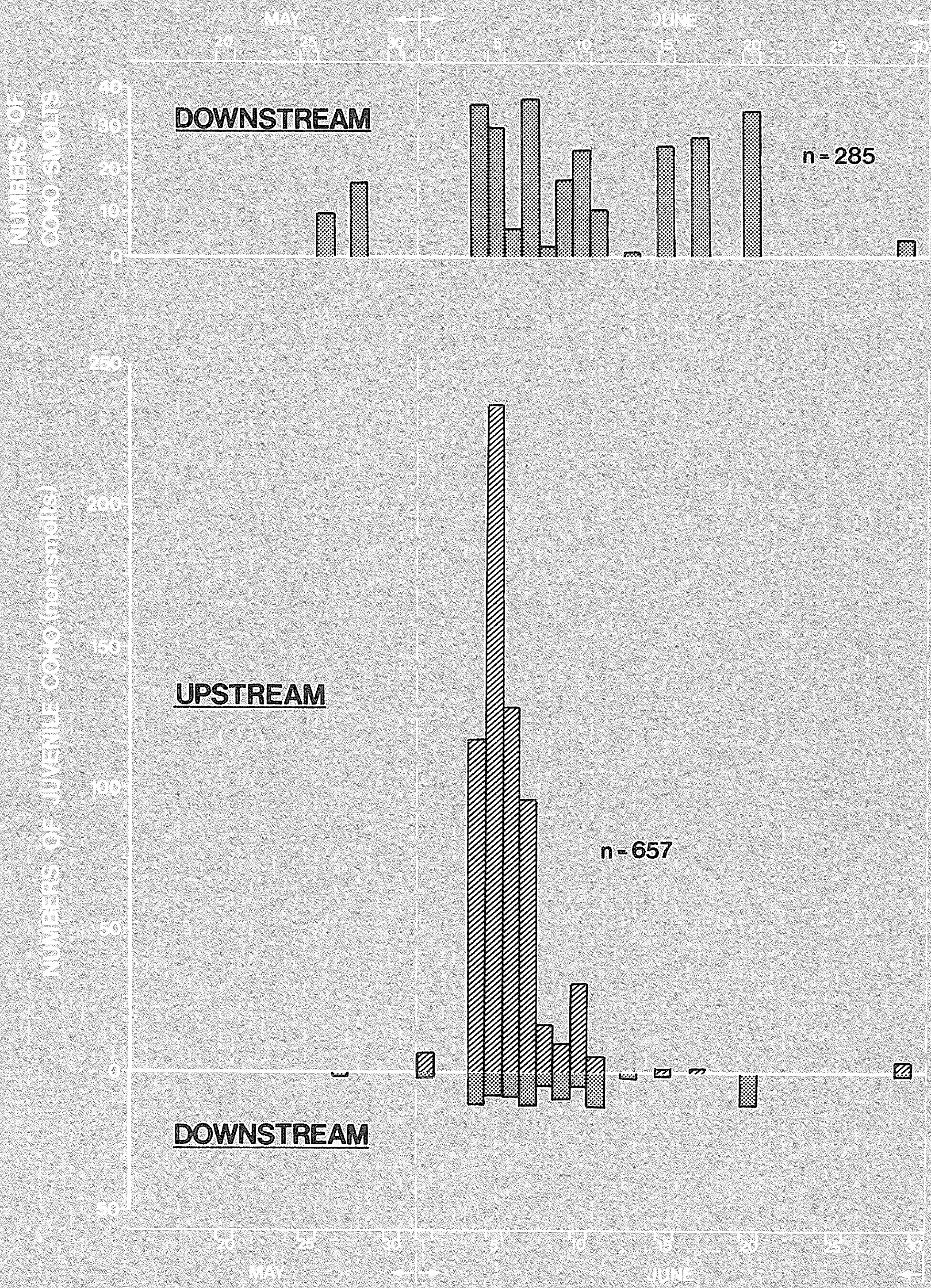

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FIGURE 3.2

TEMPERATURES RECORDED AT MILE 18 POND OUTLET AND THE MORICE RIVER AT OWEN CREEK AND DISCHARGE OF THE MORICE RIVER, APRIL-OCTOBER 1982

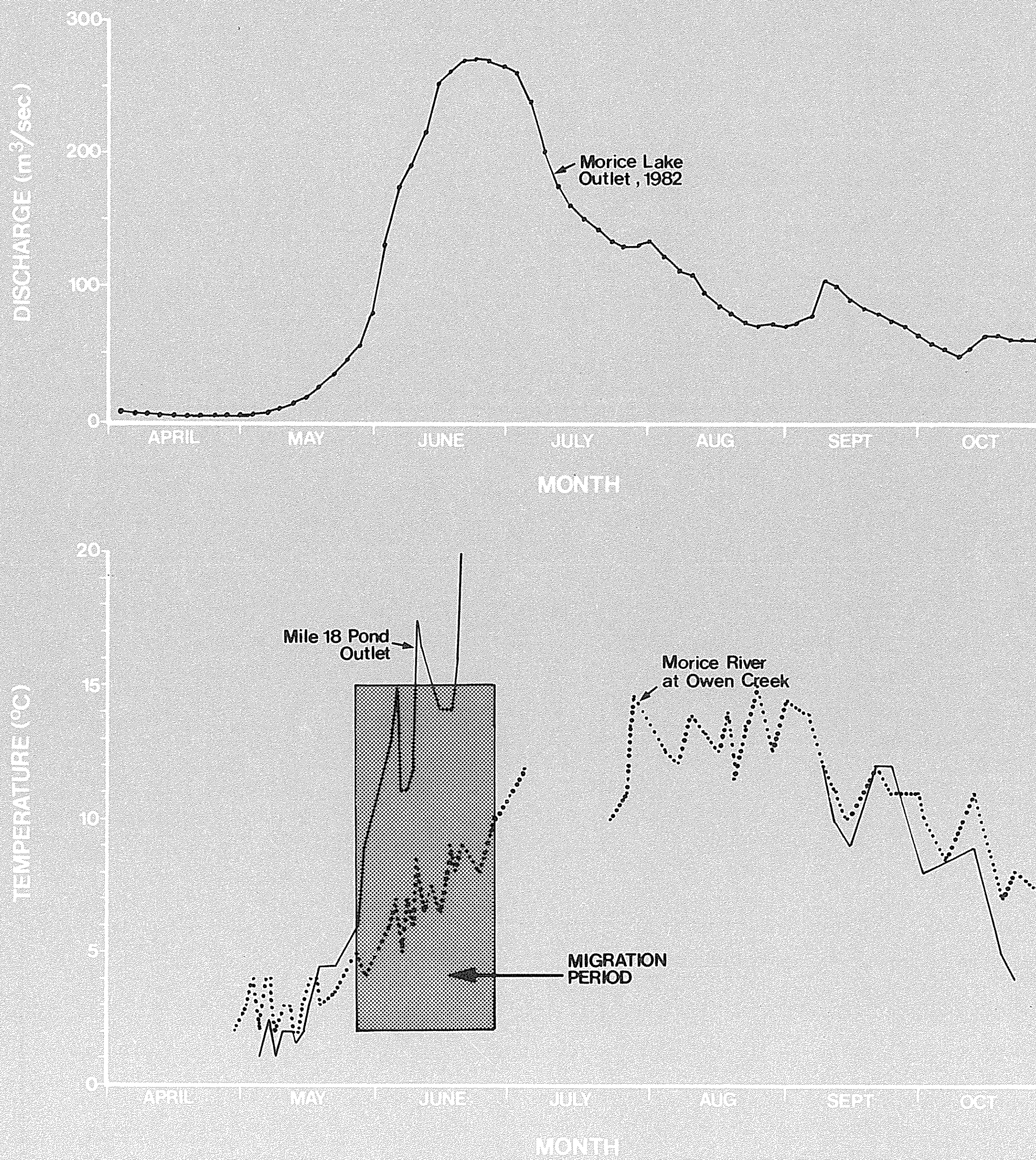

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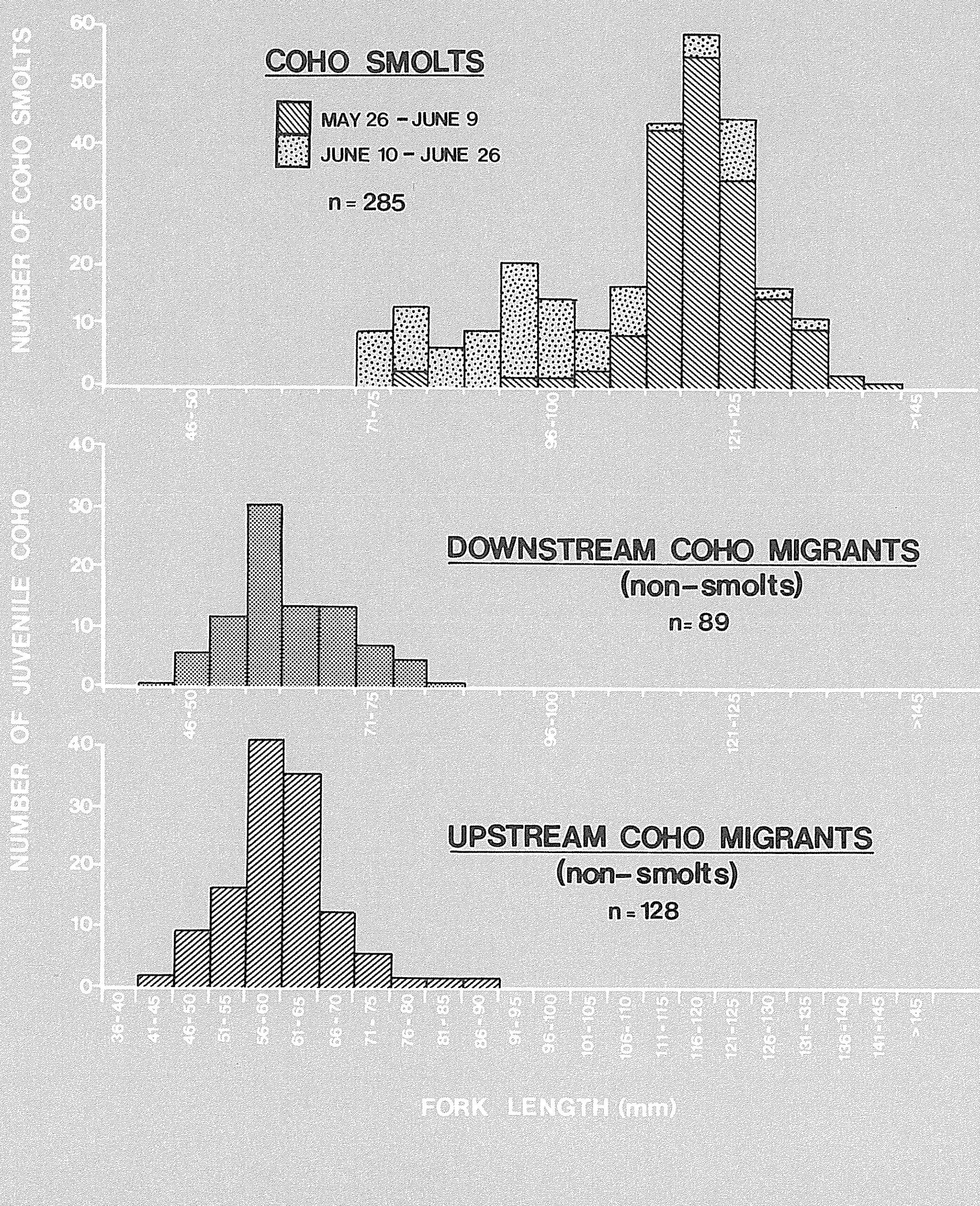
FIGURE 3.3

LENGTH-FREQUENCY DISTRIBUTION OF JUVENILE COHO IN MILE 18 POND



ecology of coastal and interior pond systems limits the reliability of production comparisons. A more intensive study of coho salmon movements throughout the year in addition to some stocking experiments could provide a better basis for evaluating potential production of smolts from this and similar ponds.

5.0 SUMMARY

Juvenile coho migration studies were conducted on Mile 18 Pond between May and November 1982 to determine the timing and extent of coho salmon smolt movements from a pond site adjacent to the Morice River. The 0.5 ha pond had a maximum depth of 1 m, a mean depth of 0.6 m, and is connected to a side channel of the Morice River by a stream 250 m long.

A total of 285 coho salmon smolts was caught in a downstream trap between May 26 and June 28, 1982. The large size of smolts produced in the pond suggests that it is a productive habitat for juvenile coho growth. A total of 657 juvenile coho was caught in the upstream trap, with peak immigration in June. The immigration of juvenile coho into Mile 18 pond coincided with rapidly rising flows in the Morice River, suggesting that these juveniles may have been avoiding freshet conditions in the mainstem river. Water temperatures ranged from 6°C to 20°C in the connecting stream during the migration period.

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SECTION E

STEELHEAD TROUT SPAWNING AND FRY EMERGENCE STUDIES IN THE MORICE RIVER DURING 1982

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1.0 INTRODUCTION

Studies to determine the timing and location of steelhead trout spawning and subsequent fry emergence were conducted from May to September, 1982 in the Morice River. These spawning studies provide a third year's estimate of the timing of steelhead trout spawning in the upper Morice River and supplement information presented in Section A. Fry emergence timing was examined at spawning sites identified in this study. Data describing the timing of steelhead trout fry emergence in the Morice River had not been collected prior to this study.

2.0 METHODS

2.1 Spawning Studies

Swimmers in dry suits examined a variety of sites in the upper 15 km of the Morice River on four occasions during May and June, 1982. This section of the river from the outlet of Morice Lake to Gosnell Creek remains ice-free throughout the winter, and visibility is generally adequate for underwater observation until early June. Details describing the number and location of adult steelhead trout were recorded. Nose velocity (0.12 m above substrate) was measured at suspected redd sites using a Marsh-McBirney Model 201 current meter. At discharges greater than 150 m^3/sec, the main channel was too hazardous to swim and observations were restricted to side channel sites and limited stretches of the mainstem where steelhead trout spawners had been previously observed. During high flow conditions in mid-June, angling at known steelhead spawning sites was conducted as an alternate method to assess steelhead trout presence.

Water temperatures were recorded from June 15 to the end of fry emergence in late August using a Kahl thermograph installed 1 km downstream from the outlet of Morice Lake. Prior to this, spot water temperatures were recorded by field crews whenever possible at a variety of sites in the upper river.

Morice River discharge measurements were obtained from the Water Survey of Canada gauging station (Station No. 08ED002) located 1 km downstream of the Morice Lake outlet.

2.2 Fry Emergence Studies

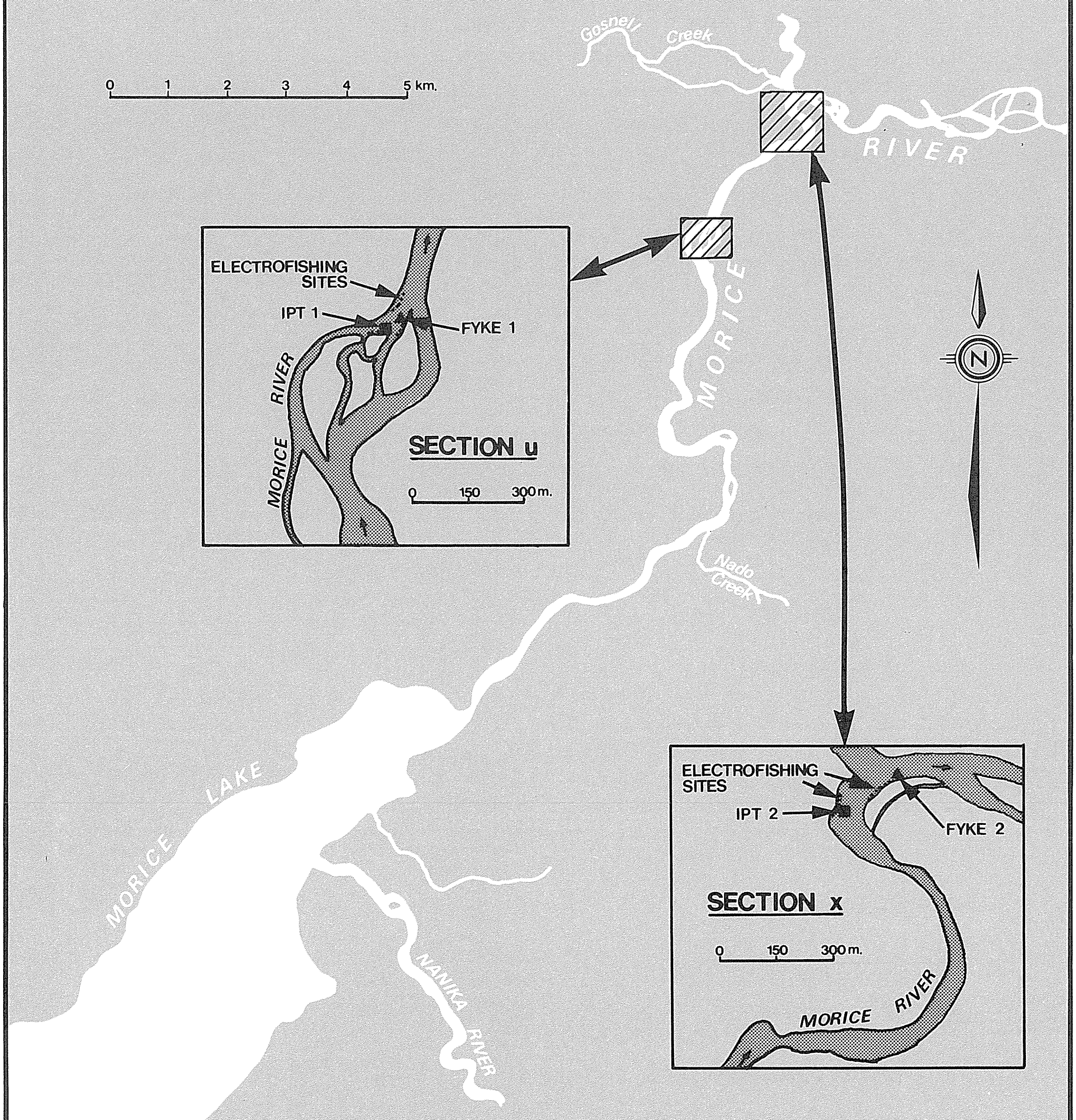
Two approaches were used to determine the timing of fry emergence. The first was to conduct downstream trapping in the immediate vicinity of spawning locations. The second approach was to electrofish selected sites in the vicinity of spawning areas on a repetitive basis throughout the emergence period.

2.2.1 Downstream Trapping

Incline plane traps (IPTs) were maintained at two sites in the upper Morice River from August 4 to September 3, 1982. In a large side channel, a wooden 61 x 91 cm IPT (IPT 1) with 13 m of fence panel (covered with 3-4 mm mesh hardware cloth) were installed nearshore downstream of a spawning area identified in early June, 1982 (Figure 2.1).

FIGURE 2.1

LOCATION OF DOWNSTREAM TRAPS AND ELECTROFISHING SITES IN THE MORICE RIVER, AUGUST 1982



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A second similar-sized IPT (IPT 2) with a 3.5 m fence panel was located on the left margin of the main channel, approximately 200 m upstream of the Gosnell Creek confluence with the Morice River. The faster, deeper water of the main channel at this lower site restricted the amount of fencing which could be utilized.

Two fyke nets with 1.2 x 1.2 m^2 openings tapering to a 12 cm diameter exit hole and joined to live boxes by a 2 m long plastic pipe were installed, one near each IPT, to supplement catch data (Figure 2.1). Fence panels, 3 m long were used as leads to the fyke nets. Fyke 2 was removed after 1 week because of fry mortality problems.

Fish were collected from all traps on a daily basis, anesthetized with 2-phenoxyethanol, measured (fork lengths) and then released downstream of Gosnell Creek. A sample of 30 steelhead trout fry and up to 10 coho and chinook salmon fry were retained overnight for weight determination. Measurements were taken with a Mettler electronic balance, accurate to 0.001 gm. These fish were released the following morning downstream of the trap sites.

2.2.2 Electrofishing

Electrofishing sites sampled on a repetitive basis provided an alternate means of assessing the timing of steelhead trout fry emergence. Approximately 400-500 m^2 of fry habitat was selected in the vicinity of each of the two trapping sites (Figure 2.1) and was sampled every third day from July 27 to September 3 using a Smith-Root Model VII electroshocker. A crew of two worked their way upstream through the same sites during each collection. All fish captured were measured and released downstream of the sample sites. After August 14, a sample of fry was retained (live) to obtain additional weight measurements.

2.2.3 Fry Quality

Condition factor (CF) and a developmental index (KD), as outlined in Bams (1970), were determined for steelhead fry on a daily basis as follows:

$$CF = \frac{10^2 \times W}{L^3}$$

$$K_D = 10 \sqrt[3]{W \quad L}$$

where W = weight in milligrams

L = fork length in millimeters

3.0 RESULTS AND DISCUSSION

3.1 Steelhead Trout Spawning Studies

Observations in the vicinity of the spawning grounds indicated that most steelhead trout spawning occurred during the last week of May and the first week of June (Table 3.1), similar to timing in 1979 (Section A). However, these conclusions are limited by the wide time interval between observations, and by restricted visibility after the first week of June.

Since steelhead trout observed on May 20 were in bright condition and not in the immediate vicinity of spawning gravels, most spawning had probably not started. Discharge on May 20 was 33.4 m^3/sec, the lowest on record for this date. By the following week (May 27), the discharge had nearly doubled (Figure 3.1), and some paired fish were observed, suggesting that spawning had commenced. By June 8, no fish were observed in the lake outlet area, and of the 13 steelhead trout observed in downstream sites, all but two were single fish. It is assumed that these were males remaining in the vicinity of redd sites after spawning, a behaviour similar to that reported for male steelhead trout in the Chilko River (Spence 1980, 1981). Everest (1973) and Winter (1976) have suggested that male steelhead trout arrive earlier, and leave spawning areas later than females, and that spawning often occurs over a 3 to 7 day period. No fish were observed or angled after June 14 despite repeated examination of sites which had been used by steelhead trout the week before. Spawning was probably completed by this time, however, poor visibility limited observations. The timing of spawning for steelhead trout in the Morice River is similar to that reported for a number of other streams with summer runs of steelhead (Table 3.2). Spawning in these sytems typically occurs from mid-May through to mid-June.

Water temperatures during the main spawning period (May 20 - June 9) ranged from 3-6°C (Table 3.1). This is slightly lower than temperatures recorded during the 1979 spawning period (5-7°C) and is generally lower than temperatures recorded for steelhead trout spawning in most other systems (Table 3.2). The B.C. Fish and Wildlife Branch (pers. comm., I. McGregor) found that steelhead trout in Thompson River tributaries typically spawn at 3-6°C and suggests that the actual time of spawning may be related more to increasing discharge rather than water temperature. The broad range of temperatures at which spawning occurs throughout the Skeena River and its tributaries further suggests that factors other than temperatures may be important in determining time of spawning.

TABLE 3.1
Summary of Results from Snorkel Surveys Conducted in the Upper Morice River Between May 20 and June 14, 1982

Date	Temperature (°C) Lake Outlet	Temperature (°C) Above Gosnell	Discharge (m^3/sec)	Section Surveyed by Snorkelling	Number of Steelhead	Remarks
May 10	3		14.1		1	Very low discharge. Aerial reconnaissance.
May 20	3	5	33.4	Morice Lake to below Nado.	11	3 swimmers. All but one were fish in upper 2 km. No apparent spawning activity.
May 27	3-4	-	59.2	Morice Lake to Nado.	13	1 swimmer. Some evidence of paired fish. Fish observed from boat holding in spawning area.
June 8-9	5	6	192-200	Upper 1 km and all sidechannels to Gosnell.	13	2 swimmers. No fish observed in the upper section. Most steelhead found in 3 km stretch above Gosnell Creek. Most observations were of single fish. Only 1 pair observed.
June 14	-	6	256	Areas where fish were observed on June 8-9.	0	No fish observed despite repeated passes through areas which held steelhead previously. Visibility low but should have seen fish if they were present.
June 16	6	7	262	All sites that held fish previously	0	Angled specific areas to determine whether fish were present.

Steelhead trout were observed in six spawning locations (Figure 3.2), similar to those observed during the 1979 studies (Section A). No new spawning locations were identified in 1982. Although these observations suggest that steelhead trout may be quite specific in their choice of spawning sites, radio telemetry studies conducted by Spence (1981) in the Chilko River suggest that steelhead trout spawning distributions can vary considerably from year to year in that system.

Spence (1981) reported that most summer steelhead trout in the Chilko River spawned in side channels and on the crests of chinook salmon redds. Five of the six spawning areas identified during 1982 in the Morice River are also extensively used by chinook salmon (Sites A, B, C, U and X on Figure 3.2). It is not known whether the side channel at Site 0 is used by chinook salmon spawners.

Nose velocities at 11 areas suspected to be redds ranged from 46-86 cm/sec while depths ranged from 70-175 cm (Table 3.3). Although nose velocities recorded during spawning are similar to those reported in other rivers (Smith 1973; Bovee 1978), the upper depths are greater. This may be a reflection of the larger size of the Morice River. If so, this suggests that upper depth limits are less critical than velocity in determining spawning preference.

3.2 Steelhead Trout Fry Emergence Studies

The absence of fry in electrofisher samples on July 27 suggests emergence had not begun (Appendix E1, Table E1.1). The low electrofishing catches on August 4 suggest that a small part of the emergence occurred before the traps were installed on August 5. Peak fry emergence in 1982 occurred during the period from August 9 to 13 (Figure 3.3). The IPT trap results indicated that 80% of the fry emergence occurred during a 12-day period from August 8 to 19. Based on these data, fry emergence occurred after freshet which typically peaks from mid-June to mid-July (Figure 3.1).

Fry catches in the IPTs were likely a better indicator of emergence timing since conditions at the traps changed the least during the study, they were checked daily, and more fish were caught by IPT traps than by electrofishing. Electrofishing sites had to be changed during the study as water levels dropped. From mid-August onward, a higher proportion of fry captured at the electrofishing sites were larger than the 27-32 mm fork length typical of newly-emerged fry (Appendix E1, Table E1.1). Presumably, these larger fry had taken up residence in the sample areas, and their presence tended to extend the emergence timing curve derived from the electrofishing

FIGURE 3.1: MEAN DAILY WATER TEMPERATURE AND DISCHARGE IN THE UPPER MORICE RIVER (lake outlet), MAY–AUGUST 1982

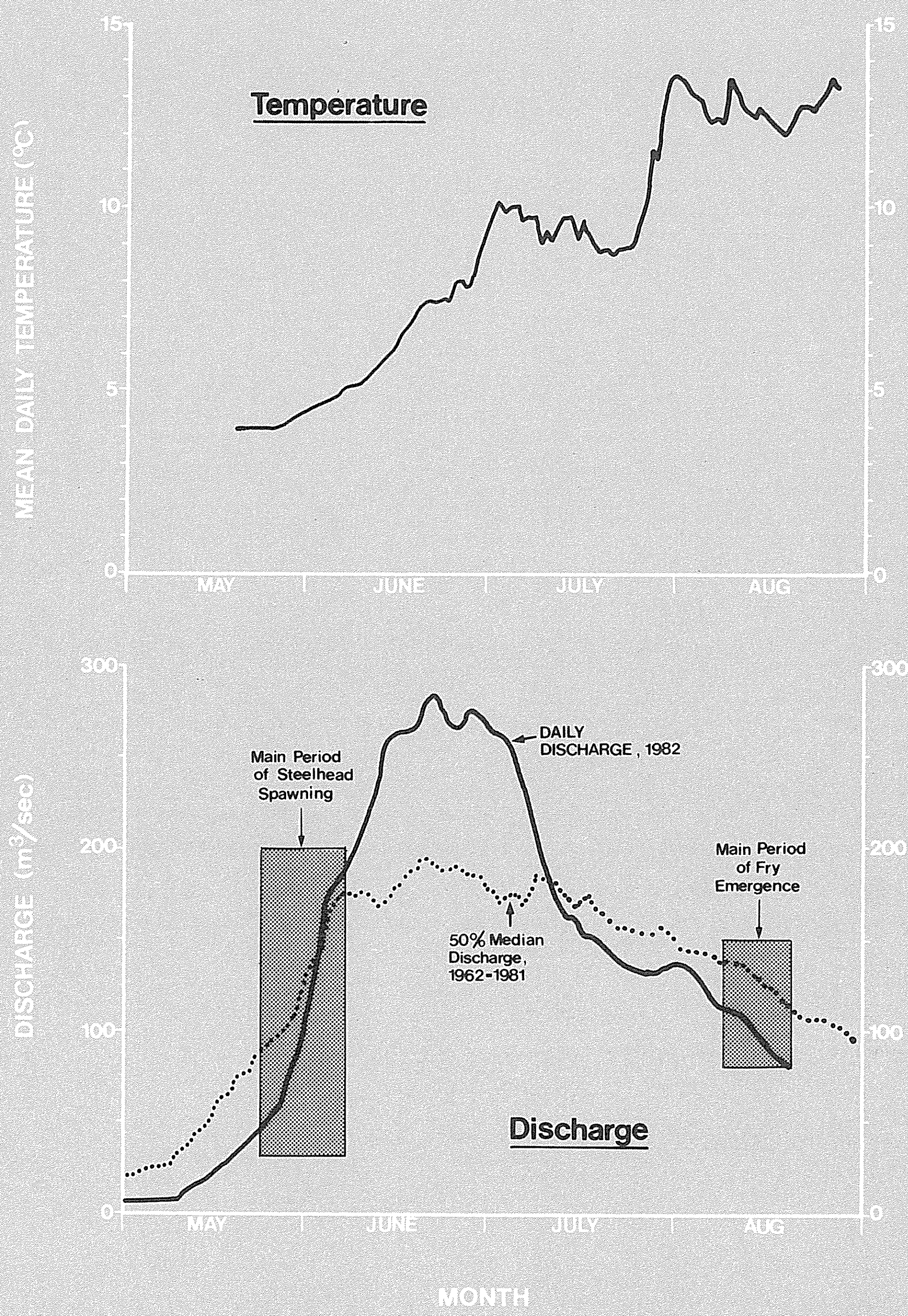

FIGURE 3.2

LOCATION OF STEELHEAD SPAWNING AREAS IN THE MORICE RIVER, 1982

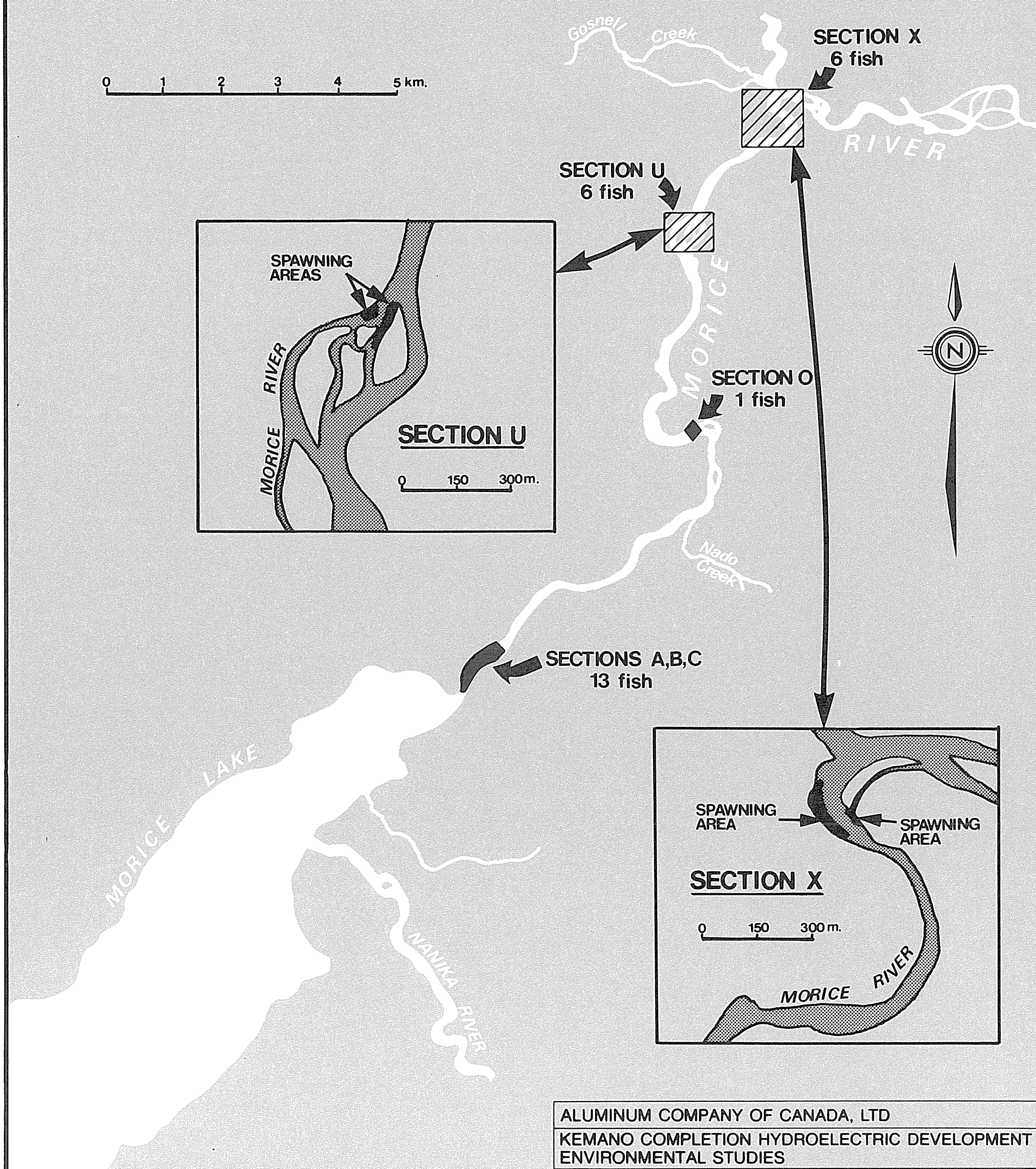

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TABLE 3.2
Spawning Dates and Water Temperatures in Other Summer Steelhead Trout Systems

Location	Time of Spawning	Temperature Range (°C)	Source of Data
Morice River			
tributaries	May 15 - June 7	8 - 12	Section A
mainstem	May 7 - June 15	5 - 7	Section A
Chilko River 1979	May 15 - June 7	6 - 7.5	Spence (1980)
Chilko River 1980	May 12 - June 9	5.5 - 11	Spence (1981)
Zymoetz River			
mainstem	up to 2nd week of June	6 - 8	M. Lough (pers. comm.)[1]
Clore River	last 2 weeks of May	6 - 7	M. Lough (pers. comm.)
Kitwanga River	2nd and 3rd week May	12	M. Lough (pers. comm.)
Shegunia River	June 2	7	M. Lough (pers. comm.)
Skeena River			
sidechannels	June 2	12.5	M. Lough (pers. comm.)
Toboggan Creek	May 15-18	8 - 11	M. Lough (pers. comm.)
Thompson River			
tributaries	mid-May to 1st	3 - 6	I. McGregor (pers. comm.)[2]
mainstem	week of June	10 - 14	I. McGregor (pers. comm.)
Rogue River	Jan. - Feb.	7.5	Everest (1973)

1 Mike Lough, B.C. Fish and Wildlife Branch, Smithers, B.C.

2 Ian McGregor, B.C. Fish and Wildlife Branch, Kamloops, B.C.

TABLE 3.3
Physical Characteristics of Suspected Steelhead Trout Redd Sites Measured on June 8 and 9, 1982 in the Upper Morice River

				Nose Velocity (cm/sec)			Depth (cm)		
Fish #[1]	Site[2]	Channel	Substrate (cm)	Right	Left	$\bar{x}$	Right	Left	Mean
1	O	Side	1-15	80	64	72	68	72	70
2	U	Side		75	96	86	112	69	90
3	U	Side		52	93	72	112	43	78
4	U	Side	No measurements made.						
5	U	Side		51	42	46	92	88	90
6	U	Side		63	61	62	144	133	138
7	U	Side		72	78	75	122	114	118
8	X	Main		72	68	70	116	138	127
9	X	Main	0-20	46	55	50	86	90	88
10	X	Main	10	50	52	51	110	102	106
11	X	Main		55	60	58	114	128	121
12 & 13	X	Main		60	40	50	175	174	175

	Range	Mean
Nose Velocities	46-86 cm/sec.	62.9 cm/sec
Depth	70-175 cm	109.2 cm

1 All fish except 12 & 13 were single fish

2 Refer to Figure 3.2 for specific location

sample into late August. To correct for this, fry greater than 32 mm fork length were not considered newly-emerged and were not used in deriving the emergence timing curves in Figure 3.3.

Previous incidental observations in the Morice River (Section A) had suggested that most steelhead trout emergence occurred between August 15 and September 15. The results of the 1982 studies indicate that the bulk of emergence occurs earlier, and that it is virtually complete by the end of August. The 1982 emergence timing is comparable to that reported for steelhead trout fry emergence in the Suskwa River, another tributary of the Bulkley River (Chudyk 1981). Approximately 80% of fry emerging from an incubation box in this system did so during an 11-day period between August 6 and 16th.

The best estimate of the number of accumulated temperature units (ATUs) from egg deposition to emergence is 664 (Appendix E1, Table E1.2). This is based on the 644.6 shown plus a correction of 19 ATUs to account for a 0.5^{o}C/day warming trend between the thermograph location at the outlet of Morice Lake from July 3 onward, and the Gosnell Creek area, where fry trapping studies were conducted. The estimated number of ATUs assumes that peak spawning occurred on June 1 and peak emergence occurred on August 11. Chudyk (1981) reports Suskwa River steelhead required 615 to 627 ATUs to emergence, which is slightly lower than the best estimate from this study and represents only a 4 day difference in peak emergence time. Skagit River summer steelhead require 565 ATUs to button-up (or fully absorb their yolks) (Stober et al. 1981). Estimates of maximum and minimum numbers of degree days required to emergence for Morice River steelhead trout are as follows:

Maximum	(assumes May 20 to August 20) =	826 ATUs
Minimum	(assumes June 10 to August 5) =	537 ATUs
Best Estimate	(assumes June 1 to August 11) =	664 ATUs

Detailed data describing newly-emerged steelhead trout fry length, weight, condition factor (CF) and a developmental index (KD) are provided in Figure 3.4.

4.0 SUMMARY

Observations of steelhead trout spawning in the upper Morice River during May and June 1982 suggested that most spawning occurred during the last week of May and the first week of June. This was similar to 1979 observations but later than 1980 observations (Section A). Spawning occurred during rapidly increasing spring flows. A review of other summer steelhead trout systems suggests that increasing discharge associated with the spring freshet may be more important in determining spawning timing than specific water temperatures. The four areas identified as spawning sites during the 1982 studies were in similar locations to areas used in 1979.

Most steelhead trout fry emergence in 1982 occurred during a relatively short period in August, peaking between August 9 - 13. The best estimate of the number of accumulated temperature units from egg deposition to emergence is 664 ATUs, slightly higher than reported for a nearby tributary of the Bulkley River.

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FIGURE 3.3: TIMING OF STEELHEAD FRY EMERGENCE BASED ON DATA FROM INCLINED PLANE AND FYKE TRAPS AND ELECTROFISHING SITES IN AREAS 1 & 2, MORICE RIVER, 1982

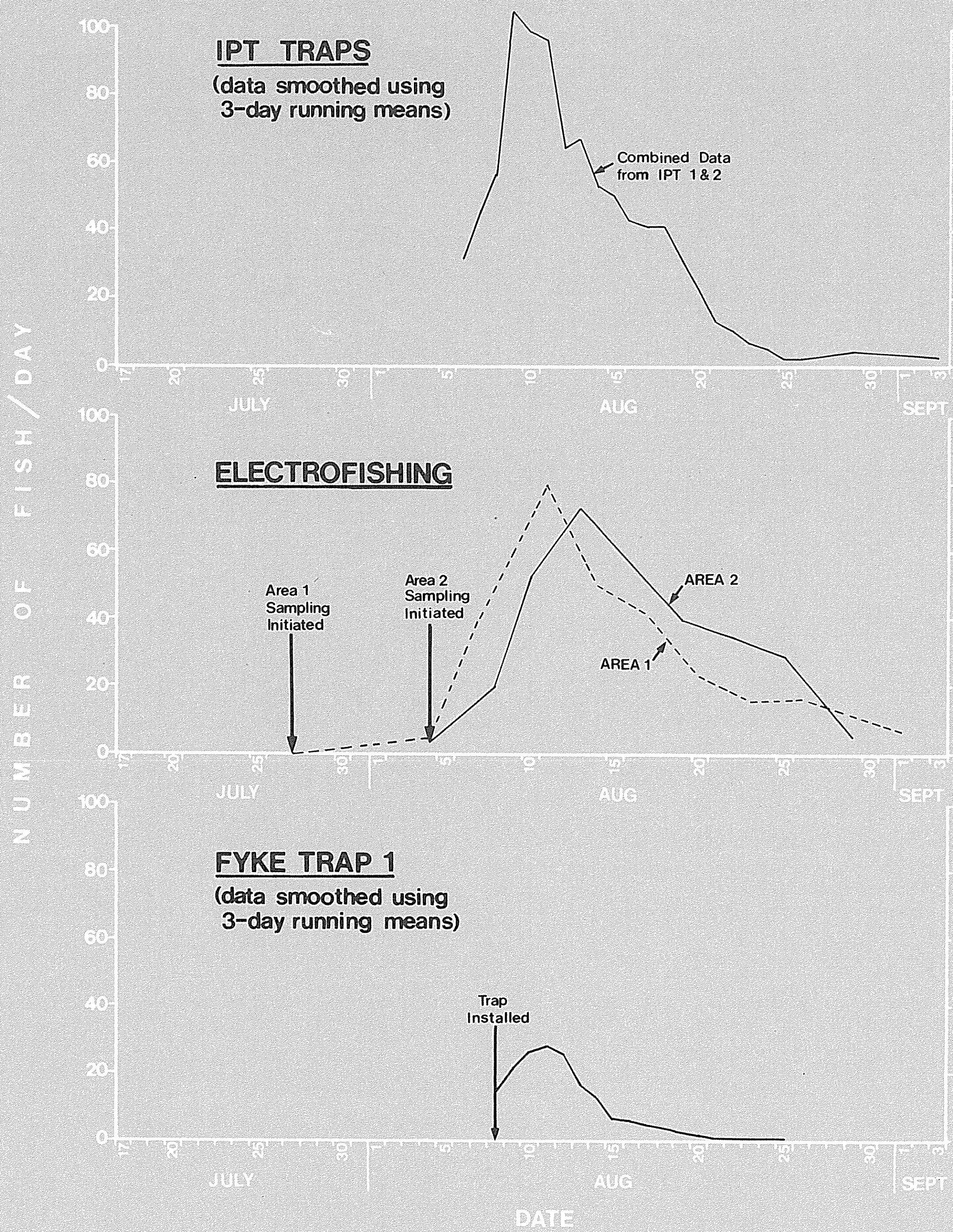

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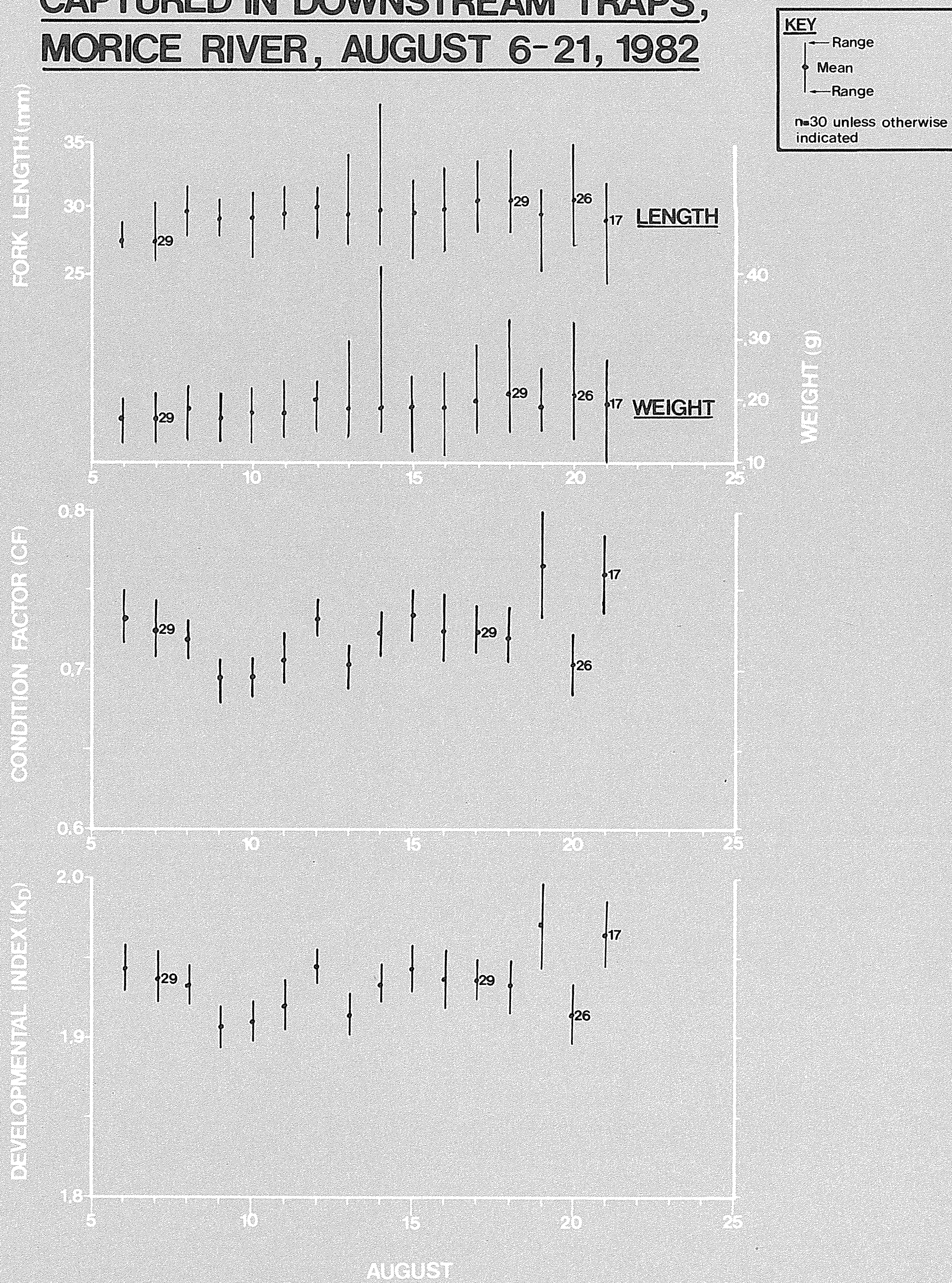
FIGURE 3.4: FORK LENGTHS, WEIGHTS, CONDITION FACTORS AND DEVELOPMENTAL INDICES OF STEELHEAD CAPTURED IN DOWNSTREAM TRAPS, MORICE RIVER, AUGUST 6-21, 1982



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APPENDIX E1

Morice River Steelhead Fry Emergence Data, 1982

TABLE E1.1
Daily Steelhead Fry Catch in Incline Plane Traps and Fyke Nets, and at Two Electroshocking Sites in the Upper Morice River, July 27 to September 3, 1982

Date		IPT #1	IPT #2	Fyke 1	Electrofishing[1] Area # 1	Area #2
July	27	-	-	-	0	
Aug	4	-	-	-	4	3
	5	-	-	-		
	6	13	20	-		
	7	11	20	-	39	
	8	33	40	-		20
	9	48	49	14		
	10	55	86	30		52
	11	27	31	34	79	
	12	52	36	17		
	13	27	19	23		73
	14	16	52	8	50 (10%)	
	15	12	34	8		
	16	9	26	5		56
	17	29	21	4	41 (25%)	
	18	8	31	2		
	19	12	22	1		39 (40%)
	20	1	17	0	23 (20%)	
	21	4	12	0		
	22	1	6	0		34 (43%)
	23	0	7	0	15 (50%)	
	24	0	4	0		
	25	0	1	0		28 (43%)
	26	0	1	0	16 (59%)	
	27	1	4	0		
	29	1	1	0		4 (78%)
Sept.	1	2	2	0	6 (54%)	
	3	0	1	0		

1 Numbers given are of fry less than 32 mm fork length. Figures in brackets indicate the percentage reduction in catch by eliminating steelhead fry greater than 32 mm fork length from total catches.

TABLE E1.2
Mean Daily Water Temperature at Morice Lake Outlet and Accumulated Temperature Units to Fry Emergence, May 20 to August 15, 1982

Date		Mean Daily Temperature (°C)	Accumulated Temperature Units (°C)	Date		Mean Daily Temperature (°C)	Accumulated Temperature Units (°C)
May	20	4.0	-	June	27	7.8	167.0
	21	4.0	-		28	8.1	175.1
	22	4.0	-		29	8.8	183.9
	23	4.0	-		30	9.3	193.2
	24	4.0	-	July	1	9.8	203.0
	25	4.0	-		2	10.1	213.1
	26	4.0	-		3	9.7	222.8
	27	4.0	-		4	9.5	232.3
	28	4.1	-		5	9.6	241.9
	29	4.2	-		6	9.3	251.2
	30	4.3	-		7	9.1	260.3
	31	4.4	-		8	9.0	269.3
June	1	4.5	4.5*		9	9.4	278.7
	2	4.6	9.1		10	9.2	287.9
	3	4.7	13.8		11	9.5	297.4
	4	4.8	18.6		12	9.7	307.1
	5	4.9	23.5		13	9.7	316.8
	6	5.0	28.5		14	9.2	326.0
	7	5.1	33.6		15	9.7	335.7
	8	5.2	38.8		16	9.3	345.0
	9	5.2	44.0		17	8.8	353.8
	10	5.3	49.3		18	8.7	362.5
	11	5.5	54.8		19	8.9	371.4
	12	5.6	60.4		20	8.8	380.2
	13	5.8	66.2		21	8.9	389.1
	14	6.0	72.2		22	8.9	398.0
	15	6.2	78.4		23	9.0	407.0
	16	6.6	85.0		24	9.5	416.5
	17	6.8	91.8		25	10.2	426.7
	18	7.0	98.8		26	11.6	438.3
	19	7.3	106.1		27	11.3	449.6
	20	7.4	113.5		28	12.8	462.4
	21	7.4	120.9		29	13.5	475.9
	22	7.4	128.3		30	13.7	489.6
	23	7.5	135.8		31	13.6	503.2
	24	7.4	143.2				
	25	8.0	151.2				
	26	8.0	159.2				

(Continued)

TABLE E1.2 (Continued)

Date	Mean Daily Temperature (°C)	Accumulated Temperature Units (°C)
August 1	13.3	516.5
2	13.1	529.6
3	13.0	542.6
4	12.7	555.3
5	12.4	567.7
6	12.5	580.2
7	12.4	592.6
8	13.6	606.2
9	13.3	619.5
10	12.8	632.3
11	12.6	644.9**
12	12.5	657.4
13	12.7	670.1
14	12.5	682.6
15	12.4	695.0

* Assumed peak spawning

** Peak of fry emergence

SECTION F

DISTRIBUTION AND ABUNDANCE OF STEELHEAD TROUT PARR IN THE MORICE RIVER DURING SEPTEMBER 1982

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1.0 INTRODUCTION

Previous studies of juvenile steelhead trout in the Morice and Bulkley Rivers indicated that age 1+ and 2+ parr were present throughout a number of tributaries and in main and side channel locations of the Morice and Bulkley Rivers (Section A). However, little information describing the distribution and abundance of older age class (i.e. age 2+ to 4+) steelhead parr was obtained in these studies. Results from scale analysis on returning adult steelhead indicated that the majority (70%) of Morice River steelhead resided in freshwater for four years before migrating to sea (Whately et al. 1978). More recent scale analyses from adult steelhead captured in the Bulkley and lower Morice Rivers in 1982 indicate a higher proportion of steelhead returning after 3 years freshwater rearing than in the earlier study (pers. comm., Mike Lough, B.C. Fish and Wildlife Branch).

Data from other river systems suggest that steelhead juveniles initially rear in tributaries and shallow, low velocity areas, and move to faster, deeper water as they grow (Everest and Chapman 1972). Angling catches in log jams in the Morice River during August (Shepard and Algard 1977) indicate use of this habitat type by older parr. However, angling catches do not accurately reflect abundances of different age classes as angling tends to selectively capture older parr. Sampling with back-pack electrofishers in 1979 and 1981 favoured the capture of fry and young parr along river margins (Section A). Physical limitations of this technique in deeper and faster water resulted in less effective sampling in those areas most likely to be used by older parr. In this study, the use of an electrofisher mounted on a riverboat enabled sampling of areas not effectively sampled by back-pack electrofishing gear.

1.1 Study Objective

The objective of this study was to obtain information on the distribution and abundance of all age classes of steelhead parr using a boat electrofisher along the margins and in midstream areas of the mainstem Morice and Bulkley Rivers.

1.2 Study Area Description

The study area included the mainstem Morice and Bulkley Rivers from Morice Lake downstream to the confluence with the Suskwa River, between Moricetown and Hazelton (Figure 1.1).

2.0 METHODS

Field studies were conducted by a crew of 3 between September 6 and 13, 1982.

2.1 Electrofisher Operation

A modified 21-foot Gregor river boat equipped for electrofishing was used to enumerate steelhead parr. Modifications included a Honda portable generator and electrical system capable of 110 or 220 volt AC output. The generator powered a Coffelt VVP 15 electrofisher, which has three outputs: AC current; DC current and pulsed DC. In this study, the DC pulse current was used with a 500 volt output and a current varying between 3 and 6 amp. The front electrodes (anodes) consisted of two adjustable wands fitted with copper rings from which four 6 mm steel cables 1 m long were suspended. The wands were adjustable for both distance from the bow of the boat and distance apart. The cathodes consisted of 9 mm steel cables 15 m long suspended from the mid-ships steering station of the boat. The boat hull was used as ground (Plate 1).

Other modifications included a rubberized foredeck with a bow rail approximately 1 m high. Foot pedals at the bow and at the steering station enabled electrofisher operation by either the netter or the boat operator. In this case the electrofisher was operated by the netter from the bow. A small-mesh dip net with a 3 m long insulated pole was used to collect fish.

2.2 Site Selection

Sample sites were selected randomly in each reach of the Morice/Bulkley system (Section A). The Universe Transverse Mercator grids on 1:50,000 topographic sheets were numbered along each reach. Two numbers were randomly drawn for each reach, and the reach sites were identified by the numbered UTM grid on the topographic sheet. All sites were at least 1 km long. The sample site in Reach 7 was based on its proximity to a suitable boat launch site due to access difficulties in this section of the Bulkley River.

The length and number of sampling sites varied depending on habitat diversity and reach length. Reach 2 had three sampling sites due to the highly diverse habitat while Reach 7 was limited to one site due to the high turbidity and low visibility. The remaining Reaches (1, 3-6) had two sites each.

FIGURE 1.1: STEELHEAD TROUT PARR ELECTROFISHING SITES IN THE MORICE/BULKLEY SYSTEM, SEPT. 1982

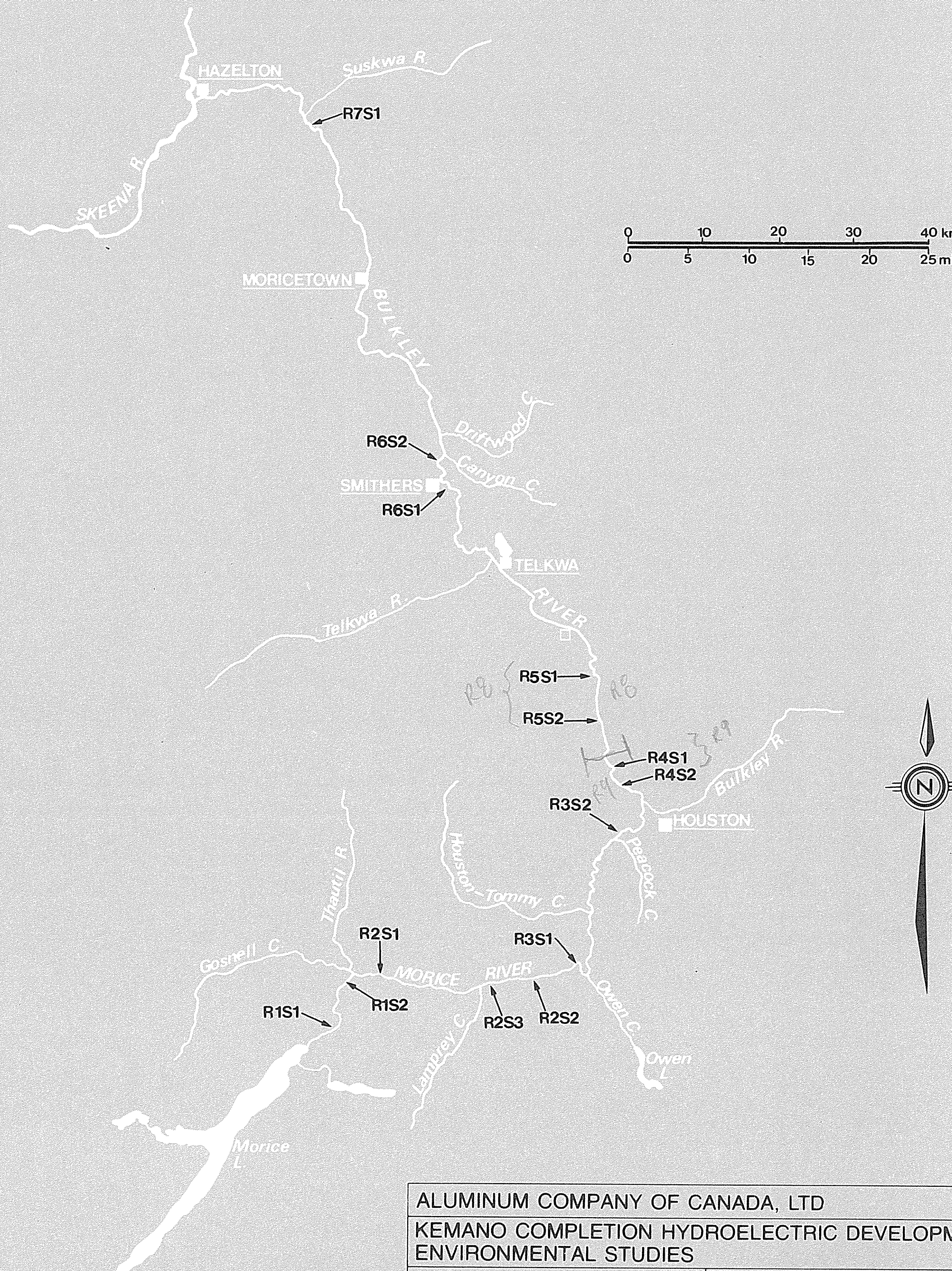

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Plate 1: River boat modified for electrofishing. Note adjustable anodes on the bow.

Plate 2: Scale removal from steelhead trout parr for subsequent age analysis.

Landmarks were identified at the upstream and downstream end of each site and marked on the topographic sheets. The length of each sampling site was subsequently determined with a map wheel on the topographic sheets.

2.3 Sampling Methods

2.3.1 Electrofishing Procedure

The margin and mid-stream areas at each river site were sampled equally. During the margin sampling, the boat was kept in a nose-to-shore position, while drifting downstream broadside through the site. This enabled observation and capture of any fish upstream and downstream of the anodes as well as between the anodes. Both margins were sampled at each site.

Two mid-stream passes were made, one at approximately one-third of the river width from each margin at each site. The boat was positioned with the bow pointed downstream for these mid-stream passes. The engine was set in reverse so the river current was more rapid than the boat. This caused the affected fish to surface ahead (downstream) of the boat and facilitated capture. At Site 1 of Reach 1, the uppermost sampling site in the Morice River, a single mid-stream sample was taken because of the narrowness of the river channel.

2.3.2 Physical Description

A physical description of each margin and mid-stream line was obtained during each fishing pass. An observer at the bow estimated the percentage cover provided by instream logs, boulders and vegetation as well as overstream vegetation and cutbanks. The substrate was categorized as fines (0.0-0.1 cm), small gravel (0.1-4 cm), large gravel (4-10 cm), cobble (10-30 cm), boulder (30+ cm), and bedrock. The percentage composition of each category was estimated for each margin and mid-stream pass. Turbidity was estimated from the depth at which the bottom substrate was obscured. River widths were determined at the upper and lower ends of each site with a hip chain. Midstream temperature was taken using a hand-held thermometer at each site.

2.3.3 Fish Sampling and Enumeration

All species sampled were counted and the data recorded. Only steelhead parr were netted and retained for length and weight determination. Scales were taken for aging (Plate 2). Because juvenile steelhead cannot be visually distinguished from rainbow trout, in this study both species are collectively referred to as steelhead parr, although some resident rainbow trout may have been included in the sample. Other species were counted but not collected. Salmon and steelhead fry were not visually separated during sampling and were grouped together.

Captured steelhead parr were retained live in water-filled pails. Fish were anaesthetized with 2 phenoxy-ethanol and fork lengths were measured. Scales were removed for subsequent analysis by the Department of Fisheries and Oceans. Technical problems with a top-loading balance prevented weight determinations except in Reach 6 where a triple beam balance was used. The anaesthetized fish were allowed to recover in river water before being released at the sampling site. Fulton's condition factor (k) (Ricker 1975) was determined for parr from Reach 6 as follows:

$$K = \frac{100 \times W}{L^3}$$

where: W = weight (g)
L = length (cm)

3.0 RESULTS

Steelhead trout, chinook, coho and pink salmon, largescale suckers, mountain whitefish, longnose dace, Dolly Varden char, Pacific lamprey and prickly sculpins were captured by boat electrofishing. The number and relative abundance of each species by reach is presented in Table 3.1. Physical characteristics of each sampling site are given in Appendix F1.

3.1 Steelhead Parr Distribution and Abundance

The catch of steelhead parr in the Morice/Bulkley Rivers was substantially higher in the lower reaches than in the upper reaches (Table 3.2). Since the length and number of sampling sites in each reach varied, the catch data were standardized to catch per kilometer of river and weighted distributions (corrected for reach length) were determined for comparison between reaches. Results indicate a progressive increase in number of parr as the sampling proceeded downstream. The number of steelhead parr captured per km of river in the Bulkley River was approximately 8 times higher than in the Morice River.

Parr catches corrected for total reach length indicate that mainstem areas in the Bulkley River (Reaches 4-7) account for a very high percentage (93%) of all parr rearing in this system. This estimate does not take into account parr rearing in side channels or any differences in susceptibility of parr to capture in the various sections of the river.

Only two parr were captured in the mid-stream areas during the entire sample. All other steelhead parr were captured within approximately 3-5 m of the river margin despite nearly equal sampling efforts in both margin and mid-stream habitats. Large numbers of steelhead parr were typically found in mainstem margin areas such as that shown in Plate 3.

3.2 Steelhead Parr Length, Age and Weight Measurements

Of 201 steelhead parr enumerated during this study, 109 were captured and retained for length measurements and scale sample collection (Appendix F3). Most parr were age 2+ (54%) and age 3+ (32%), with smaller percentages of age 1+ (8%) and age 4+ (6%) fish. The weighted distribution of each age class by reach is presented in Figure 3.1.

TABLE 3.1

Summary of Distribution and Relative Abundance Estimates for Fish Species Other Than Steelhead Parr Enumerated During Boat Electrofishing Surveys in the Morice and Bulkley Rivers

	Catch/km by Reach (% Composition)													
	1		2		3		4		5		6		7	
Steelhead Trout Parr	0.4	(0.6)	1.7	(1.3)	4.0	(2.8)	6.2	(3.9)	22.0	(15.0)	22.8	(8.4)	32.0	(17.7)
Coho/Chinook/ Steelhead Fry	1.2	(1.8)	15.7	(12.4)	18.0	(12.8)	12.2	(7.7)	21.2	(14.4)	84.8	(31.3)	43.0	(23.8)
Mountain Whitefish	32.8	(49.8)	44.0	(34.8)	61.5	(43.6)	88.5	(55.6)	54.7	(37.2)	99.6	(36.8)	31.0	(17.1)
Largescale Suckers	4.8	(7.3)	3.6	(2.9)	4.5	(3.2)	9.5	(6.0)	10.0	(6.8)	24.8	(9.2)	4.0	(2.2)
Adult Steelhead Trout	1.2	(1.8)	2.9	(2.3)	1.5	(1.1)	1.2	(0.8)	1.6	(1.1)	5.2	(1.9)	12.0	(6.6)
Adult Pink Salmon	12.8	(19.5)	29.0	(22.9)	7.0	(5.0)	19.8	(12.4)	7.5	(5.1)	4.0	(1.5)	1.0	(0.6)
Adult Coho Salmon	1.0	(1.5)	0.2	(0.2)	0	(0)	0.2	(0.1)	0.6	(0.4)	0	(0)	0	(0)
Adult Chinook Salmon	5.6	(8.5)	0.7	(0.5)	0	(0)	0.2	(0.1)	0	(0)	0	(0)	0	(0)
Longnose Dace	2.0	(3.0)	7.6	(6.0)	3.0	(2.1)	7.5	(4.7)	8.8	(6.0)	4.8	(1.8)	19.0	(10.5)
Unidentified	4.0	(6.1)	15.2	(12.0)	41.0	(29.1)	10.8	(6.8)	10.9	(7.4)	20.0	(7.4)	10.0	(5.5)
Others[1] - La	0		4.3	(3.4)	0.5	(0.4)	1.5	(0.9)	8.4	(5.7)	4.8	(1.8)	29.0	(16.0)
- DV	0		0		0		1.5	(0.9)	0.6	(0.4)	0		0	
- Sc	0		1.4	(1.1)	0		0	0.6	(0.4)		0		0	
Total	65.8	(99.9)	126.3	(99.8)	141.0	(100.1)	159.1	(99.9)	146.9	(99.9)	270.8	(100.1)	181.0	(100)

1 La = Pacific lamprey; Sc = Prickly sculpin; DV = Dolly Varden char

TABLE 3.2
Steelhead Parr Catch Estimates by Reach in the Mainstem Morice and Bulkley Rivers, September 1982

	Total Parr Catch	River Length Sampled (km)	Total Parr Catch/Km	Reach Length (km)	Catch/km x Channel Length	Weighted Distribution (%)
Reach 1	1	2.5	0.4	15.4	6.2	0.1
Reach 2	7	4.2	1.7	33.8	57.5	1.4
Reach 3	8	2.0	4.0	27.8	111.2	2.7
Reach 4 R9	25	4.0	6.2	18.1	112.2	2.7
Reach 5 R8	71	3.2	22.0	35.0	770.0	18.7
Reach 6 R6	57	2.5	22.8	31.2	711.4	17.3
Reach 7 R3	32	1.0	32.0	73.4	2,348.8	57.1
Total	**201**				4,117.3	

The mean length, weight and condition factor for all four age classes is summarized in Table 3.3. Mean lengths of steelhead parr ranged from 90 mm (age 1+) to 204 mm (age 4+) and mean weights ranged from 7 g (age 1+) to 39 g (age 3+). Weights and condition factors are for parr captured in Reach 6 only. There appears to be little difference in the mean lengths of age 2^+ and age 3^+ parr. The mean condition factor of each age class (Table 3.3) was greater than 1.0, suggesting that steelhead parr were in good condition in September, 1982. Scale analysis by the Department of Fisheries and Oceans suggested that rearing conditions in 1979 (first year of 3^+ parr) were likely poorer than in 1980, which may account for the similar size of age 2^+ and 3^+ parr.

3.3 Distribution and Abundance of Other Fish Species

During the course of the electrofishing surveys, observations describing numbers and distributions of other fish species present were recorded. Although this information was incidental to the main objective of the study, it provides further insight into fish distributions, particularly in the Bulkley River where no surveys of adult resident populations have been conducted. This information is presented in Table 3.1.

Salmon and steelhead trout fry numbers tended to increase as sampling proceeded downstream. The sampling technique did not enable observers to separate fry by species, but most fry observed below Reach 2 were probably chinook salmon and steelhead trout. Fry abundances along the margins of sites in Reach 6 were approximately double those in the next highest site (Reach 7), and were approximately four times as high as in Reaches 1-3 of the Morice River mainstem margin sites (Appendix F2, Table F2.1). Virtually no fry were observed during mid-channel sampling.

Mountain whitefish were commonly observed throughout the Morice and Bulkley Rivers and were the most abundant fish observed in all reaches except Reach 7. The highest numbers of mountain whitefish observed were in Reach 4 in the vicinity of Houston and in Reach 6. Mountain whitefish observations were an equal mix of adult and juvenile fish (including fry). Unlike the salmon and trout species, 27% of the whitefish observed were in mid-channel sites (Appendix F2, Table F2.1). This confirms earlier snorkel observations which indicated the use of a broad range of river habitats by mountain whitefish (Section A).

Largescale suckers were observed throughout the sample sites, particularly in Reach 6 (Table 3.3). An estimated 85% of the suckers observed were adult fish. Most largescale suckers were observed while sampling margin sites; approximately 19% of

Plate 3: Mainstem habitat in Reach 5, typical of areas where steelhead trout parr were caught.

FIGURE 3.1: DISTRIBUTION OF STEELHEAD PARR IN THE MAINSTEM MORICE/BULKLEY SYSTEM DURING SEPT. 1982

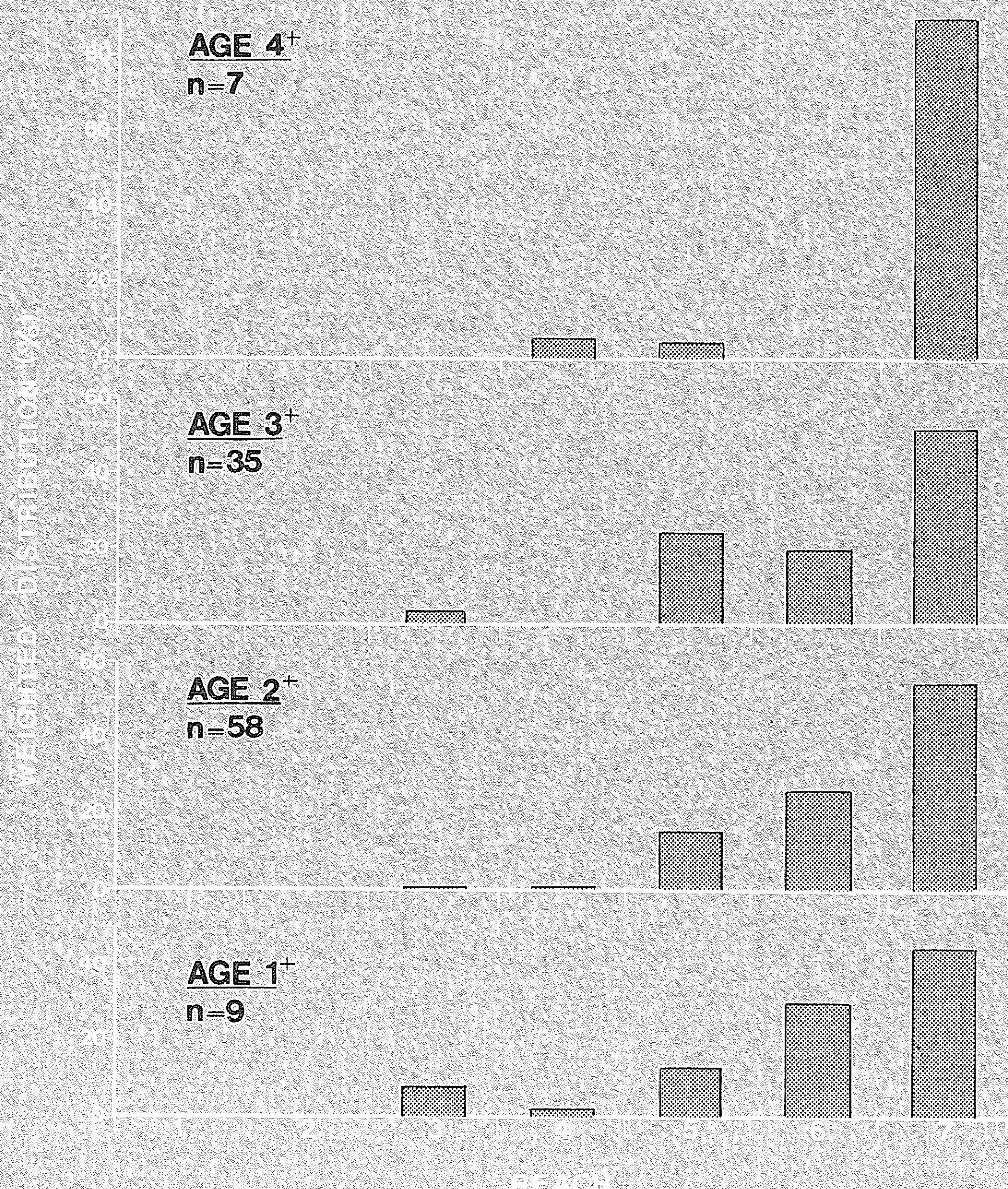

TABLE 3.3
Mean Length, Weight and Condition Factor
(± Standard Deviation) of Steelhead Parr Captured
in Mainstem Morice and Bulkley Rivers, September 1982

n	Age	1^+	2^+	3^+	4^+
104	Length (mm)	89.8 ± 9.9	142.0 ± 19.9	153.8 ± 25.0	204.0 ± 29.0
41	Weight[1] (g)	7.1 ± 2.2	27.2 ± 8.3	38.7 ± 13.8	-
41	Condition Factor[1]	1.2 ± 0.2	1.1 ± 0.1	1.1 ± 0.8	-

[1] Reach 6 fish only

the observations were in mid-channel sites, usually deep, low velocity areas (Appendix F2, Table F2.1).

Longnose dace were observed in all reaches of the Morice and Bulkley Rivers, with the most numerous observations in Reach 7. More than half of the longnose dace observations (56%) were in mid-channel sites (Appendix F2, Table F2.1).

Adult steelhead trout were observed in all reaches with the highest numbers in the lower sites on the Bulkley River. Since the sampling was conducted during steelhead migration, results are probably not indicative of steelhead overwintering areas.

Pink salmon spawners were observed throughout the Morice and Bulkley River sites. These observations confirm the findings of 1981 studies on pink salmon spawning which indicated that small numbers of pink salmon spawn throughout the Bulkley River (Section H). Some pink salmon may have been moving upstream to spawning sites in the Morice River.

4.0 DISCUSSION

Boat electrofishing proved an effective means of capturing steelhead parr in the Bulkley River compared to other techniques used in past studies. Results of the boat electrofishing survey demonstrated a marked increase in steelhead trout parr abundance as sampling proceeded downstream from the upper reaches of the Morice River to sites along the Bulkley River. Parr catches in the four reaches of the Morice River averaged 3 parr/km compared to an average of 26 parr/km in the Bulkley River. These numbers provide a comparison of the relative abundance of parr between reaches, although they do not represent total numbers present. A similar trend of higher steelhead parr catches in the lower reaches of the Bulkley River was found in boat electrofishing surveys conducted by the B.C. Fish and Wildlife Branch subsequent to these surveys (pers. comm., D. Tredger). Boat electrofishing may underestimate parr abundance in the Morice River since log jams, which are more abundant in the Morice River and which provide important steelhead parr habitat (Section A), are not effectively sampled using this technique.

Approximately 99% of the steelhead parr observed during this survey were in marginal sites (i.e. generally within 5 m of the river edge), often at the interface of faster current areas. Parr were not observed near mid-stream boulders even though cover and current interfaces were available at these sites. Age 2+ and 3+ steelhead parr comprised 86% of the total parr sampled. Since the electrofishing surveys were conducted during September, these fish likely remain in freshwater for at least an additional winter prior to smolting at ages 3^+ and 4^+, respectively. This corroborates results of scale analyses of returning adults which indicate most (93%) returning adults are from age 3+ and 4+ smolts (Whately et al. 1978).

Previous surveys have been relatively unsuccessful in locating these age 2+ and 3+ steelhead parr. Tributary surveys (Tredger 1981 and 1983; Section A) suggest that older age classes of steelhead parr tend to move out of tributaries into the mainstem Morice and Bulkley Rivers. Sampling in Reach 2 with back-pack electrofishers indicated the importance of side channels as reaing habitat for steelhead fry and age 1^+ parr (Sections B and J). The boat electrofishing surveys conducted during this study confirm the importance of the main channel, particularly the Bulkley River mainstem, in providing rearing habitat for these older parr.

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APPENDIX F1

Physical Characteristics of Fish Habitat Sampled in the Mainstem Morice/Bulkley River System, September 1982

SAMPLE AREA DESCRIPTION

September 09/82

Stream Name Morice River

Reach and Site Number R1 Site 1

Hydraulic Unit Sampled

Length 1 km

Wetted Width (m) Top 40 Bottom 49

Turbidity (m) 1.5

Temperature (C°) 11.5

Cover:

	LBM	LMS[1]	RMS	RBM
Instream log (m^2) x Depth (m)	10	-	0	20
Instream boulders (m^2)	25	-	30	20
Instream vegetation (m^2)	0	-	0	0
Overstream vegetation (m^2)	0	-	0	30
Cutbanks (m^2)	10	-	0	5

Substrate:

	LBM	LMS	RMS	RBM
Fines (%)	0	-	0	0
Small gravel (%)	0	-	0	0
Large gravel (%)	5	-	5	10
Cobble (%)	15	-	25	10
Boulder (%)	80	-	70	80
Bedrock (%)	0	-	0	0
Average Depth (m)	0.75		1.5	1.0

Legend

LBM = Left Bank Margin
LMS = Left Midstream
RMS = Right Midstream
RBM = Right Bank Margin

1 Not Sampled

SAMPLE AREA DESCRIPTION

September 09/82

Stream Name Morice River

Reach and Site Number R1 Site 2

Hydraulic Unit Sampled

Length >1 km

Wetted Width (m) Top 47
Bottom 64

Turbidity (m) <1.5

Temperature (C°) 12

Cover:

	LBM	LMS	RMS	RBM
Instream log (m^2) x Depth (m)	25	0	0	20
Instream boulders (m^2)	0	1	1	10
Instream vegetation (m^2)	0	0	0	0
Overstream vegetation (m^2)	30	0	0	25
Cutbanks (m^2)	10	0	0	15

Substrate:

	LBM	LMS	RMS	RBM
Fines (%)	10	0	0	0
Small gravel (%)	10	5	10	5
Large gravel (%)	15	10	15	10
Cobble (%)	35	40	40	30
Boulder (%)	30	45	35	30
Bedrock (%)	0	0	0	15
Average Depth (m)	0.5	1.5	2	1.0

Legend

LBM = Left Bank Margin
LMS = Left Midstream
RMS = Right Midstream
RBM = Right Bank Margin

SAMPLE AREA DESCRIPTION

September 09/82

Stream Name Morice River

Reach and Site Number R 2 Site I

Hydraulic Unit Sampled

Length I km

Wetted Width (m) Top 61 Bottom 83

Turbidity (m) 1.5

Temperature (C°) 11.5

Cover:

	LBM	LMS	RMS	RBM
Instream log (m^2) x Depth (m)	25	0	0	35
Instream boulders (m^2)	10	0	0	0
Instream vegetation (m^2)	0	0	0	0
Overstream vegetation (m^2)	15	0	0	25
Cutbanks (m^2)	5	0	0	10

Substrate:

	LBM	LMS	RMS	RBM
Fines (%)	15	0	0	25
Small gravel (%)	25	20	30	35
Large gravel (%)	25	15	35	25
Cobble (%)	30	45	20	15
Boulder (%)	10	20	15	0
Bedrock (%)	0	0	0	0
Average Depth (m)	2	<3	2	<1

Legend

LBM = Left Bank Margin
LMS = Left Midstream
RMS = Right Midstream
RBM = Right Bank Margin

SAMPLE AREA DESCRIPTION

September 09/82

Stream Name Morice River

Reach and Site Number R2 Site 2

Hydraulic Unit Sampled

Length <1 km

Wetted Width (m) Top 75 Bottom 52

Turbidity (m) 1 m

Temperature (C°) 11.5

Cover:

	LBM	LMS[1]	RMS	RBM
Instream log (m^2) x Depth (m)	20	-	0	15
Instream boulders (m^2)	0	-	0	0
Instream vegetation (m^2)	40	-	0	35
Overstream vegetation (m^2)	0	-	0	0
Cutbanks (m^2)	10	-	0	10

Substrate:

	LBM	LMS[1]	RMS	RBM
Fines (%)	10	-	10	15
Small gravel (%)	60	-	60	50
Large gravel (%)	20	-	20	35
Cobble (%)	10	-	10	-
Boulder (%)	0	-	0	-
Bedrock (%)	0	-	0	-
Average Depth (m)	<1	2	1.5-2	.3-1.5

Legend

LBM = Left Bank Margin
LMS = Left Midstream
RMS = Right Midstream
RBM = Right Bank Margin

1 Cover and substrate not visible

SAMPLE AREA DESCRIPTION

September 06/82

Stream Name Morice River

Reach and Site Number R3 Site 2

Hydraulic Unit Sampled

Length 1 km

Wetted Width (m) Top 65 Bottom 71

Turbidity (m)

Temperature (C°)

Cover:

	LBM	LMS	RMS	RBM
Instream log (m^2) x Depth (m)	10	0	0	5
Instream boulders (m^2)	15	1	0	25
Instream vegetation (m^2)	5	0	0	5
Overstream vegetation (m^2)	50	0	0	40
Cutbanks (m^2)	0	0	0	0

Substrate:

	LBM	LMS	RMS	RBM
Fines (%)	0	0	0	0
Small gravel (%)	0	0	0	0
Large gravel (%)	10	20	20	20
Cobble (%)	80	80	80	20
Boulder (%)	10	0	0	60
Bedrock (%)	0	0	0	0
Average Depth (m)	0.5-1.0	<1	1	.3-.6

Legend

LBM = Left Bank Margin
LMS = Left Midstream
RMS = Right Midstream
RBM = Right Bank Margin

SAMPLE AREA DESCRIPTION

September 10/82

Stream Name Morice River

Reach and Site Number R2 Site 3

Hydraulic Unit Sampled

Length 1.75 km

Wetted Width (m) Top 63 Bottom 101

Turbidity (m) 1

Temperature (C°) 11.5

Cover:

	LMB	LMS[1]	RMS[1]	RBM
Instream log (m^2) x Depth (m)	15	-	-	10
Instream boulders (m^2)	5	-	-	0
Instream vegetation (m^2)	20	-	-	10
Overstream vegetation (m^2)	0	-	-	10
Cutbanks (m^2)	20	-	-	10
Substrate:				
Fines (%)	15	-	-	35
Small gravel (%)	35	-	-	35
Large gravel (%)	35	-	-	30
Cobble (%)	15	-	-	0
Boulder (%)	0	-	-	0
Bedrock (%)	0	-	-	0
Average Depth (m)	0.5	<1.5	<1.5	0.5

Legend

LBM = Left Bank Margin
LMS = Left Midstream
RMS = Right Midstream
RBM = Right Bank Margin

1 Cover and substrate not visible

SAMPLE AREA DESCRIPTION

September 09/82

Stream Name Morice River.

Reach and Site Number R3 Site 1

Hydraulic Unit Sampled Run 95% Pool 5%

Length 1 km

Wetted Width (m) Top 53 Bottom 78

Turbidity (m) 1.5 m

Temperature (C°) 13

Cover:

	LBM	LMS	RMS	RBM
Instream log (m^2) x Depth (m)	5	0	1	30
Instream boulders (m^2)	0	0	0	0
Instream vegetation (m^2)	10	0	0	20
Overstream vegetation (m^2)	70	0	0	90
Cutbanks (m^2)	5	0	0	10

Substrate:

	LBM	LMS	RMS	RBM
Fines (%)	20	0	0	10
Small gravel (%)	15	25	25	35
Large gravel (%)	5	25	50	35
Cobble (%)	60	50	25	20
Boulder (%)	0	0	0	0
Bedrock (%)	0	0	0	0
Average Depth (m)	>.5	1-1.5	1-1.5	>0.5

Legend

LBM = Left Bank Margin
LMS = Left Midstream
RMS = Right Midstream
RBM = Right Bank Margin

SAMPLE AREA DESCRIPTION

September 07/82

Stream Name Bulkley River

Reach and Site Number R4 Site 1

Hydraulic Unit Sampled

Length 1.0 km

Wetted Width (m) Top 97 Bottom 63

Turbidity (m)

Temperature (C°)

Cover:

	LBM	LMS	RMS	RBM
Instream log (m^2) x Depth (m)	35	0	0	25
Instream boulders (m^2)	0	0	0	0
Instream vegetation (m^2)	0	0	0	15
Overstream vegetation (m^2)	20	0	0	5
Cutbanks (m^2)	30	0	0	10

Substrate:

	LBM	LMS	RMS	RBM
Fines (%)	20	0	0	25
Small gravel (%)	25	10	10	30
Large gravel (%)	35	30	40	30
Cobble (%)	20	60	50	15
Boulder (%)	0	0	0	0
Bedrock (%)	0	0	0	0
Average Depth (m)	0.75	1.5	2	1.5

Legend

LBM = Left Bank Margin
LMS = Left Midstream
RMS = Right Midstream
RBM = Right Bank Margin

SAMPLE AREA DESCRIPTION

September 07/82

Stream Name Bulkley River

Reach and Site Number R4 Site 2

Hydraulic Unit Sampled

Length 1.0 km

Wetted Width (m) Top 63
Bottom 78

Turbidity (m)

Temperature (C°)

Cover:

	LBM	LMS	RMS	RBM
Instream log (m^2) x Depth (m)	5	0	0	20
Instream boulders (m^2)	5	1	1	5
Instream vegetation (m^2)	0	0	0	0
Overstream vegetation (m^2)	0	0	0	5
Cutbanks (m^2)	0	0	0	10

Substrate:

	LBM	LMS	RMS	RBM
Small gravel (%)	30	0	0	0
Large gravel (%)	30	25	25	20
Cobble (%)	30	60	60	70
Boulder (%)	10	15	15	10
Bedrock (%)	0	0	0	0
Average Depth (m)	1	1	2	0.75

Legend

LBM = Left Bank Margin
LMS = Left Midstream
RMS = Right Midstream
RBM = Right Bank Margin

SAMPLE AREA DESCRIPTION

September 08/82

Stream Name Bulkley River

Reach and Site Number R5 Site 1

Hydraulic Unit Sampled

Length 1 km

Wetted Width (m) Top 88
Bottom 68

Turbidity (m) 0.5

Temperature (C°) 13

Cover:

	LBM	LMS	RMS	RBM
Instream log (m^2) x Depth (m)	1	0	0	25
Instream boulders (m^2)	0	0	0	0
Instream vegetation (m^2)	0	0	0	10
Overstream vegetation (m^2)	0	0	0	20
Cutbanks (m^2)	0	0	0	10

Substrate:

	LBM	LMS	RMS	RBM
Fines (%)	0	0	0	0
Small gravel (%)	10	10	10	20
Large gravel (%)	30	30	30	20
Cobble (%)	60	60	60	60
Boulder (%)	0	0	0	0
Bedrock (%)	0	0	0	0
Average Depth (m)	>0.5	1.5	1.5	>1.0

Legend

LBM = Left Bank Margin
LMS = Left Midstream
RMS = Right Midstream
RBM = Right Bank Margin

SAMPLE AREA DESCRIPTION

September 08/82

Stream Name Bulkley River

Reach and Site Number R5 Site 2

Hydraulic Unit Sampled

Length 1.75 km

Wetted Width (m) Top 98 Bottom 66

Turbidity (m) 0.25 - 0.5

Temperature (C°) 13

Cover:

	LBM	LMS	RMS	RBM
Instream log (m^2) x Depth (m)	20	0	0	25
Instream boulders (m^2)	15	0	0	0
Instream vegetation (m^2)	0	0	0	0
Overstream vegetation (m^2)	15	0	0	35
Cutbanks (m^2)	5	0	0	0

Substrate:

	LBM	LMS	RMS	RBM
Fines (%)	30	10	0	10
Small gravel (%)	35	20	0	15
Large gravel (%)	20	20	35	25
Cobble (%)	0	50	60	30
Boulder (%)	15	0	5	20
Bedrock (%)	0	0	0	0
Average Depth (m)	>1.0	>1.5	>1.5	>1.0

Legend

LBM = Left Bank Margin
LMS = Left Midstream
RMS = Right Midstream
RBM = Right Bank Margin

SAMPLE AREA DESCRIPTION

September 11/82

Stream Name Morice River

Reach and Site Number R6 Site 1

Hydraulic Unit Sampled

Length 1.5 km

Wetted Width (m) Top 111
Bottom 81

Turbidity (m) 0.25

Temperature (C°) 11.5

Cover:

	LBM	LMS[1]	RMS[1]	RBM
Instream log (m^2) x Depth (m)	2	0	0	0
Instream boulders (m^2)	10	15	5	25
Instream vegetation (m^2)	0	0	0	0
Overstream vegetation (m^2)	0	0	0	0
Cutbanks (m^2)	0	0	0	0

Substrate:

	LBM	LMS[1]	RMS[1]	RBM
Fines (%)	0	-	-	5
Small gravel (%)	10	-	-	5
Large gravel (%)	25	-	-	15
Cobble (%)	40	-	-	30
Boulder (%)	25	-	-	25
Bedrock (%)	0	-	-	20
Average Depth (m)	0.75	<1.0	<1.0	0.5

Legend

LBM = Left Bank Margin
LMS = Left Midstream
RMS = Right Midstream
RBM = Right Bank Margin

1 Substrate not visible

SAMPLE AREA DESCRIPTION

September 12/82

Stream Name Morice River

Reach and Site Number R6 Site 2

Hydraulic Unit Sampled

Length 1 km

Wetted Width (m) Top 106
Bottom 104

Turbidity (m) 0.25 - 0.5

Temperature (C°)

Cover:

	LBM	LMS[1]	RMS[1]	RBM
Instream log (m^2) x Depth (m)	0	0	0	5
Instream boulders (m^2)	25	0	0	15
Instream vegetation (m^2)	0	0	0	0
Overstream vegetation (m^2)	0	0	0	0
Cutbanks (m^2)	0	0	0	0
Substrate:				
Fines (%)	0	-	-	0
Small gravel (%)	10	-	-	10
Large gravel (%)	20	-	-	25
Cobble (%)	40	-	-	25
Boulder (%)	30	-	-	40
Bedrock (%)	0	-	-	0
Average Depth (m)	0.75	<2	1.0	0.5

Legend

LBM = Left Bank Margin
LMS = Left Midstream
RMS = Right Midstream
RBM = Right Bank Margin

1 Substrate not visible

SAMPLE AREA DESCRIPTION

September 13/82

Stream Name Morice River

Reach and Site Number R7 Site I

Hydraulic Unit Sampled

Length I km

Wetted Width (m) Top 52 Bottom 78

Turbidity (m) 0.25

Temperature (C°) 12

Cover:

	LBM	LMS[1]	RMS[1]	RBM
Instream log (m^2) x Depth (m)	5	-	-	5
Instream boulders (m^2)	20	-	-	10
Instream vegetation (m^2)	0	-	-	0
Overstream vegetation (m^2)	0	-	-	0
Cutbanks (m^2)	0	-	-	0

Substrate:

	LBM	LMS[1]	RMS[1]	RBM
Fines (%)	15	-	-	25
Small gravel (%)	20	-	-	20
Large gravel (%)	10	-	-	10
Cobble (%)	40	-	-	35
Boulder (%)	15	-	-	10
Bedrock (%)	0	-	-	0
Average Depth (m)	0.25	1.0	1.5	0.5

Legend

LBM = Left Bank Margin
LMS = Left Midstream
RMS = Right Midstream
RBM = Right Bank Margin

I Cover and substrate not visible

APPENDIX F2

Catch Data from Electrofishing in the
Mainstem Morice/Bulkley River System, September 1982

TABLE F2.1
Catch Data from Electrofishing in the Mainstem Morice/Bulkley Rivers, September 1982

Reach (Site)	Date	River Length Sampled (km)	Location in Channel[1]	Steelhead Parr	Salmon and Steelhead Fry	Mountain Whitefish Juv.	Mountain Whitefish Adults	Largescale Suckers Juv.	Largescale Suckers Adults	Longnose Dace	Adult Steelhead Trout	Adult Pink Salmon	Others[2]	Unidentified
1 (1)	Sept. 9/82	1.0	L. Marg.	0	1	10	8	0	2	0	0	0	2 Co. 1 Ch.	1
			L. Mid.	-	-	-	-	-	-	0	0	0	0	-
			R. Mid.	0	0	0	3	0	0	0	0	0	0	0
			R. Marg.	0	0	3	11	0	8	0	0	0	0	0
			Total	0	1	13	22	0	10	0	0	0	2 Co. 1 Ch.	1
1 (2)	Sept. 9/82	>1.0	L. Marg.	0	0	2	12	0	1	2	0	16	1 Co. 3 Ch.	2
			L. Mid.	0	0	0	13	0	0	1	0	0	10 Ch.	2
			R. Mid.	0	0	0	1	0	0	0	0	0	1 Co.	2
			R. Marg.	1	2	4	15	0	1	2	3	16	0	3
			Total	1	2	6	41	0	2	5	3	32	2 Co. 13 Ch.	9
2 (1)	Sept. 9/82	1.0	L. Marg.	2	20	14	22	0	0	5	1	21	5 Lamp. 1 Ch. 2 Sculp. 1 D.V.	9
			L. Mid.	0	0	2	3	0	0	9	0	0	0	1
			R. Mid.	0	0	5	4	0	0	1	0	0	2 Ch.	1
			R. Marg.	2	12	8	6	0	0	0	2	9	4 Lamp. 3 Sculp.	1
			Total	4	32	29	35	0	0	15	4	39	9 Lamp. 3 Ch. 5 Sculp. 1 D.V.	12
2 (2)	Sept. 10/82	1.0	L. Marg.	2	23	9	11	0	4	2	3	32	7 Lamp.	9
			L. Mid.	0	0	0	0	0	0	2	0	1	0	2
			R. Mid.	0	0	12	16	7	0	3	1	0	0	1
			R. Marg.	1	2	13	7	1	1	9	1	17	0	12
			Total	3	25	34	34	8	5	16	5	50	7 Lamp.	24

(Continued)

TABLE F2.1 (Continued)

Reach (Site)	Date	River Length Sampled (km)	Location[1] in Channel	Steelhead Parr	Salmon and Steelhead Fry	Mountain Whitefish Juv.	Mountain Whitefish Adults	Largescale Suckers Juv.	Largescale Suckers Adults	Longnose Dace	Adult Steelhead Trout	Adult Pink Salmon	Others[2]	Unidentified
2 (3)	Sept. 10/82	1.7	L. Marg.	0	3	6	1	0	0	0	2	14	1 Co.	16
			L. Mid.	0	0	0	2	0	0	0	0	0	0	0
			R. Mid.	0	0	7	8	0	1	0	0	4	0	1
			R. Marg.	0	6	16	13	0	1	1	1	24	2 Lamp. 1 Sculp.	11
			Total	0	9	29	24	0	2	1	3	42	1 Co. 2 Lamp. 1 Sculp.	28
3 (1)	Sept. 9/82	1.0	L. Marg.	3	7	12	15	0	1	0	0	7	0	27
			L. Mid.	0	0	5	1	0	0	1	1	0	0	1
			R. Mid.	0	0	12	3	0	1	0	0	0	0	10
			R. Marg.	0	0	18	19	0	5	0	1	0	0	25
			Total	3	7	47	38	0	7	1	2	7	0	63
3 (2)	Sept. 6/82	1.0	L. Marg.	2	10	9	2	0	1	0	0	3	1 Lamp.	10
			L. Mid.	0	0	1	0	0	0	4	0	1	0	0
			R. Mid.	0	0	3	3	0	0	0	0	0	0	4
			R. Marg.	3	19	11	9	0	1	1	1	3	0	5
			Total	5	29	24	14	0	2	5	1	7	1 Lamp.	19
4 (1)	Sept. 7/82	1.0	L. Marg.	4	20	24	23	3	11	1	2	4	1 Co. 1 Ch.	13
			L. Mid.	0	3	16	20	0	1	3	0	7	1 Lamp. 2 D.V.	2
			R. Mid.	0	0	9	37	0	1	4	1	6	0	2
			R. Marg.	13	15	32	44	0	10	0	0	40	1 D.V.	6
			Total	17	38	81	124	3	23	8	3	57	1 Co. 1 Ch. 1 Lamp. 3 D.V.	23

(Continued)

TABLE F2.1 (Continued)

Reach (Site)	Date	River Length Sampled (km)	Location[1] in Channel	Steel-head Parr	Salmon and Steel-head Fry	Mountain Whitefish Juv.	Mountain Whitefish Adults	Largescale Suckers Juv.	Largescale Suckers Adults	Long-nose Dace	Adult Steelhead Trout	Adult Pink Salmon	Others[2]	Unidentified
4 (2)	Sept. 7/82	1.0	L. Marg.	1	9	50	2	0	5	6	0	4	5 Lamp.	9
			L. Mid.	0	0	10	13	1	1	12	0	1	2 D.V.	4
			R. Mid.	1	0	7	8	0	3	4	0	2	1 D.V.	4
			R. Marg.	6	2	27	32	0	2	0	2	15	0	3
			Total	8	11	94	55	1	11	22	2	22	5 Lamp. 3 D.V.	20
5 (1)	Sept. 8/82	1.0	L. Marg.	24	29	22	12	6	1	4	0	5	12 Lamp. 1 Co. 1 D.V.	6
			L. Mid.	1	0	13	23	0	0	5	0	0	1 Co. 5 Lamp.	7
			R. Mid.	0	0	1	17	0	0	10	1	0	3 Lamp.	4
			R. Marg.	35	30	9	18	4	13	1	0	11	2 Lamp.	4
			Total	60	59	45	70	10	14	20	1	16	22 Lamp. 2 Co. 1 D.V.	21
5 (2)	Sept. 8/82	1.7	L. Marg.	6	3	9	19	1	6	2	1	2	1 Lamp. 1 Sculp.	10
			L. Mid.	0	0	0	0	0	0	1	1	0	1 Lamp	0
			R. Mid.	0	0	1	1	0	0	0	1	0	1 Lamp.	0
			R. Marg.	6	6	10	20	0	1	5	1	6	2 Lamp. 1 Sculp. 1 D.V.	4
			Total	12	9	20	40	1	7	8	4	8	5 Lamp 2 Sculp. 1 D.V.	14

(Continued)

TABLE F2.1 (Continued)

Reach (Site)	Date	River Length Sampled (km)	Location in Channel[1]	Steel-head Parr	Salmon and Steel-head Fry	Mountain Whitefish Juv.	Mountain Whitefish Adults	Largescale Suckers Juv.	Largescale Suckers Adults	Long-nose Dace	Adult Steelhead Trout	Adult Pink Salmon	Others[2]	Unidentified
6 (1)	Sept. 11/82	1.5	L. Marg.	19	67	120	51	1	27	0	3	1	1 Lamp.	25
			L. Mid.	0	0	20	12	0	16	5	0	0	0	0
			R. Mid.	0	0	3	5	0	0	2	1	0	1 Lamp.	0
			R. Marg.	15	73	0	0	0	14	0	7	8	7 Lamp	20
			Total	34	140	143	68	1	57	7	11	9	9 Lamp.	45
6 (2)	Sept. 12/82	1.0	L. Marg.	13	38	8	8	0	2	0	0	0	0	1
			L. Mid.	0	0	2	1	0	0	4	0	0	1 Lamp.	1
			R. Mid.	0	5	2	0	0	0	0	0	0	2 Lamp.	1
			R. Marg.	10	29	14	3	1	1	1	2	1	0	2
			Total	23	72	26	12	1	3	5	2	1	3 Lamp.	5
7 (1)	Sept. 13/82	1.0	L. Marg.	7	5	4	12	0	0	13	6	0	10 Lamp.	5
			L Mid.	0	0	0	0	0	0	3	0	0	5 Lamp.	0
			R. Mid.	0	0	0	0	0	0	0	0	0	0	0
			R. Marg.	25	38	8	7	0	4	3	6	1	14 Lamp.	5
			Total	32	43	12	19	0	4	19	12	1	29 Lamp.	10

1 L. Marg. = Left Bank Margin
L. Mid. = Left Midstream
R. Mid. = Right Midstream
R. Marg. = Right Bank Margin

2 Co. = Coho Salmon
Ch. = Chinook Salmon
Lamp. = Lamprey
Sculp. = Sculpin
D.V. = Dolly Varden char

APPENDIX F3

Age, Length, Weight and Condition Factor Data for
Steelhead Parr Captured in the Mainstem Morice/Bulkley Rivers,
September 1982

TABLE F3.1
Age, Length, Weight and Condition Factors for Steelhead Trout Parr Captured in the Mainstem Morice/Bulkley Rivers, September 1982[1]

Reach	Length (mm)	Age	Reach	Length (mm)	Age	Weight (g)	Condition Factor	Reach	Length (mm)	Age	Weight (g)	Condition Factor	Reach	Length (mm)	Age
2	165	3+	5	209	3+	-	-	6	141	2+	30.0	1.07	7	181	2+
2	142	2+	5	140	3+	-	-	6	133	2+	25.0	1.06	7	209	4+
2	76	2+	5	143	3+	-	-	6	143	3+	38.5	1.21	7	95	1+
3	79	1+	5	151	3+	-	-	6	167	3+	53.5	1.15	7	138	1+
3	163	3+	5	136	3+	-	-	6	145	2+	31.5	1.03	7	182	4+
4	162	2+	5	110	2+	-	-	6	90	1+	10.0	1.37	7	146	2+
4	81	1+	5	165	2+	-	-	6	132	2+	25.5	1.11	7	125	2+
4	139	3+	5	159	2+	-	-	6	150	3+	35.5	1.05	7	160	2+
4	147	2+	5	156	3+	-	-	6	130	3+	24.3	1.11	7	178	3+
4	221	4+	5	164	2+	-	-	6	110	2+	16.0	1.20	7	150	3+
4	142	2+	5	143	2+	-	-	6	149	3+	36.7	1.11	7	167	3+
5	154	2+	5	142	3+	-	-	6	140	2+	30.5	1.11	7	132	3+
5	135	2+	5	158	2+	-	-	6	155	3+	46.0	1.24	7	144	3+
5	140	3+	5	102	1+	-	-	6	141	2+	33.0	1.18	7	109	2+
5	139	3+	5	138	2+	-	-	6	152	2+	42.8	1.22	7	124	2+
5	128	2+	5	255	3+	-	-	6	136	2+	26.0	1.03			
5	162	4+	5	180	2+	-	-	6	125	2+	19.8	1.01			
5	178	2+	5	158	2+	-	-	6	85	1+	6.0	0.98			
5	149	3+	6	129	2+	20.0	0.93	6	141	2+	32.5	1.16			
5	170	2+	6	144	3+	31.2	1.04	6	155	2+	40.0	1.07			
5	136	3+	6	138	2+	28.0	1.07	6	137	2+	26.5	1.03			
5	139	3+	6	132	2+	23.5	1.02	6	88	1+	7.5	1.10			
5	155	2+	6	143	2+	29.0	0.99	6	128	2+	21.0	1.00			
5	177	2+	6	161	3+	48.5	1.16	6	127	2+	21.0	1.03			
5	171	2+	6	147	2+	32.5	1.02	6	144	2+	35.0	1.17			
5	162	2+	6	125	3+	22.7	1.16	6	137	3+	25.0	0.97			
5	130	3+	6	143	2+	47.2	1.61	6	130	2+	22.6	1.03			
5	169	3+	6	111	2+	14.0	1.02	6	122	2+	17.0	0.94			
5	143	2+	6	179	3+	67.0	1.16	6	79	1+	5.0	1.01			
5	109	1+	6	119	2+	17.5	1.04								

1 Weight and condition factor determined for fish sampled from Reach 6 only

SECTION G

HABITAT PREFERENCES AND DENSITIES OF JUVENILE SALMONIDS IN THE MORICE RIVER DURING SEPTEMBER 1982

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1.0 INTRODUCTION

A knowledge of the distribution of fish in relation to specific environmental factors is essential in assessing the effects of changing flow regimes on rearing salmonids within a river system. Depth, velocity, cover and substrate are important factors affecting fry density (Everest and Chapman 1972). Habitat requirements of juvenile salmonids may also vary with species, age, and time of year, and are specific for a given river system (Reiser and Bjornn 1979).

This study was undertaken to determine habitat preferences specific to Morice River juvenile chinook (Oncorhynchus tshawytscha) and coho salmon (O. kisutch), and steelhead trout (Salmo gairdneri) based on habitat measurements made at sites where fish were directly observed. In the Morice River, fish are active and maintaining territories from May through to the end of October. The part of this period with the lowest flows and least available habitat is September to October (Section A; Shepherd 1979). This study was therefore conducted during early September (1982) when habitat availability may be limiting. The objectives were:

1. To develop juvenile salmonid rearing criteria which were required for the modelling of habitat-discharge relationships in the Morice River (preferred substrate and cover types were identified and preferences ranges for depth and velocity were determined for chinook, coho, and steelhead juveniles); and

2. To obtain fry density estimates for chinook, coho, and steelhead juveniles rearing in the Morice River.

The study area was located in the upper Morice River from approximately 1 km upstream of Gosnell Creek in Reach 1 to Lamprey Creek in Reach 2 (Figure 1.1). The lower reaches were not included in the study since heavy rains had increased turbidity levels in the water which reduced visibility for observing fry.

2.0 METHODS

2.1 Study Duration and Design

The study was conducted between September 6 and 16, 1982. Observation sites were originally selected randomly throughout the width of the river. However, much of the Morice River has deep, fast flow and the majority of these sites are not utilized by juvenile salmonids. To obtain an adequate sample size, some observations were made at locations where fish were observed during preliminary surveys (non-random selection). Of the 203 observation sites, 75 were selected non-randomly and 128 were selected randomly.

2.2 Data Collection

Both SCUBA and snorkelling were used to observe fry. In shallow water (< 45 cm) observations were sometimes made from shore. Efforts were made to sample the range of habitats available in the Morice River. A one meter square of perforated copper tubing was used to mark stations. At randomly selected sites, the square was thrown into the river and observations made at the point where it landed. At non-randomly selected sites, it was placed in areas where fish were observed during preliminary surveys. Following the positioning of the quadrat, the diver waited from 2 to 10 minutes for the fish to redistribute themselves. Actual observation time was 5 minutes per station.

Divers recorded species, estimated age and number of juvenile salmonids within the area marked by the quadrat. Only those fry judged to be utilizing the area directly over the quadrat were counted and observed. Fry swimming directly through an area were not enumerated. Depth and average velocity (at 0.4 of the total depth from the bottom) were measured at 2 points within each station using a Marsh-McBirney flow meter. During data collection, the depths sampled ranged from 15 to 325 cm and water velocities from 0 to 95 cm/s. Macrohabitat (i.e. pool, riffle, back eddy, run, etc.), cover type and the distance from the centerpoint of the quadrat to the nearest cover were also recorded. Substrate was ranked in size categories according to the estimated percent of each type present within the station (Bovee and Cochnauer 1977). The cover and substrate categories used in data analysis are listed below.

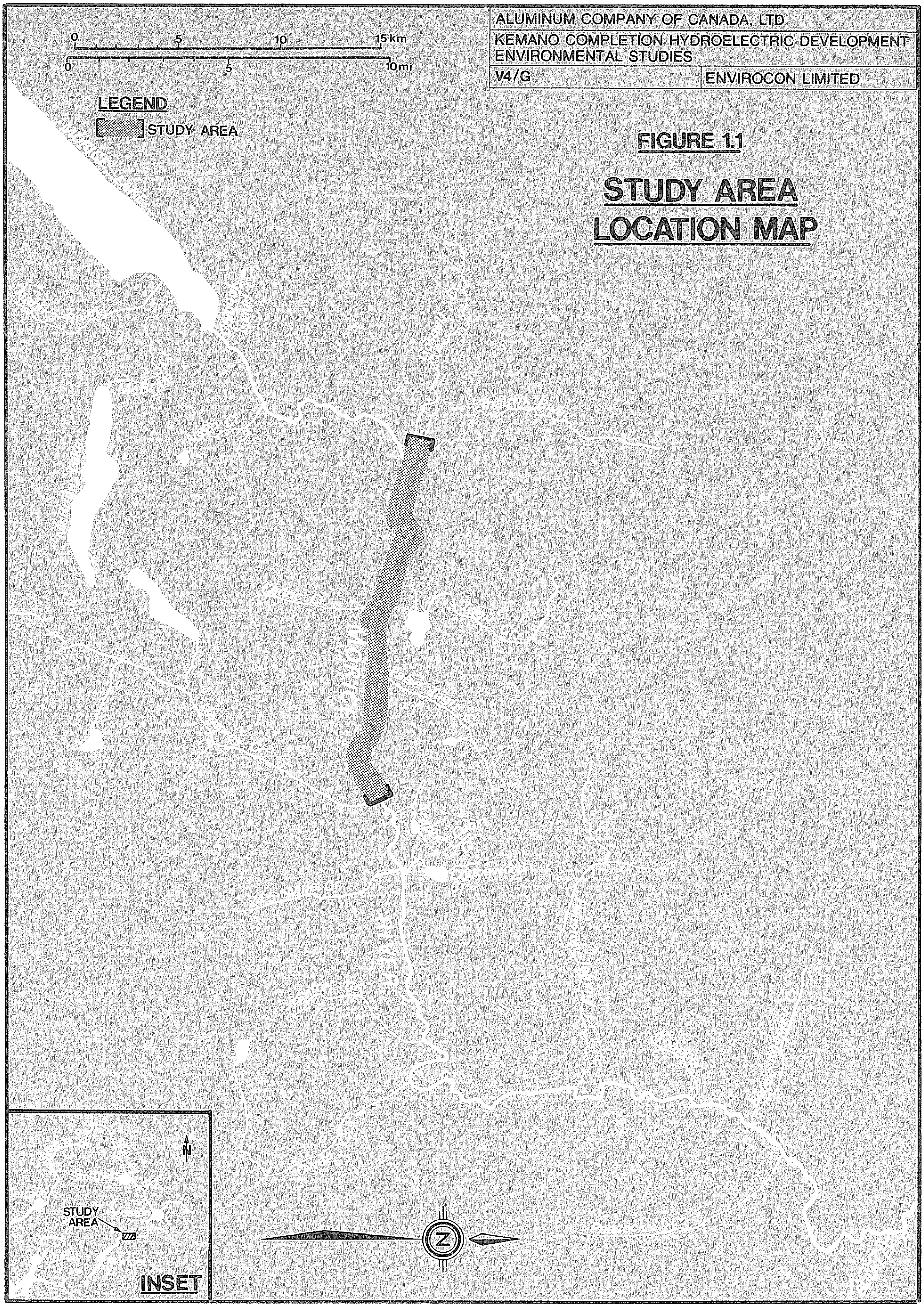
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FIGURE 1.1
STUDY AREA
LOCATION MAP
LEGEND
STUDY AREA
0
5
10
15 km
0
5
10 mi
MORICE LAKE
Nanika River
Chinook Island Cr.
Gosnell Cr.
McBride Cr.
McBride Lake
Nado Cr.
Thautil River
Cedric Cr.
Tagit Cr.
MORICE
False Tagit Cr.
Lamprey Cr.
Trapper Cabin Cr.
Cottonwood Cr.
24.5 Mile Cr.
RIVER
Houston Tommy Cr.
Fenton Cr.
Knapper Cr.
Below Knapper Cr.
Owen Cr.
Peacock Cr.
BULKLEY R.
Skeena R.
Bulkley R.
Smithers
Terrace
STUDY AREA
Houston
Kitimat
Morice L.
INSET
N

COVER CATEGORIES

0. No Cover (within 300 cm)
1. Cobble (61-250 mm)
2. Boulder (251-4,000 mm)
3. Aquatic Vegetation
4. Submerged Log/Branch Debris
5. Submerged Root Wad
6. Log Jam
7. Overhanging Log/Branch Debris
8. Overhanging Root Wad
9. Overhanging Vegetation
10. Undercut Bank

SUBSTRATE CATEGORIES

1. Organic
2. Clay
3. Clay and Silt
4. Silt (<1 mm)
5. Silt and Sand
6. Sand (1-2 mm)
7. Sand and gravel
8. Gravel (3-60 mm)
9. Gravel and Cobble
10. Cobble (61-250 mm)
11. Cobble and Boulder
12. Boulder (251-4,000 mm)

All categories of cover and substrate were examined.

2.3 Fry Density Calculations

Average fry densities (fish/m^2) were calculated for various intervals of depth and velocity and for the categories of cover and substrate. Fry densities were used in subsequent analysis in order to "equalize" sampling effort.

2.4 Habitat Preference Analysis

Habitat preferences for steelhead trout fry and coho and chinook salmon fry were developed based on cumulative frequency distributions of fry density data for depth and velocity. Habitat preference ranges were based on the 10th and 90th percentiles (80% extending in both directions from the median) of the cumulative distributions for combined random and non-random data. Although probability of use (POU) curves were calculated based on Bovee (1982), this approach was not used due to limitations of the data collected.

Cover and substrate categories with the highest fish densities calculated from combined random and non-random sampling site observations were described as the preferred habitat based on these factors.

The information obtained in the present study was considered later when defining habitat criteria for modelling habitat-discharge relationships for juvenile salmonids in the Morice River (Volume 15, Appendix D2).

3.0 RESULTS

Of a total 514 juvenile salmonids observed in combined random and non-random sites, coho salmon fry represented 48% (248), while chinook salmon and steelhead trout fry comprised 44.5% (228) and 7.5% (38) of the total, respectively. Both steelhead trout and chinook salmon fry were most commonly found along the margins of the main channel, utilizing overhanging rootwads or log jams for cover. Coho salmon fry were primarily observed in back eddies and pools of side channels.

From the 203 stations sampled, only 15 salmonids (3% of total) were thought to have overwintered in this area; 5 chinook, 4 coho, and 6 steelhead were visually estimated to be greater than 0+ in age.

3.1 Chinook Salmon

Of the three species examined, chinook salmon fry utilized the deepest and fastest water. When the data were corrected for sampling effort, 80% of the chinook salmon fry (based on the cumulative frequency distribution) were observed in sites with average velocities ranging from 4 to 47 cm/s and depths from 90 to 310 cm (Table 3.1). The highest average chinook salmon fry density was found at a velocity interval of 10-20 cm/s and a depth interval of 250-300 cm (Table 3.2). The highest single density value (18 fry/m^2) was observed in an area of submerged rootwad cover, at a depth of 120 cm and a velocity of 11 cm/s, over silt substrate (Appendix G1).

The highest average fish densities were found over substrate of sand and organics and associated with a cover of submerged rootwad (Figure 3.1). Ninety-two percent of all chinook salmon fry observed were associated with some form of cover, usually rootwads.

3.2 Coho Salmon

Eighty percent of the coho salmon fry were found in shallow areas with depths ranging from 10 to 120 cm and low velocities ranging from 2 to 28 cm/s (based on the cumulative frequency distribution of corrected data) (Table 3.1). Average density for coho salmon fry was highest in the depth interval of 0-50 cm and the velocity interval of 0-10 cm/s (Table 3.2). Fry were most abundant over substrate overgrown with macrophytic algae and near overhanging cover in the form of rootwads or vegetation (Figure 3.2). Nearly all coho salmon fry (99.6%) were associated with some type of cover, usually within 200 cm. Fry were not observed at depths greater than 1.5 m.

TABLE 3.1
Habitat Preferences (Depth and Velocity) of Juvenile Salmonids in the Morice River, September 1982[1]

	10th to 90th Percentile	25th to 75th Percentile
Chinook Salmon		
Depth (cm)	90-310	160-260
Velocity (cm/s)	4 - 47	10 - 39
Coho Salmon		
Depth (cm)	10 - 120	20 - 70
Velocity (cm/s)	2 - 28	4 - 15
Steelhead Trout		
Depth (cm)	10 - 80	20 - 50
Velocity (cm/s)	2 - 32	5 - 19

[1] Based on cumulative frequency distributions of fry density data

TABLE 3.2
Mean Salmon Fry Densities and 95% Confidence Intervals for Depth and Velocity

DEPTH

Depth Interval cm	Chinook Salmon fish/m²			Coho Salmon fish/m²			Steelhead Trout fish/m²		
	n[1]	$\bar{x}$[2]	C.I.[3]	n[1]	$\bar{x}$[2]	C.I.[3]	n[1]	$\bar{x}$[2]	C.I.[3]
0-50	90	0.7	0.4-1.0	90	1.8	1.1-2.5	90	0.3	0.1-0.5
>50-100	84	1.2	0.6-1.7	84	0.8	0.3-1.4	84	0.1	0.0-0.2
>100-200	22	1.8	0.0-3.6	22	0.5	0.0-1.4	22	0.0	-
>150-200	2	3.0	-*	2	0.0	-	2	0.0	-
>200-250	1	0.0	-	1	0.0	-	1	0.0	-
>250-300	2	8.0	-	2	0.0	-	2	0.0	-
>300-350	2	2.0	-	2	0.0	-	2	0.0	-

VELOCITY

Velocity Interval cm/s	Chinook Salmon fish/m²			Coho Salmon fish/m²			Steelhead Trout fish/m²		
	n[1]	$\bar{x}$[2]	C.I.[3]	n[1]	$\bar{x}$[2]	C.I.[3]	n[1]	$\bar{x}$[2]	C.I.[3]
0-10	77	1.2	0.6-1.9	77	2.5	1.6-3.5	77	0.3	0.1-0.5
>10-20	59	1.7	0.8-2.5	59	0.7	0.3-1.1	59	0.2	0.1-0.3
>20-30	26	0.6	0.0-1.2	26	0.2	0.0-0.4	26	0.1	0.0-0.2
>30-40	13	0.5	0.0-1.4	13	0.1	0.0-0.1	13	0.1	0.0-0.2
>40-50	9	0.9	0.0-1.8	9	0.0	-	9	0.1	0.0-0.3
>50-60	7	0.1	0.0-0.4	7	0.3	0.0-0.9	7	0.0	-
>60-70	8	0.4	0.0-0.9	8	0.5	0.0-1.5	8	0.0	-
>70-80	3	0.0	-	3	0.0	-	3	0.0	-

1 Number of sites observed
2 Mean fry density
3 95% confidence intervals
* Insufficient data to compute confidence interval

The highest single density value (18 fry/m^2) was observed in a still pool 30 cm deep, 200 cm from the nearest cover (overhanging vegetation) over a silt substrate (Appendix G1).

3.3 Steelhead Trout

Steelhead trout fry were the smallest species observed averaging 32.6 mm long (Table 3.3). Based on the 10th to 90th percentiles of the cumulative frequency distribution, steelhead fry were observed in the shallowest depths of the three species examined (10-80 cm) (Table 3.2). However, the velocity range of 2 to 32 cm/s was intermediate to those where chinook and coho salmon fry were most often found (Table 3.2). Although fry were found at depths up to 90 cm and in velocities not greater than 40 cm/s, they were most abundant at depths less than 50 cm and velocities less than 10 cm/s (Table 3.2).

Steelhead fry were associated with cover 81% of the time, and were most often observed in shallow pools within half a meter of overhanging rootwads, vegetation or log jams (Figure 3.3). As with coho salmon, the highest densities of steelhead trout fry were observed above organic substrate (Figure 3.3).

The highest single density value of steelhead trout fry observed was 4 fry/m^2 at three sites, all less than 50 cm deep in relatively calm water (< 11 cm/s; Appendix G1).

3.4 Fry Densities

Non-random density estimates of chinook and coho salmon fry were similar, and were approximately 6 times the estimates for steelhead trout (Table 3.3). Large differences were observed between density estimates from random and non-random sampling, with the density of fry in non-randomly selected sites being 15-25 times that found with random sampling. In 37% of the non-random samples, more than one species of juvenile salmonid was utilizing the habitat within a site. All non-randomly selected sites had at least one juvenile present. Only 18% of the random sites were utilized by juvenile salmonids; 8.7% had more than one species.

Physical limitations imposed on the divers by high current velocities in parts of the river, such as mid-channel areas, resulted in the exclusion of these areas from the estimates. Therefore, not all of the available macrohabitat was sampled equally, possibly resulting in overestimates of mean densities for the river. However, snorkelling surveys revealed that salmonid fry do not utilize these areas for rearing.

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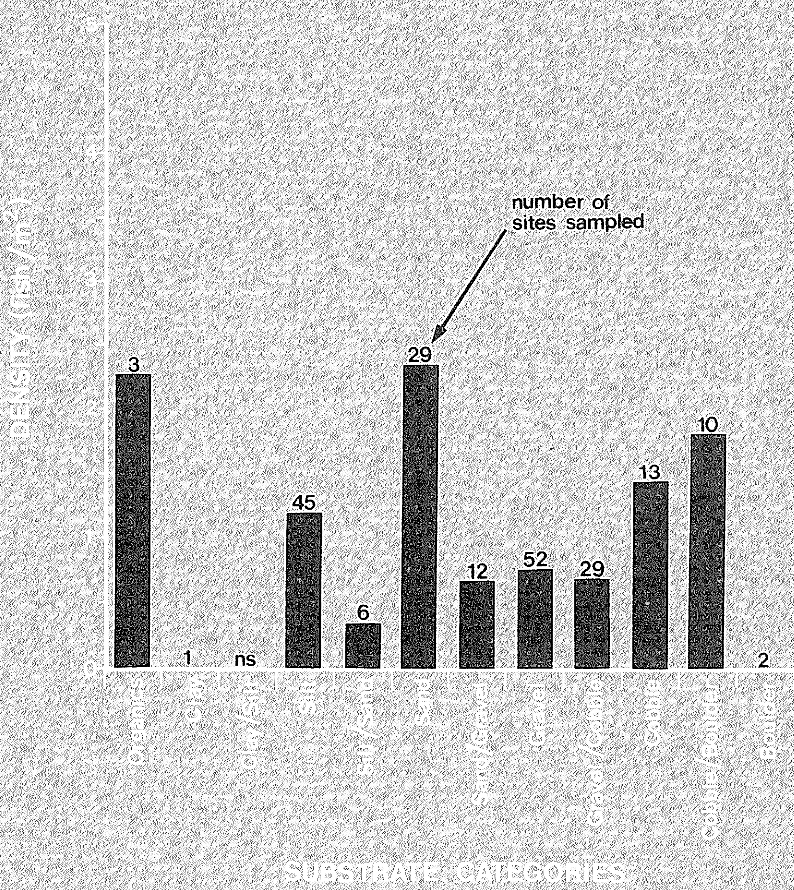
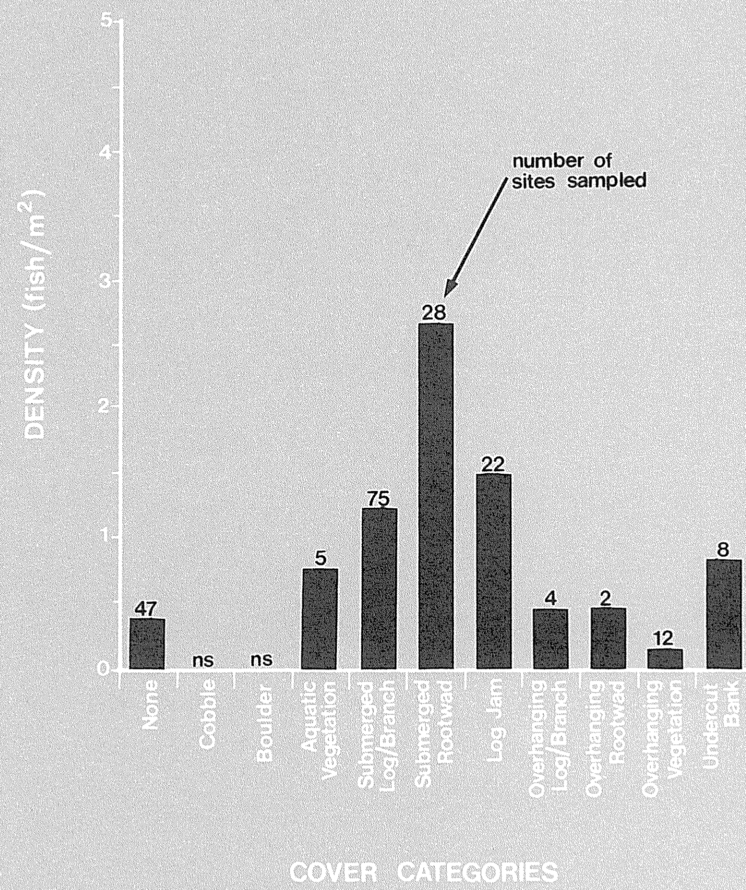
NOTES
- data from combined sampling
- total number of Chinook fry observed = 228
- ns = no sample

FIGURE 3.1 : AVERAGE CHINOOK FRY DENSITY IN RELATION TO SUBSTRATE AND COVER





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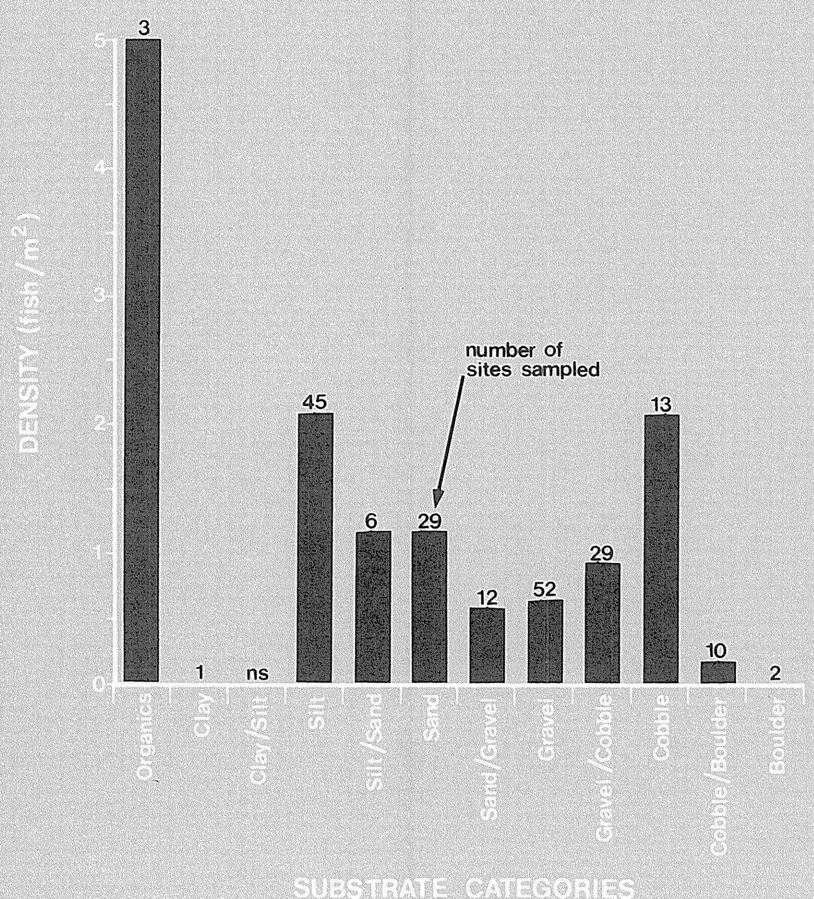
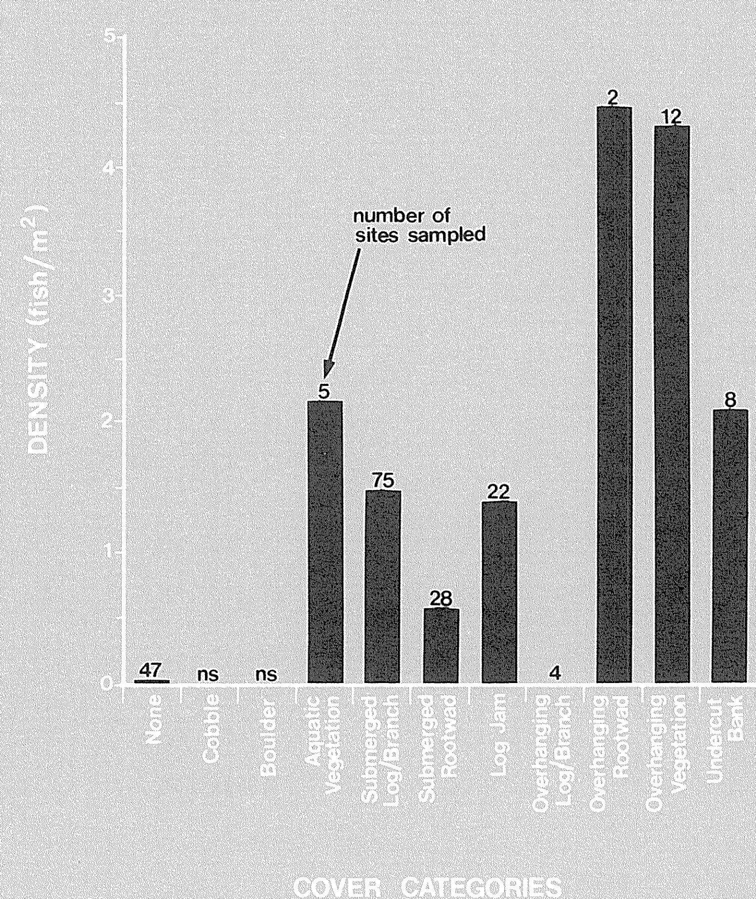
NOTES
- data from combined sampling
- total number of Coho fry observed = 248
- ns = no sample

FIGURE 3.2 : AVERAGE COHO FRY DENSITY IN RELATION TO SUBSTRATE AND COVER





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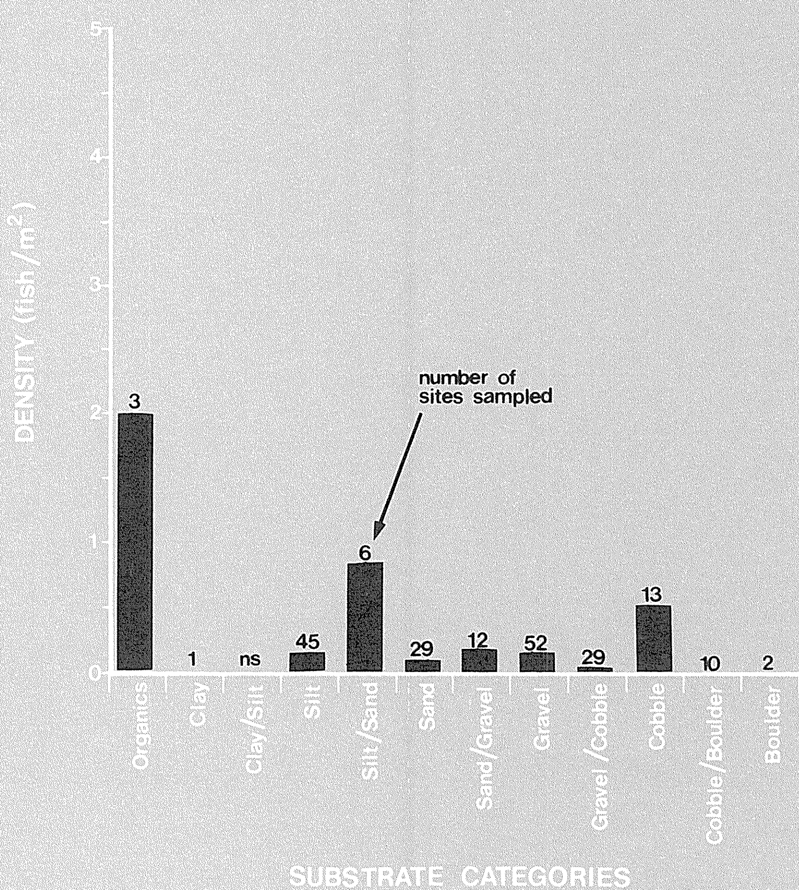
NOTES

- data from combined sampling
- total number of Steelhead fry observed = 38
- ns = no sample

FIGURE 3.3: AVERAGE STEELHEAD FRY DENSITY IN RELATION TO SUBSTRATE AND COVER



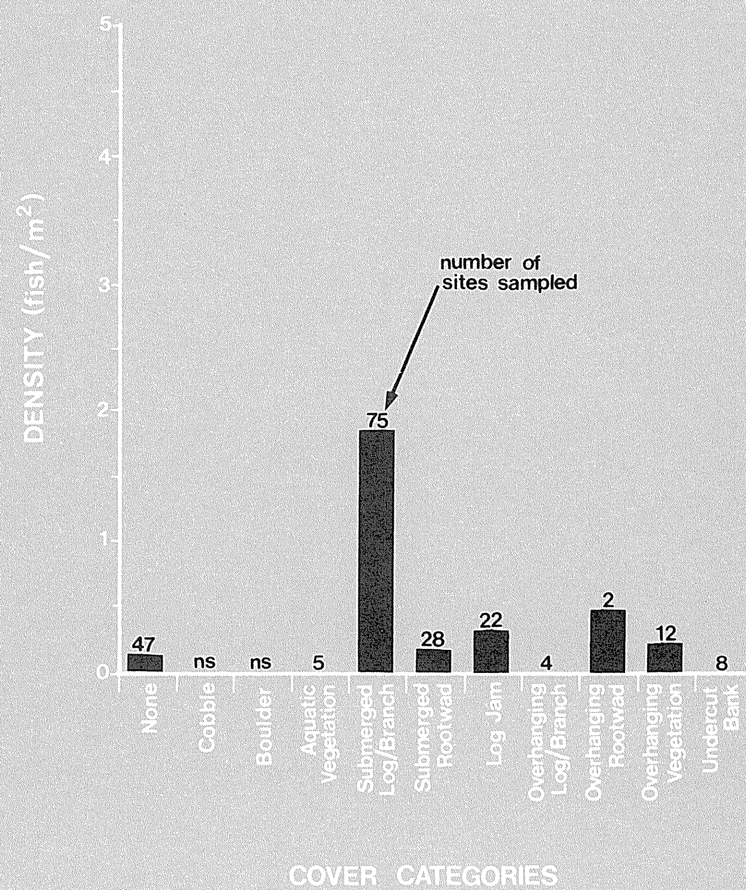


TABLE 3.3
Average Fry Densities Based on Observations of Juvenile Chinook and Coho Salmon and Steelhead Trout in the Morice River, September 1982

Species	Sample Method	No. of Stations	Total No. of Fry	Average Fry Density (fish/m^2)	95% Confidence Limits (fish/m^2)	Mean[1] Length (mm)
Chinook salmon	Non-random	75	207	2.76	1.89-3.63	64.8
	Random	128	21	0.16	0.04-0.29	
Coho salmon	Non-random	75	233	3.11	2.16-4.06	49.9
	Random	128	15	0.12	0.47-0.71	
Steelhead Trout	Non-random	75	34	0.45	0.23-0.671	32.6
	Random	128	4	0.03	0.01-0.054	

1 Since mean lengths were not measured during this study, they were estimated from electrofishing data collected in the Morice River during August 1982 (Section E)

Furthermore, results from boat electrofishing surveys (Section F) suggest that rearing salmonid fry do not use mainstem midchannel habitat. Therefore, it is unlikely that densities were overestimated.

4.0 DISCUSSION

4.1 Habitat Preferences

The data in Table 3.3 indicate that sample sizes were small in some of the categories. This was partly a reflection of the difficulty in adequately sampling all habitat category combinations and partly a result of the decision to discontinue random sampling since the number of fish being observed was often too small to analyze habitat preferences. Despite the small sample sizes, the distributions obtained were likely adequate for the intended purpose.

4.1.1 Chinook Salmon

In this study, chinook salmon fry were most abundant in areas with velocities between 4 and 47 cm/sec. Overall, the upper velocity suitable for chinook juveniles (47 cm/s) was greater than that for coho salmon or steelhead trout juveniles. The range of velocities utilized by chinook juveniles in this study is similar to those ranges described by Shepherd (1979) and found in earlier Envirocon studies (Table 4.1; Section A). However, in the Nechako River study (Volume 5, Section G), the upper velocity was lower (32 cm/s). This difference may be attributable to the smaller size of Nechako River fish sampled in early summer compared to the Morice River fish, or it may reflect the small sample size at velocities greater than 35 cm/s in the Nechako River.

In this study, chinook fry utilized relatively deep waters, 90 to 310 cm. Both upper and lower depth limits were considerably greater than for coho salmon or steelhead trout juveniles. Studies conducted by Envirocon on the Nechako River (Volume 5, Section G), by Shepherd (1979) on the Morice River, and by Thompson (1972) on some B.C. streams (Table 4.1) indicated shallower depth preferences (30 to 135 cm) for 0+ chinook salmon. The greater preferred depth range for Morice River fish may be partly attributable to differences in age and body size of the fish at time of sampling. Average length of chinook salmon fry was estimated at approximately 64.8 mm during this study, which is 13.4 mm larger than Nechako River fry. However, this difference may in part relate to the depths of observation. For example, the deepest observation in the Nechako River was at a depth less than 140 cm, and no data were available for comparison to the greater depths observed in this study.

Fry were most often observed along the margins of the main channel in deep back eddies near rootwad and log jam cover. Most were found over sand or organic substrate although a variety of substrates were used.

TABLE 4.1
Habitat Utilization by Juvenile Salmonids: Comparison with Literature Values

Species	Depth (cm)	Velocity (cm/s)	Substrate	Cover	Macrohabitat	Season	Location	Reference
Chinook Fry	**90 to 310**	**4 to 47**	**sand, organic**	**rootwad, log jams**	**main channel**	**fall**	**Morice River**	**present study**
	>15	2 to 50	-	rootwad, log jams	main and side channels	fall	Morice River	Section A
	30 to 135	<60	silt, stone, cobble	-	mainstream log jams	summer	Morice River	Shepherd (1979)
	30 to 110	3 to 32	gravel	-	mainstream	early summer	Nechako River	Volume 5, Section G
	15 to 30	>15	silt	-	-	summer	Idaho Streams	Everest and Chapman (1972)
	30 to 122	6-24	-	-	-	-	B.C. Stream	Thompson (1972)
Coho Fry	**10 to 120**	**2 to 28**	**sand, cobble**	**overhanging rootwad**	**side channel**	**fall**	**Morice River**	**present study**
	>15	0-15		log debris, rootwad, vegetation	side channel pool, pond	summer	Morice River	Section A
	90 to 120	0-14	silt	weeds, logs	side channel	summer	Morice River	Shepherd (1979)
	6 to 70	<60	-	overhanging vegetation, bank	side channel marginal back eddies	summer	B.C. Streams	Mundie (1969)
	-	12 to 40	gravel	overhanging vegetation, logs	main stream back eddies	spring	Big Qualicum River	Lister & Genoe (1970)
Steelhead Fry	**10 to 80**	**2 to 32**	**organics, silt, sand**	**overhanging rootwad, log jams**	**main channel riffles, pools**	**fall**	**Morice River**	**present study,**
	<85	<35	cobble	debris, rootwad, vegetation	marginal flats side-pools	fall	Idaho Streams	Everest & Chapman (1972)
	<15	<15	rubble	-	-	summer	Idaho Streams	Everest & Chapman (1972)
	<30	3 to 26	-	-	-		Idaho Streams	Stuehrenberg (1975)
	18 to 67	6 to 49	-	-	-		B.C. Stream	Thompson (1972)

4.1.2 Coho Salmon

The depth preferences of Morice River coho salmon (10 to 120 cm) are similar to those described for other locations (Table 4.1), but are shallower than those utilized by chinook salmon (90 to 310 cm). This difference may be a result of species-specific requirements or size differences (chinook salmon mean length, 65 mm; coho salmon mean length, 50 mm).

The velocity ranges described for coho salmon in this study (2 to 28 cm/s) compared well with data from other studies (Table 4.1). Coho salmon fry utilized slower water than either Morice River chinook salmon or steelhead trout juveniles. This difference may be largely species-specific. Studies in 1979 (Section A) found that Morice River 1+ coho salmon occupied similar velocities as 0+ coho (0-15 cm/s) suggesting that, throughout their freshwater rearing period, juvenile coho salmon, regardless of body size, prefer slower velocities than fry of most other salmonid species.

Coho salmon preferred side channel habitat with back eddies and pools. Fry primarily used areas over sand or cobble substrate. Most fry (99.6%) were associated with cover. Both coho and chinook salmon underyearlings were most often found within 2 m of cover. Ruggles (1966) noted that coho salmon fry avoided densely shaded areas.

4.1.3 Steelhead Trout

Morice River steelhead trout fry utilized velocities from 2 to 32 cm/s most heavily, a range between those preferred by chinook and coho salmon. This is similar to velocity ranges reported in the literature (Table 4.1).

Of the three species, steelhead trout fry preferred the shallowest water (10 to 80 cm). Everest and Chapman (1972) found a similar depth range (0 to 85 cm) for 0+ steelhead trout during a fall study. They found that steelhead trout and chinook salmon of the same age class and body size chose nearly identical habitats. However, because of different emergence times, size differences were large and competition for the same space was minimized.

Steelhead trout fry, similar to chinook salmon fry, were most abundant along main channel margins near overhanging rootwads and log jams. Fry preferred shallow riffles and pools over a substrate of organics, silt or sand. Many riffle areas occupied by the fry were shallow with cover in the form of large gravel or cobble substrate.

Were it possible to rank the factors influencing habitat selection by juvenile salmonids in the Morice River, it is unlikely that substrate would be important in initially drawing fry to a particular area. Although substrate, depth, and velocity are closely interrelated, substrate preferences were least distinctive (Table 4.1). For both chinook salmon and steelhead trout, literature sources cite similar cover and macrohabitat preferences and substrate preferences which range in size from silt to cobble. In general, salmonid fry were most abundant along the margins of the main channels and side channels.

The criteria derived in this study provide information necessary to evaluate changes in fry habitat availability due to changes in flow. However, it should be noted that habitat preferences (hence criteria) vary with species, body size and time of year, and may be distinctive for each river system (Chapman 1966).

4.2 Fry Densities

In a survey of the factors limiting salmonid production in streams, Allen (1969) assembled data on salmonid fry densities and estimated the average fry density for fish 5 cm in length (roughly the average length of fish in the present study) to be 1.18 fish/m^2. His estimate was derived for streams 3 to 9 m wide. In this study, average fry densities in the Morice River, based on random sampling, ranged from 0.03 for steelhead trout to 0.16 fish/m^2 for chinook salmon (Table 3.3). At the time of sampling, the wetted width of mainstem and side channels within the study area ranged from 90 to 125 m, an order of magnitude greater in size than Allen's streams. Large rivers usually have a smaller proportion of their area suitable for juvenile rearing (Allen 1969) and consequently are proportionately less productive than small rivers. For example, most of the main channel areas of the Morice River have depth and velocity characteristics unsuitable for juvenile salmonids. A comparison of Allen's (1969) density estimate of 1.18 fish/m^2 for small streams with the estimates obtained in this study (0.03 fish/m^2 for steelhead trout to 0.16 fish/m^2 for chinook salmon) for the Morice River suggests that the Morice River is relatively unproductive, as would be expected for a river of its size.

4.2.1 Chinook Salmon

The Morice River chinook salmon density estimate (0.16 fish/m^2), based on random sampling, is somewhat low compared to literature values (Table 4.2). This difference may be partly attributed to differences in timing of the studies, to differences in the amount of good rearing habitat available, fish size differences, or river size

TABLE 4.2
Densities of Juvenile Salmonids in Streams: Comparison with Literature Values

Species	Density	Comments	Reference
Chinook Salmon	0.16	- Morice River, September 1982. Random Sampling	-present study
	.054(1982) .016(1981)	- Morice River, October 1981 and 1982, based on electrofishing in side channels.	-Section J
	1.35	- Idaho, estimate of summer rearing; median stream size 4-5 m	-Sekulich and Bjornn (1977)
	0.3 - 1.7	- 4 streams in Idaho. Mean stream size 3-9 m	Bjornn et al. (1977)
Coho Salmon	0.12	- Morice River, September 1982. Random Sampling	-present study
	.103(1982) .292(1981)	- Morice River, October 1981 and 1982, based on electrofishing in side channels	-Section J
	0.27	- B.C. streams based on population estimate and stream area	-Hunter (1959)
	2.94 (1962) 1.26 (1965)	- Oregon Streams	-Chapman (1962, 1965)
Steelhead Trout Fry	0.03	- Morice River, September 1982. Random Sampling	-present study
	.064(1982) .053(1981)	- Morice River, October 1981 based on electrofishing in side channels	-Section J
	0.7 - 1.08	- Idaho streams; median width 4-5 m	-Bjornn (1978)
	1.7	- 4 streams in Idaho. Flows range from 0.11 to 1.3 m^3/s	-Bjornn et al. (1974)

differences. In addition, the Idaho streams on which the literature estimates are based are likely warmer and more productive. Differences between the density estimates obtained in this study and those obtained in October 1981 and 1982 (Section J) are likely due to differences in methods, timing and habitats sampled.

4.2.2 Coho Salmon

The density estimate for coho salmon fry (Table 4.2) in the Morice River (0.12 fish/m^2), based on random sampling, was similar to that obtained by Hunter (1959) cited in Allen (1969) in some B.C. streams (0.27 fish/m^2). However, the Morice River estimate was low compared to Chapman's (1962, 1965) estimates of coho salmon rearing densities in Oregon streams (2.94 and 1.26 fish/m^2, respectively). The differences are likely attributable to the same factors outlined for chinook salmon. The estimate obtained in this study compares well with the estimate obtained by electrofishing in October of 1982 but is lower than the estimate obtained in 1981 (Section J) in Reach 2 side channels.

4.2.3 Steelhead Trout

The density estimate for Morice River steelhead trout fry, based on random sampling, was also low (0.03 fish/m^2) when compared to literature estimates (Table 4.2) but was within a factor of two of those estimates obtained by electrofishing in Reach 2 in 1981 and 1982 (Section J). The differences are likely attributable to the factors outlined for chinook salmon.

However, the density estimates of steelhead trout fry obtained in this study may have been further underestimated because of the difficulties in observing fry in the shallow sites typically utilized in September. Furthermore, steelhead fry were the smallest of the three species. Therefore, the electrofishing results are likely better estimates. Too few steelhead trout parr were observed to obtain density estimates.

The apparent low densities found in the Morice River may be misleading when compared to literature values for two reasons. First, it is not clear whether the literature estimates were based on random or non-random sampling, or some combination. From this study it is apparent that random sampling can affect density estimates by at least an order of magnitude. Second, in the Morice River, chinook and coho salmon and steelhead trout live sympatrically and a total of the densities may provide a better density estimate. If the other studies cited were dealing with allopatric populations, totalling the estimates determined in the Morice River might be reasonable. The density estimates for the Morice River (based on random sampling) for all species combined is 0.31 fish/m^2, which is at the lower end of most literature estimates (Table 4.2).

The density data discussed above reflect abundance of fish in relation to the surface area of the Morice River, and are not a reflection of densities of fish in preferred habitat areas. The densities calculated from non-random sampling results may provide a better reflection of fish abundance in preferred habitats (Table 3.3).

5.0 SUMMARY

Observations at 203 sites in the Morice River were made during September 1982, to determine the habitat preferences and rearing densities of chinook and coho salmon fry, and steelhead trout fry.

Habitat preferences were distinctive for each species. Chinook salmon fry generally preferred faster, deeper water (depth range 90 to 310 cm; velocity range 4 to 47 cm/s) than coho salmon fry and steelhead trout fry, and most chinook fry utilized areas over sand and organic substrate. Coho salmon fry were abundant in shallow slow water (depth range 10 to 120 cm; velocity range 2 to 28 cm/s) with organic substrate and overhanging cover in the form of rootwads or vegetation. Steelhead trout fry occupied shallow riffles and pools, usually less than 100 cm deep, with velocities between those preferred by chinook and coho salmon (2 to 32 cm/s). Most steelhead trout fry were observed over organic substrate. Both steelhead trout and chinook salmon fry were most commonly found along the margins of the main channel, utilizing overhanging rootwads or logjams for cover. Juvenile coho salmon primarily used the back eddies and pools in side channels.

Average fry densities at randomly selected sites were: chinook salmon (mean length 64.8 mm), 0.16 fish/m^2; coho salmon (mean length 49.9 mm), 0.12 fish/m^2; and recently emerged steelhead trout (mean length 32.6 mm), 0.03 fish/m^2. Densities were more than an order of magnitude higher in non-randomly selected sites, which may reflect abundance in preferred habitats.

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APPENDIX G1

Detailed Observations of Juvenile Salmonids in the Morice River During September 1982

TABLE GI.I
Observations of Juvenile Salmonids in the Morice River during September 1982

Record Number	Date	Station Number	Type of Sample (Random/ Non-Ran)	Number of Fry Observed: Chinook Salmon	Coho Salmon	Steelhead Trout	Average Depth (m)	Velocity (cm/s)	Substrate	Cover (Distance)	Cover (Type)	Cover (% Shade)	Macro Habitat
1	10 09 82	1	N	2	6	0	.48	5	6	.75	6	-	S2
2	10 09 82	2	N	7	0	1	.37	28	7	2	6	-	M4
3	10 09 82	3	N	6	0	0	.56	33.5	9	2.0	5	-	M4
4	10 09 82	4	N	2	0	0	.60	45.5	8	.5	7	-	M4
5	10 09 82	5	R	0	0	0	.61	7.5	4	0	0	-	M4
6[1]	**10 09 82**	**6**	**N**	**3**	**7**	**4**	**.41**	**.5**	**1**	**0**	**4**	-	**M2**
7	10 09 82	7	R	0	0	0	1.20	76	8	1.25	6	-	M4
8	10 09 82	8	R	0	0	0	.79	62	10	.10	5	-	M5
9	10 09 82	9	N	9	6	2	.61	6	6	.3	5	-	M5
10	10 09 82	10	N	6	0	0	.31	3	10	.6	5	-	M6
11	10 09 82	11	R	1	0	0	.56	55	9	4	0	-	M4
12	11 09 82	1	R	0	0	0	.46	38.5	9	0.75	5	-	S4
13	11 09 82	2	R	0	2	0	.46	2	11	1.0	4	-	S2
14	11 09 82	3	R	0	0	0	.70	28.5	11	.6	7	-	M4
15	11 09 82	4	R	0	0	0	.40	49.5	9	.5	10	-	S4
16	11 09 82	5	N	1	6	0	.48	8	6	.5	10	-	S2
17	11 09 82	6	N	4	0	0	.82	20	6	.4	4	-	S2
18	16 09 82	19	N	1	2	0	.52	18.7	8	0.5	6	-	M5
19	11 09 82	8	N	4	0	0	.67	47.5	11	.5	4	-	M4
20	11 09 82	9	R	0	0	0	.97	74.5	9	.5	4	-	S3
21	11 09 82	10	R	0	0	0	.71	19.5	4	1	4	-	S2
22	11 09 82	11	R	0	0	1	.49	7	5	.5	6	-	S2
23	11 09 82	12	R	0	0	0	.18	31.5	8	2	4	-	S3
24	12 09 82	1	R	0	0	0	.80	22.5	4	1	10	-	M5
25	12 09 82	2	N	0	6	0	.27	0	4	.5	9	-	M6
26	12 09 82	3	N	2	0	1	.48	5.5	4	.4	6	-	M6

(Continued)

TABLE G1.1 (Continued)

Record Number	Date	Station Number	Type of Sample (Random/ Non-Ran)	Number of Fry Observed: Chinook Salmon	Coho Salmon	Steelhead Trout	Average Depth (m)	Velocity (cm/s)	Substrate	Cover (Distance)	Cover (Type)	Cover (% Shade)	Macro Habitat
27	12 09 82	4	N	1	1	0	.18	11	8	.5	6	-	M4
28	12 09 82	5	N	0	8	0	.31	12	6	.7	4	-	M4
29	12 09 82	6	R	0	0	0	.60	16	8	.5	7	-	M4
30	12 09 82	7	N	0	2	0	.33	50.7	8	0	6	-	S3
31	12 09 82	8	N	0	0	3	.39	12	10	4	0	-	M2
32	12 09 82	9	N	0	0	2	.30	0	1	.5	4	-	S3
33[1]	12 09 82	10	N	0	1	1	.50	36	8	.5	4	-	M4
34[1]	**12 09 82**	**11**	**N**	**1**	**0**	**4**	**.20**	**10.5**	**8**	**4**	**10**	-	**M3**
35	12 09 82	12	R	0	0	0	.35	70.5	10	.4	6	-	M3
36	12 09 82	13	N	8	0	1	.35	16	4	.3	5	-	M2
37	12 09 82	14	N	0	2	2	.31	5	5	.3	6	-	M2
38	12 09 82	15	N	1	5	1	.24	10.5	5	.3	8	-	M2
39	12 09 82	16	N	1	6	2	.26	7.5	10	1.0	4	-	M5
40	12 09 82	17	N	1	0	1	.25	22.5	5	.2	5	50	M4
41	12 09 82	18	N	10	0	0	.91	8	8	0	4	0	M5
42[1]	12 09 82	19	N	1	3	1	.88	5.5	4	.1	6	0	M5
43[1]	**12 09 82**	**20**	**N**	**18**	**0**	**0**	**1.2**	**11**	**4**	**0**	**5**	**100**	**M5**
44	12 09 82	21	N	12	0	0	.63	16.5	6	.2	6	0	M2
45	12 09 82	22	R	0	0	0	1.21	17	6	.5	5	0	M5
46	13 09 82	1	R	0	0	0	1.41	51.5	9	.6	5	30	M4
47	13 09 82	2	N	0	0	0	3.25	9	6	0	6	90	M2
48	13 09 82	3	R	0	0	0	.86	18.5	6	.5	4	80	M4
49	13 09 82	4	N	4	0	0	3.1	14	6	.5	4	35	M2
50	13 09 82	5	N	16	0	0	2.75	6	6	.2	4	50	M5
51	13 09 82	6	N	2	0	0	.47	13	6	.5	4	15	M2
52	13 09 82	7	N	2	0	0	.56	27.5	8	.4	5	65	M5

(Continued)

TABLE G1.1 (Continued)

Record Number	Date	Station Number	Type of Sample (Random/ Non-Ran)	Number of Fry Observed: Chinook Salmon	Number of Fry Observed: Coho Salmon	Number of Fry Observed: Steelhead Trout	Average Depth (m)	Velocity (cm/s)	Substrate	Cover (Distance)	Cover (Type)	Cover (% Shade)	Macro Habitat
53	13 09 82	8	N	4	0	0	1.19	19.5	8	.5	0	50	M4
54	13 09 82	9	N	0	6	0	.27	20	9	.2	6	20	M2
55	13 09 82	10	N	0	9	1	.34	0	10	0	6	100	M5
56	13 09 82	11	N	4	4	0	.40	16	10	.2	5	85	M4
57	13 09 82	12	R	0	0	0	.71	39	8	0	4	80	M4
58	13 09 82	13	N	3	0	0	.90	19.5	11	.7	5	20	M4
59	13 09 82	14	N	2	4	0	.62	6.5	4	0	5	5	M4
60	13 09 82	15	N	12	0	0	.62	16	11	4	0	0	M4
61	13 09 82	16	N	6	0	0	.79	6.5	8	0	5	35	-
62	13 09 82	17	R	0	0	0	.38	20	4	.6	5	25	S4
63	**13 09 82**	**18**	**N**	**0**	**8**	**4**	**.36**	**3.5**	**4**	**.5**	**4**	**80**	**M5**
64	**13 09 82**	**19**	**N**	**0**	**18**	**0**	**.31**	**0**	**4**	**2.0**	**9**	**0**	**S2**
65	13 09 82	20	N	0	1	0	.47	12.5	4	.3	3	20	-
66	13 09 82	21	N	0	17	0	.50	0	9	.5	4	0	-
67	13 09 82	22	N	0	2	0	.36	0	4	1.0	4	15	S5
68	13 09 82	23	N	0	15	0	.35	0	4	.5	4	0	S5
69	13 09 82	24	N	0	2	0	-	-	8	.6	5	80	S5
70	13 09 82	25	N	0	6	0	.16	5	4	.5	9	20	S2
71	14 09 82	1	N	0	8	1	.60	4.5	10	.25	9	90	M2
72	14 09 82	2	N	8	0	0	1.12	4.5	10	.5	5	90	M5
73	14 09 82	3	N	1	3	2	.53	5	8	.75	9	35	S2
74	14 09 82	4	N	0	4	0	.25	1	4	.5	4	75	S2
75	14 09 82	5	N	4	8	0	.60	5	1	.5	4	60	S2
76	14 09 82	6	N	0	2	0	.79	2.5	7	.6	4	40	S2
77	14 09 82	7	N	0	10	0	1.02	0	8	0	3	50	S2
78	14 09 82	8	N	0	4	0	.16	12	7	4	8	0	S4

(Continued)

TABLE GI.1 (Continued)

Record Number	Date	Station Number	Type of Sample (Random/ Non-Ran)	Number of Fry Observed: Chinook Salmon	Coho Salmon	Steelhead Trout	Average Depth (m)	Velocity (cm/s)	Substrate	Cover (Distance)	Cover (Type)	Cover (% Shade)	Macro Habitat
79	14 09 82	9	N	1	1	0	.16	15	8	.5	4	-	S2
80	14 09 82	10	N	7	0	0	.23	3.5	4	.75	4	3	S4
81	14 09 82	11	N	0	10	0	.47	1	4	.3	9	100	S2
82	14 09 82	12	R	0	0	1	.16	10.5	8	.5	4	0	M2
83	14 09 82	13	R	0	0	0	.25	24	9	.5	4	0	M3
84	14 09 82	14	R	0	0	0	2.75	24	11	.3	4	0	M4
85	14 09 82	15	R	0	0	0	.35	9	9	.5	10	25	M5
86	14 09 82	16	R	0	0	0	2.4	17	8	.5	5	0	M4
87	14 09 82	17	R	0	1	0	.68	15	6	0	4	0	M4
88	14 09 82	18	R	0	0	0	.66	66	11	4	0	-	M4
89	14 09 82	19	R	0	0	0	.86	50	7	.5	4	0	M4
90	14 09 82	20	R	0	0	0	.81	70	11	4	0	0	M4
91	14 09 82	21	R	0	0	0	.34	41	9	.5	7	15	S4
92	14 09 82	22	R	0	0	0	.38	33	8	0	0	0	M4
93	14 09 82	23	R	0	0	0	.41	0	4	.5	9	20	S2
94	14 09 82	24	R	0	0	0	.61	23	8	4	0	0	S3
95	14 09 82	25	R	0	0	0	.42	.5	8	4	0	0	S2
96	14 09 82	26	R	0	0	0	.66	7.5	10	4	0	30	S3
97	14 09 82	27	R	0	0	1	.58	12	9	.5	4	50	M2
98	14 09 82	28	R	0	0	0	.99	4.5	6	4	0	0	S5
99	14 09 82	29	R	0	0	0	1.07	5.5	4	4	0	0	S5
100	14 09 82	30	R	0	0	0	.60	7.5	4	4	0	0	S5
101	14 09 82	31	R	0	0	0	.71	10	6	4	0	0	S2
102	14 09 82	32	R	0	0	0	1.45	25	7	.5	4	0	S2
103	14 09 82	33	R	0	0	0	.82	13	13	4	9	20	S2
104	14 09 82	34	R	0	0	0	.65	5	12	1	4	0	S2

(Continued)

TABLE G1.1 (Continued)

Record Number	Date	Station Number	Type of Sample (Random/ Non-Ran)	Number of Fry Observed: Chinook Salmon	Coho Salmon	Steelhead Trout	Average Depth (m)	Velocity (cm/s)	Substrate	Cover (Distance)	Cover (Type)	Cover (% Shade)	Macro Habitat
105	14 09 82	35	R	0	0	0	.32	12	4	.6	4	15	M2
106	14 09 82	36	R	0	0	0	1.14	27	12	.5	9	0	M2
107	15 09 82	1	R	0	0	0	.93	3	4	.5	4	5	S2
108	15 09 82	2	R	0	0	0	.33	51	9	4	0	0	M4
109	15 09 82	3	R	4	3	0	.55	23	9	.3	4	5	M2
110	15 09 82	4	R	0	1	0	.40	4	4	4	0	10	S4
111	15 09 82	5	R	0	0	0	.37	50	8	1	4	0	M3
112	15 09 82	6	R	0	0	0	.60	7	8	3	0	0	S4
113	15 09 82	7	R	0	0	0	.42	5.5	4	.5	9	75	S4
114	15 09 82	8	R	0	0	0	.49	7	10	.6	4	10	S4
115	15 09 82	9	R	0	1	0	1.07	5	4	.3	4	35	S2
116	15 09 82	10	R	0	1	0	.83	7.5	4	1.7	9	0	S4
117	15 09 82	11	R	0	0	0	.67	10	4	.3	6	0	S4
118	15 09 82	12	N	0	11	0	.81	7	4	1.5	10	-	S4
119	15 09 82	13	R	0	0	0	.90	95	8	0	0	-	M4
120	15 09 82	14	R	0	1	0	.42	22	9	.5	4	25	M2
121	15 09 82	15	R	0	0	0	.15	3	9	4	0	0	-
122	15 09 82	16	R	0	0	0	.38	7.5	8	.2	4	20	-
123	15 09 82	17	R	0	0	0	.59	17	11	.3	4	40	M5
124	15 09 82	18	R	0	0	0	.23	7	6	4	4	75	-
125	15 09 82	19	R	0	1	0	.36	16	4	.6	4	0	S4
126	15 09 82	20	N	1	8	0	.29	5	4	.4	9	95	S5
127	15 09 82	21	R	0	0	0	.20	45	9	.7	0	0	S4
128	15 09 82	22	R	0	0	0	.17	10	5	.5	4	5	S2
129	15 09 82	23	R	0	0	0	.56	66	8	4	0	0	S4
130	15 09 82	24	R	0	1	0	.43	13	4	.5	4	50	S4

(Continued)

TABLE G1.1 (Continued)

Record Number	Date	Station Number	Type of Sample (Random/ Non-Ran)	Number of Fry Observed: Chinook Salmon	Coho Salmon	Steelhead Trout	Average Depth (m)	Velocity (cm/s)	Substrate	Cover (Distance)	Cover (Type)	Cover (% Shade)	Macro Habitat
131	15 09 82	25	R	0	0	0	.61	4.5	6	4	0	-	S2
132	15 09 82	26	R	0	0	0	.82	1	8	1	0	-	-
133	15 09 82	27	R	0	0	0	.98	45	8	4	0	-	S4
134	15 09 82	28	R	0	0	0	.31	9	8	.4	4	5	S4
135	15 09 82	29	R	0	0	0	.67	38	8	0	4	25	S4
136	15 09 82	30	R	0	0	0	.42	12	4	1	5	25	M2
137	15 09 82	31	N	0	4	0	.29	3	6	.5	4	50	S2
138	15 09 82	32	R	0	0	0	.28	1.5	9	.2	4	5	S2
139	15 09 82	33	R	0	2	0	.26	5	8	.2	9	10	S2
140	15 09 82	34	R	0	0	0	.18	8	8	1	4	10	S3
141	15 09 82	35	R	0	0	0	.24	59	8	4	0	-	S3
142	16 09 82	1	R	0	0	0	1.78	12	9	1.5	3	0	M2
143	16 09 82	2	R	0	0	0	1.07	22	9	.8	10	0	M5
144	16 09 82	3	R	6	0	0	1.95	17	9	-	8	-	M2
145	16 09 82	4	R	0	0	0	.60	20	8	4	0	-	M2
146	16 09 82	5	R	0	0	0	.20	34	2	.2	3	5	S3
147	16 09 82	6	R	0	0	0	.45	24	4	.4	5	0	M2
148	16 09 82	7	R	0	0	0	.43	37	8	4	0	-	M2
149	16 09 82	8	R	1	1	0	.60	14	7	.5	4	-	S2
150	16 09 82	9	R	0	0	0	.64	15	4	.5	4	-	S2
151	16 09 82	10	R	0	0	0	1.05	63	9	.4	4	-	-
152	16 09 82	11	R	3	0	0	.73	3.5	4	.3	4	-	-
153	16 09 82	12	R	0	0	0	.48	15	6	.4	4	85	S2
154	16 09 82	13	R	0	0	0	.71	65	4	.2	4	75	S2
155	16 09 82	14	R	0	0	0	.69	4	4	.8	10	15	S2
156	16 09 82	15	R	2	0	0	.50	14	4	.5	4	75	S2

(Continued)

TABLE GI.I (Continued)

Record Number	Date	Station Number	Type of Sample (Random/ Non-Ran)	Number of Fry Observed: Chinook Salmon	Coho Salmon	Steelhead Trout	Average Depth (m)	Velocity (cm/s)	Substrate	Cover (Distance)	Cover (Type)	Cover (% Shade)	Macro Habitat
157	16 09 82	16	R	0	0	0	.93	7	4	.5	4	4	S2
158	16 09 82	17	R	0	0	0	.66	51	8	.7	4	30	S4
159	16 09 82	18	R	0	0	0	.33	15	7	.4	4	5	S2
160	16 09 82	19	R	0	0	0	.40	22	6	.6	4	98	S4
161	16 09 82	20	R	0	0	0	.38	18	4	.4	4	40	S2
162	16 09 82	21	R	0	0	0	.55	17	7	1	4	95	S4
163	16 09 82	22	R	0	0	0	.38	10	4	.4	4	20	S4
164	16 09 82	23	R	0	0	0	.67	21	4	-	4	97	S4
165	16 09 82	24	R	0	0	0	.32	28	7	.4	4	30	S4
166	16 09 82	25	R	0	0	0	.72	21	8	.4	4	80	M4
167	16 09 82	26	R	0	0	0	.83	16	5	.5	4	20	M2
168	16 09 82	27	R	1	0	0	1.06	32	6	.6	4	8	M4
169	16 09 82	28	R	0	0	0	.30	60	8	4	0	0	M4
170	16 09 82	29	R	1	0	0	1.10	65	8	.4	5	20	M4
171	16 09 82	30	R	1	0	0	.61	28	9	.7	5	-	M4
172	16 09 82	31	R	0	0	1	.80	3	7	.3	5	80	M4
173	16 09 82	32	R	0	0	0	1.04	30	6	.5	5	-	M4
174	06 09 82	1	N	4	0	0	.26	5	6	1.5	3	-	M5
175	06 09 82	2	N	0	0	0	1.29	8.4	6	1.5	6	-	M5
176	06 09 82	3	N	0	0	0	1.08	8.3	6	.5	6	-	M5
177	06 09 82	4	R	0	0	0	.32	28	9	1	5	-	M4
178	06 09 82	5	R	0	0	0	.52	20.8	9	4	0	-	M2
179	06 09 82	6	R	0	0	0	.57	16.5	0	4	0	-	M5
180	06 09 82	7	R	0	0	0	.55	17.6	8	4	0	-	M4
181	06 09 82	8	R	0	0	0	.71	14.7	11	-	0	-	M4
182	06 09 82	9	N	4	2	0	.33	16	4	1	4	-	S2

(Continued)

TABLE G1.1 (Continued)

Record Number	Date	Station Number	Type of Sample (Random/ Non-Ran)	Number of Fry Observed: Chinook Salmon	Coho Salmon	Steelhead Trout	Average Depth (m)	Velocity (cm/s)	Substrate	Cover (Distance)	Cover (Type)	Cover (% Shade)	Macro Habitat
183	06 09 82	10	N	0	0	0	.48	7	8	-	0	-	S2
184	06 09 82	11	R	0	0	0	.18	8	8	-	0	-	S3
185	06 09 82	12	R	0	0	0	1.46	39.4	9	-	0	-	M4
186	06 09 82	13	R	0	0	0	1.27	34.4	9	-	0	-	M4
187	06 09 82	14	R	0	0	0	.73	24.6	8	-	0	-	M4
188	06 09 82	15	R	0	0	0	.71	14.7	8	-	0	-	M4
189	06 09 82	16	R	0	0	0	.55	17.6	8	-	0	-	M4
190	06 09 82	17	R	0	0	0	.57	16.5	8	-	0	-	M4
191	06 09 82	18	R	0	0	0	.52	20.8	7	2	5	-	M4
192	06 09 82	19	N	3	3	0	.52	18.7	6	.5	4	-	M5
193	07 09 82	1	N	4	0	0	.26	5	6	1.5	4	-	M5
194	07 09 82	2	N	7	0	0	1.29	8.4	6	1.5	6	-	M5
195	07 09 82	3	N	1	0	0	1.08	8.3	6	.5	6	-	M5
196	07 09 82	4	R	1	0	0	.32	28	9	1	5	-	M4
197	07 09 82	6	R	0	0	0	.57	16.5	10	-	0	-	M5
198	07 09 82	9	N	6	2	0	.33	16	4	1	4	-	S2
199	07 09 82	10	N	0	0	0	.48	7	8	-	0	-	S2
200	07 09 82	11	R	0	0	0	.18	8	8	-	0	-	S3
201	07 09 82	16	R	0	0	0	.55	17.6	8	-	0	-	M4
202	07 09 82	17	R	0	0	0	.57	16.5	8	-	0	-	M4
203	07 09 82	18	R	0	0	0	.52	20.8	7	2	6	-	M4

1 Bold-faced lines indicate highest single densities observed for each species