JUVENILE COHO STUDIES AT THE

TELKWA RIVER KM 1011 PONDS

1997

Prepared by

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for

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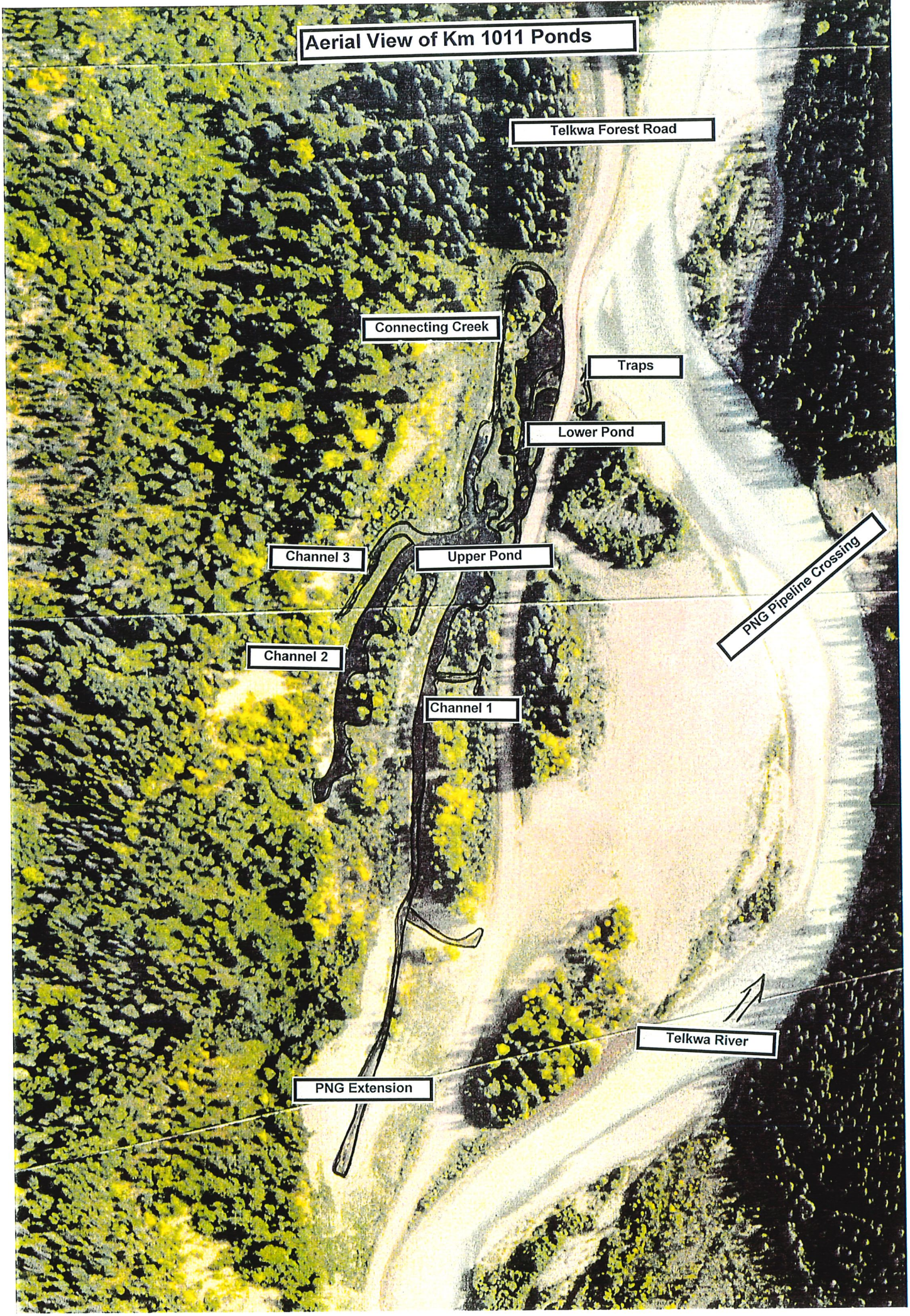
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1.0 INTRODUCTION

1.1 Background

The Telkwa River Ponds are located 18 km southwest of Smithers at Km 1011 on the Telkwa River Forest Road. The ponds were constructed in 1993 by the Department of Fisheries and Oceans (DFO) as a pilot juvenile coho enhancement project. A special feature of the ponds was the development of culvert design features to prevent beavers from blocking outlet culverts and restricting fry recruitment into the ponds (Finnegan and Marshall 1997). The inlet channels to these ponds were extended in 1995 as compensation for impacts of Pacific Northern Gas Ltd.'s pipeline crossing from the Telkwa River at this location.

Coho populations have been monitored at these pond locations for four years using a mark-and-recapture method for estimating fish populations. The results of these four years of study are presented in Bustard (1996).

The results to date indicate that the pond development has successfully created coho habitat. Estimates of pre-smolt coho conducted in May just prior to the timing of outmigration indicated that production in the ponds has increased at least 10-fold, from just over 200 coho pre-smolts prior to development to 1500-3000 pre-smolts post-development (Bustard 1996).

Monitoring the actual smolt out-migration was undertaken for the first time in the spring of 1996. The objectives were to better define the timing of smolt outmigration from the ponds and to compare the numbers of smolts captured in downstream traps to the mark-and-recapture estimates derived in early May.

The 1996 results indicated that there was a problem with smolts leaving the ponds during the spring and summer period. Early May estimates indicated approximately 2800 pre-smolts[1] were present in the ponds in 1996. However, only 235 coho smolts actually left the ponds during the period from early May through early August.

A series of tests was conducted during 1996 leading to the conclusion that coho smolts in the Km 1011 Ponds were having difficulty locating the culvert outlet from the ponds leading to the Telkwa River. The mid-pond entrance to the culvert and plywood walls on the outlet "cage" were both identified as reasons that coho may have difficulty finding the exit.

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[1] In this study, we have assumed that coho >74 mm in early May will smolt during that season. The minimum size of coho smolts leaving the ponds in the past two years is 77 mm and 78 mm fork length.

The Watershed Restoration Program has considerable interest in the construction of off-channel ponds such as those at Km 1011 at other locations in northwestern British Columbia. It is important to gain as much information concerning the correct design and potential productivity from existing off-channel pond developments such as the Km 1011 Ponds. Most studies have been conducted in coastal and more southern locations.

1.2 Study Objectives

The study objectives for the 1997 work were as follows:

1.) To undertake a second year of evaluating coho smolt outmigration from the Km 1011 Ponds following modification to the culvert outlets.

2.) To compare the mark-and-recapture population estimates to the actual number of coho smolts leaving the system.

3.) To continue to measure the extent and timing of juvenile movements into the pond complex.

Funding for this project was provided by the Watershed Restoration Program (Province of B.C.) through Pacific Inland Resources Ltd.

2.0 METHODS

2.1 Timing

Field studies were initiated on May 7, 1997 and traps were operated continuously until August 1, when the outlet discharge had dropped to a trickle. The study ended approximately one week earlier than in 1996.

2.2 Water Temperature and Discharge

Methods for recording water temperature and discharge were identical to those used in 1996 (Bustard 1996). It should be noted that the staff gauge on the Telkwa River was re-installed, so levels between years do not correspond directly to each other.

The thermograph in the lower ponds was in place from early May to September 16, 1997.

Preliminary discharge data from the Water Survey Gauge on the Telkwa River 10 km upstream from the pond site is not available for the period from mid-June through to late July, so Telkwa River discharge data does not cover the complete period of the studies.

An estimate of the total wetted pond area by section was conducted in late May to allow fish production in the ponds to be expressed on a unit area basis. A hip chain was used to measure channel lengths, and an Elsom tape and laser binoculars were used for widths.

At the initiation of the 1997 studies, it was intended that modifications would be made to the entrance area of Culvert #1 (Figure 1) including cutting openings in the plywood siding and in the culvert near the pond exit. This was not accomplished due to deep water at this culvert. Instead, holes were cut in the top end of Culvert #2 and a log that had been left in the culvert was used to loosen a blockage in the middle of this culvert. Further cleaning of this culvert using a back hoe and chain hook-up was undertaken in late June. This appeared to be adequate, and coho smolts were captured at the downstream box shortly after the trap installation and immediately after the initial culvert cleaning.

2.3 Mark-and-Recapture Estimates

Methods used to conduct the population estimates were nearly identical to those used in past years. The marking was conducted between May 9-10th and the recaptures were undertaken on May 14-15th, prior to the 1997 coho smolt outmigration based on observations at the downstream traps. All fish captured during the marking portion of the surveys were marked with an upper caudal clip.

A total of 70 minnow traps baited with roe were used for both the marking and the recapture. Trapping effort was increased in the PNG extension channels to provide better coverage in this section compared to past years. Ten additional traps were set overnight in the lower ponds on May 11 to collect fish for trap tests. This provided an additional source of information for CPUE of coho at this site and a check of the ratio of marked to unmarked fish.

Scales were retained from 66 coho ranging in size from 50 to 135 mm fork length. Five samples were retained from coho in each 5-mm size range. These scales were submitted to DFO for age analysis[2].

Population estimates were conducted using the Chapman modification to the Peterson formula (Chapman 1951), and the 95% confidence intervals were calculated using the standard error of the estimate (Robson and Regier 1971). The estimates were separated by pond section and by coho less than and larger than 75 mm fork length. This is the size break-off that has been used for the past three years to separate pre-smolts from those coho probably remaining in the ponds for an additional season.

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[2] Greg Bonnell - Habitat Enhancement Branch, DFO. Data is not available for these fish at the time of report preparation.

2.4 Upstream and Downstream Traps

The same upstream and downstream trap boxes that were used in 1996 were installed in the short section of the outlet stream located between the road and the mainstem Telkwa River (Figure 1).

A description of the trap configuration is given in Bustard (1996). Trap boxes were operational by May 8, and were checked daily until the end of June. After this date they were checked every second day until August 1, when outlet flows were reduced to a trickle. The downstream trap was not fishing due to high flows during the period May 14 to May 17th. The fence panels were still in place at this time, and fish movements did not occur. The upstream box was removed from May 15-17th due to high water.

All fish captured were sorted by species, counted, examined for marks and released in the direction of capture. Fork lengths from a sample of 30 fry were measured daily. All yearling coho and coho smolts were measured to the nearest mm. Representative weights were obtained from 127 coho smolts and a sample of other fish species and other life history phases. Scales were retained from 50 coho smolts for aging. The results of the aging analysis are not available at this date.

A check to ensure that fish were unable to escape from the downstream holding box was conducted on May 11th. Sixteen marked coho smolts captured in the lower pond were placed in the box overnight. All fish were present in the box the following day.

2.5 Other Observations

Observations of wildlife species (including amphibians) associated with the pond complex were noted as part of the data collected at the site and are summarized in Appendix 4 Table 1.

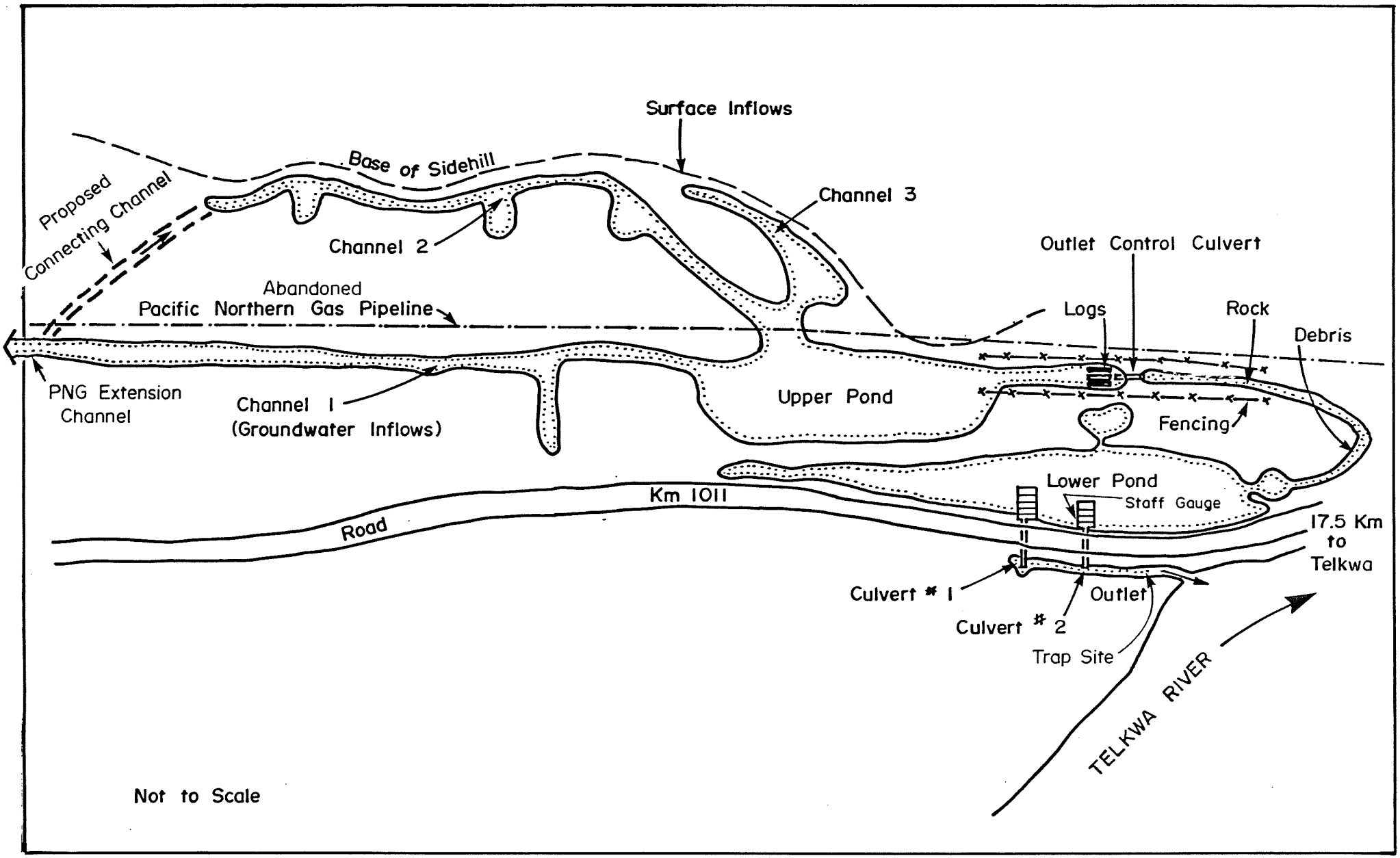


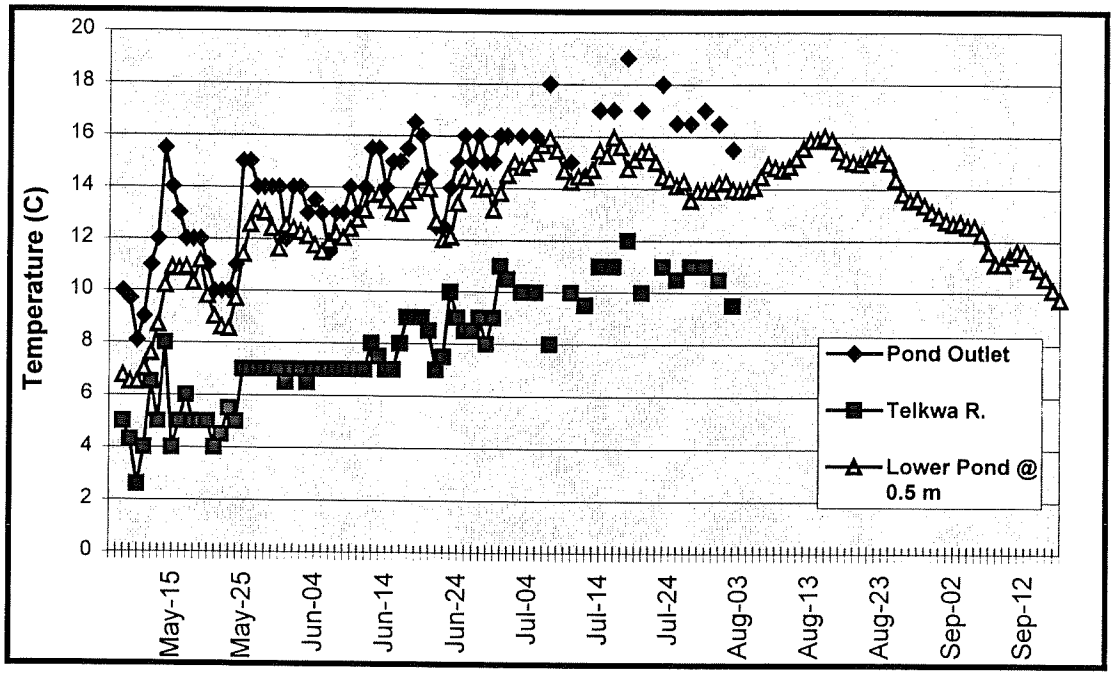
Figure 1. Approximate Configuration of Ponds at Km 1011 on Telkwa River Forest Road.

3.0 RESULTS

3.1 Water Temperature and Streamflow Summaries

Water temperatures collected during the studies are summarized in Figure 2 with a more complete record presented in Appendix 1 Table 1. Water temperatures in Km 1011 Pond rose from 7°C on May 7 to 16°C in late July. Mean monthly temperatures in the lower pond (collected at 0.5 m depth) were within 1°C of those measured in 1996 (Table 1).

Figure 2. Water Temperatures in Km 1011 Pond and the Telkwa River 1997.



The mean monthly Telkwa River water temperatures were slightly cooler in May and 1-2°C warmer during June and July 1997 compared to a year earlier. Km 1011 Pond was 4-6°C warmer than the mainstem river during the summer period (Table 2). Water temperatures in the outlet creek tend to be 1-2°C warmer than the pond temperatures, presumably reflecting surface water temperatures. Temperatures in the outlet creek rose to 19°C during mid-July.

Km 1011 discharge estimates are summarized in Figure 3, with more detailed information provided in Appendix 1 Table 1. The highest outlet discharge was measured shortly after the trap box installation (1200 l/min). This was prior to the rise in the Telkwa River mainstem discharge, and presumably resulted from localized surface run-off into the pond

Table 1. Mean Monthly Water Temperatures in Km 1011 Ponds Compared to the Mainstem Telkwa River During the Period May to August 1996 and 1997.

Month	Km 1011 Pond		Telkwa River		Difference	
	1996	1997	1996	1997	1996	1997
May	10.2	10.6	6.3	5.6	3.9	5.0
June	12.5	13.0	6.5	7.9	6.0	5.1
July	14.7	14.8	8.5	10.4	6.2	4.4
Aug	13.8	14.6	nm[3]	nm		
Sept (to 17th)	11.1	10.8				

complex. After May 10th, the outlet discharge tended to respond to levels in the Telkwa River mainstem, with higher flows lagging 1-2 days behind rises in the Telkwa River levels. A similar pattern was noted in 1996.

By late July, the pond outlet discharge was reduced to a trickle, and remained nearly dry throughout September. We suspect that there may be some subsurface flow through the road bed from the lower pond, as there is still a small flow in the creek between the upper and lower pond.

Discharge data for the Telkwa River is incomplete at the time of report preparation (Appendix 1 Table 1). The available data indicates that 1997 was a more typical streamflow year compared to 1996 when the rise in spring discharge was 2-3 weeks later than normal, and flows remained high through until late July. Peak flows occurred on June 4th in both years.

Dissolved oxygen levels in the ponds were in the 6-11 ppm range during the May surveys (Appendix 1 Table 2). This is similar to levels measured at these locations between 1993 and 1996 (Bustard 1993 to 1996). Based on these measurements, conditions were suitable throughout the ponds for fish rearing during early May.

Dissolved oxygen levels measured during March 11, 1997[4] indicated that levels dropped to unsuitable levels for coho rearing in portions of Channel 2 during the late winter period. This has been a consistent pattern for the past four winters (Bustard 1996) and emphasizes the need to improve winter flows through this significant rearing section of the Km 1011 Pond complex to improve the suitability of this section for overwintering coho.

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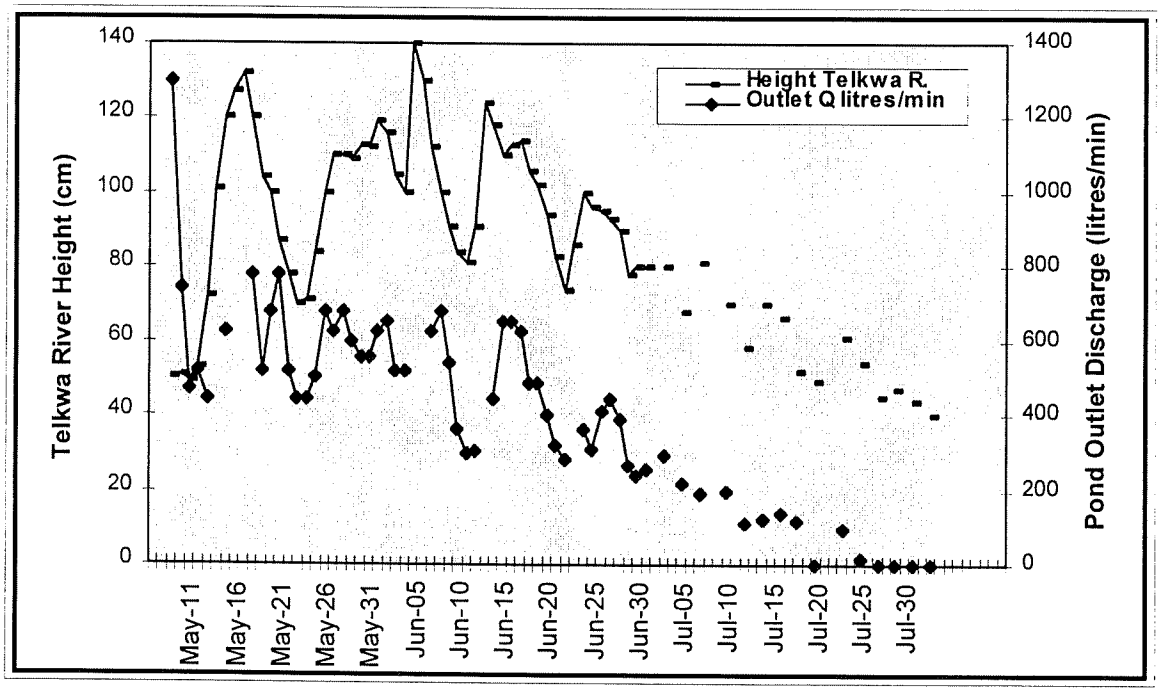
[3] No measurements conducted.

[4] Memo to Alan Baxter, Pacific Inland Resources Ltd. dated March 28, 1997.

Figure 3. Telkwa River Water Levels Versus Km 1011 Outlet Flows.



Channel 2 comprises approximately 22% of the total area of the pond complex estimated as just over 8700 m^2 of habitat (Table 2).

Table 2. Summary of Wetted Area Estimates[5] for the Seven Sections of Km 1011 Ponds.

Section of Km 1011 Pond[6]	Area (m*m)	% of Total
Lower Pond	2284	26.1
Upper Pond	1878	21.5
Creek	314	3.6
Channel 1	1281	14.7
Channel 2	1945	22.3
Channel 3	306	3.5
PNG Channels	728	8.3
TOTAL	**8736**	**100.0**

[5] Measured on June 5, 1997.
[6] See Figure 1.

3.2 Fish Sampling Results

3.2.1 Pond Mark-and-Recapture Population Estimates

Juvenile coho were captured in all sections of the pond complex. In total, 547 coho were captured during the sampling (Table 3). This is less than one-half of the total captured in 1996 and the lowest number since pond construction in 1993.

The catch per unit effort (CPUE) of 3.6 coho per trap was the lowest on record (Table 3). Catches were down in all sections. A second round of trapping in the lower pond to collect fish to test the holding box resulted in a similar low CPUE of 4.9 coho/trap, similar to the 5.1 coho per trap estimated for this section during the population work.

Similar to past years, a number of other fish species were present in the catches (Appendix 2 Table 1). The catch included two rainbow trout yearlings and 21 peamouth chub (captured mainly in the creek between the upper and lower ponds). Together, these other species comprised 4.7% of the total catch. This is the highest number of peamouth chub captured in the pond complex since the ponds were constructed. A total of 27 peamouth chub were sampled in the initial lower pond area prior to construction in May 1993. No mountain whitefish or Dolly Varden char were sampled in 1997.

Table 4 summarizes the results of the population estimates by section and size category. The total population estimate for all coho in all sections was 1395 fish (95% confidence intervals of 959-1831). Of this, 1124 (80%) were 75 mm or larger and it was assumed

Table 3. Summary of Coho Captured in Minnow Traps in Sections 1 to 7 Km 1011 Ponds, May 1994-1997.

Section	Number of Traps				Coho Captured				Coho CPUE[7]			
	1994	1995	1996	1997	1994	1995	1996	1997	1994	1995	1996	1997
1 Lower Pond	30	30	30	30	160	180	284	152	5.3	6.0	9.5	5.1
2 Creek-Debris	10	10	10	10	102	74	201	56	10.2	7.4	20.1	5.6
3 Creek-Rock	10	10	10	10	61	55	137	29	6.1	5.5	13.7	2.9
4 Upper Pond	20	20	20	20	99	92	234	56	5.0	4.6	11.7	2.8
5 Channel 1	20	20	20	20	98	54	141	36	4.9	2.7	7.1	1.8
6 Channel 2	20	20	18	20	115	92	84	55	5.8	4.6	4.7	2.8
7 Channel 3	20	18	10	20	130	110	84	63	6.5	6.1	8.4	3.2
8 PNG Extension			8	20			88	100			11.0	5.0
TOTAL	130	128	126	150	765	657	1253	547	5.9	5.1	9.9	3.6

[7] CPUE = catch per unit effort = number of fish/trap.

Table 4. Juvenile Coho Population Estimates in Km 1011 Ponds, May 1997.

SECTION	SIZE CATEGORY	M	C	R	N	SE (N)	95% C.I.
1	<75 mm	10	2	0	32	33.0	65
	>74 mm	98	42	9	425	113.7	223
2	<75 mm	1	5	0	11	12.0	24
	>74 mm	30	20	4	129	48.5	95
3	<75 mm	4	3	0	19	20.0	39
	>74 mm	15	7	2	42	19.4	38
4	<75 mm	9	3	1	19	10.9	21
	>74 mm	27	17	5	83	26.0	51
5	<75 mm	5	3	0	23	24.0	47
	>74 mm	21	7	0	175	176.0	345
6	<75 mm	9	3	2	12	3.9	8
	>74 mm	30	13	3	108	45.1	88
7	<75 mm	15	3	1	31	17.9	35
	>74 mm	33	12	4	87	30.3	59
PNG EXTENSION	<75 mm	14	9	3	37	13.6	27
	>74 mm	47	30	12	113	21.2	42
TOTAL	**<75 mm**	**67**	**31**	**7**	**271**	**80.1**	**157**
	>74 mm	**301**	**148**	**39**	**1124**	**142.4**	**279**
Combined	**all sizes**	**368**	**179**	**46**	**1395**	**222.5**	**436**

that many of these fish would be leaving the ponds as smolts within six weeks of the estimates.

The total estimated population of coho in the ponds compared to previous sample results is presented in Table 5. The results indicate that the overall estimate of coho was the lowest since pond construction in 1993. The combined totals of pre-smolt coho (>74 mm) and smaller coho juveniles (<75 mm) represented approximately one-third of the 1996 population estimate.

Table 5. Juvenile Coho Population Estimates in Km 1011 Ponds, May 1993 to 1997.

Year	Juvenile Coho Estimates		
	>74 mm (95% CI)	<75 mm	Combined
1993[8]	222 (179-263)	964	1186
1994	2304 (1777-2832)	336	2640
1995	1549 (1223-1875)	296	1845
1996	2820 (2163-3477)	1484	4304
1997	**1124 (845-1403)**	**271**	**1395**

The results of the population estimate suggest that survival of coho in the Km 1011 ponds from May 1996 through to May 1997 was relatively poor. Traps maintained at the pond outlet during the summer of 1996 indicated that 2431 coho fry and 764 yearling coho moved upstream into the ponds, mainly during the period May through July (Bustard 1996). In addition to these immigrants, just under 1500 smaller coho (<75mm) were present in the ponds and would probably not leave until the following season, leading to an estimate of 4679 coho in the ponds[9]. The May 1997 estimate of 1395 fish is just under 30% of this total.

The situation in Km 1011 Ponds during the summer of 1996 was confounded by the presence of a large number of coho smolts that did not leave the ponds (235 of an estimated 2820 pre-smolts actually left the ponds during the summer of 1996). We suspect that the presence of these large coho residing in the ponds through the summer and presumably winter period resulted in significant mortality to smaller fish entering the ponds. Some direct predation by smolts on fry was observed during the trapping operation.

The fate of the 1996 coho smolts remains unresolved. We are still not certain whether these fish left the ponds during the very late fall (after the October/early November 1996 trap operation) or very early in the spring of 1997 - as there was not an unusual proportion of large coho smolts in the May 1997 surveys. For example, only 13 of 411 coho greater than 74 mm were 115 mm fork length or larger[10].

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[8] Pre-construction.

[9] The total number may actually be higher than this since there may also have been some recruitment of coho fry spawned upstream from the trap site in 1996.

[10] Scale data from 1995 coho sampling indicated age 3+ coho in the Km 1011 ponds exceeded 115 mm fork length (aging conducted by DFO Fish Morphology Lab). 1997 scale data not available to date.

Table 6. Mean Fork Lengths of Coho Sampled During Mark-and-Recapture Population Estimates in the Km 1011 Ponds, May 1997.

	<75 mm)		>74 mm (pre-smolts)	
	fl (mm)	n	fl (mm)	n
1993	Pre-construction[11]			
1994	66.3	63	100.6	648
1995	70.2	47	99.6	533
1996	65.9	472	89.9	752
1997	68.6	91	93.8	411

The mean fork length of coho sampled during the mark-and-recapture estimates is shown in Table 6. The mean size of the >74 mm category was 93.8 mm, in the mid-range of coho pre-smolt sizes recorded at these ponds since 1994. The largest coho captured was 131 mm fork length

3.2.2 Fish Upstream Movements Into Km 1011 Pond

In total, 1584 fish were passed upstream into Km 1011 Ponds. Juvenile coho comprised 99% of the fish moving upstream (Table 7). Upstream coho migrants were comprised of a combination of fry (829) and yearling fish (738). A small number of rainbow trout and mountain whitefish yearlings and two cutthroat parr comprised the remainder of the sample (Appendix 2 Table 1). No cutthroat have been sampled in the ponds in past years.

Coho fry numbers in 1997 were down significantly to approximately 34% of 1996 levels (Table 7). Declines were noted throughout the May to July period. The number of yearling coho moving upstream into the ponds in 1997 was very similar to the 1996 levels. The trapping data continues to indicate that yearling coho migrating upstream during the spring and early summer form an important component of the coho recruitment into off-channel habitat at Km 1011.

The first coho fry were captured in the upstream trap on May 11, very similar to the date of first upstream migration in 1996 (Figure 4 and Appendix 3 Table 1). After this early pulse of fry, upstream fry migrants dropped off until mid-June. Approximately 80% of the fry upstream migration occurred during the period June through July. Some fry upstream migration occurred through until the end of July, when flows in the outlet creek dropped to a trickle and were insufficient to allow fish passage into the ponds.

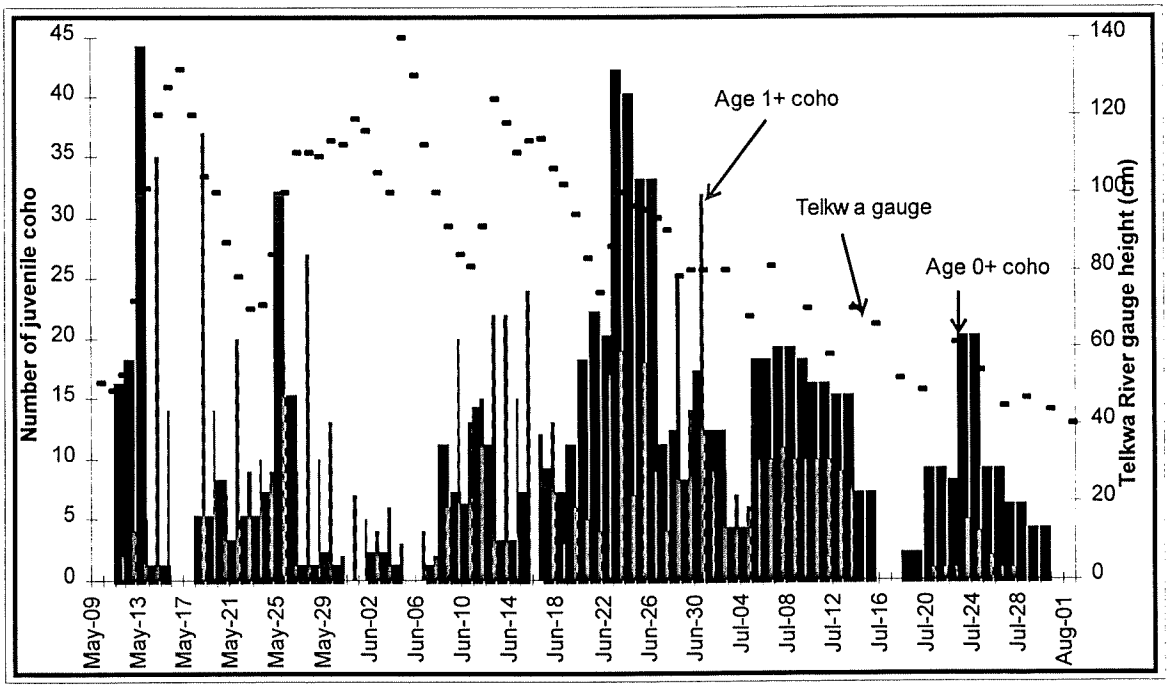
[11] Mean fork lengths separated at 75 mm is not available.

Table 7. Summary of Upstream Fish Movements into Km 1011 Ponds by Month in 1996 and 1997.

	Coho 0+		Coho 1+		Rainbow		Cutthroat		Whitefish	
Month	1996	1997	1996	1997	1996	1997	1996	1997	1996	1997
May	553	170	233	253	0	8	0	0	1	1
June	980	351	440	349	2	2	0	1	7	4
July	861	308	76	136	0	2	0	1	0	0
August 1-9	37	dry	9	dry	0	dry	0	dry	0	dry
TOTAL	2431	829	764	738	2	12	0	2	8	5

The first yearling coho migrants were captured on May 11th and they continued to migrate upstream throughout the period of trap operation. Numbers declined after the middle of July, as the Telkwa River mainstem flows declined. Yearling migrants were also most abundant during the May and June period in 1996 (Table 7).

Figure 4. Juvenile Coho Upstream Migration Versus Telkwa River Gauge Height from May 8 to August 1, 1997.



Unlike 1996, the pattern of fry and yearling migrants was not so closely associated with the highest flow periods in the mainstem river and significant movements occurred on steady or even declining flows in the Telkwa.

A summary of upstream coho migrants fish lengths is presented in Appendix 3 Table 2 and Appendix 3 Figures 1-3. The mean size of upstream migrant fry ranged from 33 to 44 mm fork length depending upon month. The mean size of coho fry in July was approximately 6 mm larger than in July 1996. Most yearling coho were less than 80 mm fork length. The 1997 yearlings were approximately 10 mm larger than migrants in 1996 for the period May through July.

3.2.3 Fish Downstream Movements Out of Km 1011 Ponds

A total of 1440 fish were captured in the downstream traps during the study period (Table 8). This total included 1382 coho smolts, 34 pre-smolts, 12 coho fry, 10 rainbow parr (presumably steelhead), and two mountain whitefish.

The main differences between 1997 and 1996 results were an increase in smolt numbers and a decrease in coho fry numbers moving downstream (Table 8). The low number of smolts leaving the ponds in 1996 presumably reflected the inability of smolts to find the outlet culvert from the ponds.

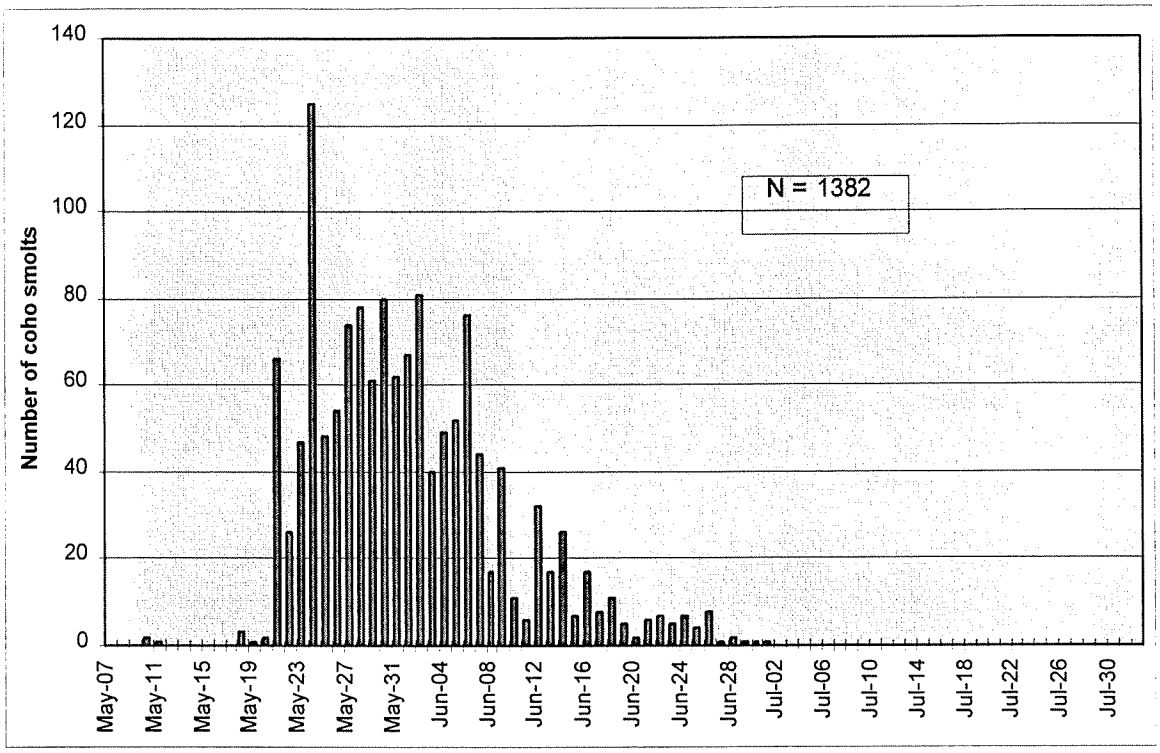
Table 8. Summary of Downstream Fish Movements from Km 1011 Ponds by Month in 1996 and 1997.

	Coho						Rainbow		Whitefish	
	Smolts		Pre-smolts[12]		Fry		Parr		>0+	
Month	1996	1997	1996	1997	1996	1997	1996	1997	1996	1997
May	21	730	1	2	2	0	7	2	2	1
June	205	650	9	18	51	4	18	8	1	1
July	9	2	9	14	238	8	0	0	1	0
August 1-9	0	dry	2	dry	4	dry	0	dry	0	dry
TOTAL	235	1382	21	34	295	12	25	10	4	2

Nearly all of the smolt movements (95%) occurred from May 21 to June 17th (Figure 5). No coho smolts were captured after July 2nd. The earliest significant smolt movement (66

[12] These fish were larger juveniles not yet exhibiting smolt characteristics (loss of parr marks - silver colouration and black tip to caudal fin). We suspect these fish would be smolting later this season.

Figure 5. Timing of Coho Smolt Downstream Migration, 1997.



fish on May 21st) coincided with opening a blockage caused by beavers in Culvert #2. The largest number of smolts captured was 125 fish on May 24th.

Coho smolts averaged 101 mm fork length and 10.8 grams (Table 9). This is very similar to the 1996 results from a smaller sample size (144 smolts in 1996 compared to 1296 smolts in 1997). More detailed length-frequency and length-weight information for coho smolts collected during this study is presented in Appendix 3 Figures 4 and 5.

Scale analysis for aging of coho smolts sampled at the downstream trap are not available at the time of this report preparation. Scale analysis from coho sampled in these ponds in May 1995 suggests the coho smolts are a mix of ages ranging from age 1+ to age 3+ (Bustard 1996).

Only 12 coho fry were captured in the downstream trap during the 1997 season. This compares to 295 fry captured in 1996 (Table 8). The 1996 fry were newly-emerged fish, including many less than 33 mm fork length. We suspect that these fry were derived from coho spawners entering the pond system during a small freshet in the fall of 1995.

Table 9. Summary of Smolt Length and Weight Characteristics at the Outlet to Km 1011 Ponds, 1996 and 1997.

	Length (mm)		Weight (g)	
	1996	1997	1996	1997
Mean	99.7	101.4	10.0	10.8
Number	144	1296	144	127
Range	77-147	78-150	4.7-35.2	5.3-24.5
Std	11.5	8.5	3.9	2.9

4.0 DISCUSSION AND CONCLUSIONS

4.1 Population Estimate and Coho Smolt Migration

The mark-and-recapture population estimates conducted in May 1997 resulted in an estimate of 1124 coho 75 mm or larger in the ponds prior to smolt migration (Table 5). This is the lowest estimate since pre-construction of the ponds (1993). The 95% confidence intervals range from 845 up to 1403 fish.

A total of 1382 coho smolts were captured in the downstream trap at the pond outlets. This is at the upper end of the estimated range derived from the mark-and-recapture studies. The data does suggest that the mark-and-recapture estimates did provide a reasonable estimate of the coho smolt output from the ponds in 1997.

It should be noted that an additional 120 coho yearlings larger than 75 mm fork length moved up into the ponds in May and June, and some of these fish may have subsequently left the ponds as smolts. However few of the upstream migrants exhibited smolt characteristics at the time of upstream movement.

An exodus of large coho smolts that we assumed had remained in the ponds for an additional season did not materialize. The 1997 smolt migrants were similar in size characteristics to 1996 smolts. We do not know the fate of the fish that failed to leave in the spring and fall of 1996.

The ratio of marked fish in the pond population also leads to some confusion. The mark-and-recapture estimates conducted in May provides an estimate of marked to unmarked fish for those coho larger than 74 mm. Both the recapture and the second trapping to obtain fish to test the holding box in mid-May indicated approximately 26% of the larger coho were marked with an upper caudal clip (Table 10). However, only 12% of the smolts captured in the downstream box were marked.

Table 10. Ratio of Marked to Unmarked Coho in the 1997 Telkwa Pond Studies.

	Total Number of Fish	Number of Marks	Percentage Marked
Smolts @ downstream trap	1382	168	12.2
Mark-and-recapture			
>74 mm	148	39	26.4
<75 mm	31	7	22.6
Holding box trapping	43	11	25.6

This suggests that a portion of the coho that we assume are going to leave as smolts (>74mm in early May) may remain in the ponds and do not leave until the following year. At the same time, the marks become increasingly difficult to identify by mid-June and some marks in the latter portion of the smolt run may have been missed. In 1996, the ratio of marked to unmarked coho was between 11% and 14% of the total in both the mark-and-recapture and the downstream trapping of smolts (Bustard 1996).

The results of the population estimate suggests that survival of coho (excluding smolts that did not leave in 1996) was approximately 30%. This is considerably lower than the average 68% survival from fry to smolt stage based on a compilation of pond studies reported by Koning and Keeley (1997). It is particularly low considering the large number of yearlings present in the ponds in early May 1996 and the large number that subsequently entered the system during the rest of the summer from May 1996 through May 1997. We suspect there was probably heavy predation on the 2400 coho fry entering the ponds during the summer of 1996, particularly by coho smolts.

4.2 Upstream Coho Migration into Km 1011 Ponds

The 1997 trapping studies indicated that coho migrants move into the off-channel pond site from mid-May through to the end of July. A total of 829 coho fry and 738 yearlings moved up into Km 1011 during the study.

The timing of the upstream migration is nearly identical to that noted in 1996. The first fry were noted at the traps on May 11th in 1997 and May 12th in 1996. Fry and yearling coho immigrations continued through the spring and early summer until flows dropped in the Telkwa and the outlet ponds to a point unsuitable for fry movement. This occurred on July 30th in 1997 and August 9th in 1996.

Streamflow levels in the Telkwa River have a large bearing on the movement of coho into the Km 1011 Ponds. The outlet discharge in the ponds is directly related to the mainstem Telkwa River discharge (Figure 3).

The number of coho fry moving upstream into Km 1011 was down significantly in 1997 compared to the 1996 results (829 compared to 2431 fry). Yearling numbers were very similar between years. In both years, between 700-800 yearlings have entered the pond complex. These observations continue to indicate that yearling coho moving into the pond complex constitute an important component of the coho recruitment to this off-channel habitat.

4.3 Productivity Estimates in Km 1011 Ponds

Based on the mark-and-recapture estimates, the Km 1011 Ponds have produced between 1124 and 2820 coho smolts annually. The actual number of smolts leaving the ponds in 1997 was approximately 20% higher than the mark-and-recapture estimate. These estimates correspond to production estimates ranging from 13 to 26 coho smolts/100 m^2 during the past four years (Table 11).

Koning and Keeley (1997) have summarized off-channel pond production estimates from 19 studies in a combination of interior and coastal locations. Based on these estimates they have developed a relationship between surface area of the ponds and the estimated number of salmonid fish present[13]. Using their relationship and based on a pond area of 0.87 ha yields a production estimate of 2750 salmonids.

Table 11. Coho Production Estimates in Km 1011 Ponds from 1993 to 1997.

Year	>74 mm	All Coho Combined	Smolts/ 100 m*m	Total Coho/ 100 m*m
1993	222	1186	Area not known	
1994	2304	2640	26.4	30.2
1995	1549	1845	17.7	21.1
1996	2820	4304	32.3	49.3
1997	1124	1395	12.9	16.0
Mean (94-97)	**1949**	**2546**	**22.3**	**29.1**

[13] Log_{10} fish number = 0.51 log_{10} pond area (ha)+ 3.47, n=19, r^2 = 0.64, P<0.001.

This is close to the mean of 2546 coho for the period 1994-97 (post-pond construction). In both 1995 and 1997 the estimates were significantly lower than these projections, while the 1996 estimates far exceeded the production estimates based on these other studies.

A second analysis of coho smolt yield reported by Marshall and Britton (1990) for 27 streams, ponds and side channels indicates production yields of 73 smolts/100 m^2 or 46 g/100m^2. This is considerably higher than the mean of 22 smolts/100m^2 (Table 11) or 23 g/100m^2 calculated in this study[14].

The downstream smolt trapping program, in conjunction with the mark-and-recapture estimates, continues to provide valuable coho production estimates for off-channel pond developments. These data, in conjunction with fish timing and recruitment into the ponds, is increasing our understanding of how these off-channel areas function and potential limitations to production.

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[14] Assumes a mean smolt weight of 10.4 g/m^2 based on a mean of 1996 and 1997 (Table 9).

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Appendix 1 Table 1. Summary of Water Temperature and Streamflow Information for Telkwa Ponds, May 7 to August 1, 1997.

Date	Min	Max	Mean	Outlet @ Trap	Telkwa R.	Outlet Q (litres/sec)	Q cfs	Fry Upstream	Telkwa gauge ht	Telkwa Discharge
May-07	6.5	7.0	6.8	10.0	5.0					21.8
May-08	6.2	6.8	6.5	9.7	4.3	21.7	0.77		50	21.8
May-09	6.2	6.8	6.5	8.1	2.6	12.4	0.44	0	51	21.4
May-10	6.8	7.2	7.0	9.0	4.0	7.9	0.28	0	49	21.4
11	7.1	8.1	7.6	11.0	6.5	8.7	0.31	16	53	24.3
12	8.0	9.4	8.7	12.0	5.0	7.4	0.26	18	72	35.7
13	9.5	10.9	10.2	15.5	8.0			44	101	54.5
14	10.6	11.2	10.9	14.0	4.0	10.4	0.37	1	120	66.1
15	10.6	11.1	10.9	13.0	5.0		0.00	1	127	77.1
16	10.5	11.3	10.9	12.0	6.0		0.00		132	84.1
17	9.7	10.9	10.3	12.0	5.0	13.0	0.46		120	66
18	10.2	12.1	11.2	12.0	5.0	8.7	0.31	5	104	51.8
19	9.1	10.5	9.8	11.0	5.0	11.3	0.40	5	100	47.2
20	8.8	9.2	9.0	10.0	4.0	13.0	0.46	8	87	40
21	8.2	9.0	8.6	10.0	4.5	8.7	0.31	3	78	35.2
22	8.0	9.1	8.6	10.0	5.5	7.4	0.26	5	70	32
23	8.7	10.7	9.7	11.0	5.0	7.4	0.26	5	71	33.9
24	10.7	12.1	11.4	15.0	7.0	8.4	0.30	7	84	43
25	11.8	13.3	12.6	15.0	7.0	11.3		32	100	56
26	12.6	13.6	13.1	14.0	7.0	10.4	0.37	15	110	60.3
27	12.6	13.4	13.0	14.0	7.0	11.3	0.40	1	110	60
28	12.0	12.8	12.4	14.0	7.0	10.0	0.35	1	109	60
29	11.1	12.1	11.6	14.0	7.0	9.3	0.33	2	113	62.4
30	12.0	13.0	12.5	12.0	6.5	9.3	0.33	1	112	62.3
31	12.0	12.8	12.4	14.0	7.0	10.4	0.37	0	119	69.8
Avg			**10.6**	**12.1**	**5.6**					
Jun-01	12.0	12.5	12.3	14.0	7.0	10.8	0.38	0	116	69.3
2	12.0	12.2	12.1	13.0	6.5	8.7	0.31	2	105	56.6
3	11.5	12.0	11.8	13.5	7.0	8.7	0.31	2	100	53.1
4	11.1	11.9	11.5	13.0	7.0		0.00	1	140	81.7
5	11.6	12.2	11.9	11.5	7.0		0.00	0	130	75.8
6	12.0	12.4	12.2	13.0	7.0	10.4	0.37	0	112	58.5
7	11.9	12.2	12.1	13.0	7.0	11.3	0.40	1	100	49.3
8	11.8	13.0	12.4	14.0	7.0	9.0	0.32	11	91	44
9	12.3	13.2	12.8	13.0	7.0	6.0	0.21	7	84	40.2
10	12.8	13.4	13.1	14.0	7.0	5.0	0.18	6	81	41.2
11	13.2	14.2	13.7	15.5	8.0	5.1	0.18	14	91	53.1
12	13.5	14.0	13.8	15.5	7.5		0.00	11	124	76.7
13	13.2	13.8	13.5	14.0	7.0	7.4	0.26	3	118	71.1
14	12.7	13.4	13.1	15.0	7.0	10.8	0.38	3	110	63.8
15	12.5	13.5	13.0	15.0	8.0	10.8	0.38	7	113	73.3
16	13.0	14.0	13.5	15.5	9.0	10.4	0.37	0	114	na
17	13.5	14.1	13.8	16.5	9.0	8.1	0.29	9	106	na
18	13.8	15.0	14.4	16.0	9.0	8.1	0.29	7	102	na
19	13.2	14.7	14.0	14.5	8.5	6.7	0.24	11	94	na
20	12.2	13.2	12.7	12.5	7.0	5.3	0.19	18	83	na
21	11.8	12.2	12.0	12.5	7.5	4.7	0.17	22	74	na
22	11.7	12.5	12.1	14.0	10.0		0.00	20	86	na
23	12.6	14.2	13.4	15.0	9.0	6.0	0.21	42	100	na
24	14.0	14.7	14.4	16.0	8.5	5.2	0.18	40	96	na
25	14.0	14.5	14.3	15.0	8.5	6.8	0.24	33	95	na
26	13.9	14.0	14.0	16.0	9.0	7.4	0.26	33	93	na
27	13.0	15.0	14.0	15.0	8.0	6.5	0.23	11	90	na
28	12.8	13.5	13.2	15.0	9.0	4.5	0.16	12	78	na
29	13.6	14.0	13.8	16.0	11.0	4.0	0.14	8	80	na
30	14.0	15.0	14.5	16.0	10.5	4.3	0.15	17	80	na
Avg			**13.0**	**14.3**	**7.9**					

Appendix 1 Table 1. Summary of Water Temperature and Streamflow Information for Telkwa Ponds, May 7 to August 1, 1997.

Date	Min	Max	Mean	Outlet @ Trap	Telkwa R.	Outlet Q (litres/sec)	Q cfs	Fry Upstream	Telkwa gauge ht	Telkwa Discharge
Jul-01	14.9	15.1	15.0				0.00	24		na
2	14.6	15.0	14.8	16.0	10.0	4.9	0.17	8	80	na
3	14.6	15.3	15.0							na
4	15.1	15.6	15.4	16.0	10.0	3.6	0.13	8	68	na
5	15.3	16.0	15.7							na
6	15.7	16.1	15.9	18.0	8.0	3.2	0.11	36	81	na
7	14.9	16.0	15.5							na
8	14.5	14.8	14.7							na
9	13.9	14.6	14.3	15.0	10.0	3.3	0.12	56	70	na
10	14.1	14.8	14.5							na
11	13.9	15.0	14.5	14.5	9.5	1.9	0.07	32	58	na
12	14.5	14.9	14.7							na
13	14.9	16.0	15.5	17.0	11.0	2.1	0.07	30	70	na
14	14.3	16.2	15.3							na
15	15.7	16.2	16.0	17.0	11.0	2.3	0.08	14	66	na
16	15.2	16.0	15.6							na
17	14.3	15.2	14.8	19.0	12.0	2.0	0.07	0	52	na
18	14.9	15.3	15.1							na
19	15.3	15.5	15.4	17.0	10.0	0.0	0.00	4	49	na
20	15.3	15.5	15.4							na
21	14.7	15.3	15.0							na
22	14.0	14.9	14.5	18.0	11.0	1.6	0.06	26	61	na
23	14.1	14.6	14.4							na
24	13.9	14.3	14.1	16.5	10.5	0.2	0.01	40	54	na
25	14.0	14.5	14.3							na
26	13.1	14.0	13.6	16.5	11.0	0.0	0.00	18	45	na
27	13.8	14.0	13.9							na
28	13.8	14.0	13.9	17.0	11.0	0.0	0.00	12	47	na
29	13.8	14.0	13.9							30.7
30	13.8	14.6	14.2	16.5	10.5	0.0	0	8	44	28.4
31	14.0	14.5	14.3							25.1
Avg			**14.8**	**16.7**	**10.4**					
Aug-01	13.7	14.2	14.0	15.5	9.5	0.0	0	0	40	23.7
2	13.8	14.0	13.9							22.2
3	13.9	14.0	14.0							22.6
4	14.0	14.1	14.1							26.8
5	14.1	14.8	14.5							32.5
6	14.8	15.0	14.9							33
7	14.7	14.9	14.8							35.9
8	14.6	14.8	14.7							30.2
9	14.7	15.0	14.9							29.9
10	15.0	15.3	15.2							32.8
11	15.3	15.8	15.6							35.7
12	15.8	15.9	15.9							41.6
13	15.7	16.0	15.9							50
14	16.0	16.0	16.0							37
15	15.7	16.0	15.9							28.8
16	15.0	15.8	15.4							24.8
17	14.9	15.3	15.1							25.2
18	14.9	15.1	15.0							25.9
19	14.9	15.0	15.0							24.9
20	15.0	15.3	15.2							31.6
21	15.2	15.4	15.3							29.9
22	15.2	15.5	15.4							26.1
23	14.7	15.3	15.0							22.3
24	14.0	14.7	14.4							21.2
25	13.6	14.0	13.8							22.5

Appendix 1 Table 1. Summary of Water Temperature and Streamflow Information for Telkwa Ponds, May 7 to August 1, 1997.

Date	Min	Max	Mean	Outlet @ Trap	Telkwa R.	Outlet Q (litres/sec)	Q cfs	Fry Upstream	Telkwa gauge ht	Telkwa Discharge
26	13.5	13.6	13.6							29.3
27	13.4	13.8	13.6							23.2
28	13.2	13.5	13.4							20.6
29	13.0	13.2	13.1							18.5
30	12.9	13.0	13.0							17.3
31	12.5	13.0	12.8							
Avg			**14.6**							
Sep-01	12.5	12.8	12.7							17.1
2	12.6	12.8	12.7							17.4
3	12.5	12.6	12.6							16.1
4	12.4	12.7	12.6							18.8
5	11.8	12.7	12.3							15.8
6	11.3	11.8	11.6							14.8
7	11.0	11.2	11.1							13
8	11.0	11.2	11.1							14.5
9	11.3	11.5	11.4							17.5
10	11.5	11.7	11.6							
11	11.3	11.8	11.6							
12	11.0	11.3	11.2							
13	10.8	11.0	10.9							
14	10.2	10.9	10.6							
15	10.0	10.2	10.1							
16	9.5	10.0	9.8							
17			0.0							
Avg			**10.8**							

Appendix 1 Table 2. Summary of Dissolved Oxygen and Temperature Measurements Taken in the Telkwa Ponds on May 9, 1997.

Pond Section	Depth (m)	Dissolved Oxygen (ppm)	Temperature (C)	TDS (ppm)
Lower Pond	0.0	9.8	9.5	180
	0.5	10.0	8.5	
	1.0	10.1	8.0	
	1.5	10.2	7.5	
Upper Pond	0.0	10.5	10.0	190
	0.5	11.1	6.0	
	1.0	11.0	5.5	
	1.5			
Channel 1	0.0	9.0	8.0	200
(lower end)	0.5	8.2	6.5	
Channel 2	0.0	9.9	10.8	240
	0.5	10.6	9.1	
	0.7	11.2	8.5	
Channel 3	0.0	11.2	9.0	
	0.5	10.5	5.0	
PNG extension:				
Main channel	0.0	7.5	6.0	80
	0.5	6.3	5.0	
Telkwa River	Surface	12.5	2.1	50
Pond Outlet	Surface	10.5	8.0	200

Appendix 2 Table 1. Summary of Fork Lengths of Rainbow and Cutthroat Trout, Mountain Whitefish . and Peamouth Chub Captured in Pond Study, 1997.

	Rainbow Trout			Mountain Whitefish		Cutthroat	Peamouth chub
	Outlet traps			Outlet traps			
	Upstream	Downstream	Mark-recapture	Upstream	Downstream	Upstream	Mark-recapture
	38	44	83	50	62	108	66
	38	49	102	52	125	130	69
	38	61		54			70
	38	62		58			71
	41	62		62			93
	41	63					93
	42	69					94
	43	91					96
	43	91					97
	48	103					97
	48						98
	49						103
							104
							105
							108
							108
							110
							112
							113
							116
							120
count	12	10	2	5	2	2	21
max	49	103	102	62	125	130	120
min	38	44	83	50	62	108	66
avg	42.3	69.5	92.5	55.2	93.5	119.0	97.3
std	4.1	19.3	13.4	4.8	44.5	15.6	16.0

Appendix 3 Table 1. Summary of Upstream and Downstream Trapping Results at the Outlet to the Telkwa Ponds 1997

DATE	UPSTREAM				DOWNSTREAM					
	COHO				COHO	PRE	COHO	RBT	OTHER	MARKS
	AGE O	AGE 1+	RBT	MW	SMOLTS	SMOLTS	FRY			
May-07	Downstream box installed									
May-08	Upstream box installed				Downstream box fishing - no catch					
9	0	0			0					
10	0	0			2					0
11	16	2			1					0
12	18	4			0				MW-125	
13	44	5			0					
14	1	35			Not fishing due to high water - upstream box fishing					
15	1	14	1		Not fishing due to high water - upstream box removed					
16	Not fishing - high water				Not fishing - high water					
17					Partially fishing - installed upstream box					
18	5	37			3					0
19	5	14			1					0
20	8	7	3		2	1				0
21	3	20	1		66			1		7
22	5	9	2	1	26					2
23	5	10	1		47					7
24	7	9			125					10
25	32	19			48					4
26	15	9			54					5
27	1	27			74					6
28	1	10			78					9
29	2	13			61					8
30	1	2			80					11
31	0	7			62	1		1		8
Jun-01	0	5			67					13
2	2	4			81					10
3	2	6			40					3
4	1	3		1	49					7
5	0	0			52					9
6	0	4			76			1		13
7	1	2			44			1		5
8	11	6	2		17					3
9	7	20			41					2
10	6	13			11					1
11	14	15			6	2				0
12	11	22			32	1		1		5
13	3	22			17			1		4
14	3	15			26			1		3
15	7	24	1 CT		7	2				1
16	0	12			17					3
17	9	13			8					1
18	7	3			11	1				2
19	11	6			5			1	1-MW	0
20	18	5			2					0
21	22	4		1	6					0
22	20	17		1	7					1
23	42	19		1	5					2
24	40	7			7	3	1	2		1
25	33	18			4	1				1
26	33	9			8	2	1			1
27	11	4			1	2				0
28	12	25			2	1				0
29	8	14			1	3				0
30	17	32			0	0	2			0
Jul-02	24	18	1 CT		2					0

Appendix 3 Table 1. Summary of Upstream and Downstream Trapping Results at the Outlet to the Telkwa Ponds 1997

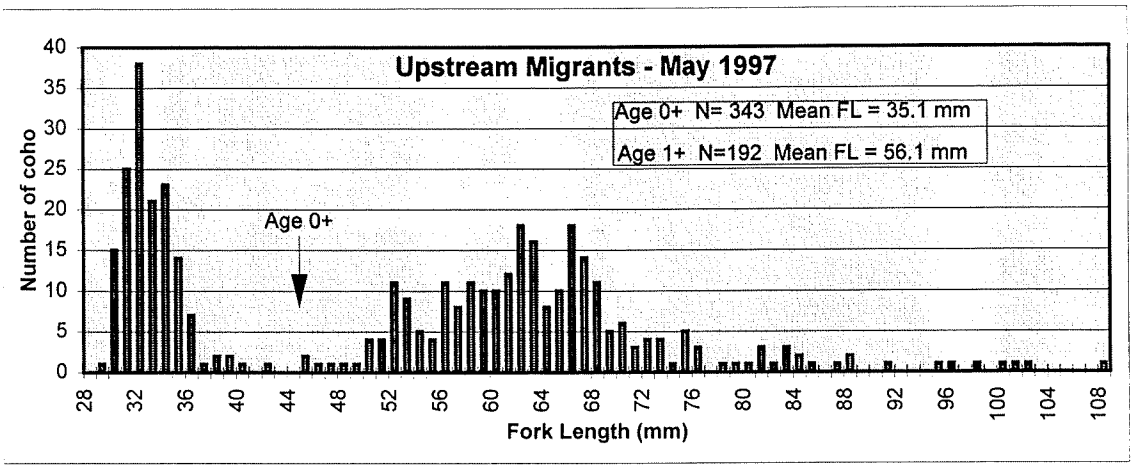
DATE	UPSTREAM				DOWNSTREAM					
	COHO AGE O	AGE 1+	RBT	MW	COHO SMOLTS	PRE SMOLTS	COHO FRY	RBT	OTHER	MARKS
4	8	13	1		0	0	1			
6	36	20			0	1	2			
9	56	31	1		0	5	1			
11	32	20			0	2	0			
13	30	18			0	0	2			
15	14	0			0	6	2			
17	0	0			0	0	0			
19	4	0			0					
22	26	3			0					
24	40	9			0					
26	18	3			0					
28	12	1			0					
30	8	0			0					
Aug-01	0	0			0					
TOTAL	**829**	**738**	**12**	**5**	**1382**	**34**	**12**	**10**	**0**	**168**
										12.2

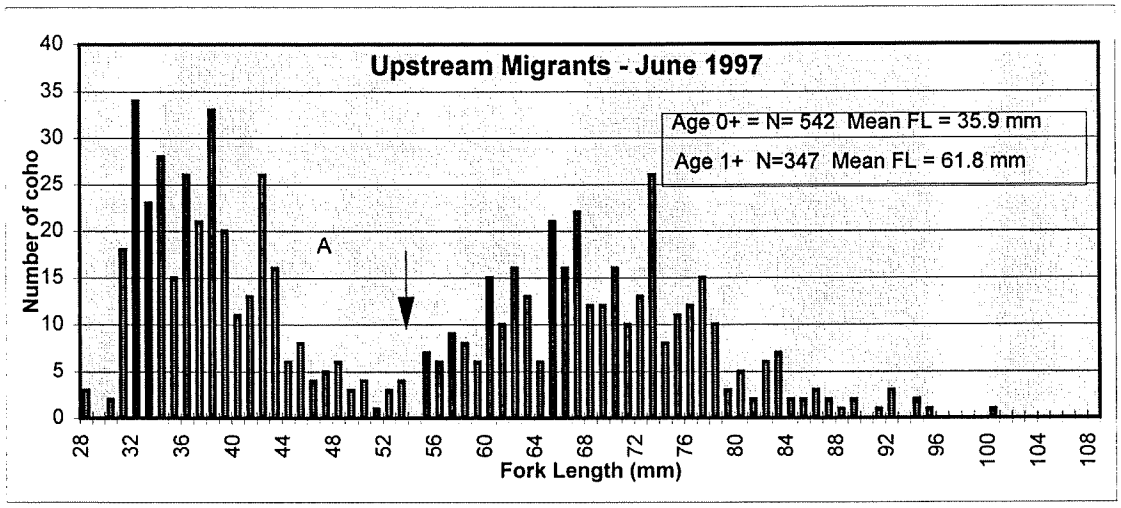
Appendix 3 Table 2. Summary of Length Measurements of Upstream Coho Migrants in Km 1011 Ponds in 1996 and 1997.

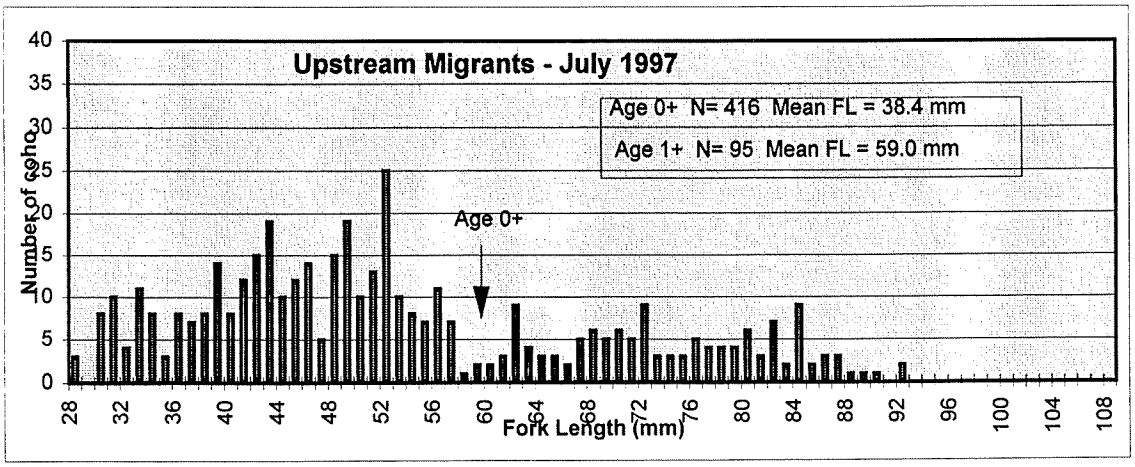
	Age 0+					
	MAY		June		July	
	1996	1997	1996	1997	1996	1997
Number	343	151	542	325	416	303
Size Range (mm)	30-43	29-42	30-47	28-50	30-49	28-57
Mean Fork Length	35.1	32.8	35.9	37.6	38.4	44.4
Std	2.4	2.2	2.9	4.8	4.3	7.6

	Age 1+					
	MAY		June		July	
	1996	1997	1996	1997	1996	1997
Number	192	256	347	350	95	132
Size Range (mm)	44-81	45-108	48-96	51-100	50-72	58-92
Mean Fork Length	56.1	64.1	61.8	69.2	59.0	73.9
Std	7.2	10.4	6.8	8.8	5.4	8.6

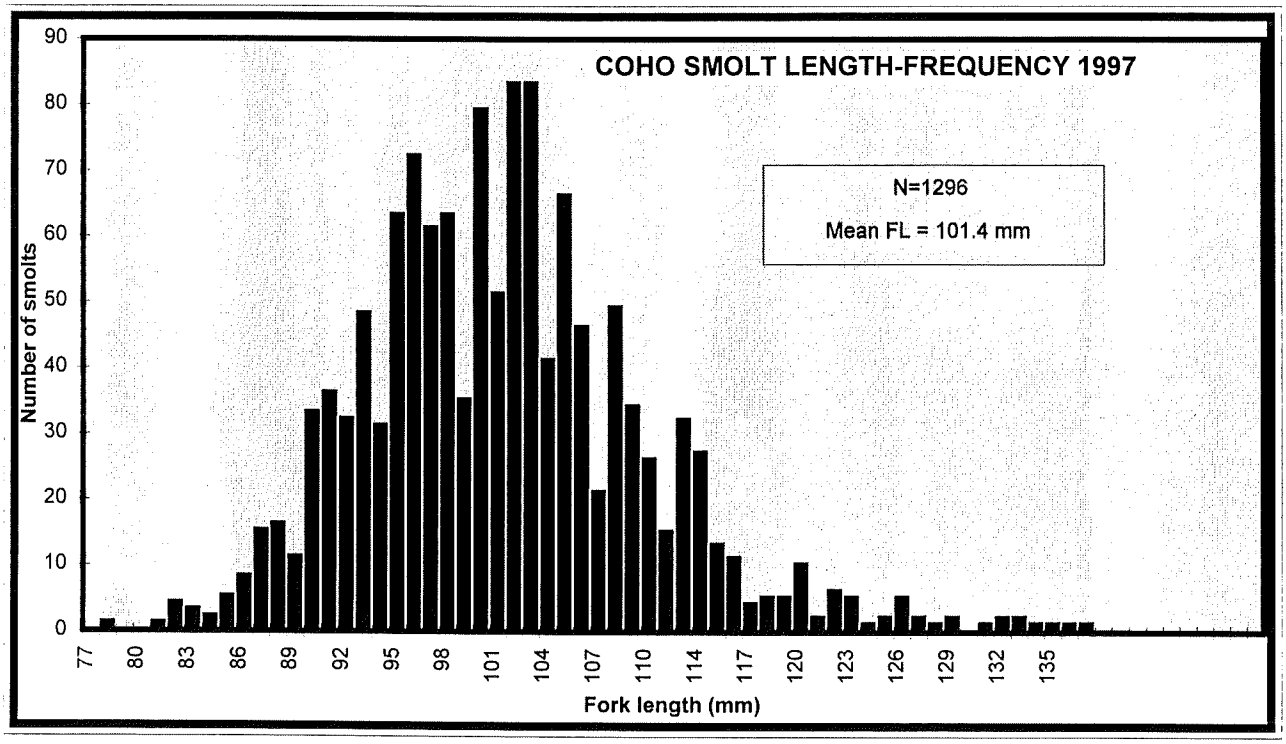
Appendix 3 Figures 1 to 3
Summary of Fork Lengths of Upstream Coho Migrants

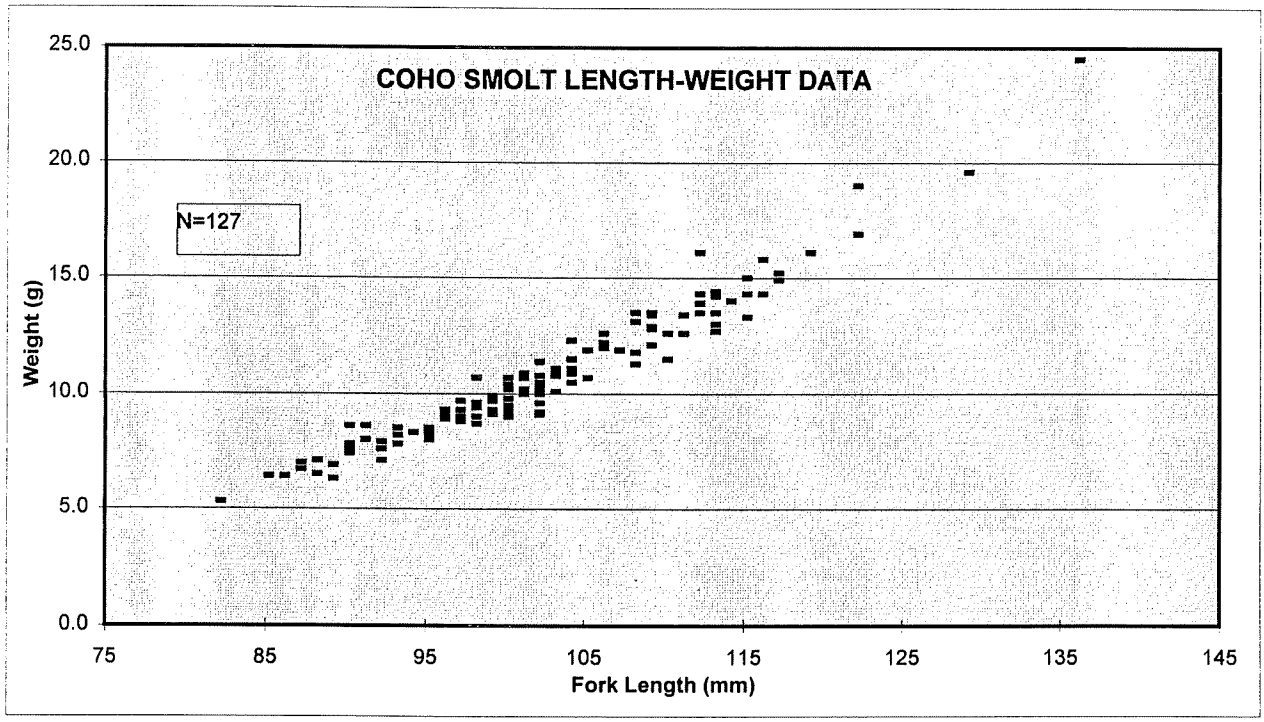






Appendix 3 Figures 4 and 5
Coho Smolt Length-Frequency and Length-Weight Information for Km 1011 Ponds 1997.





Appendix 4 Table 1. Wildlife Observations in the Vicinity of Km 1011 Pond, 1997.

	Birds	Amphibians	Other
May-06	2 geese on Telkwa R. at staff gauge		black bear on PNG line
May-08	1 kingfisher at lower pond	1 salamander in PNG extension pond	
May-09		1 W. toad in d/s trap	2 moose at upper pond
May-10	2 geese on Telkwa R. u/s from trap	1 W. toad in d/s trap	
	2 greater yellowlegs in pond		
May-12		3 W. toads in lower pond	
May-14		1 W. toad in d/s trap	
May-15			beaver activity damming
			up trough
May-16	1 kingfisher	1 W. toad in d/s trap	
May-17	2 geese at staff gauge		
	1 kingfisher/1 male merganser in pond		
May-19	1 kingfisher		
May-20		1 W. toad in d/s trap	
May-21		1 W. spotted frog in d/s trap	
May-24	1 kingfisher	1 W. toad	
May-25		3 W. toads/1 W. spotted frog	1 leech
May-29	1 female goldeneye		
Jun-02	uid duck in lower pond		
Jun-03	1 kingfisher	tadpole at pond outlet	
Jun-04	1 kingfisher	tadpole in d/s trap	
Jun-06		several tadpoles @ d/s trap	
Jun-07	4 geese at PNG line/1 kingfisher		
Jun-08		tadpoles abundant in ponds	
Jun-12	sandpiper at trap area	tadpole in d/s trap	leech in d/s trap
Jun-13	2 female goldeneye on lower pond	2 W. toads/tadpoles in d/s trap	
	2 geese on Telkwa R.		
Jun-14	1 sandpiper/1 kingfisher on pond	3 tadpoles in d/s trap	
Jun-15		1 W. toad/tadpoles in d/s trap	leech, dragonfly nymph
Jun-16		1 W. toad/12 tadpoles in d/s trap	
Jun-17		5 tadpoles in d/s trap	
Jun-18		2 tadpoles	several leeches
Jun-21		1 W. spotted frog in d/s trap	
Jun-22		tadpoles abundant in ponds, d/s trap	
Jun-23		1 W. spotted frog	
Jun-24	1 kingfisher		
Jun-25	1 kingfisher	3 W. toads in d/s trap	
Jun-26	2 geese in lower pond	school of tadpoles in lower pond	
Jun-27		fewer tadpoles	
Jun-28		large school of tadpoles	
Jun-29		few tadpoles	
Jun-30		several tadpoles @ culvert outlet	
Jul-02		tadpoles @ fence	
Jul-04	uid duck	several tadpoles in d/s trap/ponds	
Jul-06		5 tadpoles	

Appendix 4 Table 1. Wildlife Observations in the Vicinity of Km 1011 Pond, 1997.

	Birds	Amphibians	Other
Jul-09	2 kingfisher	1 W. toad in d/s trap	
Jul-11		tadpoles @ lower pond culvert	
		tadpole with legs d/s	
Jul-15	1 kingfisher	tadpoles abundant	
Jul-19		tadpoles in lower pond	
Jul-22		1 W. toad/49 tadpoles in d/s trap	
Jul-24		school of tadpoles in lower pond	
Jul-26		school of tadpoles in lower pond	
Jul-30		school of tadpoles in lower pond	
		~100 tadpoles in d/s trap	
Aug-01		50 tadpoles, 5 leeches & several uid	
		invertebrates in d/s trap	
		school of tadpoles in lower pond	
Note:	uid = unidentified		