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Puntledge River :

Biophysical Assessment of Streams Tributary to Comox Lake

by:

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ABSTRACT

At low stream flows, during September 21-October 6, 1994, an intensive biophysical assessment was conducted in streams tributary to Comox Lake, on Vancouver Island. Principal objectives of the study were to determine: 1) existing fish habitat characteristics and present use, potential distribution, and carrying capacity of anadromous and resident species; 2) limitations and/or benefits to fish production resulting from operation of a hydroelectric storage dam at the lake's outlet; 3) potential mitigation options, or other opportunities to increase stream carrying capacity, or facilitate access to the system; and 4) in a companion study, stocking stategies based on available habitat, and objectives of fisheries agencies and B.C. Hydro.

Generally, the 1994 standing stock of wild fish populations (cutthroat trout, rainbow trout, and Dolly Varden char), in streams, was below theoretical capability throughout most of the drainage. However, the production of both cutthroat trout and Dolly Varden may be close to (or at) capability in sections of Comox Creek and Eric Creek, tributary to the Cruickshank River, by far the largest system in the drainage.

All indications of the 1994 field program suggest that the stocking of hatchery coho fry in the Cruickshank drainage, and the Puntledge River, exceeded carrying capacity in 1994. Summer releases to Eric and Rees creeks (Cruickshank system) totalled 234,222 coho fry, compared to a theoretical capability, at low flows, of just under 30,000 fish, for these streams. For the Puntledge River, the 1994 release of 95,238 coho fry compares to a theoretical capability of just over 18,000 fish, at low flows. In flowing streams, data consistently indicated major outmigrations (and/or mortality) of coho fry from these systems, prior to fall sampling. This was particularly evident for the release to Rees Creek, where it is speculated that low stream temperatures (ie. <7°C), at time of release, likely drive the vast majority of hatchery coho out of this stream. Major downstream migrations of coho fry, displaced from Rees and Eric creeks, were evidenced in the Cruickshank River mainstem. Coho densities were low in most of the mainstem consistent with a general lack of suitable cover. However, in the lowermost Cruickshank mainstem, where such cover is more abundant, coho fry were found in high densities (relative to theoretical capability), which was reflected in poor condition of fish.

In Eric Creek, at least, coho and summer steelhead releases are likely detrimental to wild trout and char production. In the Cruickshank drainage as a whole, resident species are probably impacted from outplanting. Even though releases of steelhead fry are far smaller than those of coho (total 20,600 in 1994) these may also be detrimental to wild trout and char production in Comox and Eric creeks. Clearly, the greatest issue in the present fisheries management of tributaries to Comox Lake is the need to integrate hatchery programs for all species (most recently including chinook salmon), with full consideration of wild fish production, within the constraints of natural capability (carrying capacity).

Although the hydroelectric storage dam inevitably resulted in some loss of stream habitat (backflooding), the quantity and quality of habitat is not a major issue for the Comox Lake drainage. With efficient passage facilities now in place at the dam, and downstream migration of juveniles assured by the recent installation of Eicher screens in the penstock, anadromous fish production in the upper watershed could be restored to historic levels. It is preferable that all fish production in tributaries to the lake should ultimately be derived through natural ascent and reproduction of all relevant stocks, now enabled by the fishway and the Eicher screens. Selective operation of the fishway may prove valuable in precluding further passage of stocks not wanted in the upper drainage (eg. winter steelhead), whose ascent as far as the dam may have been facilitated by fish passage improvements downstream.

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1.0 INTRODUCTION

The Puntledge River drainage is a major system on Vancouver Island. It empties into the Strait of Georgia at Courtenay, roughly half way up the eastern coast of the island. It consists of three major components: 1) the Lower Puntledge River and tributaries; 2) Comox Lake; and 3) streams tributary to Comox Lake, dominated by the Upper Puntledge and Cruickshank rivers (Fig. 1). B.C. Hydro presently operates a hydroelectric facility on the system. This facility was originally constructed in 1913, and consists of an impoundment dam at the outlet of Comox Lake, a low diversion dam and penstock intake 4 km downstream, and the penstock itself, which diverts water to a powerhouse located another 5.5 km downstream (Fig. 1).

Historically, the Puntledge River system supported diverse stocks of salmon and trout, that provided excellent fisheries, both freshwater and marine (Rimmer *et al.*, 1994). It was considered to be one of the more important salmonid production areas on the east coast of Vancouver Island (B.C. Hydro, 1994)[1]. It is acknowledged that the hydroelectric developments on the system have resulted in the decline of anadromous stocks which utilized habitat upstream of the diversion and/or the storage dam at the outlet of Comox Lake (*ibid.*). Various attempts have been made to mitigate or compensate for the hydroelectric impacts through cooperative programs involving B.C. Hydro, federal and provincial fisheries agencies, and local interest groups.

A major component has been the development and operation of a full scale hatchery, located near the powerhouse, and a smaller rearing facility located adjacent to the diversion dam (Fig. 1). A coho colonization program, using surplus juveniles (fry and pre-smolts) from the hatchery, has been conducted in the upper part of the drainage (Comox Lake and tributaries) since 1981. In addition, adult coho (spawners) have been transported to the upper watershed annually since 1985 (B.C. Hydro, *op.cit.*). Since 1982, steelhead juveniles have occasionally been released to the Cruickshank River system, and annually since 1992. Lastly, in 1993, hatchery chinook fry releases were initiated, also to the Cruickshank River. In order to assure safe passage of juvenile fish outmigrating from the upper watershed, Eicher screens were installed by B.C. Hydro in 1993, at water intakes lower river in the system.

Although the first fishway in the storage dam at the outlet of Comox Lake was installed in 1927, it was not until 1991 that design modifications ensured reliable passage of fish into Comox Lake and its tributaries (Rimmer *et al.*, *op.cit.*). However, this fishway has not come into play, since returning adult fish are diverted and retained for hatchery brood stock collection at the diversion dam downstream (Fig. 1). When stocks have been adequately rebuilt by the hatchery program, surplus adults will then be free to ascend into Comox Lake, and its tributaries. It is felt that wild production, thus achieved, represents the most significant fisheries enhancement (or restoration) potential for the system (B.C. Hydro, *op.cit.*).

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[1] *Request for Proposal: Comox Lake tributaries aquatic biophysical assessment and enhancement strategies*. Issued by Environmental Affairs, B.C. Hydro and Power Authority, Burnaby. File: 525-234.04, dated June 14, 1994.

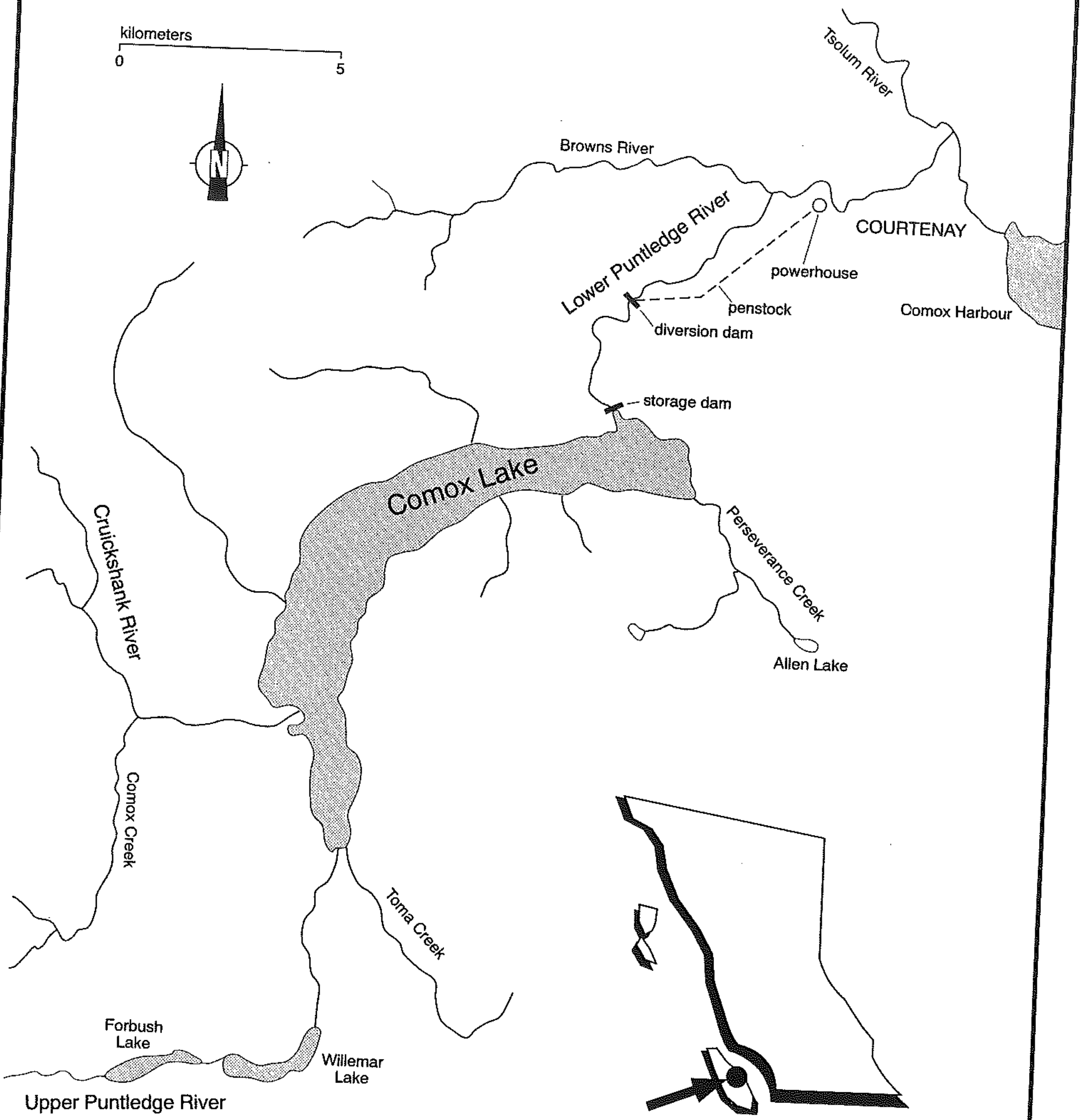

Figure 1. The Puntledge River system, including the Comox Lake drainage.

As an evaluation of this potential, and in order to develop sound salmonid stocking strategies for the meantime, B.C. Hydro elected to conduct a fisheries oriented biophysical assessment addressing all streams flowing into Comox Lake. The specific objectives were to document the following:

1. *existing fish habitat characteristics and present use, potential distribution, and carrying capacity of anadromous and resident species;*
2. *limitations and/or benefits to fish production resulting from operation of the dam;*
3. *potential mitigation options, or other opportunities to increase stream carrying capacity or facilitate access to the system; and*
4. *stocking strategies based on available habitat, and the objectives of Department of Fisheries and Oceans, B.C. Environment*[2]*, and B.C. Hydro.*

Under contract agreement, the first three of these responsibilities, constituting the actual biophysical assessment, were undertaken by R.P. Griffith and Associates (Sidney, B.C.), and are addressed herein. The subsequent development of appropriate stocking strategies, as well as a summary of all relevant data/literature, was undertaken by Global Fisheries Consultants Ltd. (White Rock, B.C.), and is addressed in a companion document.

2.0 BACKGROUND

2.1 Study Area

The total drainage area of the Puntledge River system is 841 km^2 (Rimmer *et al.*, 1994). Influent tributaries to Comox Lake constitute roughly half of this total area. Comox Lake itself has a surface area of approximately 2,000 ha (*ibid.*), and a length of approximately 15 km. The largest tributary is the Cruickshank River, with a drainage area of 214 km^2. This system originates from the outlet of Moat Lake, in Forbidden Plateau, to the northwest of Comox Lake. From its origin, it flows southeast, entering the south end of Comox Lake, 11 km from the outlet dam (Fig. 1). The total length of the Cruickshank River mainstem is just over 22 km; however, access for migratory fish is restricted by barrier falls (> 50m)[3], located 17.5 km upstream of Comox Lake (Fig. 2).

Three major tributaries flow into the Cruickshank River. All are downstream of the barrier falls. Starting from the bottom of the system, they are: 1) Comox Creek, 15 km in

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[2] B.C. Ministry of Environment, Lands and Parks.

[3] Observed by helicopter, during overflight of the system on August 26, 1994; photograph provided in Appendix 1.

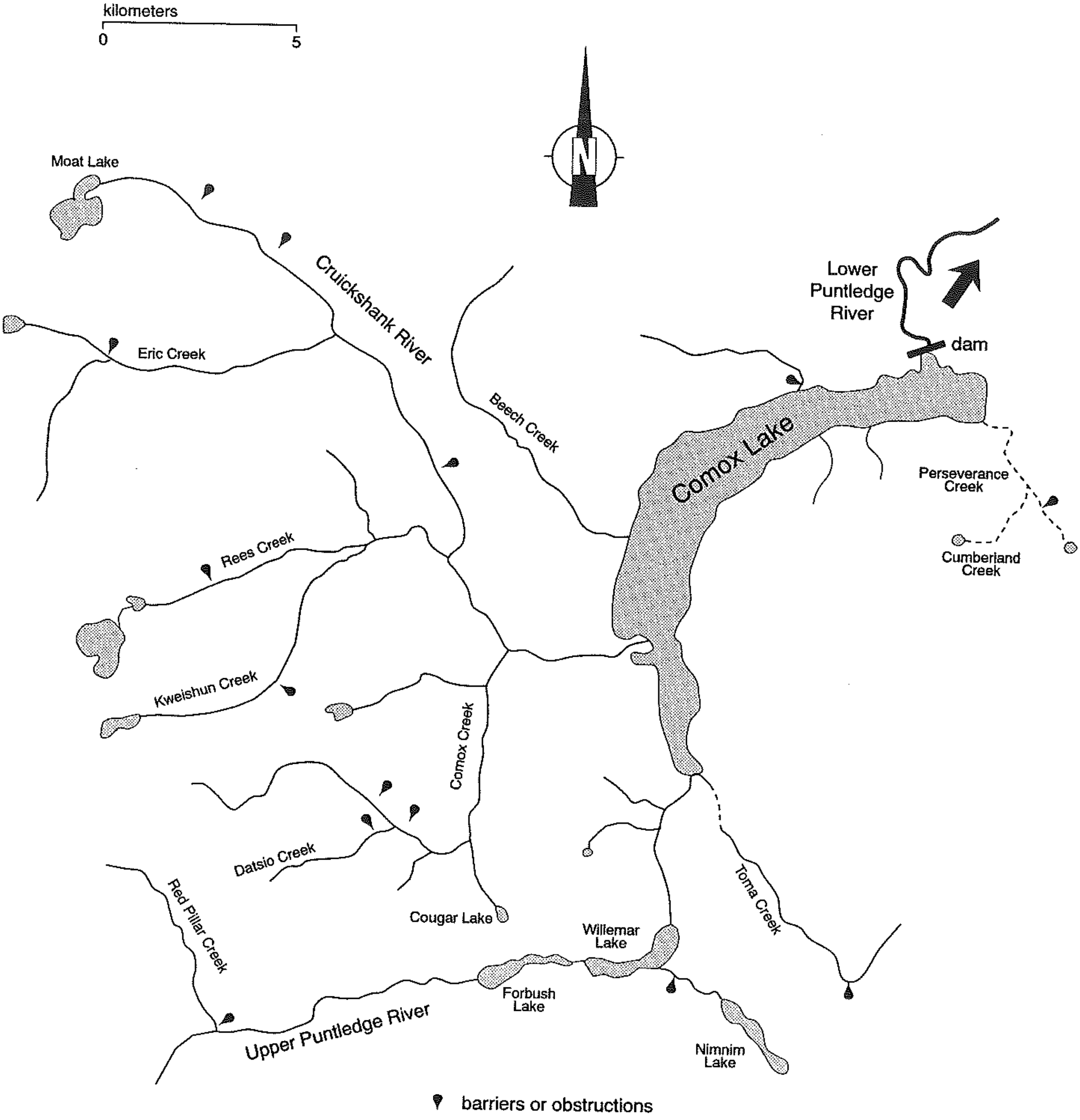

Figure 2. Study area; Comox Lake drainage

length; 2) Rees Creek, 10 km in length; and 3) Eric Creek, 8.5 km in length (Fig. 2). Kweishun Creek (8 km in length), which is tributary to Rees Creek, is another significant watercourse within the Cruickshank drainage. All of these streams are lake-headed. As shown in Figure 2, two sets of falls are present on Comox Creek. The first is located 7.5 km upstream of the Cruickshank River mainstem, and consists of a constricted (bedrock-controlled) vertical falls of 3.1 m, at its lowest point (Appendix 1). Approximately 1 km further upstream, there is another set of larger falls, consisting of a series of vertical drops, confined within an extremely narrow bedrock fissure (ave. < 3 m width), and totalling nearly 30 m in height (Appendix 1). Although specific barriers have previously been reported for Rees, Kweishun, and Eric creeks (Caw, 1977a), these were not observed during helicopter overflights of these streams. However, in all cases, extremely steep sections result in gradient barriers toward the relevant headwater lakes, which are nestled amongst high mountains, icefields, and glaciers. The same applies to Comox Creek, and the uppermost Cruickshank River itself (Fig. 2).

The Upper Puntledge River is the second largest tributary to Comox Lake (Fig. 2). It has a drainage area of 92 km^2 (Rimmer *et al.*, *op.cit.*), and is approximately 20 km in length. It arises as the outlet of Puntledge Lake, at low elevation (ca. 550 m). However, its headwaters receive inflows from Red Pillar Creek, which originates from the Cliffe and Comox glaciers, to the north. From its origin, the Upper Puntledge River flows east, and then north, emptying into the extreme south end of Comox Lake. Its course includes Forbush Lake (48.5 ha; Burridge, 1955) and Willemar Lake (89 ha; *ibid.*), which constitute 2 km and 2.5 km of the total system length, respectively. There are numerous small and precipitous tributaries to the Upper Puntledge River, throughout its length. Red Pillar Creek is the largest, but there is a gradient barrier (ie. > 40%) and/or falls just upstream of its confluence with the Upper Puntledge River. The only other significant tributary to the system is Nimnim Creek, which drains Nimnim Lake to Willemar Lake; and in this case there is a barrier (> 90%) within 1.5 km of Willemar Lake (Fig. 2).

Following the Cruickshank and Upper Puntledge rivers, Toma Creek and Perseverance Creek are the next largest tributaries to Comox Lake. The drainage area of Toma Creek is 20.2 km^2, and its total length is approximately 9 km. It originates to the southeast of Comox Lake, and flows northwest, entering the south end of the lake, immediately adjacent to the mouth of the Upper Puntledge River (Fig. 2). Excessive gradient (ie. > 30%) precludes fish use of at least the uppermost 2 km of this stream. The drainage area of Perseverance Creek is 26.3 km^2 and its mainstem length is 4.5 km. It originates at the outlet of Allen Lake, east of Comox Lake (Fig. 2). At a point approximately 0.6 km downstream of Allen Lake there is a series of sandstone falls consisting of 5 steps, ranging from 0.5 m to 1.6 m in height, and totalling close to 4.5 m (Appendix 1). Cumberland Creek, tributary to Perseverance Creek, represents a large portion of this system's total drainage area. However, it is dammed (to form a small reservoir) 0.8 km upstream of Perseverance Creek. A steep concrete spillway at the dam, and natural falls downstream, preclude fish passage at any flows (Appendix 1).

Despite their relatively large size, both Toma and Perseverance creeks are subject to dewatering (reduction to seepage flows only) over some portion of their length, during low flows. Smaller tributaries to the lake (Fig. 2) appear to dry up entirely, or very nearly so. The annual flow regime in the Comox Lake drainage is derived from Water Survey of Canada records for the Cruickshank River (Appendix 2), provided in Figure 3 and Table 1. Minimum monthly flows (ave. 4.5 m^3/s), averaging approximately 25% of mean annual discharge (ave. 17.5 m^3/s), occur during late summer (August-September). During fall, discharges increase with the typically wet coastal conditions at this time of year. Discharges drop somewhat during winter and early spring, due to the partial storage of precipitation as snow (and/or ice) at higher elevations within the drainage. The latter contributes, as meltwater, to peak discharges in the system during May-June. However, as evidenced in January 1994, heavy rains at lower elevations within the drainage may result in peak discharges during winter.

2.2 Watershed Development

In comparison to the portion of the watershed downstream of Comox Lake, the upper drainage has been subject to fewer aspects of human development. The Lower Puntledge drainage has been greatly subject to logging, agricultural, industrial, and urban development. This has resulted in widespread habitat degradation, alteration of flow regimes, and effects on water quality (Rimmer *et al.*, 1994). In comparison, direct impacts to the upper watershed have been primarily limited to logging and associated road construction. However, this has been extensive. By the mid 1950's, most of the accessible areas had been logged and were supporting well established second growth (Burridge, 1955). Since then, harvesting has extended into some headwater areas, notably within the Cruickshank River system. However, young second growth is now developing here as well, and activity has declined to the point where many road systems are now unusable.

In terms of fisheries, the greatest impact to the upper watershed has likely been the indirect effects of the hydroelectric developments downstream of Comox Lake; ie. the loss (or severe restriction) of fish passage into the lake, and its tributaries, for certain stocks of anadromous salmonids (Bengeyfield and McLaren, 1994; Rimmer *et al., op.cit.*). The first storage dam at the outlet of Comox Lake was constructed in 1913, by Wellington Colliery Company Ltd., to supply electricity to several coal mines (Russell, 1990). No facilities for fish passage were provided. In 1927, a wooden fishway was constructed, but it did not work efficiently, if at all. In 1957-58 the dam was reconstructed to increase its height (presently 6.4 m), and a new concrete fishway was included. Again, however, this proved ineffective and passage remained impaired, except at certain lake levels and flow stages. In 1965, the fishway was closed to divert adult fish into a new spawning channel, downstream of the dam. As noted earlier, it was not until 1991 that modifications of the fishway, by B.C. Environment, enabled fish passage over a range of flows and fluctuating lake levels; but it will not come into play until total adult returns exceed hatchery brood stock requirements, and surplus fish are allowed upstream of the hatchery facilities.

In addition to the physical presence (and effect) of the dam at the outlet of Comox Lake, Rimmer *et al.* (*op.cit.*) list a variety of other possible impacts of the hydroelectric developments on the fish stocks of the Puntledge system. These may include: 1) loss of natural flow regimes; 2) increased summer water temperatures; 3) increased fish health problems; 4) backflooding of important habitat; 5) scouring of the channel and loss of gravel; 6) deposition of fines; 7) extreme low flows; 8) delay and/or confusion of adult immigra-

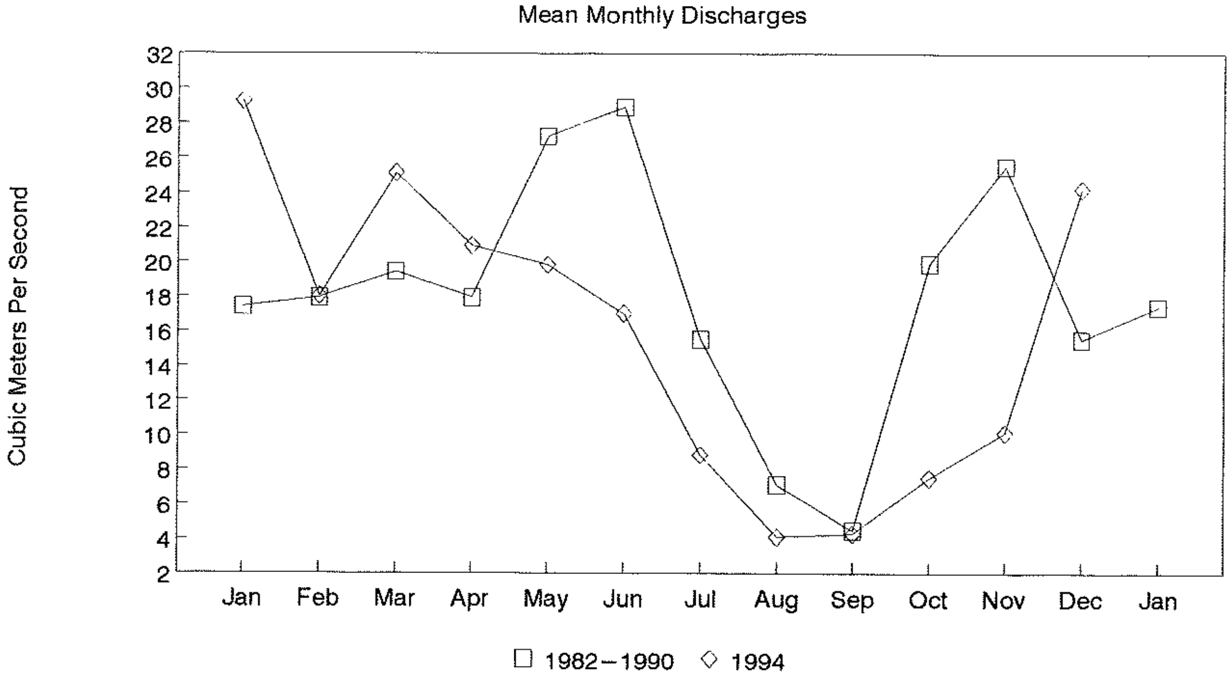

Figure 3. Summary of discharges for the Cruickshank River, near the mouth (WSC Sta.08HB074).

Table 1. Discharge records for WSC Sta.08HB074, in the Cruickshank River, near the mouth.

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
							(all values in m^3/s).						
Mean monthly ; 1982–1990 [1]	17.4	17.9	19.4	17.9	27.2	28.9	15.5	7.1	4.5	19.9	25.5	15.5	17.5
Mean monthly ; 1994 [2]	29.3	18.0	25.1	20.9	19.8	17.0	8.8	4.1	4.3	7.5	10.1	24.2	15.8

Minimum daily flows :

Range (1982–90)	1.84 – 3.25 m^3/s
Mean (1982–90)	2.50 m^3/s
1994	2.57 m^3/s

Mean daily flows during electrofishing program, September 21 – October 6, 1994 :

Range	2.72 – 3.61 m^3/s
Mean	3.10 m^3/s

[1] Water Survey of Canada (1991)

[2] unpublished preliminary data (Water Survey of Canada, Vancouver)

tion; and 9) aggravated passage for some stocks, at natural falls in the lower river, due to flow manipulation. All of these concerns apply specifically to the system downstream of Comox Lake, and in most cases, more data are required to confirm their validity, and/or the magnitude of their effects. In any event, they have no direct bearing on the upper watershed, at the present time, since it is functionally isolated with disuse of the fishway at the Comox Lake storage dam. An earlier exception was the intake of juvenile fish, downstreaming (or displaced) from Comox Lake, into the penstock and through the turbines. However, with installation of the screening devices installed by B.C. Hydro in 1993, safe downstream passage of fish has now been secured. With respect to the other impacts listed above, it should be noted that some implications may apply to the upper watershed, once the fishway comes into use, and continuity (re. fish migration/production) of the upper and lower watersheds is restored (eg. fish passage in the lower river, fish health).

2.3 Fish Species and Distribution

The Puntledge River system supports populations of all five Pacific salmon species; chinook (*Oncorhynchus tschawytscha*), coho (*O. kisutch*), pink (*O. gorbuscha*), chum (*O. keta*), and sockeye (*O. nerka*). It also supports steelhead trout (*O. mykiss*) and anadromous cutthroat trout (*O. clarki*), as well as resident rainbow trout, cutthroat trout and Dolly Varden char (*Salvelinus malma*). Estimates of salmon escapement to the system from 1953 to 1989 are provided by (Rimmer *et al.*, 1994). Numbers of sockeye have been low throughout this period (max. 407). Coho, pink, and chum have all fluctuated to varying degrees, but have generally retained their numbers over the period of record: *ca.* 7,000; 9,000; and 35,000, respectively. Chinook have shown a dramatic decline, particularly during the 1980s; eg. from 1,500 in 1983, to 330 in 1989.

Corresponding records are not available for steelhead trout. Both winter run and summer run stocks are present within the Puntledge drainage (Rimmer, *et al. op.cit.*), and as outlined below, it is summer run fish that are most relevant to the upper watershed (Comox Lake and influent tributaries). Since the late 1980s, the number of returning summer adults has dropped below 100 fish. In 1993-94, the return was estimated at only 30 adults, including both wild and hatchery fish. Accordingly, Puntledge summer steelhead are viewed as being *at high risk of extinction* (*ibid.*).

Natural distribution of anadromous stocks in the upper watershed no longer applies, due to the dam at the outlet of Comox Lake, the previously ineffectual fishway and the collection of adults for hatchery use, at present. The historic distribution of salmonids in the system is not well documented. However, on the strength of all data available, Bengeyfield and McLaren (1994) conclude that Stotan and Nibs falls, on the Lower Puntledge River, downstream of Comox Lake, served as a barrier to anadromous fish except steelhead and chinook salmon. With respect to steelhead, Rimmer *et al.* (*op. cit.*) distinguish that it was only summer run fish that could ascend these obstructions. It appears that all other anadromous stocks, including winter steelhead, were restricted to the lower watershed (*ibid.*). There has been some suggestion, that coho salmon may also have been present in the tributaries to Comox Lake, prior to dam construction (Russell, 1990), but there is no firm evidence to support this (Bengeyfield and McLaren, *op.cit.*). All data indicates that these streams supported summer steelhead, chinook salmon, and resident populations of rainbow trout, cutthroat trout, and Dolly Varden char (Rimmer *et al.; op. cit.*).

2.4 Fisheries Enhancement Activities

An extensive description of fisheries enhancement activities in the Puntledge system is given by Rimmer *et al.* (1994). A chronological summary of these and other developments is provided by Bengeyfield and McLaren (1994). The list is extensive, reflecting the great impacts on the system (hydroelectric and otherwise), and diverse attempts to mitigate for them. However, in themselves, the various attempts at enhancement for some stocks may have resulted in further impacts on others (*ibid.*). For instance, fisheries on enhanced stocks may have increased the interception, and rate of decline, of weaker stocks (notably, wild stocks). The abundance of vulnerable hatchery-released fish appears to have resulted in the attraction of predators (eg. seals and dogfish) in large numbers, and associated increases in rates of predation. Outplanting of hatchery fish, and modification of naturally selective barriers, may have resulted in the artificial extension of some species' distributions, at the possible expense of naturally occurring species (*ibid.*).

The latter implications are of particular significance to the upper drainage. Between 1968 and 1977, Stotan and Nibs falls were modified to facilitate passage for salmon adults. Rimmer *et al.* (*op.cit.*) suggest that this could result in the superimposition of coho production on that of chinook and summer steelhead in the Puntledge system, upstream of the falls. Since these modifications have likely facilitated the passage of winter run steelhead, the potential for inter-breeding with summer run fish may also been increased (*ibid.*). However, with respect specifically to the upper drainage, the most profound implication seems to be the extension of the above possibilities, to the Upper Puntledge River, the Cruickshank River, and other tributaries to Comox Lake, if the fishway in the storage dam ever comes into free and continual use.

The main issue at the present time appears to be the effect of the ongoing releases of hatchery salmonids to the upper watershed. By far, the most significant of these is that for coho salmon. Since 1981, an average of 1.9 million (range of 0.2 to 2.9 million) surplus coho juveniles have been outplanted annually, in Comox Lake and/or its tributaries (B.C. Hydro 1994), notably the Cruickshank River system (Rimmer *et al.*, *op.cit.*). In addition, variable numbers of adult coho have been transported to the upper watershed, since 1986 (*ibid.*). In 1982, the first release of hatchery summer steelhead fry (10,700 fish) was conducted in the Cruickshank River. This was followed by the release of 42,000 summer steelhead parr in 1985. At the same time, another 25,000 parr were released to Rees Creek. However, there were no further releases of steelhead to the upper watershed until 1992. Since then, 5,000 to 15,000 summer steelhead fry have been released annually to Comox, Rees, and Eric creeks (Cruickshank drainage), on an experimental basis. Lastly, the first large release of hatchery chinook fry to the upper watershed occurred in 1993. This involved the release of 82,000 fish to the Cruickshank system (Rimmer *et al.*, *op.cit.*). There is no indication of any integration of these releases, relative to stream carrying capacity or potential impacts on resident trout and char.

3.0 METHODS

In preparation for ground activities (and to acquire an aerial video record), a helicopter overflight of all major tributaries to Comox Lake was conducted on August 26, 1994. Following this, an intensive field data collection program was conducted in the system during September 21 - October 6, 1994. Timing was selected to coincide with low flows (Fig. 3), and decline of the growing season, consistent with capability model requirements (Ptolemy, 1992). As shown in Table 1, mean flows in the Cruickshank River for July and August 1994 (8.8 m^3/s and 4.1 m^3/s, respectively) were considerably lower than the average for years on record (15.5 m^3/s and 7.1 m^3/s, respectively; 1982-90). Furthermore, the average for the whole of 1994 (15.8 m^3/s) was also somewhat lower than the average for other recorded years (17.5 m^3/s; Table 1). However, the mean for September 1994 (4.3 m^3/s) was virtually identical to the norm (4.5 m^3/s). Throughout the field program there was minimal precipitation. As a result, during this period, mean daily flows in the Cruickshank River ranged only between 2.72 m^3/s and 3.61 m^3/s (Appendix 2), averaging 3.10 m^3/s, as monitored near the mouth. This compares to a mean minimum daily flow of 2.50 m^3/s for the period of record (Table 1). For 1994, the minimum daily flow was again close to this norm (2.57 m^3/s), and occurred on October 19 (Appendix 2).

3.1 Habitat Stratification and Description

Following standard B.C. Environment and Department of Fisheries and Oceans methodologies (Anon., 1989), habitat descriptions addressing the full channel width were completed for all streams and/or stream reaches investigated during the 1994 field program in the Comox Lake drainage. Prior to entering the field, planning for sampling was based on the reach mapping of the Cruickshank and Upper Puntledge drainages provided by Rimmer *et al.* (1994), based on earlier studies of these systems (Caw, 1977a; 1977b; Russell, 1990). With some adjustments on the basis of the 1994 findings, these designations were used to conduct fish sampling and habitat description on a reach-specific basis. Smaller tributaries were investigated as warranted (ie. size, discharge, etc.). In the final analysis, full habitat descriptions were completed at a total of 32 different sites within the drainage. Length and area measurements were by tape or rangefinder, as appropriate. Gradient was determined by clinometer, later verified with topographic mapping.

3.2 Fish Sampling

The principal sampling technique was electrofishing, following standard procedures outlined by deLeeuw (1981). Captures were conducted at a total of 42 sites, in: 1) the Cruickshank River mainstem, from its mouth to a point approximately 4 km downstream of Moat Lake; 2) Comox, Datsio, Rees, Kweishun, and Eric creeks, all tributary to the Cruickshank system; 3) the Upper Puntledge River mainstem, to a point 1 km upstream of Forbush Lake; 4) the first 2.5 km of Toma Creek; and 5) Perseverance Creek, to a point 0.5 km downstream of Allen Lake. Full population estimates were completed at a total of 34 sites.

In such cases, electrofishing sites were completely enclosed by small-mesh stopnets, and sampling was by the 2-capture removal method. All fish captured were measured for length (fork length). Weights were also obtained from all captures, using a top-loading electronic balance, accurate to 0.1g. To maximize the data set, measurements were also obtained from all incidental captures (eg. stunned fish pinned against the outside of site containment nets). However, such fish were not included in site population estimates. Due to potential error from moisture, fry <35 mm were not weighed. For such individuals, values were computed on the basis of length/weight relationships of larger fry. Across the spectrum of captures, scale samples were obtained from a total of 140 specimens, of different species and sizes, to aid age separation of the populations.

In most of the cases where population estimates were derived, sites were selected to be as closely *representative*, as possible, of *average* habitat conditions for the given stream and reach. However, in some cases, population estimates were derived for specific habitat types in order to address specific issues (eg. species distribution and/or fish abundance in particularly suitable habitat). In addition, sampling was restricted to *spot shocking* at a total of 8 sites, to test quickly for specific species and/or cohorts, on a presence/absence basis, in most favourable habitat. In such cases, only a downstream stopnet was employed, as population estimates were not intended.

3.3 Evaluation of Standing Stock vs. Theoretical Capability for Juvenile Fish

The model used in this study to compute theoretical capability for juvenile salmonids has been developed by B.C. Environment from an extensive data base specific to B.C. streams (Ptolemy, 1992). A description of the model, and details relating to its application, are provided in Appendix 3. All entries and results relate to conditions at the end of the growing season, consistent with the timing of the 1994 sampling in the Comox Lake drainage. Resultant standing stock capability (carrying capacity) estimates are expressed in terms of potential fish numbers per unit area of suitable/usable habitat for a given species/cohort.

At any given sampling site, the proportion of the total site area that is actually usable by different species/cohorts may vary widely. Consequently, in order to compare sampling results to corresponding capability estimates, it is necessary to adjust the former, relative to the specific degree of usability/suitability of each site, for each species/cohort of fish. This adjustment is based on probability of use procedures, following Bovee and Cochnauer (1977), using water depth and velocity as the principal delineators of habitat partitioning (and use) for juvenile fish.

At all 34 electrofishing sites, where population estimates were undertaken, water depth/velocity transects (by means of mechanically driven electronic flow meter) were used to derive mean probability of use estimates on a site-specific and species/cohort-specific basis. These values were generated from transect data and a computer spreadsheet developed by B.C. Environment (Bech *et al.*, 1994) employing probability of use curves based on B.C. data. The spreadsheet provides results for coho and chinook juveniles, as well as rainbow trout. Provided that a given transect is representative of hydraulic conditions throughout a sampling site, the mean composite (depth x velocity) probability of use for the transect provides the requisite estimate of the degree to which the total hydraulic habitat is actually usable for a given species/cohort of fish. Accordingly, this enables adjustment of the initial sampling results (based on total site area), for direct comparison to capability estimates (ie. what was found *vs.* the theoretical maximum, in suitable/usable habitat).

At the time analyses were initiated for the 1994 field data from the Comox Lake drainage, Dolly Varden char had yet to be included in the B.C. Environment hydraulic suitability (probability of use) spreadsheet. In order to derive appropriate habitat use curves for the purposes of this study (and other studies involving char species), the leading authority with the U.S. Fish and Wildlife Service[4] was consulted, as were those with knowledge specific to B.C.[5]. On the basis of 1) these consultations, 2) the literature, 3) data specific to B.C., and 4) curves for both Dolly Varden (Anon., 1981) and bull trout (Pratt, 1984), provided by the U.S. Fish and Wildlife Service, tentative derivatives were established by R.P. Griffith and Associates, and were incorporated in the B.C. Environment spreadsheet.

All of the preceding relates specifically to the influences of water depth and velocity only. An attempt was also made to assess potential limitation, at each site, related to substrate composition and/or complexity, and availability of other cover for fish. For cover elements, other than streambed substrates, the method of quantifying individual and collective components (% of total site area) followed standard procedures outlined by deLeeuw (1981). For substrates, an estimate was made of the proportion of total site area containing suitable bed materials for salmonid fry and parr (with separate estimates for each). As a rule, suitable materials for fry (ie. cover) were deemed to range from large gravel to moderate size boulders. For parr, the general range was from large cobble to large boulders. Specific area measurements were obtained by tape.

In order to generally assess water quality in stream habitat throughout the drainage, and more specifically to enable capability modelling (Ptolemy, 1992), water samples were collected from a total of 14 locations within the Comox Lake drainage (Appendix 4). These were obtained from all streams investigated, with 5 samples addressing different sections of the Cruickshank River mainstem, and 2 samples for the Upper Puntledge River. These samples were frozen in the field, and were subsequently delivered to M.B. Research Laboratories (Sidney, B.C.) for analysis.

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[4] Ken Bovee, U.S. Fish and Wildlife Service, Fort Collins, Colorado.

[5] Poul Bech, Fisheries Section, B.C. Environment, Surrey.
Gerry Oliver, Fisheries Section, B.C. Environment, Cranbrook.
Ron Ptolemy, Fisheries Branch, B.C. Environment, Victoria.
Pat Slaney, Fisheries Research, B.C. Environment, Vancouver.
Bill Westover, Fisheries Section, B.C. Environment, Cranbrook.

4.0 RESULTS

4.1 Stream Flows and Streamlength

All of the larger streams within the Comox Lake drainage are shown in Figure 2. However, under the low flow conditions during the field investigation (Table 1), many streams (or stream sections) were found to be dry. Figure 4 shows all streams found to be flowing during the September-October field program in 1994, and identifies homogeneous stream reaches of each watercourse. Some examples of larger streams, that were dry, are illustrated in Figures 5 to 8. During the August 26 helicopter overflight of the drainage, surface flows disappeared below the streambed substrates in the uppermost Puntledge River, Rees Creek, and Kweishun Creek, at the approximate locations shown in Figure 4.

During the September-October field program, the Toma Creek channel was totally dry for approximately 1 km, commencing not far upstream of Comox Lake (Fig. 5). However, standing water was present in an adjacent flood plain area (Fig. 9), and surface flows were encountered 1.5 km further up the stream (Fig. 10), and thereafter. With two exceptions, the entire length of Perseverance Creek was found to be dry (Figs. 11 and 12). The exceptions were: 1) two isolated clay controlled pools (15 to 25 m^2) immediate downstream of the lowermost road crossing (1.2 km upstream of Comox Lake); and 2) a trickle of flow over the sandstone falls on this stream (Appendix 1), approximately 4 km upstream of Comox Lake. Small pools (20 to 30 m^2) were present both above and below these falls.

Fish sampling was conducted at both of these sites in Perseverance Creek, as well as both the standing and flowing water in Toma Creek. All flowing streams shown in Figure 8 were also sampled. For the Cruickshank River, which was flowing throughout its length, Water Survey of Canada discharge data are provided in Appendix 2. For the Puntledge River (not monitored above Comox Lake) and all other flowing streams, discharge determinations (from depth/velocity transects) were completed as part of the habitat surveys during the field program, and are provided in Appendix 5.

4.2 Access Constraints

The Cruickshank River was investigated from its mouth, to the base of its steep headwaters (ave. 15%), 2.5 km downstream of Moat Lake. Due to a major road washout, approximately 0.5 km downstream of Rees Creek, all access to the Cruickshank drainage, upstream of this point, was by ATV and hiking (Fig. 13). Fording of the Cruickshank mainstem was required at the washout, and again, just upstream. The lower Cruickshank mainstem, and the Comox Creek drainage, were accessible by road. This road is impassable beyond a bridge washout just upstream of the 30 m barrier falls on this system. Another washout, further downstream, is passable at low flows (fording, four wheel drive). Both Toma Creek and Perseverance Creek are also accessible by road, throughout most of their lengths.

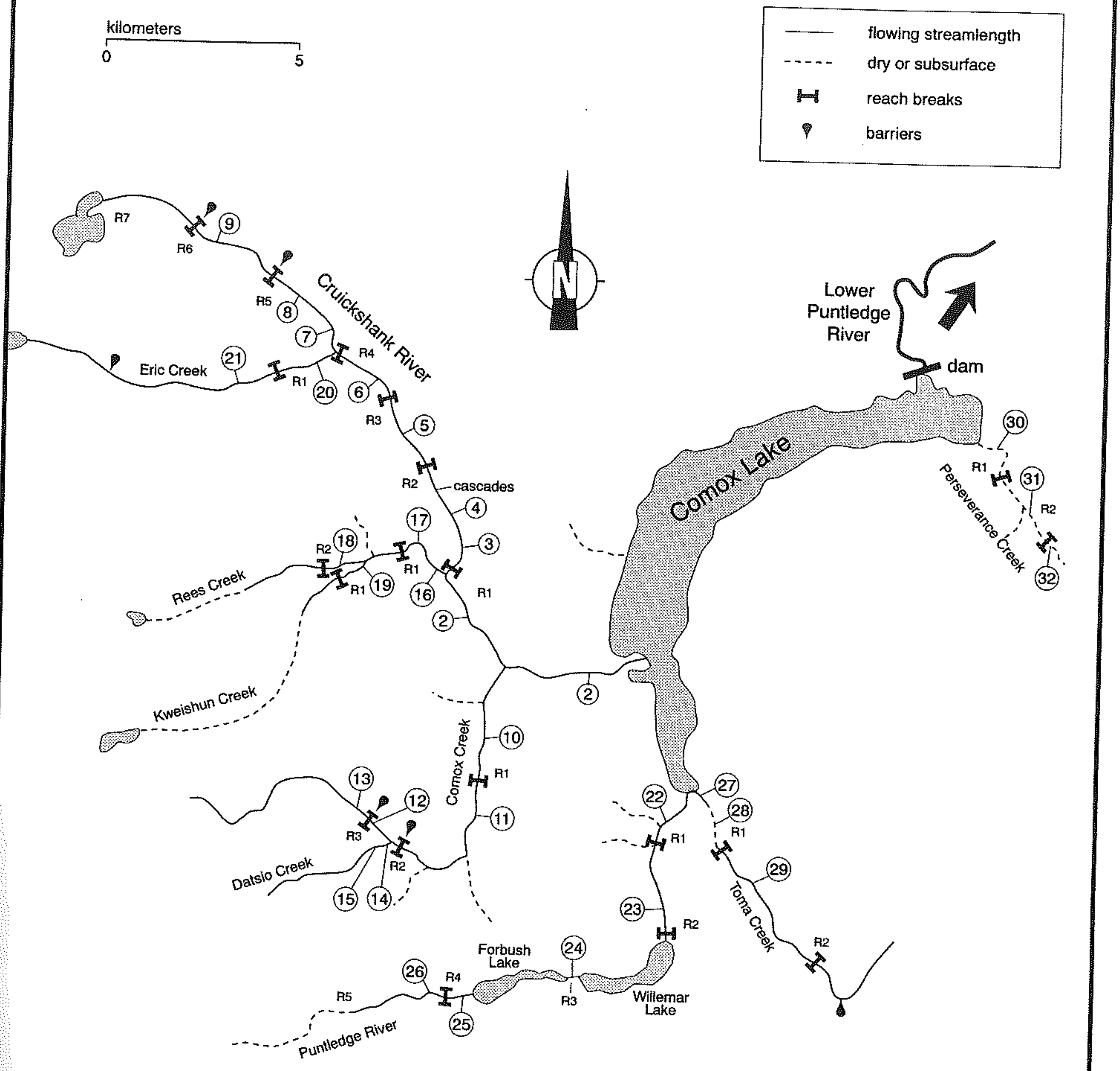

Figure 4. Location for habitat survey sites, Comox Lake drainage, September - October, 1994.

Figure 5. Beech Creek; September 1994.

Figure 6. Toma Creek, Reach 1; September 1994 (Habitat survey site 28).

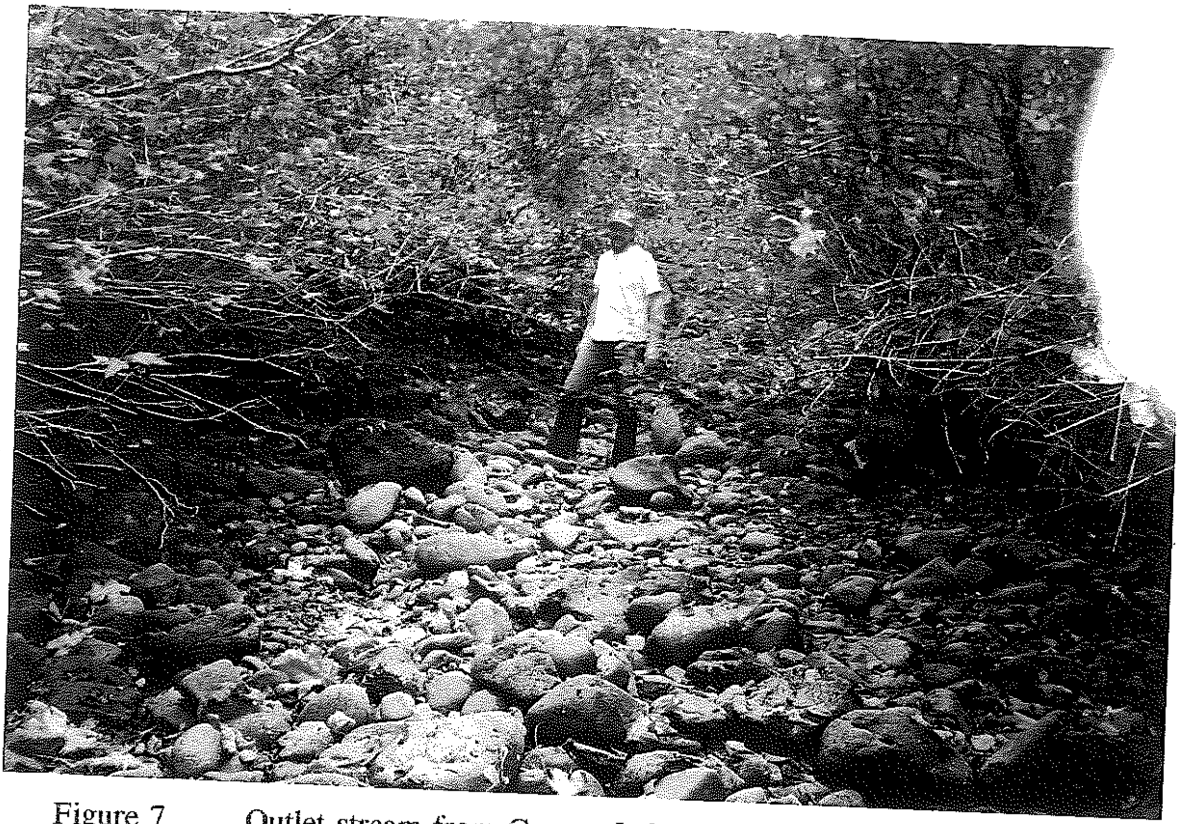

Figure 7. Outlet stream from Cougar Lake; September 1994.

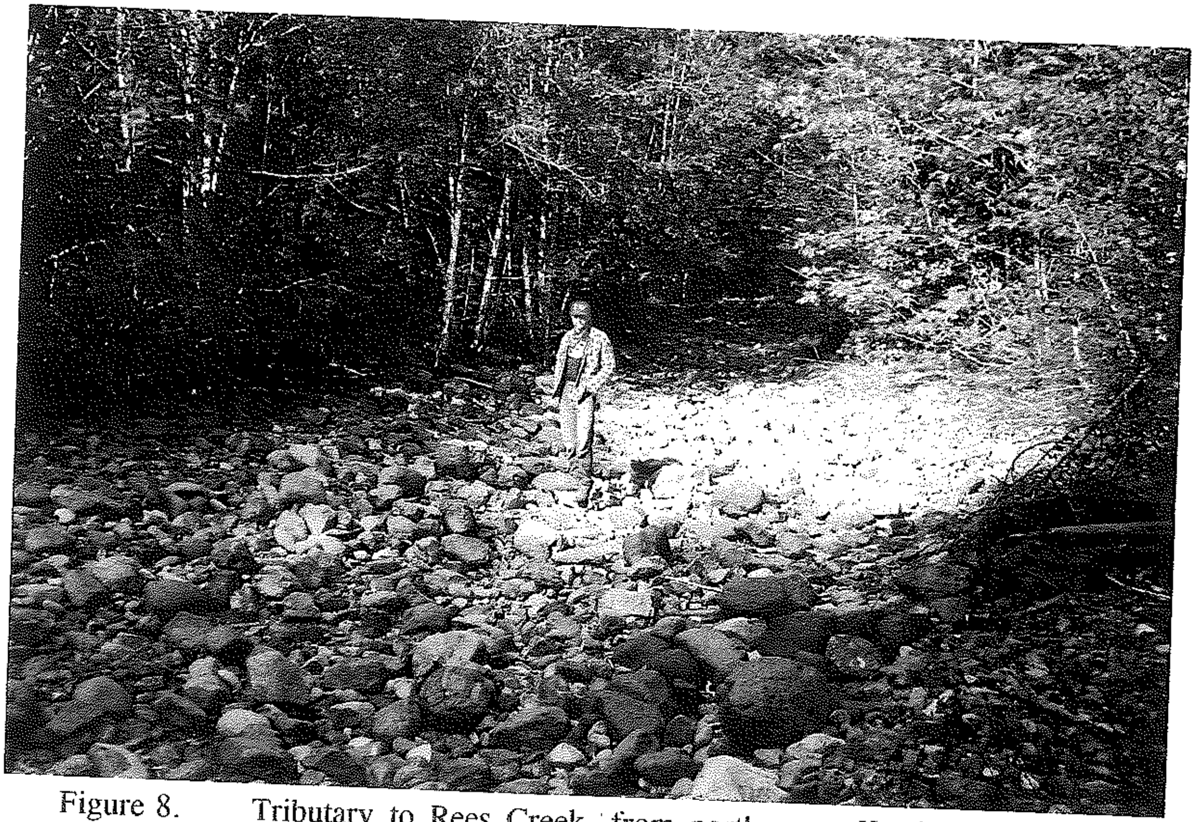

Figure 8. Tributary to Rees Creek, from north, near Kweishun Creek confluence; September 1994.

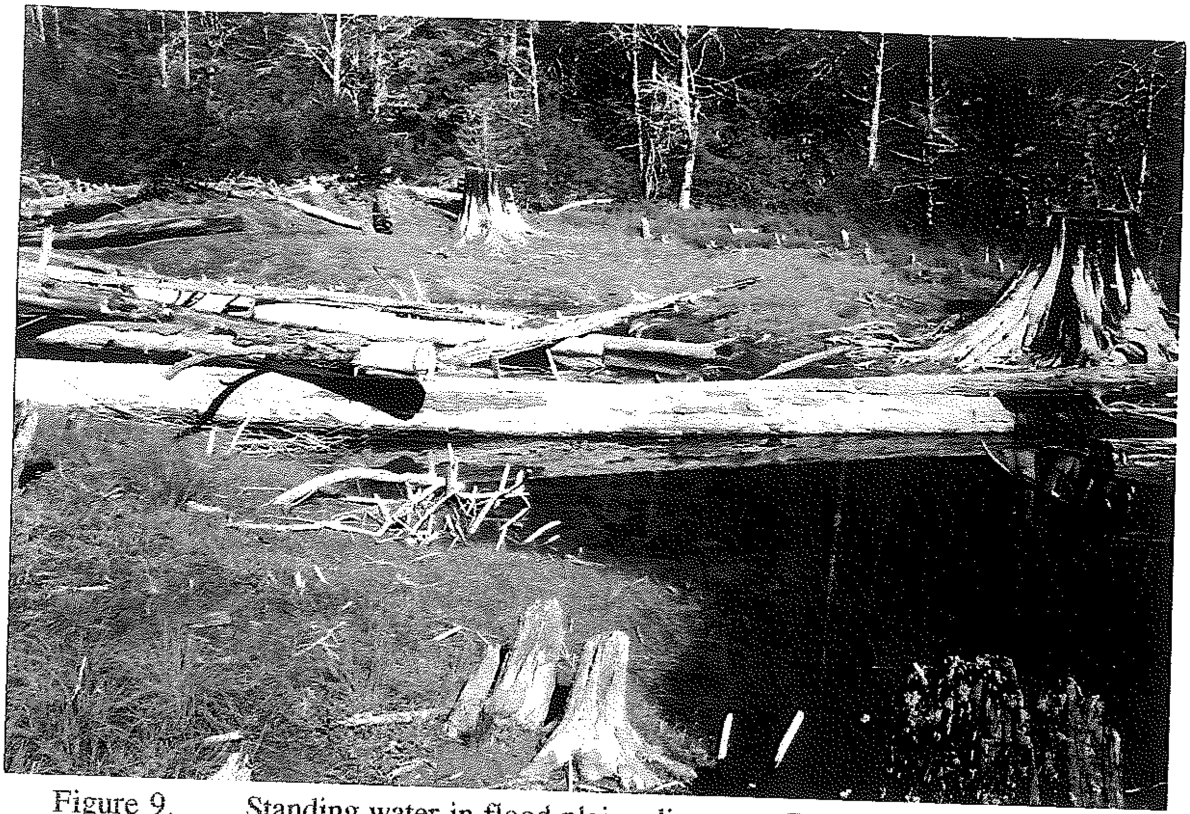

Figure 9. Standing water in flood plain adjacent to Toma Creek Reach 1; location of electrofishing site 39.

Figure 10. Toma Creek, Reach 2; habitat survey site 29, showing electrofishing site 40.

Figure 11. Perseverance Creek, Reach 1; habitat survey site 30.

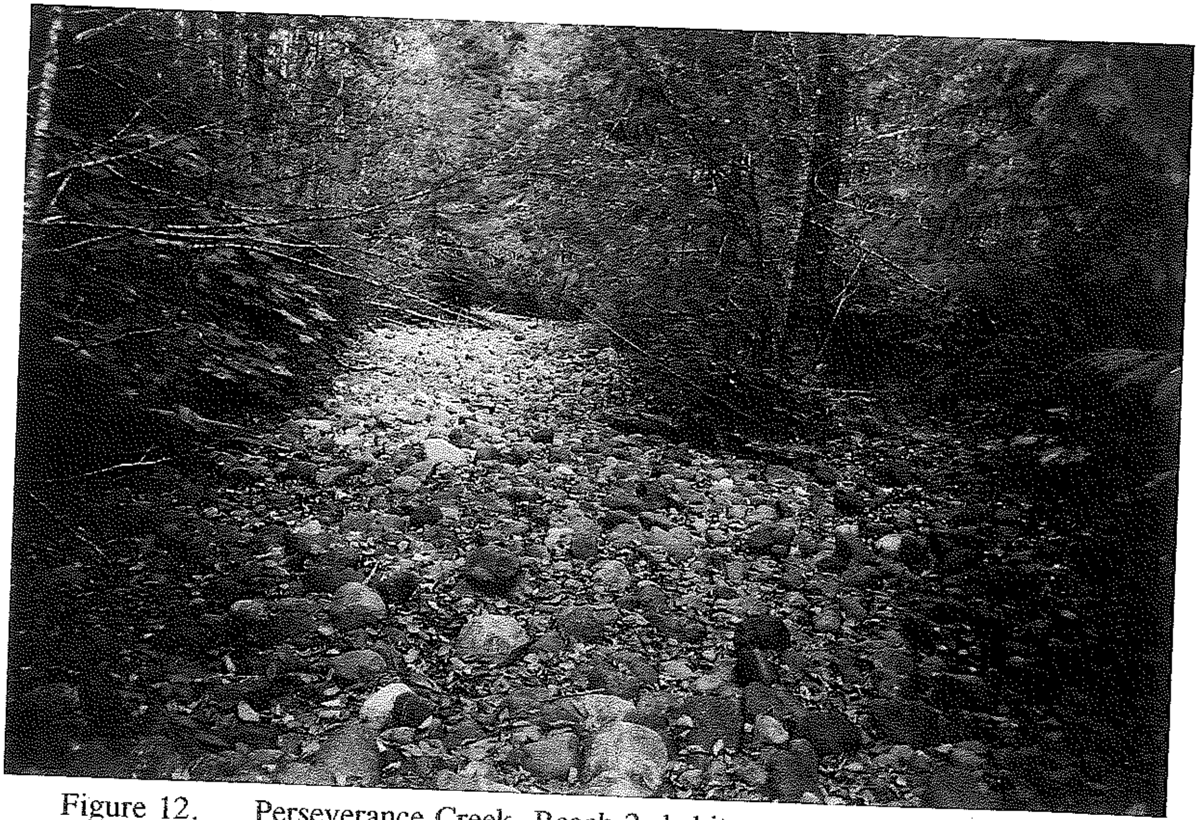

Figure 12. Perseverance Creek, Reach 2; habitat survey site 31.

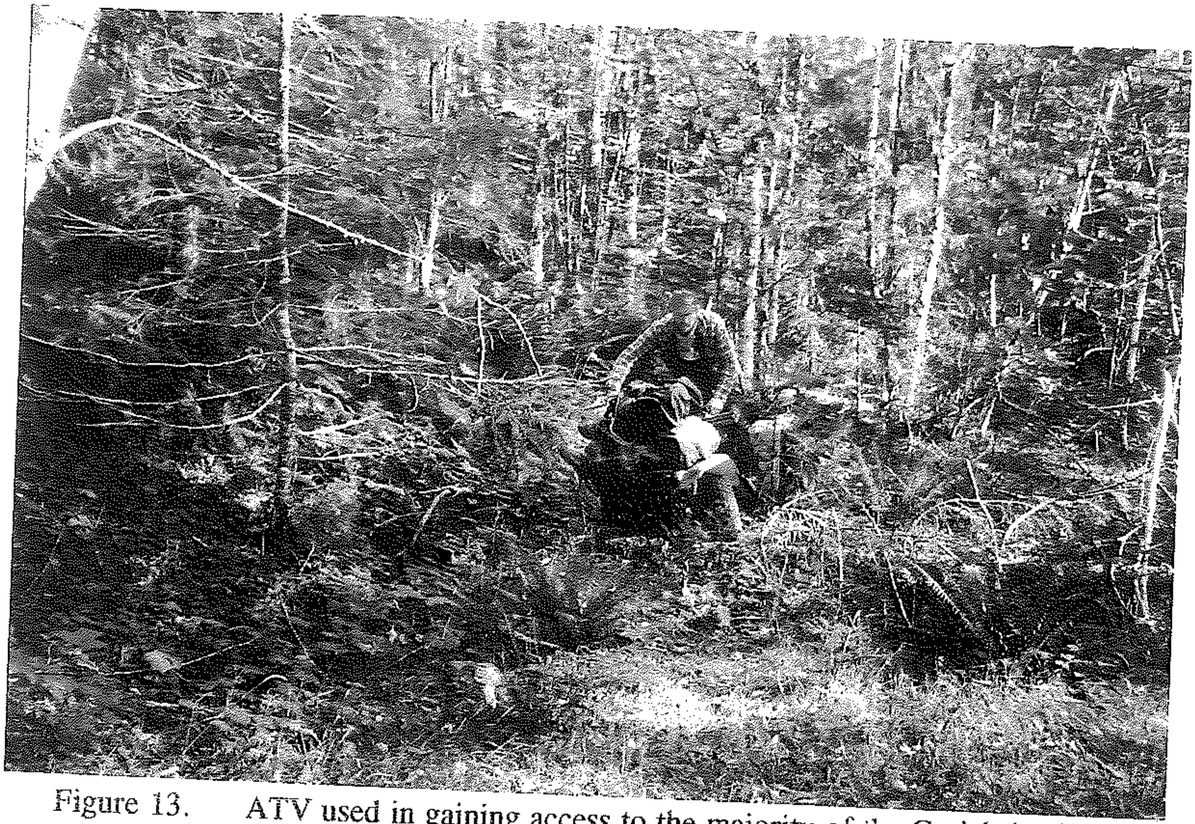

Figure 13. ATV used in gaining access to the majority of the Cruickshank River drainage.

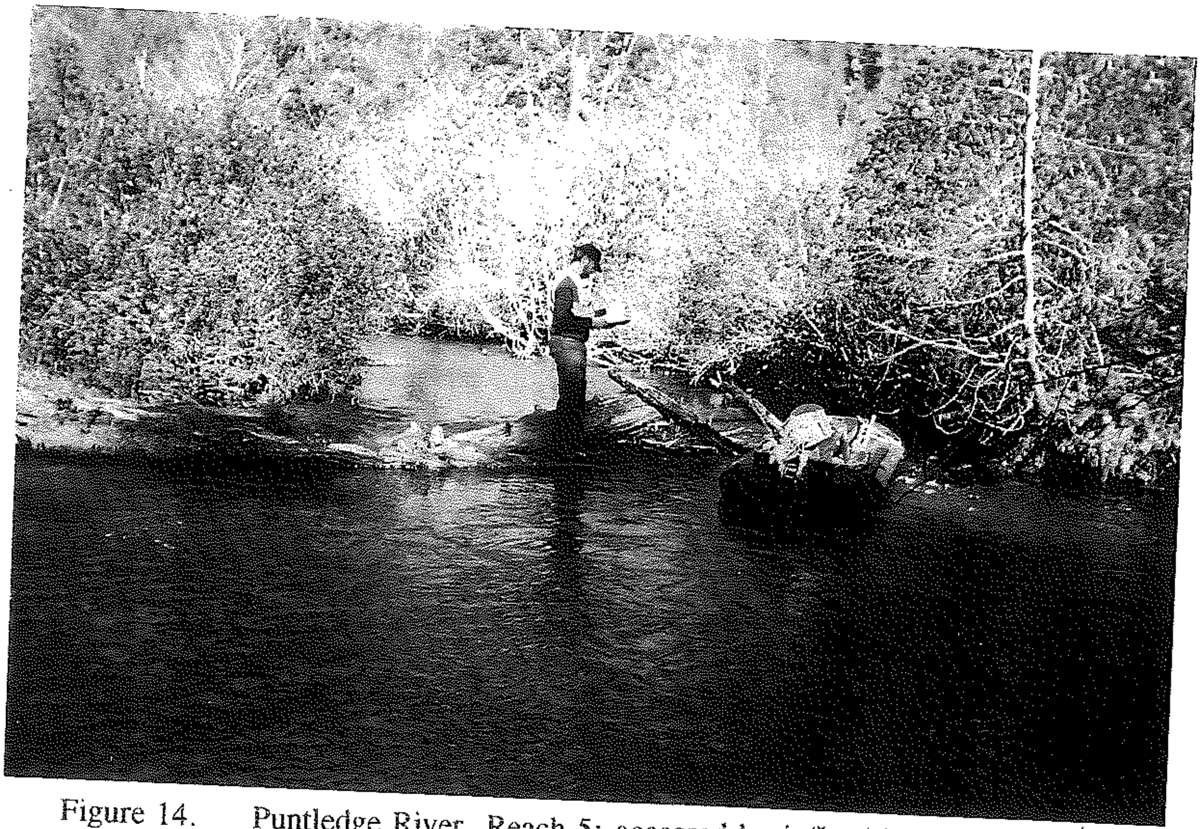

Figure 14. Puntledge River, Reach 5; accessed by inflatable boat (habitat survey site 26).

The Puntledge River is accessible by road only as far as the north end of Willemar Lake. All points further upstream were investigated by means of inflatable boat, during the 1994 field program. This was continued as far as possible upstream of Forbush Lake (Fig. 14), until further progress was precluded by lack of water depth, and increasing obstructions.

4.3 General Stream Habitat Characteristics

Detailed habitat descriptions, on a reach-specific basis, were completed at a total of 32 survey sites in the Comox Lake drainage, during the 1994 field program. The location of these sites is shown in Figure 4. Full details, and photo reference, are provided in Appendix 5. A summary of selected characteristics, for all sites, is given in Table 2.

4.3.1 Cruickshank River mainstem

The Cruickshank River is the largest tributary to Comox Lake. Collectively, all streams in this drainage represented approximately 80% of total flowing streamlength, in the Comox Lake drainage, at the time of investigation in 1994 (Fig. 4). Following the reach mapping in Rimmer *et al.* (1994), the Cruickshank mainstem was investigated on the basis of five reaches to the barrier falls, 3 km upstream of Eric Creek (Fig. 4). Reach 1 (to just upstream of Rees Creek) is relatively unconfined, with a mean gradient close to 0.5%. Hydraulic habitat is characterized by long, rather featureless glides, with periodic riffles (Fig. 15), over substrates dominated by gravels and cobbles (Table 2). In the lower half of Reach 1 (ie. downstream of Comox Creek; Fig. 4), organic debris, overhanging and/or instream vegetation, and cutbanks contribute significantly to fish cover (Fig. 15). This is not the case upstream of Comox Creek (Fig. 16). In fact, for the vast majority of the Cruickshank mainstem, below the barrier falls (ie. Reaches 1 to 5; Fig. 4), fish cover at low flows is limited almost exclusively to streambed substrates (Table 2). This is related to the general (if gradual) increase in stream gradient from Reach 1 to Reach 5 (*ibid.*), and the associated increase in boulder abundance and size, within the channel, and along the banks (Appendix 5).

In Reaches 2 to 4, with a mean gradient in the order of 2.5%, glide and riffle/rapid habitats predominate (Table 2). Pools are principally limited to small pockets at the stream margins, behind boulder accumulations (Fig. 17). In Reach 5, the stream profile becomes stepped, resulting in greater pool formation (Fig. 18), despite the higher gradient (Table 2). However, further up Reach 5, the proportion of pool habitat again declines due to the continuing increase in gradient (*ibid.*), and associated hydraulic turbulence (Fig. 19). In Reaches 3 (particularly) and 4, the channel is less confined than in Reaches 2 and 5, shallow glide and riffle/rapid habitats predominate (Fig. 20), and boulders tend to be smaller (Appendix 5). In Reach 4, there is somewhat more debris and overhanging bank cover, due to ongoing erosion (Fig. 21), but fish cover remains greatly dominated by the streambed substrates (Table 2).

Table 2. Summary of selected habitat survey results for streams tributary to Comox Lake, September–October 1994.

Stream	Site No.	Reach		Channel Width (m)	Gradient (%)	Hydraulic Habitat (%)[1]			Cover[1] (%)	Proportion of Total Cover (%)			Gravels[1] (%)
		No.	Length (km)			Pool	Glide / Run	Riffle / Rapid		Substrates[2]	Organics[3]	Cutbanks	
Cruickshank River	1	1	7	40	0.5	10	60	30	25	50	30	10	30
	2	1		30	0.8	10	50	40	30	>70	<25	5	15
	3	2	4	25	2.0	15	30	55	40	>90	<10	–	15
	4	2		20	2.5	20	30	50	50	>90	<10	–	15
	5	3	1.5	25	2.5	10	50	40	35	>90	<10	–	25
	6	4	2	20	3.0	15	40	45	40	>85	<10	5	25
	7	5	3	15	3.5	25	35	35	60	>90	<10	–	20
	8	5		10	6.0	15	35	40	65	90	10	–	10
	9	6	2.5	6	<0.5	45	50	5	15	–	70	30	60
Comox Creek	10	1	3.5	15	1.5	10	30	60	30	40	35	25	10
	11	2	4	14	2.0	10	30	60	50	>85	10	<5	15
	12	3	1	25	1.0	10	60	30	20	–	80	20	60
	13	4	–	8	4.0	5	20	75	15	25	50	25	35
Datsio Creek	14	1	0.15	8	4.5	15	25	60	30	80	15	5	25
	15	2	–	6	>10	25	30	30	50	70	20	10	20
Rees Creek	16	1	2	13	0.8	10	70	20	10	–	65	35	45
	17	1		12	0.5	30	60	10	30	–	60	40	50
	18	2	2	11	2.0	10	40	50	25	50	40	10	35
Kweishun Creek	19	1	0.75	9	2.0	15	50	35	55	60	35	5	30
Eric Creek	20	1	1.3	14	2.5	15	35	50	60	85	10	5	25
	21	2	4	18	1.5	15	45	40	40	55	15	30	25
Puntledge River	22	1	1.5	21	0.5	15	60	25	25	5	70	25	55
	23	2	2	20	0.8	15	60	25	30	25	55	20	40
	24	3	0.4	11	1.0	5	65	30	15	10	65	25	60
	25	4	0.6	10	0.5	30	60	10	35	–	85	15	70
	26	5	3.5	8	1.0	10	75	15	45	–	85	15	65
Toma Creek	27	1	1.5	8	<0.5	100	–	–	50	–	90	10	30
	28	1		8	0.5	dry	–	–	–	–	–	–	60
	29	2	4.5	10	4.0	20	40	40	50	50	30	20	25
Perseverance Creek	30	1	1.5	10	0.5	dry	–	–	–	–	–	–	45
	31	2	2.5	7	4.0	dry	–	–	–	–	–	–	20
	32	3	0.6	8	2.5	dry	–	–	–	–	–	–	15

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[1] assessed over full wetted width

[2] cover provided by boulders and other inorganic streambed materials

[3] LOD, smaller debris, overhanging vegetation and instream vegetation

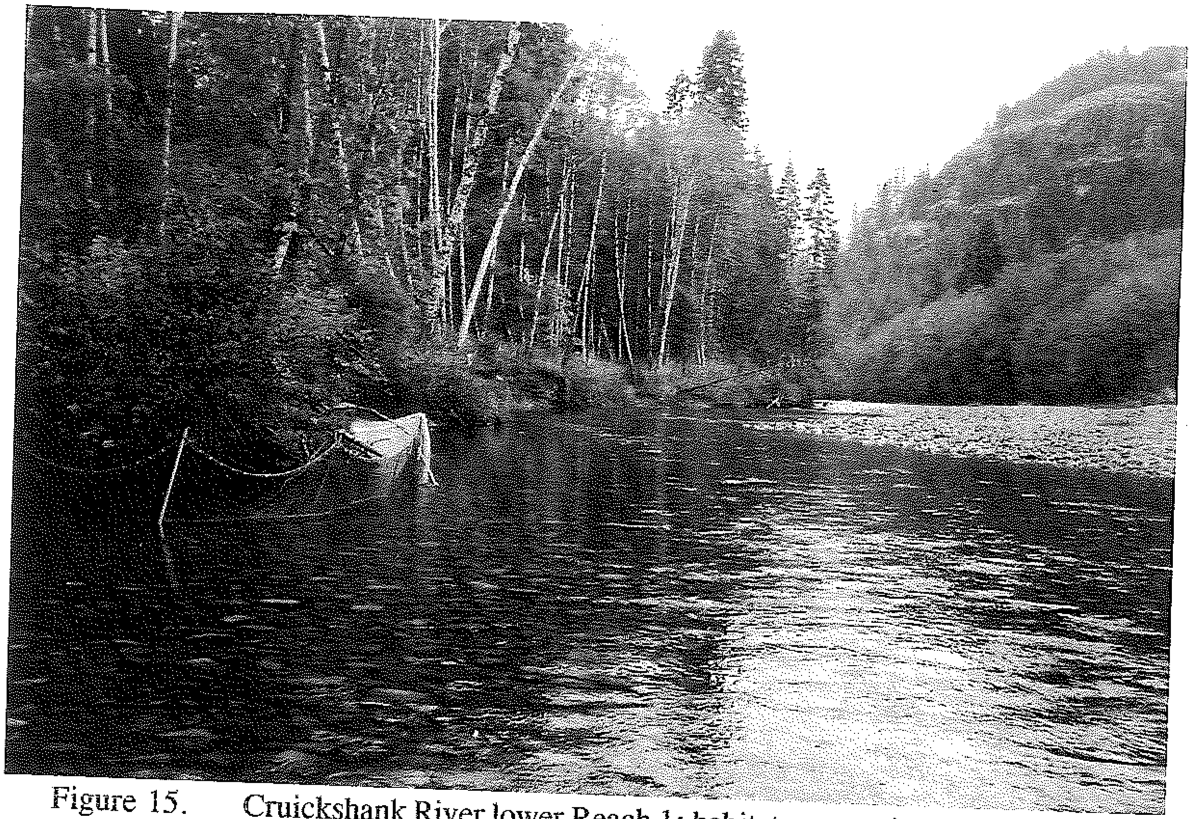

Figure 15. Cruickshank River lower Reach 1; habitat survey site 1 (showing electrofishing site 1).

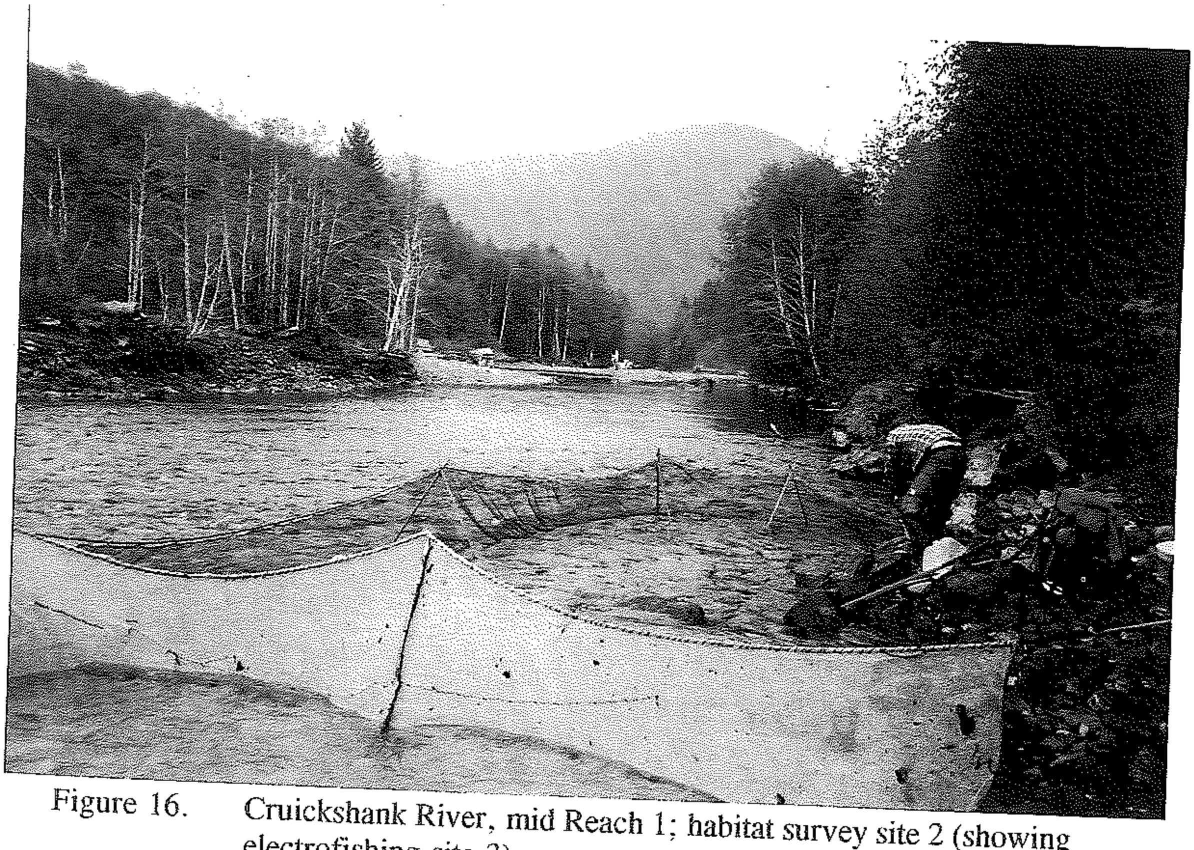

Figure 16. Cruickshank River, mid Reach 1; habitat survey site 2 (showing electrofishing site 3).

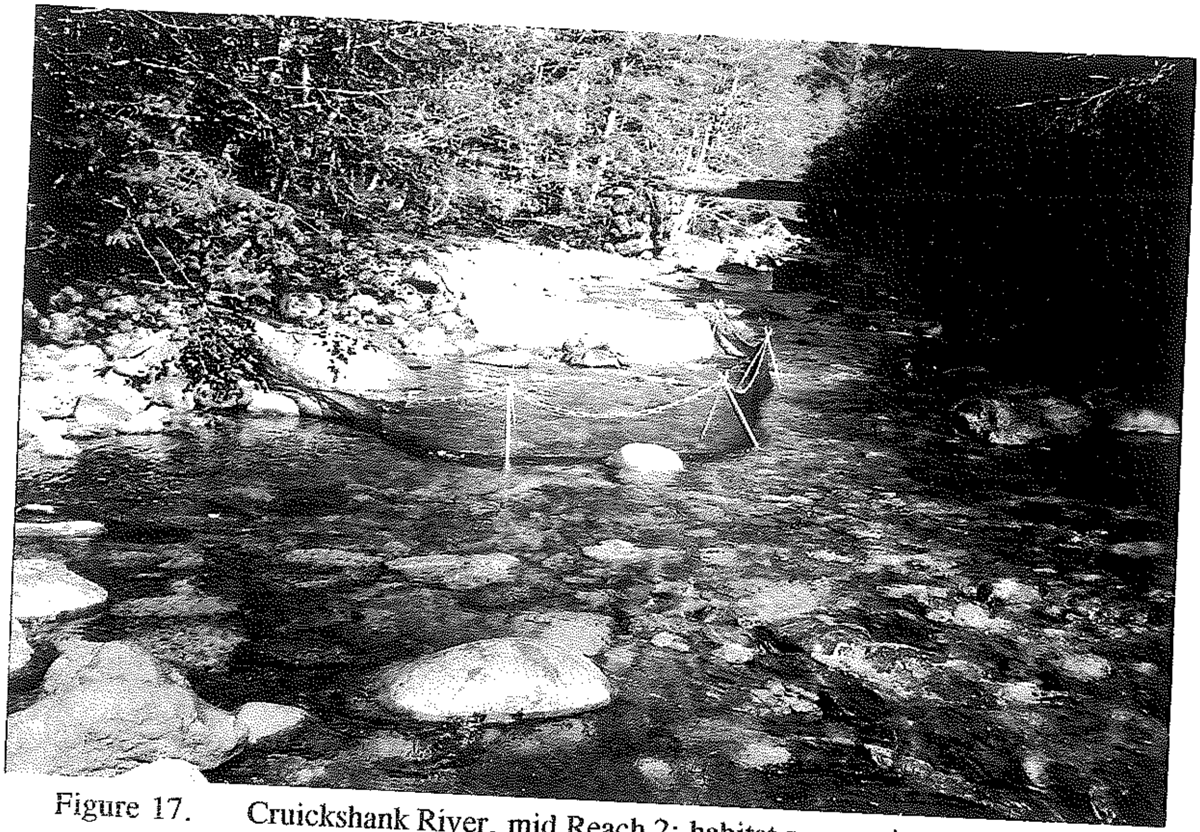

Figure 17. Cruickshank River, mid Reach 2; habitat survey site 4 (showing electrofishing site 6).

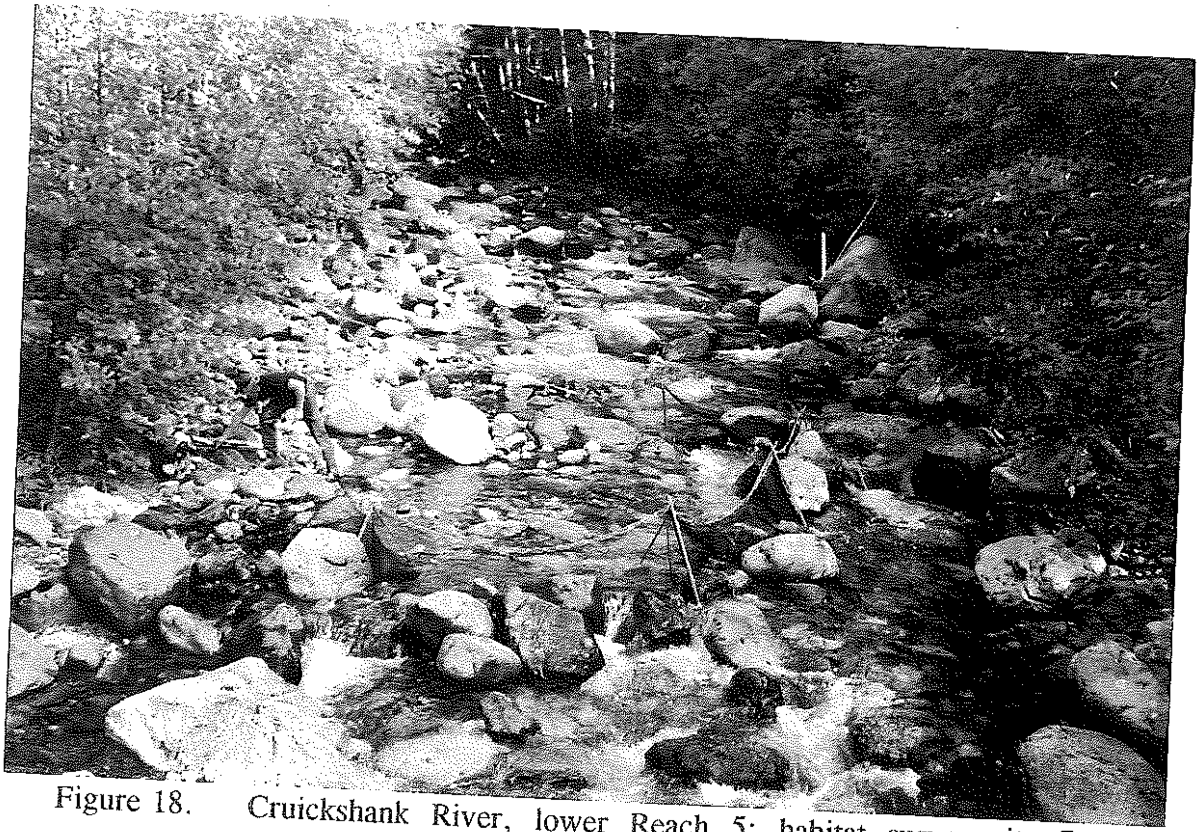

Figure 18. Cruickshank River, lower Reach 5; habitat survey site 7 (showing electrofishing site 9).

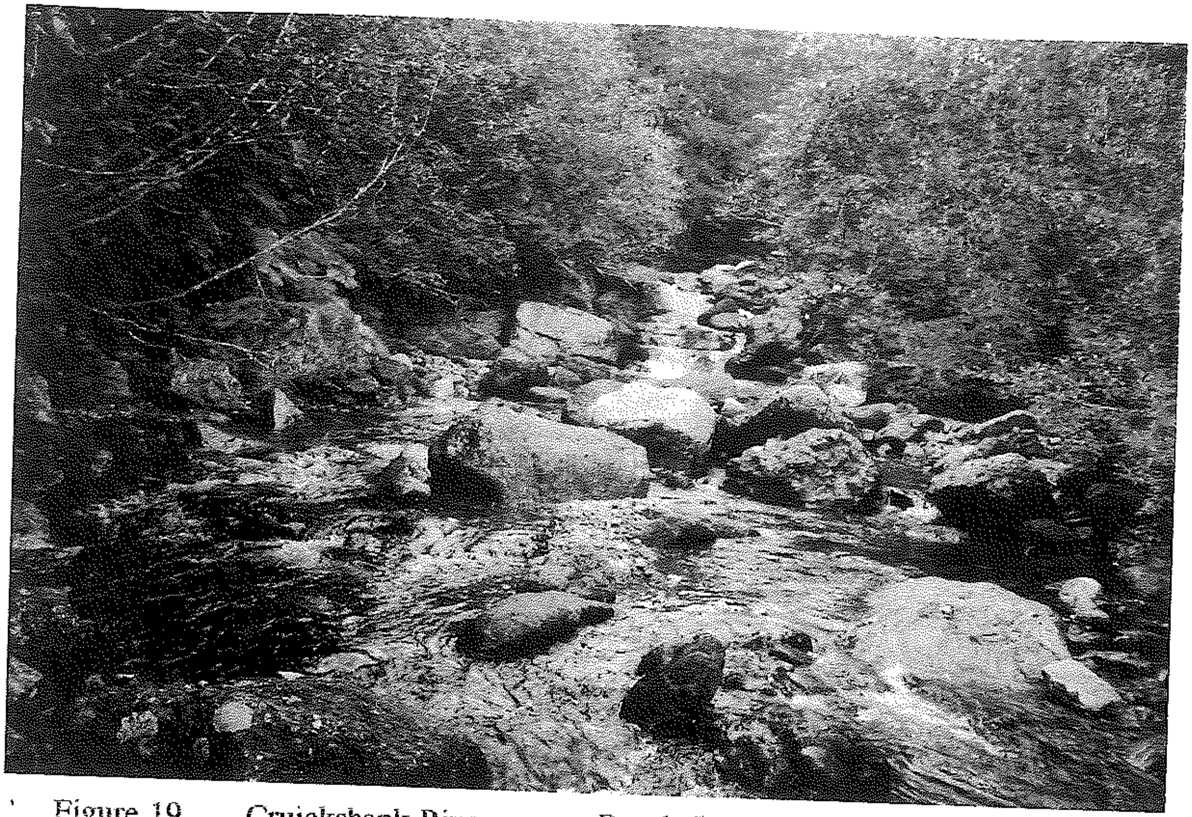

Figure 19. Cruickshank River, upper Reach 5; habitat survey site 8.

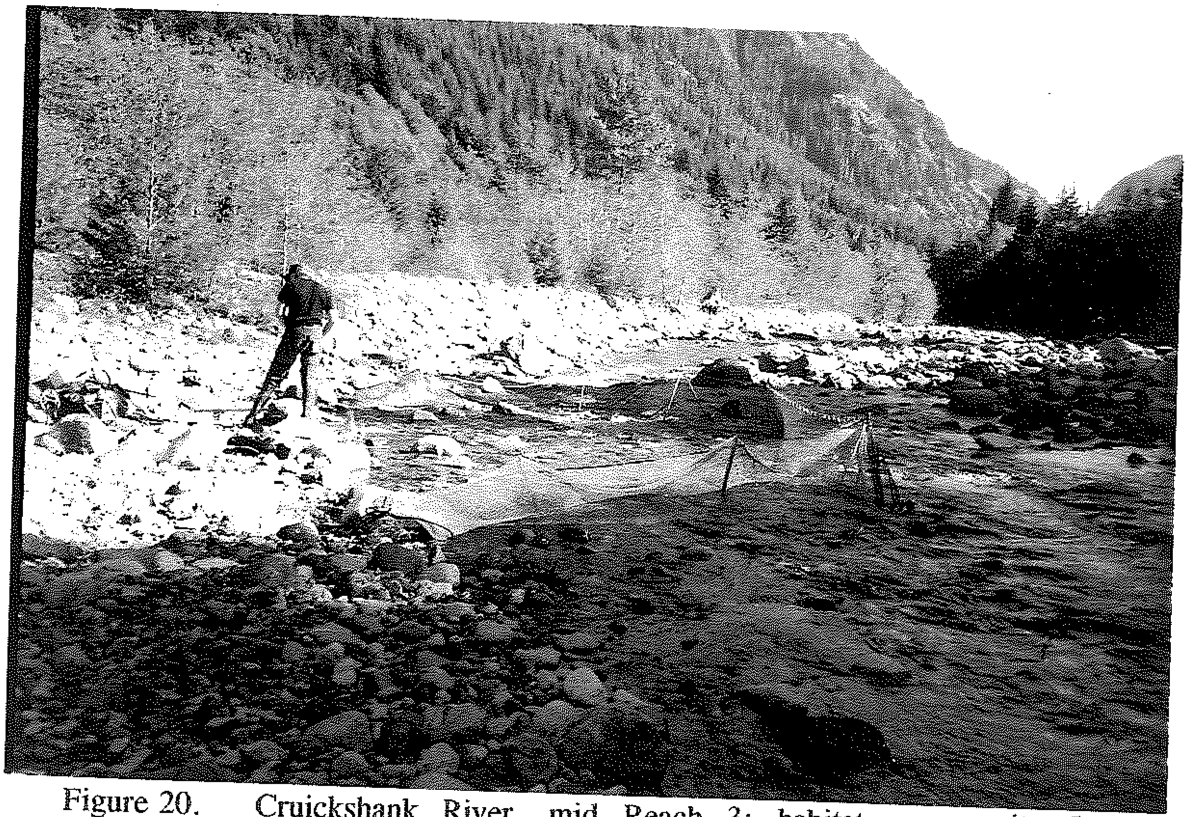

Figure 20. Cruickshank River, mid Reach 3; habitat survey site 5 (showing electrofishing site 7).

Figure 21. Cruickshank River, lower Reach 4; habitat survey site 6 (showing electrofishing site 8).

Figure 22. Cruickshank River, mid Reach 6; habitat survey site 9.

During the 1994 investigation, the uppermost 5 km of the Cruickshank mainstem, above the barrier falls, was addressed as two additional (and greatly different) reaches, near equal in length (Fig. 4). Reach 6, immediately upstream of the falls, consists of an unusual (for the system) low gradient section (< 0.5%), flowing through an extensive meadow/marsh area (Fig.22). There are numerous side channels and meanders, and hydraulic habitat is greatly dominated by sluggish glide and pool habitat (Fig. 23). Bed substrates are 90% fines and gravels (Appendix 5), and offer little cover for fish. Most cover is in the form of cutbanks, vegetation and occasional debris, none of which is greatly abundant or very complex (Fig. 23). Reach 7 is the first 2.5 km of the Cruickshank mainstem, below the outlet of Moat Lake. As noted earlier, it averages 15% gradient, and it arises abruptly from the meadow area containing Reach 6. Some sections of Reach 7 are extremely steep and, as observed from the air (Fig. 24), there are numerous vertical falls, perhaps in the order of 5 m or more.

With respect to gravels (spawning substrates) in the Cruickshank mainstem, abundance and composition fluctuates from reach to reach (Table 2). The greatest concentration is in Reach 6 (60%; Table 2), above the barrier falls. Downstream of the falls, gravels are most abundant in lower Reach 1 (30%). However, gravels are also abundant (25%) in Reaches 3 and 4, and generally, spawning habitat does not appear to be limiting anywhere in the Cruickshank River mainstem as observed at low flows (ie. fall spawning species). However, conditions (and opportunities) may be quite different for spring spawning species, at greatly higher flows (Fig. 3). In addition, gravels appear to contain a large amount of fines throughout the mainstem, and compaction varies from moderate to high in the five reaches downstream of the barrier falls (Appendix 5).

4.3.2 Comox Creek system

In the first two reaches (7.5 km) of Comox Creek, below the first set of falls (Fig. 2), hydraulic habitat is generally dominated by riffle/rapid and glide over boulder/cobble substrates. Mean gradient ranges from approximately 1.5% at the bottom to 4% at the top, averaging 2% to 2.5%, overall. In Reach 1 (Fig. 25), bed substrates are somewhat smaller, and overhanging vegetation and cutbanks more greatly contribute to total fish cover (Table 2). In Reach 2 (Fig. 26), gradient increases, boulders are larger, and streambed substrates represent the great majority of available cover (Table 2). Gravels are somewhat more abundant, as well (*ibid.*).

The section of Comox Creek designated as Reach 3 consists of the 1 km (approx.) of streamlength between the first (3.1 m) and second (30 m) falls on the system (Fig. 2). The key interest here is the unconfined upper portion of this reach, immediately downstream of the second falls. Much like Reach 6 (the meadow area) in the Cruickshank mainstem, this portion of Comox Creek (Fig. 27) is dominated by glide habitat over extensive gravel beds (Table 2). Cover is limited across the channel, due to the dominance of gravels, but there is some very complex bank habitat, associated with channel instability and flooding. In Reach 4, upstream of the second falls (barrier), the channel again becomes more confined, considerably steeper, and habitat is almost entirely riffle and glide, swift flowing and rather laminar (Table 2). Cover for fish is again limited by the small size of bed materials, coupled with the high water

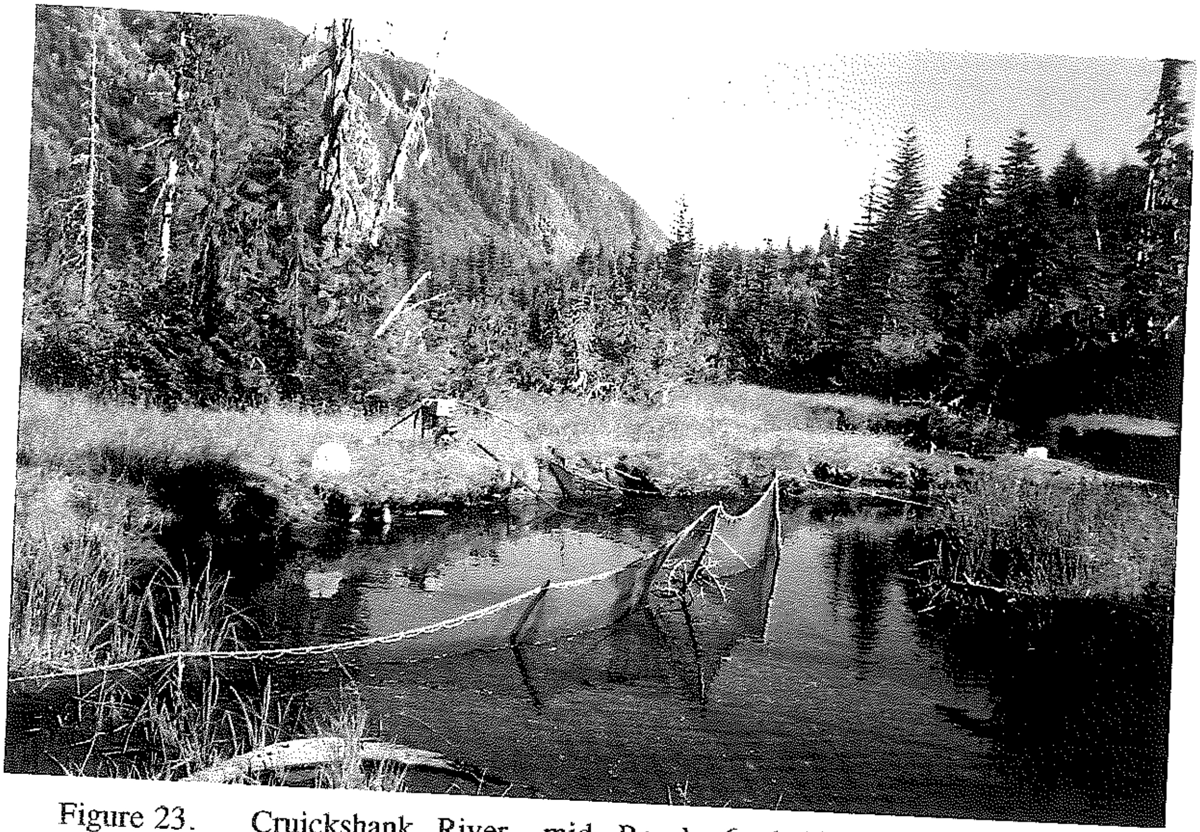

Figure 23. Cruickshank River, mid Reach 6; habitat survey site 9 (showing electrofishing site 12).

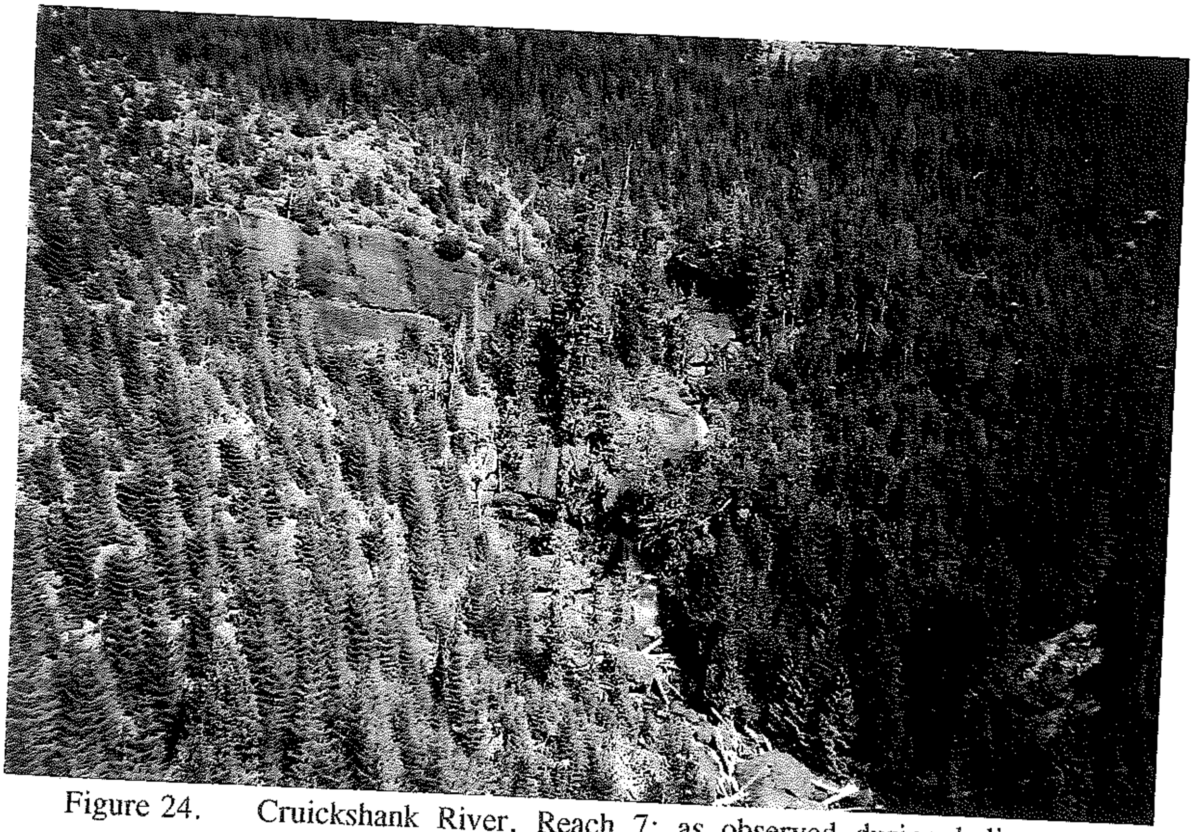

Figure 24. Cruickshank River, Reach 7; as observed during helicopter overflight on August 26, 1994.

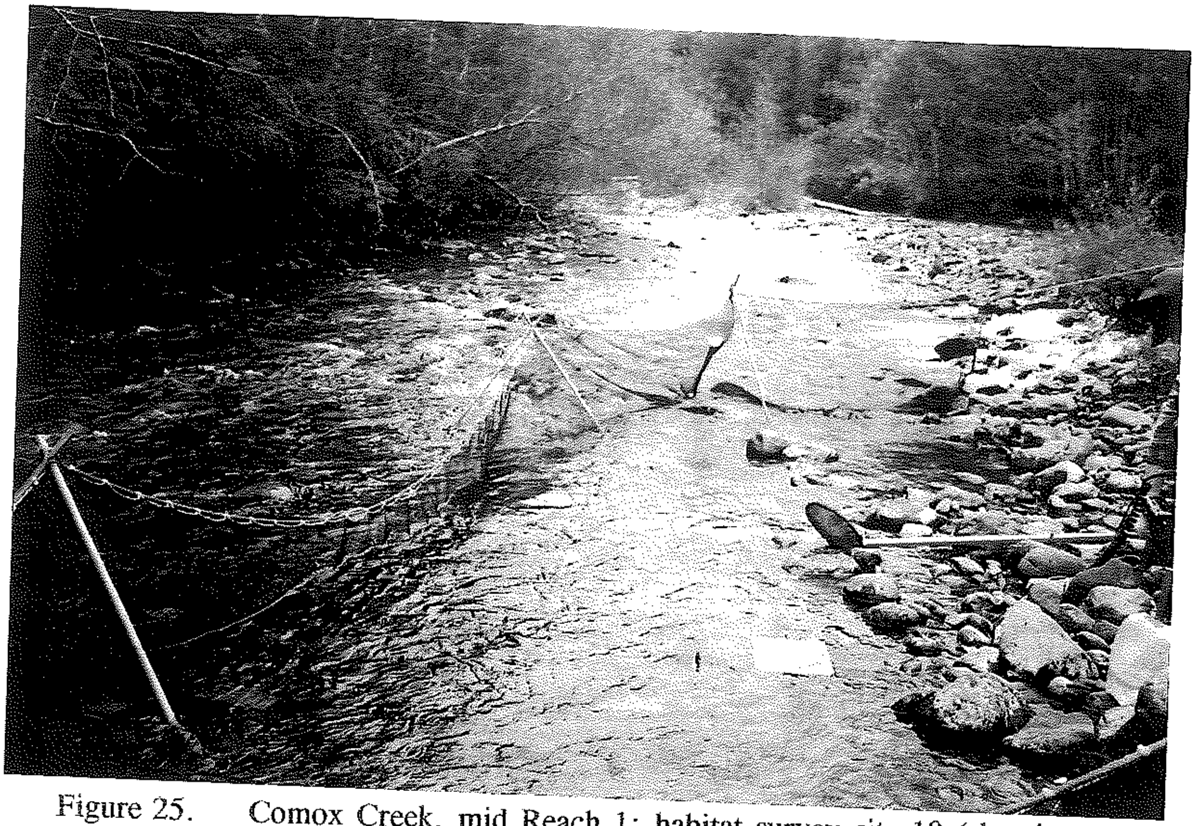

Figure 25. Comox Creek, mid Reach 1; habitat survey site 10 (showing electrofishing site 14).

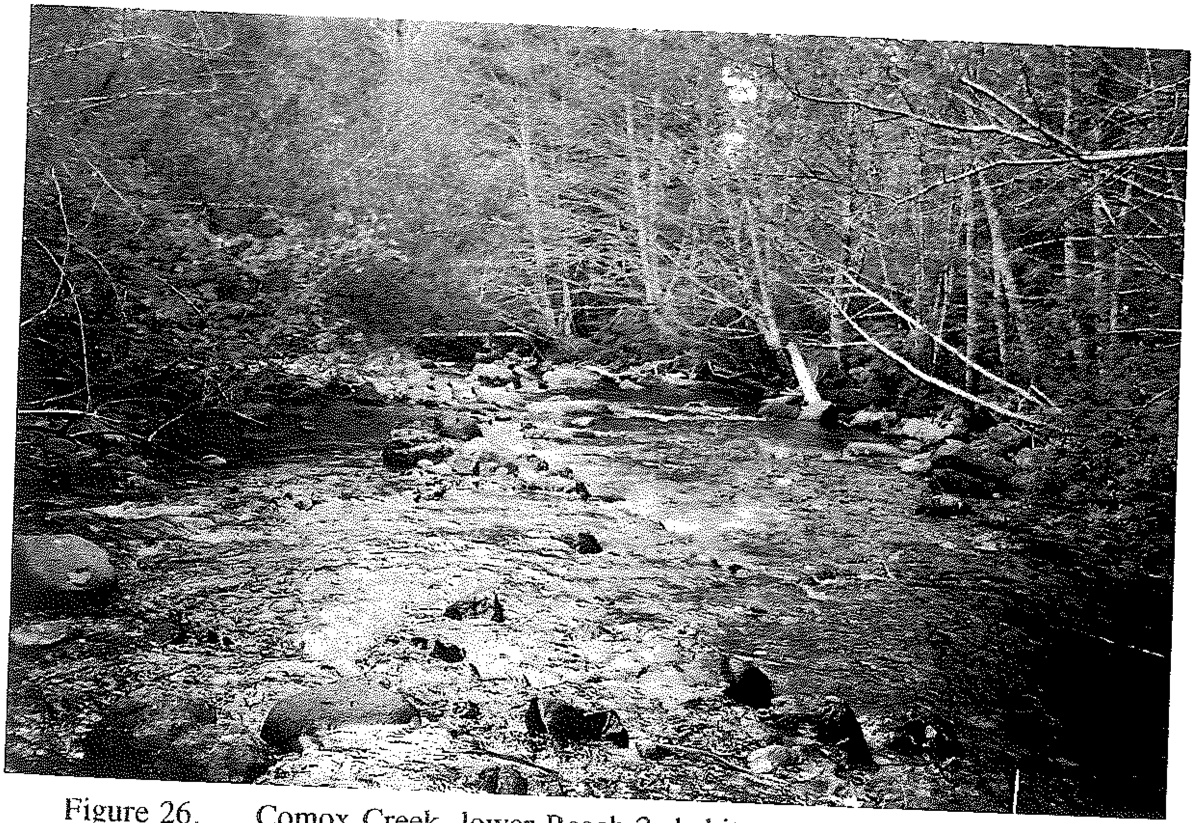

Figure 26. Comox Creek, lower Reach 2; habitat survey site 11.

Figure 27. Comox Creek, upper Reach 3; habitat survey site 12.

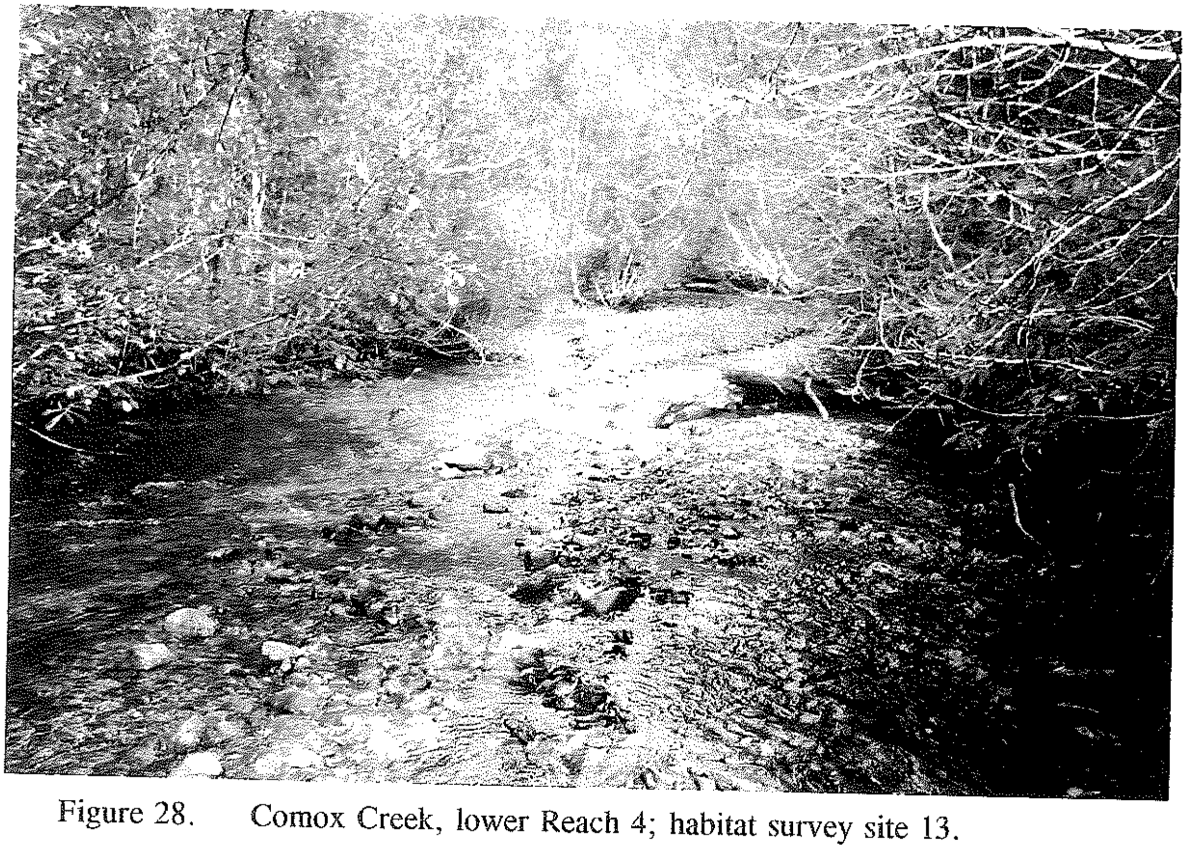

Figure 28. Comox Creek, lower Reach 4; habitat survey site 13.

velocities (Fig. 28). Overhanging vegetation and cutbanks are major contributors to available cover (Table 2), but the effect of these elements is also limited, due to the swift flows.

Datsio Creek was the only tributary to Comox Creek found to be flowing at the time of inspection. In the first short (150 m) reach of this stream, gradient averages approximately 4.5%, and habitat is again dominated by riffle and glide over relatively small bed substrates (Fig. 29). Gravels are moderately abundant, and cover is diverse for fry and smaller parr, but the low abundance and small size of boulders, coupled with shallow water depths (Appendix 5), limit the potential for larger fish. The second reach of Datsio Creek rises abruptly from the end of the first. It develops a stepped profile, with considerably larger boulders, and is far more complex than Reach 1 (Fig. 30). Gradient is in excess of 10% near the bottom of Reach 2, and appears to progressively increase upstream (to > 40%).

4.3.3 Rees Creek system

The first reach of Rees Creek is comparable to the lower section of Reach 1 of the Cruickshank River mainstem. Gradient is low (ave. 0.5 to 1%), hydraulic habitat is predominantly glide, over small bed substrates (Table 2), and particularly near the bottom of the reach, habitat lacks complexity (Fig. 31). Further upstream, however, complex bank habitat (cutbanks, vegetation, debris) becomes moderately abundant (Fig. 32), and there are numerous side channels (dry at time of investigation) and flooded backwaters. In Reach 2, gradient increases (ave. 2.5%+), and habitat becomes more similar to that in Comox Creek (Fig. 33). Gravels are abundant, but cover for fish is somewhat limited by the relatively small size of the streambed substrates (Table 2). As observed during the August 26 helicopter overflight, diminishing flows persisted in Rees Creek for approximately 3.5 km upstream of Kweishun Creek, at which point they disappeared within the bed substrates. This was approximately 1.5 km downstream of the steep (ave. > 25%) headwater section of the Rees Creek mainstem (Fig. 2).

Kweishun Creek was the only tributary to Rees Creek found to be flowing during the 1994 field program; and as observed by helicopter on August 26, surface flows in this stream disappeared within the bed substrates approximately 2.5 km upstream of Rees Creek (Fig. 4). Mean gradient in the flowing section of Kweishun Creek ranges from 2% at the bottom to 8% at the top. Based on topographic mapping, the lowermost 750 m was designated Reach 1, with a mean gradient of 2 to 2.5%. In this reach, hydraulic habitat is again dominated by riffle and glide, over bouldery/cobbly substrates (Fig. 34). Bed materials are relatively large (Appendix 5), resulting in greater cover availability for fish (Table 2). Gravels suitable for spawning are also moderately abundant, and occur in frequent patches. In both Rees and Kweishun creeks, gravels tend to be somewhat less compacted, compared to other portions of the Cruickshank River drainage (Appendix 5).

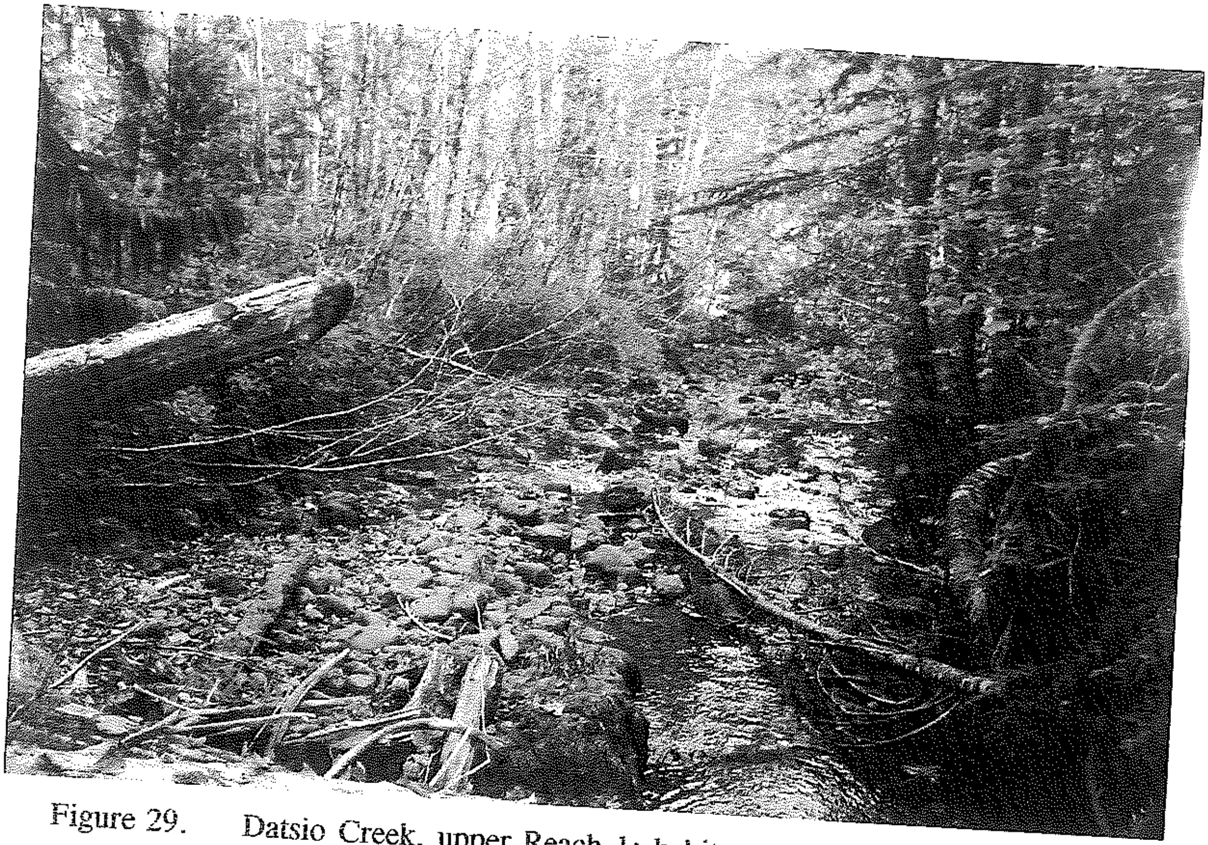

Figure 29. Datsio Creek, upper Reach 1; habitat survey site 14 (showing location of electrofishing site 18).

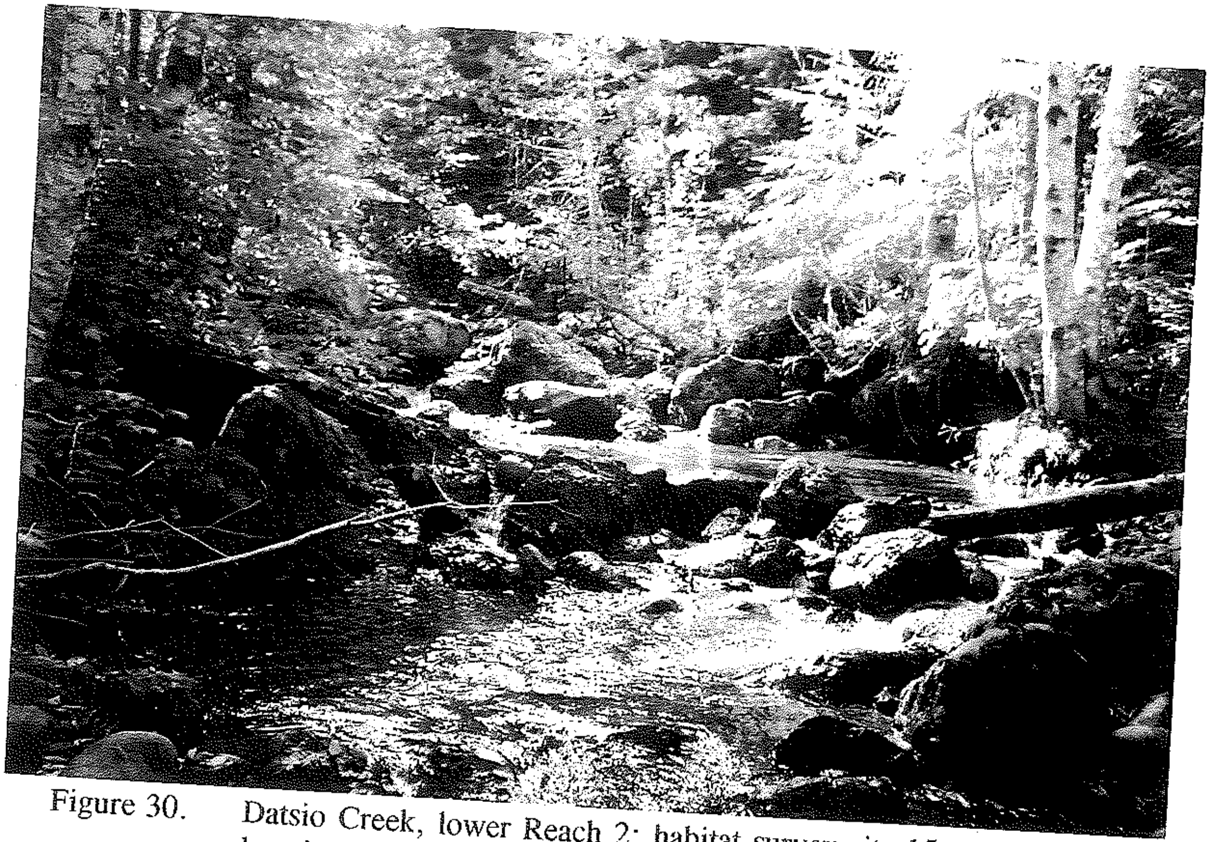

Figure 30. Datsio Creek, lower Reach 2; habitat survey site 15 (showing location of electrofishing site 19).

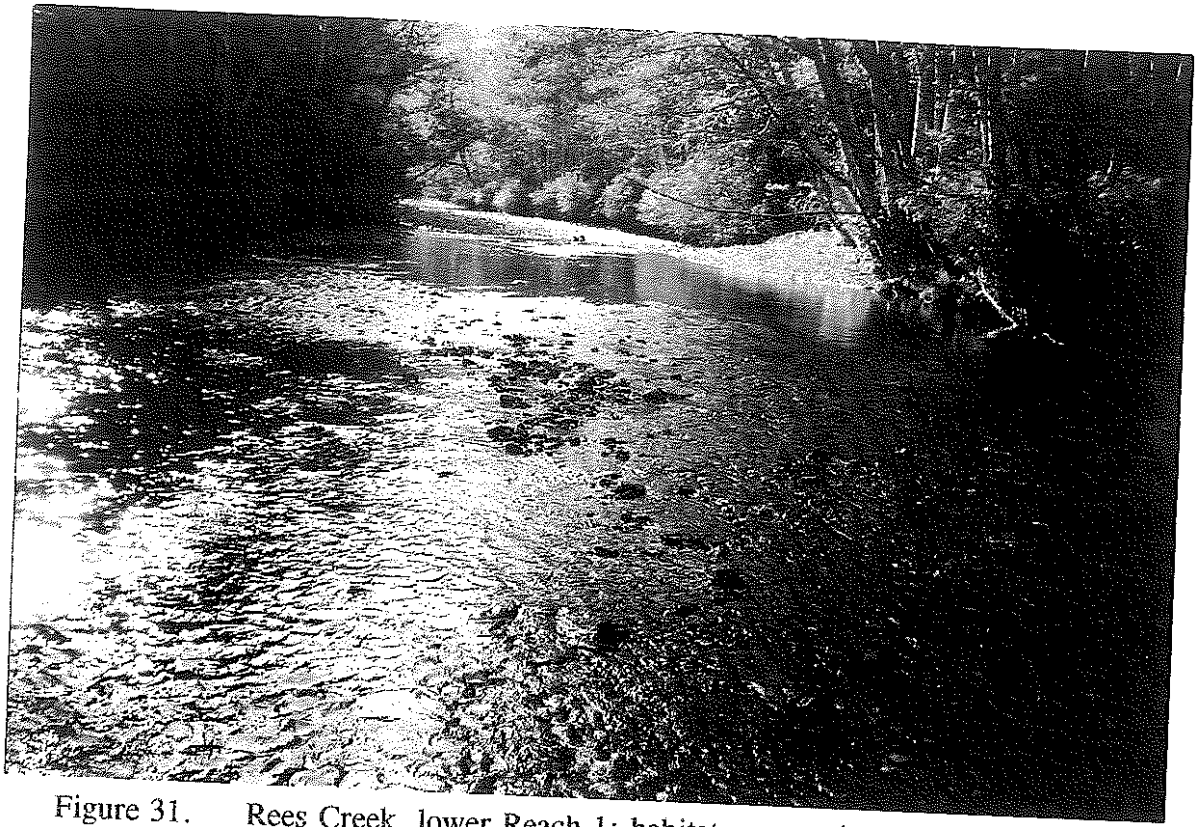

Figure 31. Rees Creek, lower Reach 1; habitat survey site 16.

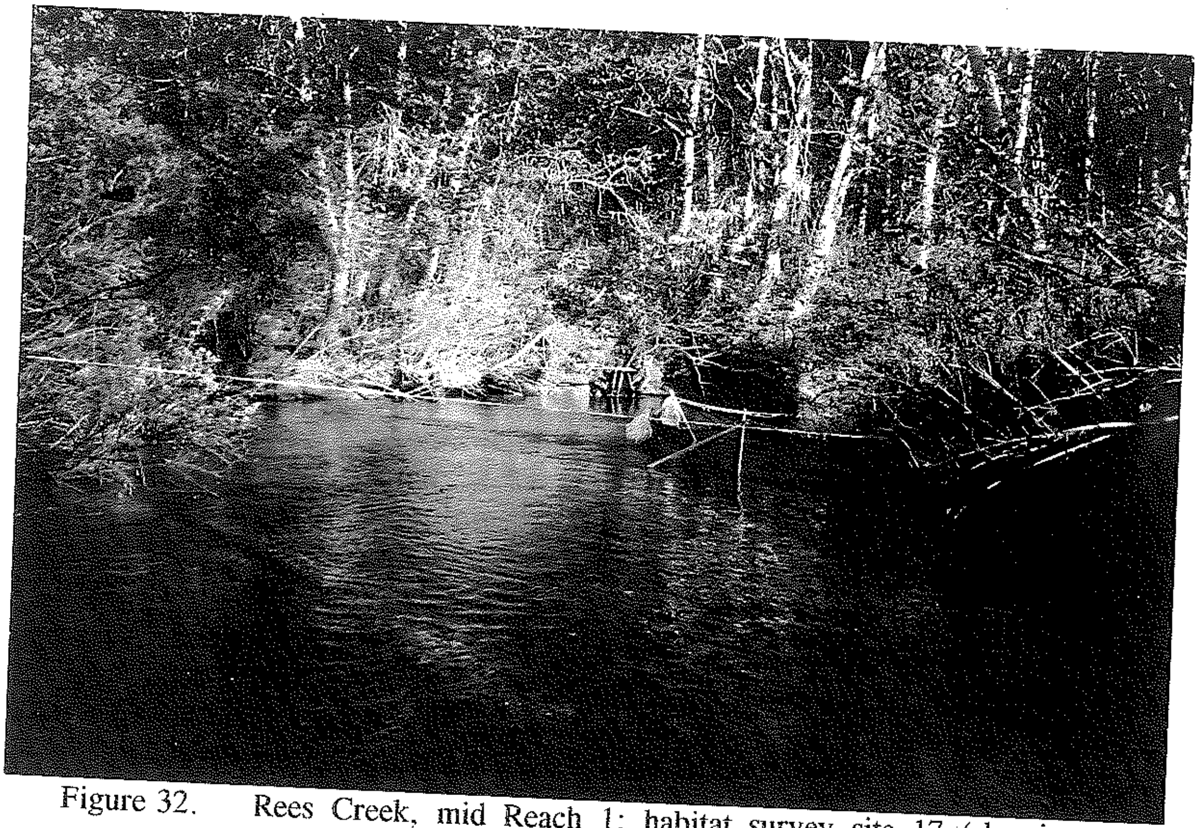

Figure 32. Rees Creek, mid Reach 1; habitat survey site 17 (showing electrofishing site 20).

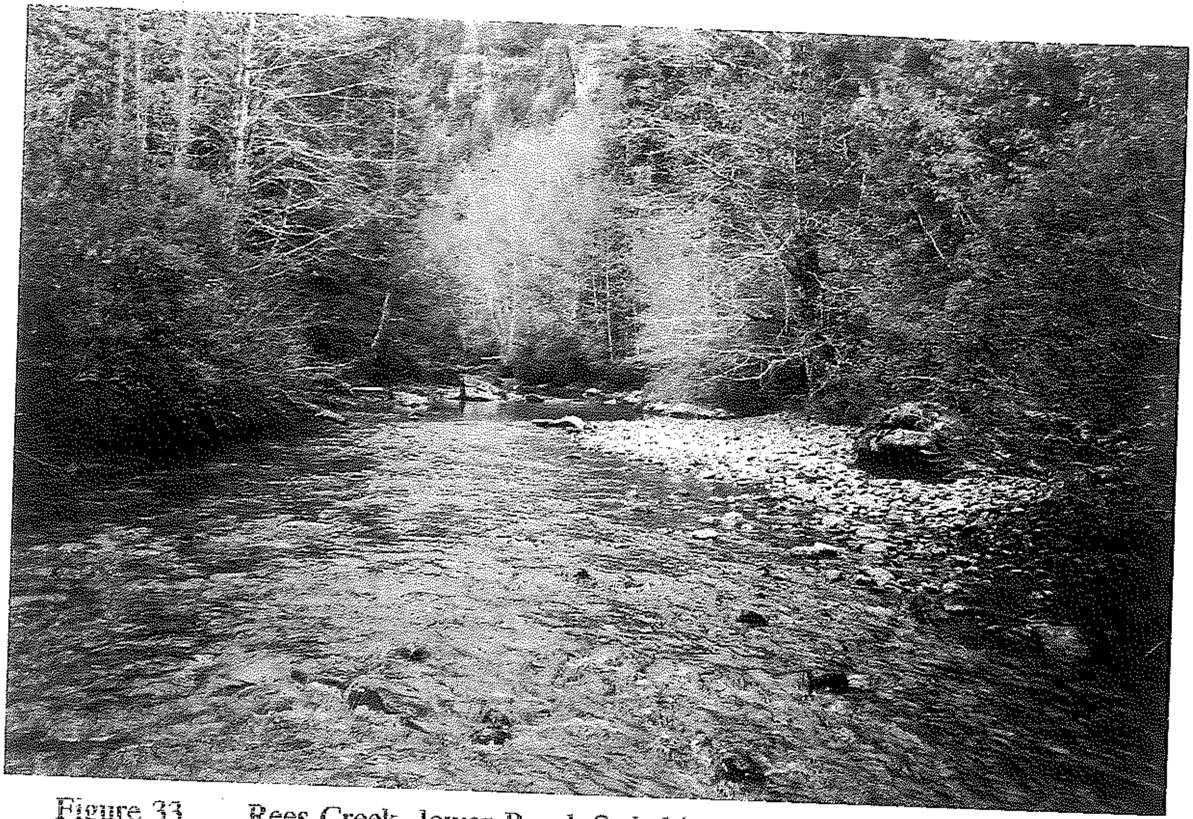

Figure 33. Rees Creek, lower Reach 2; habitat survey site 18.

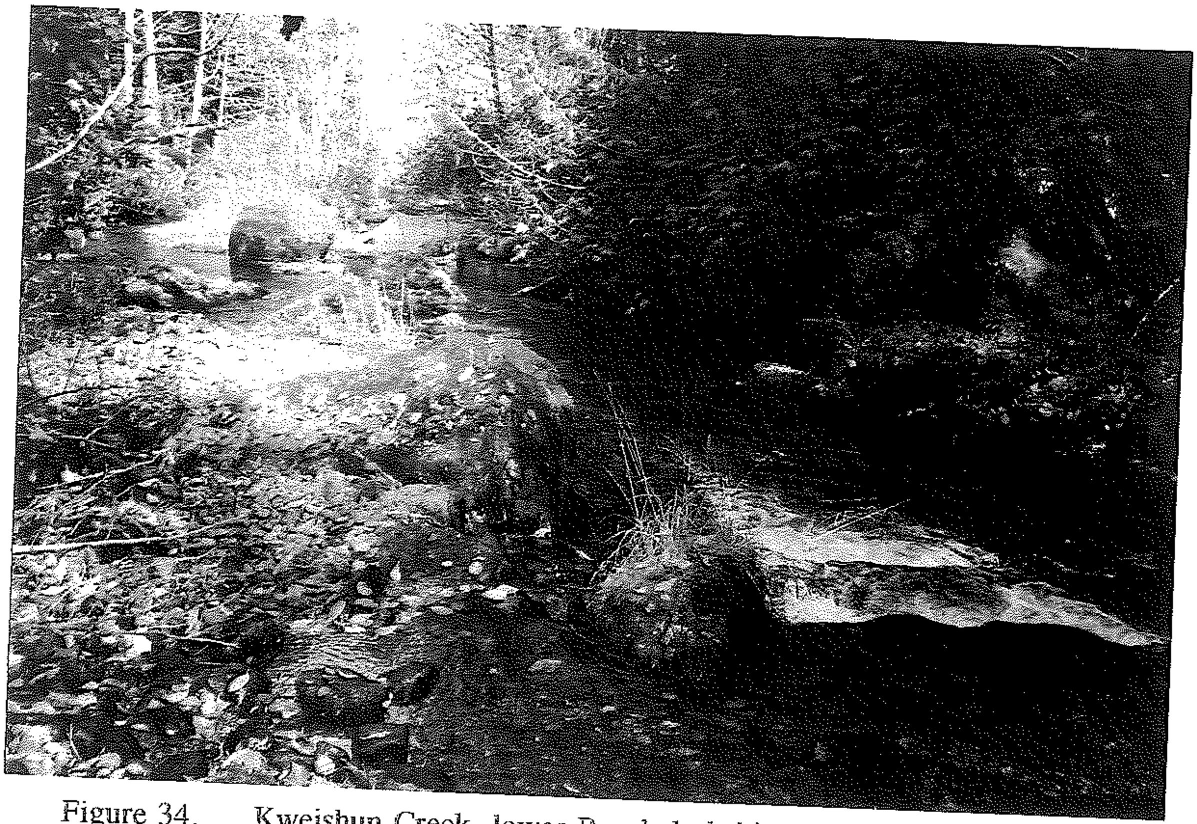

Figure 34. Kweishun Creek, lower Reach 1; habitat survey site 19.

4.3.4 Eric Creek system

The mean gradient over the lowermost 6 km of Eric Creek is approximately 2.5%. At 6 km, the gradient increases abruptly (> 10%), and continues to do so (ave. > 30%), over the remaining 2.5 km to Faith Lake. Unlike Rees and Kweishun Creeks, surface flows were present in Eric Creek, throughout its length, during the helicopter overflight of the system on August 26, 1994. However, due to the rapid increase in gradient, it is only the lowermost 6 to 6.5 km that is of value, in terms of migratory fish production.

The first reach of this system (Fig. 35) is 1.3 km in length, and contains habitat very similar to that in Reach 2 of Comox Creek (Fig. 26). Again, habitat is dominated by riffle and glide, over bouldery/cobbly bed materials, which represent the great majority of cover for fish. Other cover is limited to overhanging vegetation, and the occasional shallow cutbank (Table 2). Conditions are quite different in Reach 2 (Fig. 36), which represents the majority of the usable length (approx. 4 km). In this reach, there is less riffle, and a higher proportion of glide habitat. Substrates are smaller (Appendix 5), and provide less cover for fish. The frequency and proportion of cutbanks (in particular), overhanging vegetation, and debris cover is higher in Reach 2 than it is in Reach 1, but total cover is substantially lower (Table 2), principally due to the smaller (and less complex) bed materials.

Within the main channel of Eric Creek, gravel is moderately abundant, and proportions are similar in Reaches 1 and 2 (Table 2). However, some substantial bars occur within the main channel of Reach 2, and at least one side channel with extensive gravel beds (dry at time of observation) was also observed in this reach during the 1994 investigations (Fig. 37). The latter, in particular, might offer exceptional spawning potential for spring spawning species (perhaps avoiding high flow conditions in the Cruickshank River mainstem).

All tributaries to Eric Creek are precipitous, and most are little more than debris torrents (Fig. 38). Flows could not be detected in any of them, during the August 26 overflight; and those investigated on the ground during September and October 1994 were found to be entirely dry.

4.3.5 Puntledge River mainstem

In previous discussions, the name Upper Puntledge River has been used to specify and distinguish the section of the river, upstream of Comox Lake (as opposed to the Lower Puntledge River, downstream of the lake; Fig. 4). The same distinction will be made, as warranted, in further discussions. However, in the presentation of results, all reference to the Puntledge River relates to the portion of this system upstream of Comox Lake. Accordingly, in sections dealing with the results, it will simply be referred to as *the Puntledge River*, consistent with official gazetting and mapping. This also avoids confusion between the distinct upper and lower portions of this river (ie. upstream and downstream of Forbush and Willemar lakes).

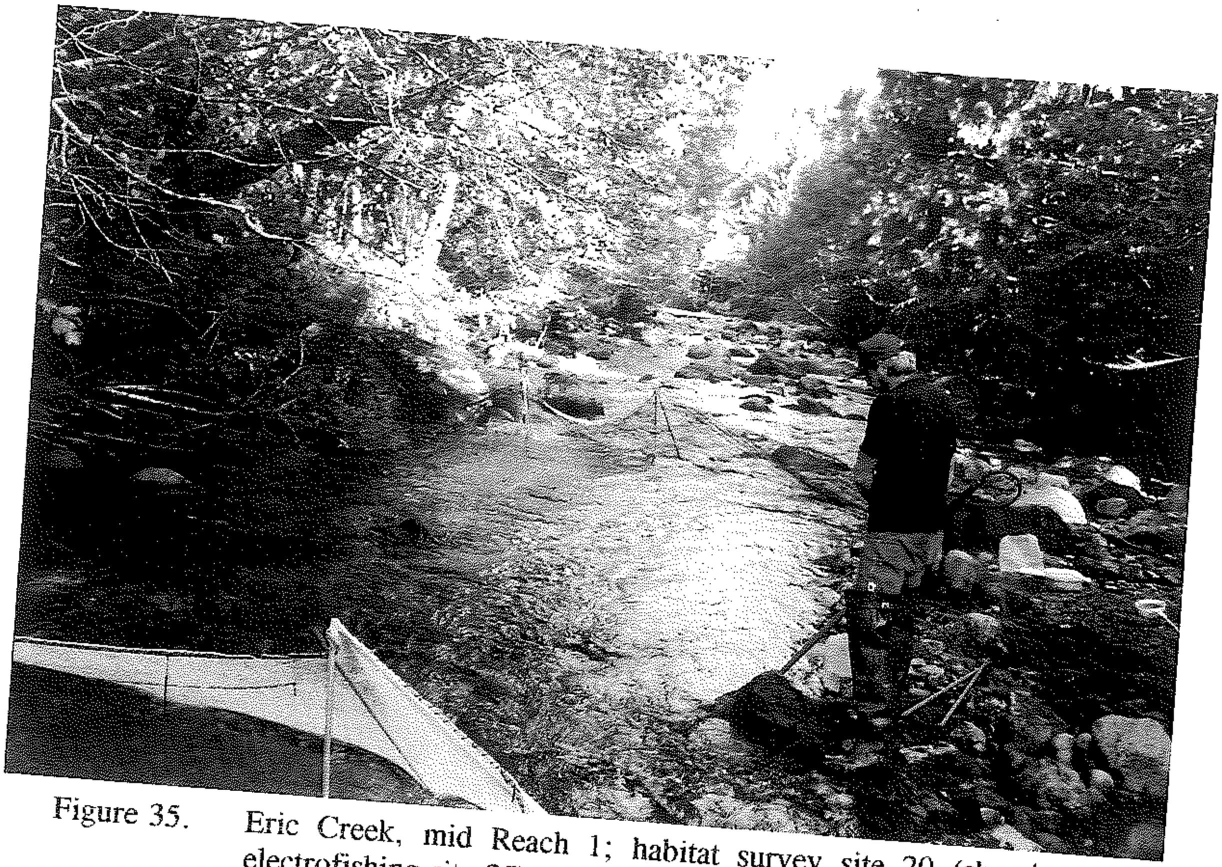

Figure 35. Eric Creek, mid Reach 1; habitat survey site 20 (showing electrofishing site 25).

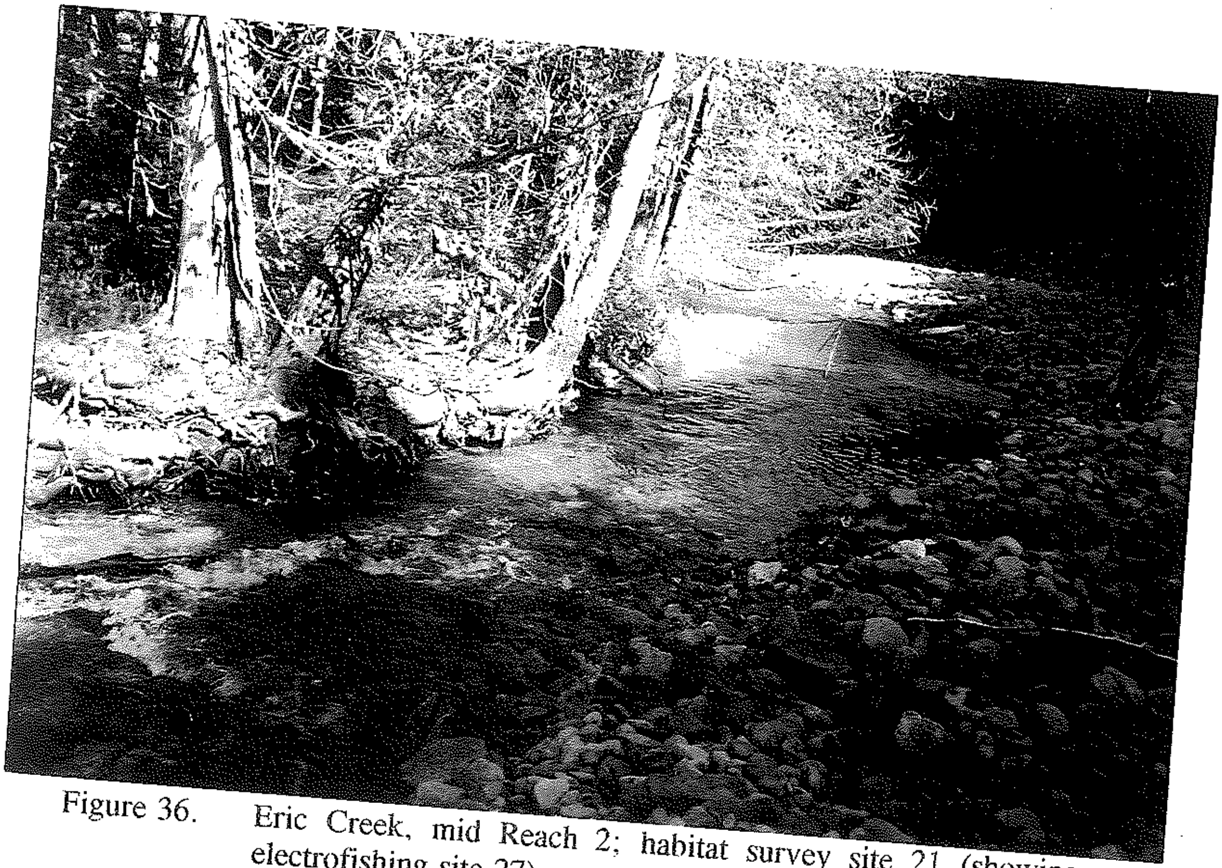

Figure 36. Eric Creek, mid Reach 2; habitat survey site 21 (showing electrofishing site 27).

Figure 37. Dry side channel with gravel beds; Eric Creek, Reach 2.

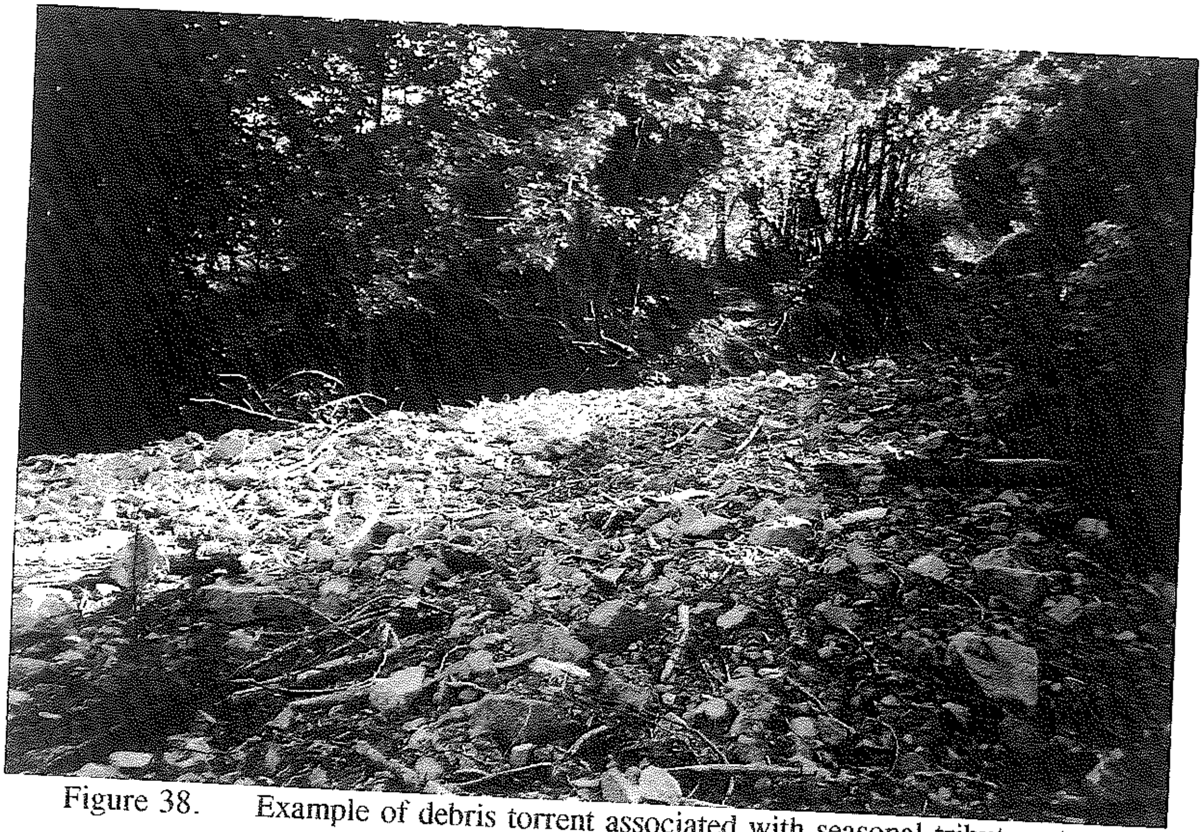

Figure 38. Example of debris torrent associated with seasonal tributary to Eric Creek, Reach 2.

The section below the lakes is only 3.5 km in length, and is comprised of two reaches. The differences between these reaches is relatively minor (Table 2). In both cases, mean gradient is < 1%, and glide habitat dominates throughout. Bed substrates consist primarily of gravels and cobbles, but are somewhat smaller in Reach 1 (Fig. 39), than they are in Reach 2 (Fig. 40). However, even in Reach 2, bed materials do not provide substantial cover for fish. In both reaches, overhanging vegetation, cutbanks, and debris provide by far the greatest proportion of available cover (Table 2). In terms of total cover, Puntledge River Reaches 1 and 2 appear to be slightly lower than average, compared to all other stream sections investigated (% cover; Table 2). This is often the case in low gradient sections, where complex bank cover predominates, but is limited to narrow areas along the stream margins. Small substrates provide little cover over the rest of the wetted width. In such cases, estimates of cover abundance, as a percentage of total stream area, decline as stream width increases. Accordingly, such estimates may be misleading for larger streams, like the Puntledge River (Table 2). In fact, complex bank cover is routinely present in Reaches 1 and 2 of this system, as shown in Figures 39 and 40. Gravels are abundant, throughout. The proportion of fines is fairly high (10 to 15%), but compaction is only low to moderate (Appendix 5).

Reach 3 of the Puntledge River is the short (400 m) section between Willemar and Forbush lakes. It is flume-like, and is dominated by shallow glide habitat over gravel/cobble substrates (Table 2). It is particularly featureless, in terms of rearing habitat, but provides excellent and abundant spawning habitat (Appendix 5).

Gravels are also greatly abundant in Reaches 4 and 5 of the Puntledge River, upstream of Forbush Lake (Figs. 41 and 42). The major difference between these reaches, is the slight increase in gradient, and narrower width, from Reach 4 to Reach 5 (Table 2). In both reaches, fish cover is dominated by overhanging vegetation, cutbanks, and debris. In Reach 5, the slightly narrower stream width results in a greater abundance of cover, relative to total area (*ibid.*), as discussed above.

As observed during the August 26 overflight, flows in the Puntledge River disappeared within the bed materials in Reach 5, approximately 4 km upstream of Forbush Lake. However, a variety of isolated side channels and backwaters were present both above and below this point.

4.3.6 Toma Creek

A description was provided earlier, regarding the absence of surface flows in lower Toma Creek, at the time of 1994 field activities. The channel was entirely dry for approximately 1 km, commencing approximately 500 m upstream of the lake (Fig. 6). The section immediately above the lake consists of a rather diffuse and braided channel, in marsh-like surroundings (site 27; Table 2). In this area, some channel sections were found to contain standing water, with complex cover (Fig. 43), similar to an isolated backwater (Fig. 9) found adjacent to the dry channel, higher up in Reach 1, as previously noted.

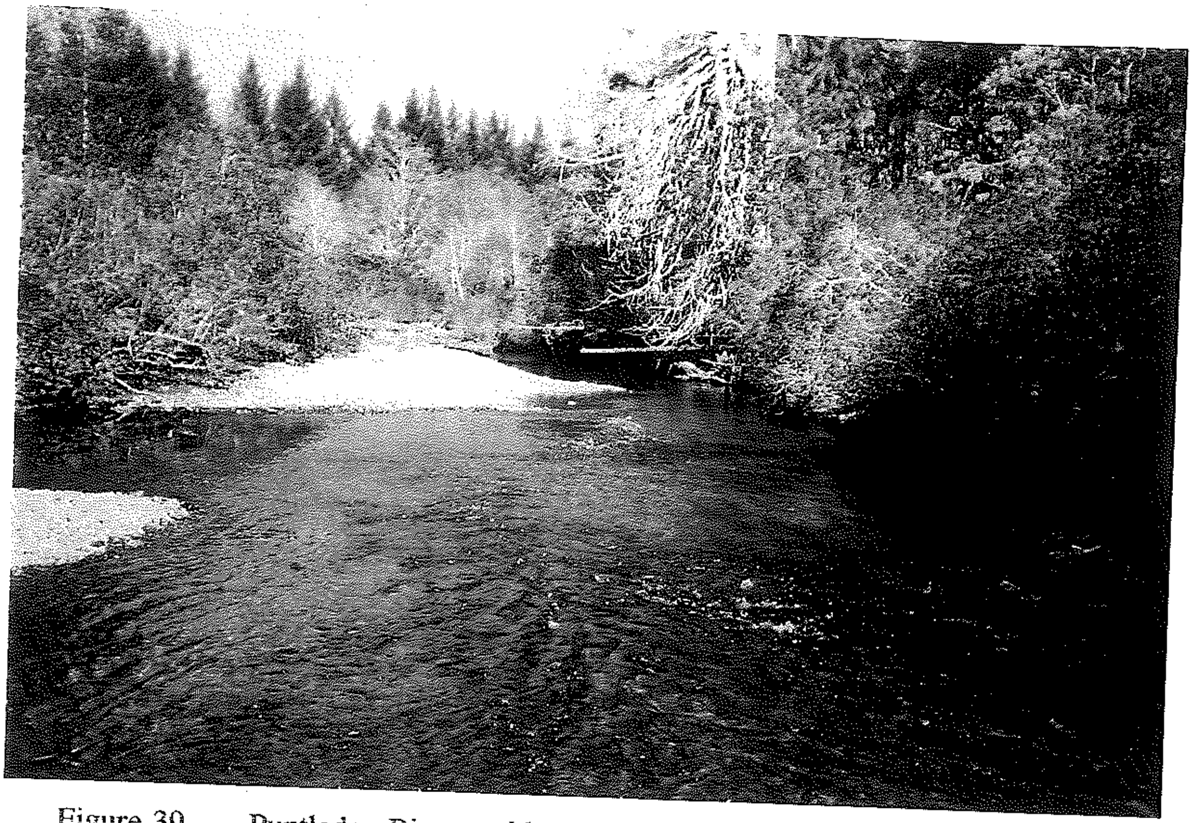

Figure 39. Puntledge River, mid Reach 1; habitat survey site 20.

Figure 40. Puntledge River, mid Reach 2; habitat survey site 21.

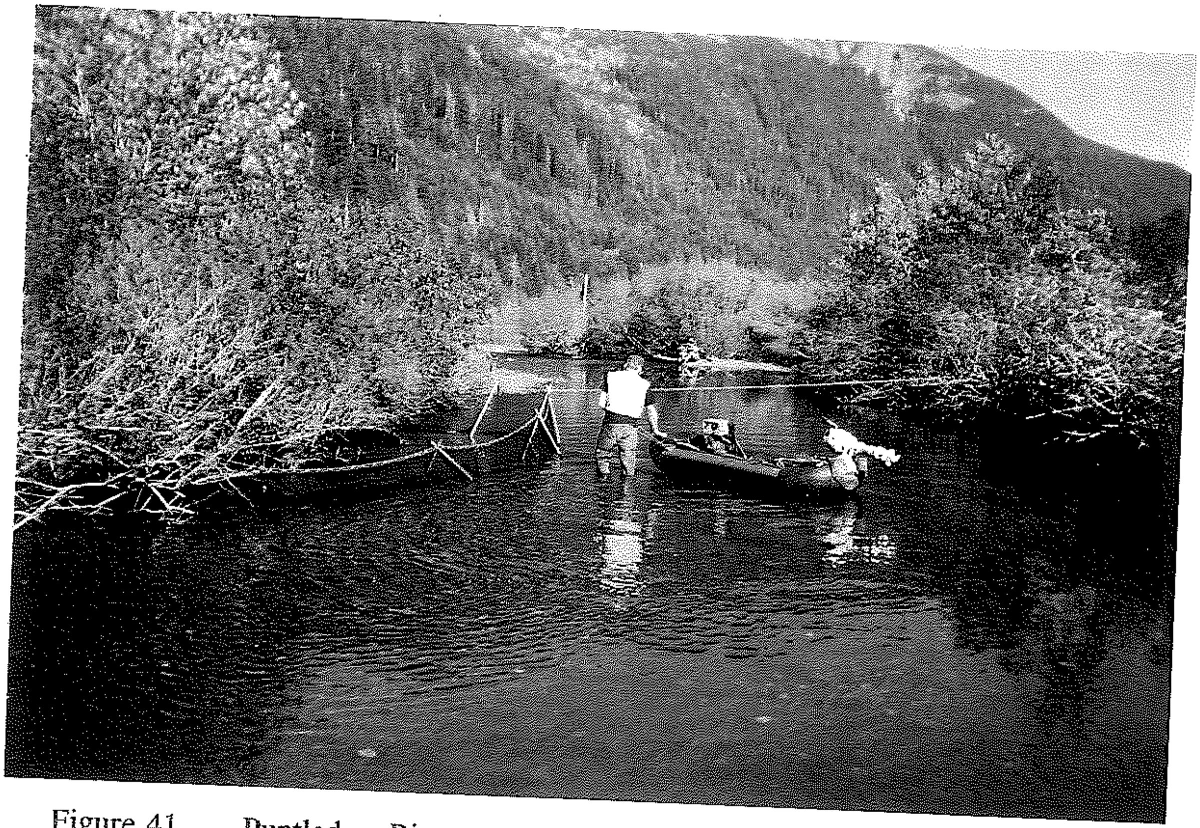

Figure 41. Puntledge River, Reach 4; habitat survey site 25 (showing electrofishing site 35).

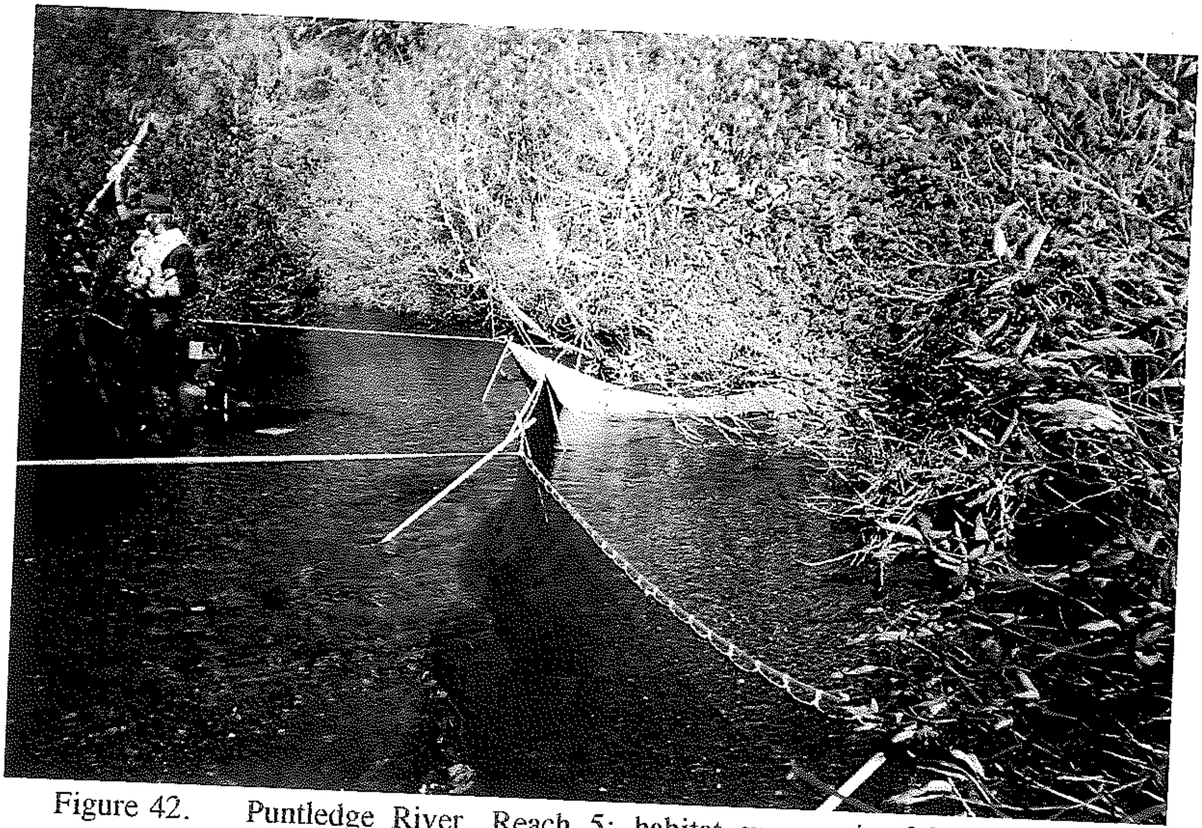

Figure 42. Puntledge River, Reach 5; habitat survey site 26 (showing electrofishing site 37).

Within the dry section of lower Toma Creek, the streambed largely consists of gravels (60% at site 28; Table 2). Although fines are also abundant (35%), spawning potential may be high due to the total area available. Seasonal increases in precipitation and stream discharge in later October and November would probably result in the development of surface flows, for fall spawning species (Fig. 3). Flows should also be at least adequate for spring spawning species (*ibid.*). Due to the drying of the channel at low flows, the spawning potential in lower Toma Creek is not supported by sustained rearing capability, except perhaps in the marshy area immediately upstream of Comox Lake.

As was also noted earlier, normal flowing (0.09 m^3/s; Appendix 5) stream habitat was found in the second reach of Toma Creek, at a point approximately 2.5 km upstream of Comox Lake (site 29; Table 2). Surface flows persisted at least as far as an upper road crossing, 6 km upstream of Comox Lake (designated the top of Reach 2; Fig. 4). Gradient in this portion of the system averages 3.5 to 4%. Hydraulic habitat is again dominated by riffle and glide, over moderately sized bed substrates, which provide the majority of cover for fish (site 29; Table 2). However, complex bank cover in the form of overhanging vegetation, cutbanks, and debris is also moderately represented (Fig. 10). Gravels are reasonably abundant, compaction is low to moderate (Appendix 5). This section of Toma Creek seemed a near ideal nursery stream at low flows. At the same time, there was clear evidence of major flood events, and associated impacts (eg. bank erosion).

4.3.7 Perseverance Creek

As noted earlier, two small isolated pools, immediately downstream of the lowermost road crossing of this stream (1.2 km upstream of Comox Lake), was the only water found in lower Perseverance Creek. These pools (Fig. 44) had only persisted due to their containment in a clay outcrop. Folds/holes in this outcrop, gravels, and a few cobbles and boulders, were the only forms of fish cover. However, inspection of the dry channel, both downstream (Fig. 11) and upstream (Fig. 12) of this location, suggested an abundance of complex cover for fish, during periods of active flow. In the first reach, gravels are abundant (site 30; Table 2), and spawning opportunities appeared excellent. But needless to say, implications relative to the lack of complimentary rearing capability are more severe here than in Toma Creek, since the absence of flows persisted throughout the full length of this stream (sites 31 and 32; Table 2).

4.4 Species Distribution from Electrofishing Captures

The location of the 42 electrofishing sites sampled in the Comox Lake drainage, during the 1994 field program, is shown in Figure 45. To some extent, species distribution was affected by releases of hatchery fish within the study area. A summary of pertinent releases is given in Table 3. As outlined earlier, large releases of coho fry, to the Comox Lake drainage, are conducted on an annual basis. However, for this species only the 1994 release is directly relevant to this investigation, since all individuals captured during the 1994 sampling were found to be underyearlings (scale analyses and length frequency distributions). With respect to steelhead, the 1992-94 releases are the first conducted in the Comox Lake drainage,

Figure 43. Lowermost Reach 1 of Toma Creek; habitat survey site 27 (location of electrofishing site 38).

Figure 44. Isolated pools in Reach 1 of Perseverance Creek (electrofishing site 41).

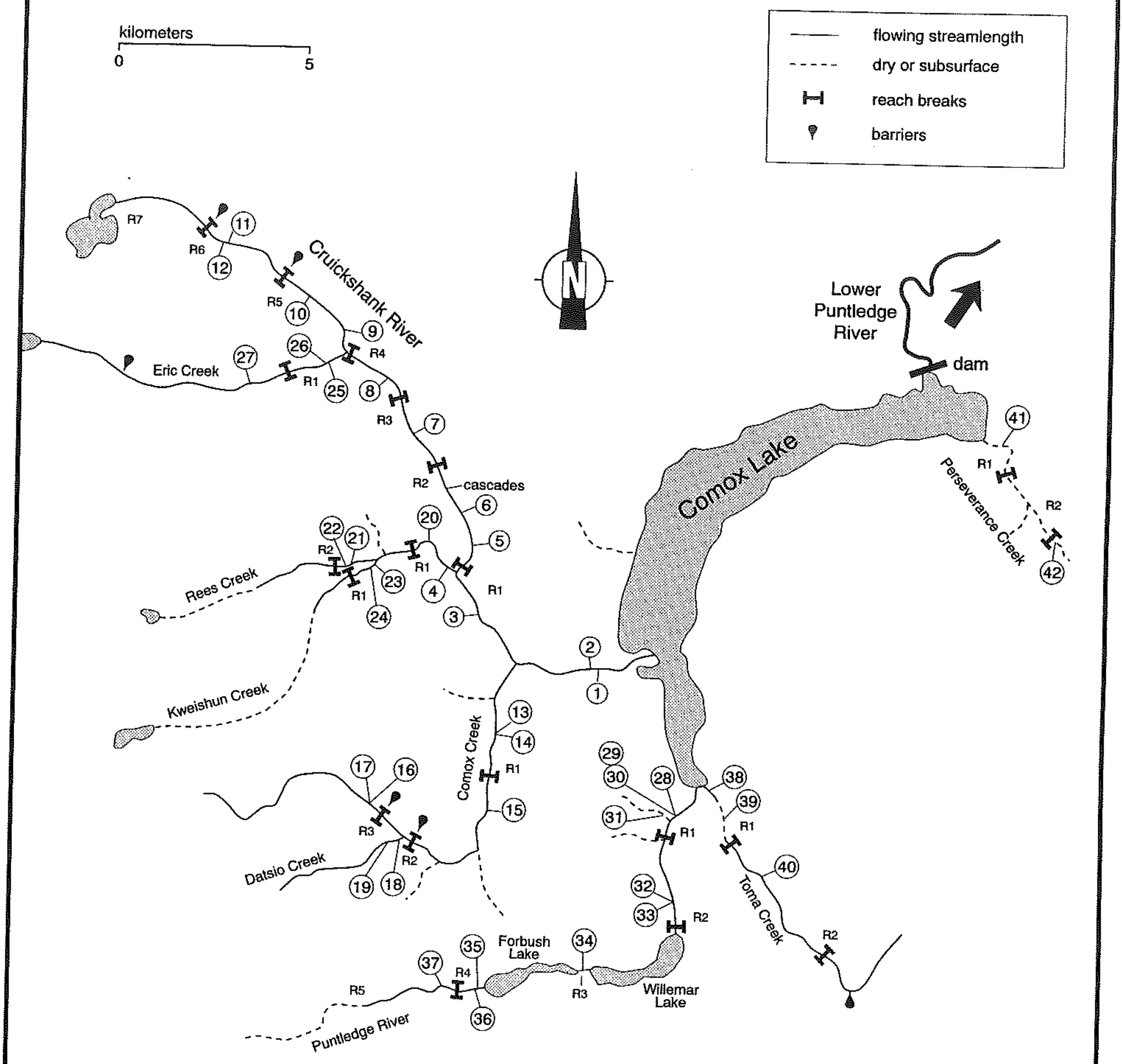

Figure 45. Location for electrofishing sites, Comox Lake drainage, September - October, 1994.

Table 3. Summary of hatchery fish releases pertinent to the 1994 biophysical assessment of the Comox Lake drainage.

Species	Release Date	Receiving Water	Number of Fish	Age of Fish	Fish Size
Coho [1]	June 15, 1994	Rees Creek	117,111	Fry	ave. 2 – 4 g
	"	Eric Creek	117,111	"	"
	"	Cruickshank River (lower Reach 1)	33,333	"	"
	"	Puntledge River (Reaches 1 & 2)	95,238	"	"
	"	Comox Lake	371,007	"	"
	Fall 1993	Cruickshank River (lower Reach 1)	337	Adults	n / a
	"	Comox Lake	268	"	n / a
Steelhead [3] (summer run)	July 14, 1992	Comox Creek	10,000	Fry	1.69 g
		Rees Creek	10,000	"	1.69 g
	July 8, 1993	Comox Creek	15,000	"	0.60 g
		Rees Creek	5,000	"	0.55 g
		Eric Creek	5,000	"	0.55 g
	July 6, 1994	Comox Creek	10,500	"	1.2 g
		Rees Creek	5,050	"	1.2 g
		Eric Creek	5,050	"	1.2 g

[1] Data courtesy of H. Genoe and D. Miller (Puntledge Hatchery, Dept. of Fisheries and Oceans) [2] Rimmer *et al.* (1994)

since 1985 (Rimmer *et al.*, 1994). For these releases, oldest individuals would have been age 2+ at the time of sampling in 1994. For coho, 9.3% of all fry released in 1994 were marked by adipose clip (B. Bengeyfield[6], *pers. comm.*); all steelhead releases were unmarked (R. Ptolemy[7], *pers. comm.*).

Consistent with previous reporting, salmonid species captured in tributaries to Comox Lake were limited to cutthroat trout, rainbow trout (and steelhead), coho salmon, and Dolly Varden char. The only other species captured were sculpins (*Cottus aleuticus*) and stickleback (*Gasterosteus aculeatus*). Cutthroat trout was the species most widely distributed, and most frequently encountered (Table 4). This species was found in all streams sampled, with the single exception of Datsio Creek; and was captured at a total of 31 sites overall. Dolly Varden char was the second most widetly distributed species, and was captured in all streams investigated, except the mainstem of Comox Creek and Rees Creek (Table 4). However, frequency of occurrence was very low in the Cruickshank River mainstem. In the Puntledge

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[6] President, Global Fisheries Consultants Ltd., White Rock, B.C.

[7] Senior Rivers Biologist, Stock Management Unit, B.C. Fisheries Branch, Victoria, B.C.

River, Dolly Varden were only encountered upstream of Forbush Lake, and overall, they were captured at a total of only 16 electrofishing sites within the entire study area.

Rainbow/steelhead trout were captured at a total of 20 electrofishing sites, but were not present in Toma Creek or Perseverance Creek, nor the Puntledge River upstream of Willemar Lake (Table 4). The presence of this species in lower Comox Creek, as well as Rees and Eric creeks, may be attributable to stocking (Table 3). It seems likely that this applies to Reaches 5 and 6 (at least) of the Cruickshank mainstem; but in this case, indirectly. In a program to develop recreational fisheries on a number of lakes in Forbidden Plateau, stocking of Moat Lake was initiated with the release of 25,000 rainbow fry in 1985. Similar releases (reduced to 20,000 fry in 1989) were conducted on three other occasions in the following 6 years (to 1991)[8]. During the helicopter overflight of the Comox Lake drainage, on August 26, 1994, considerable fish feeding activity was observed at the surface of Moat Lake, indicating the presence of a large trout population. As will be emphasized later, it seems certain that the rainbow caught in Reach 6 of the Cruickshank River (ie. above the main barrier falls), are attributable to displacement of fish from Moat Lake. The only stream, or stream section, where rainbow captured in 1994 sampling might be viewed as exclusively native, is the Puntledge River downstream of Willemar Lake (Table 4). In earlier electrofishing, this species was captured in this section of the Puntledge River, but was not present at sites in Comox Creek, or the Cruickshank River mainstem (Russell, 1990).

Coho fry were captured at a total of 19 electrofishing sites during the 1994 sampling program. They were captured in all streams into which hatchery fish were released in 1994; ie. Rees Creek, Eric Creek, the Cruickshank River mainstem, and Puntledge River Reaches 1 and 2, downstream of Willemar Lake (Table 3). They were also found in isolated standing water in Toma and Perseverance creeks (Table 4).

4.5 Sampled Fish Densities (1994 Standing Stock)

Full data for all electrofishing sites completed in the Comox Lake drainage, during the 1994 field program, are provided in Appendix 6. As noted earlier, 8 of the total 42 sites involved *spot-shocking* to sample for fish on a presence/absence basis only. Results at these sites will be referred to in the context of other findings. For the remaining 34 sites, where detailed population estimates were derived, a summary of sampled fish densities (fish/m^2) is provided in Table 5. The identification of age groups (cohorts) was based on length frequency analysis, aided by scale samples from a total 140 specimens, addressing all species and sizes of salmonids captured. A summary of general habitat characteristics, specific to each electrofishing site (ie. within net enclosures) is given in Table 6.

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[8] Provincial stocking records, Fish Culture Section, B.C. Fisheries Branch, Victoria.

Table 4. Summary of fish species distribution, based on electrofishing captures in tributaries to Comox Lake, September–October 1994.

Stream / Section	Site No.	Site Type / Description	Cutthroat Trout : **CT**	Rainbow Trout : **RB**	Dolly Varden : **DV**	Coho Salmon : **CO**	Sculpins	Stickle–back
Cruickshank River Comox Lake to Rees Creek	1	complex debris	◆			◆	◆	
	2	representative	◆				◆	
	3	representative	◆		◆		◆	
	4	representative (with debris)	◆	◆		◆	◆	
Rees Creek to Eric Creek	5	representative	◆	◆			◆	
	6	representative	◆			◆	◆	
	7	representative		◆				
	8	representative	◆	◆	◆	◆		
upstream of Eric Creek	9	representative		◆		◆		
	10	representative pool		◆				
	11	representative (shallow)		◆				
	12	representative (deep)		◆				
Comox Creek	13	representative	◆	◆			◆	
	14	representative	◆	◆			◆	
	15	representative	◆				◆	
	16	representative						
	❶ 17	deep complex pool / run						
Datsio Creek	18	representative			◆			
	❶ 19	complex step pools			◆			
Rees Creek	20	complex debris	◆	◆		◆	◆	
	21	representative	◆	◆		◆	◆	
	❶ 22	deep complex pool / run	◆	◆		◆		
Kweishun Creek	23	representative	◆		◆		◆	
	❶ 24	deep complex pool / run	◆		◆	◆	◆	
Eric Creek	25	representative	◆	◆	◆	◆		
	26	representative	◆	◆	◆	◆		
	27	representative	◆	◆	◆	◆		
Puntledge River downstream of Willemar L.	28	representative pool and debris	◆	◆		◆	◆	◆
	29	representative riffle	◆	◆		◆	◆	
	30	representative glide					◆	◆
	❶ 31	complex backwater				◆		◆
	32	representative pool (with debris)	◆	◆		◆	◆	
	33	representative glide / riffle	◆	◆		◆	◆	
upstream of Willemar L.	34	representative	◆				◆	◆
	35	representative	◆		◆		◆	
	❶ 36	complex backwater	◆		◆			◆
	37	representative	◆		◆		◆	◆
Toma Creek	❶ 38	isolated flood channel	◆		◆			
	❶ 39	isolated backwater	◆		◆	◆		
	40	representative	◆		◆			
Perseverance Creek	41	isolated pool	◆		◆	◆	◆	
	42	isolated pool	◆					

❶ spot–shocking sites; for presence / absence data only; population estimates not derived

Table 5. Summary of sampled fish densities (fish/m^2) at electrofishing sites for which population estimates were derived in tributaries to Comox Lake, September–October 1994.

Stream / Section	Site	CT 0+	CT 1+	CT 2+	CT 3+	RB 0+	RB 1+	RB 2+	RB 3+	DV 0+	DV 1+	DV 2+	DV 3+	CO	CO m *
Cruickshank River															
Comox Lake to Rees Creek	1	0.04	–	–	–	–	–	–	–	–	–	–	–	3.33	0.43
	2	0.05	–	–	–	–	–	–	–	–	–	–	–	–	–
	3	0.11	–	–	–	–	–	–	–	–	0.05	–	–	–	–
	4	0.15	0.11	0.04	–	0.04	–	–	–	–	–	–	–	0.04	–
Rees Creek to Eric Creek	5	0.11	–	0.02	–	–	0.02	0.02	–	–	–	–	–	–	–
	6	0.08	0.02	–	–	–	–	–	–	–	–	–	–	0.02	–
	7	–	–	–	–	0.29	0.02	–	0.02	–	–	–	–	–	–
	8	–	–	0.02	0.02	–	–	0.02	–	–	0.02	–	–	0.10	–
upstream of Eric Creek	9	–	–	–	–	0.31	0.13	0.04	0.04	–	–	–	–	0.04	–
	10	–	–	–	–	0.10	0.22	0.10	0.02	–	–	–	–	–	–
	11	–	–	–	–	0.27	0.05	0.03	–	–	–	–	–	–	–
	12	–	–	–	–	0.27	0.04	0.07	0.04	–	–	–	–	–	–
Comox Creek	13	0.83	0.06	0.03	–	0.06	0.06	–	–	–	–	–	–	–	–
	14	0.42	–	–	–	0.18	–	–	–	–	–	–	–	–	–
	15	0.80	0.06	0.03	–	–	–	–	–	–	–	–	–	–	–
	16	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Datsio Creek	18	–	–	–	–	–	–	–	–	0.48	0.16	–	–	–	–
Rees Creek	20	0.18	0.06	–	–	0.12	–	–	–	–	–	–	–	0.12	–
	21	0.25	–	–	–	0.02	–	–	–	–	–	–	–	0.07	–
Kweishun Creek	23	0.33	–	–	–	–	–	–	–	0.25	0.03	–	–	–	–
Eric Creek	25	0.02	–	–	–	–	0.02	–	–	–	0.08	–	–	0.19	0.02
	26	0.07	0.04	–	–	–	0.04	–	–	–	0.07	–	0.04	0.20	–
	27	–	–	0.02	0.04	–	0.02	0.02	–	0.04	0.22	0.07	–	0.92	0.07
Puntledge River															
downstream of Willemar L.	28	–	–	0.03	–	0.14	0.03	–	–	–	–	–	–	0.51	–
	29	0.02	–	–	–	0.09	–	–	–	–	–	–	–	0.02	–
	30	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	32	0.29	–	–	–	0.20	–	–	–	–	–	–	–	0.61	0.15
	33	0.06	–	–	–	0.04	0.03	0.01	–	–	–	–	–	0.13	0.03
upstream of Willemar L.	34	0.04	–	–	–	–	–	–	–	–	–	–	–	–	–
	35	0.03	0.03	–	–	–	–	–	–	0.41	0.07	–	–	–	–
	37	0.11	0.05	–	–	–	–	–	–	0.18	0.05	–	–	–	–
Toma Creek	40	0.27	0.04	0.02	–	–	–	–	–	0.35	0.18	–	–	–	–
Perseverance Creek	41	0.25	0.11	–	–	–	–	–	–	0.06	–	–	–	9.92	0.96
	42	0.26	–	–	–	–	–	–	–	–	–	–	–	–	–

* hatchery coho marked with adipose clip

Table 6. Summary of hydraulic and other habitat features at electrofishing sites for which population estimates were derived in tributaries to Comox Lake, September–October 1994.

Stream / Section	Site No.	Hydraulic Habitat (%) Riffle	Pool	Glide	Rapid	D_{90} (cm)	Substrate Cover (%) Trout / Char Fry	Trout / Char Parr	Other Cover (%) Vegetation	Debris, etc.	Cutbanks	Water Temperature °C	Date
Cruickshank River													
Comox Lake to Rees Creek	1	–	60	40	–	20	40	8	16	20	7	10.5	Sep 30
	2	10	5	85	–	30	95	45	–	–	–	9.5	Oct 1
	3	50	10	40	–	70	90	50	–	–	–	10.0	Sep 30
	4	20	20	60	–	50	90	40	–	7	–	11.0	Sep 23
Rees Creek to Eric Creek	5	10	20	55	15	90	100	60	–	–	–	12.5	Sep 27
	6	30	20	30	20	80	95	70	–	–	–	12.0	Sep 27
	7	10	15	50	25	35	95	40	–	–	–	12.0	Sep 26
	8	5	25	40	30	90	100	80	–	–	–	11.0	Sep 26
upstream of Eric Creek	9	30	20	40	5	90	95	75	–	–	–	11.5	Sep 25
	10	10	65	20	5[1]	–[2]	60	50	–	–	–	12.0	Sep 23
	11	10	70	20	–	8	30	–	–	4	1	14.0	Sep 24
	12	–	90	10	–	6	20	–	4.5	8	1.5	14.0	Sep 24
Comox Creek	13	35	20	45	–	60	85	50	–	–	–	10.0	Sep 30
	14	70	10	20	–	35	95	60	–	–	–	10.0	Sep 30
	15	30	10	50	10	70	100	80	–	–	–	10.0	Sep 29
	16	75	5	15	5	40	80	25	1.5	–	–	8.0	Sep 28
Datsio Creek	18	60	10	30	–	50	95	70	–	–	–	8.5	Sep 28
Rees Creek	20	–	40	60	–	4	10	–	12	3.5	7	8.5	Sep 27
	21	20	40	40	–	60	80	50	–	–	–	8.5	Sep 28
Kweishun Creek	23	30	20	50	–	40	90	50	14	1	0.5	7.5	Sep 28
Eric Creek	25	40	15	45	–	70	90	50	3	–	1	10.0	Sep 25
	26	50	15	35	–	60	90	60	4	–	–	10.0	Sep 25
	27	30	30	40	–	35	95	20	–	2.5	4	10.0	Sep 25
Puntledge River													
downstream of Willemar L.	28	–	70	30	–	10	40	–	30	25	5	14.0	Oct 3
	29	55	10	35	–	15	90	–	19.5	1.5	–	14.5	Oct 3
	30	–	30	70	–	20	85	–	–	–	–	14.5	Oct 3
	32	–	30	70	–	20	95	10	29	23	1.5	16.5	Oct 5
upstream of Willemar L.	33	25	15	60	–	35	90	15	23	6	–	15.0	Oct 5
	34	10	20	70	–	15	80	–	47	6.5	–	13.0	Oct 4
	35	–	50	50	–	8	20	–	25	10	3.5	9.0	Oct 4
	37	15	15	70	–	8	–	–	20	7	7	8.0	Oct 4
Toma Creek	40	20	30	50	–	30	80	40	3.5	1.5	0.5	10.0	Oct 1
Perseverance Creek	41	–	100	–	–	30	40	10	–	–	–	9.0	Oct 6
	42	–	100	–	–	15	70	5	–	–	4.5	10.0	Oct 6

[1] in this case, a cascade over bedrock [2] bedrock dominant

The fish densities in Table 5 are based on the total area netted off, and sampled, at each site. However, due to hydraulic constraints in particular (ie. water depth and/or velocity), only a portion of a given site may be usable (suitable) for any species/age group of fish (eg. Stalnaker and Arnette, 1976; Bovee and Cochnauer, 1977). In order to express and standardize the raw sampling results (Table 5) on the basis of the area of *suitable habitat only*, they were adjusted with the water depth/velocity data, from representative transects completed at each site (Appendix 6).

Employing the B.C. Environment spreadsheet (Bech *et al.*, 1994), the transect data were used to generate mean weighted hydraulic suitability (probabilities-of-use) values, for each species and size class of fish (Table 7). These values represent the proportion of total site area where hydraulic conditions were actually suitable for a given species and size of fish. Each value is weighted on the basis of the specific degree of usability (for depth and velocity combined), and the associated proportion of site area, for each cell (between measurement stations) along the transect. In the procedure, yearlings and older juveniles are collectively addressed as *parr*. Although no chinook salmon were captured during the 1994 sampling (Table 5), values are provided in Table 7, given the reported history (and recent releases) of this species within the study area (Rimmer *et al.*, 1994).

A summary of the electrofishing results, adjusted by specific hydraulic suitabilities (ie. based on the area of suitable habitat only), is provided in Table 8. The values in Table 8 may be directly compared, and exhibit distinct trends in fish numbers from stream to stream, and site to site. The most extreme example is the 22.6 coho/m^2 at site 41, one of the two small isolated pools in lowermost Perseverance Creek (Fig. 44). This clearly demonstrates the susceptibility of juvenile salmonids to stranding, in very high densities, in systems with intermittent flows. The presence of coho fry in Perseverance Creek is most interesting, since hatchery fish were not released to this stream in 1994 (Table 3). The implications of this will be addressed in a following section. It should be noted, however, that low numbers of cutthroat trout and Dolly Varden char, were also present at site 41 (Table 8).

An exceptionally high density of coho (5.2 fish/m^2) was also obtained at site 1, in the lowermost Cruickshank River mainstem (Fig. 45). This was in the vicinity of the mainstem release of 33,333 coho fry in 1994 (Table 3); however, coho were totally absent at site 2, just 300 m upstream of site 1 (Fig. 45). As noted earlier, site 1 focused on complex bank cover (Fig. 15), more common in this portion of the system, but not at site 2, nor in the great majority of streamlength, from upper Reach 1 to the barrier falls at the top of Reach 5 (Tables 2 and 6). With at total 12.1m^2 of complex overhead and instream cover, site 1 (28.1m^2 in total) produced the capture of 95 juvenile coho (Appendix 6). The absence or low abundance of such cover at other sites in the Cruickshank mainstem (Table 6) was accompanied by the low numbers or absence of coho (Table 8), consistent with the great reliance of this species, on quiet complex habitat, reported in the literature (eg. Hartman, 1965; Glova and Mason, 1977; Nickelsen and Reisenbichler, 1977). The total number of coho captured at sites 2 to 9 (inclusive) was only 7 fish (Appendix 6). Site 9, 150 m upstream of Eric Creek (Fig. 45) was the uppermost location in the Cruickshank mainstem where any coho were encountered (Table 8). The single individual captured here was obviously a hatchery fish which had strayed after release in Eric Creek (Table 3).

Table 7. Summary of the mean weighted suitability of water depth and velocity for different fish species and age / size groups at electrofishing sites in tributaries to Comox Lake, September–October 1994.

Stream / Section	Site No.	Hydraulic Means		Mean Weighted Hydraulic Suitability (max. = 1.000)							
		Depth (m)	Velocity (m/s)	CT Fry	CT Parr	RB Fry	RB Parr	DV Fry	DV Parr	Coho	Chinook
Cruickshank River											
Comox Lake to Rees Creek	1	0.414	0.038	0.650	0.947	0.653	0.883	0.826	0.954	0.640	0.846
	2	0.295	0.225	0.583	0.694	0.583	0.675	0.755	0.839	0.258	0.373
	3	0.228	0.616	0.444	0.303	0.446	0.255	0.480	0.494	0.041	0.173
	4	0.365	0.258	0.457	0.716	0.459	0.682	0.659	0.750	0.196	0.366
Rees Creek to Eric Creek	5	0.291	0.391	0.501	0.567	0.502	0.527	0.551	0.610	0.183	0.406
	6	0.356	0.363	0.452	0.576	0.452	0.560	0.607	0.660	0.349	0.446
	7	0.190	0.436	0.429	0.364	0.429	0.331	0.535	0.561	0.056	0.144
	8	0.380	0.370	0.390	0.595	0.390	0.573	0.561	0.677	0.288	0.368
upstream of Eric Creek	9	0.200	0.321	0.690	0.436	0.690	0.392	0.744	0.739	0.240	0.334
	10	0.291	0.015	0.819	0.850	0.821	0.815	0.951	0.898	0.626	0.766
	11	0.147	0.003	0.998	0.555	1.000	0.470	1.000	0.994	0.234	0.466
	12	0.393	0.001	0.616	0.997	0.620	0.954	0.900	1.000	0.731	0.900
Comox Creek	13	0.232	0.064	0.841	0.740	0.844	0.676	0.908	0.913	0.491	0.669
	14	0.125	0.329	0.567	0.312	0.570	0.253	0.542	0.523	0.043	0.147
	15	0.362	0.256	0.454	0.712	0.454	0.696	0.651	0.742	0.307	0.547
	16	0.183	0.630	0.233	0.199	0.233	0.160	0.286	0.289	0.005	0.035
Datsio Creek	18	0.128	0.134	0.746	0.462	0.746	0.385	0.744	0.781	0.159	0.314
Rees Creek	20	0.501	0.141	0.408	0.969	0.415	0.906	0.686	0.890	0.554	0.799
	21	0.266	0.126	0.514	0.551	0.515	0.523	0.689	0.785	0.295	0.410
Kweishun Creek	23	0.248	0.157	0.770	0.715	0.771	0.650	0.848	0.882	0.406	0.568
Eric Creek	25	0.245	0.459	0.567	0.586	0.570	0.489	0.574	0.604	0.164	0.395
	26	0.159	0.229	0.647	0.452	0.650	0.381	0.687	0.750	0.185	0.342
	27	0.347	0.216	0.404	0.722	0.405	0.688	0.622	0.728	0.427	0.576
Puntledge River											
downstream of Willemar L.	28	0.392	0.000	0.614	0.967	0.614	0.952	0.895	1.000	0.745	0.867
	29	0.199	0.749	0.184	0.070	0.184	0.059	0.192	0.241	0.003	0.027
	30	0.128	0.007	0.994	0.515	1.000	0.416	0.973	0.894	0.218	0.438
	32	0.405	0.081	0.572	0.958	0.572	0.943	0.827	0.950	0.633	0.889
	33	0.335	0.414	0.275	0.565	0.277	0.545	0.420	0.517	0.182	0.345
upstream of Willemar L.	34	0.231	0.199	0.673	0.830	0.685	0.687	0.750	0.794	0.253	0.575
	35	0.401	0.019	0.603	1.000	0.603	0.994	0.925	1.000	0.800	0.900
	37	0.375	0.343	0.382	0.610	0.382	0.593	0.524	0.614	0.439	0.502
Toma Creek	40	0.425	0.051	0.557	0.995	0.558	0.954	0.816	0.957	0.700	0.872
Perseverance Creek	41	0.253	0.000	0.821	0.709	0.824	0.650	0.941	0.971	0.439	0.607
	42	0.138	0.000	0.990	0.540	0.997	0.444	0.954	0.815	0.255	0.490

Table 8. Summary of adjusted fish densities (fish/m^2), based on weighted hydraulic suitability at electrofishing sites in tributaries to Comox Lake, September–October 1994.

Stream / Section	Site	CT 0+	CT 1+	CT 2+	CT 3+	RB 0+	RB 1+	RB 2+	RB 3+	DV 0+	DV 1+	DV 2+	DV 3+	CO
Cruickshank River														
Comox Lake to Rees Cree	1	0.06	–	–	–	–	–	–	–	–	–	–	–	5.20
	2	0.09	–	–	–	–	–	–	–	–	–	–	–	–
	3	0.25	–	–	–	–	–	–	–	–	0.10	–	–	–
	4	0.33	0.15	0.06	–	0.09	–	–	–	–	–	–	–	0.20
Rees Creek to Eric Creek	5	0.22	–	0.04	–	–	0.04	0.04	–	–	–	–	–	–
	6	0.18	0.03	–	–	–	–	–	–	–	–	–	–	0.06
	7	–	–	–	–	0.68	0.06	–	0.06	–	–	–	–	–
	8	–	–	0.03	0.03	–	–	0.03	–	–	0.03	–	–	0.35
upstream of Eric Creek	9	–	–	–	–	0.45	0.33	0.10	0.10	–	–	–	–	0.17
	10	–	–	–	–	0.12	0.27	0.12	0.02	–	–	–	–	–
	11	–	–	–	–	0.27	0.11	0.06	–	–	–	–	–	–
	12	–	–	–	–	0.44	0.04	0.07	0.04	–	–	–	–	–
Comox Creek	13	0.99	0.08	0.04	–	0.07	0.09	–	–	–	–	–	–	–
	14	0.74	–	–	–	0.32	–	–	–	–	–	–	–	–
	15	1.76	0.08	0.04	–	–	–	–	–	–	–	–	–	–
	16	–	–	–	–	–	–	–	–	–	–	–	–	–
Datsio Creek	18	–	–	–	–	–	–	–	–	0.65	0.20	–	–	–
Rees Creek	20	0.44	0.06	–	–	0.29	–	–	–	–	–	–	–	0.22
	21	0.49	–	–	–	0.04	–	–	–	–	–	–	–	0.24
Kweishun Creek	23	0.43	–	–	–	–	–	–	–	0.29	0.03	–	–	–
Eric Creek	25	0.04	–	–	–	–	0.04	–	–	–	0.13	–	–	1.16
	26	0.11	0.09	–	–	–	0.10	–	–	–	0.09	–	0.05	1.08
	27	–	–	0.03	0.06	–	0.03	0.03	–	0.06	0.30	0.10	–	2.15
Puntledge River														
downstream of Willemar L.	28	–	–	0.03	–	0.23	0.03	–	–	–	–	–	–	0.68
	29	0.11	–	–	–	0.49	–	–	–	–	–	–	–	6.67
	30	–	–	–	–	–	–	–	–	–	–	–	–	–
	32	0.51	–	–	–	0.35	–	–	–	–	–	–	–	0.96
	33	0.22	–	–	–	0.14	0.06	0.02	–	–	–	–	–	0.71
upstream of Willemar L.	34	0.06	–	–	–	–	–	–	–	–	–	–	–	–
	35	0.05	0.03	–	–	–	–	–	–	0.44	0.07	–	–	–
	37	0.29	0.08	–	–	–	–	–	–	0.34	0.08	–	–	–
Toma Creek	40	0.48	0.04	0.02	–	–	–	–	–	0.43	0.19	–	–	–
Perseverance Creek	41	0.30	0.16	–	–	–	–	–	–	0.06	–	–	–	22.60
	42	0.26	–	–	–	–	–	–	–	–	–	–	–	–

Distinctly higher coho densities were encountered in Eric Creek itself, as would be expected, given the large numbers of hatchery fry (117,000) released to this stream in 1994 (Table 3). However, consistent with the results in the Cruickshank mainstem, the limited presence of debris and cutbank cover at site 27 in Eric Creek (Table 6; Fig. 36), resulted in a doubling of coho densities found at the two other sites in this system (sites 25 and 26; Table 8), where such cover was nearly absent (Table 6; Fig. 35).

Another result for coho (Table 8) also warrants explanation, but for different reasons. When the sampled densities at site 29, in the Puntledge River, were adjusted on the basis of hydraulic suitability, the very low density of coho (0.02 fish/m^2; Table 5) was greatly expanded (6.7 fish/m^2; Table 8). This site was dominated by riffle/glide habitat (Table 6), with shallow mean depth, high mean velocity, and extremely low hydraulic suitability for coho juveniles (0.003/1.000; Table 7). The latter estimate is consistent with the limited potential of riffle habitat, for coho, reported widely in the literature (eg. Hartman; Glova and Mason; Nickelsen and Reisenbichler, *op.cit.*). Since the initial sampling result (0.02 coho/m^2) actually consisted of just a single fish (Appendix 6), the capture may best be explained as a matter of *chance*, and discounted. At the same time, this clearly indicates the limitations and potential pitfalls in any attempt to mathematically model fish populations in natural habitats. All other results have been rigorously scrutinized in this respect, and will similarly be qualified, as warranted.

4.6 Theoretical Standing Stock Capability

While standardization of sampling results on the basis of usable habitat enables direct comparisons between fish numbers at different sites, the most instructive evaluation of existing standing stock is relative to site capability (carrying capacity). In the B.C. Environment model to estimate juvenile salmonid standing stock capability in streams (Ptolemy, 1992), fish size is a critical component. During the 1994 sampling of tributaries to Comox Lake, fork length and weight measurements were obtained from all salmonids captured. Results are summarized for major stream components in Tables 9 and 10. In the capability model, separate estimates are generated for distinctly different *size classes* of trout and char species *combined* (Appendix 3). Since the size of all age groups of rainbow, cutthroat, and Dolly Varden broadly overlapped in both the Cruickshank and Puntledge systems (Figs. 46 and 47), these three species must be considered collectively, for the purposes of the model (Ptolemy, *op.cit.*).

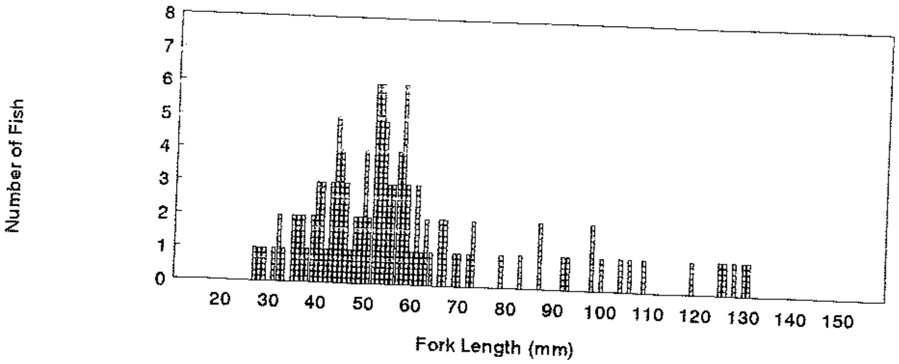
For the following reasons, age 3+ trout and char were excluded from the modelling process: 1) numbers of fish captured were particularly few, and associated data were highly variable (Tables 6 and 7); 2) electrofishing, restricted to edge habitats in larger streams, is not an accurate or efficient method for sampling older age groups, and 3) the 1994 sampling is unlikely to have produced reliable results for them.

Table 9. Summary of fish length statistics from all electrofishing captures in tributaries to Comox Lake, September–October 1994 (mean length and standard deviation values in *millimeters*).

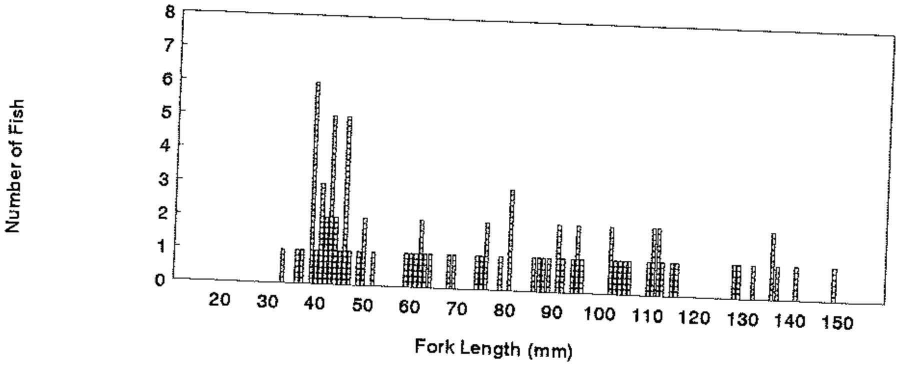
Stream / Section		CT 0+	CT 1+	CT 2+	CT 3+	RB 0+	RB 1+	RB 2+	RB 3+	DV 0+	DV 1+	DV 2+	DV 3+	CO
Cruickshank River														
downstream of Eric Creek	**Mean**	**54.2**	**101.5**	**134.3**	**189.0**	**53.2**	**100.0**	**142.5**	**180.0**	–	**93.3**	–	–	**67.8**
	S.D.	5.0	13.0	12.5	–	8.7	12.0	6.5	–	–	4.1	–	–	9.1
	n	17	4	3	1	10	2	2	1	–	3	–	–	101
upstream of Eric Creek	**Mean**	–	–	–	–	**42.7**	**90.8**	**115.6**	**136.3**	–	–	–	–	**71.0**
	S.D.	–	–	–	–	5.4	8.5	10.5	3.7	–	–	–	–	–
	n	–	–	–	–	27	14	8	3	–	–	–	–	1
Comox Creek	**Mean**	**57.1**	**103.3**	**130.5**	–	**73.8**	**114.0**	–	–	**47.7**	**87.0**	–	–	–
	S.D.	9.3	13.4	0.5	–	4.0	1.0	–	–	3.7	–	–	–	–
	n	40	4	2	–	6	2	–	–	3	1	–	–	–
Rees Creek	**Mean**	**42.7**	**85.7**	–	–	**53.0**	**95.0**	–	–	**53.1**	**86.3**	–	–	**63.3**
	S.D.	8.1	6.6	–	–	6.5	–	–	–	7.8	3.7	–	–	6.7
	n	39	3	–	–	3	1	–	–	15	3	–	–	10
Eric Creek system	**Mean**	**46.0**	**100.0**	**128.0**	**195.5**	–	**98.0**	**129.0**	–	**51.7**	**96.3**	**132.0**	**134.0**	**64.7**
	S.D.	8.0	–	–	13.5	–	12.6	–	–	5.8	12.0	10.0	–	7.9
	n	3	1	1	2	–	3	1	–	3	15	2	1	59
Puntledge River														
downstream of Willemar L.	**Mean**	**63.1**	–	**128.0**	–	**57.4**	**106.5**	**129.0**	–	–	–	–	–	**73.9**
	S.D.	7.5	–	–	–	7.7	15.6	–	–	–	–	–	–	7.9
	n	12	–	1	–	19	4	1	–	–	–	–	–	55
upstream of Willemar L.	**Mean**	**53.8**	**103.3**	–	–	–	–	–	–	**58.6**	**87.5**	–	–	–
	S.D.	5.3	10.2	–	–	–	–	–	–	5.0	7.9	–	–	–
	n	6	3	–	–	–	–	–	–	16	4	–	–	–
Toma Creek	**Mean**	**54.2**	**109.0**	**131.0**	–	–	–	–	–	**58.9**	**96.6**	**126.0**	–	**80.0**
	S.D.	6.3	6.2	–	–	–	–	–	–	5.2	13.2	–	–	–
	n	12	5	1	–	–	–	–	–	10	11	1	–	1
Perseverance Creek	**Mean**	**52.5**	**103.5**	–	–	–	–	–	–	**72.0**	–	–	–	**67.4**
	S.D.	9.3	11.5	–	–	–	–	–	–	–	–	–	–	6.8
	n	9	2	–	–	–	–	–	–	1	–	–	–	192

Table 10. Summary of fish weight statistics from all electrofishing captures in tributaries to Comox Lake, September–October 1994 (mean weight and standard deviation values in *grams*).

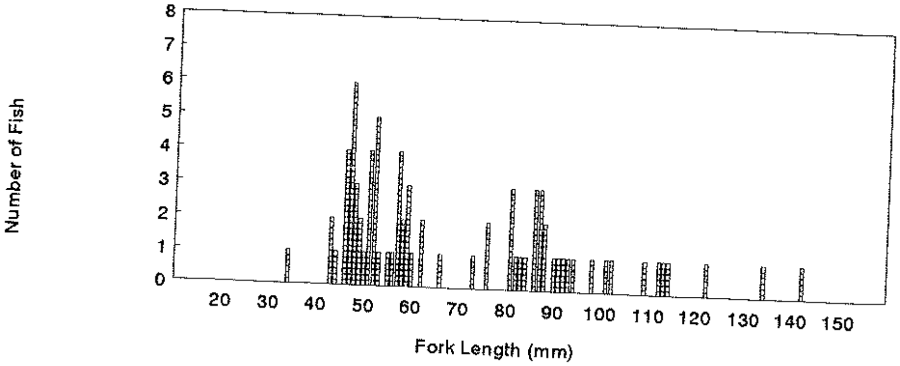
Stream / Section		CT 0+	CT 1+	CT 2+	CT 3+	RB 0+	RB 1+	RB 2+	RB 3+	DV 0+	DV 1+	DV 2+	DV 3+	CO
Cruickshank River														
downstream of Eric Creek	**Mean**	**1.8**	**11.4**	**30.8**	**81.9**	**1.8**	**10.4**	**28.5**	**60.0**	–	**8.6**	–	–	**3.7**
	S.D.	0.5	4.3	11.4	–	0.9	3.6	3.5	–	–	1.9	–	–	1.4
	n	17	4	3	1	10	2	2	1	–	3	–	–	101
upstream of Eric Creek	**Mean**	–	–	–	–	**1.0**	**8.3**	**17.6**	**28.0**	–	–	–	–	**4.5**
	S.D.	–	–	–	–	0.5	2.3	3.7	3.5	–	–	–	–	–
	n	–	–	–	–	27	14	8	3	–	–	–	–	1
Comox Creek	**Mean**	**2.2**	**12.7**	**24.9**	–	**4.6**	**14.8**	–	–	**1.2**	**7.4**	–	–	–
	S.D.	0.9	4.3	0.2	–	1.2	0.3	–	–	0.2	–	–	–	–
	n	40	4	2	–	6	2	–	–	3	1	–	–	–
Rees Creek	**Mean**	**0.9**	**6.9**	–	–	**1.5**	**10.4**	–	–	**1.5**	**6.2**	–	–	**3.1**
	S.D.	0.5	1.3	–	–	0.5	–	–	–	0.6	0.6	–	–	1.0
	n	39	3	–	–	3	1	–	–	15	3	–	–	10
Eric Creek	**Mean**	**1.0**	**10.2**	**21.0**	**79.6**	–	**11.6**	**23.5**	–	**1.5**	**10.7**	**26.1**	**30.6**	**3.4**
	S.D.	0.5	–	–	16.0	–	4.9	–	–	0.4	4.6	5.4	–	1.2
	n	3	1	1	2	–	3	1	–	3	15	2	1	59
Puntledge River														
downstream of Willemar L.	**Mean**	**2.7**	–	**21.6**	–	**2.3**	**15.1**	**25.6**	–	–	–	–	–	**4.9**
	S.D.	0.9	–	–	–	1.0	5.5	–	–	–	–	–	–	1.6
	n	12	–	1	–	19	4	1	–	–	–	–	–	55
upstream of Willemar L.	**Mean**	**1.7**	**11.1**	–	–	–	–	–	–	**2.1**	**7.7**	–	–	–
	S.D.	0.5	2.8	–	–	–	–	–	–	0.7	2.7	–	–	–
	n	6	3	–	–	–	–	–	–	16	4	–	–	–
Toma Creek	**Mean**	**1.9**	**13.9**	**21.8**	–	–	–	–	–	**1.9**	**9.9**	**20.2**	–	**5.7**
	S.D.	1.1	2.6	–	–	–	–	–	–	0.5	4.4	–	–	–
	n	12	5	1	–	–	–	–	–	10	11	1	–	1
Perseverance Creek	**Mean**	**2.3**	**9.3**	–	–	–	–	–	–	**3.1**	–	–	–	**2.8**
	S.D.	1.1	3.2	–	–	–	–	–	–	–	–	–	–	0.9
	n	9	2	–	–	–	–	–	–	1	–	–	–	192



CUTTHROAT TROUT

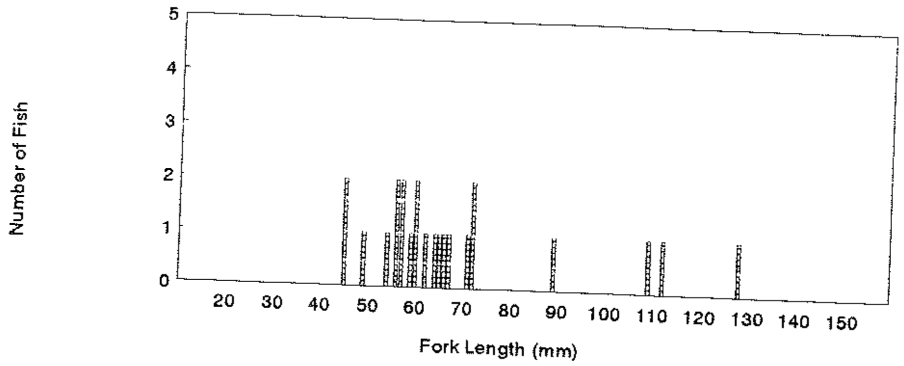


RAINBOW TROUT

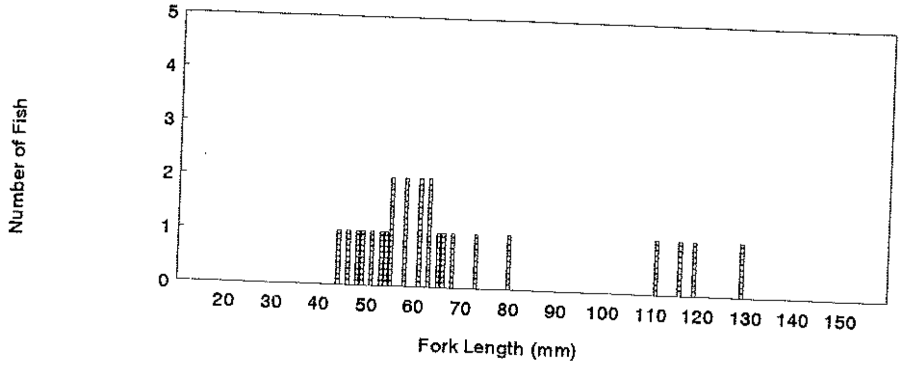


DOLLY VARDEN CHAR

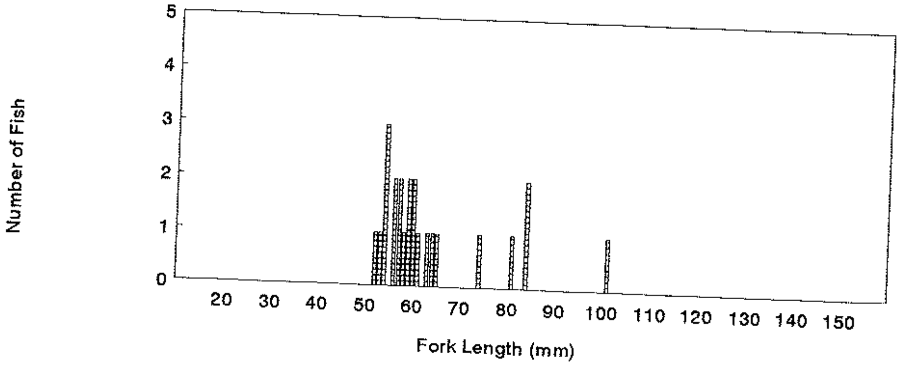
Figure 46. Length frequency distribution of trout and char juveniles captured at electrofishing sites in the Cruickshank River drainage, September–October 1994.



CUTTHROAT TROUT



RAINBOW TROUT



DOLLY VARDEN CHAR

Figure 47. Length frequency distribution of trout and char juveniles captured at electrofishing sites in the Puntledge River drainage, September–October 1994.

For ages 0+ to 2+, computations of mean fish weight, for trout and char combined, are provided in Table 11. As noted, some estimates have been made where captures of specific age groups were lacking. These estimates are based on data from other streams (or stream sections) within the study area. Mean weights are also provided for coho, with similar substitutions where this species was not captured. Although the size of coho does substantially overlap with that of trout and char (Figs. 48 and 49), coho are addressed by a unique model formula, deriving a separate capability estimate (Appendix 3). This is due to their more specialized and restricted habitat requirements (ie. pool or glide with complex bank cover), and surface orientation (R. Ptolemy, *pers. comm.*). In addition, the size of coho in the Cruickshank and Puntledge systems is generally transitional between trout/char fry and smaller parr, although broad overlaps do occur.

For all relevant streams, resultant standing stock capability estimates (fish/m^2) are summarized in Table 12. Again, single combined estimates are provided for trout and char, by age group (size class), and a separate estimate is derived for coho. Chinook salmon have been excluded from the modelling process, since no fish of this species were captured in the 1994 sampling program. Chinook fry often emigrate from streams earlier in the summer, and therefore are not addressed by the fall (low flows) assessment program.

Furthermore, in the absence of captures, no size data are available. This is critical, since chinook (unlike coho) are addressed in the same capability formula as trout and char (Ptolemy, 1992). If there is a substantial overlap in the size of chinook, trout, and char, then all three are modelled collectively. In such case, results for trout/char fry or yearlings in Tables 11 and 12 (and all subsequent analyses) would be altered accordingly. Only if chinook were shown to constitute a distinctly separate size class, would independent capability estimates be appropriate. While a transitional size of chinook, relative to trout fry and parr, has frequently been reported (eg. Chapman and Bjornn, 1969; Everest and Chapman, 1972), the added presence of char can result in much broader overlaps. This is even evidenced for char and coho, within the Comox Lake drainage itself (Figs. 48 and 49). The full implications of this will be discussed in a later section. However, on the strength of these issues, no attempt was made to derive hypothetical data for chinook, in these and following analyses.

4.7 Standing Stock *vs.* Theoretical Capability in 1994

Comparisons between theoretical capability estimates (Table 12) and 1994 standing stock estimates (Table 8) are provided in Tables 13 (Cruickshank drainage), 14 (Puntledge River), and 15 (Toma and Perseverance creeks). For each trout/char size class, and for coho, the 1994 densities are expressed as percentages of corresponding capability estimates. To elucidate trends, site-specific results have also been averaged. Sections are employed, as opposed to reaches, to facilitate discussions, as well as to reflect the functional division of the relevant streams, relative to fish access and production.

Table 11. Mean fish size (weight) for combined age / size classes of trout and char from captures at electrofishing sites in tributaries to Comox Lake, September–October 1994.

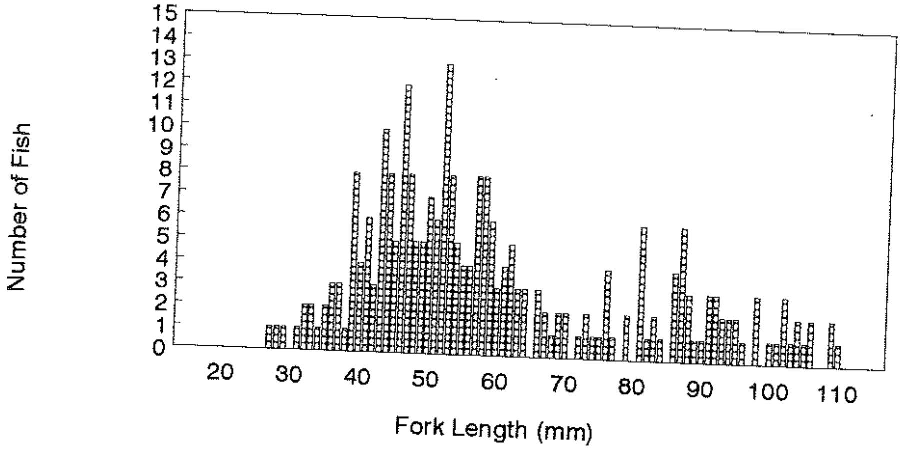
Stream / Section	Data Sources (Site Nos.)	Trout / Char Age 0+		Trout / Char Age 1+		Trout / Char Age 2+		Coho Age 0+	
		Size (g)	*n*	Size (g)	*n*	Size (g)	*n*	Size (g)	*n*
Cruickshank River									
downstream of Eric Creek	1 – 8	1.8	27	10.2	9	29.9	5	3.7	101
upstream of Eric Creek	9 – 12	1.0	27	8.3	14	17.6	8	4.5	1
Comox Creek system	13 – 18	2.5	49	12.5	7	24.9	2	4.9	–
Rees Creek system	20 – 24	1.1	57	7.1	7	18.0	–	3.1	10
Eric Creek system	25 – 27	1.3	6	10.8	19	24.2	4	3.5	59
Puntledge River									
downstream of Willemar Lake	28 – 33	2.5	31	15.1	4	23.6	2	4.9	55
upstream of Willemar Lake	34 – 37	2.0	32	9.2	7	20.0	–	4.5	–
Toma Creek	38 – 40	1.9	22	11.2	16	21.0	2	5.7	1
Perseverance Creek	41 – 42	2.6	10	9.3	2	20.0	–	2.8	192

Note : where there were no captures for a given age/size class (*n* = 0), values have been estimated from the other results.

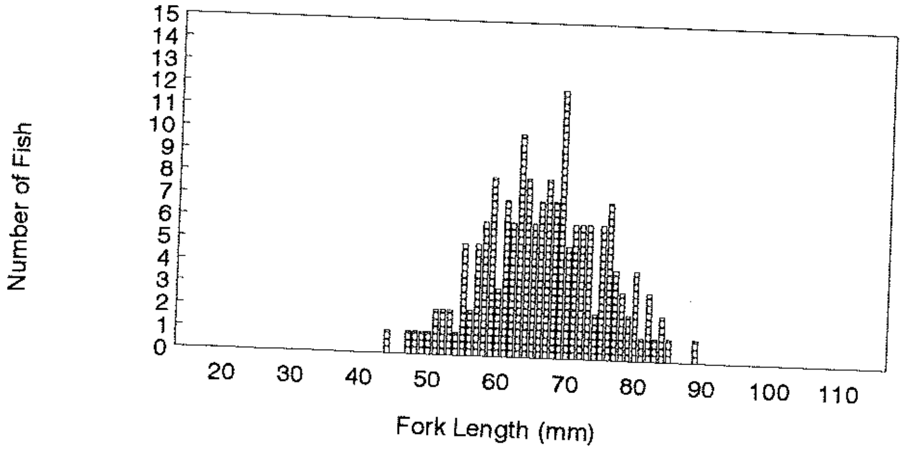
Table 12. Projections of standing stock capability for juvenile salmonids captured within tributaries to Comox Lake, September–October 1994.

Stream / Section	Alkalinity (mg / L)	Theoretical Standing Stock Capability at Low Flows (fish / m^2)			
		Trout / Char Age 0+	Trout / Char Age 1+	Trout / Char Age 2+	Coho Age 0+
Cruickshank River					
downstream of Eric Creek	18.7 *	0.87	0.15	0.05	0.87
upstream of Eric Creek	19.0 *	1.58	0.19	0.09	0.72
Comox Creek	19.0	0.63	0.13	0.11	0.66
Rees Creek	11.0	1.09	0.17	0.14	0.84
Kweishun Creek	16.0	1.32	0.20	0.14	0.98
Eric Creek	17.0	1.15	0.14	0.07	0.89
Puntledge River					
downstream of Willemar Lake	40.0	0.92	0.15	0.10	0.89
upstream of Willemar Lake	14.0	0.68	0.15	0.11	0.64
Toma Creek	56.0	1.43	0.24	0.09	0.88
Perseverance Creek	31.0	0.78	0.22	0.09	1.41

* mean value of 2 or more determinations

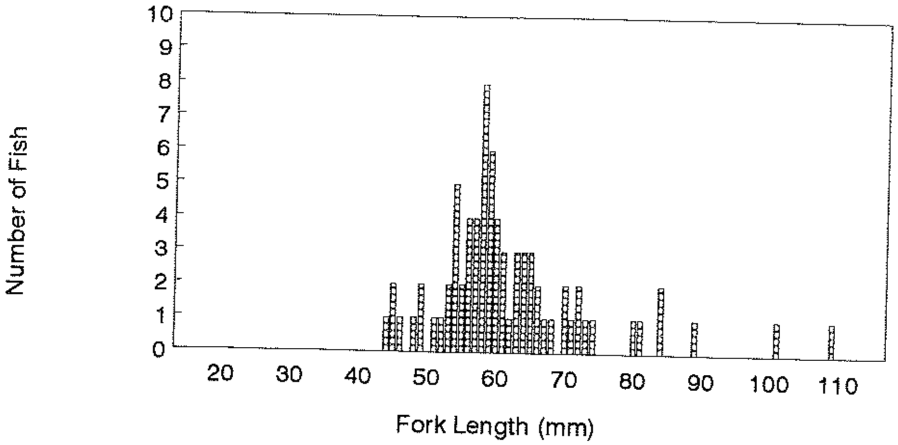


TROUT AND CHAR

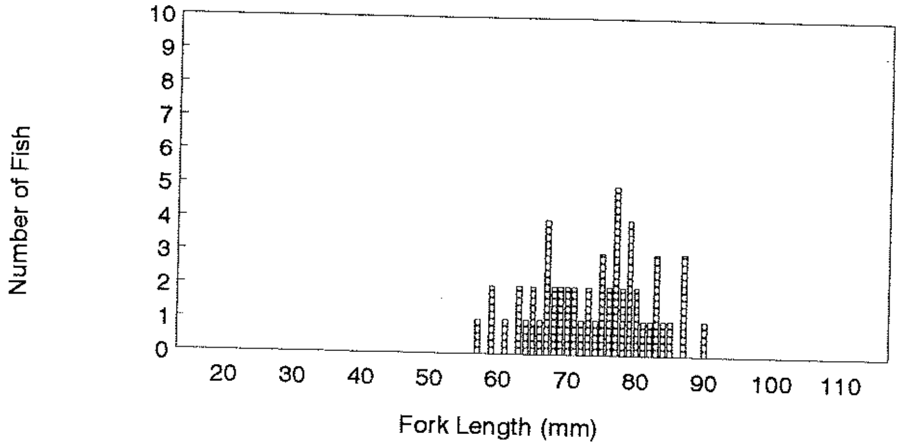


COHO SALMON

Figure 48. Length frequency distribution of trout and char juveniles, compared to coho, from electrofishing captures in the Cruickshank River drainage, September–October 1994.



TROUT AND CHAR



COHO SALMON

Figure 49. Length frequency distribution of trout and char juveniles, compared to coho, from electrofishing captures in the Puntledge River drainage, September–October 1994.

Table 13. Summary of adjusted sampling results (fish/m^2) at representative electrofishing sites in the Cruickshank River and associated tributaries, September–October 1994, compared to corresponding estimates of standing stock capability.

Stream / Section	Site No.	Adjusted Density (fish/m^2)				Percent of Theoretical Capability (%)			
		T/C 0+	T/C 1+	T/C 2+	Coho	T/C 0+	T/C 1+	T/C 2+	Coho
Cruickshank River									
Comox Lake to Rees Creek	1 *	0.06	–	–	5.20	6.9	0.0	0.0	597.7
	2	0.09	–	–	–	10.3	0.0	0.0	0.0
	3	0.25	0.10	–	–	28.7	66.7	0.0	0.0
	4	0.42	0.15	0.06	0.20	48.3	100.0	120.0	23.0
	Mean	**0.21**	**0.06**	**0.02**	**1.35**	**23.6**	**41.7**	**30.0**	**155.2**
Rees Creek to Eric Creek	5	0.22	0.04	0.07	–	25.3	26.7	140.0	0.0
	6	0.18	0.03	–	0.06	20.7	20.0	0.0	6.9
	7	0.68	0.06	–	–	78.2	40.0	0.0	0.0
	8	–	0.03	0.07	0.35	0.0	20.0	140.0	40.2
	Mean	**0.27**	**0.04**	**0.04**	**0.10**	**31.0**	**26.7**	**70.0**	**11.8**
upstream of Eric Creek	9	0.45	0.33	0.10	0.17	28.5	173.7	111.1	23.6
	10	0.12	0.27	0.12	–	7.6	142.1	133.3	0.0
	11	0.27	0.11	0.06	–	17.1	57.9	66.7	0.0
	12 *	0.44	0.04	0.07	–	27.8	21.1	77.8	0.0
	Mean	**0.32**	**0.19**	**0.09**	**0.04**	**20.3**	**98.7**	**97.2**	**5.9**
Comox Creek	13	1.06	0.17	0.04	–	168.3	130.8	36.4	0.0
	14	1.06	–	–	–	168.3	0.0	0.0	0.0
	15	1.76	0.08	0.04	–	279.4	61.5	36.4	0.0
	16	–	–	–	–	0.0	0.0	0.0	0.0
Datsio Creek	18	0.65	0.20	–	–	103.2	153.8	0.0	0.0
	Mean	**0.91**	**0.09**	**0.02**	**0.00**	**143.8**	**69.2**	**14.5**	**0.0**
Rees Creek	20 *	0.73	0.06	–	0.22	67.0	35.3	0.0	26.2
	21	0.53	–	–	0.24	48.6	0.0	0.0	28.6
Kweishun Creek	23 *	0.72	0.03	–	–	54.5	15.0	0.0	0.0
	Mean	**0.66**	**0.03**	**0.00**	**0.15**	**56.7**	**16.8**	**0.0**	**18.3**
Eric Creek	25	0.04	0.17	–	1.16	3.5	121.4	0.0	130.3
	26	0.11	0.29	–	1.08	9.6	207.1	0.0	121.3
	27	0.06	0.33	0.15	2.15	5.2	235.7	214.3	241.6
	Mean	**0.07**	**0.26**	**0.05**	**1.46**	**6.1**	**188.1**	**71.4**	**164.4**

(T/C = trout and char combined)

* sites with > 10% debris and/or other overhead cover

Table 14. Summary of adjusted sampling results (fish/m^2) at representative electrofishing sites in the Puntledge River, upstream of Comox Lake, compared to corresponding estimates of standing stock capability (September–October 1994).

Stream / Section	Site No.	Adjusted Density (fish/m^2)				Percent of Theoretical Capability (%)			
		T/C 0+	T/C 1+	T/C 2+	Coho	T/C 0+	T/C 1+	T/C 2+	Coho
Puntledge River									
downstream of Willemar L.	28 *	0.23	0.03	0.03	0.68	25.0	20.0	30.0	76.4
	29 *	0.60	–	–	6.67	65.2	0.0	0.0	749.4
	30	–	–	–	–	0.0	0.0	0.0	0.0
	32 *	0.86	–	–	0.96	93.5	0.0	0.0	107.9
	33 *	0.36	0.06	0.02	0.71	39.1	40.0	20.0	79.8
	Mean	**0.41**	**0.02**	**0.01**	**1.80**	**44.6**	**12.0**	**10.0**	**202.7**
upstream of Willemar L.	34 *	0.06	–	–	–	8.8	0.0	0.0	0.0
	35 *	0.49	0.10	–	–	72.1	66.7	0.0	0.0
	37 *	0.63	0.16	–	–	92.6	106.7	0.0	0.0
	Mean	**0.39**	**0.09**	**0.00**	**0.00**	**57.8**	**57.8**	**0.0**	**0.0**

(T/C = trout and char combined)

* sites with > 10% debris and/or other overhead cover

Table 15. Summary of adjusted sampling results (fish/m^2) at a representative electrofishing site in Toma Creek, and isolated pools in Perseverance Creek, compared to corresponding estimates of standing stock capability (September–October 1994).

Stream / Section	Site No.	Adjusted Density (fish/m^2)				Percent of Theoretical Capability (%)			
		T/C 0+	T/C 1+	T/C 2+	Coho	T/C 0+	T/C 1+	T/C 2+	Coho
Toma Creek	40	0.91	0.23	0.02	–	**63.6**	**95.8**	**22.2**	**0.0**
Perseverance Creek	41	0.37	0.16	–	22.60	**47.4**	**72.7**	**0.0**	**1602.8**
	42	0.26	–	–	–	**33.3**	**0.0**	**0.0**	**0.0**

4.7.1 Cruickshank River and tributaries

4.7.1.1 Coho

The extremely dense population of coho at site 1, in the lowermost Cruickshank mainstem (Fig. 45), was far in excess of theoretical capability (ie. nearly 600%; Table 13). This single result was sufficient to infer super-saturation (155%) of all of the mainstem, to the Rees Creek confluence, when results for the four relevant sampling sites are averaged (*ibid.*). However, other than at site 1, coho were either absent or at densities well below theoretical capability, at all other sites in the Cruickshank mainstem, including site 2, just upstream (Fig. 45). The same applies to Comox Creek (no coho captured at any site) and Rees Creek. The former is not surprising, since coho fry were not released to Comox Creek in 1994 (Table 3). However, the low densities (relative to theoretical capability) in Rees Creek would not be expected, given the release of 117,000 coho fry to this stream. Results were most surprising at site 20 (Fig. 32), where the density of coho was only slightly in excess of 25% of theoretical capability (Table 13), although both cover (Table 6) and hydraulic conditions (Table 7) were superior for coho.

Results were quite different in Eric Creek, where coho densities exceeded theoretical capability at all three sampling sites (Table 13). Densities were only moderately in excess of theoretical capability (121 to 130%) at the two sites where debris and cutbank cover was lacking (sites 25 and 26; Table 6). At the third, where a modest amount of such cover was present (site 27), the 1994 density was nearly 250% of theoretical capability. For the full sampled length of Eric Creek, collectively, coho densities in 1994 consistently exceeded theoretical capability by an average of approximately 60% overall (Table 13).

4.7.1.2 Age 1+ and older trout / char

Age 1+ trout/char also exceeded corresponding capability estimates at all three sampling sites in Eric Creek, and by an average of 88% (*ibid.*). In the 1994 sampling results, the greatest component of this size class, in usable habitat, was Dolly Varden (ave. 0.17 fish/m^2), followed by rainbow trout (0.06 fish/m^2), and lastly, cutthroat trout (0.03 fish/m^2; Table 8). The same ranking, and similar numerical differences, apply on the basis of total sampled area (Table 5). Dolly Varden also dominated the age 2+ size class (ave. 0.03 fish/m^2 vs. 0.01 fish/m^2 for both rainbow and cutthroat; Table 8). This species/age group was only encountered at one site (site 27), where it exceeded theoretical capability *by* 114% (Table 13). This is attributed to the presence of complex bank cover at this particular site, consistent with similar findings in other systems (Griffith, 1995a)[9].

In the section of the Cruickshank mainstem between Rees and Eric creeks, age 2+ trout/char exceeded theoretical capability at both sites where this age/size class was encountered (140% at sites 5 and 8; Table 13). However, based on all four sites in this section

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[9] The Yalakom River, near Lillooet. Findings relate to bull trout (*Salvelinus confluentus*), formerly considered to be Dolly Varden, in British Columbia.

they averaged only 70% of capability. This was notably higher than the corresponding average for the lowermost section of the mainstem, downstream of Rees Creek (30%; *ibid.*). In the section between Rees and Eric creeks, the 1994 densities of age 2+ fish were equally divided (on average) between rainbow and cutthroat trout (Table 8). No rainbow parr, of any age, were captured in the lower Cruickshank mainstem downstream of Rees Creek (*ibid.*). No age 2+ Dolly Varden were caught at any site, in any section of the Cruickshank mainstem (*ibid.*).

With the exception of the single coho juvenile at site 9 (150m upstream of Eric Creek), rainbow trout was the only species captured in the Cruickshank mainstem upstream of Eric Creek. Both 1+ and 2+ age/size classes averaged extremely close to 100% of theoretical capability for the four sites upstream of Eric Creek (97.2 to 98.7%; sites 9-12; Table 13). Age 1+ and 2+ rainbow substantially exceeded capability estimates, at both sites downstream of the barrier falls on this section of the mainstem (sites 9 and 10; Table 13). Above the falls (sites 11 and 12), densities of both of these age groups were moderately within corresponding capability estimates, at both sites (*ibid.*). The results suggest that densities of rainbow trout, downstream of the falls, may be augmented by populations above. As noted earlier, the latter seem best explained by the stocking of Moat Lake, with rainbow trout, in odd years since 1985 (most recently with 10,000 fry in 1993; D. Stanton, *pers. comm.*[10]). Previous sampling of the Cruickshank River drainage (Caw, 1977a; Russell, 1990) did not indicate the presence of rainbow trout in the system. Based on the abundance of gravel, and numerous fry in Reach 6, immediately upstream of the falls (sites 11 and 12; Table 5), substantial natural reproduction may be taking place here, in addition to presumed recruitment by fish displaced from Moat Lake. Diminished flows and/or freezing, during winter, may prompt the downstream migration of some proportion of the total fry and parr populations, to Reach 5 below the falls.

The natural reproduction of fish originating from Moat Lake, within Reach 5 itself, would add to this phenomenon. At site 10, in Reach 5, an age 3+ fish (141 mm) was found to be a mature female, with loose atrophying eggs, as well as primordia for the following season. An age 2+ fish (128 mm) also revealed eggs, developing for 1995 (Fig. 50). A maturing female rainbow (180 mm) was also captured at site 7, in the Cruickshank mainstem, downstream of Eric Creek (Fig. 51). A mature male cutthroat (189mm) was captured at site 8, just upstream (Fig. 45). In Eric Creek mature cutthroat trout (Fig. 52) and a small ripe female Dolly Varden (Fig. 53) were captured, but the only age 2+ rainbow trout from this stream (Table 8) showed only slight sexual development (male).

4.7.1.3 Trout / char fry

With respect to trout/char fry, the 1994 sampling results were highly uniform, throughout the Cruickshank River mainstem, indicating densities in the order of 20 to 30% of theoretical capability (Table 13). Notable exceptions were the extremely low densities at sites 1 and 2, downstream of Comox Creek (Fig. 45), and the exceptionally high density of rainbow fry at site 7 (Table 8), approximately 2.5 km downstream of Eric Creek (Fig. 20). For all

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[10] Fish Culture Technician, B.C. Fisheries Branch, Victoria.

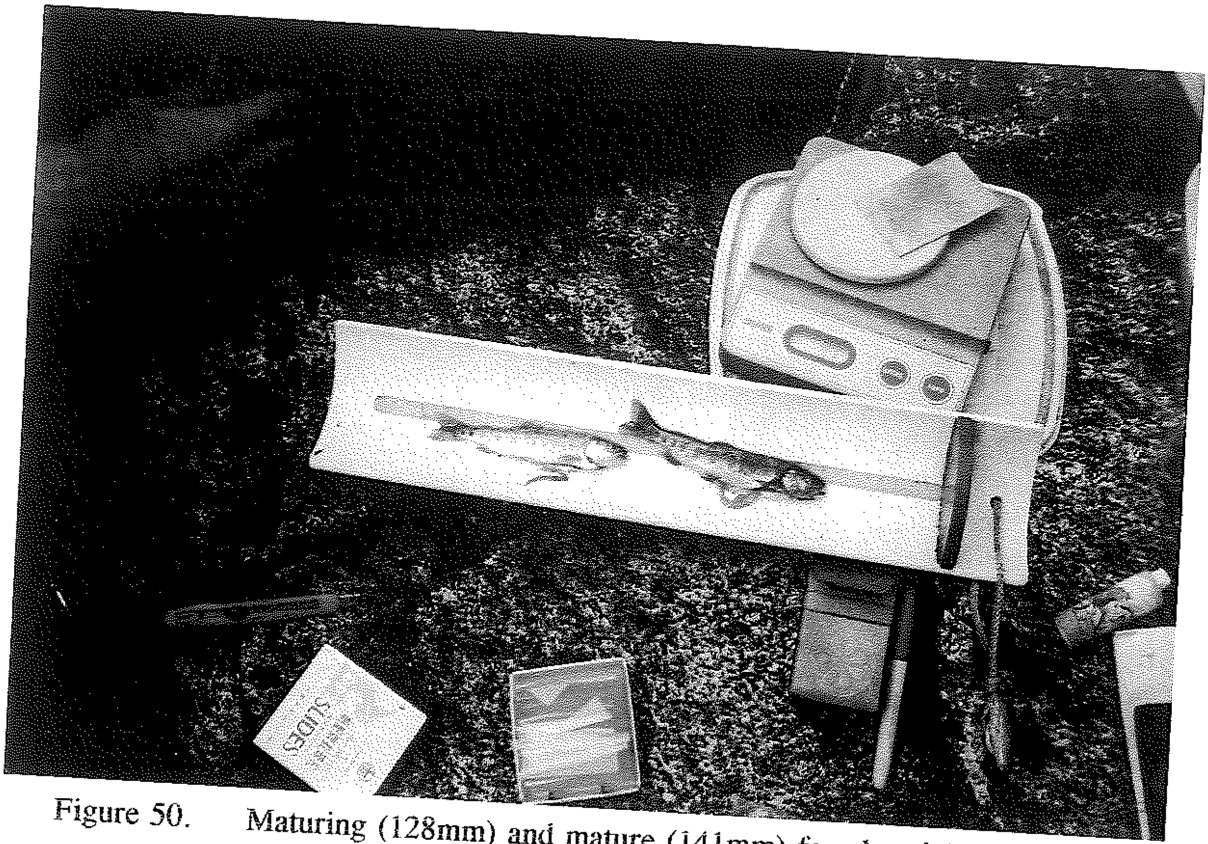

Figure 50. Maturing (128mm) and mature (141mm) female rainbow trout captured at electrofishing site 10, in the Cruickshank River mainstem, Reach 5.

Figure 51. Maturing female rainbow trout (180mm) captured at electrofishing site 7, in the Cruickshank River mainstem, Reach 3.

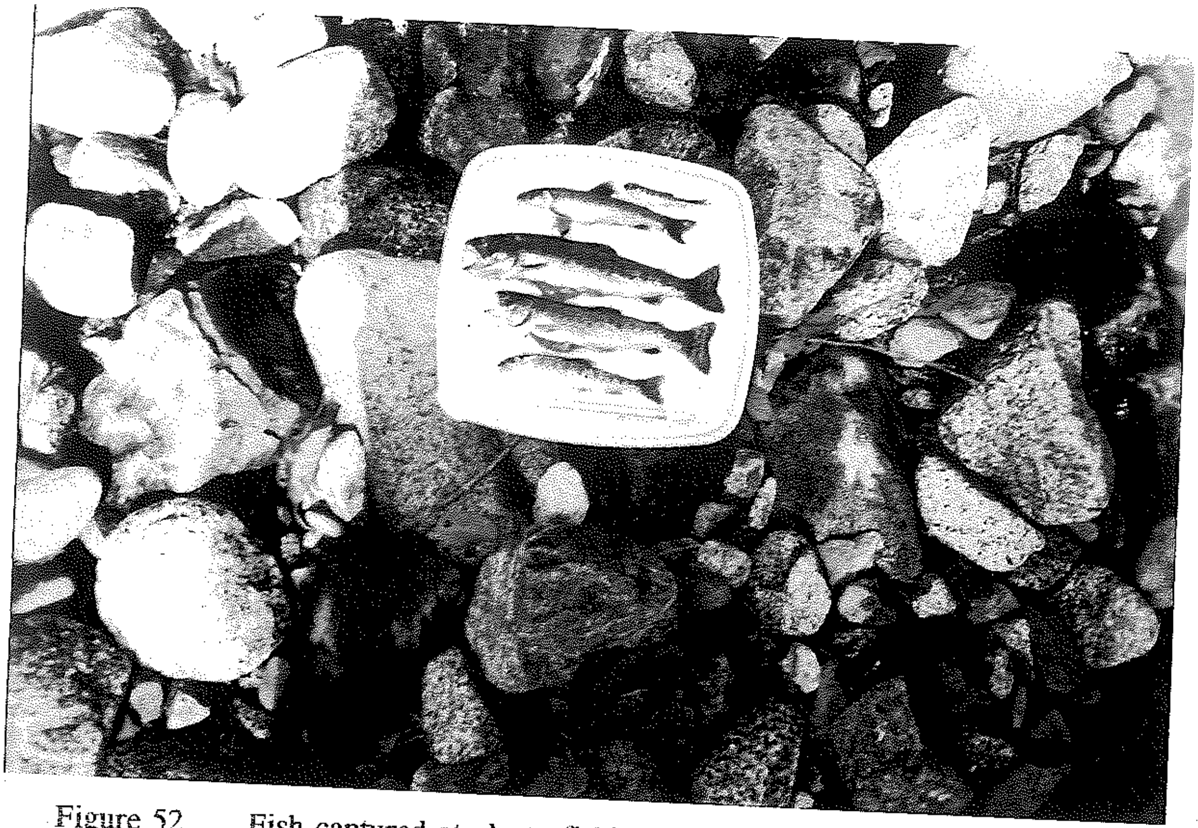

Figure 52. Fish captured at electrofishing site 27 in Eric Creek, showing mature female cutthroat trout (209mm) in centre.

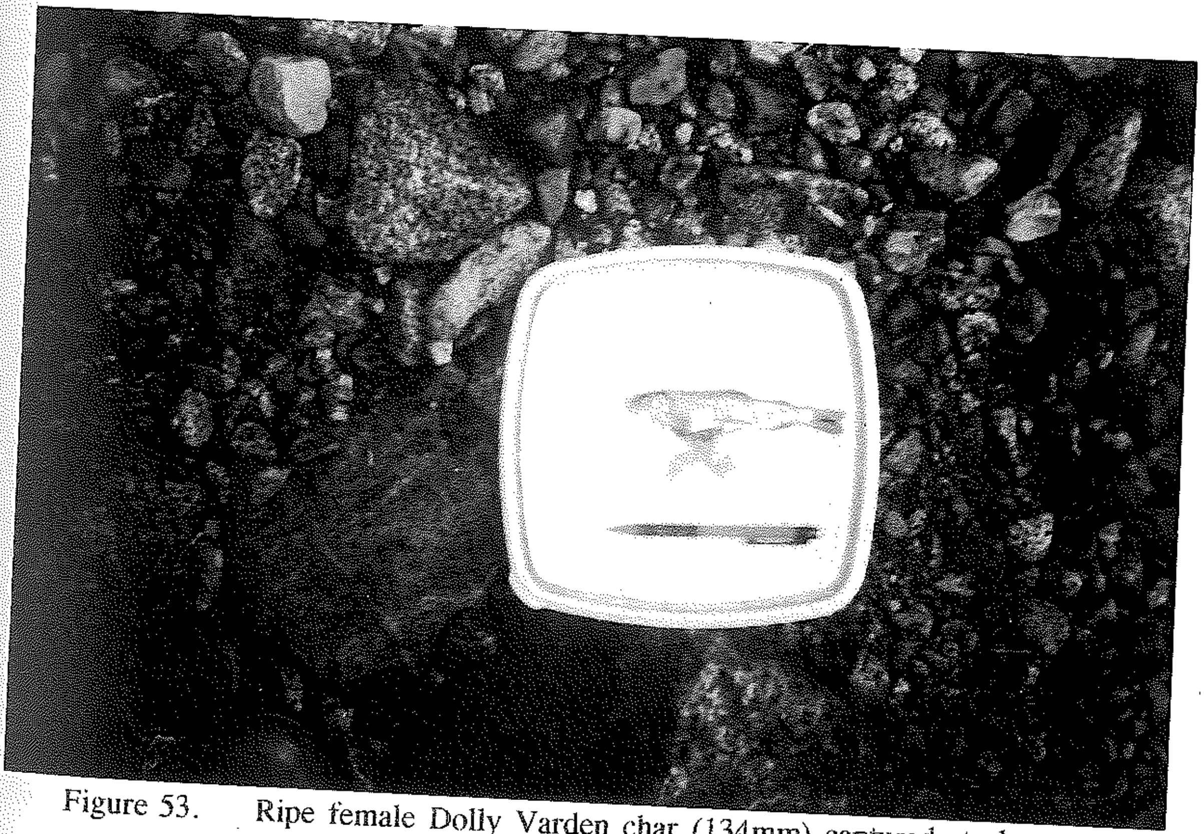

Figure 53. Ripe female Dolly Varden char (134mm) captured at electrofishing site 26 in Eric Creek.

sampling sites in the Comox Creek drainage (including Datsio Creek), 1994 fry densities averaged 144% of theoretical capability (sites 13 to 18; Table 13). However, for the 3 sites in the Comox Creek mainstem downstream of the first falls, at the top of Reach 2 (sites 13 to 15; Fig. 45), fry densities were consistently higher, and averaged very close to twice (205%) the corresponding capability estimates. In each case, fry populations consisted solely of rainbow and cutthroat trout (primarily the latter; Table 8). Parr populations in the Comox Creek mainstem were also composed exclusively of rainbow and cutthroat trout, with the latter predominating (*ibid.*). Age 1+ were most abundant, but it was only at the lowermost site in the system that the 1994 density exceeded theoretical capability (site 13); and for the three sites in Comox Creek downstream of the first falls (sites 13 to 15), the density of age 1+ fish averaged 64% of capability. Age 2+ fish averaged only 24% of corresponding capability. The absence of any fish at site 16 (as well as spot-shocking site 17; Appendix 6) strongly suggests that Comox Creek is barren, upstream of the second falls, at the top of Reach 3 of this system (Fig. 45).

As evidenced by the captures in Datsio Creek (including spot-shocking site 19; Appendix 6), fish production between the two falls (Reach 3) on Comox Creek is likely limited to Dolly Varden char (Table 4). This was the only incidence where an allopatric population of char was encountered, and fry densities were almost precisely equal to the corresponding capability estimate (103%; Table 13). Parr densities were somewhat higher, but were still reasonably close to the estimate of theoretical capability (154%; *ibid.*).

4.7.2 Puntledge River

With the exception of coho, results for the Puntledge River indicate only moderate exploitation of the system, for all size classes of fish (Table 14). As previously discussed, the extreme (and anomalous) result for coho at site 29 (749% of capability; *ibid.*) is highly misleading, as is its influence on the computation of the mean degree of saturation, relative to capacity, downstream of Willemar Lake (203%; Table 14). Excluding this site, coho densities actually averaged 66% of theoretical capability, and only marginally exceeded it at one site (108% at site 32; Table 11).

Debris, cutbank, and other complex bank cover (sites 28 and 32; Table 6; Figs. 54 and 55) did not contain the high densities obtained from such habitat at site 1, in the lowermost Cruickshank River (Table 13; Fig. 15). This is attributed to the much greater abundance of such habitat in the Puntledge River (Table 2), coupled with its short streamlength, compared to the Cruickshank drainage.

Consistent with its lack of cover and complexity (*ibid.*), the short section of the Puntledge River between Willemar and Forbush lakes (Reach 3; Fig. 45) appears to receive little use for rearing of any size classes or species of salmonids (site 34; Table 14), although use as spawning habitat is suspected, given the substantial abundance and diversity of gravels (Appendix 5). Upstream of Forbush Lake, Dolly Varden and cutthroat trout densities were both substantial, and approached or exceeded theoretical capability, with progression upstream

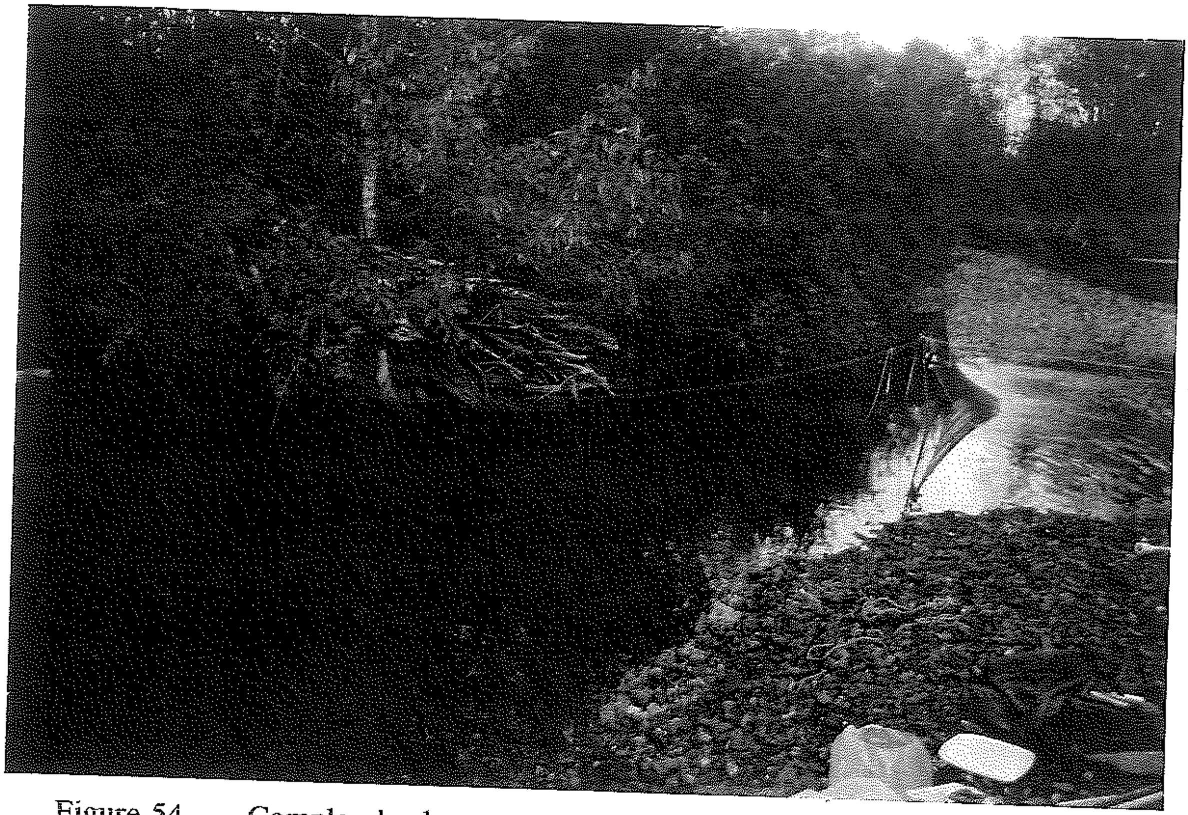

Figure 54. Complex bank cover at electrofishing site 28 in the Puntledge River, Reach 1.

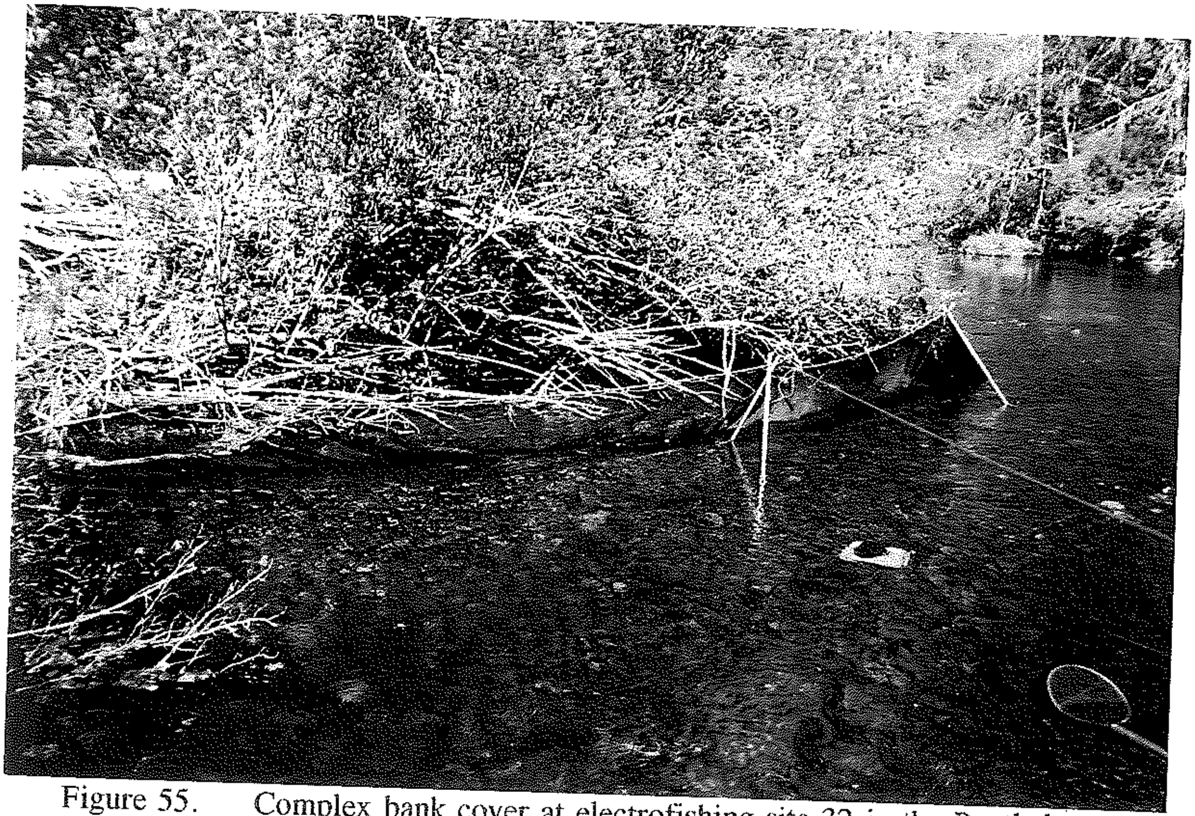

Figure 55. Complex bank cover at electrofishing site 32 in the Puntledge River, Reach 2.

(from site 36 to 37; Table 14). This may be related to gradual dewatering of the channel (and resultant concentration of fish), in the 4 km immediately upstream of Forbush Lake. Consistent with the limitation of hatchery coho releases, to the section of the Puntledge River downstream of Willemar Lake, this species was not captured in complex backwater habitat immediately upstream of Forbush Lake (spot-shocking site 35; Appendix 6). However, coho were captured in similar habitat at spot-shocking site 31 (Table 1; Appendix 6), adjacent to the mainstem downstream of Willemar Lake (Fig. 45).

4.7.3 Toma and Perseverance creeks

Results in the flowing portion of Toma Creek (site 40; Table 15; Fig. 10) were very similar to those in the Puntledge River, upstream of Forbush Lake. Both Dolly Varden and cutthroat trout were present at moderate to high densities relative to theoretical capability. Dolly Varden tended to dominate fish numbers (Table 5). In addition to Dolly Varden and cutthroat, coho salmon were also present at site 39 (Table 1; Appendix 6), the isolated backwater (Fig. 9) adjacent to the dry portion of lower Toma Creek (Fig. 45). However, coho were not present in standing water (Fig. 38), further downstream at site 38 (Table 4; Fig. 45; Appendix 6). Dolly Varden and cutthroat were present, with Dolly Varden apparently dominating fish numbers (Appendix 6).

In Perseverance Creek, the results at site 41 reveal densities 16 times the corresponding capability estimate (Table 15) in the isolated pool habitat at the bottom of the system (Figs. 44 and 45). In comparable habitat upstream (site 42; Table 6), however, cutthroat fry (in allopatry) were present at a density well below theoretical capability (Table 15). Cutthroat trout, and a single Dolly Varden fry (Appendix 6), were also captured at the lower site (site 41; Table 8), at moderate (combined) densities, relative to capability (Table 15). Due to lack of water in Perseverance Creek (Figs. 11 and 12; Appendix 5), it seems inconceivable that these fish could be part of stream resident populations.

Since hatchery coho fry were not released directly to Perseverance Creek in 1994 (Table 3), these fish were either progeny of coho adults released to the lake in 1993 (*ibid.*), and/or immigrant fry, from Comox Lake. The latter would seem most likely, since the rate of adipose clips in the capture (8.9%: Appendix 6) was very close to that for all 1994 hatchery coho at time of release (9.3%). Juvenile immigrations might also apply to the cutthroat and Dolly Varden at the lower site (site 41), but not the upper site (42), which was located immediately upstream of a series of falls impassable to fry (Appendix 1). It seems likely that cutthroat trout, are downstream emigrants from populations associated with Allen Lake, at the top of the system (Fig. 1).

4.8 Cover Type and Abundance *vs.* Hydraulic Suitability

All adjustment of sampled fish densities (and subsequent comparisons to theoretical capabilities) is based on the mean weighted suitability of hydraulic conditions, at each site, for each species/age group of fish. However, equivalent cover availability must also be present, to constitute *fully suitable habitat*, in compliance with the juvenile capability model (Ptolemy, 1992).

Juveniles of all four salmonid species captured in tributaries to Comox Lake, in 1994, share similar *preferences* for pool habitats with debris, cutbanks, and other complex bank cover (literature reviews provided by Griffith, 1979; 1980). Rainbow trout, cutthroat trout, and Dolly Varden char may also rely solely on streambed substrate cover, and faster flowing habitats (*ibid.*; and as evidenced throughout the study area; Tables 4 and 6). Coho may occasionally be found in association with substrate cover, and/or in faster flowing habitats (eg. the individual captured at site 29 in the Puntledge River), but their principal reliance is on pool habitats, with dense bank cover (eg. Glova and Mason, 1977).

Based on the site-specific values provided in Tables 6 and 7, average cover availability at electrofishing sites in different streams and stream sections is compared to corresponding mean weighted hydraulic suitability averages, in Table 16. For trout and Dolly Varden, total cover is the sum of the substrate component (fry or parr), plus other cover (overstream and instream vegetation, debris, cutbanks, etc.). For coho, only the latter is used.

In Table 16, both indices (total cover, hydraulic suitability) are expressed as percentages of total sampled area[11]. The objective is to evaluate the implications of using the hydraulic suitabilities, alone, in adjusting the fish capture results, for comparison to capability estimates. In all comparisons, a 10% (of sampled area) margin of error is allowed for the measurement of the two separate indices. Where discrepancies exceed this margin, relevant entries are boxed in Table 16.

The most consistent discrepancies are for coho in the Cruickshank River system. While suitable cover for this species does exist in some portions of the drainage (eg. lowermost Reach 1; Rees Creek; Table 2), average results (Table 16) reveal a universal inadequacy of cover, relative to hydraulic conditions, throughout the Cruickshank River, and its tributaries. Furthermore, it should be noted that the allowance of a 10% margin of error actually represents ≥ 65% inflation in the assessment of suitable cover for coho (ie. relative to estimates of 0.0 to 15.5% of sampled area; Table 16). However, in addition to the lack of suitable cover, average hydraulic conditions in the Cruickshank River drainage are not highly suitable for coho either (range = 16 to 46%, overall ave. = 30%; *ibid.*).

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[11] These values, like those in Table 6, relate specifically to juvenile habitat at electrofishing sites, and are separate and independent estimates for cover and hydraulics. They should not be confused with the reach averages in Table 2, which jointly consider cover and hydraulics, and address the full wetted width of the given survey section.

Table 16. Comparison of mean estimates of cover availability and weighted hydraulic suitability (both as % of total site area) for electrofishing sites where population estimates were derived in tributaries to Comox Lake, September–October 1994 (boxes identify cases where total cover abundance is *inferior* to hydraulic suitabilty, with a 10% margin for error).

Stream / Section	Substrate Cover (%)		Other Cover [1] (%)	Mean Weighted Hydraulic Suitability (%)						
	Fry	Parr		CT Fry	CT Parr	RB Fry	RB Parr	DV Fry	DV Parr	Coho
Cruickshank River										
Comox Lake to Rees Creek	79	36	12.6	53	$\boxed{67}$	54	$\boxed{62}$	68	$\boxed{76}$	$\boxed{28}$
Rees Creek to Eric Creek	98	63	0.0	44	53	44	50	56	63	$\boxed{22}$
upstream of Eric Creek	51	31	4.7	$\boxed{78}$	$\boxed{71}$	$\boxed{78}$	$\boxed{66}$	$\boxed{90}$	$\boxed{91}$	$\boxed{46}$
Comox Creek	90	54	0.4	52	49	53	45	60	62	$\boxed{21}$
Datsio Creek	95	70	0.0	75	46	75	39	74	78	$\boxed{16}$
Rees Creek	45	25	11.3	46	$\boxed{76}$	47	$\boxed{72}$	$\boxed{69}$	$\boxed{84}$	$\boxed{43}$
Kweishun Creek	90	50	15.5	77	72	77	65	85	$\boxed{88}$	$\boxed{41}$
Eric Creek	92	43	4.8	54	$\boxed{59}$	54	52	63	$\boxed{69}$	$\boxed{26}$
Puntledge River										
downstream of Willemar L.	80	5	32.7	53	$\boxed{62}$	53	$\boxed{58}$	66	$\boxed{72}$	36
upstream of Willemar L.	33	0	42.0	55	$\boxed{81}$	56	$\boxed{76}$	73	$\boxed{80}$	50
Toma Creek	80	40	5.5	56	$\boxed{100}$	56	$\boxed{95}$	82	$\boxed{96}$	$\boxed{70}$

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[1] total of overstream and instream vegetation, logs and debris, roots and cutbanks, etc.

With respect to trout and char, cover in the Cruickshank River system appears to be somewhat inadequate (relative to hydraulic suitability) for parr in the mainstem downstream of Rees Creek, and for all species and size classes in the mainstem upstream of Eric Creek (*ibid.*). The latter is largely attributable to the lack of substrate cover in the meadow area (sites 11 and 12; Table 6), in Reach 6, upstream of the barrier falls (Fig. 45). Conditions are far superior in Reach 5, between the falls and Eric Creek, downstream (*ibid.*). Generally speaking, however, suitable cover for trout/char parr is far less abundant than that for fry, throughout the Cruickshank River drainage (ave. 53% *vs.* 86%, including all cover; Table 16). This is the case for all trout/char species in Rees Creek, and for cutthroat and Dolly Varden (rainbow borderline) in Eric Creek (*ibid.*). In terms of hydraulics, more than 50% of the total sampled area in the Cruickshank system was suitable for all trout and char age/size groups. For all sites in the drainage, overall averages ranged from 56% (hydraulically suitable) for rainbow parr, to 76% for Dolly Varden parr (*ibid.*).

Hydraulic habitat in the Puntledge River is equally suitable for trout and char (53% to 80%; Table 16). The availability of cover for parr is inferior to the hydraulic conditions, both downstream and upstream of Willemar Lake (*ibid.*). Although complex bank cover (debris, cutbanks, etc.) is far more abundant and consistently present in the Puntledge River (Table 2), it does not represent a great proportion of total stream area, and does not compensate for the lack of large bed substrates for trout and char parr (Table 16).

The same does not apply to coho. Allowing the 10% margin for error, bank cover is equal to hydraulic suitability for these fish (on average), both downstream and upstream of Willemar Lake (*ibid.*). Furthermore, average hydraulic suitability in the Puntledge River is somewhat higher for coho than it is in most of the Cruickshank drainage (*ibid.*). However, even within the Puntledge River, a reasonably large stream, hydraulic conditions are more suitable for all size classes of trout and char, then they are for coho (ave. 53 to 80% suitability for trout and char; 36 to 50% for coho; *ibid.*).

At the single flowing sampling site in Toma Creek Reach 2 (site 40; Fig. 45), hydraulic conditions appeared nearly ideal for parr of all trout/char species (95 to 100% suitability), but cover availability was not as suitable (Table 16). Although hydraulic conditions were inferior for fry, cover was more than adequate (*ibid.*). Perseverance Creek is not addressed in Table 16, since results for the isolated pools, that were the only sampling opportunity in this stream, are irrelevant with respect to fish/habitat associations. Such pools represent the *only* habitat available for fish, in this stream, at low flows. The same applies to the standing water encountered in the lowermost section (Reach 1) of Toma Creek (sites 38 and 39; Fig. 45).

It should be emphasized that with only one exception, cover availability was at least equal to hydraulic suitability for trout/char fry, throughout the study area (Table 16). The one exception was the Cruickshank River mainstem, upstream of Rees Creek (*ibid.*). This is principally attributable to the very small size of bed substrates at electrofishing sites 11 and 12 (Appendix 6), in the meadow area of Reach 6. Although there was some bank cover at these sites (Table 6), it was not sufficient to compensate for the lack of streambed cover (eg. Fig. 23).

4.9 Implications with Respect to Fish Stocking in 1994

4.9.1 Coho salmon in the Cruickshank River system

As previously noted, 9.3% of all hatchery coho released to Comox Lake and its tributaries, in 1994, were marked by means of adipose clips. During the 1994 electrofishing within the system, 39 fish were marked, of the total 419 coho captured (Appendix 6), representing precisely 9.3%. It would seem safe to conclude that all coho captured were from the fry releases to the drainage (Table 3). As noted earlier, the proportion of marked coho in the total capture from Perseverance Creek was 8.9%, which strongly supports the earlier speculation that these fish had immigrated from Comox Lake. Major movements of coho fry, from the lake into small tributary streams, have routinely been observed (H. Genoe[12], *pers. comm.*). There is also the possibility that some proportion of the fry in Perseverance Creek were progeny of the natural reproduction of coho adults released to Comox Lake in 1993, particularly as Perseverance Creek is closest to the north (outlet) end of the lake. The possibility of a natural coho component especially applies to the Cruickshank River, to which transported coho adults were directly released in the fall of 1993 (Table 3). This could have contributed to the high densities of coho fry at site 1, in particular. However, this is not supported by the ratio of marked *vs.* unmarked fish in the capture. This ratio was 12.9% at site 1 (Table 5), as opposed to 10.5% at time of release, specific to Cruickshank releases (B. Bengeyfield, *pers. comm.*). Similarly, these results do not indicate the immigration of coho fry from Comox Lake (specific mark rate of 8.3% for fry releases to the lake; *ibid.*). The most logical explanation for all coho in the Cruickshank system is the release of hatchery fry directly to it, and most substantially in Rees and Eric creeks (Table 3).

Regardless of their origin, the large number of coho fry in the small isolated pool at site 41 in Perseverance Creek (192 fish of the 419 coho captured at *all* sites in the drainage; Appendix 6) are clearly indicative of losses incurred within intermittent streams. The high density of coho, concentrated within the pool at site 41 (Table 15), is reflected in the extremely poor condition of these fish (Table 17)[13]. Similarly, condition was relatively poor for the single coho caught in the isolated backwater adjacent to the dry channel of lower Toma Creek (spot-shocking site 39; Appendix 6). Presumably, this fish was also an immigrant from releases to Comox Lake, although it was not marked. However, it is interesting that no coho were captured in the complex standing water at site 38 (Fig. 43), lower in the system, and very close to the lake. This may be related to predation by Dolly Varden and/or cutthroat in view of the high numbers of parr of these species (Appendix 6). This speculation is supported by the corresponding absence of trout/char fry, as well as coho.

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[12] Manager, Puntledge Hatchery, Department of Fisheries and Oceans, Courtenay.

[13] The high numbers of coho at site 41 also indicate the level of potential mortalities in all other former pools, that had totally dried prior to inspection.

Table 17. Summary of fish condition factor ($k \times 10^{-5}$) statistics from all electrofishing captures in tributaries to Comox Lake, September–October 1994[1].

Stream / Section		CT 0+	CT 1+	CT 2+	CT 3+	RB 0+	RB 1+	RB 2+	RB 3+	DV 0+	DV 1+	DV 2+	DV 3+	CO
Cruickshank River														
downstream of Eric Creek	**Mean**	**1.07**	**1.04**	**1.21**	**1.21**	**1.11**	**1.00**	**0.98**	**1.03**	–	**1.04**	–	–	**1.12**
	S.D.	0.11	0.11	0.09	–	0.06	0.00	0.01	–	–	0.18	–	–	0.10
	n	17	4	3	1	10	2	2	1	–	3	–	–	101
upstream of Eric Creek	**Mean**	–	–	–	–	**1.15**	**1.09**	**1.13**	**1.10**	–	–	–	–	**1.26**
	S.D.	–	–	–	–	0.16	0.08	0.10	0.07	–	–	–	–	–
	n	–	–	–	–	27	14	8	3	–	–	–	–	1
Comox Creek	**Mean**	**1.08**	**1.11**	**1.12**	–	**1.11**	**1.00**	–	–	**1.08**	**1.12**	–	–	–
	S.D.	0.09	0.05	0.02	–	0.13	0.01	–	–	0.14	–	–	–	–
	n	40	4	2	–	6	2	–	–	3	1	–	–	–
Rees Creek	**Mean**	**0.99**	**1.10**	–	–	**0.99**	**1.21**	–	–	**0.94**	**0.96**	–	–	**1.19**
	S.D.	0.10	0.11	–	–	0.05	–	–	–	0.06	0.04	–	–	0.14
	n	39	3	–	–	3	1	–	–	15	3	–	–	10
Eric Creek	**Mean**	**0.98**	**1.02**	**1.00**	**1.05**	–	**1.15**	**1.09**	–	**1.06**	**1.14**	**1.12**	**1.27**	**1.19**
	S.D.	0.09	–	–	0.00	–	0.11	–	–	0.17	0.15	0.02	–	0.14
	n	3	1	1	2	–	3	1	–	3	15	2	1	59
Puntledge River														
downstream of Willemar L.	**Mean**	**1.05**	–	**1.03**	–	**1.12**	**1.18**	**1.19**	–	–	–	–	–	**1.19**
	S.D.	0.09	–	–	–	0.15	0.03	–	–	–	–	–	–	0.14
	n	12	–	1	–	19	4	1	–	–	–	–	–	55
upstream of Willemar L.	**Mean**	**1.03**	**0.99**	–	–	–	–	–	–	**1.04**	**1.10**	–	–	–
	S.D.	0.06	0.03	–	–	–	–	–	–	0.13	0.14	–	–	–
	n	6	3	–	–	–	–	–	–	16	4	–	–	–
Toma Creek	**Mean**	**1.11**	**1.06**	**0.97**	–	–	–	–	–	**0.91**	**1.03**	**1.01**	–	**1.11**
	S.D.	0.20	0.09	–	–	–	–	–	–	0.06	0.12	–	–	–
	n	12	5	1	–	–	–	–	–	10	11	1	–	1
Perseverance Creek	**Mean**	**1.06**	**0.80**	–	–	–	–	–	–	**0.70**	–	–	–	**0.91**
	S.D.	0.17	0.19	–	–	–	–	–	–	–	–	–	–	0.06
	n	9	2	–	–	–	–	–	–	1	–	–	–	192

[1] condition factor *k*, in Weight$_g$ = *k* (Fork Length$_{mm}$)^3

Coho condition was also relatively poor in the Cruickshank River mainstem, downstream of Eric Creek (Table 17). Ninety-five (95) of the total 101 coho captured in this section (sites 1 to 8; Fig. 45) were obtained from site 1, where modelling results again indicated over-population of the available habitat (Table 13). The low numbers of coho at all other sites in the Cruickshank mainstem (*ibid.*), the poor overall condition (Table 17), the high occupation of the bank cover at site 1 (Fig. 15), and the limited availability of such cover in most of the mainstem (Table 2), are all indicative of the general lack of suitability of the Cruickshank River, as rearing habitat for coho (Table 16). The single coho captured at site 9, in the Cruickshank mainstem immediately upstream of Eric Creek, exhibited good condition (Table 17). Presumably, this individual was able to find a suitable niche, and was not subject to high intra-specific competition.

In Eric Creek itself, the condition of coho fry (*ibid.*) was also slightly above average, compared to other streams on Vancouver Island, subjected to the same type of assessment (Griffith, 1992; 1993; 1995b). However, the reverse was the case for cutthroat trout, fry in particular (Table 17). Furthermore, only three trout fry were captured at the three electrofishing sites in Eric Creek (Appendix 6). All were cutthroat[14], despite the release of 5,000 steelhead fry to this stream in 1994 (Table 3). In any event, given the well demonstrated dominance of coho fry over both rainbow/steelhead (eg. Hartman, 1965) and cutthroat trout (eg. Glova and Mason, 1977), it seems likely that the low densities of trout fry in Eric Creek were related to the high densities of coho (Table 13); particularly at site 27, where no trout fry were captured (Table 8). However, as reported in the literature (*op. cit.*), and as evidenced by the captures at site 27 in particular, coho are less successful in defending territory against yearling and older trout.

Results in Rees Creek were greatly different from those in Eric Creek. Although the 1994 hatchery releases of both coho and steelhead were similar to those in Eric Creek (Table 3), very few fish of either species were captured in Rees Creek (Table 8). None were captured in Kweishun Creek, but fish were not released to this tributary. Modelling indicated that the 1994 standing stock of all size classes and species of fish was consistently below theoretical capability, at all sampling sites (Table 13). This was especially the case for coho (*ibid.*). Although streambed substrate cover was inferior in the Rees Creek system, compared to Eric Creek, the abundance of bank cover was substantially better, as were the hydraulic conditions for all species/size classes, except trout fry (Table 16). Substantial coho and trout/char parr densities were expected in the relatively complex pool/glide habitat at site 20 (Fig. 32), in particular.

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[14] It is acknowledged that differentiation between cutthroat and rainbow fry is always subject to some level of doubt, especially for smaller individuals. Identification, reported here and elsewhere reflects the dominance of cutthroat characteristics, involving general colouration, fin colouration, parr markings, border of adipose fin, hyoid slashes, head shape, maxillary size, etc. Hyoid teeth (absence/presence) were used as the ultimate criterion for parr (Scott and Crossman, 1973).

Some numbers of fish were probably contained within the various backwaters associated with lower Rees Creek, as in the Puntledge River and Toma Creek systems (sites 31 and 39; Table 4). No opportunities for efficient electrofishing and/or quantitative estimation, for such habitat, were located. However, given the results at site 20, and elsewhere in the Rees Creek system (Table 13), it seems doubtful that substantial numbers of fish would have been found in the backwaters.

The presence of coho at site 1, in the lowermost Cruickshank River is consistent with the release of hatchery fry to this portion of the mainstem in 1994 (Table 3). However, the exceptionally high densities (compared to all other sites in the Cruickshank system) also suggest the added influx of downstream migrants or displacement from the much larger releases to Rees and Eric creeks. As further evidence of this, Eric Creek appeared to be super-saturated with coho fry at the time of investigation in 1994 (Table 13).

The different results for Rees Creek (well below saturation; *ibid.*) are most likely explained by stream temperature. The Aureole Ice Field and Comox Glacier lie at the headwaters of the Rees Creek mainstem and Kweishun Creek, respectively (NTS 1:50,000 topographic map 92 F/11). On September 28, 1994, the temperature of Kweishun Creek was just 7.5°C (Table 6). For Rees Creek, it was 8.5°C (*ibid.*). This compares to corresponding temperatures of 12°C in the Cruickshank River mainstem, and 10°C in lower portions of Eric and Comox creeks (*ibid.*). For both Rees Creek and Kweishun Creek, surface flow of water was interrupted 2.5 to 3.5 km above their confluence, as early as late August 1994 (helicopter overflight). Accordingly, there was no direct influence of fresh meltwater, at the time the above temperature determinations were obtained. If anything, the combined effect of reduced flow and subsurface seepage through bed materials would have meant warmer temperatures, than for continuous surface flows, extending to the headwaters (glaciers).

Coho were released in mid-June 1994 (Table 3), and it is very likely that temperature in the system was below 7°C, at the time. This is accepted as a metabolic threshold for juvenile salmonids, triggering downstream fish movement, notably for coho and steelhead (Bustard, 1973). It is very probable that a large proportion of these fish, abruptly subjected to such thermal conditions (after initial hatchery development), would leave the system. Others might not survive. Wild populations of cutthroat trout and Dolly Varden char may have adapted to the cold thermal regime, so as to exploit the spawning opportunities (ie. significant densities of cutthroat fry in Rees Creek, and both cutthroat and Dolly Varden fry in Kweishun Creek; Table 8). For example, a small redd site was very evident at site 23, in Kweishun Creek, and its vicinity produced numerous newly-emerged cutthroat fry (Appendix 6). Delayed emergence is a survival strategy related to low stream temperatures, as demonstrated by populations of this species in alpine and sub-alpine environments (eg. Griffith, 1994a; 1994b; 1994c).

4.9.2 Coho salmon in the Puntledge River

Based on the 1994 sampling results, there was no indication of excessive standing stock of coho in the Puntledge River, downstream of Willemar Lake, at the time of investigation (early October). Aside from the distorted and misleading results at site 29, coho were found at theoretical capacity at only one location (108% of capability at site 32; Table 14), and averaged only 66% of capability, excluding site 29. In addition, no trout/char size class exceeded theoretical capability at any site, and all densities were low, on average (max. 45%; *ibid.*). Furthermore, for most species and age groups, including coho, condition factors (Table 17) were amongst the best for the drainage, and compare well with those for other Vancouver Island systems (Griffith, 1992; 1993; 1995b). In general, all indications were of stress free fish populations, at moderate densities relative to stream capability, individually and collectively.

4.9.3 Steelhead trout in the Cruickshank River system

As noted above, the absence of steelhead fry in captures from Eric Creek (and near absence of trout fry, altogether) was likely attributable to the high densities of hatchery coho fry. At the time the steelhead fry were released in 1994 (early July; Table 3), coho densities were undoubtedly even higher (relative to habitat capability), than they were at the time of sampling in late September (Table 13). Given the habitat interactions between coho and steelhead fry, and the sub-dominance of the latter (Hartman, 1965), there was likely little capacity to retain the hatchery steelhead fry at the time of their release. The relatively high density of rainbow yearlings (0.06 fish/m^2) in 1994 suggests that fry retention must have been substantially higher in 1993. The same applies to cutthroat and Dolly Varden (Table 8). This is consistent with the smaller releases of coho fry, to Eric Creek, in 1993[15]. Also, only a single age 2+ rainbow was captured in Eric Creek. Others were captured at sites 7 and 8, in the Cruickshank mainstem, immediately downstream (Table 8). These fish could be survivors from the 1992 steelhead fry releases (Table 3), outmigrating from Eric Creek, as would be expected. Since no steelhead releases have been marked in any way, it is not possible to confirm this, and these fish might equally be stream resident. However, despite the clear evidence of a resident cutthroat population in Eric Creek (Fig. 52), and resident rainbow in the adjacent Cruickshank mainstem (Figs. 50 and 51), the same did not apply to rainbow in Eric Creek. All indications, including the absence of age 3+ rainbow (ie. pre-dating first release in 1992; Table 3), suggest that all rainbow trout captured in Eric Creek, in 1994, were attributable to the program of steelhead releases since 1992 (Table 8). The same may also apply to the relatively high densities of age 2+ rainbow, in the Cruickshank River downstream of Eric Creek (Table 16).

In Rees Creek, the absence of rainbow trout parr (Table 8) at electrofishing sites addressing representative habitat, is consistent with the general lack of suitable cover for these fish (Table 16). However, cover was certainly more than ample at site 20 (Fig. 32), as well as site 22, where spot-shocking was conducted in particularly deep bouldery habitat, especially for rainbow parr (Appendix 6). Cutthroat parr were captured at both sites, but only a single rainbow parr was captured, at site 22 (Appendix 6). At sites 21 and 22, only a single rainbow fry was captured (*ibid.*). Only two were captured at site 20 (*ibid.*), but with adjustment on the basis of hydraulic suitability, the density here was far superior to those upstream (Table

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[15] Total releases to the Cruickshank system where 150,438 fry in 1993 compared to 268,755 in 1994 (B. Bengeyfield, *pers. comm.*).

5). In a following section, the 1994 results will be interpreted to show reasonable retention of the 1994 steelhead fry releases to Rees Creek, despite the very low numbers of these fish that were actually captured. There is great potential for error, when comparison is made to another relatively small number; ie. the release size of only 5,050 steelhead fry to this stream (Table 3). The lack of rainbow parr in captures from Rees Creek is not encouraging. It may indicate that hatchery steelhead released to this stream in mid July (*ibid.*) may also be subject to cold temperatures (ie. close to, or below 7°C), with similar consequences to those speculated for coho (eg. emigration and/or mortality).

In 1994, only steelhead fry were released to Comox Creek, and this stream received the largest numbers of such fish (10,500; Table 3). Comox Creek also appeared to contain the most concentrated standing stock of cutthroat fry, in particular (Table 8). A very critical factor in the evaluation of the 1994 results for this stream is the legitimacy of the differentiation and identification of fry of the two trout species, upon which major implications rely. At all sites where trout fry were captured (sites 13 to 15; Fig. 45), larger individuals (ie. > 60mm) could confidently be identified (see footnote 14). However, there was often doubt in smaller specimens (particularly < 50mm), and judgement was influenced by fry that could positively be identified, as well as by parr representation.

Using external characteristics, and the presence of hyoid teeth (or not) as the ultimate criterion, there was no doubt in the identification of age 1+ and older trout. Rainbow and cutthroat parr in the Cruickshank River system are distinctly different in appearance, with virtually no hint[16] of the blended (hybridized) characteristics often displayed by sympatric resident populations in large lake systems (eg. Cowichan Lake; Griffith, 1989). This enabled reliable differentiation of these fish, but in addition to this, it supports the conclusion that all rainbow trout in the system originate from recent stocking (including those in the upper mainstem, undoubtedly attributable to the recent stocking of Moat Lake).

If all identification of trout fry was correct, modelling indicates that fry habitat in the Comox Creek mainstem, below the first falls (Reaches 1 and 2; Fig. 45), was saturated with cutthroat trout in 1994 (Tables 8 and 13). Steelhead fry were far fewer in number, and were concentrated toward the bottom of the system, as might be expected (Table 8). Cutthroat were most abundant upstream (*ibid.*). These implications for fry are supported by the similar findings for parr (*ibid.*). For all five sites in the Comox Creek drainage (including site 18, in Datsio Creek), trout/char fry densities averaged 144% of corresponding theoretical capability (Table 13). However, site 16 was located upstream of the second falls (barrier) on this stream, and was barren of all fish. Furthermore, cutthroat appeared to be restricted to the first two reaches of the system, downstream of the first set of falls (potential barrier, to this species). For the three sites in this section of the mainstem, accessible to migratory cutthroat (sites 13 to 15; Fig. 45), fry densities actually averaged just over 200% of theoretical capability (Table 13), and all were trout (Table 8). No Dolly Varden were captured in the system downstream of the first falls (*ibid.*).

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[16] Some rainbow exhibited faint gold hyoid slashes, but this is common even for allopatric populations.

Since condition factors are at least average, for all species and age groups in the Comox Creek system (including trout fry; Table 17), the 1994 densities may not have exceeded actual capability. Again, no mathematical model can be expected to address all biological contingencies, nor to be precisely accurate in all cases. However, the implications of the modelling exercise, coupled with the apparent lack of rainbow (steelhead) in the system, suggests a limitation of Comox Creek to support the program of steelhead fry releases, on top of what appears to be concentrated natural recruitment of cutthroat trout.

Based on the 1994 findings, Comox Creek may well be a specially important nursery system for cutthroat trout populations in Comox Lake. Any benefits, in terms of steelhead production, could be at the expense of lake populations and production. It may also be that Datsio Creek is a significant spawning/recruitment site for migratory Dolly Varden (Tables 8 and 13). While the first falls on Comox Creek may be a barrier to trout at high spring flows (Appendix 1), migratory char are notorious for their ability to ascend obstructions impassable to other species (McPhail and Baxter, 1994). As with the cutthroat fry in Comox Creek below the first falls, the density of both Dolly Varden fry and parr at site 18 in Datsio Creek again suggests concentrated spawning/recruitment (103% and 154% of corresponding theoretical capabilities; Table 13). It is highly unlikely that Datsio Creek, and the short third reach of Comox Creek (*ca.* 1 km), between the two falls, could support a spawning population sufficient to saturate the habitat in Datsio Creek. However, it is assumed that the excellent and abundant spawning habitat in upper Reach 3 would also be used for the spawning/recruitment of Dolly Varden, likely migratory from Comox Lake.

All indications are that the Comox Creek system may be of particular significance to the production of resident cutthroat trout and Dolly Varden char, likely associated with the lake. The first set of falls appears to partition the system, with concentrated recruitment of cutthroat trout downstream, and Dolly Varden char upstream. Wild fry populations appear to have been at (or above) capacity in both sections, in 1994, and in all respects, continued releases of steelhead fry, to this system, would seem ill-advised. This includes the great possibility of adult steelhead (summer run) ascending the first falls on the system (at most favourable flows), and the associated potential of displacing Dolly Varden from Reach 3 of the Comox Creek mainstem, and/or Datsio Creek.

4.10 Theoretical Capacity for Fish Stocking

In preceding discussions, comparison of 1994 standing stock to theoretical capability was assessed on the basis of weighted usable area. Stream-specific and/or section-specific averages were derived, and compared, on the understanding that all sampling sites were representative (individually or collectively) of habitat in the relevant streams. However, in addition to the area estimates used thusfar, population estimates also include fish numbers (by species and age group) *per meter of streamlength*, at each site (Appendix 6). For the 1994 sampling, these results are summarized in Table 18. In this case, the values are not adjusted on the basis of weighted hydraulic suitability. They are simply the standard estimates of the number of fish at each site, divided by site length (Appendix 6).

Table 18. Summary of unadjusted fish densities (fish per meter streamlength), at electrofishing sites in tributaries to Comox Lake, September–October 1994 (number of banks indicates partial *vs.* full sampling of streamwidth).

Stream / Section	Site	Banks	CT 0+	CT 1+	CT 2+	CT 3+	RB 0+	RB 1+	RB 2+	RB 3+	DV 0+	DV 1+	DV 2+	DV 3+	CO
Cruickshank River															
Comox Lake to Rees Creek	1	1	0.10	–	–	–	–	–	–	–	–	–	–	–	10.14
	2	1	0.24	–	–	–	–	–	–	–	–	–	–	–	–
	3	1	0.46	–	–	–	–	–	–	–	–	0.21	–	–	–
	4	1	0.53	0.40	0.13	–	0.13	–	–	–	–	–	–	–	0.13
Rees Creek to Eric Creek	5	1	0.48	–	0.11	–	–	0.11	0.11	–	–	–	–	–	–
	6	1	0.47	0.11	–	–	–	–	–	–	–	–	–	–	0.11
	7	1	–	–	–	–	1.41	0.12	–	0.12	–	–	–	–	–
	8	1	–	–	0.14	0.14	–	–	0.14	–	–	0.14	–	–	0.62
Rees Creek to barrier falls	9	1	–	–	–	–	1.38	0.58	0.19	0.19	–	–	–	–	0.19
	10	1	–	–	–	–	0.49	1.10	0.49	0.12	–	–	–	–	–
upstream of barrier falls	11	2	–	–	–	–	1.14	0.22	0.11	–	–	–	–	–	–
	12	1	–	–	–	–	0.94	0.13	0.26	0.13	–	–	–	–	–
Comox Creek	13	1	1.83	0.13	0.07	–	0.13	0.13	–	–	–	–	–	–	–
	14	1	1.30	–	–	–	0.55	–	–	–	–	–	–	–	–
	15	1	3.91	0.31	0.16	–	–	–	–	–	–	–	–	–	–
	16	1	–	–	–	–	–	–	–	–	–	–	–	–	–
	18	1	–	–	–	–	–	–	–	–	1.97	0.66	–	–	–
Rees Creek	20	1	0.41	0.14	–	–	0.27	–	–	–	–	–	–	–	0.27
	21	1	0.96	–	–	–	0.09	–	–	–	–	–	–	–	0.26
Kweishun Creek	23	1	1.86	–	–	–	–	–	–	–	1.41	0.17	–	–	–
Eric Creek	25	1	0.11	–	–	–	–	0.11	–	–	–	0.46	–	–	1.14
	26	1	0.19	0.10	–	–	–	0.10	–	–	–	0.19	–	0.10	0.51
	27	2	–	–	0.09	0.17	–	0.09	0.09	–	0.17	1.03	0.34	–	4.57
Puntledge River															
downstream of Willemar L.	28	1	–	–	0.11	–	0.48	0.11	–	–	–	–	–	–	1.72
	30	1	–	–	–	–	–	–	–	–	–	–	–	–	–
	32	1	0.88	–	–	–	0.61	–	–	–	–	–	–	–	2.28
	33	1	0.30	–	–	–	0.20	0.15	0.04	–	–	–	–	–	0.85
upstream of Willemar L.	34	1	0.16	–	–	–	–	–	–	–	–	–	–	–	–
	35	1	0.14	0.14	–	–	–	–	–	–	1.62	0.27	–	–	–
	37	1	0.46	0.20	–	–	–	–	–	–	0.73	0.20	–	–	–
Toma Creek	40	2	0.86	0.14	0.07	–	–	–	–	–	1.13	0.57	–	–	–

In most cases, sampling was limited to the side of the stream (ie. stream width excessive; or mid channel hydraulics excessive for installation/maintenance of stopnets, and/or efficient electrofishing). This approach is also most conducive to the assessment of juvenile fish populations, which tend to be restricted to (and/or prefer) habitats at or near the stream margins (eg. reviews provided by Griffith 1979; 1980). Cases where sampling addressed the full stream width (ie. both banks) are identified in Table 18. In such cases, the result in terms of fish per meter of stream is obviously obtained directly from the length of the sampling site.

In subsequent analyses (ie. Tables 19 and 20), for sites where only one bank was sampled, results were doubled, to estimate and account for the corresponding populations of juvenile fish along the other (unsampled) bank; adjustment is also made for the estimated frequency of mainstem braiding (ie. more than two margins) and/or abundance of side channels (ie. additional streamlength), based on conditions during the 1994 field investigations. Although the sampled densities are not otherwise adjusted themselves, the issue of specific habitat suitability (based on water depth/velocity transects) is addressed in the lineal assessment of fish numbers, through the application of the earlier estimates of 1994 standing stock *vs.* theoretical capability, on the basis of sampled area.

In Tables 13 to 15, 1994 densities of fish (based on area) were expressed as percentages of corresponding theoretical capability, at each site, including full adjustment on the basis of specific hydraulic suitability/usability (weighted usable area), for each species and size class of fish. In Table 19, these percentages (in decimal form) are applied to the lineal sampling results (Table 18), to estimate total potential standing stock at capacity (saturation). Consistent with the capability estimates, trout and char are again dealt with collectively, by size class. In Table 20, the lineal capability estimates are applied to total usable streamlength (at low flows), to generate corresponding estimates of stream-specific and/or section-specific capacity for hatchery fry (coho and steelhead), in addition to wild populations, at full theoretical standing stock capability (ie. 100% saturation).

For steelhead estimates, existing (1994) densities of wild trout/char fry were deducted from the lineal capability estimates, in deriving specific capability for hatchery steelhead. In designating wild production, rainbow fry in Comox and Rees creeks (1994) were assumed to be hatchery steelhead, and were not included in corresponding estimates of wild fish. However, due to the inability to differentiate wild from hatchery rainbow, in the Cruickshank River mainstem, all such fish were designated wild, in order to err on the side of conservatism. Since fry releases, of any species, would be inadvisable upstream of the major barrier falls (> 50m) on the Cruickshank mainstem, results in Tables 19 and 20 address streamlength only as far as these falls. The same applies to the falls on Comox Creek.

The final results (Table 20) indicate a much greater capacity of the Cruickshank River drainage to theoretically accommodate hatchery fish, of both species, compared to the Puntledge River. This is principally attributable to the great disproportion in terms of total streamlength, between the 2 systems.

Table 19. Summary of: 1) average 1994 fish densities; 2) proportion of theoretical capability; and 3) resultant estimates of saturation densities, for different trout/char size classes and coho, in tributaries to Comox Lake.

Stream / Section	Standing Stock in September–October 1994: Sampled Densities (fish / m) T/C 0+	T/C 1+	T/C 2+	Coho	Proportion of Theoretical Capability [1] T/C 0+	T/C 1+	T/C 2+	Coho	Resultant Estimate of Densities at Saturation [2] (fish / m) T/C 0+	T/C 1+	T/C 2+	Coho
(T/C = trout and char combined)												
Cruickshank River												
Comox Lake to Rees Creek	0.73	0.31	0.07	5.14	0.24	0.42	0.30	1.55	3.09	0.73	0.22	3.31
Rees Creek to Eric Creek	1.18	0.24	0.25	0.37	0.31	0.27	0.70	0.12	3.81	0.90	0.36	3.14
Eric Creek to barrier falls	1.87	1.68	0.68	0.19	0.18	1.58	1.22	0.12	10.39 [3]	1.06	0.56	1.58
Comox Creek (below falls)	5.15	0.38	0.15	0.00	2.05	0.64	0.24	0.00	2.51	0.59	0.63	*
Rees Creek	1.73	0.14	0.00	0.53	0.58	0.18	0.00	0.27	2.99	0.79	*	1.93
Kweishun Creek	6.54	0.34	0.00	0.00	0.55	0.15	0.00	0.00	11.89 [3]	2.27	*	*
Eric Creek	0.26	1.01	0.17	2.62	0.06	1.88	0.71	1.64	4.21	0.54	0.24	1.59
Puntledge River												
downstream of Willemar L.	1.24	0.13	0.08	2.43	0.39	0.15	0.13	0.66	3.15	0.87	0.64	3.68
upstream of Forbush L.	2.95	0.81	0.00	0.00	0.58	0.58	0.00	0.00	5.10	1.40	*	*

[1] Capability = 1.00 [2] Saturation = 100% Capability [3] due to very small size of fry in this section in 1994 (Appendix 6) * estimate cannot be calculated

Table 20. Summary of total potential numbers of <u>fall</u> hatchery fry (steelhead and/or coho) in tributaries to Comox Lake, at capacity, based on September–October 1994 investigation (boxes indicate suspected over–estimation, due to lack of adequate cover elements in relevant streams, or stream sections).

Stream / Section	Fall Standing Stock 1994: Hatchery Steelhead (fish / m)	Wild Trout / Char Fry (fish / m) [1]	Theoretical Saturation for Trout / Char Fry (fish / m) [1]	Capability Available for Steelhead Fry (fish / m)	Length at Low Flows (km): Main Channel	Braiding and/or Side Channels	Potentialal Total Numbers of Hatchery Fry in Fall: Steelhead	Coho [1]
Cruickshank River								
Comox Lake to Rees Creek	?	0.73	3.09	2.36	7	+ 10%	18,172	25,487
Rees Creek to Eric Creek	?	1.18	3.81	2.63	7.5	+ 5%	20,711	24,728
Eric Creek to barrier falls	?	1.87	10.39 [2]	8.52	3	+ 0%	25,560	4,740
Comox Creek (below falls)	0.45	5.15	2.51	0	7.5	+ 25%	0	*
Rees Creek	0.36	1.73	2.99	1.26	6.5	+ 50%	12,285	18,818
Kweishun Creek	0.00	6.54	11.89 [2]	5.35	2.5	+ 10%	14,713	*
Eric Creek	0.00	0.26	4.21	3.95	6	+ 15%	27,255	10,971
Puntledge River								
downstream of Willemar L.	0.00	1.24	3.15	1.91	3.5	+ 40%	9,359	18,032
upstream of Forbush L.	0.00	2.95	5.10	2.15	4	+ 30%	11,180	*

[1] based on values in Table 19 [2] see footnote 3, Table 19 ? unknown proportion (if any) of sampled populations of rainbow trout * estimate cannot be calculated

4.10.1 Coho salmon

4.10.1.1 Rees and Eric creeks

Consistent with earlier discussions, results for coho are most profound. Total potential for hatchery fry in Rees and Eric creeks (site of 1994 releases) is estimated at approximately 18,800 fish and 11,000 fish, respectively (Table 20). Acknowledging that these are fall numbers, and that 1994 releases were conducted in early summer (Table 3), nonetheless the release sizes (117,000 fry to each system) appear to have been excessive. Even at 50% survival (release to fall sampling), the viable streamlength of Eric Creek should have produced nearly 8.5 coho fry per meter (8.45/m, including braiding and side channels), as opposed to the average of just over 2.6 fry/m that was obtained from sampling (Table 19). Assuming 50% survival from mid-summer release to fall standing stock, the 1994 results (lineal capability estimates; Table 19) indicate that release sizes should not have exceeded 37,600 fish for Rees Creek (total potential x 2; Table 20), and 21,900 fish for Eric Creek (same calculation). However, in the case of Rees Creek, where conditions (temperature?) appear to limit retention of coho below theoretical capability levels, releases should probably be limited to no more than approximately 10,300 fish, twice the standing stock in the fall of 1994. At the same time, there is no guarantee that even these numbers would remain in the system, if the speculation about adverse temperatures is correct.

4.10.1.2 Cruickshank River mainstem

Based on hydraulic conditions (water depths and velocities) alone, the Cruickshank River mainstem should theoretically be able to support by far the largest total numbers of coho fry in the drainage (eg. nearly 55,000 fish, downstream of the barrier falls; Table 20). Accordingly, if surplus fry from the 1994 releases to Rees and Eric creeks were displaced from these streams, a greater number should have been accommodated in the Cruickshank mainstem. Assuming 50,000 emigrants from each release (figures above would suggest a much higher number), and 50% survival to fall sampling, mainstem densities of coho fry should easily have reached the theoretical saturation level of approximately 3 fish/m (Table 19); this was certainly not the case for the 7.5 km between Rees and Eric creeks (0.37 coho/m; Table 19).

The average sampled density for the lowermost 7 km of mainstem, downstream of Rees Creek, significantly exceeded the 3 coho/m projected above (5.14 fish/m; Table 19). However, this is almost entirely attributable to the results at a single site (10.14 coho/m at site 1; Table 18) addressing complex bank habitat (debris, cutbanks, etc.), that was more abundant in the lowermost 3.5 km of the river. Although mainstem hydraulic conditions, at low flows, may be relatively suitable for coho fry, the type(s) and abundance of cover elements are not. Accordingly, capability estimates based on hydraulics alone (Tables 19 and 20) over-estimate the mainstem's capability to accommodate coho.

All 1994 results suggest an exodus (and/or mortality) of coho fry, following releases to Rees and Eric creeks, and lack of retention within most of the Cruickshank mainstem, due to the prevailing absence of suitable cover. No doubt, the high densities of such fish, in suitable but limited habitat near the mouth of the system (site 1; Table 13), reflects a great concentration of fish displaced from upstream, possibly in addition to fish released to this section of the mainstem itself. These conclusions are also supported by the greatly different results for coho in the Puntledge River. With an abundance of complex bank cover close to hydraulic suitability (Table 16), coho fry were found in good densities (relative to capability), at nearly all sites sampled (Table 14). The exception (site 30) was a featureless glide[17] that lacked suitable cover for coho fry (Table 6), and did not produce salmonids of any species (Table 5).

4.10.1.3 Puntledge River

In assessing the average standing stock, per meter of streamlength, for the 1994 sampling in the Puntledge River (Table 19), the highly distorted results at site 29 have again been excluded. With this adjustment, sampled densities of coho fry averaged 66% of theoretical capability, at remaining sites (including site 30) in the Puntledge River mainstem (Table 14). Adjusting the sampled lineal density (ave. 2.43 coho/m) on this basis, it is estimated that the system can support 3.68 coho/m, at capacity. These adjustments, based solely on hydraulic conditions, are deemed valid for the Puntledge River, given the near equal abundance of suitable cover. However, even with more frequent braiding and side channels, the limited length of the Puntledge River, downstream of Willemar Lake (3.5 km), results in relatively low capability for total standing stock of coho fry (ie. 18,000 fish; Table 20). This is far less than that required to accommodate the 95,238 hatchery coho fry, released to this section in 1994 (Table 3).

Based on the mean sampled density of coho (2.43 fish/m; Table 19), the estimated total standing stock in the Puntledge River, downstream of Willemar Lake, was only 11,907 fish; including braids and side channels; this suggests the departure (or mortality) of roughly 83,000 hatchery fry. In view of such levels of over-seeding, it is interesting that all sampling sites were not over-populated (relative to capability), as was site 1 in the lowermost Cruickshank River mainstem, and the 3 sites in Eric Creek (Table 13). On the other hand, if results for the coverless habitat at site 30 in the Puntledge River are excluded (in addition to site 29), the densities of coho at the remaining sites averaged very close to full capability (88%).

The abundance/availability of suitable cover in the Puntledge River and the Cruickshank drainage, relative to the numbers of fish released, is also significant. As postulated above, the limited complex bank cover in the lowermost 3.5 km of the Cruickshank mainstem likely served as a receptacle for major emigrations from the 234,000 coho released upstream (to Rees and Eric creeks; Table 3). Even in this portion of the system, the abundance of such cover is far less than it is in the similar length of the Puntledge River, downstream of Willemar Lake (Table 2). Particularly with a smaller release to the latter system (95,000 fry; Table 3), a far lower concentration of fish might be expected. Accepting limitations of the modelling process, as well as sampling procedures and interpretations (eg. coho capture at site 29 by chance, or

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[17] Sampled to ensure representative coverage of all habitats in the Puntledge River. Such habitat is common, particularly in the lowermost 1.5 km of the river.

not), it may be possible that coho fry densities in the Puntledge River were at capacity, or close to it, when sampled in the fall of 1994. Given the relatively short streamlength in total (3.5 km), equilibration (relative to capability) was likely complete, prior to fall sampling. In the much larger Cruickshank system, however, the densities in Eric Creek suggest that equilibration was ongoing, causing severe and progressive crowding of fish in the limited amount of suitable habitat at the bottom of the Cruickshank mainstem.

As a final note, the results of sampling in Perseverance Creek clearly illustrate the fate of potentially large numbers of hatchery fish released to (and/or immigrating into) streams with intermittent flows. In addition to extremely poor condition of the fish in the isolated pool at site 41 (Table 17), the dense numbers were an obvious target to predation (eg. abundant heron prints were observed); and again, the most severe implications were for the many other pools in the system with porous substrates, that were completely dry, and likely stranded *thousands* of fish as flows diminished, and nearly all of the stream dried entirely.

4.10.2 Steelhead trout

4.10.2.1 Comox Creek

Given the conservative releases of hatchery steelhead fry (total 20,600 in 1994; Table 3), compared to coho (234,000 to the Cruickshank system alone), it is not surprising that results for the former were not so profound. In fact, in the absence of marking, much of their fate is hard to ascertain. The 1994 sampling results suggested the over-saturation (relative to theoretical capability) of available trout/char fry habitat, in the 7.5 km of Comox Creek, downstream of the first falls (sites 13 to 15; Table 13). Proportions of cutthroat fry *vs.* steelhead fry, in Comox Creek, are somewhat in doubt, due to the inherent difficulties of differentiating between smaller fry of these species. An earlier assessment of the system (Russell, 1990) indicated relatively low densities of cutthroat fry, but only a single site was investigated. The 1994 results suggest that the section of Comox Creek downstream of the first falls was saturated with the recruitment of wild cutthroat fry (Table 20). On average, the lineal density of steelhead fry appeared to be 0.45 fish/m (*ibid.*); this results in a total estimate of 4,219 fish, when applied to the streamlength of 7.5 km, including consideration of braiding.

While the reduction from a release size of 10,500 fry might be accounted for by natural mortality (ie. close to 50%, hypothesized earlier), some emigration may also be indicated, given that the stream appears to have been at capacity for trout fry, with the natural recruitment of cutthroat. However, no major displacement is evidenced, given the particularly low densities of trout fry (all cutthroat), at sites 1 and 2 in the Cruickshank mainstem, downstream of Comox Creek (Table 8). While the absence of trout fry at site 1 might be explained by the extremely high numbers of coho fry, the same does not apply to site 2, cobbly/bouldery habitat, unoccupied (characteristically) by coho (Appendix 6). It is possible, however, that some numbers of displaced fish may have been accommodated in the 2 km of the Cruickshank mainstem between these sites, and the confluence of Comox Creek (Fig. 1).

It is also possible that displacement (and/or mortality) of steelhead fry was not as severe as preceding estimates might suggest. Accepting that some numbers of steelhead fry may have been incorrectly identified as cutthroat, the total number of steelhead fry might have been considerably higher than the 4,200 fish estimated above. Based on the results in Table 19, the total standing stock of trout fry (cutthroat and steelhead combined) in the 7.5 km of Comox Creek, below the first falls, is estimated at 48,281 fish. If only 20% of these were steelhead, in the fall of 1994, this would clearly account for the summer release of 10,500 fish. At the same time, however, results did consistently indicate over-saturation of this system (below the first falls) with trout fry. Accordingly, some displacement and/or stress might be expected, for both the wild cutthroat and the hatchery steelhead.

A final observation for Comox Creek has to do with parr numbers. As noted earlier, species differentiation was conclusive for these fish, and once again, steelhead were considerably fewer in number (Table 8), and were apparently restricted to the lower portion of the system (site 13 only; Fig. 45), as were steelhead fry (sites 13 and 14); this tends to support the speculation that cutthroat vastly dominated fry numbers, as initially reported (Table 8).

4.10.2.2 Eric Creek

In Eric Creek, the total absence of steelhead fry at all sampling sites, is particularly interesting, especially as the release size of 5,050 fish was well within the theoretical capability for steelhead fry in this system (Table 20). It may be explained by chance, given a theoretical average density of only 0.73 fry per meter of streamlength, from stocking 5,050 fish to this stream, including consideration of braiding and side channels; however, cutthroat fry were also very few (Table 8). These results suggest displacement of trout fry (of both species), cohabiting with coho juveniles at high densities (Table 13). On the other hand, densities of age 1+ trout were high, compared to those of fry in 1994. As noted earlier, this would be explained by smaller coho releases in 1993. However, including Dolly Varden, the 1994 standing stock of age 1+ fish exceeded theoretical capability at all 3 sites in Eric Creek, and by an average of 88% (Table 13). If age 1+ steelhead are excluded from the population estimates (Table 8) and the above calculations, age 1+ cutthroat and Dolly Varden (combined ave. 0.21 fish/m^2) still exceed theoretical capability (0.14 fish/m^2; Table 12) by 50%. In fact, Dolly Varden alone (ave. 0.12 fish/m^2; Table 8) represent 86% of the total estimated capability for age 1+ fish. Accordingly, stocking of steelhead may be in conflict with wild production in this stream as well. Implications may be most severe for the cutthroat and Dolly Varden parr, given that the availability of suitable cover appears to be slightly more limiting to these species, than to steelhead (Table 16).

4.10.2.3 Rees Creek

At face value, results for steelhead fry in Rees Creek appear to be equally poor to those for coho fry (Table 8). However, at the mean 0.36 steelhead fry per meter, obtained from sampling, the flowing portion of Rees Creek contained an estimated 3,510 steelhead fry (0.36 fish/m x 6.5 km x 1.5 braiding and side channels). This represents nearly 70% of the summer release of 5,050 fish, and may be a reasonable outcome for a particularly cold stream. The release size is well within the theoretical capability for steelhead fry (Table 20).However, caution must be exercised in evaluating the results for fry, in view of the low numbers involved (captures and release size). In addition, no steelhead parr were captured at representative sites (Table 5). On the other hand, one such fish (95mm; age 1+) was captured in particularly deep and complex habitat (substrate cover) at spot-shocking site 22 (Table 1), indicating some survival/retention from earlier releases. Furthermore, the capacity for steelhead fry in Rees Creek may be limited by cover availability for parr (Table 16), so that the capacity indicated in Table 20 may be indirectly excessive (as indicated in the table). The same applies to portions of the Cruickshank mainstem, and all of the Puntledge River, as is also indicated in Table 20.

The 1994 results indicate better success of the steelhead releases, in exploiting the under-utilized habitat in Rees Creek, compared to coho. Certainly, hydraulic conditions and cover type/abundance are more suited to steelhead fry, than they are to coho (Table 13). In addition, hatchery trout fry often show an exceptional tolerance of (and adaptability to) cold water conditions (eg. Griffith, 1994c).

5.0 DISCUSSION

5.1 Methods Used and Reliability of Results

There are inherent limitations to any single point-in-time assessment of freshwater fish populations and their habitat. In the 1994 study of the Comox Lake drainage, the scope and depth of data collection were extensive. However, many estimates had to be made, and even though the data are numerous and diverse, they are no more than a collection of samples and observations from a broad continuum in time and conditions. In addition, all methods of data collection and analysis are subject to their own constraints, and none are perfect, nor totally accurate. Furthermore, no matter how extensive the data base, there is always the risk that various considerations may be overlooked, under-estimated, or misinterpreted during either the collection or analysis of the data.

However, the reality of resource management is that decisions must be made despite such limitations. The key responsibility is to provide the best possible interpretation and understanding of key issues and dynamics, to enable the most appropriate management decisions, based on the information at hand. In terms of the information itself, the ideal is a balanced compromise between detail, precision, and scope. By virtue of necessity, one is usually at the expense of another. In this study of Comox Lake tributaries, it is felt that an adequate balance was achieved, although it may always be argued that more information would be most desirable, or that any given estimate (or methodology) may not be entirely accurate. The key point is that the methodologies used in this study have enabled an understanding and interpretation of fish production in the system, that would not have been possible in their absence. The fact that the various approaches to different issues converge on the same logical conclusions is the ultimate testament to their value.

Mathematical models have been used to allow the requisite comparison of sampled fish numbers/densities to theoretical capability estimates in this assessment of the Comox Lake drainage. It must be accepted that no such model will be precise in all applications, or highly accurate in any given case. With respect to the Ptolemy (1992) capability model, it is based on thousands of data sets specific to B.C. streams. The same applies to the B.C. Environment probability of use data (and spreadsheet) used in association with it. Both are based upon, and address, a wide range of stream sizes, and relate to habitat usability (as opposed to preferences) under an even greater range of conditions. They are based on actual fish densities sampled over this broad range, and provide a meaningful estimate of habitat capability specific to British Columbia salmonids. However, limitations of the model must be acknowledged in evaluating the results presented in this study. This applies especially to Dolly Varden. In this case, the preliminary hydraulic suitability data, and subsequent stream modelling (R.P. Griffith and Associates), were principally based on data from the U.S. Fish and Wildlife Service, and may be less reliable in applications to B.C. streams. However, relatively few fish of this species were captured, and accordingly, any associated error would be minimal.

The most fundamental aspect of the field data is the manner in which they are collected, and how accurately they reflect the true conditions and dynamics of the system under investigation. In highly intensive investigations of salmonids and their habitat, the desire for results of maximum possible resolution may necessitate exhaustive and detailed sampling procedures, at any given site (eg. Bovee, 1994). From a program perspective, such intensity directly limits the number of sites that may be addressed within the resources (time, budget) available for any given investigation. The trade-off between sampling intensity and *scope* is particularly critical in the assessment of entire drainages, such as that conducted for the tributaries to Comox Lake. The first objective must be a strategic inventory to identify, as fully as possible, all important fish populations and habitat resources within the system. Hence, the scope of the investigation is of key importance, and Figures 8 and 45 clearly demonstrate a wide distribution of sampling effort within the drainage.

In terms of intensity, in any given locale, a second trade-off must be made between diversification and replication of sampling. As indicated in Table 4, the emphasis in fish sampling throughout the Comox Lake drainage was on sites representative of *average* habitat conditions of the given stream or stream section. As warranted, specific habitats were sampled to address specific issues; notably, rigorous tests of species presence at most favourable sites, given absences elsewhere. Although site-specific replication was sacrificed, in order to maximize the scope of the investigation, the spacing of representative sampling was kept as close as possible, in order to provide a *continuum* of replicates.

Conditions and influences vary from site to site, even within distinct stream reaches. Accordingly, differences would be expected between representative sites at any different locations. However, in the assessment of stream populations, as employed for the Comox Lake system, results are always standardized on the basis of *usable habitat*, by virtue of the modelling process. Consequently, results should directly reflect the broad issues of population dynamics (ie. recruitment/exploitation of suitable habitat) as they affect any given site. The indicated dynamics should make sense, with results at one site supporting the next, progressively, throughout the drainage. The closer the spacing between sites, the more they should support each other, and more accurately reflect the associated dynamics (Poole, 1974).

As outlined in preceding sections, results of the 1994 investigation of the Comox Lake drainage reflect the above, with consistent trends both within and between different data sets. Generally speaking, data are mutually supportive, and enable interpretation of the dynamics of fish production within the system. It is fully acknowledged, however, that such interpretation is greatly limited by the restriction of most data to a single point in time.

Lastly, a very critical issue in the collection of field data, particularly by electrofishing, is the care with which the sampling is actually conducted. For sites where population estimates are to be derived, the most important factor is the efficient and *unobtrusive* installation of stopnets. This involves careful selection of the site to be sampled, ensuring the ability to successfully install nets, while adequately addressing representative habitat conditions. In the Comox Lake drainage, extreme care was exercised in this regard. Stopnets were always fed out from the downstream end of sites; were quietly extended from the shore, and then upstream; were sealed across the top end; and were pinned closely to the stream bottom with rocks, in addition to lead lines. To favour speed and efficiency in this process site areas were kept relatively small (primarily 25-50m^2), as long as all requisite habitat features were adequately represented. This approach does not only ensure utmost confidence in the capture results at all sites, it also enables the greatest number of sites and utmost confidence overall.

5.2 Major Implications of 1994 Results Relative to Stream Capability

For the most part, results of the 1994 assessment indicate that the majority of fish populations were below theoretical capability, in streams tributary to Comox Lake. Cases where standing stock did exceed corresponding capability estimates, on a routine basis, are mostly attributable to stocking with hatchery coho fry. Where modelling indicated extreme cases of over-saturation with fish (eg. sites 1 and 41; Tables 13 and 15), this was also confirmed by poor fish condition, as well as low numbers (or absence) of sub-dominant species/size groups.

In the isolated cases indicating saturation of stream capability with *wild* populations alone, the standing stock estimates rarely exceeded 150% of corresponding capability estimates: eg. rainbow parr in the Cruickshank River mainstem, upstream of Eric Creek; Dolly Varden in Datsio Creek; cutthroat and Dolly Varden fry and parr at site 37, in the Puntledge River upstream of Forbush Lake (Tables 13 and 14). These findings generally attest to both the validity and reasonable accuracy of the modelling procedures.

A possible exception to the above is the result for cutthroat fry in Comox Creek, particularly at site 15 (279% of corresponding capability estimate; Table 13). However, with the makeup of parr captures (ie. no rainbow) influencing recording of small trout fry as cutthroat, these results may be misleading. Some of the smaller fish may have been hatchery steelhead fry, adding to the over-saturation at this site, as well as at the other sites in this stream (Tables 8 and 13). All other cases where severe over-saturation was indicated (ie. > 200% theoretical capability) were clearly attributable to hatchery releases.

All indications of the 1994 field program suggest that the stocking of coho in both the Cruickshank drainage and the Puntledge River appears to have been excessive in 1994. Compared to the release of > 95,000 fish to the Puntledge River downstream of Willemar Lake, in 1994, the total capability (at low flows) was estimated at just over 18,000 fish (Table 20). Similarly, compared to the release of > 117,000 coho fry to both Rees Creek and Eric Creek in 1994, corresponding capability estimates were just 18,800 fish and 11,000 fish, respectively (*ibid.*). In Eric Creek, coho densities in 1994 (Table 13) appear to have resulted in the displacement of trout fry (sub-dominant), including hatchery steelhead, which were also released to this system in 1994.

Results consistently suggest emigration of coho fry from all streams where they were released in 1994. The retention of coho super-saturation in Eric Creek (Table 13), is consistent with ongoing displacement on a density-dependent basis, with progressive decline in stream discharge (and total wetted area). In contrast, the very low densities in Rees Creek (*ibid.*) suggest some form of severe physical constraint. Although data are few, cold water temperatures (ie. likely <7°C at time of releases, and/or afterwards) seem the most plausible explanation.

Due to a lack of suitable cover (in particular) and hydraulic conditions, coho fry were not significantly accommodated within the Cruickshank River mainstem in 1994, except in the lowermost 3.5 km (downstream of Comox Creek), where some amount of complex bank cover is present (Table 16). The great concentration of coho fry in this habitat (site 1; Table 13) is indicative of the large numbers of fish displaced from Eric and Rees creeks, and not retained further upstream in the mainstem. This influx was in addition to the 33,000 hatchery fry released to this portion of the mainstem itself. The poor condition of fish at site 1 (Table 17) reflects the stress associated with severe over-crowding.

In comparison to the Cruickshank system, the Puntledge River downstream of Willemar Lake contains far superior habitat for coho juveniles (Table 16). The total capability of this stream section is limited by its short length (3.5 km), and restriction of fish cover elements to the stream margins (Figs. 39 and 40). Consistent with this, fall 1994 sampling results indicated the displacment of large numbers of hatchery fish from this stream.

From a biological perspective, excessive coho releases can be harmful to other stream populations of fish; eg. the profound lack of trout fry in the presence of excessive coho densities in Eric Creek (Table 13). It is also possible that the great numbers of surplus coho, passing through the Cruickshank and Puntledge river mainstems, following their release, may explain variably low trout fry densities. This is supported by the higher trout fry densities throughout Comox Creek (Table 13), the Puntledge River upstream of Willemar Lake (Table 14), and Toma Creek (Table 15); the only stream sections sampled that were not subject to coho releases in 1994.

It is unknown to what extent populations of piscivorous cutthroat trout and Dolly Varden predate upon juvenile coho in Comox Lake. However, given that large numbers of coho fry are released directly to the lake, in addition to those obviously displaced from the Cruickshank and Puntledge systems, predation certainly seems a plausible explanation of poor adult returns from releases (B. Bengeyfield, *pers. comm.*). This is particularly likely, since an earlier assessment of the drainage (Russell, 1990) concluded that other food resources, for predaceous fish in the lake, may be limited. As evidence of this, very few non-salmonids were captured during the 1994 investigation of streams (Table 4).

5.3 Further Evaluation of the Coho Fry Stocking Program

Clearly, the most significant findings of the 1994 field program, in the Comox Lake drainage, related to the releases of hatchery coho fry, their fate, and their apparent impacts on native stocks (including attempts to restore summer steelhead). Indications were that numbers released to all streams were excessive, relative to habitat capability (carrying capacity), in 1994. Earlier studies of Comox Lake and its tributaries (eg. Caw, 1977a; 1977b; Russell, 1990) did not approach the level or intensity of assessment conducted in 1994. However, even the limited sampling by Russell (*op.cit.*) indicated that future coho stocking rates *should be conservative*, to avoid over-exploitation of resources within the drainage.

The detailed investigation in 1994 indicated that the total theoretical carrying capacity of the Cruickshank River system (excluding Comox Creek), and the Puntledge River downstream of Willemar Lake, was just under 104,000 coho fry, at low autumn flows (Table 20). This compares to a total release of just over 362,000 hatchery coho, in mid June 1994 (Table 3). Even assuming 50% natural mortality from release to late September (ie. 164,750 survivors), this still represents over 1.7 times the total number of fish that could theoretically be supported. Furthermore, most of the capacity estimates derived for coho are likely over-estimates, since cover availablity was limiting (relative to hydraulic suitability), in most cases (Table 16).

The concept of stocking (outplanting) hatchery coho in Comox Lake and its tributaries was initially proposed with the development of the Puntledge Hatchery (Marshall, 1972; 1974). Since 1980, a model by Marshall and Britton (1990) has often been used to determine coho outplanting rates. Accordingly, efforts were made to compare projections, from this model, to those obtained from the 1994 field assessment, for the Comox Lake drainage (Table 20).

The Marshall and Britton (*op. cit.*) model is an equation predicting coho smolt yield, based solely on *accessible* streamlength or area, by virtue of two constants derived from regression analyses (Table 21). According to the model, projections are based on the stream as a whole (not by reach), and separate values are generated by total streamlength and area. For relevant tributaries to Comox Lake, both results are provided in Table 22. However, the authors report inferior estimates using area, for streams > 20,000m^2. This applies to all relevant streams in the Comox Lake drainage (*ibid.*), and accordingly projections based on streamlength would be favoured. Comox Creek has been excluded from Table 22, due to the established moratorium for coho releases to this specific stream (J.C. Wightman[18], *pers. comm.*). The section of the Puntledge River upstream of Willemar Lake has been included, due

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Table 21. Predictive model for coho carrying capacity of streams, in terms of smolt numbers (Marshall and Britton, 1990).

Model Equation : $y = ax^{b}$

Where :

y = coho smolt numbers

x = length (km) or area (m^2)

a = 1134.3 for length; or 3.1001 for area

b = 1.1507 for length; or 0.7899 for area

to its relative suitability of habitat, for coho (Table 16), but is treated separately, given the presence of Willemar and Forbush lakes.

In terms of area estimates, the model does not specify what width measurement (flow stage) is appropriate. In Table 22, mean channel width (Table 2), and full channel length (of usable stream gradient) have been employed, assuming bank-to-bank wetted width, and no interruptions of surface flows, at the time of fry releases. In order to derive fry equivalents from smolt numbers, a *fry to smolt* survival rate of 10% was employed. Bams (1991) reports a range of 0 to 20% as typical for survival from release to smolt, for coho outplanting programs. Unfortunately, no mean is provided, but recent biostandards (B.C. Environment, 1994) give a rate of 8% for coho. Data are available for coho smolts leaving Comox Lake (B. Bengeyfield, *pers. comm.*), but use of these data would be inappropriate, due to the presence and influence of the lake itself (differential survival, predation, etc.), and the lack of direct relevance to the tributary streams (ie. 1994 indication that most coho fry are displaced or emigrate to the lake, soon after release).

Based on the range of projections (length *vs.* area) from the above procedure, the 1994 releases of coho fry to the Cruickshank and Puntledge systems (*ibid.*) might be viewed as being within theoretical carrying capacity for coho, employing the Marshall and Britton (1990) model. However, given that greatest reliance should be placed on the projections based on streamlength (*ibid.*), 1994 releases to Rees and Eric creeks might better be viewed as marginally excessive, and that to the Puntledge River (downstream of Willemar Lake) grossly excessive, even using this procedure (Table 22).

Table 22. Theoretical coho carrying capacity for streams tributary to Comox Lake, based on standards provided by Marshall and Britton (1990).

Stream	Reach [1]				Numbers Based on Stream Length		Numbers Based on Stream Area		Releases in 1994
	Number	Length (km)	Width (m)	Area (m^2)	Smolts	Fry	Smolts	Fry	
Rees Creek	1	2	13	26,000					
	2	2	11	22,000					
	3	3	12	36,000					
Total		7		84,000	10,646	**106,459**	24,047	**240,472**	117,111
Eric Creek	1	1.3	14	18,200					
	2	4	18	72,000					
	3	1.2	10	12,000					
Total		6.5		102,200	9,776	**97,757**	28,076	**280,764**	117,111
Cruickshank River mainstem									
	1	7	35	245,000					
	2	4	20	80,000					
	3	1.5	20	30,000					
	4	2	15	30,000					
	5	3	12	36,000					
Total		17.5		421,000	30,556	**305,557**	85,901	**859,006**	0
Puntledge River (to Willemar Lake)	1	1.5	20	30,000					
	2	2	20	40,000					
Total		3.5		70,000	4,795	**47,950**	20,822	**208,218**	95,238
Puntledge River (Willemar Lake to Red Pillar Creek)	3 & 4	1	10	6,000					
	5	3.5	9	31,500					
	6	7.5	8	60,000					
Total		12		97,500	19,794	**197,944**	27,051	**270,514**	0

[1] measurements premised on flows at time of release (June; Fig. 3)

[2] beyond range of values provided

Even if all 1994 (and previous) releases were within the projections based on the Marshall and Britton (*op.cit.*) model, as applied here, shortcomings in the procedure would nonetheless raise serious concerns. Firstly, in terms of habitat suitability to coho specifically, there is no comparison between the Cruickshank and Puntledge rivers (Table 16), and yet the two are treated equally, using the Marshall and Britton (*op. cit.*) methodology, which is based on streamlength and/or area only. In addition, the model (in terms of fry numbers) relies heavily on a theoretical survival rate to smolt, from release. Variation in smolt size, between systems, is not addressed. Furthermore, and equally important, there is no consideration of native fish populations, their numbers, and/or existing levels of habitat exploitation.

Alternate and more precise methodologies of assessing fish populations and carrying capacity in streams (eg. Bovee and Cochnauer, 1977) were in their infancy, when the Marshall and Britton (*op. cit.*) model was first developed. However, results of the 1994 assessment of tributaries to Comox Lake have demonstrated that coho release rates, moderately supported by this model, may be excessive.

5.4 Steelhead Fry Stocking

Much of the preceeding discussions might also apply to the recently initiated program of summer steelhead fry releases to the Cruickshank drainage, if they were conducted in the same kind of numbers as those for coho. The numbers are greatly smaller (Table 3), but even so, a variety of evidence suggests that even these low numbers of fish may be excessive.

The prime example is Comox Creek, where the standing stock of trout fry appeared to be well above theoretical capability at all sites sampled below the first falls on this system. Although results may be inaccurate as to exact proportions of cutthroat *vs.* steelhead fry (differentiation of smallest individuals), results for parr, coupled with those for fry, suggest that this stream section is important to wild cutthroat production. Consequently, with super-saturation of fry habitat, as indicated in 1994, the releases of steelhead fry may result in negative impacts on wild trout production (fry, at least) in this stream.

The retention of all trout fry, in Eric Creek, may be subject to the impacts of large coho fry releases. However, modelling results also indicate that the theoretical standing stock potential for age 1+ fish in this stream is exceeded by wild trout/char production alone. The addition of steelhead yearlings (1993 releases) contributed to over-saturation, by nearly 90% of theoretical capability (Table 13).

Rees Creek is the one case where steelhead fry releases seem to be of minimal concern, relative to wild production. While there may be some concern about low water temperatures in this system, it was estimated that nearly 70% of the 5,050 fry released to this stream in 1994 were present at the time of fall sampling. This estimate is subject to particular error, due to the low numbers of fish used to generate it. Superior success in Rees Creek may be attributable to 1) the apparent lack of success (retention) of coho releases to the system, and

2) the relatively low use/exploitation of available habitat by wild trout and char. Although numbers of wild fish (notably cutthroat fry) are moderately high (Table 8), the size of fish is small, consistent with the cold temperatures of this stream (Tables 9 and 10). Consequently, substantial capability (based on fish size; Ptolemy, 1992) is available to accommodate hatchery steelhead (Table 13). However, releases to Kweishun Creek should probably be avoided (as in the past), in order to safeguard the natural recruitment of both cutthroat and Dolly Varden (Table 8).

In addition to continued releases to Rees Creek, consideration might be given to direct releases of steelhead fry to the Cruickshank River mainstem. Although hydraulic conditions may be somewhat limiting to steelhead fry in some portions of the mainstem (Table 16), its superior size nonetheless results in substantial capacity to accommodate steelhead fry (*ca.* 39,000 to Eric Creek; Table 20). Such releases may not be advisable in the mainstem upstream of Eric Creek, even though the capacity for additional fry theoretically exists here as well (Table 13). In the 3 km downstream of the major falls in this section of the river, rainbow parr populations appeared to be at capacity in 1994 (sites 9 and 10; *ibid.*). Furthermore, cover availability for fry may limit capability below the estimate in Table 20, which is based on hydraulic suitability only (Table 16). Lastly, it would not seem advisable to stock the remaining 2.5 km of usable streamlength above the barrier falls. Although rainbow trout in the mainstem downstream are best explained by displacement from Moat Lake (ultimately), rates of survival over the >50m falls may be low. Furthermore, such displacement may reflect seasonal (eg. winter) over-crowding of habitat above the falls, and/or harshness of winter conditions (cold temperatures, freezing). In addition, if steelhead imprinted on specific conditions upstream of the falls, returning adults might persist in attempts at passage, to the detriment of spawning success.

5.5 Chinook Stocking

Since no chinook juveniles were captured in the 1994 assessment of the streams tributary to Comox Lake, requisite data are not available to project potential stream capabilities and relevant numbers of fish, for this species. However, generally speaking, hydraulic conditions were consistently less suitable to chinook juveniles than to trout fry and/or parr, throughout the study area (Table 7). On the other hand, they were consistently superior for chinook, compared to coho (*ibid.*). Assuming similar utilization of cover by chinook and trout juveniles (eg. Chapman and Bjornn, 1969; Everest and Chapmen, 1972), conditions should be adequate for this species (as they are for trout) in much of the Cruickshank system (Table 16). However, cover availability may be limiting for chinook fry (typically equivalent to small trout parr), especially in the Puntledge River and Toma Creek (*ibid.*). Although the same may apply to some portions of the Cruickshank River (*ibid.*), it seems safe to conclude that it offers the greatest potential for chinook, as it does for steelhead (Table 20). This conveys the same concerns about release sizes and locations, for chinook, as previously discussed for coho and steelhead. Future releases of all species must be compatible with each other (relative to total carrying capacity), and equally important, wild stocks as well. Any massive releases of chinook, similar to those of coho, could have significant consequences to steelhead (Bjornn, 1978).

5.6 Significance of the Dam at the Outlet of Comox Lake

The major significance of the storage dam at the outlet of Comox Lake. relative to the drainage upstream[19], was its preclusion of historic fish migration, until an effective fishway was provided in 1991. Assuming that this fishway can now efficiently pass adult salmon and steelhead, the presence of the dam is of relatively little significance, with respect to the lake and its tributaries. What is more significant is the potential extension of species distribution (eg. coho, winter steelhead), as a result of fish passage improvements at natural barriers (Stotan and Nibs falls) downstream of the lake. At present, all adult salmonids are prevented from further upstream passage, at the hatchery facilities adjacent to the diversion dam on the Puntledge River, 4 km downstream of Comox Lake (Fig. 1). Should adults be allowed past this facility in the future, the dam at the outlet of the lake could represent the only remaining barrier to the extension of species distribution into the upper watershed.

Greatest concerns may relate to winter steelhead, which could conceivably dilute the summer run stock, and/or outcompete the latter, due to larger numbers of winter run fish (Rimmer *et al.*, 1994). Since winter run steelhead have not been introduced to the upper watershed in any hatchery releases (ie. no imprinting), it may be that adult fish would not stray above the lower Puntledge River (S. Rimmer[20], *pers. comm.*). However, should this prove not to be the case, selective closure of the fishway in the dam at the outlet of Comox Lake may provide the ultimate line of defence. The same might apply to coho. In this case, the proportion of the adult run, surviving release as fry in the upper watershed, would definitely be expected to ascend the fishway in the outlet dam, and seek the streams of their release. It might be possible to preclude this through fishway closure, on the ground that natural coho production is not documented for the upper watershed, under historic conditions. This position could only be supported if the ongoing program of hatchery fry releases (and adult transportation to the upper watershed) was also terminated. This seems unlikely, as well as potentially counter-productive to the overall fisheries values of the Puntledge system, as a whole. In fact, allowance of natural coho passage and production is perhaps the most appropriate approach to the future production of this species, in the upper watershed.

5.7 Alternate Enhancement and Management Options

The detailed assessment in 1994 indicated the potential impacts of coho releases to the Cruickshank River system, as conducted in 1994 (and previously). All results suggest that anything above the numbers of fish indicated in Table 20 could be detrimental to wild trout and char. Furthermore, values in Table 20 do not include consideration of chinook, which should also be restored to the Cruickshank system, if historic conditions are to be re-established. On the other hand, the Puntledge River to be the case, selective closure of the

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[19] It is acknowledged that implications, as part of the overall hydroelectric developments, are quite different with respect to the lower Puntledge system, downstream of the lake.

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fishway in the dam at the outlet of Comox Lake may downstream of Willemar Lake seems most suited to coho (Table 16), and of only moderate significance to the production of wild stocks (Tables 8 and 14). To compensate for the great impacts on fish habitat and production, throughout the Puntledge system (Rimmer *et al.*, 1994), it would seem justified to promote this particular potential for coho, as some level of compensation for the species.

The most appropriate approach to future production of coho, in Comox Lake and its tributaries, would be to allow natural ascent and reproduction of adults accuring from past fry releases. With major cutbacks on hatchery fry production and releases (or their elimination), greater numbers of adult coho would presumably be available for natural passage over the dam, at the outlet of Comox Lake. If the program of fry releases to the upper watershed has been successful, a portion of the total adult return would be expected to undertake such migration naturally.

The ratio of marked *vs.* unmarked coho in the 1994 investigation did not indicate significant natural recruitment from adults liberated to Comox Lake and the Cruickshank River in 1993 (the incidence of marked fish in the total capture of coho was precisely the ratio for the total fry release). However, there is no guarantee that any of the transported adults had originated from the upper watershed, would home on suitable spawning habitat, or successfully reproduce. Presumably, fish originating from releases to the upper watershed would successfully home and reproduce, but subsequent fry recruitment would only be as significant as the number of such adults, and the success of their pairing and reproduction.

If figures are not already available, it would be extremely worthwhile to obtain an estimate of the numbers of adult coho that might be expected, at the present time, to ascend into Comox Lake, and reproduce naturally within its tributaries. Again, this should include consideration of adult numbers spared by cutbacks in (or elimination of) fry releases to the upper watershed. Theoretically, if numbers of adults are adequate, natural spawning should ultimately result in the full recruitment of the streams tributary to Comox Lake, consistent with their carrying capacities for the species.

The greatest risk of this approach would be the possibility of naturally-originating impacts of coho fry (ie. over-abundance), similar to those indicated from the fry releases in 1994. However, if the 1994 results and their interpretation are accurate, and the associated theory (species-specific habitat capability) is legitimate, natural equilibrium should soon be established. Although some level of natural coho production might be expected in the Cruickshank River system (Table 20), this would theoretically be controlled by the general lack of suitable cover for juveniles of this species (Table 16). Accordingly, the principal value of this system for wild trout and char, and the restoration of steelhead and chinook, should be emphasized. Natural coho production would most likely be concentrated in the Puntledge River (*ibid.*). For the section of this river downstream of Willemar Lake, risks with respect to trout and/or char production would seem to be minimal, as previously noted.

There is the additional risk, however, that natural coho production might extend further up the Puntledge River system, particularly in view of the abundant gravels (Table 2) and suitable rearing conditions (Table 16) in the section upstream of Forbush Lake. This could be to the possible detriment of cutthroat trout and Dolly Varden char, in this portion of the system (Table 14). Presumably, the latter provide recruitment to populations in Forbush and Willemar Lakes (Osmund-Jones and Carmichael, 1979a; 1979b), which might decline. On the other hand, this might result in superior growth/size of lake adults, particularly with the addition of coho fry as prey.

The development of natural return and spawning of coho, as proposed here, must entail subsequent monitoring of stream populations, to ensure biological acceptability relative to all stocks in the drainage. This should be undertaken in any event, particularly if hatchery fry releases are continued; and even if such releases are drastically cut back, as recommended here, on the strength of the 1994 assessment.

Ideally, ultimate management of chinook salmon and summer steelhead, in the upper watershed, should aim towards the same reliance on natural ascent and reproduction, as proposed for coho. However, with critically low numbers of both stocks, ongoing fry release programs will obviously be required for the time being. It would be most advisable to consider steelhead fry and chinook fry equally, collectively, and cooperatively, in prescribing release rates, relative to the theoretical stream capabilities (for steelhead) provided in Table 20. With subsequent monitoring, and collection of specific data from chinook juveniles, further modelling may be used to determine more precise capabilities for this particular species.

5.8 Habitat Enhancement Relative to Other Management Requirements

The greatest shortcoming of habitat in tributaries to Comox Lake, is the drying of many streams, at low flows, either partially or entirely (eg. Figs. 5 to 8). This, and the potential consequences to fish, were best illustrated in Perseverance Creek in 1994 (Figs. 11 and 12). However, drying of the upper portions of Rees Creek, Kweishun Creek, and the Puntledge River, upstream of Forbush Lake (Fig. 4) must also impact on fish production. Short of storage facilities and delayed releases in these systems, there are no realistic opportunities to improve these conditions.

Another constraint to migratory fish production is the number of natural barriers on different streams (Appendix 1). Certainly, modification of the falls at the top of Cruickshank River Reach 5, and those at the top of Comox Creek Reach 3, would not be feasible, even if it could be justified. On the other hand, it would certainly be possible to modify the smaller falls at the top of Comox Creek Reach 2, in order to facilitate fish passage (Appendix 1). However, in this case, the apparent allopatry of Dolly Varden, upstream of these falls (Table 8), might be detrimentally affected. In addition, there may be little advantage to other stocks, given the short length of Reach 3 (1 km), its principal value as spawning habitat (Fig. 27), and the apparent saturation of fry habitat in Reaches 1 and 2, downstream (Table 13). A more detailed evaluation should be completed, before any modification of the falls is considered further. The implications with respect to Dolly Varden may be most important, since recruitment of this species seems to be concentrated in relatively few areas within the drainage. With respect to the falls on upper Perseverance Creek (Appendix 1), there would be no advantage to modifying them, due to the near total drying of this stream, at low flows.

The availability of spawning habitat does not seem to be a major limiting factor in any stream sections investigated in 1994 (Table 2). As previously emphasized, however, the abundance and/or type of cover is variably limiting to different species and/or age groups, throughout the drainage (Table 16). Attempts might conceivably be made to enhance the availability of specific cover, at select locations. For instance, additional debris might be installed to increase the availability of complex bank cover for coho, in Reach 1 of the Cruickshank River. Alternatively, large bed materials might be installed in the Puntledge River, downstream of Willemar Lake, to enhance cover for trout. Following Table 16, variations on this theme might apply throughout the drainage, and at some point in time (ie. when natural equilibrium of fish species and populations is achieved), might be worth addressing at specific sites.

Presumably, there were losses of stream habitat, with construction of the storage dam at the outlet of Comox Lake. However, for the most part, densities of wild fish stocks throughout the drainage are not limited by the amount of suitable habitat, in total. Saturation of available habitat is indicated for different species and age groups, in some stream sections (Tables 13 to 15), but these are typically in upstream areas, well above the lake. Most cases (and worst cases) of the over-saturation of habitat (and associated productive capability) were directly attributable to hatchery releases. Clearly, the most pressing concern is not the abundance or type of habitat in the system, but rather the number and distribution of hatchery fish that are added to it. For the foreseeable future, all efforts should be directed towards development and monitoring of compatible hatchery programs, hopefully towards ultimate provision of (and reliance upon) natural production within/from the tributaries to Comox Lake. Once stocks have become established, then it may be relevant to consider habitat enhancement options to maximize production of specific stocks in the systems supporting them.

6.0 SUMMARY AND CONCLUSIONS

1. During September 21 - October 6, 1994, an intensive biophysical assessment was conducted in streams tributary to Comox Lake.

2. The largest system is the Cruickshank River, and its three major tributaries, Comox Creek, Rees Creek, and Eric Creek.

3. The Cruickshank system was found to contain cutthroat trout, rainbow trout, Dolly Varden char and coho salmon.

4. All coho in the Cruickshank River mainstem upstream of Comox Creek appeared to be attributable to displacement following fry releases of this species to Rees and Eric creeks; such displacement added to coho densities from a release to the mainstem itself, downstream of Comox Creek.

5. In the lowermost Cruickshank River mainstem (downstream of Comox Creek) a limited abundance of complex bank cover is available, and was found to contain high (ie. 600%) densities of coho fry, relative to theoretical capability.

6. This was reflected in the inferior condition of these fish.

7. There is very little cover suitable for coho in other sections of the Cruickshank River, and reflecting this, very few individuals of this species were captured in the mainstem upstream of Comox Creek.

8. Generally speaking, habitat throughout the Cruickshank River mainstem is most suited to trout and char, although there are also some limitations of cover availability for parr.

9. Large numbers of coho fry, displaced from Rees and Eric creeks, simply pass through the majority of the Cruickshank River, becoming concentrated in the first available habitat (in any quantity), low in the system.

10. Based on detailed sampling and capability modelling, the 1994 release of coho fry to Rees Creek (117,000 fish in mid June) exceeded the stream's carrying capacity for these fish (19,110 fish), at low flows.

11. However, cold water temperatures (< 7°C) may lead to massive emigration (and/or mortality) of coho fry released to Rees Creek; ie. all fish densities, including coho, were well below theoretical capability in this stream, at low flows, in 1994.

12. There appears to have been better retention and survival (*ca.* 70%) from the conservative release of steelhead fry to Rees Creek, in 1994 (5,050 fish released in early July); however, this result may be particularly subject to error, due to low fish numbers (released and captured).

13. Based on fish densities at low flows, there is no indication of detrimental effects of hatchery fry releases on wild populations of cutthroat and Dolly Varden in the Rees Creek system; the latter appear to have adapted to the cold water temperatures in this system.

14. In Eric Creek, the results of the 1994 coho fry releases were quite different to those in Rees Creek; at low flows, densities of coho fry exceeded theoretical capability at all sites sampled in Eric Creek, and averaged just over 160% of corresponding capability estimates.

15. Consistent with this, very few cutthroat fry were captured in Eric Creek; furthermore, there was no capture of any steelhead fry, which were also released to this stream in 1994 (5,050 fish in early July).

16. Higher densities of age 1+ fish, of both trout species, may be related to the smaller releases of coho fry in 1993.

17. The combined density of age 1+ trout and char exceeded theoretical capability at all sites sampled in Eric Creek, and averaged nearly 190% of corresponding capability estimates.

18. Wild populations of age 1+ Dolly Varden and cutthroat trout alone exceeded theoretical capability in this stream; this was aggravated by the presence of age 1+ steelhead (survivors from the 1992 release).

19. Accordingly, steelhead fry releases could be detrimental to wild trout and char populations in Eric Creek, at the yearling stage.

20. The 1994 release of coho fry to Eric Creek appeared detrimental to trout fry, and based on estimated total capability at low flows (8,700 coho fry), the size of the release (117,000 fish in mid June) was excessive, as in Rees Creek.

21. In 1994, steelhead fry were released to Comox Creek (10,500 fish in early July), but coho fry were not.

22. There may be some doubt in the identification of smaller fry (cutthroat *vs.* steelhead), but in any event total trout/char fry densities downstream of the first falls on Comox Creek exceeded theoretical capability at all sampling sites, at low flows in 1994, and averaged over 200% of corresponding capability estimates.

23. It appeared that densities of wild cutthroat trout fry in this section of Comox Creek exceeded total capacity, by themselves, and constituted the most concentrated recruitment of the species observed in the drainage.

24. Although there was no evidence of stress or major displacement of trout fry, the addition of steelhead could be detrimental to the cutthroat production in Comox Creek, based on the capability modelling.

25. The best option for future steelhead (and chinook) fry releases would seem to be the Cruickshank River mainstem; habitat here is particularly suited to trout fry, and is greatly underutilized at present (*ca.* 20 to 30% of theoretical capability in 1994).

26. Downstream of the barrier falls, the Cruickshank mainstem has the theoretical capacity for nearly 64,500 steelhead fry, based on conditions and fish size at low flows.

27. In the mainstem between Eric Creek and the barrier falls, opportunities for steelhead fry releases (*ca.* 25,500 fish; Table 20) may be ill advised, given the excessive densities of age 1+ and 2+ rainbow in this section of the river in 1994 (sites 9 and 10; Table 16); the capacity for steelhead fry in Table 20 may also be inflated in this case, due to the small size of rainbow fry captured here in 1994, as well as inferior cover availability, relative to hydraulic suitability, for these fish (Table 16).

28. It is assumed that rainbow trout in the upper Cruickshank mainstem (including the section above the barrier falls) originated from the stocking of Moat Lake, initiated in 1985.

29. Based on capability modelling, the Cruickshank mainstem downstream of the barrier falls may also have the capacity to support close to 55,000 coho fry, at low flows;

however, this may be an over-estimate, since cover availability (not considered in the modelling process) may greatly limit the mainstem capability to accommodate coho, as evidenced by the 1994 results.

30. The availability of suitable cover may also limit the capacity of the Cruickshank River mainstem for steelhead parr.

31. Of all tributaries to Comox Lake, the Puntledge River, downstream of Willemar Lake, appears to be the stream most suited to coho, and of least importance to wild trout and char.

32. Its theoretical carrying capacity for coho juveniles, at low flows, (*ca.* 18,000 fish) is limited by its short length (3.5 km).

33. Certainly, the 1994 release of hatchery coho to this stream section (95,000 fish in mid June) appears excessive.

34. As further evidence of the overstocking of coho fry in the major tributaries to the lake (and the lake itself), major immigrations of released fry (from the lake) were indicated for Perseverance Creek, which subsequently dried almost entirely; one of two small isolated pools that constituted nearly the entire wetted area in this stream in early October 1994, produced large numbers of very poorly conditioned coho fry, at excessive densities (16 x theoretical capability).

35. Large numbers of fish are likely lost with the gradual drying of this and similar tributaries (perhaps including lower Toma Creek).

36. The most profound indication of the detailed assessment in 1994 is the need for responsible, cooperative stocking programs for all species (now including chinook) in all tributaries to Comox Lake.

37. Results of the assessment provide at least some guidelines, based on extensive biophysical data and analyses, of specific stream capabilities for fry releases of different species, if such releases are to be continued.

38. Certainly, ongoing releases will be required for summer steelhead and chinook salmon; until specific data are available for chinook juveniles in the system (to enable integration in the modelling process, perhaps at a mid-summer stage), this species should be treated equally and collectively with steelhead, relative to stream capabilities derived in this investigation.

39. With respect to coho, consideration should be given (in the future, if not at present) to permitting natural ascent and reproduction of the species, upstream of Comox Lake, via the fishway in the storage dam at the outlet of Comox Lake, as the natural alternative to ongoing fry releases.

40. Ideally, the same should be the objective of enhancement programs for summer steelhead and chinook salmon production in the upper watershed.

41. Ultimately it should be the biophysical aspects of the drainage, and the relevant fish species, that determine the future distribution and level of fish production in the tributaries to Comox Lake.

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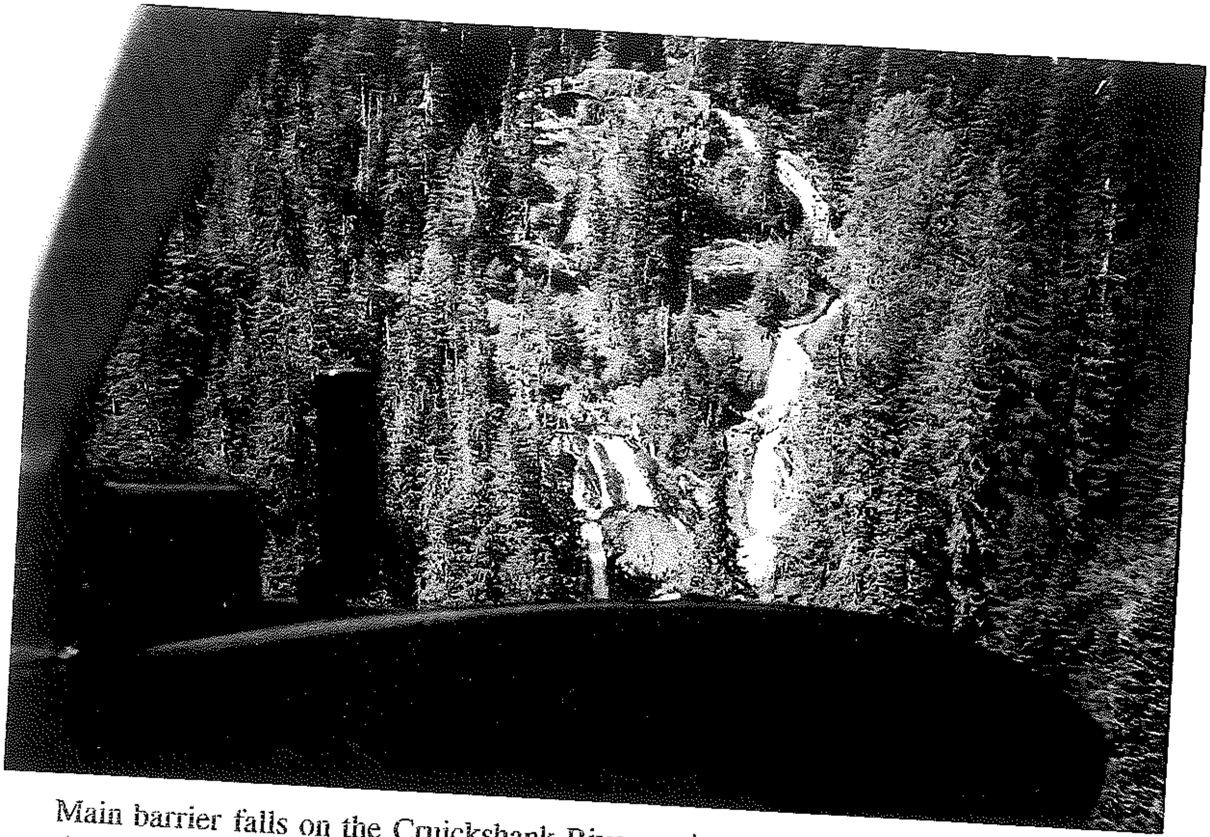
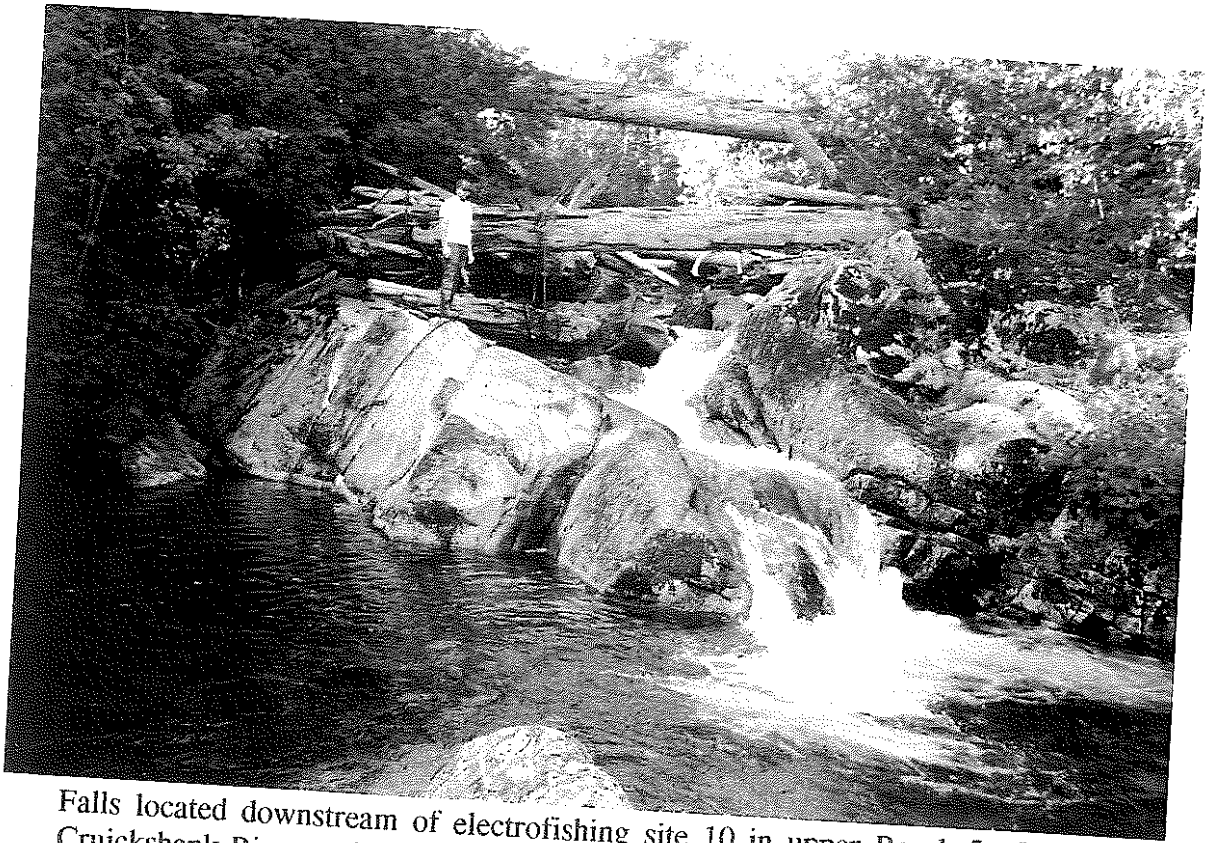
Appendix 1.

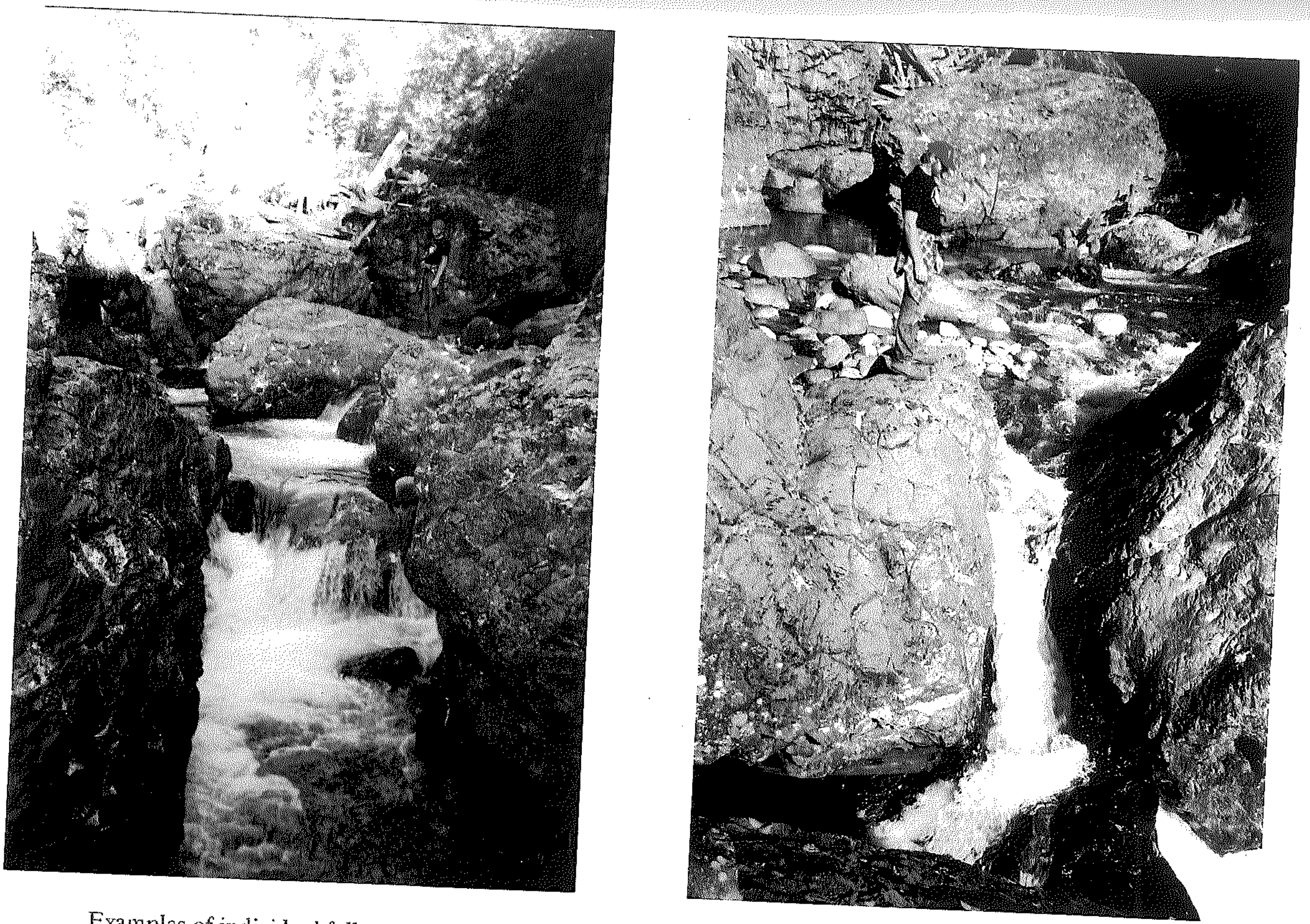
Photographic documentation of natural obstructions to fish passage in streams tributary to Comox Lake.
(as observed during low flows, August–October 1994)



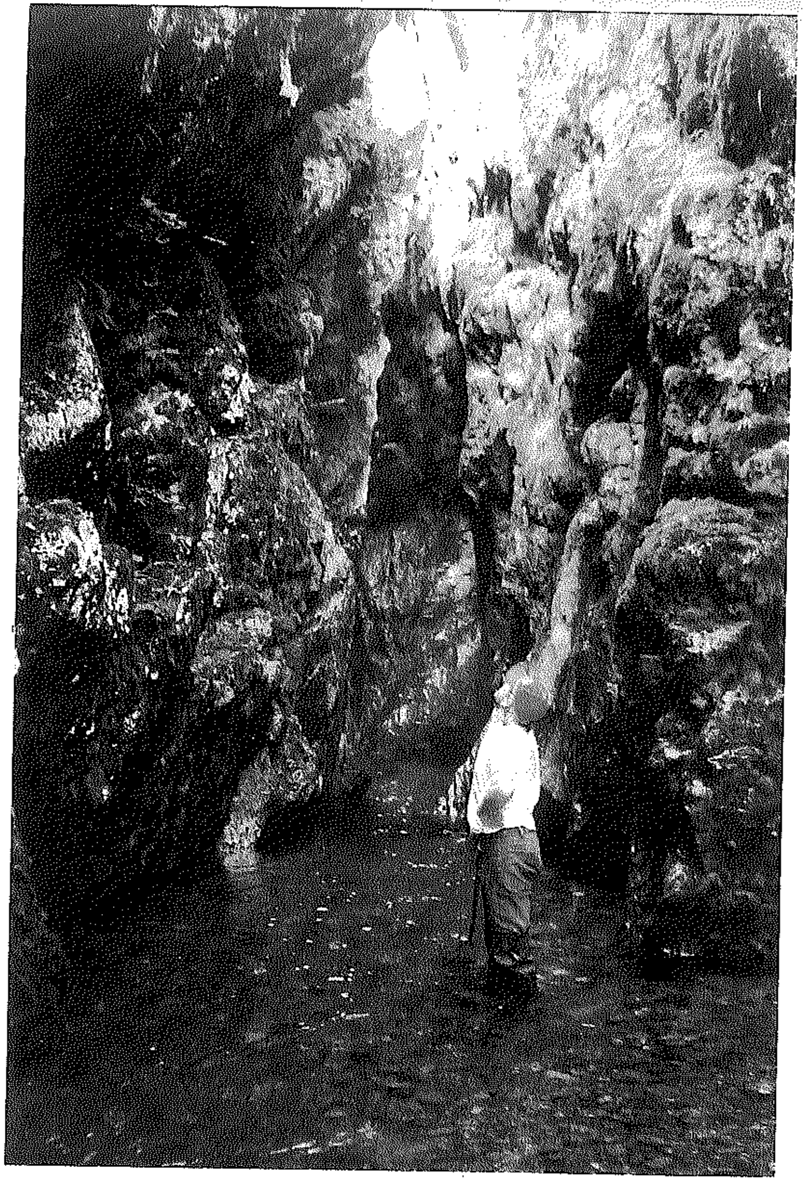
Main barrier falls on the Cruickshank River mainstem (17.5 km upstream of the mouth), as observed by helicopter, August 26, 1994.



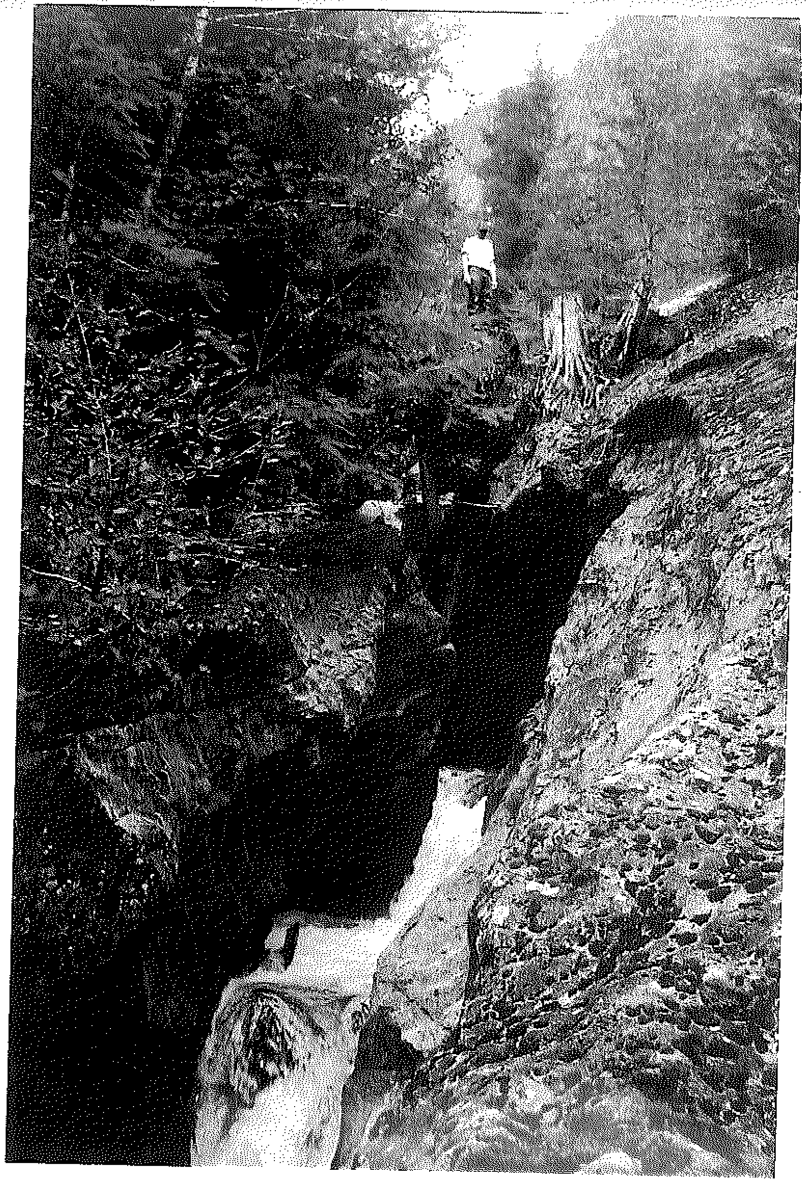
Falls located downstream of electrofishing site 10 in upper Reach 5 of the Cruickshank River mainstem, approx. 2.5 km upstream of Eric Creek.



Examples of individual falls and chutes within the cascades in Reach 2 of the Cruickshank River mainstem.



Base of major (30m) falls at the top of Comox Creek Reach 3 (note the extremely narrow fissure).



Top of same falls; a major drop (>10m) is below those shown, but could not be photographed.

Lower falls (3.1 m) at the top of Reach 2 of Comox Creek (note plunge pool).

Sandstone falls at the top of Perseverance Creek Reach 2, approx. 4 km upstream of Comox Lake (note low discharge).

Concrete spillway below small impoundment on Cumberland Creek, 0.8 km upstream of Perseverance Creek (note total lack of flow).

Appendix 2.

Flow records for Cruickshank River Sta.08HB074 for the period 1982–1990 (Water Survey of Canada, 1991) and 1994 (unpublished data, Water Survey of Canada, Vancouver).

CRISS CREEK NEAR SAVONA - STATION NO. 08LF007

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

MAXIMUM INSTANTANEOUS DISCHARGE (m³/s)	MAXIMUM DAILY DISCHARGE (m³/s)	MINIMUM DAILY DISCHARGE (m³/s)	TOTAL DISCHARGE (dam³)	YEAR
---	---	---	---	1912
---	12.6 ON MAY 10	---	---	1913
---	15.1 ON MAY 05	---	---	1914
---	41.6 ON JUN 27	---	---	1915
---	20.7 ON JUN 04	---	---	1916
---	19.3 ON MAY 29	---	---	1917
---	12.7 ON MAY 08	---	---	1918
---	9.63 ON MAY 23	---	---	1919
---	9.60 ON JUN 08	---	---	1920
---	19.3 ON MAY 24	---	---	1921
---	36.8 ON MAY 29	0.057B ON FEB 20	74 400	1962
---	18.4 ON MAY 24	0.085 ON SEP 29	54 500	1963
---	19.2 ON JUN 12	0.059 ON AUG 24	48 300	1964
---	16.3 ON JUN 01	0.130B ON MAR 24	39 900	1965
---	18.2 ON MAY 09	0.091 ON SEP 09	56 800	1966
---	22.4 ON MAY 23	0.014 ON OCT 08	49 400	1967
---	18.4 ON MAY 21	0.108 ON AUG 11	59 300	1968
---	47.3 ON JUL 06 *	0.130 ON AUG 31	95 300	1969
---	20.4 ON MAY 26	0 ON AUG 18 *	34 500	1970
---	45.6 ON JUN 09	0 ON AUG 17	73 600	1971
---	31.7 ON MAY 24	0.023 ON AUG 24	84 900	1972
---	28.6 ON MAY 24	0 ON AUG 15	35 500	1973
---	19.4 ON JUN 13	0.021 ON SEP 21	44 200	1974
---	36.8 ON MAY 31	0.057 ON MAR 06	72 900	1975
22.1 AT 06:00 PST ON MAY 11	18.4 ON MAY 11	0.153B ON MAR 04	63 000	1976
16.2 AT 06:25 PST ON APR 26	14.2 ON APR 26	0.014 ON AUG 21	43 600	1977
22.8 AT 02:44 PST ON JUN 06	19.3 ON JUN 06	0.119A ON AUG 15	63 100	1978
---	16.4 ON MAY 25	0.004E ON AUG 29	35 700	1979
22.2 AT 19:50 PST ON JUN 05	20.2 ON JUN 05	0.025A ON APR 03	52 600	1980
14.4 AT 06:42 PST ON MAY 22	13.1 ON MAY 22	0.120 ON AUG 29	60 100	1981
---	19.0 ON JUL 05	0.153B ON APR 02	60 400	1982
---	12.9 A ON MAY 25	0.069 ON AUG 26	51 500	1983
---	26.6 A ON JUN 10	0.065B ON DEC 31	65 100	1984
21.9 AT 02:16 PST ON MAY 26	20.3 ON MAY 26	0.012 ON AUG 30	47 000	1985
18.1 AT 01:05 PST ON MAY 29	16.2 ON MAY 29	0.053B ON FEB 20	34 900	1986
16.9 AT 22:06 PST ON MAY 01	14.1 ON MAY 01	0.004 ON SEP 28	25 500	1987
13.8 AT 01:17 PST ON MAY 14	12.6 ON MAY 14	0.024B ON FEB 02	27 300	1988
9.96 AT 02:05 PST ON MAY 11	9.21 ON MAY 10	0.026B ON FEB 04	39 200	1989
53.9 AT 07:32 PST ON JUN 13 *	41.5 ON JUN 13	0.150B ON DEC 20	103 000	1990
			55 000	MEAN

- MANUAL GAUGE
SEE REFERENCE INDEX)

B - ICE CONDITIONS
E - ESTIMATED

* - EXTREME RECORDED FOR THE PERIOD OF RECORD

CROASDAILE CREEK NEAR GRAY CREEK - STATION NO. 08NH061

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	YEAR
---	---	---	---	---	0.094	0.029	0.011	0.016	---	---	---	---	1930
---	---	---	---	---	---	0.041	0.021	0.019	---	---	---	---	1931
---	---	---	---	---	0.094	0.035	0.016	0.018	---	---	---	---	MEAN

LOCATION - LAT 49 37 56 N DRAINAGE AREA, 5.44 km²
LONG 116 46 47 W REGULATED

CROASDAILE CREEK NEAR GRAY CREEK - STATION NO. 08NH061

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

MAXIMUM INSTANTANEOUS DISCHARGE (m³/s)	MAXIMUM DAILY DISCHARGE (m³/s)	MINIMUM DAILY DISCHARGE (m³/s)	TOTAL DISCHARGE (dam³)	YEAR
---	---	---	---	1930
---	---	---	---	1931
			---	MEAN

CRUICKSHANK RIVER NEAR THE MOUTH - STATION NO. 08HB074

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	YEAR
---	---	---	---	26.2	48.0	18.4	6.91	4.76	59.6	13.1	15.2	---	1982
25.4	39.5	34.2	15.5	35.7	33.1	21.0	9.12	6.49	13.2	49.6	4.05	23.7	1983
23.3	19.5	20.0	14.2	19.3	28.9	21.0	8.93	5.16	36.5	15.8	10.5	18.6	1984
5.59	4.65	5.16	16.9	24.0	19.2	10.5	4.97	4.22	12.9	7.45	7.76	10.3	1985
27.8	25.1	27.0	13.1	31.5	28.1	12.7	5.98	3.60	6.95	17.4	26.9	18.8	1986
24.3	26.6	37.2	19.1	32.0	27.9	13.0	7.30	5.43	2.63	23.8	15.3	19.5	1987
11.8	12.6	12.8	23.4	31.4	29.5	20.7	10.3	4.65	6.74	29.8	19.6	17.8	1988
8.33	7.50	8.03	23.5	25.9	23.7	13.3	5.93	3.07	16.0	17.1	21.0	14.5	1989
12.5	7.37	10.7	17.3	18.9	21.7	8.58	4.24	2.90	24.8	55.6	19.6	17.0	1990
17.4	17.9	19.4	17.9	27.2	28.9	15.5	7.08	4.48	19.9	25.5	15.5	17.5	MEAN

LOCATION - LAT 49 34 45 N DRAINAGE AREA, 214 km²
LONG 125 12 03 W NATURAL FLOW

CRUICKSHANK RIVER NEAR THE MOUTH - STATION NO. 08HB074

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

AXIMUM INSTANTANEOUS DISCHARGE (m³/s)	MAXIMUM DAILY DISCHARGE (m³/s)	MINIMUM DAILY DISCHARGE (m³/s)	TOTAL DISCHARGE (dam³)	YEAR
442 AT 11:13 PST ON OCT 22 *	382 ON OCT 25 *	2.79 ON OCT 03	---	1982
299 AT 19:11 PST ON FEB 11	194 ON MAR 09	2.17 ON DEC 29	749 000	1983
330 AT 16:16 PST ON OCT 09	199 ON OCT 09	2.89 ON OCT 03	588 000	1984
62.4 AT 21:30 PST ON OCT 20	53.2 ON OCT 21	2.32 ON OCT 09	325 000	1985
205 AT 10:20 PST ON MAY 26	172 ON MAY 26	2.40 ON OCT 22	593 000	1986
319 AT 03:25 PST ON MAR 05	274 ON MAR 05	1.84 ON OCT 28 *	615 000	1987
274 AT 16:05 PST ON NOV 05	137 ON NOV 05	3.25E ON JAN 08	562 000	1988
244 AT 01:24 PST ON DEC 04	124 ON DEC 04	2.50 ON SEP 24	456 000	1989
---	360 ON NOV 11	2.32 ON SEP 29	536 000	1990
			553 000	MEAN

E - ESTIMATED

* - EXTREME RECORDED FOR THE PERIOD OF RECORD

CRYSTAL CREEK NEAR NELSON - STATION NO. 08NJ033

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	YEAR
---	---	---	---	---	---	---	---	---	---	---	---	1923
---	---	---	---	---	---	---	---	---	---	---	---	1924
---	---	---	---	0.014	0.012	0.008	0.011	---	---	---	---	1925
---	---	---	---	---	---	0.027	0.022	---	---	---	---	1926
---	---	---	---	---	---	---	---	---	---	---	---	1927
---	---	---	---	0.014	0.012	0.018	0.017	---	---	---	---	MEAN

ION - LAT 49 33 58 N DRAINAGE AREA, 2.23 km²
LONG 117 15 40 W NATURAL FLOW

CRYSTAL CREEK NEAR NELSON - STATION NO. 08NJ033

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

IMUM INSTANTANEOUS DISCHARGE (m³/s)	MAXIMUM DAILY DISCHARGE (m³/s)	MINIMUM DAILY DISCHARGE (m³/s)	TOTAL DISCHARGE (dam³)	YEAR
---	---	0.023 ON AUG 17	---	1923
---	---	0.008 ON AUG 11 *	---	1924
---	0.017 ON MAY 10 *	0.017 ON SEP 26	---	1925
---	---	0.008E ON AUG 03	---	1926
---	---	0.020E ON AUG 25	---	1927
			---	MEAN

E - ESTIMATED

* - EXTREME RECORDED FOR THE PERIOD OF RECORD

CUISSON CREEK (EAST FORK) ABOVE DAM - STATION NO. 08KE037

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	YEAR
---	---	---	---	---	---	0.053	0.019	0.014	---	---	---	1989
---	---	---	---	---	---	0.053	0.019	0.014	---	---	---	MEAN

N - LAT 52 34 52 N DRAINAGE AREA, 7.8 km²
LONG 122 16 09 W NATURAL FLOW

DATA CONTRIBUTED BY -
BC MINISTRY OF ENVIRONMENT

CUISSON CREEK (EAST FORK) ABOVE DAM - STATION NO. 08KE037

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

UM INSTANTANEOUS DISCHARGE (m³/s)	MAXIMUM DAILY DISCHARGE (m³/s)	MINIMUM DAILY DISCHARGE (m³/s)	TOTAL DISCHARGE (dam³)	YEAR
---	---	---	---	1989
			---	MEAN

CUISSON CREEK (SOUTH FORK) NEAR MARGUERITE - STATION NO. 08KE008

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	YEAR
---	---	---	---	---	---	0.073	---	---	---	---	---	1949
---	---	---	---	---	0.367	0.083	0.054	---	---	---	---	1952
---	---	0.150	0.288	0.049	0.054	0	0	---	---	---	---	1953
---	---	---	---	---	2.01	0.391	0.019	---	---	---	---	1955
---	---	---	---	3.58	0.491	0.063	0.044	---	---	---	---	1956
---	---	0.150	0.288	1.81	0.731	0.122	0.029	---	---	---	---	MEAN

- LAT 52 31 05 N
LONG 122 19 40 W NATURAL FLOW

4	55.9	9.60 E	44.2 A	18.9	17.0	10.9	11.1	4.45	3.52	2.85	11.1	10.0 E	4
5	33.9	8.60 E	30.1 E	15.6	18.9	11.5	10.8	4.28	3.35	2.76	10.5	8.64 E	5
6	22.5	8.30 E	18.2 E	14.6	22.6	10.7	11.3	4.06	3.19	2.72	12.6	7.48 E	6
7	18.0	7.80 E	16.3 E	13.8	28.7	11.9	11.9	3.98	9.59	2.65	9.78	6.51 E	7
8	15.1	6.50 E	15.1 E	17.1	31.5	11.1	11.3	7.50	10.9	2.58	11.6	6.34 A	8
9	14.5	6.70 E	13.6 A	21.4	31.3	10.6	10.1	8.29	7.40	2.64	19.5	6.28 A	9
10	15.1	6.60 E	12.9	18.0	28.2	11.0	9.18	6.06	5.71	2.72	15.1	6.28 E	10
11	14.3	8.60 E	11.8	19.4	29.1	14.2	8.65	4.91	4.90	2.64	12.8	6.44 E	11
12	14.0	26.8 E	11.0	25.8	26.6	16.3	8.36	4.42	4.44	2.62	11.7 A	6.75 E	12
13	16.1	24.5 E	10.5	20.7	20.0	33.1	8.65	4.13	4.30	2.63	10.9 E	6.94 E	13
14	19.3	24.0 E	11.0	17.5	18.2	32.4	8.83	3.95	4.48	2.99	10.6 E	7.22 E	14
15	15.3	49.9 E	10.9	16.1	18.0	27.3	8.78	3.79	4.55	2.86	10.4 E	7.40 E	15
16	14.1	41.2 E	10.9	16.2	19.0	22.8	8.67	3.78	4.67	2.74	9.94 A	7.62 A	16
17	12.4	28.5 E	11.1	20.2	19.0	22.8	8.67	3.88	4.43	2.64	9.43 E	24.5 E	17
18	11.2	22.1 E	10.6	26.8	19.4	20.3	8.20	3.71	4.18	2.61	9.37 E	48.0 E	18
19	10.2	18.6 E	9.18	34.5	19.9	17.4	7.74	3.76	3.91	2.57	9.29 E	88.5 E	19
20	9.59	14.2 E	9.44	31.5	20.2	16.1	7.62	3.74	3.74	3.61	8.83	62.1 E	20
21	52.5 E	13.0 E	10.2	29.5	19.1	16.9	7.68	3.62	3.61	5.41	7.86 A	22.5 E	21
22	109 E	11.7 E	8.91	25.9	19.1	17.5	7.63	3.53	3.45	4.32	7.79 A	37.3 E	22
23	94.0 E	10.4 E	7.86	21.1	18.3	18.7	7.47	3.44	3.29	4.39	8.07 A	52.4 E	23
24	87.0 E	8.80 E	7.18	18.6	18.8	22.8	7.25	3.34	3.20	4.58	7.79 E	81.0 E	24
25	52.0 E	9.20 E	6.85	16.7	19.9	19.5	7.21	3.23	3.14	18.6	7.46 A	52.0 E	25
26	29.5 E	12.8 E	7.10	16.4	18.4	17.6	6.57	3.17	3.05	39.0	6.83 A	26.8 E	26
27	25.0 E	26.0 E	9.91	18.1	14.7	16.7	5.76	3.09	3.02	31.7	6.21 A	28.5 E	27
28	23.1 E	63.0 E	15.8	21.6	13.6	16.1	5.34	3.03	2.98	18.7	5.72 A	30.9 A	28
29	19.5 E		20.6	23.3	15.2	15.5	5.07	3.03	2.97	15.0	6.18 E	24.7	29
30	19.0 E		20.1	19.8	12.9	14.4	4.89	3.01	3.03	16.1	7.42 A	20.0	30
31	14.3 E		20.7		11.7		4.62	2.96		18.3		17.4	31
TOTAL	908.59	503.40	779.33	627.7	612.5	509.4	273.14	127.12	128.72	232.54	302.97	751.40	TOTAL
MEAN	29.3	18.0	25.1	20.9	19.8	17.0	8.81	4.10	4.29	7.50	10.1	24.2	MEAN
DAM3	78500	43500	57300	54200	52900	44000	23600	11000	11100	20100	26200	64900	DAM3
MAX	109	63.0	192	34.5	31.5	33.1	16.7	8.29	10.9	39.0	19.5	88.5	MAX
MIN	9.59	6.50	6.85	13.8	11.7	10.5	4.62	2.96	2.90	2.57	5.72	6.28	MIN

SUMMARY FOR THE YEAR 1994

MEAN DISCHARGE,15.8 M3/S
TOTAL DISCHARGE, 497000 DAM3
MAXIMUM DAILY DISCHARGE, 192 M3/S ON MAR 2
MINIMUM DAILY DISCHARGE, 2.57 M3/S ON OCT 19

A-MANUAL GAUGE

E-ESTIMATED

UNPUBLISHED DATA SUBJECT
TO REVISION
Les données non publiées
sont sujets a une revision

Appendix 3.

Notes and explanations regarding the Ptolemy (1992) capability model for juvenile fish.

Juvenile Capability Estimates – Notes and Explanations

Equation for theoretical capabilities, used in this study (Ptolemy, 1992):

Trout and Char Juveniles

$$FPU = 36.3 \times (Alk)^{0.5} \times (Size)^{-1}$$

Coho Juveniles

$$FPU = 100 \times (Alk)^{0.4} \times (Size)^{-1}$$

Where:

FPU = numbers of fish/100m^2, at capacity
Alk = total alkalinity (mg/L) for late summer/fall base flow period
Size = mean fish size (g) for size class

Notes:

1. In the estimates for trout, an optional expression addressing inert filterable residues is employed for glacial streams; September–October 1994 samples from the tributaries to Comox Lake revealed inert filterable residues << 1 mg/L (Appendix 5); hence, the expression was not employed here.

2. All total alkalinity values were based on analyses of water samples collected during the September–October 1994 field session, from the relevant stream and/or stream section.

Appendix 4.

Results of water sample analyses for streams tributary to Comox Lake, September–October 1994.
(analyses conducted by MB Research Laboratories Ltd., Sidney, B.C.)

Client/Code

R.P. Griffith & Associates
1237 Munro Road
Sidney, B.C.
V8L 3R9

Date	10/07/94	No.	W22253
Source			
Type of Sample	water		
No. of Samples	14		
Comments			

Comox Lake Tributaries

SAMPLE	Date	Time	Alkalinity (mg/L $CaCO_3$)	E.C. (uS/cm)	NO_3-N (ug/L)	NO2-N (ug/L)
Cruickshank River Reach 1	01Oct94	1100hrs	18.0	35.1	45.7	ND
Cruickshank River Reach 2	27Sep94	1145hrs	21.0	34.0	49.8	ND
Cruickshank River Reach 3	26sep94	1600hrs	17.0	37.5	60.7	ND
Cruickshank River Reach 5	23Sep94	1615hrs	22.0	35.4	n/a	n/a
Cruickshank River Reach 6	24Sep94	1610hrs	16.0	29.6	n/a	n/a
Comox Creek	30Sep94	1500hrs	19.0	39.3	n/a	n/a
Datsio Creek	29Sep94	1645hrs	23.0	51.0	n/a	n/a
Rees Creek	27Sep94	1330hrs	11.0	23.6	n/a	n/a
Kweishun Creek	28Sep94	1630hrs	16.0	28.3	n/a	n/a
Eric Creek	26Sep94	1140hrs	17.0	37.5	n/a	n/a
Puntledge River Reach 1	04Oct94	1700hrs	40.0	37.6	ND	3.33
Puntledge River Reach 5	04Oct94	1330hrs	14.0	45.6	n/a	n/a
Toma Creek	05Oct94	1600hrs	56.0	111	n/a	n/a
Perseverance Creek	06Oct94	1300hrs	31.0	64.8	n/a	n/a
S_0			0.10	0.30	0.167	0.100
REF. VALUE			100	147	15.0	15.0
STD ± 2SD			100 ± 8	148 ± 8	15.1 ± 1.3	15.1 ± 1.30

SAMPLE	Date	Time	TDS (mg/L)	TSS (mg/L)	Non-Filterable Residue Inert (mg/L)
Cruickshank River Reach 1	01Oct94	1100hrs	6.67	ND	ND
Cruickshank River Reach 2	27Sep94	1145hrs	18.0	1.6	ND
Cruickshank River Reach 3	26sep94	1600hrs	15.3	ND	ND
Cruickshank River Reach 5	23Sep94	1615hrs	15.3	ND	ND
Cruickshank River Reach 6	24Sep94	1610hrs	12.0	ND	ND
Comox Creek	30Sep94	1500hrs	21.3	ND	ND
Datsio Creek	29Sep94	1645hrs	6.67	1.6	ND
Rees Creek	27Sep94	1330hrs	ND	ND	ND
Kweishun Creek	28Sep94	1630hrs	6.67	0.80	ND
Eric Creek	26Sep94	1140hrs	6.67	ND	ND
Puntledge River Reach 1	04Oct94	1700hrs	3.33	4.2	0.10
Puntledge River Reach 5	04Oct94	1330hrs	14.0	1.8	ND
Toma Creek	05Oct94	1600hrs	47.3	0.80	ND
Perseverance Creek	06Oct94	1300hrs	20.7	4.6	0.10
S_0			0.800	0.30	
REF. VALUE			50.0	5.00	
STD ± 2SD			50.4 ± 4.9	4.86 ± 0.48	

SD = standard deviation
STD = [illegible] standard calibrated to primary standard reference material
S_0 = standard deviation at zero analyte concentration

Analytical Chemist

Appendix 5.

Stream habitat survey data for tributaries to Comox Lake, September–October 1994.

Key to data entries following standard inventory procedures (Anon., 1989) :

Substrates Compaction

L = low
M = moderate
H = high

Flow Stage L = low

Bank Texture

F = fines
G = gravel
L = larges
R = bedrock

Channel Confinement

UC = unconfined
OC = occasionally confined
FC = frequently confined
CO = confined
EN = entrenched

Site 1 **Stream Survey Data** **Cruickshank mainstem**

Location: lower Reach 1; approx. 2 km upstream of Comox Lake
Access: hike from main road up the Cruickshank mainstem
Surveyed Length (m): 500
Reach Length (km): 7
Date: October 1, 1994
Stream Temperature (^{o}C): 9.5

Ave. Chan. width (m):	40
Ave. Wet. Width (m):	30
Ave. Max. Riffle Depth (cm):	20
Ave. Max. Pool Depth (cm):	>100

% Pool:	10
% Riffle/Rapid:	30
% Glide/Run:	60
% other:	

Gradient (%):	0.5
Side Channel (%):	0–10
Debris: % area	<5
% stable	0

Bed Materials:	
clay, silt, sand (<2mm)	10
small gravel (2–16mm)	10
large gravel (16–64mm)	20
small cobble (64–128mm)	20
large cobble (128–256mm)	20
boulder (>256mm)	20
bedrock	0
D_{90} (cm):	30
Compaction:	moderate

Banks:	
height (m)	1
% stable	60
texture	LGF
Confinement:	UC
Valley:Chan. Ratio:	5–10
Stage:	L
Flood Signs Ht. (m):	1.5
Braided ?:	no
Bars (%):	25

Cover (total %):	25
Components (%):	
deep water	10
L.O.D.	10
boulder	50
instream veg.	
overstream veg.	20
cutbanks	10
Crown Closure (%):	5
Aspect:	E

Obstructions: –none

Riparian Zone –mixture of moderate to large deciduous and coniferous trees; moderate sizes dominant
Development: –mostly continuous, and frequently dense

Comments: –gravels quite abundant, but tend to be large
–rearing habitat lacks complexity

For photograph, see Figure 15 in text.

Site 2

Stream Survey Data

Cruickshank mainstem

Location: mid Reach 1; approx. 2 km upstream of Comox Creek (6 km upstream of Comox Lake)
Access: directly from main road up the Cruickshank mainstem
Surveyed Length (m): 400
Reach Length (km): 7
Date: September 30, 1994
Stream Temperature (°C): 10.0

Ave. Chan. width (m):	30
Ave. Wet. Width (m):	24
Ave. Max. Riffle Depth (cm):	20
Ave. Max. Pool Depth (cm):	>100

% Pool:	10
% Riffle/Rapid:	40
% Glide/Run:	50
% other:	

Gradient (%):	0.8
Side Channel (%):	0–10
Debris: % area	0
% stable	–

Bed Materials:	
clay, silt, sand (<2mm)	5
small gravel (2–16mm)	5
large gravel (16–64mm)	10
small cobble (64–128mm)	20
large cobble (128–256mm)	30
boulder (>256mm)	30
bedrock	0
D_{90} (cm):	70
Compaction:	mod – high

Banks:	
height (m)	1.4
% stable	40
texture	LGF
Confinement:	OC
Valley:Chan. Ratio:	5–10
Stage:	L
Flood Signs Ht. (m):	2
Braided ?:	no
Bars (%):	20

Cover (total %):	30
Components (%):	
deep water	
L.O.D.	<5
boulder	>70
instream veg.	
overstream veg.	20
cutbanks	5
Crown Closure (%):	5
Aspect:	SE

Obstructions: –none

Riparian Zone Development: –mixture of small to moderate deciduous and coniferous trees; deciduous species dominant
–mostly continuous, and frequently dense

Comments: –gravels not abundant; but some spawning habitat available
–rearing habitat lacks complexity

For photograph, see Figure 16 in text.

Site 3 Stream Survey Data Cruickshank mainstem

Location: lower Reach 2; approx. 1 km upstream of Rees Creek
Access: hike from main road (ATV) up the Cruickshank mainstem
Surveyed Length (m): 300 **Date:** September 27, 1994
Reach Length (km): 4 **Stream Temperature (^oC):** 12.5

Ave. Chan. width (m):	25
Ave. Wet. Width (m):	15
Ave. Max. Riffle Depth (cm):	40
Ave. Max. Pool Depth (cm):	60

% Pool:	15
% Riffle/Rapid:	55
% Glide/Run:	30
% other:	

Gradient (%):	2
Side Channel (%):	0
Debris: % area	<5
% stable	0

Bed Materials:	
clay, silt, sand (<2mm)	5
small gravel (2–16mm)	5
large gravel (16–64mm)	10
small cobble (64–128mm)	15
large cobble (128–256mm)	25
boulder (>256mm)	40
bedrock	0
D_{90} (cm):	80
Compaction:	mod – high

Banks:	
height (m)	2
% stable	80
texture	LF
Confinement:	OC
Valley:Chan. Ratio:	5–10
Stage:	L
Flood Signs Ht. (m):	1.8
Braided ?:	yes
Bars (%):	40

Cover (total %):	40
Components (%):	
deep water	
L.O.D.	
boulder	>90
instream veg.	
overstream veg.	<10
cutbanks	
Crown Closure (%):	10
Aspect:	S

Obstructions: –none, in the vicinity of this site (cascades further upstream; see Site 4a)

Riparian Zone Development:
–mixture of moderate to large deciduous and coniferous trees; deciduous dominant
–continuous, and frequently dense

Comments:
–gravels not abundant, and mostly blended with other substrates
–good complexity of substrate cover for rearing

Photo shows electrofishing site 5.

Site 4

Stream Survey Data

Cruickshank mainstem

Location: mid Reach 2; approx. 2.5 km upstream of Rees Creek
Access: hike from main road (ATV) up the Cruickshank mainstem
Surveyed Length (m): 250
Reach Length (km): 4
Date: September 27, 1994
Stream Temperature (^{o}C): 12.0

Ave. Chan. width (m):	20
Ave. Wet. Width (m):	14
Ave. Max. Riffle Depth (cm):	40
Ave. Max. Pool Depth (cm):	70

% Pool:	20
% Riffle/Rapid:	50
% Glide/Run:	30
% other:	

Gradient (%):	2.5
Side Channel (%):	0
Debris: % area	<5
% stable	0

Bed Materials:	
clay, silt, sand (<2mm)	5
small gravel (2–16mm)	5
large gravel (16–64mm)	10
small cobble (64–128mm)	10
large cobble (128–256mm)	25
boulder (>256mm)	45
bedrock	0
D_{90} (cm):	110
Compaction:	mod – high

Banks:	
height (m)	1.4
% stable	80
texture	LF
Confinement:	FC
Valley:Chan. Ratio:	5–10
Stage:	L
Flood Signs Ht. (m):	2
Braided ?:	yes
Bars (%):	30

Cover (total %):	50
Components (%):	
deep water	
L.O.D.	
boulder	>90
instream veg.	
overstream veg.	<10
cutbanks	
Crown Closure (%):	10
Aspect:	SE

Obstructions: –series of major cascades located 400 m upstream (see Site 4a)

Riparian Zone Development:
–mixture of moderate to large deciduous and coniferous trees; deciduous dominant
–continuous, and frequently dense

Comments:
–gravels not abundant, and mostly blended with other substrates
–good complexity of substrate cover for rearing

For photograph, see Figure 17 in text.

Site 6

Stream Survey Data

Cruickshank mainstem

Location: lower Reach 4; approx. 1.5 km downstream of Eric Creek
Access: bridge crossing by old road (ATV) up the Cruickshank mainstem
Surveyed Length (m): 250 **Date:** September 26, 1994
Reach Length (km): 2 **Stream Temperature (^{o}C):** 11.0

Ave. Chan. width (m):	20
Ave. Wet. Width (m):	10
Ave. Max. Riffle Depth (cm):	40
Ave. Max. Pool Depth (cm):	70

% Pool:	15
% Riffle/Rapid:	40
% Glide/Run:	45
% other:	

Gradient (%):	3
Side Channel (%):	0
Debris: % area	<5
% stable	10

Bed Materials:	
clay, silt, sand (<2mm)	5
small gravel (2–16mm)	15
large gravel (16–64mm)	10
small cobble (64–128mm)	10
large cobble (128–256mm)	15
boulder (>256mm)	45
bedrock	
D_{90} (cm):	70
Compaction:	moderate

Banks:	
height (m)	1.5
% stable	70
texture	LF
Confinement:	OC
Valley:Chan. Ratio:	5–10
Stage:	L
Flood Signs Ht. (m):	1.5
Braided ?:	yes
Bars (%):	50

Cover (total %):	40
Components (%):	
deep water	
L.O.D.	<5
boulder	>85
instream veg.	
overstream veg.	<5
cutbanks	5
Crown Closure (%):	10
Aspect:	SE

Obstructions: –none

Riparian Zone Development: –mixture of moderate to large deciduous and moderate conifers
–continuous and frequently dense

Comments: –substantial amounts of gravels, frequently in bars
–rearing habitat complex, but constrained by boulder size

For photograph, see Figure 21 in text.

Site 5	**Stream Survey Data**	**Cruickshank mainstem**

Location:	mid Reach 3; approx. 2.5 km downstream of Eric Creek		
Access:	directly from ATV trail (old road) along the Cruickshank mainstem		
Surveyed Length (m):	250	**Date:**	September 26, 1994
Reach Length (km):	1.5	**Stream Temperature (^oC):**	12.0

Ave. Chan. width (m):	25
Ave. Wet. Width (m):	15
Ave. Max. Riffle Depth (cm):	30
Ave. Max. Pool Depth (cm):	50

% Pool:	10
% Riffle/Rapid:	40
% Glide/Run:	50
% other:	

Gradient (%):	2.5
Side Channel (%):	0
Debris: % area	<5
% stable	0

Bed Materials:	
clay, silt, sand (<2mm)	5
small gravel (2–16mm)	15
large gravel (16–64mm)	10
small cobble (64–128mm)	10
large cobble (128–256mm)	25
boulder (>256mm)	35
bedrock	
D_{90} (cm):	50
Compaction:	mod – high

Banks:	
height (m)	1.5
% stable	60
texture	LFG
Confinement:	OC
Valley:Chan. Ratio:	5–10
Stage:	L
Flood Signs Ht. (m):	2
Braided ?:	yes
Bars (%):	40

Cover (total %):	35
Components (%):	
deep water	
L.O.D.	
boulder	>90
instream veg.	
overstream veg.	<10
cutbanks	
Crown Closure (%):	<5
Aspect:	SE

Obstructions: –none

Riparian Zone Development:
–mixture of small to moderate size deciduous and coniferous trees; deciduous dominant
–continuous, but sparse at some locations

Comments: –some substantial accumulations of gravels (bars, beds); rearing habitat lacks complexity

For photograph, see Figure 20 in text.

Site 7 — Stream Survey Data — Cruickshank mainstem

Location: lower Reach 5; approx. 150 m upstream of Eric Creek
Access: bridge crossing by old road (ATV) up the Cruickshank mainstem
Surveyed Length (m): 250 **Date:** September 25, 1994
Reach Length (km): 3 **Stream Temperature (°C):** 11.5

Ave. Chan. width (m):	15
Ave. Wet. Width (m):	11
Ave. Max. Riffle Depth (cm):	30
Ave. Max. Pool Depth (cm):	80

% Pool:	25
% Riffle/Rapid:	35
% Glide/Run:	35
% other:	

Gradient (%):	3.5
Side Channel (%):	0
Debris: % area	0
% stable	–

Bed Materials:	
clay, silt, sand (<2mm)	5
small gravel (2–16mm)	10
large gravel (16–64mm)	10
small cobble (64–128mm)	10
large cobble (128–256mm)	20
boulder (>256mm)	45
bedrock	
D_{90} (cm):	120
Compaction:	moderate

Banks:	
height (m)	0.8
% stable	80
texture	LF
Confinement:	FC
Valley:Chan. Ratio:	2–5
Stage:	L
Flood Signs Ht. (m):	1.5
Braided ?:	no
Bars (%):	25

Cover (total %):	60
Components (%):	
deep water	
L.O.D.	
boulder	>90
instream veg.	
overstream veg.	<10
cutbanks	
Crown Closure (%):	20
Aspect:	SE

Obstructions: —none

Riparian Zone —mixture of small to moderate deciduous and coniferous trees
Development: —continuous and dense

Comments: —some excellent pockets of gravels behind boulders and in step pools
—rearing habitat complex and abundant

For photograph, see Figure 18 in text.

Site 8

Stream Survey Data

Cruickshank mainstem

Location:	upper Reach 5; approx. 2.5 km upstream of Eric Creek		
Access:	defunct bridge crossing, off old road (ATV) up the Cruickshank mainstem		
Surveyed Length (m):	300	**Date:**	September 23, 1994
Reach Length (km):	3	**Stream Temperature (°C):**	12.0

Ave. Chan. width (m):	10
Ave. Wet. Width (m):	8
Ave. Max. Riffle Depth (cm):	30
Ave. Max. Pool Depth (cm):	70

% Pool:	15
% Riffle/Rapid:	40
% Glide/Run:	35
% other:	

Gradient (%):	6
Side Channel (%):	0
Debris: % area	0
% stable	–

Bed Materials:	
clay, silt, sand (<2mm)	5
small gravel (2–16mm)	5
large gravel (16–64mm)	5
small cobble (64–128mm)	10
large cobble (128–256mm)	15
boulder (>256mm)	50
bedrock	10
D_{90} (cm):	130
Compaction:	moderate

Banks:	
height (m)	1.2
% stable	95
texture	LFR
Confinement:	FC
Valley:Chan. Ratio:	2–5
Stage:	L
Flood Signs Ht. (m):	1.5
Braided ?:	no
Bars (%):	10

Cover (total %):	65
Components (%):	
deep water	
L.O.D.	
boulder	90
instream veg.	
overstream veg.	10
cutbanks	
Crown Closure (%):	30
Aspect:	SE

Obstructions:
—bedrock falls immediately downstream of electrofishing site 10
—total height of 2.7 m in 3 main jumps; not a barrier to adult fish
—numerous other smaller falls in this vicinity

Riparian Zone Development:
—mixture of small to moderate deciduous and coniferous trees; conifers tend to be small
—continuous and dense

Comments:
—some pockets of gravels, but limited in abundance
—excellent rearing habitat in step pools

For photograph, see Figure 19 in text.

Site 9

Stream Survey Data

Cruickshank mainstem

Location: mid Reach 6; meadow area, approx. 1.5 km upstream of barrier falls
Access: hike down from old road (ATV) along the Cruickshank mainstem
Surveyed Length (m): 500 **Date:** September 24, 1994
Reach Length (km): 2.5 **Stream Temperature (^oC):** 14.0

Ave. Chan. width (m):	6
Ave. Wet. Width (m):	5.5
Ave. Max. Riffle Depth (cm):	5
Ave. Max. Pool Depth (cm):	80

% Pool:	45
% Riffle/Rapid:	5
% Glide/Run:	50
% other:	

Gradient (%):	<0.5
Side Channel (%):	10–40
Debris: % area	<5
% stable	70

Bed Materials:	
clay, silt, sand (<2mm)	30
small gravel (2–16mm)	40
large gravel (16–64mm)	20
small cobble (64–128mm)	10
large cobble (128–256mm)	
boulder (>256mm)	
bedrock	
D_{90} (cm):	10
Compaction:	moderate

Banks:	
height (m)	0.4
% stable	50
texture	F
Confinement:	UC
Valley:Chan. Ratio:	>10
Stage:	L
Flood Signs Ht. (m):	0.6
Braided ?:	Y
Bars (%):	5

Cover (total %):	15
Components (%):	
deep water	
L.O.D.	20
boulder	
instream veg.	10
overstream veg.	40
cutbanks	30
Crown Closure (%):	0
Aspect:	SE

Obstructions:
—major barrier falls downstream
—gradient barrier upstream (immediately below outlet of Moat Lake)

Riparian Zone Development:
—channel bordered by wide marshy flood plain; sedges, grasses and small shrubs only
—surrounding topography dominated by small to moderate conifers

Comments:
—abundant gravels, but substantially inundated with fines
—little cover for rearing; however, extremely high numbers of juveniles seen throughout

For photographs, see Figures 22 and 23 in text.

Site 10 **Stream Survey Data** **Comox Creek**

Location: mid Reach 1; approx. 2 km upstream of the Cruickshank River
Access: road along Comox Creek, from main road up the Cruickshank mainstem
Surveyed Length (m): 250 **Date:** September 30, 1994
Reach Length (km): 3.5 **Stream Temperature (^{o}C):** 10.0

Ave. Chan. width (m):	15
Ave. Wet. Width (m):	10
Ave. Max. Riffle Depth (cm):	30
Ave. Max. Pool Depth (cm):	70

% Pool:	10
% Riffle/Rapid:	60
% Glide/Run:	30
% other:	

Gradient (%):	1.5
Side Channel (%):	0
Debris: % area	<5
% stable	25

Bed Materials:	
clay, silt, sand (<2mm)	5
small gravel (2–16mm)	5
large gravel (16–64mm)	5
small cobble (64–128mm)	20
large cobble (128–256mm)	35
boulder (>256mm)	30
bedrock	
D_{90} (cm):	30
Compaction:	mod – high

Banks:	
height (m)	0.6
% stable	90
texture	LGF
Confinement:	OC
Valley:Chan. Ratio:	5–10
Stage:	L
Flood Signs Ht. (m):	1
Braided ?:	yes
Bars (%):	25

Cover (total %):	30
Components (%):	
deep water	
L.O.D.	5
boulder	40
instream veg.	
overstream veg.	30
cutbanks	25
Crown Closure (%):	20
Aspect:	N

Discharge:	wetted width (m)	9.3	mean velocity (m/s)	0.22
	mean depth (m)	0.23	discharge (m^3/s)	0.47

Obstructions: –none within Reach 1

Riparian Zone –dominated by moderate to large deciduous trees; conifers not abundant
Development: –continuous and dense

Comments: –gravels are not abundant (spawning habitat limited)
–rearing habitat rearing habitat is somewhat limited by small boulder size

For photograph, see Figure 25 in text.

Site 11 Stream Survey Data Comox Creek

Location:	lower Reach 2; approx. 4.5 km upstream of the Cruickshsnk River
Access:	road along Comox Creek, from main road up the Cruickshank mainstem
Surveyed Length (m):	200
Reach Length (km):	4
Date:	September 29, 1994
Stream Temperature (°C):	10.0

Ave. Chan. width (m):	14
Ave. Wet. Width (m):	13
Ave. Max. Riffle Depth (cm):	30
Ave. Max. Pool Depth (cm):	80

% Pool:	10
% Riffle/Rapid:	60
% Glide/Run:	30
% other:	

Gradient (%):	2
Side Channel (%):	0
Debris: % area	<5
% stable	0

Bed Materials:	
clay, silt, sand (<2mm)	5
small gravel (2–16mm)	5
large gravel (16–64mm)	10
small cobble (64–128mm)	15
large cobble (128–256mm)	20
boulder (>256mm)	45
bedrock	
D_{90} (cm):	70
Compaction:	moderate

Banks:	
height (m)	0.8
% stable	90
texture	LGF
Confinement:	FC
Valley:Chan. Ratio:	5–10
Stage:	L
Flood Signs Ht. (m):	1.5
Braided ?:	yes
Bars (%):	5

Cover (total %):	50
Components (%):	
deep water	
L.O.D.	
boulder	>85
instream veg.	
overstream veg.	10
cutbanks	<5
Crown Closure (%):	25
Aspect:	NE

Obstructions: –none, except falls at top of Reach 2

Riparian Zone –dominated by moderate to large deciduous trees; conifers not abundant
Development: –continuous and dense

Comments: –frequent patches of gravels behind boulders, and at margins (suitable for spawning)
–excellent complexity of rearing habitat

For photograph, see Figure 26 in text.

Site 12	Stream Survey Data	Comox Creek

Location: upper Reach 3; immediately downstream of barrier falls
Access: hike from road along Comox Creek, from main road up the Cruickshank mainstem
Surveyed Length (m): 600 **Date:** September 28, 1994
Reach Length (km): 1 **Stream Temperature (^{o}C):** 8.0

Ave. Chan. width (m):	25
Ave. Wet. Width (m):	10
Ave. Max. Riffle Depth (cm):	20
Ave. Max. Pool Depth (cm):	80

% Pool:	10
% Riffle/Rapid:	30
% Glide/Run:	60
% other:	

Gradient (%):	1
Side Channel (%):	10–40
Debris: % area	<5
% stable	25

Bed Materials:	
clay, silt, sand (<2mm)	15
small gravel (2–16mm)	25
large gravel (16–64mm)	35
small cobble (64–128mm)	20
large cobble (128–256mm)	4
boulder (>256mm)	1
bedrock	
D_{90} (cm):	10
Compaction:	low – mod

Banks:	
height (m)	0.3
% stable	20
texture	GF
Confinement:	UC
Valley:Chan. Ratio:	5–10
Stage:	L
Flood Signs Ht. (m):	1
Braided ?:	yes
Bars (%):	60

Cover (total %):	20
Components (%):	
deep water	
L.O.D.	10
boulder	
instream veg.	50
overstream veg.	20
cutbanks	20
Crown Closure (%):	20
Aspect:	SE

Obstructions:
–spectacular 30m barrier falls immediately upstream
–another set of smaller falls (3.1m) downstream (1 km below barrier falls)

Riparian Zone Development:
–mixture of small to large deciduous and coniferous trees; deciduous dominant
–continuous and dense
–some side channels, and flooding of riparian zone (ie. unstable)

Comments:
–gravels greatly abundant, in large bars and beds
–rearing habitat not abundant, but some of it very complex (flooded banks and vegetation)

For photograph, see Figure 27 in text.

Site 13

Stream Survey Data

Comox Creek

Location: lowermost Reach 4; immediately upstream of barrier falls
Access: road along Comox Creek, from main road up the Cruickshank mainstem
Surveyed Length (m): 200
Date: September 28, 1994
Reach Length (km): not known
Stream Temperature (^oC): 8.0

Ave. Chan. width (m):	8
Ave. Wet. Width (m):	6
Ave. Max. Riffle Depth (cm):	25
Ave. Max. Pool Depth (cm):	60

% Pool:	5
% Riffle/Rapid:	75
% Glide/Run:	20
% other:	

Gradient (%):	4
Side Channel (%):	0
Debris: % area	<5
% stable	25

Bed Materials:	
clay, silt, sand (<2mm)	10
small gravel (2–16mm)	15
large gravel (16–64mm)	20
small cobble (64–128mm)	20
large cobble (128–256mm)	10
boulder (>256mm)	20
bedrock	5
D_{90} (cm):	35
Compaction:	moderate

Banks:	
height (m)	0.4
% stable	>90
texture	LGR
Confinement:	OC
Valley:Chan. Ratio:	5–10
Stage:	L
Flood Signs Ht. (m):	0.8
Braided ?:	yes
Bars (%):	20

Cover (total %):	15
Components (%):	
deep water	
L.O.D.	
boulder	25
instream veg.	
overstream veg.	50
cutbanks	25
Crown Closure (%):	25
Aspect:	SE

Obstructions:
–spectacular 30m barrier falls immediately downstream
–another set of smaller falls (3.1m) approx. 1 km further downstream

Riparian Zone Development:
–mixture of small to large deciduous and coniferous trees; deciduous dominant
–continuous and dense

Comments:
–gravels abundant, but water velocities extremely fast
–very little complexity of rearing habitat

For photograph, see Figure 28 in text.

Site 14 Stream Survey Data Datsio Creek

Location:	Reach 1; from Comox Creek to road crossing		
Access:	road along Comox Creek, from main road up the Cruickshank mainstem		
Surveyed Length (m):	150	**Date:**	September 28, 1994
Reach Length (km):	0.15	**Stream Temperature (^oC):**	8.5

Ave. Chan. width (m):	8	**% Pool:**	15	**Gradient (%):**	4.5
Ave. Wet. Width (m):	5	**% Riffle/Rapid:**	60	**Side Channel (%):**	0
Ave. Max. Riffle Depth (cm):	10	**% Glide/Run:**	25	**Debris: % area**	<5
Ave. Max. Pool Depth (cm):	30	**% other:**		% stable	30

Bed Materials:		**Banks:**		**Cover (total %):**	30
clay, silt, sand (<2mm)	10	height (m)	0.7	**Components (%):**	
small gravel (2–16mm)	10	% stable	90	deep water	
large gravel (16–64mm)	15	texture	LGF	L.O.D.	5
small cobble (64–128mm)	25	**Confinement:**	OC	boulder	80
large cobble (128–256mm)	20	**Valley:Chan. Ratio:**	>10	instream veg.	
boulder (>256mm)	20	**Stage:**	L	overstream veg.	10
bedrock		**Flood Signs Ht. (m):**	1.5	cutbanks	5
D_{90} (cm):	25	**Braided ?:**	no	**Crown Closure (%):**	25
Compaction:	low – mod	**Bars (%):**	35	**Aspect:**	NE

Obstructions:	–gradient increases abruptly (>10%) at the top of this short reach –one moderately large debris jam immediately below road crossing (not a barrier)
Riparian Zone Development:	–mixture of small to large deciduous and coniferous trees; deciduous dominant –continuous and dense, except at road crossing

Comments:
–frequent patches of gravel suitable for spawning
–complex streambed substrate habitat for smaller fish

For photograph, see Figure 29 in text.

Site 15 Stream Survey Data Datsio Creek

Location: lower Reach 2; immediately upstream of road crossing (150m upstream of Comox Cr.)
Access: road along Comox Creek, off main road up the Cruickshank mainstem
Surveyed Length (m): 100
Date: September 28, 1994
Reach Length (km): –
Stream Temperature (°C): 8.5

Ave. Chan. width (m):	6
Ave. Wet. Width (m):	5
Ave. Max. Riffle Depth (cm):	5
Ave. Max. Pool Depth (cm):	40

% Pool:	25
% Riffle/Rapid:	30
% Glide/Run:	30
% step falls	15

Gradient (%):	>10
Side Channel (%):	0
Debris: % area	<5
% stable	50

Bed Materials:	
clay, silt, sand (<2mm)	5
small gravel (2–16mm)	10
large gravel (16–64mm)	10
small cobble (64–128mm)	10
large cobble (128–256mm)	25
boulder (>256mm)	39
bedrock	1
D_{90} (cm):	80
Compaction:	moderate

Banks:	
height (m)	0.8
% stable	90
texture	LFR
Confinement:	FC
Valley:Chan. Ratio:	5–10
Stage:	L
Flood Signs Ht. (m):	1.5
Braided ?:	no
Bars (%):	10

Cover (total %):	50
Components (%):	
deep water	
L.O.D.	5
boulder	70
instream veg.	
overstream veg.	15
cutbanks	10
Crown Closure (%):	25
Aspect:	NE

Discharge:	wetted width (m)	4.3	mean velocity (m/s)	0.20
	mean depth (m)	0.14	discharge (m^3/s)	0.12

Obstructions: –gradient increases progressively >> 10% ; falls susupected

Riparian Zone –mixture of moderate to large deciduous and coniferous trees
Development: –dense and continuous

Comments: –pockets of gravels, as well as complex rearing habitat in step pools

For photograph, see Figure 30 in text.

Site 16

Stream Survey Data

Rees Creek

Location:	lowermost Reach 1; approx. 0.5 km upstream of the Cruickshank River		
Access:	hike up stream from road (ATV) up the Cruickshank mainstem		
Surveyed Length (m):	500	**Date:**	September 27, 1994
Reach Length (km):	2	**Stream Temperature (^oC):**	8.5

Ave. Chan. width (m):	13
Ave. Wet. Width (m):	12
Ave. Max. Riffle Depth (cm):	20
Ave. Max. Pool Depth (cm):	90

% Pool:	10
% Riffle/Rapid:	20
% Glide/Run:	70
% other:	

Gradient (%):	0.8
Side Channel (%):	0–10
Debris: % area	<5
% stable	50

Bed Materials:	
clay, silt, sand (<2mm)	15
small gravel (2–16mm)	25
large gravel (16–64mm)	20
small cobble (64–128mm)	25
large cobble (128–256mm)	14
boulder (>256mm)	1
bedrock	
D_{90} (cm):	15
Compaction:	low

Banks:	
height (m)	0.5
% stable	80
texture	GF
Confinement:	UC
Valley:Chan. Ratio:	>10
Stage:	L
Flood Signs Ht. (m):	1
Braided ?:	no
Bars (%):	5

Cover (total %):	10
Components (%):	
deep water	
L.O.D.	5
boulder	
instream veg.	25
overstream veg.	35
cutbanks	35
Crown Closure (%):	15
Aspect:	SE

Obstructions: –none

Riparian Zone –mixture of small to large deciduous and coniferous trees; deciduous dominant
Development: –continuous and dense

Comments: –abundant gravels, but very little cover for rearing

For photograph, see Figure 31 in text.

Site 17 — Stream Survey Data — Rees Creek

Location: mid Reach 1; approx. 1.5 km upstream of the Cruickshank River
Access: old road (ATV trail) along Rees Creek, from road (ATV) up the Cruickshank mainstem
Surveyed Length (m): 250 **Date:** September 27, 1994
Reach Length (km): 2 **Stream Temperature (^oC):** 8.5

Ave. Chan. width (m):	12	**% Pool:**	30	**Gradient (%):**	0.5
Ave. Wet. Width (m):	12	**% Riffle/Rapid:**	10	**Side Channel (%):**	10–40
Ave. Max. Riffle Depth (cm):	20	**% Glide/Run:**	60	**Debris: % area**	5
Ave. Max. Pool Depth (cm):	90	**% other:**		% stable	50

Bed Materials:		**Banks:**		**Cover (total %):**	30
clay, silt, sand (<2mm)	25	height (m)	0.6	**Components (%):**	
small gravel (2–16mm)	30	% stable	75	deep water	
large gravel (16–64mm)	20	texture	F	L.O.D.	10
small cobble (64–128mm)	15	**Confinement:**	UC	boulder	
large cobble (128–256mm)	9	**Valley:Chan. Ratio:**	>10	instream veg.	20
boulder (>256mm)	1	**Stage:**	L	overstream veg.	30
bedrock		**Flood Signs Ht. (m):**	1	cutbanks	40
D_{90} (cm):	10	**Braided ?:**	no	**Crown Closure (%):**	20
Compaction:	low	**Bars (%):**	0	**Aspect:**	SE

Discharge:	wetted width (m)	8.7	mean velocity (m/s)	0.27
	mean depth (m)	0.17	discharge (m^3/s)	0.40

Obstructions: –none

Riparian Zone Development:
–mixture of small to large deciduous and coniferous trees; deciduous dominant
–continuous and dense

Comments:
–abundant gravels, but heavily inundated with fines
–complex bank cover, but little mid channel cover

For photograph, see Figure 32 in text.

Site 18

Stream Survey Data

Rees Creek

Location: mid Reach 2; 250m upstream of Kweishun Creek
Access: hike up the stream, from end of ATV trail from Cruickshank mainstem
Surveyed Length (m): 400
Reach Length (km): 2
Date: September 28, 1994
Stream Temperature (^{o}C): 8.5

Ave. Chan. width (m):	11
Ave. Wet. Width (m):	9
Ave. Max. Riffle Depth (cm):	10
Ave. Max. Pool Depth (cm):	80

% Pool:	10
% Riffle/Rapid:	50
% Glide/Run:	40
% other:	

Gradient (%):	2
Side Channel (%):	0–10
Debris: % area	<5
% stable	60

Bed Materials:	
clay, silt, sand (<2mm)	10
small gravel (2–16mm)	15
large gravel (16–64mm)	20
small cobble (64–128mm)	15
large cobble (128–256mm)	15
boulder (>256mm)	20
bedrock	5
D_{90} (cm):	40
Compaction:	low – mod

Banks:	
height (m)	0.6
% stable	90
texture	LGF
Confinement:	UC
Valley:Chan. Ratio:	>10
Stage:	L
Flood Signs Ht. (m):	1
Braided ?:	yes
Bars (%):	15

Cover (total %):	25
Components (%):	
deep water	
L.O.D.	5
boulder	50
instream veg.	5
overstream veg.	30
cutbanks	10
Crown Closure (%):	15
Aspect:	E

Obstructions: –one moderately large debris jam just upstream of Kweishun Creek; no problem to fish passage

Riparian Zone –mixture of small to large deciduous and coniferous trees; deciduous dominant
Development: –continuous and dense

Comments: –gravels abundant and well sorted; rearing habitat somewhat limited, especially for larger fish

For photograph, see Figure 33 in text.

Site 19

Stream Survey Data

Kweishun Creek

Location: lower Reach 1; immediately upstream of Rees Creek
Access: hike up Rees Creek from end of ATV trail from Cruickshank Creek mainstem
Surveyed Length (m): 300 **Date:** September 28, 1994
Reach Length (km): 0.75 **Stream Temperature (^oC):** 7.5

Ave. Chan. width (m):	9
Ave. Wet. Width (m):	6
Ave. Max. Riffle Depth (cm):	15
Ave. Max. Pool Depth (cm):	70

% Pool:	15
% Riffle/Rapid:	35
% Glide/Run:	50
% other:	

Gradient (%):	2
Side Channel (%):	0–10
Debris: % area	<5
% stable	50

Bed Materials:	
clay, silt, sand (<2mm)	10
small gravel (2–16mm)	10
large gravel (16–64mm)	20
small cobble (64–128mm)	15
large cobble (128–256mm)	20
boulder (>256mm)	24
bedrock	1
D_{90} (cm):	70
Compaction:	moderate

Banks:	
height (m)	0.5
% stable	90
texture	FLR
Confinement:	UC
Valley:Chan. Ratio:	>10
Stage:	L
Flood Signs Ht. (m):	1
Braided ?:	yes
Bars (%):	25

Cover (total %):	55
Components (%):	
deep water	
L.O.D.	5
boulder	60
instream veg.	5
overstream veg.	25
cutbanks	5
Crown Closure (%):	15
Aspect:	NE

Discharge:	wetted width (m)	5.7	mean velocity (m/s)	0.19
	mean depth (m)	0.16	discharge (m^3/s)	0.17

Obstructions: –none

Riparian Zone Development: –mixture of small to large deciduous and coniferous trees; deciduous dominant
–dense and continuous

Comments: –abundant pockets of gravels; one redd site in electrofishing site 23, with newly emerging trout fry
–fairly complex rearing habitat for fry; likely limited for parr

For photograph, see Figure 34 in text.

Site 20	**Stream Survey Data**	Eric Creek

Location:	mid Reach 1; approx. 0.5 km upstream of the Cruickshank River
Access:	ATV trail along Eric Creek, from Cruickshank mainstem
Surveyed Length (m):	500
Reach Length (km):	1.3

Date: September 25, 1994

Stream Temperature (°C): 10.0

Ave. Chan. width (m):	14
Ave. Wet. Width (m):	10
Ave. Max. Riffle Depth (cm):	40
Ave. Max. Pool Depth (cm):	70

% Pool:	15
% Riffle/Rapid:	50
% Glide/Run:	35
% other:	

Gradient (%):	2.5
Side Channel (%):	0
Debris: % area	<5
% stable	25

Bed Materials:	
clay, silt, sand (<2mm)	5
small gravel (2–16mm)	10
large gravel (16–64mm)	15
small cobble (64–128mm)	10
large cobble (128–256mm)	20
boulder (>256mm)	40
bedrock	
D_{90} (cm):	70
Compaction:	low – mod

Banks:	
height (m)	1
% stable	95
texture	LF
Confinement:	OC
Valley:Chan. Ratio:	5–10
Stage:	L
Flood Signs Ht. (m):	1.3
Braided ?:	no
Bars (%):	25

Cover (total %):	60
Components (%):	
deep water	
L.O.D.	
boulder	85
instream veg.	
overstream veg.	10
cutbanks	5
Crown Closure (%):	10
Aspect:	E

Obstructions: –none

Riparian Zone Development: –mixture of small to moderate deciduous and coniferous trees; deciduous dominant
–dense and continuous

Comments: –spawning gravels in frequent patches; diverse and complex streambed substrates cover

For photograph, see Figure 35 in text.

Site 21

Stream Survey Data

Eric Creek

Location: mid Reach 2; approx. 2.5 km upstream of the Cruickshank River
Access: hike up stream from end of ATV trail from the Cruickshank mainstem
Surveyed Length (m): 400
Reach Length (km): 4
Date: September 25, 1994
Stream Temperature (^oC): 10.0

Ave. Chan. width (m):	21
Ave. Wet. Width (m):	7
Ave. Max. Riffle Depth (cm):	15
Ave. Max. Pool Depth (cm):	80

% Pool:	15
% Riffle/Rapid:	40
% Glide/Run:	35
% other:	

Gradient (%):	1.5
Side Channel (%):	0–10
Debris: % area	<5
% stable	10

Bed Materials:	
clay, silt, sand (<2mm)	5
small gravel (2–16mm)	10
large gravel (16–64mm)	15
small cobble (64–128mm)	20
large cobble (128–256mm)	20
boulder (>256mm)	30
bedrock	
D_{90} (cm):	35
Compaction:	moderate

Banks:	
height (m)	0.8
% stable	70
texture	LGF
Confinement:	OC
Valley:Chan. Ratio:	5–10
Stage:	L
Flood Signs Ht. (m):	1.2
Braided ?:	yes
Bars (%):	60

Cover (total %):	40
Components (%):	
deep water	
L.O.D.	5
boulder	55
instream veg.	
overstream veg.	10
cutbanks	30
Crown Closure (%):	10
Aspect:	NE

Discharge:	wetted width (m)	4.6	mean velocity (m/s)	0.27
	mean depth (m)	0.30	discharge (m^3/s)	0.37

Obstructions: –none

Riparian Zone –mixture of small to moderate deciduous and coniferous trees; deciduous dominant
Development: –continuous and dense

Comments: –frequent gravel patches, and some very complex rearing habitat
–dry side channel with extensive gravel bed

For photographs, see Figures 36 and 37 in text.

Site 22 Stream Survey Data Puntledge River

Location:	mid Reach 1; approx. 1 km upstream of Comox Lake
Access:	bridge crossing of road to Port Alberni
Surveyed Length (m):	300
Reach Length (km):	1.5
Date:	October 3, 1994
Stream Temperature (°C):	14.0

Ave. Chan. width (m):	21
Ave. Wet. Width (m):	12
Ave. Max. Riffle Depth (cm):	15
Ave. Max. Pool Depth (cm):	>100

% Pool:	15
% Riffle/Rapid:	25
% Glide/Run:	60
% other:	

Gradient (%):	0.5
Side Channel (%):	10–40
Debris: % area	5
% stable	60

Bed Materials:	
clay, silt, sand (<2mm)	15
small gravel (2–16mm)	25
large gravel (16–64mm)	30
small cobble (64–128mm)	15
large cobble (128–256mm)	9
boulder (>256mm)	1
bedrock	
D_{90} (cm):	15
Compaction:	low – mod

Banks:	
height (m)	0.6
% stable	80
texture	GF
Confinement:	UC
Valley:Chan. Ratio:	>10
Stage:	L
Flood Signs Ht. (m):	1
Braided ?:	yes
Bars (%):	40

Cover (total %):	25
Components (%):	
deep water	
L.O.D.	30
boulder	5
instream veg.	10
overstream veg.	30
cutbanks	25
Crown Closure (%):	5
Aspect:	NE

Discharge:	wetted width (m)	8.9	mean velocity (m/s)	0.68
	mean depth (m)	0.17	discharge (m^3/s)	1.03

Obstructions: –none

Riparian Zone –mixture of small to large deciduous and coniferous trees
Development: –sparse and/or dominated by small deciduous at various locations

Comments: –some excellent spawning and rearing habitat; cover primarily limited to bank areas, but frequently complex

For photograph, see Figure 39 in text.

Site 23 | **Stream Survey Data** | **Puntledge River**

Location: upper Reach 2; approx. 3 km upstream of Comox Lake

Access: hike from road up Puntledge River, from Comox Lake

Surveyed Length (m): 300

Reach Length (km): 2

Date: October 5, 1994

Stream Temperature (^{o}C): 15.0

Ave. Chan. width (m):	20
Ave. Wet. Width (m):	16
Ave. Max. Riffle Depth (cm):	15
Ave. Max. Pool Depth (cm):	90

% Pool:	15
% Riffle/Rapid:	25
% Glide/Run:	60
% other:	

Gradient (%):	0.8
Side Channel (%):	0–10
Debris: % area	<5
% stable	60

Bed Materials:	
clay, silt, sand (<2mm)	10
small gravel (2–16mm)	15
large gravel (16–64mm)	35
small cobble (64–128mm)	20
large cobble (128–256mm)	10
boulder (>256mm)	10
bedrock	
D_{90} (cm):	25
Compaction:	low – mod

Banks:	
height (m)	0.4
% stable	90
texture	LGF
Confinement:	OC
Valley:Chan. Ratio:	5–10
Stage:	L
Flood Signs Ht. (m):	1
Braided ?:	yes
Bars (%):	20

Cover (total %):	30
Components (%):	
deep water	
L.O.D.	10
boulder	25
instream veg.	15
overstream veg.	30
cutbanks	20
Crown Closure (%):	10
Aspect:	N

Obstructions: –some large debris jams immediately downstream; another near oulet of Willemar Lake; not barriers

Riparian Zone Development:
–mixture of moderate to large deciduous and coniferous trees
–very thick shrub growths along banks

Comments: –some excellent patches of gravels; increased complexity of rearing habitat due to larger substrates

For photograph, see Figure 40 in text.

Site 24

Stream Survey Data

Puntledge River

Location:	Reach 3; between Willemar and Forbush lakes		
Access:	boat from north end of Willemar Lake		
Surveyed Length (m):	400	**Date:**	October 4, 1994
Reach Length (km):	0.4	**Stream Temperature (°C):**	13.0

Ave. Chan. width (m):	11
Ave. Wet. Width (m):	10
Ave. Max. Riffle Depth (cm):	10
Ave. Max. Pool Depth (cm):	50

% Pool:	5
% Riffle/Rapid:	30
% Glide/Run:	65
% other:	

Gradient (%):	1
Side Channel (%):	0
Debris: % area	<5
% stable	50

Bed Materials:	
clay, silt, sand (<2mm)	5
small gravel (2–16mm)	35
large gravel (16–64mm)	25
small cobble (64–128mm)	15
large cobble (128–256mm)	15
boulder (>256mm)	5
bedrock	
D_{90} (cm):	20
Compaction:	low – mod

Banks:	
height (m)	0.3
% stable	90
texture	GF
Confinement:	CO
Valley:Chan. Ratio:	2–5
Stage:	L
Flood Signs Ht. (m):	0.8
Braided ?:	no
Bars (%):	5

Cover (total %):	15
Components (%):	
deep water	
L.O.D.	5
boulder	10
instream veg.	10
overstream veg.	50
cutbanks	25
Crown Closure (%):	20
Aspect:	E

Obstructions: –none

Riparian Zone Development: –mixture of moderate to large deciduous and coniferous trees
–thick growth of shrubs along banks

Comments: –excellent spawning channel; abundant gravels; laminar flows
–featureless rearing habitat

Site 25	**Stream Survey Data**	Puntledge River

Location:	Reach 4; immediately upstream of Forbush Lake		
Access:	boat from north end of Willemar Lake		
Surveyed Length (m):	600	**Date:**	October 4, 1994
Reach Length (km):	0.6	**Stream Temperature (^{o}C):**	9.0

Ave. Chan. width (m):	10
Ave. Wet. Width (m):	8
Ave. Max. Riffle Depth (cm):	10
Ave. Max. Pool Depth (cm):	110

% Pool:	30
% Riffle/Rapid:	10
% Glide/Run:	60
% other:	

Gradient (%):	0.5
Side Channel (%):	10–40
Debris: % area	10
% stable	40

Bed Materials:	
clay, silt, sand (<2mm)	20
small gravel (2–16mm)	50
large gravel (16–64mm)	20
small cobble (64–128mm)	10
large cobble (128–256mm)	
boulder (>256mm)	
bedrock	
D_{90} (cm):	10
Compaction:	moderate

Banks:	
height (m)	0.5
% stable	80
texture	FG
Confinement:	UC
Valley:Chan. Ratio:	>10
Stage:	L
Flood Signs Ht. (m):	0.8
Braided ?:	no
Bars (%):	20

Cover (total %):	35
Components (%):	
deep water	
L.O.D.	10
boulder	
instream veg.	25
overstream veg.	50
cutbanks	15
Crown Closure (%):	25
Aspect:	E

Obstructions: —a few minor debris plugs; transient, and not a problem

Riparian Zone Development: —extremely dense growths of shrubs, but very few trees (mostly deciduous)

Comments: —abundant gravels and complex bank habitat
—substantial inundation of gravels with fines

For photograph, see Figure 41 in text.

Site 26

Stream Survey Data

Puntledge River

Location:	lower Reach 5; 1 km upstream of Forbush Lake
Access:	boat from north end of Willemar Lake
Surveyed Length (m):	400
Reach Length (km):	3.5
Date:	October 4, 1994
Stream Temperature (^{o}C):	8.0

Ave. Chan. width (m):	8
Ave. Wet. Width (m):	7.5
Ave. Max. Riffle Depth (cm):	10
Ave. Max. Pool Depth (cm):	70

% Pool:	10
% Riffle/Rapid:	15
% Glide/Run:	75
% other:	

Gradient (%):	1
Side Channel (%):	10–40
Debris: % area	<5
% stable	60

Bed Materials:	
clay, silt, sand (<2mm)	15
small gravel (2–16mm)	40
large gravel (16–64mm)	25
small cobble (64–128mm)	15
large cobble (128–256mm)	5
boulder (>256mm)	
bedrock	
D_{90} (cm):	10
Compaction:	low – mod

Banks:	
height (m)	0.5
% stable	90
texture	FG
Confinement:	UC
Valley:Chan. Ratio:	>10
Stage:	L
Flood Signs Ht. (m):	0.8
Braided ?:	no
Bars (%):	5

Cover (total %):	45
Components (%):	
deep water	
L.O.D.	15
boulder	
instream veg.	30
overstream veg.	40
cutbanks	15
Crown Closure (%):	50
Aspect:	E

Obstructions: –occasional transient debris plug, as in Reach 4 (not a problem)

Riparian Zone Development: –extremely dense shrub growth; few trees (mostly deciduous)

Comments: –abundant spawning gravels; some complex bank cover
–centre portion of stream featureless over most of the streamlength

For photograph, see Figure 42 in text.

Site 27	**Stream Survey Data**	Toma Creek

Location: lowermost Reach 1; first 500m upstream of Comox Lake
Access: hike in from old road up east side of Comox Lake
Surveyed Length (m): 200 **Date:** October 1, 1994
Reach Length (km): 1.5 **Stream Temperature (^{o}C):** 10.0

Ave. Chan. width (m):	8
Ave. Wet. Width (m):	8
Ave. Max. Riffle Depth (cm):	–
Ave. Max. Pool Depth (cm):	80

% Pool:	100
% Riffle/Rapid:	
% Glide/Run:	
% other:	

Gradient (%):	<0.5
Side Channel (%):	>40
Debris: % area	35
% stable	40

Bed Materials:	
clay, silt, sand (<2mm)	70
small gravel (2–16mm)	25
large gravel (16–64mm)	5
small cobble (64–128mm)	
large cobble (128–256mm)	
boulder (>256mm)	
bedrock	
D_{90} (cm):	1
Compaction:	low

Banks:	
height (m)	0.2
% stable	40
texture	F
Confinement:	UC
Valley:Chan. Ratio:	>10
Stage:	L
Flood Signs Ht. (m):	0.6
Braided ?:	no
Bars (%):	0

Cover (total %):	50
Components (%):	
deep water	
L.O.D.	50
boulder	
instream veg.	20
overstream veg.	20
cutbanks	10
Crown Closure (%):	15
Aspect:	N

Discharge:	(none detectable)	wetted width (m)		mean velocity (m/s)	0.00
		mean depth (m)		discharge (m^3/s)	0.00

Obstructions: —none; but channel very diffuse, with frequent debris

Riparian Zone Development:
—principally deciduous shrubs
—sparse in some areas (likely due to flooding)

Comments:
—diffuse and braided channel, within marsh–like surroundings
—very complex rearing habitat
—considerable water depth at time of sampling, but no flow

For photograph, see Figure 43 in text

Site 28

Stream Survey Data

Toma Creek

Location: mid Reach 1; approx. 1 km upstream of Comox Lake

Access: hike up stream from bridge crossing (road to Port Alberni)

Surveyed Length (m): 500

Date: October 1, 1994

Reach Length (km): 1.5

Stream Temperature (^{o}C): –

Ave. Chan. width (m):	8
Ave. Wet. Width (m):	0
Ave. Max. Riffle Depth (cm):	
Ave. Max. Pool Depth (cm):	

% Pool:	
% Riffle/Rapid:	
% Glide/Run:	
% other:	

Gradient (%):	0.5
Side Channel (%):	10–40
Debris: % area	
% stable	

Bed Materials:	
clay, silt, sand (<2mm)	35
small gravel (2–16mm)	45
large gravel (16–64mm)	15
small cobble (64–128mm)	5
large cobble (128–256mm)	
boulder (>256mm)	
bedrock	
D_{90} (cm):	4
Compaction:	

Banks:	
height (m)	0.2
% stable	30
texture	F
Confinement:	UC
Valley:Chan. Ratio:	>10
Stage:	dry
Flood Signs Ht. (m):	0.6
Braided ?:	–
Bars (%):	–

Cover (total %):	
Components (%):	
deep water	
L.O.D.	
boulder	
instream veg.	
overstream veg.	
cutbanks	
Crown Closure (%):	
Aspect:	N

Obstructions: –none

Riparian Zone –primarily deciduous shrubs
Development: –occasionally sparse (likely due to flooding)

Comments: –main channel totally dry at time of inspection; occasional isolated backwater only

For photograph, see Figure 5 in text.

Site 29

Stream Survey Data

Toma Creek

Location:	lower Reach 2; approx. 2.5 km upstream of Comox Lake		
Access:	hike from road along Toma Creek (to Port Alberni)		
Surveyed Length (m):	250	**Date:**	October 1, 1994
Reach Length (km):	4.5	**Stream Temperature (^oC):**	10.0

Ave. Chan. width (m):	10
Ave. Wet. Width (m):	5
Ave. Max. Riffle Depth (cm):	5
Ave. Max. Pool Depth (cm):	60

% Pool:	20
% Riffle/Rapid:	40
% Glide/Run:	40
% other:	

Gradient (%):	4
Side Channel (%):	0–10
Debris: % area	5
% stable	25

Bed Materials:	
clay, silt, sand (<2mm)	15
small gravel (2–16mm)	10
large gravel (16–64mm)	15
small cobble (64–128mm)	20
large cobble (128–256mm)	30
boulder (>256mm)	10
bedrock	
D_{90} (cm):	30
Compaction:	low – mod

Banks:	
height (m)	1
% stable	60
texture	GF
Confinement:	FC
Valley:Chan. Ratio:	5–10
Stage:	L
Flood Signs Ht. (m):	1.4
Braided ?:	yes
Bars (%):	40

Cover (total %):	50
Components (%):	
deep water	
L.O.D.	10
boulder	50
instream veg.	
overstream veg.	25
cutbanks	15
Crown Closure (%):	50
Aspect:	NW

Discharge:	wetted width (m)	4.6	mean velocity (m/s)	0.07
	mean depth (m)	0.27	discharge (m^3/s)	0.09

Obstructions: –none

Riparian Zone Development:
–mixture of moderate to large deciduous and coniferous trees
–deciduous dominant along stream

Comments:
–a near ideal nursery stream at low flows; however, obviously flashy
–considerable bank erosion and instability

For photograph, see Figure 10 in text.

Site 30

Stream Survey Data

Perseverance Creek

Location: mid Reach 1; approx. 1 km upstream of Comox Lake
Access: hike from road to southeast corner of Comox Lake
Surveyed Length (m): 600
Reach Length (km): 1.5
Date: October 6, 1994
Stream Temperature (^{o}C): –

Ave. Chan. width (m):	10
Ave. Wet. Width (m):	0
Ave. Max. Riffle Depth (cm):	
Ave. Max. Pool Depth (cm):	

% Pool:	
% Riffle/Rapid:	
% Glide/Run:	
% other:	

Gradient (%):	0.5
Side Channel (%):	0–10
Debris: % area	
% stable	

Bed Materials:	
clay, silt, sand (<2mm)	25
small gravel (2–16mm)	25
large gravel (16–64mm)	20
small cobble (64–128mm)	15
large cobble (128–256mm)	10
boulder (>256mm)	5
bedrock	
D_{90} (cm):	20
Compaction:	

Banks:	
height (m)	0.8
% stable	80
texture	FG
Confinement:	OC
Valley:Chan. Ratio:	5–10
Stage:	dry
Flood Signs Ht. (m):	1.2
Braided ?:	
Bars (%):	

Cover (total %):	
Components (%):	
deep water	
L.O.D.	
boulder	
instream veg.	
overstream veg.	
cutbanks	
Crown Closure (%):	
Aspect:	NW

Obstructions: –major debris jam approx. 500m upstream of Comox Lake; could be a barrier at some flows

Riparian Zone Development:
–mixture of small to large deciduous and coniferous trees
–shrub growth dense along banks; some blowdown

Comments:
–abundant gravels, in extensive beds; considerable amounts of fines, however
–bank cover complex; debris, cutbanks, roots, overhanging vegetation, etc.

For photograph, see Figure 11 in text.

Site 31 **Stream Survey Data** **Perseverance Creek**

Location:	upper Reach 2; approx. 3.5 km upstream of Comox Lake		
Access:	hike from road to Allen Lake	**Date:**	October 6, 1994
Surveyed Length (m):	500	**Stream Temperature (^oC):**	–
Reach Length (km):	2.5		

Ave. Chan. width (m):	7
Ave. Wet. Width (m):	0
Ave. Max. Riffle Depth (cm):	
Ave. Max. Pool Depth (cm):	

% Pool:	
% Riffle/Rapid:	
% Glide/Run:	
% other:	

Gradient (%):	4
Side Channel (%):	0–10
Debris: % area	
% stable	

Bed Materials:	
clay, silt, sand (<2mm)	10
small gravel (2–16mm)	10
large gravel (16–64mm)	10
small cobble (64–128mm)	15
large cobble (128–256mm)	15
boulder (>256mm)	40
bedrock	
D_{90} (cm):	40
Compaction:	

Banks:	
height (m)	0.5
% stable	90
texture	LG
Confinement:	FC
Valley:Chan. Ratio:	2–5
Stage:	dry
Flood Signs Ht. (m):	0.8
Braided ?:	
Bars (%):	

Cover (total %):	
Components (%):	
deep water	
L.O.D.	
boulder	
instream veg.	
overstream veg.	
cutbanks	
Crown Closure (%):	
Aspect:	NW

Obstructions:
–sandstone falls, approx. 4 km upstream of Comox Lake
–consists of 5 steps, ranging in height from 0.5m to 1.6m

Riparian Zone Development:
–mixture of small to moderate deciduous and coniferous trees
–shrub growth dense along banks; some blowdown

Comments:
–only the occasional patch of gravels (spawning habitat limited); but substantial substrate cover (boulders)
–bank cover complex; debris, cutbanks, roots, overhanging vegetation, etc.

For photograph, see Figure 12 in text.

Site 32 **Stream Survey Data** Perseverance Creek

Location: lower to mid Reach 3; approx. 4 km upstream of Comox Lake
Access: hike from road to Allen Lake
Surveyed Length (m): 300 **Date:** October 6, 1994
Reach Length (km): 0.6 **Stream Temperature (^{o}C):** –

Ave. Chan. width (m):	8
Ave. Wet. Width (m):	0
Ave. Max. Riffle Depth (cm):	
Ave. Max. Pool Depth (cm):	

% Pool:	
% Riffle/Rapid:	
% Glide/Run:	
% other:	

Gradient (%):	2.5
Side Channel (%):	0
Debris: % area	
% stable	

Bed Materials:	
clay, silt, sand (<2mm)	5
small gravel (2–16mm)	5
large gravel (16–64mm)	10
small cobble (64–128mm)	15
large cobble (128–256mm)	25
boulder (>256mm)	40
bedrock	
D_{90} (cm):	35
Compaction:	

Banks:	
height (m)	0.6
% stable	90
texture	LG
Confinement:	UC
Valley:Chan. Ratio:	>10
Stage:	dry
Flood Signs Ht. (m):	0.8
Braided ?:	
Bars (%):	

Cover (total %):	
Components (%):	
deep water	
L.O.D.	
boulder	
instream veg.	
overstream veg.	
cutbanks	
Crown Closure (%):	
Aspect:	NW

Discharge: –trickle of flow over falls at commencement of reach
–measured by bucket : 1.3 L / s

Obstructions: –none, other than falls at commencement of this reach (see habitat survey site 31)

Riparian Zone Development: –mixture of small to moderate deciduous and coniferous trees
–shrub growth dense along banks; some blowdown

Comments: –only the occasional patch of gravels (spawning habitat limited); but substantial substrate cover (boulders)
–bank cover moderately complex; very similar to Reach 2

Appendix 6.

Fish capture and habitat data at electrofishing sites in tributaries to Comox Lake, September–October 1994.

Key to Species :

CT	cutthroat troat
RB	rainbow/steelhead trout
CO	coho salmon
CC	sculpins (*C. aleuticus*)
SB	stickleback (*G. aculeatus*)

Electrofishing Site Data and Results

Site No.:	1	**Length (m):**	10.4	September 30, 1994
Stream:	Cruickshank River	**Area (m^2):**	28.1	
Location:	lower Reach 1; 1.5 km upstream of Comox Lake			

Species/ Cohort	Length (mm)			Mean	Capture		Population Estimates			
	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m^2	g/m^2	n/m
CT 0+	44	44	44.0	0.8	1	0	1.0	0.04	0.03	0.10
CO 0+	44	89	67.4	3.6	67	19	93.5	3.33	11.99	8.99
CO 0+^{m}	63	84	71.0	4.2	6	3	12.0	0.43	1.78	1.15
CC	45	71	54.0	–	2	1	4.0	0.14	–	0.38

Habitat Type (%) : 0 **riffle** 60 **pool** 40 **glide**

Substrates (%) :		**Cover Components (%) :**	
fines	20	canopy/vegetation	16
sm. gravel	10	stable logs,roots,etc.	20
lg. gravel	10	cutbanks	7
cobble	55	substrates (fry)	40
boulders	5	substrates (parr)	8
bedrock	0	D_{90} (cm)	20

Turbidity clear **Compaction** high **Water Temp. (°C)** 10.5

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.11	0.00	1.00	0.55	1.00	0.71	1.00	1.00	0.54	0.26
0.5	0.20	0.00	1.00	0.66	0.98	0.85	1.00	1.00	0.75	0.34
1.0	0.29	0.00	0.98	0.93	0.98	1.00	1.00	1.00	0.90	0.70
1.5	0.35	0.01	0.85	0.98	0.85	1.00	1.00	1.00	0.90	0.80
2.0	0.54	0.03	0.29	1.00	0.29	1.00	0.70	1.00	0.90	0.80
2.5	0.77	0.05	0.04	1.00	0.04	1.00	0.40	0.80	0.90	0.80
2.8	0.86	0.25	0.02	1.00	0.02	1.00	0.36	0.68	1.00	0.60
Weighted Mean	0.414	0.038	0.653	0.883	0.650	0.947	0.826	0.954	0.846	0.640

Electrofishing Site Data and Results

Site No.:	2	**Length (m):**	8.4	October 1, 1994
Stream:	Cruickshank River	**Area (m^2):**	37.0	
Location:	lower Reach 1; 1.8 km upstream of Comox Lake			

Species/ Cohort	Length (mm)			Mean	Capture		Population Estimates			
	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m^2	g/m^2	n/m
CT 0+	44	54	49.0	1.2	2	0	2.0	0.05	0.06	0.24
CC	38	79	44.5	–	16	7	28.4	0.77	–	3.39

Habitat Type (%) : 10 **riffle** 5 **pool** 85 **glide**

Substrates (%) :		**Cover Components (%) :**	
fines	5	canopy/vegetation	–
sm. gravel	5	stable logs,roots,etc.	–
lg. gravel	20	cutbanks	–
cobble	50	substrates (fry)	95
boulders	20	substrates (parr)	45
bedrock	0	**D_{90} (cm)**	30

Turbidity clear **Compaction** moderate **Water Temp. (°C)** 9.5

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.03	1.00	0.03	1.00	1.00	0.05	0.02
0.5	0.07	0.00	1.00	0.17	1.00	0.22	1.00	1.00	0.10	0.04
1.0	0.14	0.00	1.00	0.45	1.00	0.50	1.00	1.00	0.41	0.20
1.5	0.15	0.03	1.00	0.45	1.00	0.50	1.00	1.00	0.41	0.20
2.0	0.32	0.05	0.85	0.98	0.85	1.00	1.00	1.00	0.90	0.75
2.5	0.41	0.08	0.50	1.00	0.50	1.00	0.90	1.00	0.95	1.00
3.0	0.43	0.44	0.01	0.60	0.01	0.60	0.29	0.50	0.05	0.00
3.5	0.47	0.36	0.05	0.92	0.05	0.92	0.35	0.60	0.11	0.00
4.0	0.44	0.28	0.28	1.00	0.28	1.00	0.50	0.65	0.30	0.10
4.5	0.40	0.33	0.13	0.98	0.13	0.98	0.50	0.60	0.23	0.05
Weighted Mean	0.295	0.225	0.583	0.675	0.583	0.694	0.755	0.839	0.373	0.258

Electrofishing Site Data and Results

Site No.: 3 **Length (m):** 9.7 September 30, 1994

Stream: Cruickshank River **Area (m^2):** 40.7

Location: upper Reach 1; 2 km upstream of Comox Creek (6 km upstream of Comox Lake)

Species/ Cohort	Length (mm) Min.	Max.	Mean	Mean Wt(g)	Capture 1	2	Population Estimates Pop.*n*	n/m^2	g/m^2	n/m
CT 0+	46	62	52.3	1.5	3	1	4.5	0.11	0.16	0.46
DV 1+	88	98	93.0	7.5	2	0	2.0	0.05	0.37	0.21
CC	36	75	52.0	–	67	19	93.5	2.30	–	9.64

Habitat Type (%) : 50 **riffle** 10 **pool** 40 **glide**

Substrates (%) :

fines	5
sm. gravel	5
lg. gravel	10
cobble	50
boulders	30
bedrock	0

Cover Components (%) :

canopy/vegetation	–
stable logs,roots,etc.	–
cutbanks	–
substrates (fry)	90
substrates (parr)	50
D_{90} (cm)	70

Turbidity clear **Compaction** moderate–high **Water Temp. (°C)** 10.0

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.03	1.00	0.03	1.00	0.50	0.00	0.00
0.5	0.04	0.00	1.00	0.03	1.00	0.03	1.00	1.00	0.05	0.02
1.0	0.09	0.03	1.00	0.25	1.00	0.27	1.00	1.00	0.19	0.04
1.5	0.23	0.18	1.00	0.77	0.98	0.98	0.80	0.80	0.98	0.26
2.0	0.25	0.31	0.25	0.84	0.25	0.98	0.56	0.60	0.23	0.03
2.5	0.26	0.54	0.00	0.20	0.00	0.23	0.13	0.30	0.00	0.00
3.0	0.33	0.67	0.00	0.04	0.00	0.04	0.05	0.15	0.00	0.00
3.5	0.40	0.91	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
4.0	0.35	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.2	0.27	1.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weighted Mean	0.228	0.616	0.446	0.255	0.444	0.303	0.484	0.494	0.173	0.041

Electrofishing Site Data and Results

Site No.:	4	**Length (m):**	7.5	September 23, 1994
Stream:	Cruickshank River	**Area (m²):**	26.3	

Location: top of Reach 1; 100m upstream of Rees Creek

Species/ Cohort	Length (mm)			Mean	Capture		Population Estimates			
	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m²	g/m²	n/m
CT 0+	54	58	55.3	2.0	2	1	4.0	0.15	0.31	0.53
CT 1+	83	106	95.7	9.7	3	0	3.0	0.11	1.11	0.40
CT 2+	126	126	126.0	23.5	1	0	1.0	0.04	0.90	0.13
RB 0+	62	62	62.0	2.7	1	0	1.0	0.04	0.10	0.13
CO 0+	79	79	79.0	5.4	1	0	1.0	0.04	0.21	0.13
CC	42	77	55.8	–	3	1	4.5	0.17	–	–

Habitat Type (%) : 20 **riffle** 20 **pool** 60 **glide**

Substrates (%) :		**Cover Components (%) :**	
fines	10	canopy/vegetation	–
sm. gravel	5	stable logs,roots,etc.	7
lg. gravel	5	cutbanks	–
cobble	40	substrates (fry)	90
boulders	40	substrates (parr)	40
bedrock	0	D_{90} (cm)	50

Turbidity clear **Compaction** moderate–high **Water Temp. (°C)** 11.0

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.03	1.00	0.03	1.00	0.50	0.00	0.00
0.5	0.05	0.00	1.00	0.10	1.00	0.13	1.00	1.00	0.05	0.02
1.0	0.22	0.00	1.00	0.77	0.98	0.98	1.00	1.00	0.88	0.43
1.5	0.44	0.05	0.50	1.00	0.50	1.00	0.90	1.00	0.90	0.80
2.0	0.45	0.41	0.02	0.70	0.02	0.70	0.29	0.50	0.05	0.00
2.5	0.52	0.41	0.01	0.70	0.01	0.70	0.26	0.50	0.05	0.00
3.0	0.58	0.26	0.16	1.00	0.16	1.00	0.48	0.70	0.51	0.10
3.5	0.55	0.36	0.05	0.98	0.05	0.98	0.39	0.60	0.23	0.05
Weighted Mean	0.365	0.258	0.459	0.682	0.457	0.716	0.659	0.750	0.366	0.196

Electrofishing Site Data and Results

Site No.: 5 **Length (m):** 9.3 September 27, 1994
Stream: Cruickshank River **Area (m^2):** 40.9
Location: lower Reach 2; 1 km upstream of Rees Creek

Species/	Length (mm)			Mean	Capture		Population Estimates			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m^2	g/m^2	n/m
CT 0+	52	61	57.0	2.1	3	1	4.5	0.11	0.23	0.48
CT 2+	125	125	125.0	22.0	1	0	1.0	0.02	0.54	0.11
RB 1+	112	112	112.0	14.0	1	0	1.0	0.02	0.34	0.11
RB 2+	149	149	149.0	32.0	1	0	1.0	0.02	0.78	0.11
CC	41	115	60.8	–	19	11	45.1	1.10	–	4.85

Habitat Type (%) : 10 **riffle** 20 **pool** 55 **glide** 15 **rapid**

Substrates (%) :

fines	5
sm. gravel	5
lg. gravel	10
cobble	40
boulders	40
bedrock	0

Cover Components (%) :

canopy/vegetation	–
stable logs,roots,etc.	–
cutbanks	–
substrates (fry)	100
substrates (parr)	60
D_{90} (cm)	90

Turbidity clear **Compaction** moderate–high **Water Temp. (°C)** 12.5

Transect and Associated Hydraulic Suitability Data

Length	Depth	Velocity	Probability of Use								
(m)	(m)	(m/s)	RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.17	1.00	0.22	1.00	1.00	0.10	0.04
0.5	0.14	0.00	1.00	0.45	1.00	0.50	1.00	1.00	0.41	0.20
1.0	0.28	0.00	0.98	0.93	0.98	1.00	1.00	1.00	0.90	0.70
1.5	0.27	0.21	0.88	0.93	0.88	1.00	0.80	0.75	0.92	0.23
2.0	0.25	0.28	0.55	0.86	0.54	1.00	0.56	0.65	0.30	0.06
2.5	0.37	0.49	0.01	0.33	0.01	0.33	0.20	0.40	0.02	0.00
3.0	0.40	0.87	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
3.5	0.41	0.18	0.50	1.00	0.50	1.00	0.72	0.80	0.98	0.40
4.0	0.32	0.67	0.00	0.04	0.00	0.04	0.05	0.15	0.00	0.00
4.4	0.28	0.64	0.00	0.04	0.00	0.04	0.05	0.20	0.00	0.00
Weighted Mean	0.291	0.391	0.502	0.527	0.501	0.567	0.551	0.610	0.406	0.183

Electrofishing Site Data and Results

Site No.:	6	**Length (m):**	9.5	September 27, 1994
Stream:	Cruickshank River	**Area (m²):**	54.2	
Location:	mid Reach 2; 2.5 km upstream of Rees Creek			

Species/ Cohort	Length (mm)			Mean Wt(g)	Capture		Population Estimates			
	Min.	Max.	Mean		1	2	Pop.*n*	n/m²	g/m²	n/m
CT 0+	48	59	55.3	1.9	3	1	4.5	0.08	0.15	0.47
CT 1+	119	119	119.0	16.5	1	0	1.0	0.02	0.30	0.11
CO 0+	66	66	66.0	3.6	1	0	1.0	0.02	0.07	0.11
CC	47	75	61.6	–	7	2	9.8	0.18	–	1.03

Habitat Type (%) : 30 **riffle** 20 **pool** 30 **glide** 20 **rapid**

Substrates (%) :

fines	5
sm. gravel	5
lg. gravel	10
cobble	35
boulders	45
bedrock	0

Cover Components (%) :

canopy/vegetation	–
stable logs,roots,etc.	–
cutbanks	–
substrates (fry)	95
substrates (parr)	70
D_{90} (cm)	80

Turbidity clear **Compaction** moderate–high **Water Temp. (°C)** 12.0

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.10	1.00	0.13	1.00	1.00	0.10	0.04
0.5	0.12	0.00	1.00	0.35	1.00	0.36	1.00	1.00	0.31	0.14
1.0	0.26	0.00	0.98	0.86	0.98	1.00	1.00	1.00	0.90	0.62
1.5	0.38	0.03	0.66	1.00	0.66	1.00	1.00	1.00	0.90	0.80
2.0	0.31	0.03	0.85	0.98	0.85	1.00	1.00	1.00	0.90	0.75
2.5	0.43	0.00	0.50	1.00	0.50	1.00	0.90	1.00	0.90	0.80
3.0	0.41	0.03	0.50	1.00	0.50	1.00	0.90	1.00	0.90	0.80
3.5	0.39	0.31	0.17	0.98	0.17	0.98	0.50	0.60	0.23	0.05
4.0	0.44	0.75	0.00	0.00	0.00	0.00	0.05	0.10	0.00	0.00
4.5	0.48	0.82	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
5.0	0.39	0.87	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
5.5	0.46	0.54	0.00	0.23	0.00	0.23	0.10	0.30	0.00	0.00
5.7	0.46	1.26	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
Weighted Mean	0.356	0.363	0.452	0.560	0.452	0.576	0.607	0.660	0.446	0.349

Electrofishing Site Data and Results

Site No.:	7	**Length (m):**	8.5	September 26, 1994
Stream:	Cruickshank River	**Area (m²):**	40.8	
Location:	mid Reach 3; 2.5 km downstream of Eric Creek			

Species/ Cohort	Length (mm)			Mean	Capture		Population Estimates			
	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m²	g/m²	n/m
RB 0+	42	64	52.2	1.7	6	3	12.0	0.29	0.50	1.41
RB 1+	88	88	88.0	6.8	1	0	1.0	0.02	0.17	0.12
RB 3+	180	180	180.0	60.0	1	0	1.0	0.02	1.47	0.12

Habitat Type (%) : 10 **riffle** 15 **pool** 50 **glide** 25 **rapid**

Substrates (%) :

fines	5
sm. gravel	10
lg. gravel	15
cobble	45
boulders	25
bedrock	

Cover Components (%) :

canopy/vegetation	–
stable logs,roots,etc.	–
cutbanks	–
substrates (fry)	95
substrates (parr)	40
D_{90} **(cm)**	35

Turbidity clear **Compaction** moderate–high **Water Temp. (°C)** 12.0

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.28	0.34	0.25	0.91	0.25	0.98	0.56	0.60	0.23	0.04
0.5	0.29	0.28	0.54	0.93	0.54	1.00	0.56	0.65	0.30	0.09
1.0	0.18	0.75	0.00	0.00	0.00	0.00	0.05	0.10	0.00	0.00
1.5	0.25	0.62	0.00	0.03	0.00	0.04	0.05	0.20	0.00	0.00
2.0	0.30	0.80	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
2.5	0.24	0.39	0.06	0.69	0.06	0.80	0.44	0.50	0.08	0.00
3.0	0.15	0.10	1.00	0.45	1.00	0.50	1.00	1.00	0.43	0.25
3.5	0.13	0.33	0.18	0.33	0.18	0.34	0.56	0.60	0.07	0.01
4.0	0.11	0.03	1.00	0.25	1.00	0.27	1.00	1.00	0.31	0.14
4.5	0.06	0.00	1.00	0.10	1.00	0.13	1.00	1.00	0.10	0.04
4.9	0.00	0.00	1.00	0.03	1.00	0.03	1.00	0.50	0.05	0.02
Weighted Mean	0.190	0.436	0.429	0.331	0.429	0.364	0.535	0.561	0.144	0.056

Electrofishing Site Data and Results

Site No.: 8 **Length (m):** 7.3 September 26, 1994

Stream: Cruickshank River **Area (m^2):** 43.8

Location: lower Reach 4; 1.5 km downstream of Eric Creek (upstream of mainstem bridge crossing)

Species/ Cohort	Length (mm)			Mean Wt(g)	Capture		Population Estimates			
	Min.	Max.	Mean		1	2	Pop.*n*	n/m^2	g/m^2	n/m
CT 2+	152	152	152.0	46.8	1	0	1.0	0.02	1.07	0.14
CT 3+	189	189	189.0	81.9	1	0	1.0	0.02	1.87	0.14
RB 2+	136	136	136.0	25.0	1	0	1.0	0.02	0.57	0.14
DV 1+	94	94	94.0	10.8	1	0	1.0	0.02	0.25	0.14
CO 0+	59	77	68.0	3.8	3	1	4.5	0.10	0.39	0.62

Habitat Type (%) : 5 **riffle** 25 **pool** 40 **glide** 30 **rapid**

Substrates (%) :

fines	5
sm. gravel	5
lg. gravel	10
cobble	30
boulders	50
bedrock	0

Cover Components (%) :

canopy/vegetation	–
stable logs,roots,etc.	–
cutbanks	–
substrates (fry)	100
substrates (parr)	80
D_{90} (cm)	90

Turbidity clear **Compaction** moderate **Water Temp. (°C)** 11.0

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.17	1.00	0.22	1.00	1.00	0.19	0.04
0.5	0.16	0.00	1.00	0.55	1.00	0.71	1.00	1.00	0.54	0.26
1.0	0.32	0.00	0.85	0.98	0.85	1.00	1.00	1.00	0.90	0.75
1.5	0.48	;0.10	0.40	1.00	0.40	1.00	0.80	1.00	0.95	1.00
2.0	0.52	0.28	0.16	1.00	0.16	1.00	0.45	0.65	0.30	0.10
2.5	0.58	0.49	0.00	0.33	0.00	0.33	0.14	0.40	0.02	0.00
3.0	0.53	0.90	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
3.5	0.39	0.44	0.01	0.60	0.01	0.60	0.29	0.50	0.05	0.00
4.0	0.40	0.69	0.00	0.04	0.00	0.04	0.05	0.15	0.00	0.00
4.5	0.42	0.44	0.01	0.60	0.01	0.60	0.29	0.50	0.05	0.00
5.0	0.41	0.10	0.50	1.00	0.50	1.00	0.90	1.00	0.95	1.00
5.5	0.15	0.00	1.00	0.45	1.00	0.50	1.00	1.00	0.41	0.20
5.8	0.08	0.00	1.00	0.35	1.00	0.36	1.00	1.00	0.31	0.14
Weighted Mean	0.380	0.370	0.390	0.573	0.390	0.595	0.561	0.677	0.368	0.288

Electrofishing Site Data and Results

Site No.: 9 **Length (m):** 5.2 September 25, 1994

Stream: Cruickshank River **Area (m^2):** 23.4

Location: bottom of Reach 5; 150m upstream of Eric Creek (upstream of mainstem bridge crossing)

Species/ Cohort	Length (mm)			Mean	Capture		Population Estimates			
	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m^2	g/m^2	n/m
RB 0+	36	61	45.7	1.2	6	1	7.2	0.31	0.36	1.38
RB 1+	81	103	93.3	9.6	3	0	3.0	0.13	1.23	0.58
RB 2+	111	111	111.0	16.8	1	0	1.0	0.04	0.72	0.19
RB 3+	132	132	132.0	23.2	1	0	1.0	0.04	0.99	0.19
CO 0+	71	71	71.0	4.5	1	0	1.0	0.04	0.19	0.19

Habitat Type (%) : 30 **riffle** 20 **pool** 40 **glide** 5 **rapid**

Substrates (%) :		**Cover Components (%) :**	
fines	3	canopy/vegetation	–
sm. gravel	2	stable logs,roots,etc.	–
lg. gravel	10	cutbanks	–
cobble	35	substrates (fry)	95
boulders	50	substrates (parr)	75
bedrock	0	**D_{90} (cm)**	90

Turbidity clear **Compaction** moderate **Water Temp. (°C)** 11.5

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.03	1.00	0.03	1.00	0.50	0.00	0.00
0.5	0.05	0.00	1.00	0.10	1.00	0.13	1.00	1.00	0.05	0.02
1.0	0.04	0.00	1.00	0.03	1.00	0.03	1.00	1.00	0.05	0.02
1.5	0.16	0.00	1.00	0.55	1.00	0.71	1.00	1.00	0.54	0.26
2.0	0.16	0.03	1.00	0.55	1.00	0.71	1.00	1.00	0.54	0.26
2.5	0.35	0.03	0.85	0.98	0.85	1.00	1.00	1.00	0.90	0.80
3.0	0.34	0.05	0.85	0.98	0.85	1.00	1.00	1.00	0.90	0.80
3.5	0.33	0.49	0.01	0.32	0.01	0.33	0.20	0.40	0.02	0.00
4.0	0.24	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.5	0.24	1.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weighted Mean	0.200	0.321	0.690	0.392	0.690	0.436	0.744	0.739	0.334	0.240

Electrofishing Site Data and Results

Site No.: 10 **Length (m):** 8.2 September 23, 1994
Stream: Cruickshank River **Area (m²):** 40.2
Location: upper Reach 5; defunct bridge crossing, 2.5 km upstream of Eric Creek

Species/ Cohort	Length (mm)			Mean Wt(g)	Capture		Population Estimates			
	Min.	Max.	Mean		1	2	Pop.*n*	n/m²	g/m²	n/m
RB 0+	33	41	37.7	0.6	2	1	4.0	0.10	0.06	0.49
RB 1+	81	104	91.4	8.2	6	2	9.0	0.22	1.83	1.10
RB 2+	110	137	122.8	19.4	4	0	4.0	0.10	1.93	0.49
RB 3+	141	141	141.0	31.6	1	0	1.0	0.02	0.79	0.12

Habitat Type (%) : 10 **riffle** 65 **pool** 20 **glide** 5 **cascade**

Substrates (%) :

fines	0
sm. gravel	5
lg. gravel	5
cobble	25
boulders	25
bedrock	40

Cover Components (%) :

canopy/vegetation	–
stable logs,roots,etc.	–
cutbanks	–
substrates (fry)	60
substrates (parr)	50
D_{90} (cm)	bedrock

Turbidity clear **Compaction** low–moderate **Water Temp. (°C)** 12.0

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.03	1.00	0.03	0.50	0.00	0.00	0.00
0.5	0.03	0.00	1.00	0.03	1.00	0.03	1.00	0.50	0.05	0.12
1.0	0.21	0.00	1.00	0.77	0.98	0.98	1.00	1.00	0.88	0.43
1.5	0.35	0.00	0.85	0.98	0.85	1.00	1.00	1.00	0.90	0.80
2.0	0.29	0.03	0.98	0.93	0.98	1.00	1.00	1.00	0.90	0.70
2.5	0.38	0.03	0.66	1.00	0.66	1.00	1.00	1.00	0.90	0.80
3.0	0.31	0.00	0.85	0.98	0.85	1.00	1.00	1.00	0.90	0.75
3.5	0.34	;0.03	0.85	0.98	0.85	1.00	1.00	1.00	0.90	0.80
4.0	0.42	0.00	0.50	1.00	0.50	1.00	0.90	1.00	0.90	0.80
4.5	0.40	0.03	0.66	1.00	0.66	1.00	0.90	1.00	0.90	0.80
4.9	0.38	0.00	0.66	1.00	0.66	1.00	0.90	1.00	0.90	0.80
Weighted Mean	0.291	0.015	0.821	0.815	0.819	0.850	0.951	0.898	0.766	0.626

Electrofishing Site Data and Results

Site No.: 11 **Length (m):** 8.9 September 24, 1994
Stream: Cruickshank River **Area (m²):** 37.4
Location: mid Reach 6; meadow area, 1.5 km upstream of barrier falls

Species/ Cohort	Length (mm)			Mean	Capture		Population Estimates			
	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m²	g/m²	n/m
RB 0+	39	49	42.1	0.9	9	1	10.1	0.27	0.23	1.14
RB 1+	74	94	84.0	6.9	2	0	2.0	0.05	0.37	0.22
RB 2+	105	105	105.0	13.7	1	0	1.0	0.03	0.37	0.11

Habitat Type (%) : 10 **riffle** 70 **pool** 20 **glide**

Substrates (%) :

fines	25
sm. gravel	60
lg. gravel	10
cobble	5
boulders	0
bedrock	0

Cover Components (%) :

canopy/vegetation	–
stable logs,roots,etc.	4
cutbanks	1
substrates (fry)	30
substrates (parr)	0
D_{90} (cm)	8

Turbidity clear **Compaction** loose **Water Temp. (°C)** 14.0

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.08	0.00	1.00	0.35	1.00	0.36	1.00	1.00	0.31	0.14
0.5	0.16	0.00	1.00	0.55	1.00	0.71	1.00	1.00	0.54	0.26
1.0	0.24	0.00	1.00	0.86	0.98	1.00	1.00	1.00	0.90	0.51
1.5	0.15	0.00	1.00	0.45	1.00	0.50	1.00	1.00	0.41	0.20
2.0	0.12	0.00	1.00	0.35	1.00	0.36	1.00	1.00	0.31	0.14
2.5	0.16	0.01	1.00	0.55	1.00	0.71	1.00	1.00	0.54	0.26
3.0	0.16	0.01	1.00	0.55	1.00	0.71	1.00	1.00	0.54	0.26
3.5	0.13	0.00	1.00	0.35	1.00	0.36	1.00	1.00	0.41	0.20
4.0	0.04	0.00	1.00	0.03	1.00	0.03	1.00	1.00	0.05	0.02
4.1	0.00	0.00	1.00	0.03	1.00	0.03	1.00	1.00	0.00	0.00
Weighted Mean	0.15	0.003	1.00	0.470	0.998	0.555	1.00	0.994	0.466	0.234

Electrofishing Site Data and Results

Site No.:	12	**Length (m):**	7.7	September 24, 1994
Stream:	Cruickshank River	**Area (m^2):**	27.0	

Location: mid Reach 6; meadow area, 25m upstream of site 11

Species/	Length (mm)			Mean	Capture		Population Estimates			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m^2	g/m^2	n/m
RB 0+	39	46	42.7	1.1	6	1	7.2	0.27	0.29	0.94
RB 1+	92	92	92.0	8.8	1	0	1.0	0.04	0.33	0.13
RB 2+	106	112	109.0	16.2	2	0	2.0	0.07	1.20	0.26
RB 3+	136	136	136.0	29.2	1	0	1.0	0.04	1.08	0.13

Habitat Type (%) : 0 **riffle** 90 **pool** 10 **glide**

Substrates (%) :	
fines	35
sm. gravel	50
lg. gravel	10
cobble	5
boulders	
bedrock	

Cover Components (%) :	
canopy/vegetation	4.5
stable logs,roots,etc.	8
cutbanks	1.5
substrates (fry)	20
substrates (parr)	0
D_{90} (cm)	6

Turbidity clear **Compaction** loose **Water Temp. (°C)** 14.0

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.16	0.00	0.66	1.00	0.66	1.00	1.00	1.00	0.90	0.80
0.5	0.57	0.00	0.21	1.00	0.21	1.00	0.70	1.00	0.90	0.80
1.0	0.54	0.00	0.29	1.00	0.29	1.00	0.70	1.00	0.90	0.80
1.5	0.42	0.00	0.50	1.00	0.50	1.00	0.90	1.00	0.90	0.80
2.0	0.38	0.00	0.66	1.00	0.66	1.00	1.00	1.00	0.90	0.80
2.5	0.31	0.00	0.85	0.98	0.85	1.00	1.00	1.00	0.90	0.75
3.0	0.23	0.01	1.00	0.77	0.98	0.98	1.00	1.00	0.90	0.51
3.5	0.24	0.01	1.00	0.86	0.98	1.00	1.00	1.00	0.90	0.51
Weighted Mean	0.393	0.001	0.620	0.954	0.616	0.997	0.900	1.00	0.900	0.731

Electrofishing Site Data and Results

Site No.: 13 **Length (m):** 15.3 September 30, 1994

Stream: Comox Creek **Area (m²):** 33.7

Location: mid Reach 1; 2 km upstream of the Cruickshank River

Species/	Length (mm)			Mean	Capture		Population Estimates			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m²	g/m²	n/m
CT 0+	36	67	53.5	1.8	14	7	28.0	0.83	1.50	1.83
CT 1+	88	92	90.0	8.5	2	0	2.0	0.06	0.50	0.13
CT 2+	130	130	130.0	25.1	1	0	1.0	0.03	0.75	0.07
RB 0+	76	76	76.0	4.9	2	0	2.0	0.06	0.29	0.13
RB 1+	113	115	114.0	14.8	2	0	2.0	0.06	0.88	0.13
CC	43	77	61.0	–	25	10	41.7	1.24	–	2.72

Habitat Type (%) : 35 **riffle** 20 **pool** 45 **glide**

Substrates (%) :

fines	10
sm. gravel	5
lg. gravel	5
cobble	40
boulders	40
bedrock	0

Cover Components (%) :

canopy/vegetation	–
stable logs,roots,etc.	–
cutbanks	–
substrates (fry)	85
substrates (parr)	50
D_{90} (cm)	60

Turbidity clear **Compaction** moderate–high **Water Temp. (°C)** 10.0

Transect and Associated Hydraulic Suitability Data

Length	Depth	Velocity	Probability of Use							
(m)	(m)	(m/s)	RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.03	1.00	0.03	1.00	0.50	0.05	0.02
1.0	0.06	0.05	1.00	0.10	1.00	0.13	1.00	1.00	0.10	0.04
2.0	0.07	0.21	0.90	0.17	0.90	0.22	0.80	0.75	0.10	0.02
3.0	0.08	0.57	0.00	0.02	0.00	0.03	0.13	0.30	0.00	0.00
4.0	0.15	0.15	1.00	0.45	1.00	0.50	0.90	0.90	0.45	0.15
5.0	0.18	0.05	1.00	0.66	1.00	0.85	1.00	1.00	0.75	0.34
6.0	0.24	0.08	1.00	0.86	0.98	1.00	1.00	1.00	0.95	0.64
7.0	0.20	0.13	1.00	0.66	0.98	0.85	0.90	1.00	0.83	0.34
8.0	0.36	0.03	0.66	0.98	0.66	1.00	1.00	1.00	0.90	0.80
9.0	0.35	0.10	0.85	0.98	0.85	1.00	1.00	1.00	0.95	1.00
10.0	0.40	0.03	0.66	1.00	0.66	1.00	0.90	1.00	0.90	0.80
11.0	0.36	0.00	0.66	0.98	0.66	1.00	1.00	1.00	0.90	0.80
12.0	0.28	0.03	0.98	0.93	0.98	1.00	1.00	1.00	0.90	0.70
13.0	0.29	0.00	0.98	0.93	0.98	1.00	1.00	1.00	0.90	0.70
14.0	0.30	0.03	0.98	0.93	0.98	1.00	1.00	1.00	0.90	0.70
15.0	0.26	0.08	0.98	0.93	0.98	1.00	1.00	1.00	0.95	0.70
Weighted Mean	0.232	0.064	0.844	0.676	0.841	0.740	0.908	0.913	0.669	0.491

Electrofishing Site Data and Results

Site No.: 14 **Length (m):** 8.2 September 30, 1994
Stream: Comox Creek **Area (m^2):** 25.4
Location: mid Reach 1; margin of gravel bar, adjacent to site 13

Species/	Length (mm)			Mean	Capture		Population Estimates			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m^2	g/m^2	n/m
CT 0+	52	73	63.0	2.7	8	2	10.7	0.42	1.15	1.30
RB 0+	68	79	72.8	4.4	3	1	4.5	0.18	0.78	0.55
CC	49	68	57.0	–	10	6	25.0	0.98	–	3.05

Habitat Type (%) : 70 **riffle** 10 **pool** 20 **glide**

Substrates (%) :

fines	2
sm. gravel	3
lg. gravel	5
cobble	50
boulders	40
bedrock	0

Cover Components (%) :

canopy/vegetation	–
stable logs,roots,etc.	–
cutbanks	–
substrates (fry)	95
substrates (parr)	60
D_{90} (cm)	35

Turbidity clear **Compaction** moderate **Water Temp. (°C)** 10.0

Transect and Associated Hydraulic Suitability Data

Length	Depth	Velocity	Probability of Use							
(m)	(m)	(m/s)	RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.5	0.01	0.00	1.00	0.03	1.00	0.03	0.50	0.00	0.00	0.00
1.0	0.06	0.00	1.00	0.10	1.00	0.13	1.00	1.00	0.10	0.04
1.5	0.14	0.00	1.00	0.45	1.00	0.50	1.00	1.00	0.41	0.20
2.0	0.19	0.44	0.01	0.40	0.01	0.51	0.32	0.50	0.04	0.00
2.5	0.20	0.26	0.75	0.66	0.74	0.85	0.68	0.70	0.42	0.04
3.0	0.19	0.62	0.00	0.03	0.00	0.03	0.05	0.20	0.00	0.00
3.3	0.26	0.59	0.00	0.03	0.00	0.04	0.13	0.30	0.00	0.00
Weighted Mean	0.125	0.329	0.570	0.253	0.567	0.312	0.542	0.523	0.147	0.043

Electrofishing Site Data and Results

Site No.: 15 **Length (m):** 6.4 September 29. 1994

Stream: Comox Creek **Area (m²):** 31.4

Location: lower Reach 2; 4.5 km upstream of the Cruickshank

Species/	Length (mm)			Mean	Capture		Population Estimates			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m²	g/m²	n/m
CT 0+	46	73	58.7	2.3	5	4	25.0	0.80	1.87	3.91
CT 1+	114	119	116.5	16.9	2	0	2.0	0.06	1.07	0.31
CT 2+	131	131	131.0	24.6	1	0	1.0	0.03	0.78	0.16
CC	67	86	75.2	–	4	1	5.3	0.17	–	0.83

Habitat Type (%) : 30 **riffle** 10 **pool** 50 **glide** 10 **rapid**

Substrates (%) :

fines	2
sm. gravel	3
lg. gravel	10
cobble	30
boulders	55
bedrock	0

Cover Components (%) :

canopy/vegetation	–
stable logs,roots,etc.	–
cutbanks	–
substrates (fry)	100
substrates (parr)	80
D_{90} (cm)	70

Turbidity clear **Compaction** moderate **Water Temp. (°C)** 10.0

Transect and Associated Hydraulic Suitability Data

Length	Depth	Velocity	Probability of Use							
(m)	(m)	(m/s)	RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.10	1.00	0.13	1.00	1.00	0.10	0.04
0.5	0.11	0.00	1.00	0.25	1.00	0.27	1.00	1.00	0.31	0.14
1.0	0.28	0.05	0.98	0.93	0.98	1.00	1.00	1.00	0.90	0.70
1.5	0.44	0.00	0.50	1.00	0.50	1.00	0.90	1.00	0.90	0.80
2.0	0.55	0.21	0.26	1.00	0.26	1.00	0.56	0.75	0.92	0.30
2.5	0.45	0.44	0.01	0.60	0.01	0.60	0.29	0.50	0.05	0.00
3.0	0.29	0.41	0.04	0.65	0.04	0.70	0.32	0.50	0.05	0.00
3.5	0.41	0.69	0.00	0.04	0.00	0.04	0.05	0.15	0.00	0.00
4.0	0.44	0.21	0.45	1.00	0.45	1.00	0.72	0.75	0.92	0.30
4.5	0.45	0.18	0.50	1.00	0.50	1.00	0.72	0.80	0.98	0.40
4.9	0.29	0.00	0.66	1.00	0.66	1.00	1.00	1.00	0.95	1.00
Weighted Mean	0.362	0.256	0.454	0.696	0.454	0.712	0.651	0.742	0.547	0.307

Electrofishing Site Data and Results

Site No.:	16	**Length (m):**	10.5	September 28, 1994
Stream:	Comox Creek	**Area (m^2):**	47.3	

Location: 200m upstream of upper barrier falls; 9 km upstream of Cruikshank River

Species/	Length (mm)			Mean	Capture		Population Estimates			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m^2	g/m^2	n/m

NO FISH CAPTURED

Habitat Type (%) : 75 **riffle** 5 **pool** 15 **glide** 5 **rapid**

Substrates (%) :		**Cover Components (%) :**	
fines	10	canopy/vegetation	1.5
sm. gravel	20	stable logs,roots,etc.	–
lg. gravel	30	cutbanks	–
cobble	40	substrates (fry)	80
boulders	10	substrates (parr)	25
bedrock	0	D_{90} (cm)	40

Turbidity clear **Compaction** moderate **Water Temp. (°C)** 8.0

Transect and Associated Hydraulic Suitability Data

Length	Depth	Velocity	Probability of Use							
(m)	(m)	(m/s)	RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.03	1.00	0.03	0.50	0.00	0.00	0.00
0.5	0.02	0.00	1.00	0.03	1.00	0.03	1.00	0.50	0.00	0.00
1.0	0.14	0.41	0.04	0.32	0.04	0.35	0.32	0.50	0.02	0.00
1.5	0.18	0.28	0.55	0.66	0.55	0.85	0.56	0.65	0.25	0.04
2.0	0.25	0.85	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
2.5	0.27	0.80	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
3.0	0.32	0.75	0.00	0.00	0.00	0.00	0.05	0.10	0.00	0.00
3.5	0.20	0.44	0.01	0.40	0.01	0.51	0.32	0.50	0.04	0.00
4.0	0.18	0.62	0.00	0.03	0.00	0.03	0.05	0.20	0.00	0.00
4.5	0.15	0.87	0.00	0.00	0.00	0.00	0.05	0.10	0.00	0.00
Weighted Mean	0.183	0.630	0.233	0.160	0.233	0.199	0.286	0.289	0.035	0.005

Presence / Absence Electrofishing Results and Site Data

Site No.:	17	**Length (m):**	8.7	September 28, 1995
Stream:	Comox Creek	**Area (m^2):**	36.5	

Location: relatively deep and complex pool, approx. 200 m upstream of upper barrier falls (near site 16)

Species/	Length (mm)			Mean	Capture		Approximate Densities			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	$C_1 + C_2$	n/m^2	g/m^2	n/m

NO FISH CAPTURED

(this site completed as rigorous test for presence of any fish)

Habitat Type (%) : 5 **riffle** 70 **pool** 25 **glide**

Substrates (%) :		**Cover Components (%) :**	
fines	30	canopy/vegetation	5
sm. gravel	25	stable logs,roots,etc.	5
lg. gravel	25	cutbanks	2.5
cobble	10	substrates (fry)	40
boulders	10	substrates (parr)	5
bedrock	0	D_{90} **(cm)**	25

Turbidity clear **Compaction** moderate **Water Temp. (°C)** 8.0

Transect and Associated Hydraulic Suitability Data

No transect completed at this site.

Electrofishing Site Data and Results

Site No.:	18	**Length (m):**	6.1	September 28, 1994
Stream:	Datsio Creek	**Area (m^2):**	25.0	
Location:	upper Reach 1; 100m upstream of Comox Creek			

Species/	Length (mm)			Mean	Capture		Population Estimates			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m^2	g/m^2	n/m
DV 0+	43	52	48.4	1.2	6	3	12.0	0.48	0.56	1.97
DV 1+	76	87	81.3	5.7	2	1	4.0	0.16	0.91	0.66

Habitat Type (%) : 60 **riffle** 10 **pool** 30 **glide**

Substrates (%) :

fines	5
sm. gravel	5
lg. gravel	10
cobble	40
boulders	40
bedrock	0

Cover Components (%) :

canopy/vegetation	–
stable logs,roots,etc.	–
cutbanks	–
substrates (fry)	95
substrates (parr)	70
D_{90} (cm)	50

Turbidity clear **Compaction** moderate **Water Temp. (°C)** 8.5

Transect and Associated Hydraulic Suitability Data

Length	Depth	Velocity	Probability of Use							
(m)	(m)	(m / s)	RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.03	1.00	0.03	1.00	1.00	0.05	0.02
0.5	0.07	0.05	1.00	0.17	1.00	0.22	1.00	1.00	0.10	0.04
1.0	0.28	0.00	0.98	0.93	0.98	1.00	1.00	1.00	0.90	0.70
1.5	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.0	0.17	0.41	0.04	0.39	0.04	0.50	0.32	0.50	0.03	0.00
2.5	0.17	0.23	0.90	0.55	0.90	0.71	0.68	0.70	0.44	0.07
3.0	0.14	0.03	1.00	0.45	1.00	0.50	1.00	1.00	0.41	0.20
3.5	0.16	0.13	1.00	0.55	1.00	0.71	0.90	1.00	0.60	0.26
4.0	0.07	0.08	1.00	0.17	1.00	0.22	1.00	1.00	0.10	0.05
4.1	0.01	0.04	1.00	0.03	1.00	0.03	1.00	1.00	0.06	0.02
Weighted Mean	0.128	0.134	0.746	0.385	0.746	0.462	0.744	0.781	0.314	0.159

Presence / Absence Electrofishing Results and Site Data

Site No.: 19 **Length (m):** 4.8 September 28, 1995

Stream: Datsio Creek **Area (m^2):** 25.0

Location: lowermost Reach 2; approx. 200m upstream of Comox Creek

Species/ Cohort	Length (mm)			Mean Wt(g)	Capture		Approximate Densities			
	Min.	Max.	Mean		1	2	$C_1 + C_2$	n/m^2	g/m^2	n/m
DV 1+	75	75	75.0	4.2	1	0	1	0.04	0.17	0.21

(this site completed to confirm presence of Dolly Varden in Reach 2 of this stream)

Habitat Type (%) : enter **riffle** enter **pool** enter **glide** enter **OTHER**

Substrates (%) :

fines	5
sm. gravel	10
lg. gravel	10
cobble	35
boulders	40
bedrock	0

Cover Components (%) :

canopy/vegetation	–
stable logs,roots,etc.	1
cutbanks	2.5
substrates (fry)	75
substrates (parr)	50
D_{90} (cm)	70

Turbidity clear **Compaction** moderate **Water Temp. (°C)** 8.5

Transect and Associated Hydraulic Suitability Data

No transect completed at this site.

Electrofishing Site Data and Results

Site No.:	20	**Length (m):**	7.3	September 27, 1994
Stream:	Rees Creek	**Area (m^2):**	16.8	

Location: mid Reach 1; 1.5 km upstream of Cruickshank River

Species/	Length (mm)			Mean	Capture		Population Estimates			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m^2	g/m^2	n/m
CT 0+	48	52	49.7	1.2	3	0	3.0	0.18	0.21	0.41
CT 1+	93	93	93.0	8.7	1	0	1.0	0.06	0.52	0.14
RB 0+	47	50	48.5	1.2	2	0	2.0	0.12	0.14	0.27
CO 0+	63	73	68.0	4.0	2	0	2.0	0.12	0.47	0.27
CC	41	86	60.6	–	16	8	32.0	1.91	–	4.38

Habitat Type (%) : 0 **riffle** 40 **pool** 60 **glide**

Substrates (%) :

fines	35
sm. gravel	55
lg. gravel	10
cobble	0
boulders	0
bedrock	0

Cover Components (%) :

canopy/vegetation	12
stable logs,roots,etc.	3.5
cutbanks	7
substrates (fry)	10
substrates (parr)	0
D_{90} (cm)	4

Turbidity clear **Compaction** low **Water Temp. (°C)** 8.5

Transect and Associated Hydraulic Suitability Data

Length	Depth	Velocity	Probability of Use							
(m)	(m)	(m/s)	RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.17	0.00	1.00	0.66	0.98	0.85	1.00	1.00	0.75	0.34
0.5	0.23	0.00	1.00	0.77	0.98	0.98	1.00	1.00	0.90	0.51
1.0	0.51	0.05	0.29	1.00	0.29	1.00	0.80	1.00	0.90	0.80
1.5	0.63	0.09	0.15	1.00	0.15	1.00	0.60	1.00	0.95	1.00
2.0	0.71	0.23	0.05	1.00	0.05	1.00	0.34	0.63	0.74	0.20
2.4	0.76	0.52	0.00	0.87	0.00	0.87	0.22	0.51	0.11	0.00
Weighted Mean	0.501	0.141	0.415	0.906	0.408	0.969	0.686	0.890	0.799	0.554

Electrofishing Site Data and Results

Site No.: 21 **Length (m):** 11.6 September 28, 1994

Stream: Rees Creek **Area (m^2):** 45.2

Location: mid Reach 2; 250m upstream of Kweishun Creek (3 km upstream of Cruickshank River)

Species/	Length (mm)			Mean	Capture		Population Estimates			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m^2	g/m^2	n/m
CT 0+	39	53	44.8	1.0	10	1	11.1	0.25	0.24	0.96
RB 0+	62	62	62.0	2.3	1	0	1.0	0.02	0.05	0.09
CO 0+	55	75	62.3	2.6	3	0	3.0	0.07	0.17	0.26
CC	46	88	61.7	–	25	9	39.1	0.86	–	3.37

Habitat Type (%) : 20 **riffle** 40 **pool** 40 **glide**

Substrates (%) :

fines	10
sm. gravel	15
lg. gravel	15
cobble	35
boulders	20
bedrock	5

Cover Components (%) :

canopy/vegetation	–
stable logs,roots,etc.	–
cutbanks	–
substrates (fry)	80
substrates (parr)	50
D_{90} (cm)	60

Turbidity clear **Compaction** low–moderate **Water Temp. (°C)** 8.5

Transect and Associated Hydraulic Suitability Data

Length	Depth	Velocity	Probability of Use							
(m)	(m)	(m/s)	RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.03	1.00	0.03	1.00	0.50	0.05	0.02
0.5	0.06	0.03	1.00	0.10	1.00	0.13	1.00	1.00	0.10	0.04
1.0	0.23	0.23	0.90	0.77	0.88	0.98	0.68	0.70	0.74	0.13
2.0	0.45	0.05	0.50	1.00	0.50	1.00	0.90	1.00	0.90	0.80
3.0	0.61	0.00	0.15	1.00	0.15	1.00	0.60	1.00	0.90	0.80
4.0	0.46	0.00	0.40	1.00	0.40	1.00	0.80	1.00	0.90	0.80
5.0	0.34	0.49	0.01	0.32	0.01	0.33	0.20	0.40	0.02	0.00
6.0	0.09	0.28	0.55	0.25	0.55	0.27	0.56	0.65	0.06	0.01
7.0	0.09	0.31	0.25	0.25	0.25	0.26	0.56	0.60	0.05	0.00
8.0	0.06	0.13	1.00	0.10	1.00	0.13	0.90	1.00	0.11	0.04
8.7	0.00	0.00	1.00	0.03	1.00	0.03	1.00	0.50	0.06	0.02
Weighted Mean	0.266	0.126	0.515	0.523	0.514	0.551	0.689	0.785	0.410	0.295

Presence / Absence Electrofishing Results and Site Data

Site No.:	22	**Length (m):**	7.3	September 28, 1994
Stream:	Rees Creek	**Area (m^2):**	3.9	

Location: relatively deep complex pool in mid Reach 2, adjacent to site 21

Species/ Cohort	Length (mm)			Mean	Capture		Approximate Densities			
	Min.	Max.	Mean	Wt(g)	1	2	C_1+C_2	n/m^2	g/m^2	n/m
CT 0+	44	44	44.0	1.0	1	0	1	0.26	0.26	0.14
CT 1+	87	87	87.0	6.4	1	0	1	0.26	1.64	0.14
RB 1+	95	95	95.0	10.4	1	0	1	0.26	2.67	0.14
CO 0+	59	70	64.3	3.5	3	0	3	0.77	2.69	0.41

(this site completed specifically to test for presence of trout parr)

Habitat Type (%) : 25 **riffle** 35 **pool** 35 **glide** 5 **rapid**

Substrates (%) :

fines	20
sm. gravel	15
lg. gravel	15
cobble	30
boulders	10
bedrock	10

Cover Components (%) :

depth/srface turbulence	30
stable logs,roots,etc.	2.5
cutbanks	1
substrates (fry)	70
substrates (parr)	15
D_{90} (cm)	–

Turbidity clear **Compaction** low–moderate **Water Temp. (°C)** 8.5

Transect and Associated Hydraulic Suitability Data

No transect completed at this site.

Electrofishing Site Data and Results

Site No.: 23 **Length (m):** 11.6 September 28, 1994

Stream: Kweishun Creek **Area (m^2):** 65.0

Location: lowermost Reach 1; 100m upstream of Rees Creek

Species/	Length (mm)			Mean	Capture		Population Estimates			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m^2	g/m^2	n/m
CT 0+	27	57	38.9	0.7	18	3	21.6	0.33	0.22	1.86
DV 0+	34	66	53.6	1.6	7	4	16.3	0.25	0.41	1.41
DV 1+	82	91	86.5	6.4	2	0	2.0	0.03	0.20	0.17
CC	55	97	71.7	–	12	8	36.0	0.55	–	3.10

Habitat Type (%) : 30 **riffle** 20 **pool** 50 **glide**

Substrates (%) :		**Cover Components (%) :**	
fines	5	canopy/vegetation	14
sm. gravel	10	stable logs,roots,etc.	1
lg. gravel	15	cutbanks	0.5
cobble	40	substrates (fry)	90
boulders	30	substrates (parr)	50
bedrock	0	**D_{90} (cm)**	40

Turbidity clear **Compaction** moderate **Water Temp. (°C)** 7.5

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.25	1.00	0.27	1.00	1.00	0.19	0.04
0.5	0.17	0.00	1.00	0.55	1.00	0.71	1.00	1.00	0.54	0.26
1.0	0.34	0.03	0.85	0.98	0.85	1.00	1.00	1.00	0.90	0.80
1.5	0.32	0.44	0.01	0.59	0.01	0.60	0.32	0.50	0.05	0.00
2.0	0.34	0.54	0.00	0.23	0.00	0.23	0.13	0.30	0.00	0.00
2.5	0.33	0.05	0.85	0.98	0.85	1.00	1.00	1.00	0.90	0.80
3.0	0.30	0.10	0.98	0.93	0.98	1.00	1.00	1.00	0.95	0.87
3.5	0.22	0.08	1.00	0.77	0.98	0.98	1.00	1.00	0.93	0.54
4.0	0.27	0.00	0.98	0.93	0.98	1.00	1.00	1.00	0.90	0.62
4.5	0.15	0.00	1.00	0.45	1.00	0.50	1.00	1.00	0.41	0.20
5.0	0.08	0.00	1.00	0.17	1.00	0.22	1.00	1.00	0.19	0.04
5.1	0.00	0.00	1.00	0.03	1.00	0.03	1.00	1.00	0.05	0.02
Weighted Mean	0.248	0.157	0.771	0.650	0.770	0.715	0.848	0.882	0.568	0.406

Presence / Absence Electrofishing Results and Site Data

Site No.: 24 **Length (m):** 9.3 September 28, 1995
Stream: Kweishun Creek **Area (m^2):** 27.0
Location: relatively deep complex glide/pool in lowermost Reach 1, near site 23

Species/	Length (mm)			Mean	Capture		Approximate Densities			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	$C_1 + C_2$	n/m^2	g/m^2	n/m
CT 0+	52	59	55.6	2.0	5	0	5	0.19	0.37	0.54
CT 1+	77	77	77.0	5.7	1	0	1	0.04	0.21	0.11
DV 0+	46	57	51.8	1.4	4	0	4	0.15	0.20	0.43
DV 1+	86	86	86.0	5.9	1	0	1	0.04	0.22	0.11
CC	49	87	68.6	–	14	0	14	0.52	–	1.51

(this site completed to test for presence of trout/char parr, specifically)

Habitat Type (%) : 10 **riffle** 40 **pool** 50 **glide**

Substrates (%) :

fines	10
sm. gravel	10
lg. gravel	15
cobble	35
boulders	30
bedrock	0

Cover Components (%) :

depth/surface turbulence	40
stable logs,roots,etc.	2.5
cutbanks	5
substrates (fry)	75
substrates (parr)	45
D_{90} (cm)	35

Turbidity clear **Compaction** moderate **Water Temp. (°C)** 7.5

Transect and Associated Hydraulic Suitability Data

No transect completed at this site.

Electrofishing Site Data and Results

Site No.: 25 **Length (m):** 8.7 September 25, 1994
Stream: Eric Creek **Area (m²):** 47.9
Location: mid Reach 1; defunct bridge crossing, 0.7 km upstream of the Cruickshank River

Species/	Length (mm)			Mean	Capture		Population Estimates			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m²	g/m²	n/m
CT 0+	38	38	38.0	0.6	1	0	1.0	0.02	0.01	0.11
RB 1+	111	111	111.0	17.8	1	0	1.0	0.02	0.37	0.11
DV 1+	87	112	99.5	12.7	4	0	4.0	0.08	1.06	0.46
CO 0+	51	75	61.6	3.2	6	2	9.0	0.19	0.59	1.03
CO 0+^{m}	76	76	76.0	5.1	1	0	1.0	0.02	0.11	0.11

Habitat Type (%) : 40 **riffle** 15 **pool** 45 **glide**

Substrates (%) :	
fines	5
sm. gravel	5
lg. gravel	15
cobble	45
boulders	30
bedrock	0

Cover Components (%) :	
canopy/vegetation	3
stable logs,roots,etc.	–
cutbanks	1
substrates (fry)	90
substrates (parr)	50
D_{90} (cm)	70

Turbidity clear **Compaction** low–moderate **Water Temp. (°C)** 10.0

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.11	0.00	1.00	0.55	1.00	0.71	1.00	1.00	0.60	0.30
0.5	0.20	0.21	0.90	0.66	0.88	0.85	0.80	0.75	0.76	0.13
1.0	0.34	0.85	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
1.5	0.36	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.0	0.32	0.80	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
2.5	0.24	0.28	0.55	0.86	0.54	1.00	0.56	0.65	0.30	0.06
3.0	0.23	0.36	0.13	0.71	0.13	0.90	0.44	0.60	0.11	0.00
3.5	0.28	0.23	0.88	0.93	0.88	1.00	0.68	0.70	0.74	0.17
4.0	0.26	0.08	0.98	0.86	0.98	1.00	1.00	1.00	0.95	0.77
4.5	0.18	0.03	1.00	0.66	1.00	0.85	1.00	1.00	0.75	0.34
5.0	0.11	0.00	1.00	0.25	1.00	0.27	1.00	1.00	0.31	0.14
5.3	0.00	0.00	1.00	0.10	1.00	0.13	1.00	1.00	0.10	0.04
Weighted Mean	0.245	0.459	0.570	0.489	0.567	0.586	0.574	0.604	0.395	0.164

Electrofishing Site Data and Results

Site No.:	26	**Length (m):**	10.4	September 25, 1994
Stream:	Eric Creek	**Area (m²):**	27.0	

Location: mid Reach 1; adjacent to site 25 (opposite bank)

Species/ Cohort	Length (mm)			Mean	Capture		Population Estimates			
	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m²	g/m²	n/m
CT 0+	43	57	50.0	1.3	2	0	2.0	0.07	0.09	0.19
CT 1+	100	100	100.0	10.2	1	0	1.0	0.04	0.38	0.10
RB 1+	102	102	102.0	11.1	1	0	1.0	0.04	0.41	0.10
DV 1+	83	84	83.5	7.4	2	0	2.0	0.07	0.55	0.19
DV 3+	134	134	134.0	30.6	1	0	1.0	0.04	1.13	0.10
CO 0+	55	72	60.8	2.9	4	1	5.3	0.20	0.58	0.51

Habitat Type (%) : 50 **riffle** 15 **pool** 35 **glide**

Substrates (%) :

fines	5
sm. gravel	10
lg. gravel	10
cobble	35
boulders	40
bedrock	0

Cover Components (%) :

canopy/vegetation	4
stable logs,roots,etc.	–
cutbanks	–
substrates (fry)	90
substrates (parr)	60
D_{90} (cm)	60

Turbidity clear **Compaction** low–moderate **Water Temp. (°C)** 10.0

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.15	0.00	1.00	0.55	1.00	0.71	1.00	1.00	0.54	0.26
0.5	0.16	0.00	1.00	0.55	1.00	0.71	1.00	1.00	0.54	0.26
1.0	0.15	0.05	1.00	0.45	1.00	0.50	1.00	1.00	0.41	0.20
1.5	0.22	0.64	0.00	0.03	0.00	0.04	0.05	0.20	0.00	0.00
2.0	0.24	0.08	1.00	0.86	0.98	1.00	1.00	1.00	0.95	0.64
2.5	0.11	0.28	0.55	0.25	0.55	0.27	0.56	0.65	0.10	0.02
3.0	0.11	0.44	0.01	0.15	0.01	0.16	0.32	0.50	0.02	0.00
3.4	0.00	0.00	0.90	0.10	0.90	0.13	0.68	0.75	0.10	0.02
Weighted Mean	0.159	0.229	0.650	0.381	0.647	0.452	0.687	0.750	0.342	0.185

Electrofishing Site Data and Results

Length (m): 11.7 September 25, 1994

Site No.: 27 **Area (m^2):** 53.8

Stream: Eric Creek

Location: mid Reach 2; 2.3 km upstream of Cruickshank River

Species/ Cohort	Length (mm)			Mean Wt(g)	Capture		Population Estimates			
	Min.	Max.	Mean		1	2	Pop.*n*	n/m^2	g/m^2	n/m
CT 2+	128	128	128.0	21.0	1	0	1.0	0.02	0.39	0.09
CT 3+	182	209	195.5	79.6	2	0	2.0	0.04	2.96	0.17
RB 1+	81	81	81.0	5.9	1	0	1.0	0.02	0.11	0.09
RB 2+	129	129	129.0	23.5	1	0	1.0	0.02	0.44	0.09
DV 0+	44	53	48.5	1.2	2	0	2.0	0.04	0.04	0.17
DV 1+	81	114	97.8	10.6	6	3	12.0	0.22	2.37	1.03
DV 2+	0	142	88.0	17.4	2	1	4.0	0.07	1.29	0.34
CO 0+	55	82	65.8	3.5	29	12	49.5	0.92	3.18	4.23
CO 0+^{m}	69	79	72.8	4.3	4	0	4.0	0.07	0.32	0.34

Habitat Type (%) : 30 **riffle** 30 **pool** 40 **glide**

Substrates (%) :

fines	5
sm. gravel	10
lg. gravel	15
cobble	40
boulders	30
bedrock	0

Cover Components (%) :

canopy/vegetation	–
stable logs,roots,etc.	2.5
cutbanks	4
substrates (fry)	95
substrates (parr)	20
D_{90} (cm)	35

Turbidity clear **Compaction** moderate **Water Temp. (°C)** 10.0

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.21	0.05	0.90	0.77	0.88	0.98	0.68	0.70	0.73	0.11
0.5	0.23	0.41	0.04	0.54	0.04	0.69	0.32	0.50	0.05	0.00
1.0	0.29	0.82	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
1.5	0.34	0.57	0.00	0.14	0.00	0.14	0.13	0.30	0.00	0.00
2.0	0.46	0.18	0.40	1.00	0.40	1.00	0.64	0.80	0.98	0.40
2.5	0.44	0.08	0.50	1.00	0.50	1.00	0.90	1.00	0.95	1.00
3.0	0.51	0.00	0.29	1.00	0.29	1.00	0.80	1.00	0.90	0.80
3.5	0.41	0.05	0.50	1.00	0.50	1.00	0.90	1.00	0.90	0.80
4.0	0.31	0.00	0.85	0.98	0.85	1.00	1.00	1.00	0.90	0.75
4.5	0.14	0.00	1.00	0.45	1.00	0.50	1.00	1.00	0.41	0.20
4.6	0.00	0.00	1.00	0.17	1.00	0.22	1.00	1.00	0.10	0.04
Weighted Mean	0.347	0.216	0.405	0.688	0.404	0.722	0.622	0.728	0.576	0.427

Electrofishing Site Data and Results

Site No.: 28 **Length (m):** 9.3 October 3, 1994
Stream: Puntledge River **Area (m²):** 31.6
Location: mid Reach 1; 1 km upstream of Comox Lake

Species/ Cohort	Length (mm)			Mean Wt(g)	Capture		Population Estimates			
	Min.	Max.	Mean		1	2	Pop.*n*	n/m²	g/m²	n/m
CT 2+	128	128	128.0	21.6	1	0	1.0	0.03	0.68	0.11
RB 0+	54	63	57.5	2.1	3	1	4.5	0.14	0.29	0.48
RB 1+	119	119	119.0	20.3	1	0	1.0	0.03	0.64	0.11
CO 0+	73	90	79.9	6.2	12	3	16.0	0.51	3.11	1.72
CC	41	73	58.5	–	14	6	24.5	0.77	–	2.63
SB	46	46	46.0	–	1	0	1.0	0.03	–	0.11

Habitat Type (%) : 0 **riffle** 70 **pool** 30 **glide**

Substrates (%) :

fines	15
sm. gravel	30
lg. gravel	30
cobble	25
boulders	0
bedrock	0

Cover Components (%) :

canopy/vegetation	30
stable logs,roots,etc.	25
cutbanks	5
substrates (fry)	40
substrates (parr)	0
D_{90} (cm)	10

Turbidity clear **Compaction** low–moderate **Water Temp. (°C)** 14.0

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.45	1.00	0.50	1.00	1.00	0.41	0.20
0.5	0.28	0.00	0.98	0.93	0.98	1.00	1.00	1.00	0.90	0.70
1.0	0.43	0.00	0.50	1.00	0.50	1.00	0.90	1.00	0.90	0.80
1.5	0.46	0.00	0.40	1.00	0.40	1.00	0.80	1.00	0.90	0.80
2.0	0.51	0.00	0.29	1.00	0.29	1.00	0.80	1.00	0.90	0.80
2.5	0.46	0.00	0.40	1.00	0.40	1.00	0.80	1.00	0.90	0.80
3.0	0.39	0.00	0.66	1.00	0.66	1.00	0.90	1.00	0.90	0.80
3.5	0.35	0.00	0.85	0.98	0.85	1.00	1.00	1.00	0.90	0.80
3.8	0.30	0.03	0.85	0.98	0.85	1.00	1.00	1.00	0.90	0.75
Weighted Mean	0.392	0.000	0.614	0.952	0.614	0.967	0.895	1.000	0.867	0.745

Electrofishing Site Data and Results

Site No.: 29 **Length (m):** 8.9 October 3, 1994
Stream: Puntledge River **Area (m^2):** 46.3
Location: mid Reach 1; opposite bank, 20m upstream of site 28

Species/ Cohort	Length (mm)			Mean Wt(g)	Capture		Population Estimates			
	Min.	Max.	Mean		1	2	Pop.*n*	n/m^2	g/m^2	n/m
CT 0+	62	62	62.0	2.5	1	0	1.0	0.02	0.05	0.11
RB 0+	44	66	54.8	2.1	4	0	4.0	0.09	0.18	0.45
CO 0+	80	80	80.0	5.4	1	0	1.0	0.02	0.12	0.11
CC	38	86	56.9	–	72	31	126.4	2.73	–	14.21

Habitat Type (%) : 55 **riffle** 10 **pool** 35 **glide**

Substrates (%) :

fines	5
sm. gravel	20
lg. gravel	35
cobble	40
boulders	0
bedrock	0

Cover Components (%) :

canopy/vegetation	19.5
stable logs,roots,etc.	1.5
cutbanks	–
substrates (fry)	90
substrates (parr)	0
D_{90} (cm)	15

Turbidity clear **Compaction** low–moderate **Water Temp. (°C)** 14.5

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.03	1.00	0.03	0.90	0.90	0.06	0.01
0.5	0.08	0.28	0.55	0.17	0.55	0.22	0.56	0.65	0.06	0.01
1.0	0.10	0.21	0.90	0.25	0.90	0.27	0.80	0.75	0.19	0.02
1.5	0.11	0.69	0.00	0.01	0.00	0.01	0.05	0.15	0.00	0.00
2.0	0.23	0.54	0.00	0.18	0.00	0.23	0.13	0.30	0.00	0.00
2.5	0.28	0.75	0.00	0.00	0.00	0.00	0.05	0.10	0.00	0.00
3.0	0.30	0.81	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
3.5	0.30	0.85	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
4.0	0.28	0.81	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
4.5	0.22	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.0	0.16	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.3	0.23	1.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weighted Mean	0.199	0.749	0.184	0.059	0.184	0.070	0.192	0.241	0.027	0.003

Electrofishing Site Data and Results

Site No.:	30	**Length (m):**	11.2	October 3, 1994
Stream:	Puntledge River	**Area (m^2):**	51.5	
Location:	mid Reach 1; 30m upstream of site 28			

Species/	Length (mm)			Mean	Capture		Population Estimates			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m^2	g/m^2	n/m
CC	38	67	52.7	–	17	6	26.3	0.51	–	2.35
SB	32	37	35.0	–	2	1	4.0	0.08	–	0.36

Habitat Type (%) : 0 **riffle** 30 **pool** 70 **glide**

Substrates (%) :		**Cover Components (%) :**	
fines	5	canopy/vegetation	–
sm. gravel	35	stable logs,roots,etc.	–
lg. gravel	30	cutbanks	–
cobble	30	substrates (fry)	85
boulders	0	substrates (parr)	0
bedrock	0	**D_{90} (cm)**	20

Turbidity clear **Compaction** low–moderate **Water Temp. (°C)** 14.5

Transect and Associated Hydraulic Suitability Data

Length	Depth	Velocity	Probability of Use							
(m)	(m)	(m/s)	RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.03	1.00	0.03	0.50	0.00	0.00	0.00
0.5	0.02	0.00	1.00	0.03	1.00	0.03	1.00	0.50	0.00	0.00
1.0	0.04	0.00	1.00	0.03	1.00	0.03	1.00	1.00	0.05	0.02
1.5	0.07	0.00	1.00	0.17	1.00	0.22	1.00	1.00	0.10	0.04
2.0	0.11	0.00	1.00	0.25	1.00	0.27	1.00	1.00	0.31	0.14
2.5	0.16	0.00	1.00	0.55	1.00	0.71	1.00	1.00	0.54	0.26
3.0	0.16	0.00	1.00	0.55	1.00	0.71	1.00	1.00	0.54	0.26
3.5	0.21	0.01	1.00	0.77	0.98	0.98	1.00	1.00	0.88	0.43
4.0	0.21	0.03	1.00	0.77	0.98	0.98	1.00	1.00	0.88	0.43
4.5	0.24	0.00	1.00	0.86	0.98	1.00	1.00	1.00	0.90	0.51
4.7	0.26	0.02	1.00	0.86	0.98	1.00	1.00	1.00	0.90	0.51
Weighted Mean	0.128	0.007	1.00	0.416	0.994	0.515	0.973	0.894	0.438	0.218

Presence / Absence Electrofishing Results and Site Data

Site No.:	31	**Length (m):**	11.2	October 3, 1995
Stream:	Puntledge River (backwater)	**Area (m²):**	34.7	

Location: standing water in back channel, adjacent to mid Reach 1 of the Puntledge River

Species/	Length (mm)			Mean	Capture		Approximate Densities			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	$C_1 + C_2$	n/m²	g/m²	n/m
CO 0+	76	87	82.3	7.0	4	0	4	0.12	0.80	0.36
SB	34	50	42.8	–	4	0	4	0.12	–	0.36

(this site completed to test for presence of coho juveniles, specifically)

Habitat Type (%) : 0 **riffle** 100 **pool** 0 **glide**

Substrates (%) :		**Cover Components (%) :**	
fines	95	canopy/vegetation	10
sm. gravel	5	stable logs,roots,etc.	20
lg. gravel	0	cutbanks	5
cobble	0	substrates (fry)	–
boulders	0	substrates (parr)	–
bedrock	0	**D_{90} (cm)**	>1

Turbidity clear **Compaction** low–moderate **Water Temp. (°C)** 12.5

Transect and Associated Hydraulic Suitability Data

No transect completed at this site.

Electrofishing Site Data and Results

Site No.:	32	**Length (m):**	10.2	October 5, 1994
Stream:	Puntledge River	**Area (m^2):**	30.6	

Location: upper Reach 2; 50m downstream of site 33

Species/	Length (mm)			Mean	Capture		Population Estimates			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m^2	g/m^2	n/m
CT 0+	57	71	64.0	2.6	3	2	9.0	0.29	0.76	0.88
RB 0+	48	68	58.7	2.1	5	1	6.3	0.20	0.43	0.61
CO 0+	61	83	70.6	4.1	13	4	18.8	0.61	2.50	1.84
CO 0+^{m}	71	79	74.8	4.4	3	1	4.5	0.15	0.64	0.44
CC	51	74	57.8	–	14	3	17.8	0.58	–	1.75

Habitat Type (%) : 0 **riffle** 30 **pool** 70 **glide**

Substrates (%) :

fines	5
sm. gravel	10
lg. gravel	30
cobble	40
boulders	5
bedrock	0

Cover Components (%) :

canopy/vegetation	29
stable logs,roots,etc.	23
cutbanks	1.5
substrates (fry)	95
substrates (parr)	10
D_{90} (cm)	20

Turbidity clear **Compaction** moderate **Water Temp. (°C)** 16.5

Transect and Associated Hydraulic Suitability Data

Length	Depth	Velocity	Probability of Use							
(m)	(m)	(m/s)	RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.45	1.00	0.50	1.00	1.00	0.41	0.20
0.5	0.29	0.00	0.98	0.93	0.98	1.00	1.00	1.00	0.90	0.70
1.0	0.39	0.02	0.66	1.00	0.66	1.00	0.90	1.00	0.90	0.80
1.5	0.46	0.15	0.40	1.00	0.40	1.00	0.72	0.90	1.00	0.60
2.0	0.46	0.18	0.40	1.00	0.40	1.00	0.64	0.80	0.98	0.40
2.5	0.51	0.05	0.29	1.00	0.29	1.00	0.80	1.00	0.90	0.80
3.0	0.47	0.05	0.40	1.00	0.40	1.00	0.80	1.00	0.90	0.80
Weighted Mean	0.405	0.081	0.572	0.943	0.572	0.958	0.827	0.950	0.889	0.633

Electrofishing Site Data and Results

Site No.:	33	**Length (m):**	26.4	October 5, 1994
Stream:	Puntledge River	**Area (m^2):**	142.6	

Location: upper Reach 2; large braid, 0.5 km downstream of Willemar Lake

Species/	Length (mm)			Mean	Capture		Population Estimates			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m^2	g/m^2	n/m
CT 0+	45	72	62.5	2.9	4	2	8.0	0.06	0.16	0.30
RB 0+	51	73	58.0	2.7	4	1	5.3	0.04	0.10	0.20
RB 1+	80	116	102.3	13.4	2	1	4.0	0.03	0.38	0.15
RB 2+	129	129	129.0	25.6	1	0	1.0	0.01	0.18	0.04
CO 0+	57	84	67.5	4.2	6	4	18.0	0.13	0.53	0.68
CO 0+^{m}	67	78	70.3	4.5	3	1	4.5	0.03	0.14	0.17
CC	44	81	60.9	–	42	27	117.6	0.82	–	4.45

Habitat Type (%) : 25 **riffle** 15 **pool** 60 **glide**

Substrates (%) :

fines	5
sm. gravel	15
lg. gravel	30
cobble	35
boulders	15
bedrock	0

Cover Components (%) :

canopy/vegetation	23
stable logs,roots,etc.	6
cutbanks	–
substrates (fry)	90
substrates (parr)	15
D_{90} (cm)	35

Turbidity clear **Compaction** low–moderate **Water Temp. (°C)** 15.0

Transect and Associated Hydraulic Suitability Data

Length	Depth	Velocity	Probability of Use							
(m)	(m)	(m/s)	RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.25	1.00	0.27	1.00	1.00	0.19	0.04
2.0	0.19	0.10	1.00	0.66	0.98	0.85	1.00	1.00	0.79	0.42
4.0	0.31	0.15	0.85	0.98	0.85	1.00	0.90	0.90	1.00	0.56
6.0	0.47	0.28	0.22	1.00	0.22	1.00	0.45	0.65	0.30	0.10
8.0	0.60	0.26	0.16	1.00	0.16	1.00	0.48	0.70	0.51	0.10
10.0	0.69	0.23	0.09	1.00	0.09	1.00	0.34	0.63	0.74	0.20
12.0	0.36	0.10	0.66	0.98	0.66	1.00	1.00	1.00	0.95	1.00
14.0	0.34	0.36	0.11	0.90	0.11	0.92	0.44	0.60	0.11	0.00
18.0	0.33	0.87	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
22.0	0.22	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26.4	0.00	0.00	0.01	0.08	0.01	0.09	0.20	0.40	0.01	0.00
Weighted Mean	0.335	0.414	0.277	0.545	0.275	0.565	0.420	0.517	0.345	0.182

Electrofishing Site Data and Results

Site No.: 34 **Length (m):** 6.2 October 4, 1994

Stream: Puntledge River **Area (m²):** 24.2

Location: mid Reach 3; between Willemar and Forbush lakes (100m upstream of Willemar Lake)

Species/	Length (mm)			Mean	Capture		Population Estimates			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m²	g/m²	n/m
CT 0+	60	60	60.0	2.3	1	0	1.0	0.04	0.10	0.16
CC	29	78	54.7	–	17	12	57.8	2.39	–	9.32
SB	29	45	36.2	–	6	4	18.0	0.74	–	2.90

Habitat Type (%) : 10 **riffle** 20 **pool** 70 **glide**

Substrates (%) :

fines	5
sm. gravel	35
lg. gravel	30
cobble	30
boulders	0
bedrock	0

Cover Components (%) :

canopy/vegetation	47
stable logs,roots,etc.	6.5
cutbanks	–
substrates (fry)	80
substrates (parr)	0
D_{90} (cm)	15

Turbidity clear **Compaction** low–moderate **Water Temp. (°C)** 13.0

Transect and Associated Hydraulic Suitability Data

Length	Depth	Velocity	Probability of Use							
(m)	(m)	(m/s)	RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.25	1.00	0.27	1.00	1.00	0.31	0.14
0.5	0.21	0.00	1.00	0.77	0.98	0.98	1.00	1.00	0.88	0.43
1.0	0.25	0.00	1.00	0.86	0.98	1.00	1.00	1.00	0.90	0.51
1.5	0.23	0.04	1.00	0.77	0.98	0.98	1.00	1.00	0.90	0.51
2.0	0.23	0.15	1.00	0.77	0.98	0.98	0.90	0.90	1.00	0.38
2.5	0.25	0.26	0.75	0.86	0.74	1.00	0.68	0.70	0.51	0.06
3.0	0.26	0.49	0.01	0.28	0.01	0.33	0.20	0.40	0.02	0.00
3.5	0.25	0.39	0.06	0.69	0.06	0.80	0.44	0.50	0.08	0.00
3.9	0.22	0.36	0.08	0.75	0.08	0.87	0.44	0.60	0.11	0.00
Weighted Mean	0.231	0.199	0.685	0.687	0.673	0.830	0.750	0.794	0.575	0.253

Electrofishing Site Data and Results

Site No.: 35 **Length (m):** 7.4 October 4, 1994
Stream: Puntledge River **Area (m^2):** 29.6
Location: lower Reach 4; 100m upstream of Forbush Lake

Species/ Cohort	Length (mm)			Mean Wt(g)	Capture		Population Estimates			
	Min.	Max.	Mean		1	2	Pop.*n*	n/m^2	g/m^2	n/m
CT 0+	56	56	56.0	1.9	1	0	1.0	0.03	0.06	0.14
CT 1+	112	112	112.0	13.4	1	0	1.0	0.03	0.45	0.14
DV 0+	54	61	57.6	2.0	6	3	12.0	0.41	0.80	1.62
DV 1+	84	101	92.5	9.9	2	0	2.0	0.07	0.67	0.27
CC	61	100	76.5	–	3	1	4.5	0.15	–	0.61

Habitat Type (%) : 0 **riffle** 50 **pool** 50 **glide**

Substrates (%) :

fines	30
sm. gravel	40
lg. gravel	15
cobble	5
boulders	0
bedrock	0

Cover Components (%) :

canopy/vegetation	25
stable logs,roots,etc.	10
cutbanks	3.5
substrates (fry)	20
substrates (parr)	0
D_{90} (cm)	8

Turbidity clear **Compaction** moderate **Water Temp. (°C)** 9.0

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.33	0.00	0.85	0.98	0.85	1.00	1.00	1.00	0.90	0.80
0.5	0.36	0.00	0.66	0.98	0.66	1.00	1.00	1.00	0.90	0.80
1.0	0.39	0.03	0.66	1.00	0.66	1.00	0.90	1.00	0.90	0.80
1.5	0.36	0.03	0.66	0.98	0.66	1.00	1.00	1.00	0.90	0.80
2.0	0.38	0.00	0.66	1.00	0.66	1.00	1.00	1.00	0.90	0.80
2.5	0.40	0.00	0.66	1.00	0.66	1.00	0.90	1.00	0.90	0.80
3.0	0.44	0.02	0.50	1.00	0.50	1.00	0.90	1.00	0.90	0.80
3.5	0.47	0.04	0.40	1.00	0.40	1.00	0.80	1.00	0.90	0.80
4.0	0.48	0.05	0.40	1.00	0.40	1.00	0.80	1.00	0.90	0.80
Weighted Mean	0.401	0.019	0.603	0.994	0.603	1.00	0.925	1.00	0.900	0.800

Presence / Absence Electrofishing Results and Site Data

Site No.: 36 **Length (m):** 17.3 October 4, 1995
Stream: Puntledge River (backwater) **Area (m^2):** 58.8
Location: standing water in back channel, adjacent to lowermost Reach 4 of the Puntledge River

Species/	Length (mm)			Mean	Capture		Approximate Densities			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	$C_1 + C_2$	n/m^2	g/m^2	n/m
CT 0+	57	57	57.0	1.9	1	0	1	0.02	0.03	0.06
DV 0+	52	64	59.7	2.1	3	0	3	0.05	0.11	0.17
SB	42	47	44.5	–	2	0	2	0.03	–	0.12

(this site completed to test for presence of coho juveniles, specifically)

Habitat Type (%) : 0 **riffle** 95 **pool** 5 **glide**

Substrates (%) :

fines	90
sm. gravel	10
lg. gravel	0
cobble	0
boulders	0
bedrock	0

Cover Components (%) :

canopy/vegetation	10
stable logs,roots,etc.	5
cutbanks	15
substrates (fry)	–
substrates (parr)	–
D_{90} (cm)	>1

Turbidity clear **Compaction** low–moderate **Water Temp. (°C)** 9.5

Transect and Associated Hydraulic Suitability Data

No transect completed at this site.

Electrofishing Site Data and Results

Site No.:	37	**Length (m):**	9.8	October 4, 1994
Stream:	Puntledge River	**Area (m^2):**	40.2	

Location: lower Reach 5; 1 km upstream of Forbush Lake

Species/	Length (mm)			Mean	Capture		Population Estimates			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m^2	g/m^2	n/m
CT 0+	45	59	51.8	1.4	3	1	4.5	0.11	0.16	0.46
CT 1+	89	109	99.0	10.0	2	0	2.0	0.05	0.50	0.20
DV 0+	53	74	59.9	2.3	6	1	7.2	0.18	0.42	0.73
DV 1+	81	84	82.5	5.5	2	0	2.0	0.05	0.27	0.20
CC	59	82	69.6	–	5	3	12.5	0.31	–	1.28

Habitat Type (%) : 15 **riffle** 15 **pool** 70 **glide**

Substrates (%) :

fines	15
sm. gravel	50
lg. gravel	25
cobble	10
boulders	0
bedrock	0

Cover Components (%) :

canopy/vegetation	20
stable logs,roots,etc.	7
cutbanks	7
substrates (fry)	–
substrates (parr)	–
D_{90} (cm)	8

Turbidity clear **Compaction** low–moderate **Water Temp. (°C)** 8.0

Transect and Associated Hydraulic Suitability Data

Length	Depth	Velocity	Probability of Use							
(m)	(m)	(m/s)	RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.26	0.00	0.98	0.93	0.98	1.00	1.00	1.00	0.90	0.70
0.5	0.32	0.00	0.85	0.98	0.85	1.00	1.00	1.00	0.90	0.75
1.0	0.28	0.00	0.98	0.93	0.98	1.00	1.00	1.00	0.90	0.70
1.5	0.49	0.05	0.40	1.00	0.40	1.00	0.80	1.00	0.90	0.80
2.0	0.46	0.08	0.40	1.00	0.40	1.00	0.80	1.00	0.95	1.00
2.5	0.33	0.46	0.01	0.49	0.01	0.50	0.20	0.40	0.02	0.00
3.0	0.35	0.85	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
3.5	0.41	0.77	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
4.1	0.42	0.81	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
Weighted Mean	0.375	0.343	0.382	0.593	0.382	0.610	0.524	0.614	0.502	0.439

Presence / Absence Electrofishing Results and Site Data

Site No.:	38	**Length (m):**	10.4	October 1, 1995
Stream:	Toma Creek	**Area (m^2):**	44.7	

Location: standing water in one of several channels, approx. 500m upstream of Comox Lake

Species/	Length (mm)			Mean	Capture		Approximate Densities			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	$C_1 + C_2$	n/m^2	g/m^2	n/m
CT 1+	115	115	115.0	16.9	2	0	2	0.04	0.75	0.19
DV 1+	98	116	109.6	14.5	5	0	5	0.11	1.62	0.48
DV 2+	126	126	126.0	20.2	1	0	1	0.02	0.45	0.10

(this site completed to test for presence of coho juveniles, specifically)

Habitat Type (%) : 0 **riffle** 100 **pool** 0 **glide**

Substrates (%) :	
fines	95
sm. gravel	4
lg. gravel	1
cobble	0
boulders	0
bedrock	0

Cover Components (%) :	
canopy/vegetation	10
stable logs,roots,etc.	20
cutbanks	10
substrates (fry)	–
substrates (parr)	–
D_{90} (cm)	>4

Turbidity clear **Compaction** low–moderate **Water Temp. (°C)** 10.5

Transect and Associated Hydraulic Suitability Data

No transect completed at this site.

Presence / Absence Electrofishing Results and Site Data

Site No.:	39	**Length (m):**	13.0	October 1, 1995
Stream:	Toma Creek	**Area (m^2):**	45.0	

Location: standing water in one of several channels, approx. 500m upstream of Comox Lakestandbackwater adj

Species/	Length (mm)			Mean	Capture		Approximate Densities			
Cohort	Min.	Max.	Mean	Wt(g)	1	2	$C_1 + C_2$	n/m^2	g/m^2	n/m
CT 1+	112	112	112.0	13.3	1	0	1	0.02	0.30	0.08
DV 0+	62	68	65.7	2.5	3	0	3	0.07	0.16	0.23
CO 0+	80	80	80.0	5.7	1	0	1	0.02	0.13	0.08

(this site completed to test for presence of coho juveniles, specifically)

Habitat Type (%) : 0 **riffle** 100 **pool** 0 **glide**

Substrates (%) :		**Cover Components (%) :**	
fines	100	canopy/vegetation	–
sm. gravel	0	stable logs,roots,etc.	20
lg. gravel	0	cutbanks	–
cobble	0	substrates (fry)	–
boulders	0	substrates (parr)	–
bedrock	0	**D_{90} (cm)**	<1

Turbidity clear **Compaction** low–moderate **Water Temp. (°C)** 11.5

Transect and Associated Hydraulic Suitability Data

No transect completed at this site.

Electrofishing Site Data and Results

Site No.: 40 **Length (m):** 14.1 October 1, 1994

Stream: Toma Creek **Area (m^2):** 45.1

Location: lower Reach 2; 2.5 km upstream of Comox Lake

Species/ Cohort	Length (mm)			Mean Wt(g)	Capture		Population Estimates			
	Min.	Max.	Mean		1	2	Pop.*n*	n/m^2	g/m^2	n/m
CT 0+	44	67	54.2	1.9	11	1	12.1	0.27	0.51	0.86
CT 1+	101	102	101.5	11.2	2	0	2.0	0.04	0.50	0.14
CT 2+	131	131	131.0	21.8	1	0	1.0	0.02	0.48	0.07
DV 0+	52	60	56.0	1.6	4	3	16.0	0.35	0.58	1.13
DV 1+	77	92	85.8	6.1	4	2	8.0	0.18	1.09	0.57

Habitat Type (%) : 20 **riffle** 30 **pool** 50 **glide**

Substrates (%) :

fines	10
sm. gravel	10
lg. gravel	20
cobble	45
boulders	15
bedrock	0

Cover Components (%) :

canopy/vegetation	3.5
stable logs,roots,etc.	1.5
cutbanks	0.5
substrates (fry)	80
substrates (parr)	40
D_{90} (cm)	30

Turbidity clear **Compaction** low–moderate **Water Temp. (°C)** 10.0

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.21	0.49	0.13	0.71	0.13	0.90	0.44	0.60	0.11	0.00
1.0	0.23	0.23	0.90	0.77	0.88	0.98	0.68	0.70	0.74	0.13
2.0	0.36	0.08	0.66	0.98	0.66	1.00	1.00	1.00	0.95	1.00
3.0	0.28	0.00	0.98	0.93	0.98	1.00	1.00	1.00	0.90	0.70
5.0	0.50	0.03	0.40	1.00	0.40	1.00	0.80	1.00	0.90	0.80
7.0	0.62	0.02	0.15	1.00	0.15	1.00	0.60	1.00	0.90	0.80
9.0	0.65	0.05	0.15	1.00	0.15	1.00	0.60	0.95	0.90	0.80
11.0	0.38	0.04	0.66	1.00	0.66	1.00	1.00	1.00	0.90	0.80
13.0	0.27	0.06	0.98	0.93	0.98	1.00	1.00	1.00	0.95	0.62
14.1	0.27	0.05	0.98	0.93	0.98	1.00	1.00	1.00	0.95	0.62
Weighted Mean	0.425	0.051	0.558	0.954	0.557	0.995	0.816	0.957	0.872	0.700

Electrofishing Site Data and Results

Site No.: 41 **Length (m):** 5.2 October 6, 1994

Stream: Perseverance Creek **Area (m^2):** 17.7

Location: mid Reach 1; 1.2 km upstream of Comox Lake (30m downstream of lowermost road crossing)

Species/ Cohort	Length (mm)			Mean	Capture		Population Estimates			
	Min.	Max.	Mean	Wt(g)	1	2	Pop.*n*	n/m^2	g/m^2	n/m
CT 0+	41	71	52.3	1.4	3	1	4.5	0.25	0.35	0.87
CT 1+	92	115	103.5	9.3	2	0	2.0	0.11	1.05	0.38
DV 0+	72	72	72.0	2.6	1	0	1.0	0.06	0.15	0.19
CO 0+	54	85	67.5	2.8	168	7	175.3	9.92	28.13	33.71
CO 0+^{m}	62	75	66.7	2.7	17	0	17.0	0.96	2.60	3.27
CC	42	77	60.2	–	43	11	57.8	3.27	–	11.11

Habitat Type (%) : 0 **riffle** 100 **pool** 0 **glide**

Substrates (%) :

fines	40
sm. gravel	2
lg. gravel	3
cobble	15
boulders	15
clay	25

Cover Components (%) :

canopy/vegetation	–
stable logs,roots,etc.	–
cutbanks	–
substrates (fry)	40
substrates (parr)	10
D_{90} (cm)	30

Turbidity slight **Compaction** high (clay) **Water Temp. (°C)** 9.0

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.25	1.00	0.27	1.00	1.00	0.19	0.04
0.5	0.17	0.00	1.00	0.55	1.00	0.71	1.00	1.00	0.54	0.26
1.0	0.32	0.00	0.85	0.98	0.85	1.00	1.00	1.00	0.90	0.75
1.5	0.55	0.00	0.29	1.00	0.29	1.00	0.70	1.00	0.90	0.80
2.0	0.39	0.00	0.66	1.00	0.66	1.00	0.90	1.00	0.90	0.80
2.5	0.19	0.00	1.00	0.66	0.98	0.85	1.00	1.00	0.75	0.34
3.0	0.05	0.00	1.00	0.10	1.00	0.13	1.00	1.00	0.05	0.02
3.4	0.00	0.00	1.00	0.03	1.00	0.03	1.00	0.50	0.00	0.00
Weighted Mean	0.253	0.000	0.824	0.650	0.821	0.709	0.941	0.971	0.607	0.439

Electrofishing Site Data and Results

Site No.: 42
Stream: Perseverance Creek
Length (m): 7.8
Area (m²): 19.5
October 6, 1994
Location: mid Reach 2 (or beginning of Reach 3); immediately upstream of falls, 4 km upstream of Comox Lake

Species/ Cohort	Length (mm)			Mean Wt(g)	Capture		Population Estimates			
	Min.	Max.	Mean		1	2	Pop.*n*	n/m²	g/m²	n/m
CT 0+	58	68	63.2	3.0	5	0	5.0	0.26	0.77	0.64

Habitat Type (%) : 0 **riffle** 100 **pool** 0 **glide**

Substrates (%) :

fines	5
sm. gravel	30
lg. gravel	30
cobble	30
boulders	5
bedrock	0

Cover Components (%) :

canopy/vegetation	–
stable logs,roots,etc.	–
cutbanks	4.5
substrates (fry)	70
substrates (parr)	5
D_{90} (cm)	15

Turbidity clear **Compaction** low **Water Temp. (°C)** 10.0

Transect and Associated Hydraulic Suitability Data

Length (m)	Depth (m)	Velocity (m/s)	Probability of Use							
			RB fry	RB parr	CT fry	CT parr	DV fry	DV parr	Chinook	Coho
0.0	0.00	0.00	1.00	0.03	1.00	0.03	0.50	0.00	0.00	0.00
0.5	0.02	0.00	1.00	0.03	1.00	0.03	1.00	0.50	0.00	0.00
1.0	0.11	0.00	1.00	0.25	1.00	0.27	1.00	1.00	0.31	0.14
1.5	0.19	0.00	1.00	0.66	0.98	0.85	1.00	1.00	0.75	0.34
2.0	0.21	0.00	1.00	0.77	0.98	0.98	1.00	1.00	0.88	0.43
2.5	0.26	0.00	0.98	0.86	0.98	1.00	1.00	1.00	0.90	0.62
2.7	0.00	0.00	1.00	0.35	1.00	0.36	1.00	1.00	0.41	0.20
Weighted Mean	0.138	0.000	0.997	0.444	0.990	0.540	0.954	0.815	0.490	0.255