Standing Crop and Habitat Characteristics of Juvenile Salmonids at Sites in the Cowichan River System

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STANDING CROP AND HABITAT CHARACTERISTICS OF JUVENILE SALMONIDS AT SITES IN THE COWICHAN RIVER SYSTEM

by

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ABSTRACT

Fielden, R. J. and L. B. Holtby. 1987. Standing crop and habitat characteristics of juvenile salmonids at sites in the Cowichan River system. Can. MS Rep. Fish. Aquat. Sci. 1950: 65 p.

Juvenile salmonid densities, size and habitats were investigated at 90 sites in the Cowichan River system during the late summer and early winter of 1986. The sites, averaging 32 m in length, were distributed among lage, tributary, side channel, mainstem and marsh areas. Some of the sites were in areas inaccessible to anadromous fish, but where coho fry had been previously outplanted.

The largest coho were taken from the lakes sites. Mainstem sites had the next largest fry followed by tributary and then side channel fry. Side channel habitat contained the highest areal densities of coho fry, followed by tributary, mainstem and then outplant areas. Except in the Somenos system, there was a general reduction in coho densities in all areas and habitat types from late summer to early winter. Coho densities were highest in pool habitat during late summer and in slough habitat during early winter. During high-water flows in the fall, there appeared to be movement of coho fry into the Somenos system. Coho fry were not caught in many of the Somenos sites in late summer and in slough habitat during early winter. Wood debris was found to be the most important cover type for both trout and coho juveniles.

Key words: Cowichan River, coho Oncorhynchus kisutch, trout, freshwater rearing, juveniles, population estimates, outplant, size composition, age composition, winter habitat selection

RESUME

Fielden, R. J. and L. B. Holtby. 1987. Standing crop and habitat characteristics of juvenile salmonids at sites in the Cowichan River system. Can. MS Rep. Fish. Aquat. Sci. 1950: 65 p.

La densité et la taille de salmonidés juvéniles ainsi que les habitats fréquentés à 90 endroits du système de la rivière Cowichan ont fait l'objet d'une étude à la fin de l'été et au début de l'hiver 1986. Les endroits étudiés, dont la longueur moyenne s'élève à 32 m, sont situés dans des lacs, des tributaires, des chenaux secondaires, le cours principal de la rivière et des marécages. Certains des endroits sont inaccessibles aux poissons anadromes mais ont été ensemencés d'alevins de saumon coho.

Les plus gros cohos ont été capturés dans les milieux lacustres. En deuxième place vient le cours principal de la rivière, suivi des tributaires et des chenaux secondaires. Les habitats situés dans les chenaux secondaires abritaient les plus grandes densités superficielles d'alevins de coho; venaient ensuite les tributaires, le cours principal et les sites de déversement. Sauf dans le système de la Somenos, on a observé de la fin de l'été au début de l'hiver une baisse générale des densités de coho à tous les endroits et dans tous les habitats étudiés. Les plus grandes densités étaient retrouvées dans les mares à la fin de l'été et dans les fondrières au début de l'hiver. Pendant les périodes de débit élevé à l'automne, les alevins semblaient se déplacer vers le système de la Somenos. Ils n'ont pas été capturés à de nombreux endroits de ce système à la fin de l'été et dans les fondrières au début de l'hiver. Les débris ligneux se sont révélés le plus important genre de couverture pour les truites et les saumons juvéniles.

Mots-clés: rivière Cowichan, coho, Oncorhynchus kisutch, truite, élevage en eau douce, juvéniles, estimations démographiques, ensemencement, composition par âge, composition par taille, choix d'habitat d'hiver

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INTRODUCTION

The Cowichan River system (Figure 1) is one of the largest producers of coho salmon (*Oncorhynchus kisutch*) on Vancouver Island and as such has been the subject of a number of studies. Twenty-six thousand juveniles were marked and released during a study of coho productivity in the Cowichan River during the late 1930's (Neave 1941a and 1941b). An extensive downstream trapping and coded-wire tagging program has also been conducted on the system to assess the fisheries contribution and ocean migration patterns of Cowichan River coho and chinook (*O. tshawytscha*) (Argue et al. 1979, Armstrong and Argue 1977, Lister et al. 1981). In 1986, the Department of Fisheries and Oceans, Research Branch, retained Aquatic Resources Limited to conduct a preliminary study of the juvenile coho population distribution and habitat utilization of the system. This report presents the results of the study.

The specific project objectives were to:

1. Estimate the standing crops of juvenile salmonids at various sites throughout the Cowichan River system during summer low flows (August-October 1986) and immediately following the first fall storms (November-December 1986).

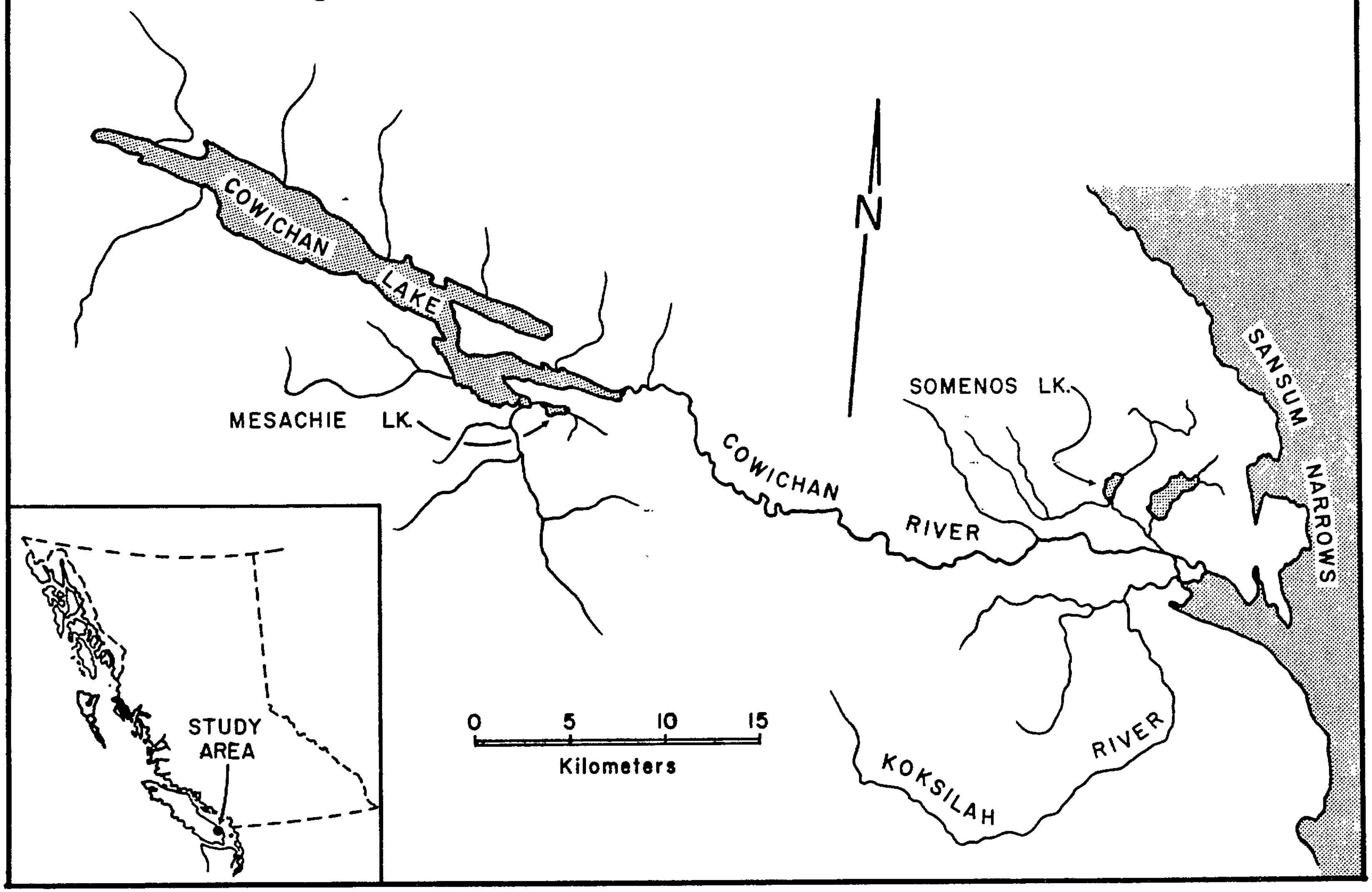
2. Quantify the habitat characteristics of areas occupied by juvenile salmonids.

3. Determine the nature of any relationships between quantitative habitat characteristics and rearing juvenile densities and species.

4. Determine the extent of shifts in distribution and habitat utilization between the summer low-flow period and the winter high flows.

The main objective of the study was to determine how important different areas of the drainage (eg. mainstem, side channel, lake and tributary habitat) were to the production of coho juveniles, and to determine if there was a shift in distribution from one area to another from late summer to winter. Secondarily, the study was to examine the relationships of juvenile size and density with habitat types (eg. glide, pool, riffle, slough and lake). As well, juvenile associations with cover type (organic debris, boulder, no cover, etc.) were to be investigated.

Figure I: COWICHAN WATERSHED



STUDY AREA

The Cowichan River system drains an area of 340 km^2 into Cowichan Bay on the southeast coast of Vancouver Island (Figure 1). There are five lakes in the system: Cowichan Lake, Bear Lake, Mesachie Lake, Somenos Lake and Quamichan Lake. Cowichan Lake is the largest lake (62 km^2), and drains into the Cowichan River which flows for 50 km before entering Cowichan Bay. Somenos Lake (6.3 km^2) and Quamichan Lake (9.7 km^2) are shallow, low lying lakes that drain into the lower reaches of the main river. Fish kills, resulting from low oxygen conditions have been reported in these eutrophic lakes during the summer (Neave 1945). Cowichan Lake, and the nearby Bear and Mesachie Lakes, are more oligotrophic in nature.

A fishway at Skutz Falls, 18 km below Cowichan Lake, was built in 1956 to aid in the upstream migration of salmon. The majority of chinook salmon spawn upstream of the falls below Cowichan Lake. Chum spawn in the main river and side channels below the falls, while coho spawn throughout the system. The escapements of chum, coho and chinook averaged 66,500, 46,400 and 6,700 fish respectively, from 1965 to 1975 (Marshall et al. 1976). The system also contains populations of Dolly Varden char (*Salvelinus malma*), cutthroat (*Salmo clarki*), rainbow (*Salmo gairdneri*), and brown trout (*Salmo trutta*). A dam at the outlet to Cowichan Lake maintains a minimum discharge of 7 $m^3 \cdot s^{-1}$. Flows reach a maximum of 326 $m^3 \cdot s^{-1}$ and average 44.9 $m^3 \cdot s^{-1}$ (Inland Waters Directorate 1980).

METHODS

SITE SELECTION

Ninety sampling sites (Figures 2-4, Table 1), 10 m to 150 m in length and scattered throughout the system, were selected for study with two objectives in mind. First, sites were chosen to sample a variety of habitat to investigate the preference of different juvenile salmonid species for particular habitat and cover types. Secondly, sample sites were chosen to help indicate shifts in habitat preferences by juvenile salmonids (particularly coho) from summer to winter. Other studies have shown that, in some systems, coho fry tend to move into the smaller tributaries, sidepools and quiet back channels during the winter (Bustard and Narver 1975, Tschaplinski and Hartman 1983). Sites along the Cowichan River and the larger tributaries were chosen close to possible overwintering habitats so that the shift to these habitats could be monitored later in the year. The lakes in the Cowichan system are important coho

Table 1. Cowichan River 1986 juvenile sampling sites .

Site number	Location
1	Robertson River (lower site)
2	Robertson River side channel
3	Millar Creek (upper site)
4	Millar Creek (lower site)
5	Sutton Creek (lower site)
6	Sutton Creek (near Millar Creek)
7	Sutton Creek (upper site)
8	Pastuch Creek (lower site)
9	Pastuch Creek (middle site)
10	Pastuch Creek (upper site)
11	Nineteen Creek
12	Honeymoon Bay
13	Honeymoon Bay
14	Honeymoon Bay
15	Honeymoon Bay
16	McKenzie Bay
17	McKenzie Bay
18	Halfway Creek (north branch)
19	Halfway Creek (south branch)
20	Halfway Creek (south-north confluence)
21	Halfway Creek (near lake)
22	Mesachie Lake
23	Mesachie Lake
24	Mesachie Lake
25	Mesachie Lake
26	Mesachie Lake
27	Bear Lake
28	Bear Lake
29	Bear Lake
30	Bear Lake
31	Bear Lake
32	Miracle Creek
33	Cowichan Lake (North Arm)
34	Cowichan Lake (North Arm)
35	Cowichan Lake (east end)
36	Cowichan Lake (east end)
37	Cowichan Lake (east end)
38	Cowichan River (below weir)
39	Cowichan River (Big Pool)
40	Oliver Creek (upper site)
41	Oliver Creek (lower site)
45	Forestry Campsite Side Channel
46	Cowichan River near Forestry Campsite S. C.
47	Asha's Side Channel (lower site)
48	Asha's Side Channel (upper site)
49	Cowichan River near Ash's S. C.

Table 1 (cont.) Cowichan River juvenile sampling sites.

Site number	Location
50	Bible Camp Side Channel (upper site)
51	Bible Camp Side Channel (lower site)
52	Cowichan River near Bible camp S. C.
53	Tzart-lam Creek
54	Cowichan River near Tzart-lam Creek
55	Bings Creek
56	Major Jimmies's Slough (upper site)
57	Major Jimmies's Slough (lower site)
58	Cowichan River South Branch (upper site)
59	Cowichan River South Branch (lower site)
60	Cowichan River North Branch (upper site)
61	Cowichan River North Branch (lower site)
62	Priest's Marsh (upper site)
63	Priest's Marsh (lower site)
64	Speed Bump Side Channel
65	Fish Gut Alley (near Somenos Creek mouth)
66	Somenos Creek (mouth)
67	Fish Gut Alley (upper site)
68	Somenos Creek (Lakes Rd. bridge)
69	Richards Creek (mouth)
70	Somenos Lake
71	Somenos Lake
72	Somenos Lake
73	Richards Creek (Innisvale)
74	Richards Creek (Richards Trench)
75	Richards Creek (Herd Rd. Bridge)
77	Pat Charlies Side Channel
78	Cowichan River (Jimmy Hall)
79	Cowichan Lake (west end)
80*	Boulder Creek (Cottonwood Cr. Tributary)
81*	Cottonwood Creek
82*	Meade Creek
83*	Upper Oliver Creek
84**	Beadnel Creek
85*	Stanley Creek
86*	Robertson River (upper site)
87*	Swampwater Creek
88*	Kalvin Creek (Kasil Valley Farms)
89*	Firewood Creek
90*	Kalvin Creek (cedar bolt area)
91*	Kalvin Creek (Fairburn Farms)
92**	Inwood Creek
93*	Bings Creek
94*	Menzies Creek

* - inaccessible to anadromous salmonids, but outplanted with coho.

** - inaccessible to anadromous salmonids; no outplanting.

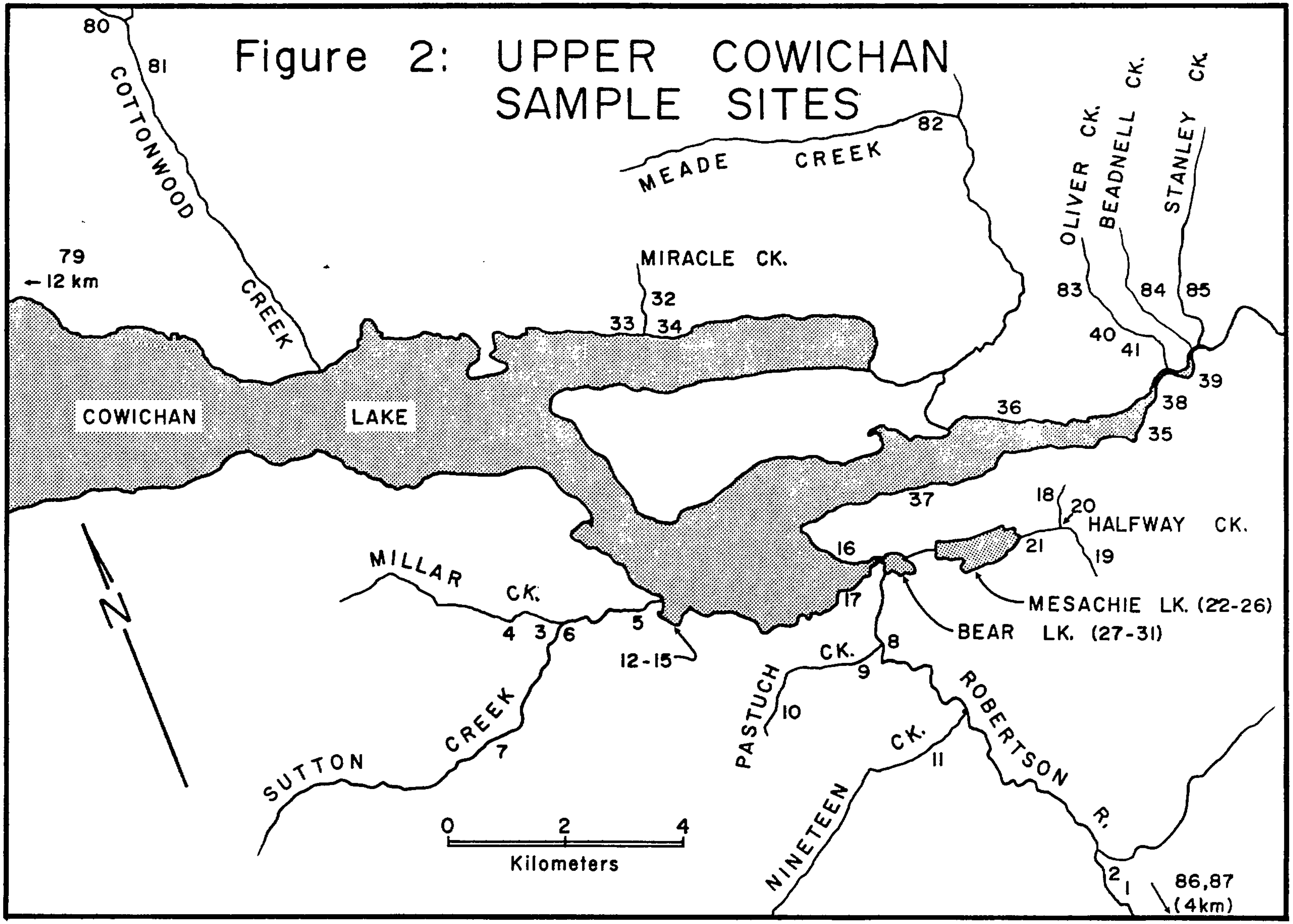


Figure 2: UPPER COWICHAN SAMPLE SITES

Figure 3: COWICHAN MAINSTEM SAMPLE SITES

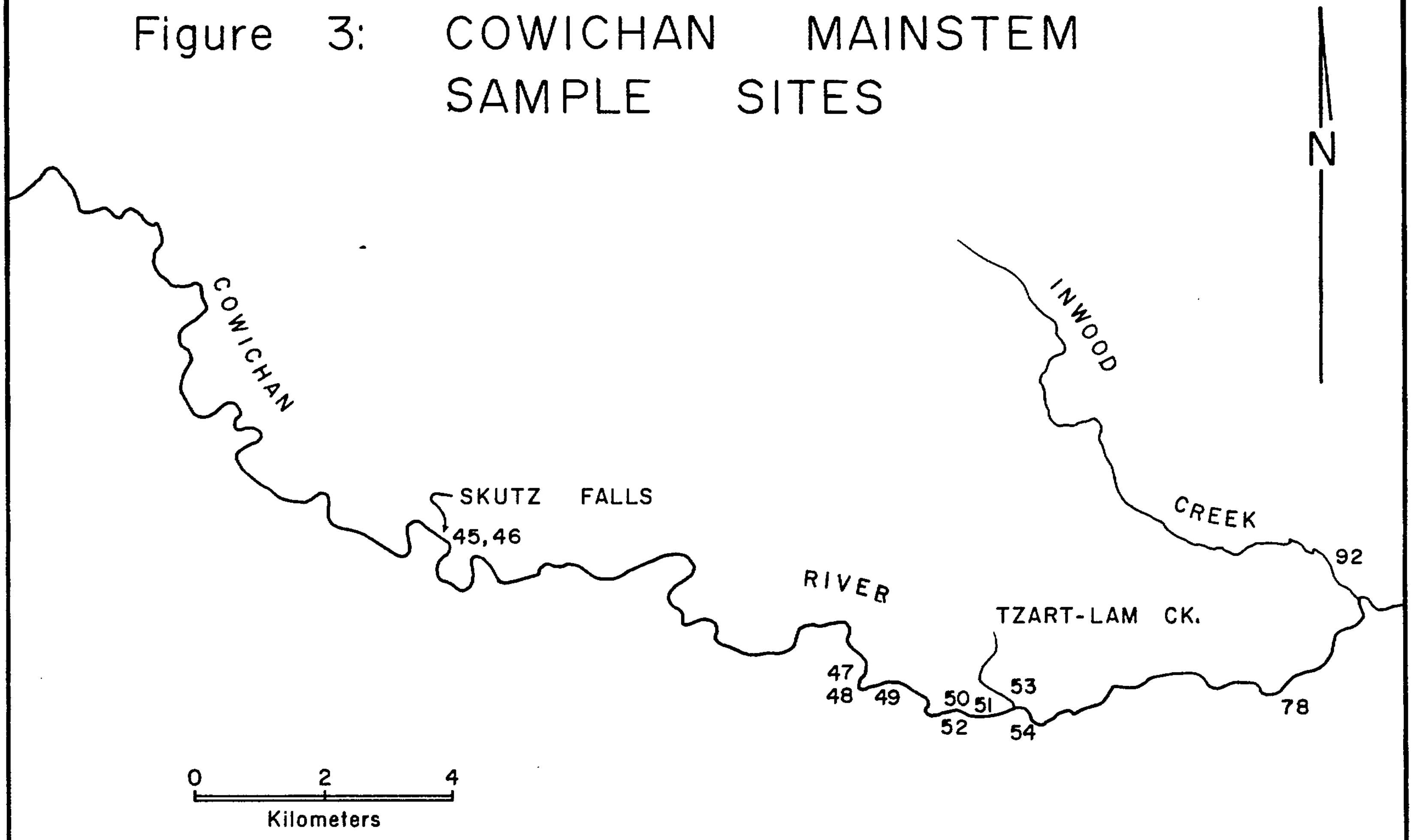
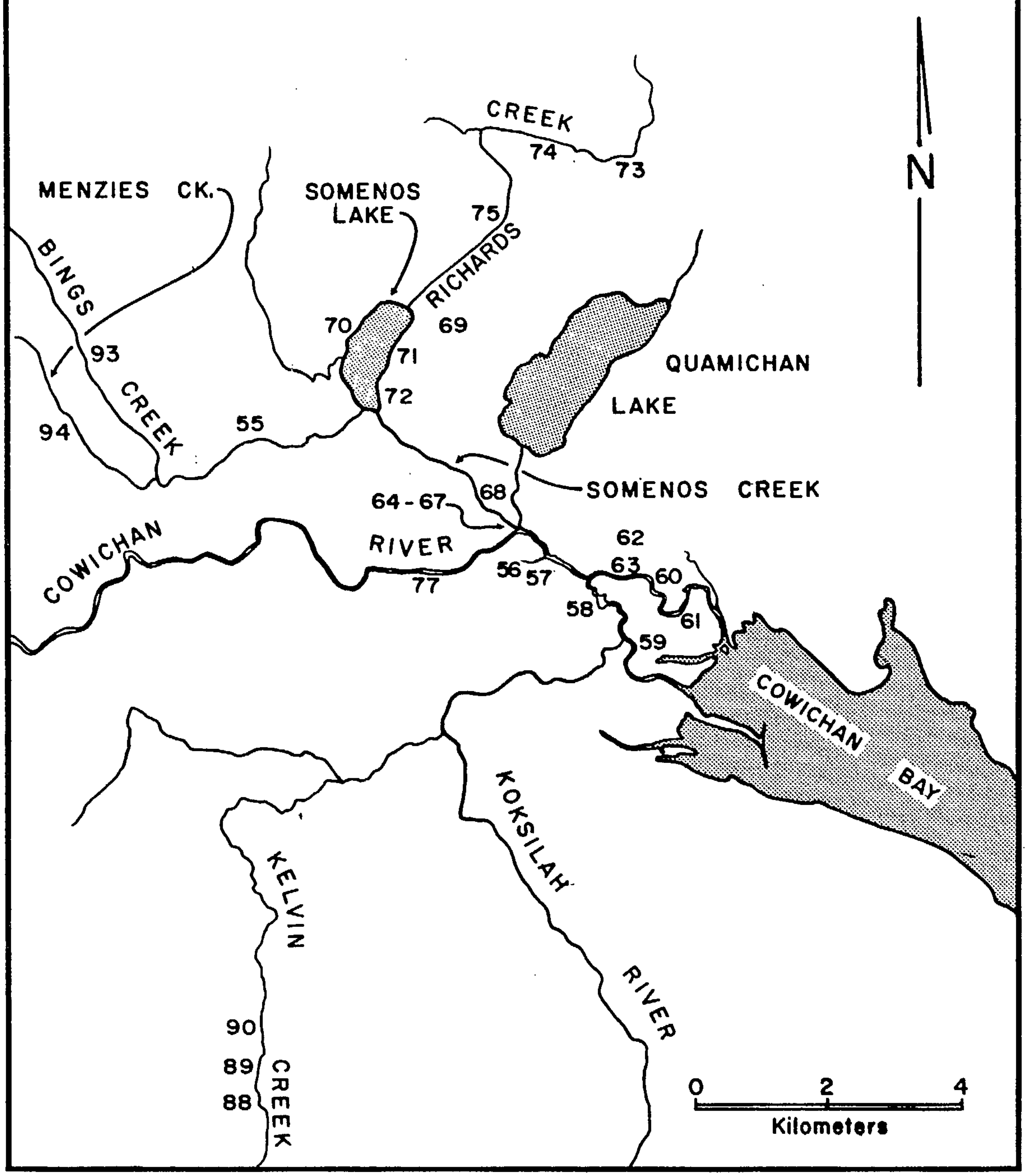


Figure 4:
LOWER COWICHAN
SAMPLE SITES



rearing areas (Argue et al. 1979). Sites along the shores of the lakes were situated near sites in inlet and outlet streams to investigate possible seasonal movements of fish between lake and stream habitat.

Of the ninety sites selected, there were; 26 tributary, 25 lake, 11 mainstem, 11 side channel and two marsh sites. In addition, 13 sites were located in tributaries inaccessible to anadromous fish, but where coho fry had been outplanted earlier in the year (Dr. B. Holtby, Pacific Biological Station, Nanaimo, B.C., V9R 5K6 pers. comm.). Fry for outplanting had been recovered earlier in the summer from drying side channel and tributary habitat. The outplant sites were studied to compare the size and densities of outplanted fry with size and densities of fry from naturally populated areas. Two additional sites were chosen in small tributaries inaccessible to anadromous fish but not planted with coho fry. These sites were examined in order that trout densities and size could be compared to those areas planted with coho.

HABITAT CHARACTERIZATION

At each stream site, four general habitat parameters were measured: wetted width, channel width, site length and discharge. A survey chain or measuring tape was used to measure the site dimensions. The velocity of the stream was determined using the floating chip method, where a floating object is timed as it drifts over a measured distance. Several velocity measurements were taken to calculate a mean. Discharge was then calculated by multiplying mean velocity by averaged depth by width. A rough sketch map of each site was prepared showing the general channel morphology, as well as the locations of distinct habitat units, depth and other significant features. At least one photograph was taken of each site.

Each site was characterized into habitat types similar to those described by Bisson et al (1981) and Helm (1985). These include eleven pool types:

1) Secondary channel pool.
2) Backwater pool associated with boulders.
3) Backwater pool associated with rootwad.
4) Backwater pool associated with large debris.
5) Trench pool associated with bedrock.
6) Plunge pool associated with large debris.
7) Lateral scour pool associated with large debris.
8) Lateral scour pool associated with rootwad.
9) Lateral scour pool associated with bedrock.
10) Flat pool.

11) Isolated pool.

Riffle was subdivided into three types of habitat: low gradient riffle, rapids and cascade. Other habitat classifications were marsh and slough.

Within each habitat type, a number of factors were measured or estimated. These included; length, width, depth, velocity, turbidity, gradient, substrate type, and percent area of overhang and crown cover. Habitat dimensions and velocity were measured as described for stream sites. Visual estimates of the percent of wetted area covered by overhanging (< 1 m above water surface) or crown vegetation (> 1 m above water surface) were made. Stream gradient was determined by estimating the drop in elevation over a measured section of stream. Water visibility was described as clear or turbid in stream habitat and in lake habitat was described by estimating the depth a light coloured object was still observable. Substrate was divided into percent surface area estimates of fines (0 - 0.1 cm), gravel (0.1 - 10 cm), cobble (10 - 30 cm), boulder (>30 cm) and bedrock. The major species of the riparian vegetation were identified at each site as well.

The width of the lake sites varied and depended on the slope of the bottom. Generally the sites were examined to a depth of approximately 7 m. Shallow sites that had flat bottoms were examined to approximately 30 m from shore.

The amount of fish cover was estimated or measured and classified into rootwad, large wood debris, small wood debris, terrestrial vegetation, aquatic vegetation, undercut bank, boulder and turbulent cover (Bisson et al. 1981). Terrestrial vegetation included cover from branches of trees or brush hanging in the water and terrestrial vegetation in the water at high water levels. Turbulent cover was produced by bubbles in plunge pools and riffles.

FISH COLLECTION AND SAMPLING

Sampling was conducted once at each site before the fall rains and once again after the fall rains. During the first sampling period, the sites accessible to anadromous fish were sampled between September 3 and September 28, 1986. The sites inaccessible to anadromous fish (outplant sites) were sampled between October 17 and October 25. All the sites were sampled again between November 25 and December 21 after the fall rains.

Marking

For mark and recapture population estimations, fish were marked with either a top or bottom caudal clip. At some sites during the summer survey, juvenile salmonids were marked with cold brands to help determine migration patterns between different sites from summer to winter. Cold brands were not used for short term mark and recapture population estimations because it took a couple of hours for the brands to show up and because it was more time consuming to mark fish with cold brands. A combination of one or two of six different brands was used to identify branding sites. The origin of the fish could then be determined from the particular combination of brands.

The fish were branded using a technique similar to that described by Nielson and Johnson (1983). The brands were cooled by placing them in a mixture of dry ice and acetone held in a small plastic thermos. Once the brand was sufficiently cooled, a fish was held against the brand head for approximately two seconds before being placed in a recovery pail. Care was taken to ensure that ice and mucus buildup on the brand heads was kept to a minimum by frequent cleaning.

Population Estimations

Fish population sizes were determined by either depletion-removal (Seber and Le Cren 1967, Platts et al. 1983), mark and recapture (Ricker 1975) or visual counts.

Depletion-Removal

An electroshocker (Smith-Root Mark VII and XIA) was the main device used to capture fish for depletion-removal estimates. This method was generally used in the smaller creeks with discharges less than 1 $m^3 \cdot s^{-1}$ and depths less than 1 m. The technique used to estimate population sizes was similar to that described by de Leeuw (1981). First the habitat unit was isolated with seine nets. Then a pass was made with the electroshocker to collect as many fish as possible. The site was then electroshocked a second time with equal intensity. If the catches were low relative to the first catch, then no more passes were necessary, but if the catches was still relatively high then more passes were made.

In areas that were free of obstruction and debris, beach seine depletion-removal was sometimes used, especially if there were large numbers of fish not associated with cover (eg. slough habitat).

At some lake sites, fish were caught for depletion-removal estimates using Gee traps. The traps were reset up to several times and successive declining catches were used to estimate populations. Fish caught in the traps were marked and released, and any recaptures removed from depletion-removal estimates.

Mark and Recapture

Mark and recapture, using Gee traps baited with salmon roe, was one method used for population estimation in bodies of water that were too large to electroshock. These areas included lake, slough and mainstem habitat. This method was particularly useful when fish were associated with debris and rubble which prevented other methods of capture. Ten to twenty traps were generally set over night at a site. The fish caught were caudal clipped the next day and released. The traps were then reset and the catch checked for the number of marked and unmarked fish.

In some of the larger sites that contained little debris or rubble, population estimates were made using beach seine mark and recapture. This method was conducted where possible because it was less time consuming and because it was observed that marked fish may have been reluctant to move into the Gee traps once the fish had been handled and marked. This reluctance could have resulted in over estimates of population size.

Visual counts

Visual counts were carried out by skin divers equipped with wet or drysuits. Diver visual counts were made in the larger water bodies where visibility was good. This method was also used as a backup to other methods whenever possible. At some lake and mainstem sites, however, where the juveniles were difficult to enumerate by other techniques, it was the only method used.

Biological sampling

All the fish captured from each habitat unit were identified to species, except for cutthroat and rainbow trout. These species were only identified as trout due to difficulty in distinguishing the juveniles. A maximum of 200 fish were sampled for length from each habitat unit. Fork length was measured with a smoltboard to ± 0.5 mm. At least 15% of the coho were then weighted to 0.03 g on an Ohaus Port-o-Gram Super C balance after being anaesthetized with 2-phenoxyethanol ($0.05\ mg \cdot L^{-1}$). The subsample weighed was selected from across the observed size range and not always representative of the sample size frequencies. Scale smears were taken from the larger coho that could possibly be age 1+ fish. Scale smears were sandwiched between microscope glass slides, and were aged using a Nikon binocular, compound microscope. Annuli were identified as areas with close and/or broken circuli and crossing over of circuli in the posterio-lateral fields of the scale. Age accuracy was checked by having two experienced readers read the samples independently.

ANALYSIS

Condition

Average lengths and weights with standard deviations were calculated for coho and trout from the different areas (mainstem, tributaries, lakes and side channels) and different habitat types (slough, glide, pool, riffle and lake). From the length and weight data, condition factors (K) were also calculated as:

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

where: W = weight in grams
L = fork length in centimeters

Length frequency data were graphed (histograms) to show the distribution of size groupings in various areas.

Population Estimation

Population estimates and 95% confidence limits using the depletion-removal method were calculated using software developed by Platts et al. (1983). Population estimates using single census mark and recapture data were calculated with the Chapman variation of the Peterson estimate equation (Ricker 1975). The equation is given as:

$$N = \frac{(M + 1)\ (C + 1)}{(R + 1)}$$

where: N = population size
M = number of fish marked.
C = catch or sample taken for census.
R = number of recaptured marks in the sample.

When R was less than 50, confidence limits ($p < 0.05$) for N were obtained by treating R as a Poisson variable and obtaining the limits for it directly from a table provided by Ricker (1975). When R was greater than 50, the limits of R were calculated using Pearson's formula (Ricker 1975), which is given as:

$$r = 1.92 \pm 1.90(R + 1.0)^{0.5}$$
$$\text{for } 1-P = 0.95$$

where: R = number of recovered marks
r = confidence limit for R

The confidence limits for population size were then calculated by replacing R in the Peterson formula with the limits for R taken from the table or calculated by Pearson's formula.

When a multiple census was carried out, population estimates were calculated using Schnabel's formula (Ricker 1975):

$$N = \frac{(C_t M_t)}{(R + 1)}$$

where: N = population size
C_t = total sample taken on day t
M_t = total number of marked fish at large on day t.

Approximate limits for confidence ($p = 0.95$) for N were obtained as for the Peterson estimate.

Habitat Specific Utilization Coefficients

Habitat specific utilization coefficients (Bisson et al. 1981) for each species was calculated as:

$$U = \frac{H - A}{A}$$

where: H = average density in habitat type of interest
A = average density of all cover types combined

Cover-density correlations

Correlation coefficients (r) (Zar 1974) were calculated between densities and cover in different habitat types. Variables included the percentage of cover (eg. rootwad, large wood debris etc.) in each site unit and species density ($no \cdot m^{-2}$).

RESULTS AND DISCUSSION

HABITAT

Table 2 summarizes the average characteristics of the 90 sites sampled during late summer-early fall and early winter field sessions. The outplant and trout sites (identified in Table 2 as "outplant") had characteristics similar to the other tributary sites, except for the September-October temperatures. The outplant sites, however, were sampled at the end of October rather than in September so that the temperatures were generally cooler (7.9 °C). In September, the warmest average temperatures (19.2 °C) were recorded at the lake sites. Mainstem sites (16.8 °C) and the side channel and tributary sites (13.0 °C) were consistently cooler. The December side channel, lake and mainstem sites all had similar average temperatures (6.6 - 7.4 °C), while tributary and outplant sites were 2 to 3 °C cooler.

Table 2 Site characteristics during late summer and early winter sampling.

Sampling period	Area	Width: Wetted (m)	Width: Channel (m)	Length (m)	Area (m^2)	Depth (m)	Velocity ($m \cdot s^{-1}$)	Discharge ($m^3 \cdot s^{-1}$)	Gradient (%)	Temp (°C)
Sept-Oct	Tributary	3.7	7.4	21.3	86	0.29	0.2	0.04	1.6	13.0
	Lake	12.8	-	46.7	594	1.63	-	-	-	19.2
	Mainstem	19.5	37.4	54.1	1,172	1.52	0.2	-	0.8	16.8
	Side channel	7.3	10.8	23.6	170	0.48	0.1	0.07	0.4	12.1
	Outplant	3.1	7.3	20.7	62	0.23	0.2	0.09	1.9	7.9
Dec	Tributary	4.9	8.1	26.9	134	0.42	0.5	1.90	1.6	4.9
	Lake	11.3	-	49.0	370	1.38	-	-	-	6.6
	Mainstem	4.5	-	34.1	107	0.90	0.2	-	0.5	6.9
	Side channel	9.8	10.7	23.2	265	0.90	0.3	2.20	0.6	7.4
	Outplant	7.7	7.8	19.4	176	0.40	0.5	0.60	2.3	4.2

- = not applicable or no data collected

Higher flows in December, due to heavy rain at the end of November, increased the area of the tributary, outplant and side channel sites. Discharge at these sites increased from an average of less than 0.1 $m \cdot s^{-1}$ to 0.6 - 2.2 $m \cdot s^{-1}$. Concurrently, wetted width, depth and water velocities increased. The largest sites were located in the Cowichan River mainstem in September. Low discharge levels at this time enabled density estimates for whole sections of the river to be made. December discharge and mid-stream flow velocities were considerably higher, making it difficult to sample the same sites during this period. Instead, new sites along the stream shores were isolated and sampled. Mainstem sites in December, therefore, were considerably smaller than comparable September sites. Few fish were considered to inhabit the high velocity areas in mid channel. The densities were therefore estimated for sections of the whole river only from the densities of fish found along the slower velocity areas along the shore. Site characteristics were similar for the lake sites during both sampling periods, even though the appearance of the site changed somewhat. Water levels increased 0.7 - 1.0 m from September to December in the four lakes sampled (Bear, Mesachie, Somenos and Cowichan Lakes), which caused a large increase in terrestrial vegetation cover. On the other hand, aquatic vegetation cover, including milfoil, pondweed, *Elodea*, and emergent and floating leaf vegetation (lily pads) decreased substantially over the same period.

Table 3 Average characteristics during late summer and early winter of sampled habitats.

Sampling Period	Habitat Type	n	Length (m)	Width (m)	Area (m^2)	Depth (m)
Sept-Oct	Pool	55	12.8	6.4	137.0	0.7
	Glide	45	13.3	8.5	205.7	0.3
	Riffle	33	8.9	3.6	53.7	0.1
	Slough	11	18.3	7.0	129.8	0.9
	Lake	35	46.7	12.9	594.3	1.6
Dec	Pool	39	11.8	5.2	63.4	0.7
	Glide	61	19.5	5.3	87.2	0.6
	Riffle	25	8.7	4.3	40.2	0.4
	Slough	13	28.3	8.4	277.0	1.3
	Lake	30	49.0	11.3	517.3	1.4

Within each site, different habitat types were sampled (Table 3). Pool habitat was most frequently sampled in September followed by glide, riffle and slough habitat. Higher discharges in December resulted in a more uniform and faster flow at some of the sites causing some of the habitats described as pool and riffle in September to resemble glide and run habitat in December. For example, a 1 - 2 m rise in the Cowichan River in December caused many of the areas that appeared as riffle and pool to assume a swift, uniform flow character with the slope of the water surface roughly parallel to the overall gradient of the stream reach. As a result, glide habitat was the most frequently sampled habitat type in December followed by pool, riffle and slough habitat. The habitat types that were more abundant (eg. pool habitat in tributaries during September, and glide habitat in side channel and mainstem areas in December) were generally sampled more often (Table 4). However, the frequency of different habitat types sampled was not necessarily representative of the frequency of habitat types present since an attempt was made to sample a variety of habitat types rather than a representative selection.

Table 4. Cowichan River system site habitat characteristics.

Sample Period	Area	Habitat Type	n	Mean Length (m)	Mean Width (m)	Mean Area (m^2)	Mean Depth (m)	Mean Vol. (m^3)
Sept	Trib.+ Outplant	Pool	39	7.9	3.3	28.2	0.3	11.2
		Glide	29	7.2	3.7	29.6	0.1	4.3
		Riffle	27	7.1	2.3	17.9	0.1	2.1
	Side Ch.	Pool	8	16.0	7.9	150.7	0.7	151.9
		Glide	7	11.5	8.7	116.0	0.5	94.4
		Riffle	2	13.8	1.0	13.8	0.1	1.1
	Mainstem	Pool	8	33.8	20.3	670.7	2.9	1,928.0
		Glide	10	34.0	23.3	812.6	0.9	665.0
		Riffle	4	19.1	14.0	315.6	0.5	148.7
	Slough (all)		11	18.3	2.0	129.8	0.9	184.3
	Lake		35	46.7	12.8	594.3	1.6	-
Dec.	Trib.+ Outplant	Pool	32	7.9	4.7	40.4	0.5	20.8
		Glide	34	11.4	5.3	49.0	0.3	15.2
		Riffle	23	8.8	4.5	42.6	0.3	14.2
	Side Ch.	Pool	3	16.0	8.3	164.0	1.0	200.0
		Glide	7	20.1	8.4	136.0	1.3	327.9
		Riffle	2	7.0	1.8	12.3	0.2	2.5
	Mainstem	Glide	18	25.3	3.8	83.8	0.7	87.1
	Slough (all)		13	28.0	8.4	277.0	1.3	498.7
	Lake		30	49.0	11.3	517.3	1.4	-

- = No data collected

The volume of tributary pool habitat sampled (Table 4) almost doubled from September to December, while glide habitat increased by four times and riffle by seven times. Habitat volume and area at the sample sites increased substantially for side channel and slough habitat as well due to the increased flows.

Pool habitat (Table 5) was classified into a variety of types. Lateral scour pools were the most common pool type followed by backwater pools and then plunge pools. Of the 26 riffle units sampled in December, 23 were classified as low gradient riffle and three were classified as rapids. None of the riffle habitat sampled in September-October were classified as rapids or cascades.

Table 5. Pool types and number sampled.

Pool Type	Sept.-Oct.	Dec.
Secondary ch.	0	1
Backwater	11	7
Trench	2	0
Plunge	6	4
Lateral scour	17	12
Flat	1	1
Isolated	6	2
Total	43	27

In general, cover in all areas and all habitat types increased substantially from September to December (Table 6) because of the increase in the volumes sampled at each site. In September-October at tributary and outplant sites, leaf cover, classified as terrestrial vegetation, was the most common cover in all but riffle habitat. Besides leaf cover, boulder cover was the most predominant in tributary pools although small wood, large wood and rootwad combined provided the most cover. Glide and riffle habitat contained less cover during September-October than pool habitat. After terrestrial vegetation, glides and riffles exhibited mainly boulder and some wood debris cover. Riffle habitat had less wood cover than glide habitat.

With higher water levels in December, wood debris became the most prevalent cover in tributary glides and pools (Table 6). Boulder cover was still the main cover type in riffle habitat, although there was an increase in turbulent cover.

Instream vegetation (pondweed, milfoil and *Elodea*) in pool and glide habitat was the most common side channel cover during September. In December however, as instream vegetation died away and water levels increased, terrestrial vegetation cover became predominant in glides. The boulder cover in September pool habitat and December glide habitat was mainly from road riprap along Speed Bump Side Channel (Figure 4). Usually, the side channels did not have much

Table 6. Types and area (m^2) of cover found in different habitat from the 1986 Cowichan River sample sites.

Area	Sample Date	Habitat Type	n	Rootwad	Lg.wood	Sm.wood	Cutbank	Turb.	Boulder	Deep	Instream vegetat.	Terrest. vegetat.
Tributary												
	September-October											
		Pool	39	23.3	26.1	15.8	18.5	2.7	37.5	4.0	2.6	102.0
		Glide	29	2.3	3.5	7.2	7.9	1.3	48.0	0.0	1.0	68.8
		Riffle	27	0.1	0.3	1.4	0.7	5.5	87.0	0.0	2.0	23.8
	December											
		Pool	35	25.5	71.0	89.0	44.0	12.0	49.6	5.0	5.0	14.8
		Glide	34	15.8	33.0	58.9	60.1	5.0	57.3	0.0	10.0	40.5
		Riffle	23	5.5	0.8	2.2	2.5	73.2	193.5	0.0	0.0	0.5
Side Channel												
	September-October											
		Pool	8	0.0	8.5	19.1	4.5	0.0	35.0	0.0	227.0	27.0
		Glide	7	0.0	0.0	6.9	0.7	0.0	0.0	0.0	24.0	8.0
		Riffle	2	0.0	0.0	1.0	0.0	0.0	4.0	0.0	0.0	0.0
	December											
		Pool	3	6.0	2.0	5.3	0.1	10.0	0.0	0.0	0.0	0.0
		Glide	7	0.8	5.4	25.2	0.0	0.0	160.0	0.0	60.0	177.0
		Riffle	2	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.2
Mainstem												
	September-October											
		Pool	8	9.5	18.0	20.0	20.0	12.0	520.0	1195.0	0.0	4.0
		Glide	10	36.0	97.0	116.0	20.0	3.0	370.0	0.0	0.0	91.5
		Riffle	4	0.0	0.0	0.0	0.0	50.5	100.0	0.0	0.0	0.0
	December											
		Glide	18	16.3	28.0	42.0	5.0	0.0	176.0	4.0	10.0	387.0
Lake-Slough (All areas)												
	September-October											
		Slough	11	5.0	4.5	32.0	2.8	0.0	0.0	60.0	768.0	360.0
		Lake	35	65.0	2,205.0	4,177.0	25.0	0.0	70.3	350.0	9,433.0	925.0
	December											
		Slough	13	38.0	11.0	71.5	19.5	0.0	0.0	500.0	232.0	586.0
		Lake	30	34.0	722.0	1,236.0	0.0	0.0	0.0	0.0	1,075.0	4,180.0

boulder cover. Wood debris cover was also not very common in side channel sites. Riffle habitat in side channels was rarely observed and sampled, hence the limited cover data for this habitat type (Table 6).

Deep cover was the dominant mainstem pool cover type observed in September, while wood debris and boulders contributed smaller amounts of cover. In September glide habitat in the mainstem, boulders formed the greatest cover type followed by wood debris. Wood debris was more common in mainstem glide than pool habitat. Boulder and turbulent cover was the only cover type in mainstem riffle habitat in September. Terrestrial vegetation became the most dominant cover type at the mainstem sites in winter (December) as water levels rose to cover bushes along the river banks.

Slough habitat had all types of cover, except for boulder and turbulent cover (Table 6). Instream vegetation was most common in the sloughs in September, while terrestrial vegetation was most common in the sloughs in December. Lake habitat provided mainly instream vegetation and wood debris cover during both sampling periods, although there was an increase in terrestrial vegetation cover in December with raised water levels (Table 6).

FISH POPULATIONS

Species composition and distribution

Coho juveniles, Dolly Varden char, cutthroat trout, rainbow trout, brown trout, cottids and brown catfish (*Ictalurus nebulosus*) were the main species of fish captured at the sample sites. Coho were found in all but two sites located on Inwood Creek and Beadnel Creek (Figures 2 & 3). These two sites were above barriers impassable to anadromous fish and were not stocked with coho. Cutthroat trout were caught throughout the system, although the juveniles were not encountered as frequently in the lake sites. Rainbow were observed mainly in the mainstem Cowichan River. Brown trout were found only in Oliver Creek and Stanley Creek, both in and above areas accessible to coho. Cottids were very common in mainstem river and lakes sites, but were not found in many of the tributary sites. Brown catfish were only encountered in Somenos Lake.

Characteristics

Age

All of the 600 - 700 coho scales taken during the study were aged as 0+ fish, although some of the coho aged from the tributaries in September were as large as 33 g. Scales taken in 1975 and 1976 indicated that 2.4% and 6.3%, respectively, of the coho smolts aged spent two winters (aged 1+) in the system (Argue et al. 1979). In Mesachie Creek, 10% of the coho aged in 1976 spent two winters in the system (Argue et al. 1979). The reason for the lack of 1+ coho in this study is not clear. Usually a greater proportion of 1+ coho arise from cooler or more unproductive systems because the fry do not reach a large enough size to smolt after the first winter. Cowichan coho with the largest average size came from the mainstem and lake habitats, which had warmer water temperatures. The tributary fry had smaller mean sizes in September but included a larger proportion of large fry in the 80 to 140 mm range (Figures 5, 6 and 8). It is possible that some of the large tributary fry were 1+ fish that failed to develop winter annuli. Some yearling chinook smolts from the Upper Fraser River were found to have no annulus formation (Tutty and Yole 1978).

Scales were aged using standard techniques (see methods). These techniques require several criteria be fulfilled to denote an annulus. The presence of areas of only broken circuli, for example, would usually indicate a false check. Given this standard, many of the mainstem and tributary fish scales sampled showed a false check at 4-8 circuli in September-October. This pattern could be explained by early emergence, however, the checks could also represent unclear annulus formation. Further studies of scale patterns for different areas of the drainage, over a range of fry sizes and at different times of the year are recommended to clarify possible aging discrepancies.

Coho size

The various lakes sampled, which had the warmest mean water temperatures (Table 2), supported the largest coho juveniles (Table 7). Lake coho fry length averaged 66.4 mm in September and 88.0 mm in December. The samples did not indicate that any one lake produced larger fry than the others. The smallest lake coho fry, on average were sampled from Mesachie Lake in September (L = 60.1 mm), but Mesachie Lake produced the largest fry in December (L = 95.8 mm). Condition factors (K) of lake coho were the largest of all the areas in September (mean K = 1.17). However in December, average lake coho condition factors decreased to K = 1.01; the lowest of all the study areas. Condition factor generally increases in salmonids after emergence until the time of smolting. As smolting progresses, the body form of the coho increases in length in greater proportion than weight increases causing a decrease in condition factor

Figure 5
Size distribution of coho juveniles from lakes and tributaries of the Cowichan system, 1986

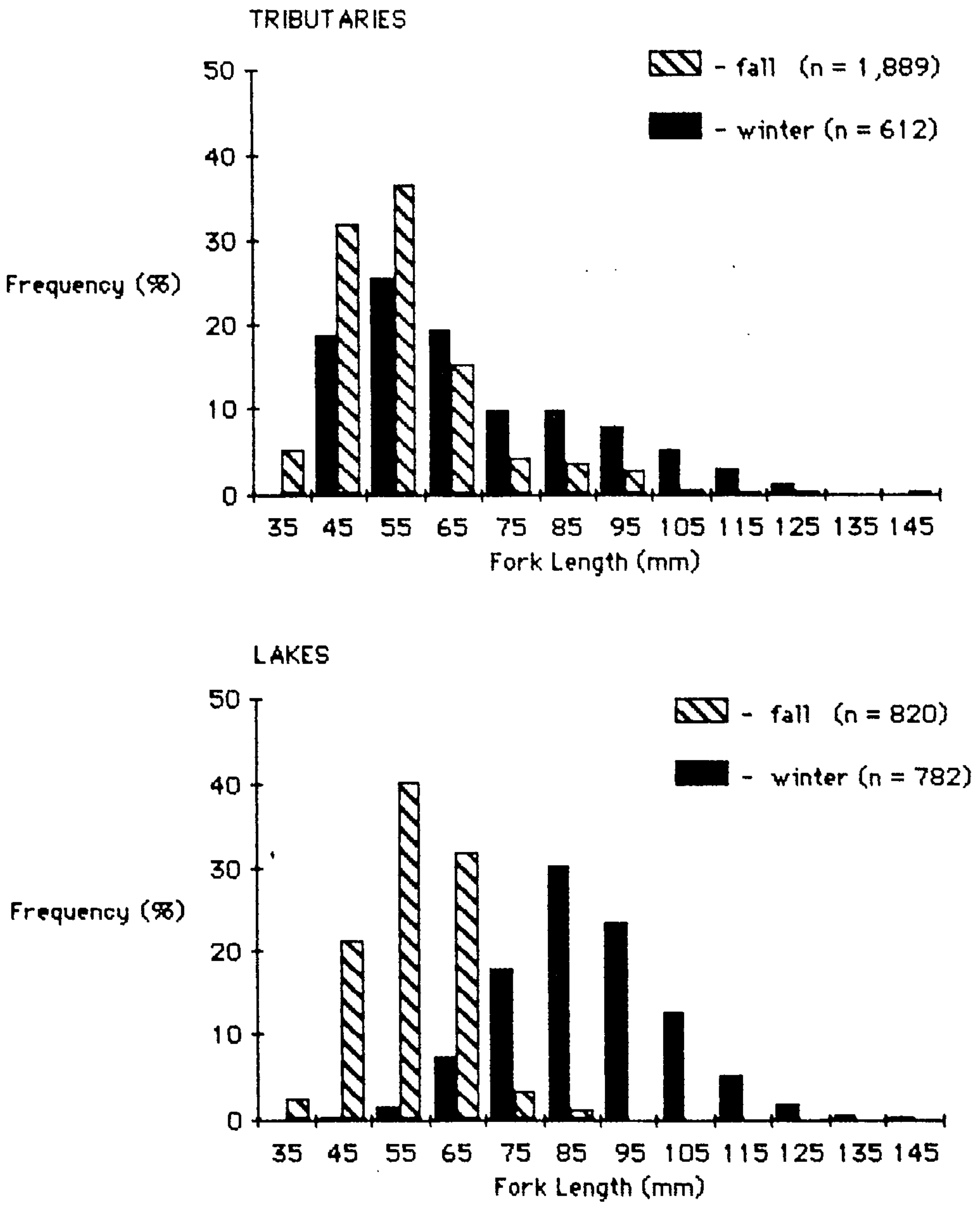


Figure 6
Size distribution of coho juveniles from mainstem and side channel areas of the Cowichan system, 1986

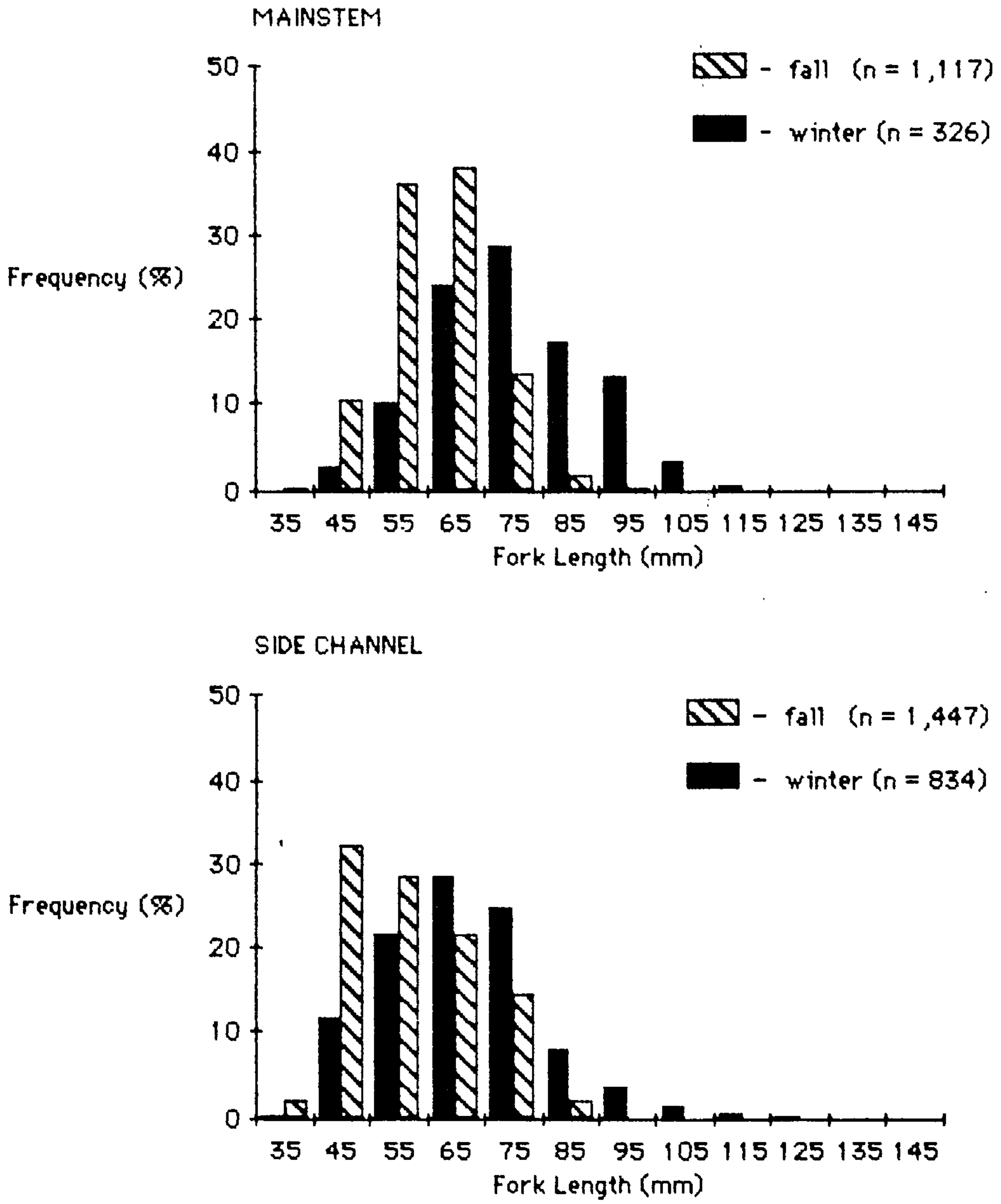


Figure 7
Size distribution of coho juveniles
from the Cowichan system, 1986

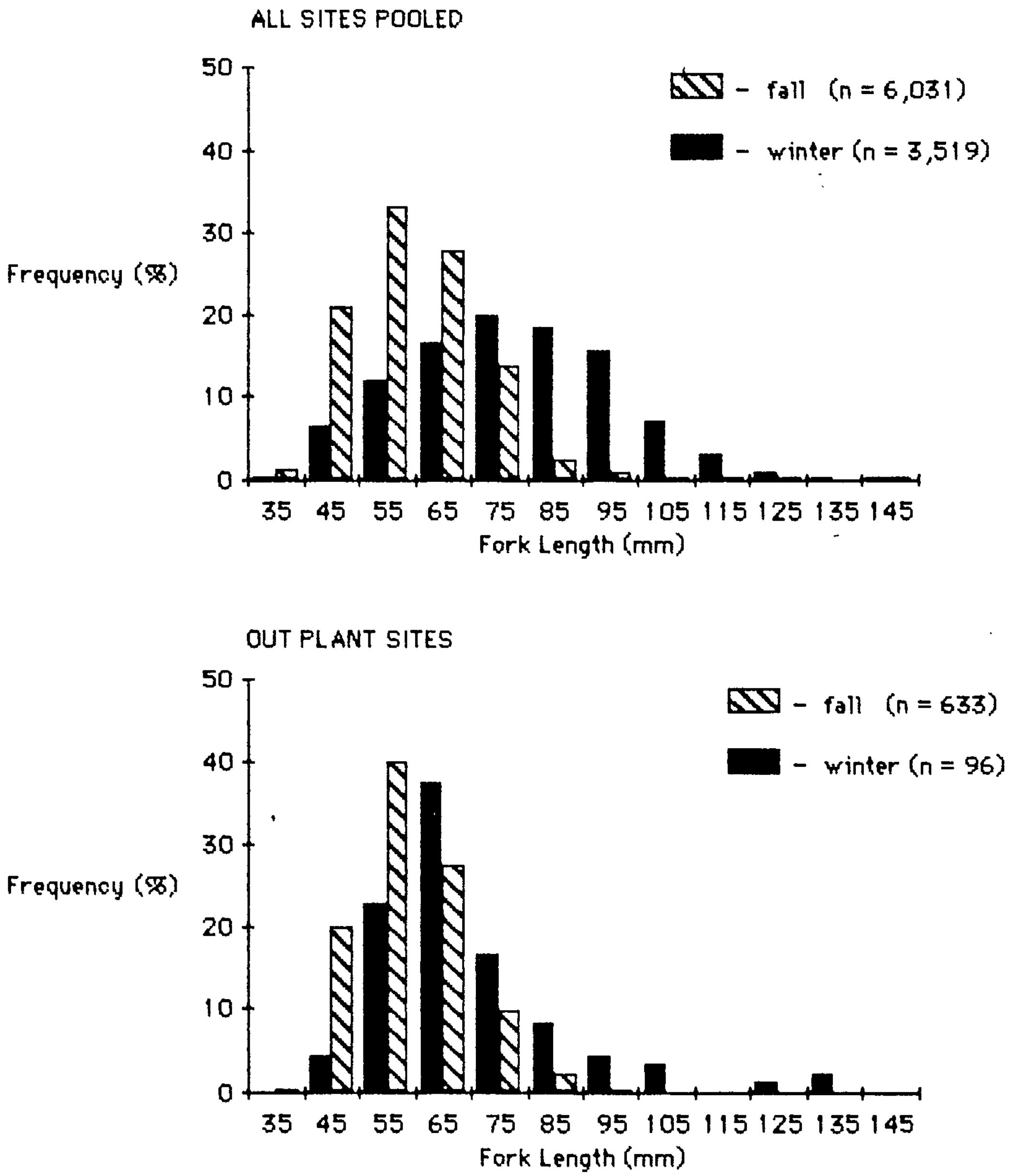


Figure 8
Size distribution of coho juveniles from
Bings and Halfway Creeks on the
Cowichan system, 1986

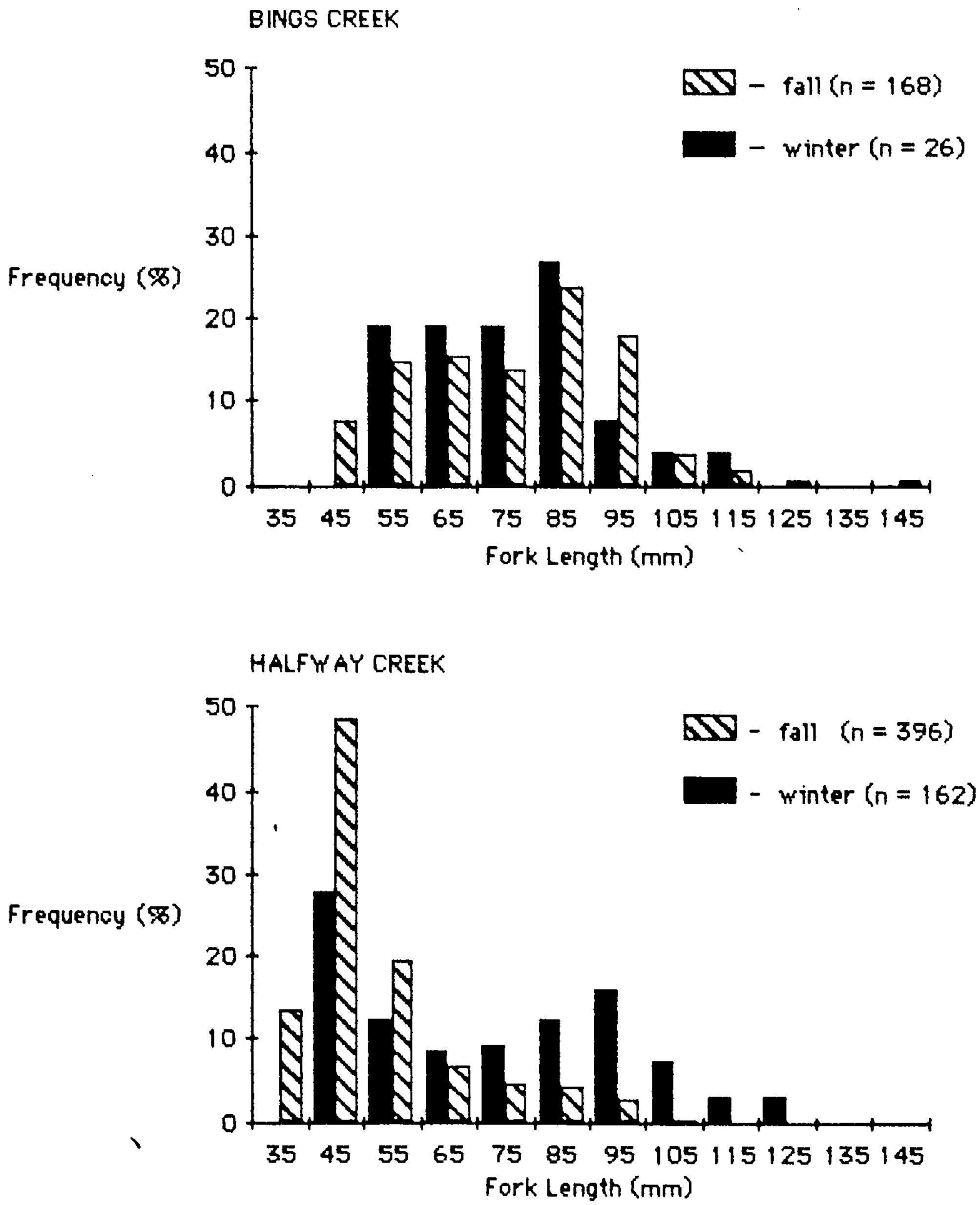


Figure 9
Size distribution of coho juveniles
from the Somenos and Priest areas
of the Cowichan system, 1986

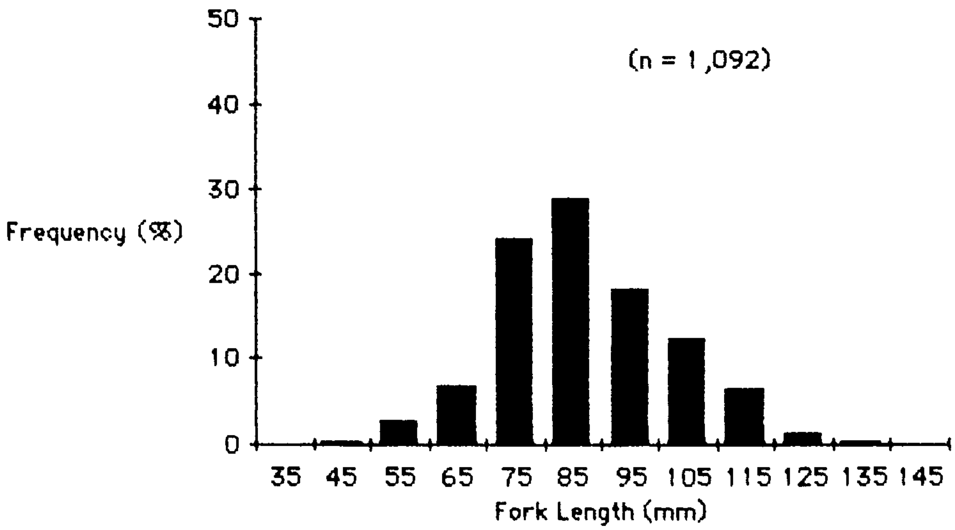


Table 7 Mean fork length and condition (K) of juveniles from various areas of the Cowichan River system.

Sample Period	Habitat	Species	Mean Length (mm)	n	St. Dev. (mm)	Min. Length (mm)	Max. Length (mm)	Mean K	n	St. Dev.	Min. K	Max. K
September-October												
	Tributaries	coho	54.7	2,110	10.2	31	141	1.08	708	0.17	0.46	2.31
	Lake	coho	66.4	830	7.9	44	98	1.17	382	0.16	0.89	2.43
	Mainstem	coho	60.6	1,117	6.9	37	91	1.11	586	0.13	0.66	2.14
	Side channel	coho	56.4	1,716	7.7	36	86	1.06	1,535	0.11	0.57	2.31
	Outplant areas	coho	57.8	633	7.9	38	91	1.07	633	0.16	0.70	2.22
	All areas	coho	58.0	6,406	8.5	31	141	1.08	3,844	0.12	0.46	2.43
	Tributaries	trout	54.8	627	14.5	29	155	-	-	-	-	-
	Mainstem	trout	59.7	128	12.8	38	122	-	-	-	-	-
	Side channel	trout	56.9	132	19.2	39	236	-	-	-	-	-
	Outplant areas	trout	68.3	473	26.5	39	220	1.01	472	0.13	0.57	2.11
	All areas	trout	60.2	1,360	19.8	29	236	-	-	-	-	-
	Tributaries	brown tr.	56.8	166	29.1	27	222	-	-	-	-	-
	Outplant areas	brown tr.	85.7	28	40.7	42	208	1.03	26	0.09	0.84	1.28
	All areas	brown tr.	60.9	194	30.9	27	222	-	-	-	-	-
December												
	Tributaries	coho	67.4	612	14.1	40	125	1.07	612	0.13	0.50	2.39
	Lakes	coho	88.0	782	12.6	44	146	1.01	782	0.08	0.68	1.85
	Mainstem	coho	74.9	326	11.5	43	115	1.05	316	0.09	0.73	1.15
	Side channel	coho	66.1	834	12.0	37	121	1.10	834	0.15	0.54	2.37
	Outplant areas	coho	69.1	96	13.4	44	130	1.11	96	0.13	0.56	1.49
	Somenos-Priest	coho	86.2	1,094	13.3	45	135	1.02	1,094	0.10	0.68	1.94
	All areas	coho	76.0	3,434	12.8	37	146	1.07	3,423	0.12	0.54	2.39
	Tributaries	Trout	69.8	439	17.4	35	234	1.03	425	0.12	0.62	1.57
	Lakes	Trout	119.4	9	66.7	54	151	0.91	8	0.06	0.80	1.06
	Mainstem	Trout	78.0	447	16.8	36	174	1.08	420	0.11	0.61	1.74
	Side channel	Trout	76.1	117	20.1	41	167	1.09	117	0.14	0.36	1.41
	Outplant areas	Trout	83.8	229	30.8	40	270	1.02	152	0.13	0.56	1.40
	All areas	Trout	76.7	1,226	21.6	35	270	1.05	1,115	0.12	0.36	1.84
	Tributaries	brown tr.	66.8	78	27.8	35	475	0.94	76	0.11	0.67	1.32
	Outplant areas	brown tr.	81.0	20	17.9	42	121	1.09	20	0.09	0.90	1.37
	All areas	brown tr.	69.7	98	26.0	35	475	0.97	96	0.11	0.67	1.37

- - no data collected

(Hoar 1939). The observed drop in condition factor may, therefore, be indicative of early smolting. Alternatively, the drop in condition factor may be the result of a redistribution of smaller and/or lower conditioned coho from riverine to lacustrine habitat.

The coho sampled from the mainstem sites were the second largest in mean size (60.6 mm in September, 74.9 mm in December) and had the second largest mean condition factor in September (K = 1.11) (Table 7). The largest fry from the Cowichan River mainstem in September were sampled from four sites in the lower reach under tidal influence. These fry were an average 66.6 mm in length, similar in size to the lake coho (Table 7). These fry had high condition factors of K = 1.18 as well.

Fry sampled from the side channel habitat were the second smallest in September (56.4 mm), next to fry from the tributaries (54.7 mm), and had the lowest mean condition factor (K = 1.06)(Table 7). Many of the side channels sampled had little or no flow and very high concentrations of fish in September. The high rearing densities and limited water exchange may have caused the formation of pinheads, observed at a few sites, and probably caused slower growth overall. When sampled in December, the side channels contained the smallest fry in the system but were one of the areas with the highest condition factor (K = 1.10). The higher condition factor could be due to the more advanced state of smolting of fry in the other areas and/or the displacement from side channel habitat of all but the higher conditioned fish.

Although fry sampled from the tributaries in September were the smallest in mean size (54.7 mm), they had the largest size range and highest standard deviation (Table 7). In September, 14 coho greater than 100 mm were sampled from tributary habitat that were all aged as 0+ fish, while no other areas produced fry larger than 100 mm. One fry sampled from Bings Creek weighed 33.38 g and was 141 mm long. The size of these fry suggests that they were age 1+ fish, although the scales indicate otherwise. The mean September condition factor for tributary fry was low (K = 1.08) compared to mainstem (K = 1.11) and lake coho (K = 1.17) and slightly higher than side channel coho (K = 1.06) (Table 7). December tributary coho were slightly larger on average (67.4 mm) than the side channel coho sampled (66.1 mm). The mean condition factor of the December tributary coho (K = 1.07) dropped slightly from September unlike the condition factor for side channel coho.

The outplanted coho were slightly larger on average

(57.8 mm) than the tributary coho in September (Table 7), but the outplanted coho were sampled about one month later. Although no previous size information was available on the outplanted coho, they were probably small when planted because most were salvaged from drying side channel and tributary habitat where fry would be highly concentrated. It appears that growth of fry in the outplant sites may have been slightly greater than the other tributary sites. The median size groups from the two areas in September-October were similar (Figures 6 and 7), while in December the median size group for outplant sites was of a larger size than observed for other tributary fry. Lower densities in the outplant sites may have resulted in slightly faster growth than the other tributary sites.

The size distributions for the various areas (Figures 5-9) all showed a unimodal pattern, except for the winter distribution in Halfway Creek, which was bimodal. The bimodal distribution in Halfway Creek is probably caused by a mixture of lake and tributary fry present in the lower reaches of Halfway Creek (see Movements page 43) .

Trout size

The largest mean sized trout (rainbow and cutthroat) sampled in September - October and December were captured from outplant sites (Table 7), possibly because competition between coho and trout was causing a smaller mean size at the other sites (Tripp and McCart 1983). Brown trout also had a larger mean size at the sites that were inaccessible to coho (Table 7). The mean size of rainbow and cutthroat at the outplant sites was 68.3 mm compared to 54.8 mm in the other tributary sites in September. Brown trout had a mean size of 85.7 mm in the outplant sites compared to 56.8 mm in the other tributary sites. Similar size differences were observed in December. In the areas accessible to anadromous fish, the largest trout juveniles were generally captured from mainstem habitat (Table 7). Side channel habitat had the second largest trout and tributary habitat had the smallest trout. No trout juveniles were captured in the lakes in September although several large trout juveniles were captured in the lakes in December resulting in a very high mean length (119.4 mm).

Size Distribution Within Different Habitat Types

Generally coho fry residing in glide habitat in tributary, side channel and mainstem sites, during both September and December, had the largest mean size of all the habitat types. The only exception was for coho in the September tributary sites (Table 8). September tributary

Table 8 Mean coho size and condition (K) from different habitat types in different areas.

Area	Sample Period	Habitat Type	Mean Length (mm)	n	Mean St. Dev. (mm)	Min. Length (mm)	Max. Length (mm)	Mean K	n	St.Dev.	Min.	Max.
Tributaries												
	September-October											
		Pool	55.0	1,331	11.2	31	141	1.07	406	0.15	0.46	2.09
		Glide	52.9	633	6.7	37	94	1.13	198	0.21	0.72	2.29
		Riffle	53.6	34	4.4	35	71	1.13	20	0.23	0.64	1.73
		Slough	53.9	212	11.9	36	108	1.13	103	0.19	0.46	1.88
	December											
		Pool	65.4	358	15.9	40	125	1.08	358	0.15	0.50	2.39
		Glide	72.2	145	13.6	40	125	1.06	145	0.10	0.65	1.45
		Riffle	60.6	16	7.3	51	80	1.11	16	0.17	0.79	1.49
		Slough	65.4	41	11.5	40	93	1.08	41	0.10	0.93	1.49
Mainstem												
	September-October											
		Pool	58.1	412	7.6	39	91	1.13	163	0.13	0.72	1.98
		Glide	62.1	696	6.4	37	87	1.10	4	0.13	0.68	2.14
		Riffle	59.0	9	7.4	45	70	1.12	8	0.07	1.11	1.20
	December											
		Glide	77.9	226	11.7	48	115	1.05	226	0.08	0.75	1.45
		Riffle	75.6	27	10.3	54	99	1.06	27	0.12	0.73	1.30
Side Channel												
	September-October											
		Pool	54.5	750	8.1	36	85	1.06	750	0.09	0.54	1.57
		Glide	61.3	206	6.5	37	86	1.08	206	0.07	0.87	1.42
		Riffle	48.9	34	6.5	40	68	1.05	33	0.08	0.86	1.21
		Slough	58.1	457	8.6	35	85	1.12	277	0.17	0.61	2.31
	December											
		Pool	63.0	147	10.6	42	93	1.10	147	0.20	0.81	2.37
		Glide	67.4	176	10.3	43	108	1.08	176	0.10	0.54	1.49
		Slough	66.8	499	13.0	37	121	1.10	499	0.15	0.26	2.26

fry with the largest mean size occupied pool habitat, while fry with the smallest mean size occupied glide habitat, although there was only 2.1 mm difference in length between the two groups. In September, tributary fry caught in pools had the largest range in size and the lowest condition factor. Glide habitat generally contained the largest fry, probably because this habitat contained the most favourable flow velocities for feeding. Bustard and Narver (1975) noted that larger coho usually occupied faster flowing water than smaller coho.

Coho from riffle habitat generally had the smallest mean size in all areas, with the exception of the September mainstem and tributary sites (Table 8). This shallower type of habitat probably provided sufficient cover for medium sized fish but was too fast for smaller fish. Pool habitat in the tributaries supported the largest range of sizes. Small fry require slow water velocities, while the large fry required the most cover. Both of these criteria were provided by pool habitat.

Pool habitat in tributaries supported trout (rainbow and cutthroat) with the largest mean size (68.5 mm) in September, while glide contained trout with the smallest mean size (55.3 mm, Table 9). In December, slough habitat contained the largest trout (95.3 mm). Notably, large trout were captured in slough habitat in the Somenos system in December, where no trout had been captured in September. Pool habitat contained the next largest trout in December (74.9mm), while glide supported the smallest trout on average (61.5 mm, Table 9).

HABITAT UTILIZATION

Juvenile Densities In Different Areas

Side Channels.

The side channels had the highest coho juvenile densities of all the areas during both low water (fall) and early winter sampling (Table 10). Areal densities as high as 14 fry$\cdot$m^{-2} (Figure 4, Site 57) were estimated. The highest densities were encountered during the late summer, when most of the channels had no flow or only groundwater flow. Numbers and densities of fry were generally lower in the side channel sites in December, although the coefficient of utilization was higher (Table 11) indicating that a greater proportion of the population resided in the side channels in winter than in the summer. Trout densities were also relatively high in the side channel habitat, with areal densities second only to tributary habitat densities during September and similar to the outplant site densities in December (Table 10). Very few cottids (0.04 fish·m^{-2} in September-October) and no Dolly Varden char were captured in the side channel sites.

Table 9 Mean trout fork length and condition (K) from different habitat types in different areas.

Area	Sample Period	Habitat Type	Mean Length (mm)	n	Mean St. Dev. (mm)	Min. Length (mm)	Max. Length (mm)	Mean K	n	St.Dev.	Min.	Max.
Tributaries												
	September-October											
		Pool	68.5	398	27.5	29	215	-	-	-	-	-
		Glide	55.3	329	14.6	30	170	-	-	-	-	-
		Riffle	56.8	342	15.8	31	220	-	-	-	-	-
		Slough	57.3	31	13.8	37	128	-	-	-	-	-
	December											
		Pool	74.9	151	22.1	40	234	1.03	151	0.13	0.71	1.57
		Glide	61.5	142	11.4	35	122	1.00	142	0.10	0.67	1.31
		Riffle	64.5	63	19.0	41	155	1.06	62	0.14	0.72	1.39
		Slough	95.3	10	17.9	65	133	1.03	10	0.15	0.81	1.51
Outplant												
	September-October											
		Pool	79.1	196	33.1	43	215	1.00	194	0.12	0.57	2.11
		Glide	64.4	134	21.6	39	170	0.98	132	0.12	0.53	1.27
		Riffle	57.8	123	20.7	39	220	1.04	123	0.12	0.84	1.41
	December											
		Pool	89.7	111	36.4	42	270	1.03	95	0.12	0.66	1.40
		Glide	77.5	70	23.2	45	150	1.01	43	0.16	0.56	1.34
		Riffle	79.5	46	27.4	40	178	1.02	24	0.12	0.75	1.22
Side Channel												
	September-October											
		Pool	54.5	750	8.1	36	85	1.06	750	0.09	0.54	1.57
		Glide	61.3	206	6.5	37	86	1.08	206	0.07	0.87	1.42
		Riffle	48.9	34	6.5	40	68	1.05	33	0.08	0.86	1.21
		Slough	58.1	457	8.6	35	85	1.12	277	0.17	0.61	2.31
	December											
		Pool	63.0	147	10.6	42	93	1.10	147	0.20	0.81	2.37
		Glide	67.4	176	10.3	43	108	1.08	176	0.10	0.54	1.49
		Slough	66.8	499	13.0	37	121	1.10	499	0.15	0.26	2.26

- = no data because weights not measured.

Table 10 Mean densities ($no \cdot m^{-1}$ and $no \cdot m^{-2}$) of juveniles in habitat areas of the Cowichan River system.

Sample Period	Area	Lineal Density ($no \cdot m^{-1}$) Coho	Total Trout	Trout <100mm	Trout >100mm	Cottid	D.Vard.	Areal Density ($no \cdot m^{-2}$) Coho	Total Trout	Trout <100mm	Trout >100mm	Cottid	D.Vard.
September-October													
	Tribs.	7.80	1.95	1.66	0.03	0.09	0.00	2.38	0.68	0.63	0.03	0.03	0.00
	Somenos System	10.12	0.57	0.55	0.02	0.01	0.00	1.31	0.14	N/A	N/A	N/A	0.00
	Mainstem	13.07	5.93	5.49	0.44	0.55	0.00	0.88	0.39	0.35	0.04	0.02	0.00
	S. Channel	30.99	3.64	3.59	0.05	0.05	0.00	4.50	0.62	0.62	0.00	0.04	0.00
	Outplant	2.43	1.52	1.29	0.26	0.24	0.00	0.77	0.54	0.48	0.07	0.16	0.00
	Lakes	3.45	0.01	0.00	0.00	0.02	0.00	N/A	N/A	N/A	N/A	N/A	N/A
	Total (-lakes)	9.37	2.40	2.15	0.14	0.15	0.00	1.80	0.55	0.51	0.03	0.03	0.00
December													
	Tribs. (-Somenos sites)	1.77	0.68	0.60	0.06	0.03	0.01	0.52	0.24	0.21	0.02	0.01	0.01
	Tribs. (+Somenos sites)	4.32	0.61	0.53	0.04	0.05	0.01	0.66	0.09	0.20	0.02	0.03	0.01
	Somenos system	13.47	0.18	0.11	0.00	0.11	0.00	2.18	0.03	0.08	0.00	0.04	0.00
	Mainstem (sites)[1]	1.19	2.63	1.71	0.01	0.60	0.00	0.31	0.70	0.47	0.00	0.19	0.00
	Mainstem (river)[2]	1.19	2.63	1.71	0.01	0.60	0.00	0.06	0.13	0.09	0.00	0.03	0.00
	S.Channel	19.75	0.46	0.41	0.05	0.00	0.00	2.51	0.17	0.16	0.01	0.00	0.00
	Outplant	0.53	0.92	0.49	0.16	0.19	0.01	0.08	0.18	0.10	0.03	0.02	0.00
	Lakes	1.14	0.00	0.00	0.00	0.98	0.03	N/A	N/A	N/A	N/A	N/A	N/A
	Total	3.70	0.88	0.58	0.07	0.29	0.02	0.64	0.26	0.19	0.02	0.04	0.02

N/A = No areal densities were calculated because only fry per meter of shore line were collected.

1. Fish densities at sample sites which were located along stream margins.

2. Fish densities estimated for whole river.

Tributaries

The tributaries had the second highest areal densities, during both high (winter) and low (fall) flow periods, although the mainstem had higher lineal densities during late summer (Table 10). Generally, numbers and densities of fish in the tributary sites decreased from late summer to early winter, except in the Somenos system. Overall tributary lineal coho densities decreased from 7.80 fry·m^{-1} in September to 1.77 fry·m^{-1} in December, and comparable utilization coefficients decreased from -0.32 to -0.61 (Table 11).

Table 11 Utilization coefficients for juvenile densities (no·m^{-1} and no·m^{-2}) in different habitat areas of the Cowichan River system.

Sample Period	Area	Lineal Density (no·m^{-1}) Coho	Trout Total	Trout <100 mm	Trout >100 mm	Cottids	Areal Density (no·m^{-2}) Coho	Trout Total	Trout <100 mm	Trout >100 mm	Cottids
September-October											
	Tribs.	-0.32	-0.42	-0.45	-0.84	I/D	0.12	0.21	I/D	I/D	I/D
	Side Ch.	1.68	0.26	0.19	-0.74	I/D	1.11	0.11	I/D	I/D	I/D
	Mainstem	0.13	1.26	0.82	1.26	I/D	-0.59	-0.30	I/D	I/D	I/D
	Outplant	-0.79	0.39	-0.57	0.33	I/D	-0.64	-0.04	I/D	I/D	I/D
	Lake	-0.67	-1.00	0.00	0.00	I/D	I/D	I/D	I/D	I/D	I/D
December											
	Trib.	-0.61	-0.23	-0.03	0.33	-0.88	-0.46	0.33	0.50	0.33	-0.33
	Side Ch.	3.98	-0.51	-0.36	-0.17	-1.00	2.32	-0.06	0.14	-0.33	-1.00
	Mainstem	-0.74	1.77	1.65	-0.83	0.66	-0.94	-0.28	-0.36	-1.00	1.00
	Outplant	-0.88	-0.03	-0.25	1.67	-0.19	-0.92	0.00	-0.29	1.00	0.33
	Lake	-0.75	-1.00	-1.00	-1.00	1.71	N/A	N/A	N/A	N/A	N/A

I/D = insufficient data.
N/A = no areal data available because only fish per meter of shoreline were collected.

While most tributary site densities declined in December, the lineal densities in the Richards Creek and Somenos Creek sites increased from 10.12 fry·m^{-1} to 13.47 fry·m^{-1} (Table 10). High densities were found at the mouth of Somenos Creek in September (53 fry·m^{-1} or 2.8 fry·m^{-2}), but the next three sites upstream in the system had no or very few fry. Most of Somenos Creek and the first 1.5 km of Richards Creek, above Somenos Lake, was covered with duckweed (*Lemna minor*) in September and had very low oxygen concentrations. At site 75 (Figure 4), 0 ppm of oxygen was measured on September 20 with a HACH kit. The other sites in the upper reaches of Richards Creek, which had steeper gradients and faster flows, had moderate concentrations of fry (8.7 fry·m^{-1} or 3.4 fry·m^{-2}) in September. In December, the site at the mouth of Somenos Creek had very low concentrations of fry (0.80 fry·m^{-1} or 0.08 fry·m^{-2}), while the other sites farther upstream had very high concentrations (22 - 43 fry·m^{-1} or 2.9 - 4.3 fry·m^{-2}). The fry throughout the Somenos system were a large mean size (mean length = 86.2 mm).

Tributary areal trout densities (no·m^{-2}) and corresponding utilization coefficients were the highest of all the areas in both September and December (Table 10). Cottid concentrations were relatively low in the tributaries (0.03 fish·m^{-2} in September and 0.01 fish·m^{-2} in December).

Mainstem

In September, mainstem coho fry densities were the second highest per unit stream length (13.1 fry·m^{-1}) next to the side channels (30.99 fry·m^{-1}, Table 10). Densities per unit area were the third highest behind side channels and tributaries. Population density estimates and utilization coefficients (Table 11) indicate that the mainstem sites had the greatest decline in relative coho numbers between late summer and early winter sampling. Lineal densities of coho fry declined from an estimated 13.07 fry·m^{-1} in September to 1.19 fry·m^{-1} in December. At the lower four mainstem sample sites, which were in the area under tidal influence, population densities declined from 7.5 fry·m^{-1} to 0.1 fry·m^{-1}. The estimated densities of trout also declined between September and December (5.93 trout·m^{-1} to 2.63 trout·m^{-1} or 0.39 trout·m^{-2} to 0.13 trout·m^{-2}), but the decline was not nearly as large as for coho. During both sampling sessions, lineal densities of trout in the mainstem sites were the greatest of all the areas sampled, although areal densities were lower than some areas (Table 10). The lineal density of cottids was highest in the mainstem during both sampling periods compared to other areas. The estimated December densities are probably more indicative of the actual densities than the September estimates for cottids, because the techniques primarily used in December (electroshocking and Gee trapping) captured cottids more efficiently than the techniques used in September (beach seining and visual counts).

Lakes

All of the lake sites had similar densities, except the sites at the west end of Cowichan Lake and in Somenos Lake (Table 12). Most sites had average densities of 1.0 fry·m^{-1} of shoreline in both September (0.02-1.78 fry·m^{-1}) and December (0.43-2.17 fry·m^{-1}). The utilization coefficients indicate that a slightly larger proportion of the juvenile coho population existed in the lakes in the winter (-0.73) than the summer (-0.67) (Table 11) because densities declined more in other areas.

Table 12 Densities of coho juveniles ($no \cdot m^{-1}$) in the lakes of the Cowichan River system.

Lake	Lineal densities by Sampling period: September	December
Cowichan Lake:		
Honeymoon Bay	1.45	0.11
McKenzie Bay	0.02	0.47
North Arm	1.08	2.17
East End	0.59	1.67
West End	21.46	-
Mesachie Lake	1.16	0.43
Bear Lake	1.78	1.13
Somenos Lake	0.00	2.38

- = No sampling conducted

In September, the average coho density at sites in the North Arm of Cowichan Lake (Figure 1), does not represent the average density for the whole area. The coho fry observed appeared to be associated with terrestrial cover of which there was little at that time. Two of the three sites that were sampled in September, however, had terrestrial cover. The greatest concentrations of coho fry were found at the west end of Cowichan Lake (21.46 $fry \cdot m^{-1}$) in September. Large schools of coho were observed mainly along the outer edge of pondweed beds.

No coho juveniles were caught by Gee trap, beach seine or electroshocker in Somenos Lake in September. This lake is eutrophic and has had fish kills during the summer in previous years (Neave 1945). Summer conditions in Somenos Lake do not appear to be favourable for salmonids. In December, average densities of 2.38 $fry \cdot m^{-1}$ of shore were estimated at the four sites in Somenos Lake. Some of the fry appeared to be moving along the lake shore in schools; one beach seine set, approximately 120 m^2 in area, caught 593 coho fry with an estimated 200 - 500 fry lost from the set. Six other sets at various sites around the lake, caught a total of 180 coho.

Few trout were observed at the lake sites (0.01 $trout \cdot m^{-1}$ in September, Table 10). All of the lakes contained large numbers of cottids that were readily caught by Gee trap. Fewer cottids were estimated in September (0.02 $cottids \cdot m^{-1}$) because they were not as readily captured by beach seine or observed by skin divers. The majority of the cottids sampled in the winter were from lakes (utilization coefficient of 1.71, Table 11).

Marsh

Two sites were located on Priest's Marsh (Figure 4, Sites 62 and 63); one site was located on the outlet and the other near the middle of the marsh. There was very little water in the marsh in September and no fry were caught. No fry were caught at the center site in December, but high densities (6.2 fry·m^{-2}) of large fry (mean length = 83.3 mm, n = 164, S.D. = 12.8) were encountered in the outlet site.

Outplant Sites

The October densities of outplanted coho fry (0.77 coho·m^{-2}) were about a third of that observed in the rest of the tributaries (2.38 coho·m^{-2})(Table 10). Densities in December, however, declined even further to about 15% (0.08 coho·m^{-2}) of the tributary sites (0.52 coho·m^{-2}). Sites such as the Upper Robertson River, Boulder Creek, Meade Creek, and Cottonwood Creek (Table 1, Figures 2-4) had no coho or very few coho in December (Table 13). All of these sites had steep gradients, little large wood debris and high discharges during the rainy season. The lower gradient outplant sites (sites 88-94), that had more moderate flows and more wood debris cover, had similar estimated densities for both the late summer and winter sampling periods. The coho populations at these sites, therefore, appeared relatively unaffected by the fall floods.

Table 13. Densities of coho and trout juveniles at the outplant sites in high (sites 80-82 & 86) and low (sites 88-91 and 93-94) gradient streams and trout densities at two sites (sites 84 and 92) that contained no coho juveniles.

		Lineal Density (no·m^{-1})		Areal Density (no·m^{-2})	
Sampling Period	Inaccessible Streams	Coho	Trout	Coho	Trout
October	Low gradient	1.76	1.33	0.53	0.56
	High gradient	4.18	2.01	1.36	0.55
	Trout only	0.00	0.80	0.00	0.34
December	Low gradient	1.06	0.70	0.17	0.14
	High gradient	0.00	1.15	0.00	0.21
	Trout only	0.00	0.51	0.00	0.12

The outplant sites had lower densities (0.54 trout·m^{-2}, Table 10) of larger trout juveniles on average (Table 7) than sites on the other tributaries (0.68 trout·m^{-2}). The higher gradient outplant sites with primarily boulder cover had higher densities of trout in December than the lower gradient sites (Table 13). The two sites inaccessible to coho (84 and 92), which contained no outplanted coho, had trout densities that were slightly less than the densities of trout in other low gradient sites with outplanted coho.

Habitat Densities

In September, the greatest coho fry densities in tributaries were observed in pool habitat (2.38 coho·m^{-2}) (Table 14). Glide habitat supported the next highest densities (1.04 coho·m^{-2}), followed by slough and finally riffle habitat with the lowest densities. After the fall rains and during higher flows in December, slough habitat had the highest densities (2.8 coho·m^{-2}) ahead of pool habitat (0.49 coho·m^{-2}). In tributaries, the higher coho densities in the slough habitat are mainly due to increased numbers of coho in the sloughs of the Somenos system. Two other slough habitat units on other tributaries had lower concentrations of coho fry in December than in September.

Average densities were calculated for the different habitat types for all the areas (side channel, mainstem, tributary and outplant sites). Pool habitat had the highest coho densities during low flows in late summer (3.19 coho·m^{-2}) and slough habitat had the highest densities during higher flows in winter (4.08 coho·m^{-2}, Table 14) due to the high densities of fry found in the Somenos system. Riffle habitat contained the lowest coho concentrations during both sampling periods (0.27 coho·m^{-2} in September-October and 0.05 coho·m^{-2} in December). Coho densities in slough habitat increased from summer to winter, but decreased in all the other habitat types suggesting that coho fry were seeking winter refuge in slough habitat. Coho fry have been found to seek winter refuge in low velocity habitat in other systems as well (Tschaplinski and Hartman 1983, Bustard and Narver 1975).

Lineal densities in the lake habitat (3.45 coho·m^{-1} in September and 1.14 coho·m^{-1} in December) were lower than observed densities in pool and slough habitat in both sessions (Table 14). Lake coho densities declined in lower proportion from September to December than densities in riffle, glide and pool habitat. For example lineal coho densities were relatively high in glide habitat in the summer (6.29 coho·m^{-1}), but were lower than found in lake habitat in the winter (0.99 coho·m^{-1}).

Table 14 Mean densities of juvenile fish (no·m⁻¹ and no·m⁻²) in different habitat types.

Area	Sample Period	Habitat Type	Lineal Density (no.m-1) Coho	Total Trout	Trout <100mm	Trout >100mm	Cottids	Areal Density (no.m-2) Coho	Total Trout	Trout <100mm	Trout >100mm	Cottids
All Areas												
	September-October											
		Pool	16.50	2.58	2.09	0.21	0.12	3.19	0.58	0.49	0.05	0.03
		Glide	6.29	2.93	2.80	0.14	0.09	1.26	0.53	0.51	0.02	0.02
		Riffle	0.58	1.92	1.89	0.03	0.00	0.27	0.65	0.64	0.01	0.00
		Slough	13.20	0.28	0.24	0.04	0.00	1.57	0.06	0.05	0.01	0.00
		Lake	3.45	0.01	-	-	0.02	N/A	N/A	N/A	N/A	N/A
	December											
		Pool	3.83	1.21	0.86	0.19	0.05	0.67	0.29	0.21	0.04	0.01
		Glide	0.99	1.26	0.87	0.02	0.30	0.22	0.32	0.25	0.00	0.08
		Riffle	0.10	0.48	0.39	0.06	0.09	0.05	0.14	0.12	0.02	0.01
		Slough	27.99	0.22	0.04	0.00	0.14	4.08	0.03	0.02	0.00	0.03
		Lake	1.14	0.00	0.00	0.00	0.98	N/A	N/A	N/A	N/A	N/A
Tributary												
	September-October											
		Pool	13.78	2.09	1.43	0.03	-	2.38	0.36	0.27	0.03	-
		Glide	6.65	2.06	2.06	0.00	-	1.04	0.35	0.35	0.00	-
		Riffle	0.27	1.72	1.70	0.03	-	0.05	0.30	0.29	0.00	-
		Slough	3.98	0.38	0.27	0.11	-	0.45	0.05	0.03	0.02	-
	December											
		Pool	2.41	1.17	0.94	0.22	-	0.49	0.28	0.22	0.05	-
		Glide	1.12	0.51	0.47	0.00	-	0.02	0.18	0.17	0.00	-
		Riffle	0.06	0.78	0.73	0.03	-	0.02	0.37	0.35	0.02	-
		Slough	7.76	0.18	0.18	0.00	-	2.80	0.07	0.07	0.00	-

- = No data collected
N/A = No areal data available because only fish per metre of shoreline were estimated.

Lineal and areal utilization coefficients calculated for coho in different habitat types (Table 15) indicated a pattern of habitat utilization similar to that described for coho densities in different habitats. Pool habitat was most important for coho in September-October, while slough habitat was utilized heavily in December.

Areal trout densities were similar in pool, glide and riffle tributary habitat in the summer (0.30-0.36 trout·m⁻²) and slightly higher in riffle habitat (0.37 trout·m⁻²) than other habitat types in the winter (Table 14). Slough habitat had low densities of juvenile trout (0.05 - 0.07 trout·m^{-2}, Table 14). The larger trout were more frequently observed in pool habitat.

Table 15 Utilization coefficients for juvenile densities (no·m^{-1} and no·m^{-2}) in different habitat types of the Cowichan River system.

Sample Period	Area	Lineal Density (no·m^{-1}) Coho	Trout Total	Trout <100 mm	Trout >100 mm	Cottids	Areal Density (no·m^{-2}) Coho	Trout Total	Trout <100 mm	Trout >100 mm	Cottids
September-October											
	Pool	1.06	0.68	0.19	1.00	-	1.03	0.27	-	-	-
	Glide	-0.21	0.90	0.59	0.33	-	-0.20	0.16	-	-	-
	Riffle	-0.93	0.25	0.07	-0.71	-	-0.82	0.43	-	-	
	Slough	0.65	-0.82	-0.86	-0.62	-	0.00	-0.87	-	-	-
	Lake	-0.57	-0.99	-	-	-	N/A	N/A	N/A	N/A	N/A
December											
	Pool	-0.44	0.91	0.99	2.52	-0.84	-0.47	0.49	0.40	1.67	-0.67
	Glide	-0.85	0.99	1.01	-0.63	-0.04	-0.82	0.64	0.67	-1.00	1.46
	Riffle	-0.99	-0.24	-0.10	0.11	-0.71	-0.96	-0.28	-0.20	0.33	-0.69
	Slough	3.11	-0.65	-0.91	-1.00	-0.55	2.25	-0.85	-0.87	-1.00	-0.08
	Lake	-0.83	-1.00	-1.00	-1.00	2.14	N/A	N/A	N/A	N/A	N/A

- = No data collected.
N/A = no areal data available because only fish per meter of shoreline were collected.

Summer densities for all the areas combined were also similar for pool, glide and riffle habitat (0.53-0.65 trout·m^{-2}). Winter densities were slightly higher in glide habitat (0.32 trout·m^{-2}) for the combined areas than in other habitat types. As in the tributary habitat, slough densities were the lowest of all the habitat types in both summer (0.06 trout·m^{-2}) and winter (0.03 trout·m^{-2}).

Cover Associations

Correlation coefficients (r), calculated between different types of cover and densities of coho and trout in tributaries and all areas combined (Tables 16 and 17), indicate that rootwad and large wood cover had the highest number of significant correlations with the densities of each species. Coho densities in all habitat areas combined were positively correlated with rootwad and large wood debris cover in September-October in all habitat types grouped together and specifically in pool habitat (Table 16). In tributaries, coho densities were also correlated significantly with rootwad and large wood debris in all habitat types, and with large wood debris in pool habitat specifically. Tributary coho densities were negatively correlated with cutbank cover in all habitat types grouped and pool habitat in the summer. During December, coho densities were correlated significantly with terrestrial vegetation cover in tributary pools and all habitat types combined and with large and small wood debris in the pools of all areas combined.

Table 16. Correlation coefficients (r) between coho density ($no \cdot m^{-2}$) and cover types within different habitats.

Area	Sample Period	Habitat Type	n	Level of signif	Cover Type: Rootwad	Large wood	Small wood	Cutbank	Turb.	Boulder	Instream vegetat.	Terrest. vegetat.
All Areas												
	September-October											
		All	143	0.17	*0.26	*0.29	0.06	-0.02	-0.08	-0.15	0.02	-0.05
		Pool	55	0.26	*0.32	0.25	0.10	-0.19	-0.09	-0.15	0.07	-0.06
		Glide	45	0.28	-0.10	0.07	0.08	-0.08	-0.12	-0.19	0.02	-0.05
		Riffle	33	0.33	0.00	-0.05	0.18	-0.09	0.04	0.05	-0.09	-0.07
	December											
		All	137	0.17	-0.05	0.01	-0.01	-0.03	-0.08	-0.10	0.16	0.06
		Pool	38	0.31	0.08	*0.34	*0.35	-0.14	-0.24	0.02	N/C	0.02
		Glide	59	0.25	-0.08	0.03	-0.03	-0.01	0.02	-0.03	-0.04	-0.07
		Riffle	25	0.38	-0.09	-0.09	-0.07	*0.40	-0.14	-0.17	N/C	0.05
Tributaries												
	September-October											
		All	60	0.25	*0.45	*0.49	0.03	*-0.43	-0.14	-0.21	-0.11	-0.10
		Pool	25	0.38	0.38	*0.43	0.06	*-0.40	-0.25	0.25	0.28	-0.20
		Glide	16	0.47	-0.20	0.10	-0.10	-0.32	N/C	0.25	N/C	0.05
		Riffle	15	0.48	0.11	0.14	-0.14	-0.04	-0.19	0.14	N/C	0.05
	December											
		All	54	0.26	-0.01	0.02	0.00	-0.05	-0.07	-0.09	-0.03	*0.70
		Pool	18	0.44	-0.02	0.18	0.24	-0.10	-0.24	-0.11	N/C	*0.45
		Glide	22	0.41	-0.11	0.29	-0.05	0.11	0.32	-0.11	-0.06	-0.04
		Riffle	14	0.50	0.10	0.13	0.09	-0.07	-0.21	0.38	N/C	0.02

* - Significant @ $p < 0.05$
N/C - no cover

In the summer, trout densities were positively correlated with rootwad cover in all habitat types and specifically in riffle habitat in tributaries and all habitat areas combined (Table 17). During December, the correlations exhibited by trout in all areas combined were with large wood debris in pools and with terrestrial vegetation in riffles. In tributaries only, however, winter trout densities were correlated with rootwads in pools, riffles and all habitat types combined, and with large wood debris in glide habitat.

Table 17. Correlation coefficients (r) between trout density ($no \cdot m^{-2}$) and cover types within different habitats.

Area	Sample Period	Habitat Type	n	Level of signif	Cover Type							
					Rootwad	Large wood	Small wood	Cutbank	Turb.	Boulder	Instream vegetat.	Terrest. vegetat.
All Areas												
	September-October											
		All	143	0.17	*0.20	*0.05	0.00	-0.02	-0.10	-0.01	0.01	-0.06
		Pool	55	0.26	-0.05	0.14	0.05	-0.03	-0.09	-0.10	*0.28	-0.09
		Glide	45	0.28	0.16	-0.17	0.19	0.05	0.02	0.17	0.01	-0.03
		Riffle	33	0.33	*0.44	-0.09	-0.27	-0.20	0.22	-0.14	0.02	-0.15
	December											
		All	137	0.17	0.09	0.01	0.01	-0.04	-0.02	-0.01	-0.04	0.03
		Pool	38	0.31	0.23	*0.61	0.12	-0.01	0.09	0.08	N/C	-0.19
		Glide	59	0.25	-0.07	-0.04	0.00	-0.07	-0.06	0.00	-0.06	0.10
		Riffle	25	0.38	0.33	-0.14	-0.13	0.37	-0.24	-0.07	N/C	*0.55
Tributaries												
	September-October											
		All	60	0.25	*0.30	0.05	-0.05	-0.23	-0.13	-0.02	-0.11	-0.15
		Pool	25	0.38	0.36	0.18	-0.02	-0.30	-0.16	0.00	0.02	N/C
		Glide	16	0.47	0.27	-0.30	0.32	-0.17	N/C	-0.19	N/C	-0.06
		Riffle	15	0.48	*0.71	-0.16	-0.30	-0.19	-0.19	0.04	N/C	0.02
	December											
		All	54	0.26	*0.43	0.16	-0.10	-0.07	-0.04	-0.01	-0.08	-0.03
		Pool	18	0.44	*0.63	0.26	-0.06	0.04	0.20	-0.02	N/C	-0.20
		Glide	22	0.41	0.18	*0.69	-0.10	-0.18	-0.04	0.00	-0.22	0.23
		Riffle	14	0.50	*0.71	-0.18	-0.21	-0.22	-0.22	-0.09	N/C	-0.16

* - Significant @ $p < 0.05$
N/C - no cover

Bisson et al. (1981) also documented the preference of coho and trout for wood debris cover, especially in the older age classes. Other studies indicate an association between coho and wood debris (Lister and Genoe 1970, Bustard and Narver 1975), but boulder cover is suggested as the preferred cover type for trout (Bustard and Narver 1975, Facchin and Slaney 1977). Boulder cover was not significantly correlated with trout densities in any habitat area or type in this study. However, trout were not differentiated into age classes, and cutthroat and rainbow were not distinguished. This lack of segregation may have reduced some correlations, since Bisson et al. (1981) note that both aged 0+ trout and aged 0+ coho did not show a strong preference for any cover type while larger fish for both species preferred wood cover. Because smaller trout were more abundant and less likely to be found in the faster flowing areas associated with boulders, the associations of the certain trout sizes for particular cover types may not have been as apparent.

Bustard and Narver (1975) and Tschaplinski and Hartman (1983) documented a close association of coho with wood debris during the winter. For the Cowichan sample sites, there were few significant correlations between coho densities and wood debris in December, although there was increased association between densities and terrestrial cover in all habitat types combined in tributaries. One possible reason for the apparent shift to terrestrial cover is that the creeks with higher percentages of terrestrial vegetation tended to be of lower gradient and less flashy than those creeks without such cover. Water levels dropped faster in the higher gradient streams so there was usually less terrestrial vegetation in the water when they were sampled. Since the lower gradient streams contained higher densities of coho fry and more terrestrial cover, than those streams with higher gradients, the observed correlations are not unreasonable.

There was a significant positive correlation between cutbank cover and December riffle habitat in all areas combined for coho. There were also significant negative correlations in the tributaries in September-October. Significant negative correlations occurred between tributary, coho densities and cutbank cover in all habitat types combined and in pools. No significant correlations existed between trout and undercut bank cover. Tschaplinski and Hartman (1983) found that coho did not inhabit areas under banks unless these sites contain tree roots or lodged debris.

There were no significant correlations between coho densities and turbulence cover. Coho prefer low velocity habitat (Bustard and Narver 1975) and therefore would avoid turbulent areas with high velocity.

<u>Movements</u>

The most evident shift in distribution of coho from late summer to early winter was the movement of fry into the Somenos system from the mainstem Cowichan. The only coho that were found during September in the Somenos system were in the sites in the upper reaches of Richards Creek and at the mouth of Somenos Creek. The four lower sites on the Cowichan River contained fairly high densities (7.5 $fry \cdot m^{-1}$)

of very large fry (mean length=66.6 mm) in September-October. In December, lower mainstem coho densities dropped almost to zero (Table 10), while sites in Somenos Lake, Richards Creek and Somenos Creek contained very high densities (up to 43 fry·m^{-1}) of large fry (mean length=86.2 mm). The large size and the decline in mainstem populations with increases in the Somenos Lake population densities suggests a movement of fry from the mainstem into the Somenos system. Similarly, it appears that mainstem fry moved into the lower reaches of Priest's Marsh in December (Table 4, sites 62-63). Some of the lower mainstem fry may also have left the river for the sea in the fall. A few of the larger fry sampled in September at site 58 (Figure 4) were silvery and appeared to be smolting.

Other movements between study areas were not as apparent because densities generally declined between summer and winter field sessions in all areas. The largest decline occurred in the mainstem coho populations, but there is little evidence of major movement of these fish into associated side channel or tributary habitat. The side channels contained the second smallest fry in the system in September (mean length=56.4 mm), while the mainstem contained the second largest fry (mean length=66.4 mm). Side channel fry sampled in December, however, were the smallest in the system, thus size shifts do not suggest movement into side channels. Several coho cold branded in September were recovered at the Forestry Side Channel site (Figure 3, site 46) and the Lower Bible Camp Side Channel site (site 48), but the branded fish were recovered from the same sites where they were branded. No fry branded in the mainstem were recovered.

Coho fry from Mesachie Lake appear to have moved into the lower reaches of the inlet creek of Halfway Creek, the inlet creek, with the increase in water levels during the fall. The lower site on Halfway Creek (Figure 2, site 21) consisted of isolated pools in September when there was no flow. The 22 m long section sampled had coho fry densities of 8.7 fry·m^{-1} of stream. The average fry length of 49.9 mm (n=110) was less than the average size for the rest of the tributary sites (sites 18 - 20). Densities in Halfway Creek increased to 16.9 fry·m^{-1} in December, when the fry averaged 86.8 mm in length (n=68), slightly under the average of 88.0 mm for Mesachie Lake coho. The average length for all tributary fry was only 67.4 mm in December (Table 7). The coho appeared to only invade the lower reaches of the Halfway Creek. The other three sites, farther upstream, had lower winter than summer coho densities and the average coho size was similar to the mean December tributary coho size.

There was no evidence of the movement of lake coho into other tributary sites. The lower site on Sutton Creek was completely dry in the summer. The fry that were sampled there in December had an average size of 70.5 mm (n = 67), which was 3.1 mm larger than other tributary fry and 17.4 mm smaller than lake fry. Therefore, the fry appear to be tributary fry that had resided in areas farther upstream. Other tributary sites near lakes, on Miracle Creek and Patush Creek, did not show evidence of the existence of lake fry in December.

EFFECTIVENESS OF SAMPLING TECHNIQUES

Gee traps, baited with salmon roe, were effective in capturing coho fry in most areas of the Cowichan system during both September-October and December (Table 18), although the traps did not catch fry during the day as readily in the winter as in the summer. Also, coho fry were more readily caught in the lakes in the winter than the summer.

Table 18. Seasonal Gee trap catches.

Sampling Period	Habitat Area	No. Traps	Coho fry	Fry per trap
Sept-Oct	Tributary	23	224	9.7
	Lake	87	35	0.4
	Mainstem	51	96	1.9
Dec.	Tributary	94	297	3.2
	Lake	249	321	1.3
	Mainstem	189	247	1.3
	Side Channel	116	1,078	9.3
	Somenos Lake	25	92	3.7
	Som. + Rich. Cr.	31	332	10.7
	Outplant	25	11	0.4

Gee trap mark and recapture and depletion-removal were the main methods of density estimation in the lakes, mainstem and deeper slough habitats in the winter time. Coho fry were much more visible in the summer such that many of these sites were enumerated by skin diver visual counts. Estimating populations by Gee trap took three days. The first day the Gee traps were set and left over night. The second day the catch was marked using caudal clips and released. The traps were then left a second night and recovered the third day to check for the number of marked and unmarked fish. This method probably overestimated population size because the marked fish did not appear to enter the traps as readily as unmarked fish. Catches were usually lower the day following marking. For example, Gee trap mark and recapture was used to estimate the population size at site 20 on Halfway Creek (Figure 2). Traps set to collect fish marked the previous day, caught 20% marked fish but when the traps were set 18 days later 39% of the fish caught were marked even though there was a greater chance that some of the marked fish had left the site (Table 19).

Table 19. Gee Trap catches of coho juveniles from Site 20 on Halfway Creek.

Capture Day	Number of traps	Number of coho marked	Total coho captured	Recaptured marks
1	14	65		
2	14		20	4
3	14		11	2
18	3		38	15

Coho fry, in some habitats such as slough habitat in Richards and Somenos Creeks, seemed to stray because marks were sometimes caught in areas out of the sites. The movement of marked fish away from a site would also tend to produce an inflated population estimate. Better population estimates would be obtained by making the site as long as possible and by waiting perhaps a week to recapture fish.

The lake population estimates based on mark-recapture using Gee traps were also suspect because few fry were caught at the lake sites and very few marked fish were recovered. The fry in the lakes seemed to stay very close to cover during the day because they were not as visible to divers as they were in the summer. Also, the fry in Lake Cowichan, Mesachie Lake and Bear Lake did not appear to stray along the shoreline as fry did in Somenos Lake, because catches generally declined with successive sets. The decline in catch numbers was used to estimate depletion-removal based population levels at many of the sites since the marked fish did not readily re-enter the traps.

Of the population estimation techniques used, electroshocker depletion-removal was probably the most accurate method in the smaller water bodies in the summer. The electroshocker was not quite as effective in the winter and may have tended to underestimate population size. The Bible Camp Side Channel (Site 50, Figure 3) was electroshocked on December 7 and produced a population estimate of 162 coho (95 % Confident limits = 143-181). Yet, on the previous day, 417 coho had been caught by nine Gee traps at the same site. When these fish were shocked they were often hidden in the cover and could not be retrieved. Bustard and Narver (1975) also observed that coho fry stay much closer to cover in the winter.

In conclusion, mark and recapture population estimates using Gee traps probably overestimated coho densities due to two factors: the greater reluctance of marked coho to re-enter the traps compared to unmarked coho, and the straying of marked fish away from the sample site, particularly in slough areas. On the other hand, the depletion-removal population estimation technique using an electroshocker tends to underestimate densities in the winter when most of the fish are amongst cover and difficult to apprehend.

SUMMARY

1) Ninety sites, averaging 32 m in length, were selected in the Cowichan River system and sampled to investigate juvenile salmonid composition, densities, size and habitat use. The sites were located in lake, tributary, side channel, mainstem and marsh areas and in areas inaccessible to anadromous fish, especially where coho fry had been outplanted.

2) The sites were divided into habitat units (types) and these were quantitatively described. Juvenile densities were estimated during low flows in September-October 1986 and again in December following fall high flows. Fish were collected by beach seine, Gee traps and electroshocker and densities were estimated by mark and recapture or depletion-removal techniques. Visual counts by skin divers were also carried out at some sites.

3) Several hundred scales smears were collected and were aged; these suggested that the coho juveniles sampled were all age 0+. However, some fry were as large as 33 g and, since previous studies have documented the presence of age 1+ coho in the system, it is likely that some yearling fish cannot readily be identified from scale patterns. Further scale studies are recommended to define annulus criteria and growth patterns for coho in the Cowichan system.

4) The largest mean sized coho were taken from the lakes both during September and December sampling periods. Fry, which were almost as large, were sampled in the area under tidal influence in the lower Cowichan River mainstem

during September. The upper mainstem sites supported the next largest fry on average followed by tributary and side channel fry. The outplant sites contained coho fry similar in average size to the tributary sites.

5) The largest mean sized trout (rainbow and cutthroat and brown trout) sampled in September-October and December, were captured from outplant sites, possibly because competition between coho and trout reduced the sizes of trout at other sites. In areas accessible to anadromous fish, the largest trout juveniles were generally captured from mainstem habitat. Side channel habitat had the second largest trout and tributary habitat had the smallest trout.

6) Generally the largest mean sized coho fry were found in glide habitat and the smallest were found in riffle habitat. Pool habitat supported the largest size range of coho. Pool habitat contained trout with the largest mean size in September-October and slough habitat was found to contain trout with the largest mean size in December. Glide contained trout with the smallest mean size in September-October and December.

7) Side channel habitat contained the highest densities ($no \cdot m^{-2}$) of coho fry during both sampling periods. The tributaries supported the next highest densities, followed by mainstem and then outplant areas. Coho fry densities of 21.46 $fry.m^{-1}$ were found along the west end of Cowichan Lake. The rest of the lake sites on Bear Lake, Somenos Lake, Mesachie Lake and the other Cowichan Lake sites supported average estimates of 1 $fry \cdot m^{-1}$ during both September and December. No fry were found at Somenos Lake sites in September, but an average of 2.38 $fry \cdot m^{-1}$ were estimated to be utilizing the lake sites in December. Areal trout densities were greatest in tributary habitat and lowest in lake habitat.

8) Most of the sites had lower coho density estimates in December than September-October. The most notable exception was the Somenos system where densities increased from zero at the lake sites and some of the Richards and Somenos Creek sites during September to relatively high densities in December. The Cowichan mainstem sites showed the largest decline in coho densities from September to December. The changes in density and the large size of the Somenos fish suggest that many mainstem fry moved into the system between September and December. Similarly, it appears that mainstem fry moved into the lower reaches of Priest's Marsh. There was little evidence of movement of mainstem coho fry into other side channel and tributary sites. Densities at those sites decreased and the size of the fry

remained small relative to other areas of the system. Most of the tributary sites near the lakes also supported lower population densities in December. The only exception was a site in the lower reaches of Halfway Creek which had high densities of large fry in December, probably originating from Mesachie Lake.

9) Coho densities were found to be the highest in pool habitat during September-October, and in slough habitat during December. Although there was a decrease in estimated areal coho densities in all habitat types from late summer to early winter, the decrease was lowest in slough habitat which further suggests slough habitat is an important wintering environment in the system.

10) Areal trout densities were similar in pool, glide and riffle tributary habitat in the summer and slightly higher in riffle than other habitat types in the winter. Slough habitat had low densities of large juvenile trout.

11) Wood debris cover types (rootwad, large wood debris and small wood debris) were the most significantly correlated with trout and coho densities, especially during September-October. No significant correlations were found between trout densities and boulder cover in contrast to the findings of other studies. There was less correlation between coho densities and wood debris during December than September and an increased association with terrestrial vegetation cover.

12) Comparisons between different sampling techniques suggested that the electoshocking depletion-removal technique underestimated fish densities in the winter at some sites. Coho and trout were often more difficult to collect during December because they were more closely associated with cover in the winter. With mark and recapture estimation techniques using Gee traps, densities tended to be overestimated because marked fish did not as readily enter the traps as unmarked fish, and because some sites could not be isolated. Marked fish may have strayed from these sites.

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