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PREPARATORY STREAM RECONNAISSANCE, SMOLT TRAPPING AND HABITAT UTILIZATION SURVEYS FOR A COHO SALMON RESEARCH PROGRAM IN NORTHERN BRITISH COLUMBIA

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ABSTRACT

Simpson, K. S. 1991. Preparatory stream reconnaissance, smolt trapping and habitat utilization surveys for a coho salmon research program in northern British Columbia. Can. Manuscr. Rep. Fish. Aquat. Sci. 2116: 28 p.

This is an account of the search for a research population of coho salmon in northern British Columbia and an associated synoptic study of the size and density of juvenile coho and trout in different habitats. Forty streams were visited in the search and we trapped smolts in 12 of these. The best catches were in Hiellen R. and in the Williams Cr. system. Catches from Graham Island had the most two year olds. Sangan River was selected part way through the search but it was replaced by Lachmach River, near Prince Rupert. An ancillary population was selected in the McDonell Lake system.

There were five populations in the habitat utilization study. Juvenile trout were the same size in riffles, glides and pools but were not as dense in riffles. Juvenile coho were of typical size and, like trout, did not differ in size between habitat types. The lack of size segregation in underyearlings is consistent with results from southern stocks. Our coho preferred pools more than reported for southern stocks but more data is needed. A research program is now in place at Lachmach River.

RÉSUMÉ

Simpson, K. S. 1991. Preparatory stream reconnaissance, smolt trapping and habitat utilization surveys for a coho salmon research program in northern British Columbia. Can. Manuscr. Rep. Fish. Aquat. Sci. 2116: 28 p.

Voici un compte rendu d'une recherche pour une population d'étude de saumons cohos du nord de la Colombie-Britannique et pour une étude synoptique connexe de la taille et de la densité des juvéniles de saumons cohos et de truites dans différents habitats. Quarante cours d'eau ont été visités dans le cadre de la recherche et nous avons piégé des smolts dans 12 de ceux-ci. Les meilleures prises viennent des bassins de la rivière Hiellen et du ruisseau Williams. Les prises de l'île Graham avaient un âge maximum de deux ans. La rivière Sangan avait été sélectionnée au cours de la recherche, mais elle a été remplacée par la rivière Lachmach, près de Prince Rupert. Une population secondaire a été sélectionnée dans le bassin du lac McDonell.

Il y avait cinq populations dans l'étude de l'utilisation de l'habitat. Les truites juvéniles avaient la même taille dans les rapides, les biefs calmes et peu profonds et les bassins, mais elles n'étaient pas aussi denses que dans les rapides. Les juvéniles cohos étaient de taille type et, comme dans le cas des truites, leur taille ne variait pas d'un type d'habitat à l'autre. L'absence de ségrégation des tailles chez les fingerlings est cohérente avec les résultats obtenus avec les stocks du sud. Nos saumons cohos avaient une préférence plus marquée pour les bassins que les stocks du sud, mais un plus grand nombre de données est nécessaire pour établier ceci avec certitude. Un programme de recherche est maintenant en cours à la rivière Lachmach.

INTRODUCTION

This is an account of preliminary work by the Coho Program of the Biological Sciences Branch to obtain more information on the coho salmon (Oncorhynchus kisutch) populations of northern British Columbia. The objectives were: (1) find a suitable population to study intensively for several years; (2) as part of the first objective, obtain additional data on the size and age of coho smolts in the region, their run timing and a rough measure of their abundance; and (3) compare the relationships between habitat type, juvenile size and density in this region to those found in a south coast population assemblage (the Cowichan River system).

More information on coho is needed from the north coast and Skeena/Nass river drainages for at least three reasons. First, the Salmon Treaty between Canada and the United States has increased the need for each country to demonstrate the extent of interceptions by the other country. Second, it is apparent that more active management of the exploitation of coho is necessary and this will require more data (Kadowaki 1988). Finally, more studies of northern coho are needed to determine in what ways they differ from the better studied southern populations. The only comprehensive, long term, data from a North American population north of Vancouver Island is from Sashin Creek in southeast Alaska (Crone and Bond 1976).

The study of the utilization of habitat types was considered a start in understanding the coho of this region. The strategy was to draw on better information from populations to the south (e.g. Fielden and Holtby 1987). Some comparable results are also available from southeast Alaska on habitat utilization by coho and other salmonids in relation to logging practices (Murphy et al. 1986; Heifetz et al. 1986).

METHODS

SELECTION OF A STUDY POPULATION

The criteria that I used to evaluate candidate stream populations are shown in Table 1. They reflect our intention to study the population for at least five years during which time we want total smolt and adult counts at a fence and complete tagging of smolts.

I initially selected candidate streams by reviewing existing data and from interviews. These streams were then inspected. Publications that were most used in picking streams were Catalogues of Salmon Streams and Spawning Escapements (Marshall et al. 1978; Brown and Musgrave 1979; Hancock et al. 1983,1983a; Hancock and Marshall 1984) and Historical Streamflow Summary reports (Environment Canada 1985). I discussed possible study populations with many people who were familiar with various areas in the region, amongst them DFO scientists, managers, technicians, enhancement personnel and fisheries officers, biologists from the B.C. Fish and Wildlife Branch and knowledgeable lay persons.

Forty streams were visited between November 1985 and October 1986 (Fig. 1). Table 2 shows the nature of these inspections which ranged from simple spot checks to smolt trapping and the assessment of habitat utilization. Many streams were obviously unsuitable, the rest were more formally rated by each criterion as having advantages in that respect, being neutral with respect to it, or having disadvantages.

SMOLT TRAPPING

Smolts were captured with a fyke net or minnow traps. The main objective was to obtain samples for age and size analysis.

The net's opening was 1.2 m square. It tapered over a net length of 3.7 m to a canvas sleeve, 0.2 m in diameter. The stretched mesh sizes in the lead, middle and codend sections were 5.1, 2.5 and 1.1 cm, respectively. The canvas sleeve was tied off during fishing.

The setting of the net varied between streams, depending on when we arrived and the nature of the site. We usually set the net in the afternoon or early evening by staking it in mid-stream and supporting it with ropes running to shore. Wherever the current and depth allowed, we angled a beach seine (2.5 cm mesh) out from each side of the net opening. The length of these leads varied with each stream but they always extended from the surface to the stream bed.

The smolts were collected from the canvas sleeve every 30 min until about evening civil twilight when the net was left to fish overnight. We usually retrieved the net by 09:00 to 10:00 the following morning.

Minnow traps with 6 mm mesh ("Gee" traps, Cuba Specialty Manufacturing Co., Fillmore NY) were baited with salted salmon roe and deployed along the banks of some of the streams. Areas of slow current and cover were favoured in setting. The traps were usually left overnight, about 22 to 24 h.

All catches were preserved in 10% buffered formalin solution. We waited 62 - 82 d for the lengths and weights of the preserved fish to mostly stabilize (from Parker 1963). Fork lengths were measured to the nearest mm and wet weights to .01 g. We took individual scales from the larger fish, two from one side and three from the other, and took a smear of scales from one side of the smaller ones. Ages were estimated by the Fish Aging Laboratory at the Pacific Biological Station (PBS). The dorsiventral diameter of the eye was measured to the nearest 0.1 mm with dial calipers. The reason for this measurement was to assess the use of eye diameter in aging coho smolts (Schubert and Fedorenko 1985).

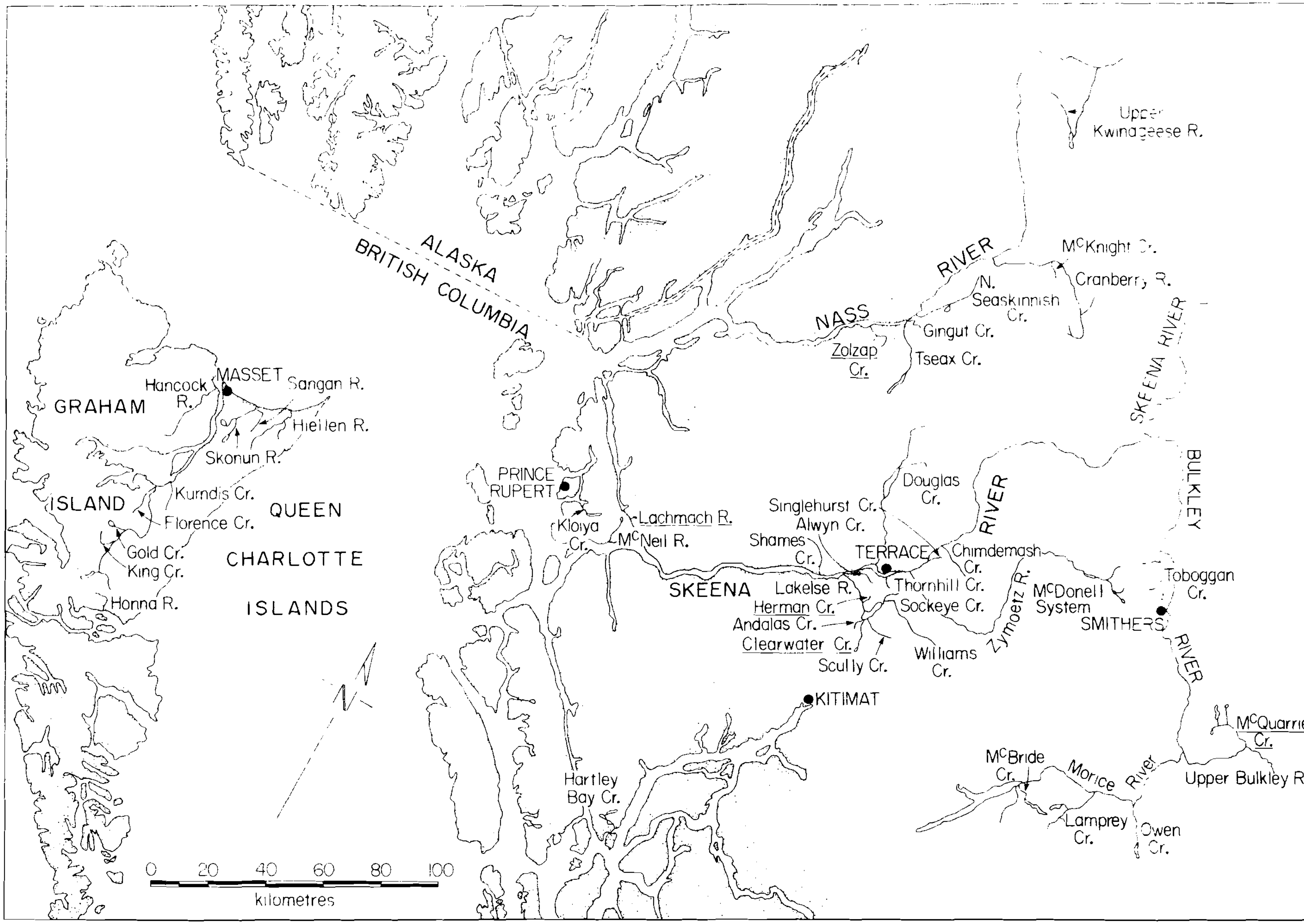

Fig. 1. Candidate streams for a northern coho study. Habitat utilization studies were made in streams with underlined names.

HABITAT UTILIZATION SAMPLING

Study Sites

Five streams were selected although one creek, Zolzap, was not sufficiently sampled due to a freshet. The others are partially described in Table 3.

Habitat Measurements

Our procedures were similar to those used by Fielden and Holtby (1987). We selected one reach in each stream, looking for a diversity of habitats. The reaches were 30 m to 60 m long. The discharges were calculated from the depth profile and current (as measured with floating chips). Measurements were usually taken in two places in the study reach using the average of several current measurements taken at each. One discharge estimate was obtained (Table 3) by averaging the results from the two measurement sites. Wetted and channel widths were recorded at the discharge measurement transects. We took three water temperatures. The composition of streamside vegetation and degree of canopy closure was subjectively estimated as was the colour and clarity of the water.

Habitats were classified into ten types, based on a more specific categorization by Bisson et al. (1982). The types were:

- Riffles
  - low gradient
  - rapids
  - cascades
- Pools
  - secondary channel
  - backwater
  - trench
  - plunge
  - lateral scour
  - dammed
- Glide

The reach was conceptually divided into its component habitat types, each called a habitat unit (i.e. there could be several units of the same habitat type). The following information was collected from each unit. We obtained sufficient length, width and depth measurements to define the area and volume. The following cover types (Bisson et al. 1982) were rated as being absent, minor, moderate, or abundant:

Small wood debris
Terrestrial vegetation
Undercut bank
Turbulence
Underwater boulders
Maximum depth

The dimensions of logs and root wads were recorded and used to calculate volumes. To characterize the substrate, we visually estimated the percent composition of fines, small gravel, large gravel, cobble, boulder and bedrock.

Fish Enumeration and Sampling

Each unit was isolated with 6 mm mesh barrier nets and fished two or three times with an electroshocker or pole seine. A third pass was omitted if the second catch was small relative to the first. The catches were to be used to estimate the population size by the depletion - removal method (Zippin 1958, Seber and Le Cren 1967) so we tried to have the same fishing effort in each pass. The time between passes varied but averaged about five minutes. The catch from each pass was kept in separate buckets and sampled after completing one or two units.

The catches were anaesthetized with 2-phenoxyethanol. Fork lengths to the nearest mm were recorded from all fish and wet weights were obtained. The balance, an Ohaus C-151, was electronic with a precision of 0.05 g. Some of the Clearwater fish were not weighed due to a malfunction in the balance and only a portion of the large Lachmach catches were weighed. We took scale smears from large coho that could be older than age 0. These were later aged by the PBS Fish Aging Laboratory.

RESULTS

SELECTION OF A STUDY POPULATION

Eighteen streams had more detailed site evaluations or habitat utilization studies. The 18 as a group were not the best potential research candidates of the 40 that were considered. We wanted to study habitat utilization from all the geoclimatic areas that we identified in the region (excluding the Queen Charlotte Islands). This included areas where we did not find any good research candidates. Nevertheless, all the best rated streams are in this group of 18.

The ratings given for each selection criterion for each of the 18 streams are shown in Table 4. Sangan R., including both the Skonun and Sangan branches, was the initial choice after the 1985 surveys which concentrated on the coastal and coastal/interior transition areas. It has road access only to the lower reaches but was selected because it was the best candidate on Graham Island, the favoured research area at that time, and because it was one of the few fenceable streams that we thought could be producing at least 20,000 smolts, which was also one of the early criteria. However, we were not able to obtain land at the favoured fence site. The alternate fence location, although a better building site, would have been expensive to access. Furthermore, we were increasingly concerned about being able to extrapolate results obtained in the northeast quadrant of Graham Island because of its unusual biogeoclimatic characteristics of moderate rainfall and low relief bogs. We decided to abandon this choice.

No other candidates on Graham Island were identified and the search shifted to the mainland and expanded into the much drier, less temperate area in the interior where we wanted to locate a study site that could supplement research from a primary site on the coast. With this new tandem approach, streams in the transitional coastal/interior area in the vicinity of Terrace (Fig. 1) were down-rated as being typical of neither area. The criterion of 20,000 smolts was reduced to 10,000 smolts.

Lachmach River was inspected in 1986 and proved to be an almost ideal choice as the coastal study system (Table 4). It looked typical of north coast streams and was one of very few coastal streams with road access. The road parallels the entire stream that is accessible to coho (about 8.5 km). It has an abundance of pond and marsh habitat and, although the size of the coho escapement was not accurately known, it appeared to be an excellent coho system. A very good fence site was found at the limit of all but the most extreme high tides. The fence site is about 1.5 h travel time from Prince Rupert.

The limiting factor in choosing an ancillary study site in the interior area was the depleted state of coho stocks in the Bulkley River system, the most accessible part. The headwaters of the Zymoetz River above McDonell Lake was my choice as the best location. The system, which is south of the Bulkley watershed but readily accessible from Smithers, still has a significant coho population and should be a useful study area. Capturing the entire smolt run would be difficult below McDonell Lake due to large spring freshets but smolt fences could be placed further up the system. Total adult captures should be feasible at the lake outlet.

SMOLT TRAPPING

The catch of coho is summarized in Table 5. The catches in the fyke net were disappointing. The second trip (May 21 - 25) was more successful than the first (May 6 - 10), comparing catches between trips in streams where the same gear was used in both trips. The only exception was Tseax River. Looking at those streams where minnow traps were used, the best catch rates were in Hiellen R. and the Williams Cr. system (including Sockeye Cr., a tributary of Williams Cr. near the Williams Cr. traps). From examining the larger smolt catches that had relatively few smolts of unknown age, it appears that the proportion of age 2. smolts was largest on Graham Island. The proportion of two year olds in the samples may be larger than shown in several streams, especially Hiellen R. and Skonun R., due to inaccurate aging of scales (see below).

The size and condition data (Table 6) and the age data in Table 5 are presented as data records only. Little can be concluded from the small sample sizes when it is considered that each smolt run was not sampled throughout its period and the gears have unknown size selectivities. Furthermore, aging of the smolts was difficult and may not be accurate. For example, the 42 Hiellen R. smolts that were aged as 1.'s had a mean length of 95 mm but there were three length modes at 70-75, 85-90, and 110-115 mm. The last mode, comprising 16 coho or 38% of the fish that were aged as 1.'s, is indistinguishable in size from the smolts that were aged as two year olds. Samples from Clearwater Cr., Cranberry R. and particularly Skonun R. also have suspiciously large smolts that were aged as yearlings but I gave precedence to scale data over size in aging them.

HABITAT UTILIZATION

Habitat Characteristics

The habitats in each reach are described in Table 7. Glides were missing in the Clearwater and McQuarrie samples. Altogether, we sampled ten pools, eight riffles and four glides. Four of the pools were backwater pools, two were plunge pools, two were lateral scour pools and there was one dammed and one secondary channel pool. No trench pools were sampled. Of the eight riffles, six were low gradient, at least one in each stream.

The amount of cover in each habitat type is shown in Table 8. In terms of frequency of significant occurrences, boulders were rated the most important cover in riffles and glides and maximum depth was highest of the rated cover types in pools. Most large wood debris and root wads were in pools, especially in Lachmach River.

Fish Populations

Catch: Our catches are shown in Table 9. Coho were caught in all the streams but only four and three were caught in Herman and McQuarrie creeks, respectively. Most of the cutthroat and rainbow trout were fry and could not be distinguished in the field. Sculpins were not recorded in Lachmach and McQuarrie creeks.

Age: All the coho that we caught in Clearwater, Zolzap and McQuarrie creeks were age 0. fry; all four Herman Cr. coho were yearlings. In Lachmach R., 191 coho were assigned ages. Of these 18 (9.4%) were apparently yearlings, based on a clear bimodal length distribution that was confirmed with scale readings. The percentages of the trout that were age 0. in each stream were: 67.3% in Herman, 60.8% in Clearwater, 94.4% in Lachmach, and 79.3% in McQuarrie.

Size and condition: For simplicity, I have only presented the size and condition summaries for age 0. coho and trout (Table 10). The data from habitat units of the same general type (riffle, pool or glide) were combined.

There are adequate samples of coho lengths from Clearwater Cr. and Lachmach River. The length of coho differed between the pools and riffles of Clearwater (glides were not present) but not between the riffle, glide and pools of Lachmach. Coho were smaller in the pools of Clearwater (57.9 mm) than in the low gradient riffles (64.5 mm, Approximate t-test, $p<.05$).[1] An adequate sample of condition factors for coho is only available from Lachmach. Conditions factors did not differ significantly between the riffle, glide and pools (Games and Howell test, $p>.05$).

In no stream did trout differ significantly between habitat types in size (F tests, $p>.05$) or condition (Games and Howell test, F test and Approximate t-test for Herman, Lachmach and McQuarrie data, respectively; all p's>.05).

Comparing coho size between streams, either within a habitat type or using combined habitat types (Table 10), Clearwater underyearlings were larger than those in Lachmach. The three coho from McQuarrie Cr. were largest of all. The differences between creeks were not as large for trout but Herman Cr. trout were slightly larger than the rest.

Abundance: The depletion - removal abundance estimates and the resultant estimated densities are shown in Table 11. Coho and trout were most abundant in the Lachmach R. reach, particularly in the two pools where the overall density was estimated to be 2.6 coho/m^2 and 1.2 trout/m^2. The next most dense coho population was in the Clearwater reach (0.6/m^2 in the pools). Trout were actually denser in the riffles and glides of Herman Cr. than in the same habitats of Lachmach but the pool density was not as great (0.8/m^2). The overall density of trout was about the same in Herman and McQuarrie creeks.

The preference for pools by coho and trout is shown another way in Table 12, where habitat specific utilization coefficients are shown (Bisson et al. 1982). The formula for this coefficient is:

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

where: H = the areal density in the habitat type (Table 11); and A = the mean areal density in the reach (combined habitat types). The only exception to the preference for pools was by trout in Herman Cr. where they were relatively

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[1]When Bartlett's test indicated significant differences in the variances of lengths or condition factors between habitat types, I used an Approximate t-test if there were two habitat types or Games and Howell's unplanned pairwise comparison if there were three types.

more dense in the glides. Riffles were probably least favoured by coho and trout in all streams although we could only get a minimum estimate of the coho in the riffle at Lachmach and the trout in Herman Cr. preferred the pool and riffles about equally.

DISCUSSION

SELECTION OF A STUDY POPULATION

We have started to study the coho in Lachmach R., based on the results of this reconnaissance. We have not been able to proceed with the McDonnel study, however. A camp and a fence foundation were constructed near the mouth of Lachmach R. in 1987 and aluminium smolt and adult fences were built in 1988 and 1989, respectively. The spring smolt emigrations in 1988, 1989 and 1990 were virtually completely counted and were about 10,000, 20,000 and 25,000, respectively (Unpubl. data, B. Finnegan, PBS, Nanaimo). All were coded wire tagged.

This selection process reflected our desire to find a population large enough to produce at least 10,000 smolts but small enough to allow us to capture all of them and the adults. This means that productive streams for coho were favoured in the selection process. This is the usual tendency and should be kept in mind when selecting a study site. We, like many investigators, wanted a typical coho system, not an exceptionally productive one. In looking for a north coast site, finding accessible streams and, to a lesser degree, finding suitable fence sites became critical considerations and they limited this tendency to select an unusually productive stream. I and other workers with north coast experience felt that Lachmach was probably a very good coho system but not exceptionally good for the region.

SMOLT TRAPPING

The generally poor net catches of coho were surprising. In planning the timing of sampling sessions, we used a long term data set from Hooknose Cr. near Bella Bella on the central coast (R. Parker, Unpubl. data in the PBS Salmon Archives). There was also published timing information from Mathers Cr. on the Queen Charlotte Islands (Shepherd 1982) and from Sashin Cr. in southeast Alaska (Crone and Bond 1976). The information indicated that the peak of coho smolt migration should be in mid-May in coastal areas. This was substantiated later from the smolt trapping in Lachmach and from more work in southeast Alaska (Shaul et al. 1987). Another long term data set further inland, at Lakelse R., indicated that the peak there was near the end of May (M. Shepard, Unpubl. data, PBS Salmon Archives). The sampling trips of May 6-

10 and May 21-25 bracketed the expected peak on the coast and the second trip should have been near the peak in interior streams. Subsequent work in Lachmach indicates that the same net is capable of catching large numbers of coho smolts as are minnow traps (Pers. comm., B. Finnegan, PBS, Nanaimo).

HABITAT UTILIZATION

Trout

The trout, of which almost all of the unidentified ones would have been cutthroat trout, were smaller than in the Cowichan tributaries[2]. The mean of creek means was 48.2 mm (SE = 1.31) versus an overall mean of 54.8 mm (SE = 0.58) in the Cowichan, even though the Cowichan samples were taken an average of one month earlier. Like coho, the size of Cowichan trout was largest and most variable in the pools. No differences related to habitat were apparent in my small sample.

The mean of mean trout densities in the northern creeks was about the same as the overall mean density in the Cowichan system ($0.64/m^2$ versus $0.68/m^2$). Excluding slough habitat (because none of my study reaches had any), Cowichan trout were virtually equally distributed between pools, glides and riffles in September - October ($0.30 - 0.36/m^2$). Looking at Herman Cr. and Lachmach R., the study streams with all three habitats, trout were sparsest in the riffles and favoured the glides in Herman Cr. and the pools in Lachmach River.

Cutthroat trout prefer pools but are usually found in glides and riffles when sympatric with coho, probably due to agonistic interference by coho (Glova 1978). There were only 6 coho estimated in the Herman Cr. reach ($0.1/m^2$). They were all in the pool. There were more than 400 coho estimated in the Lachmach reach ($1.0/m^2$), mostly in the pools. Contrary to expectations from Glova's work, trout favoured the glides in Herman Cr. and the pools in Lachmach River. The results from Cowichan (in the same area as Glova's streams) also seem at variance with the hypothesis that cutthroat will be largely forced out of the pools.

Coho

The size of underyearling coho in the study streams other than McQuarrie Cr. was typical of Sept.-Oct. coho from other coastal areas in B.C. and Alaska. The mean fork length ranged from 53.6 to 59.6 mm. The following are examples of mean sizes found elsewhere in September and October:

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[2] The citation for all results from the Cowichan system is Fielden and Holtby (1987).

Oregon:	Drift Cr. (Alsea Bay)	61mm	Chapman (1965)
Washington:	Puget Sd. creeks	64mm	Flint (1977)
Southern B.C.:	Cowichan system	55mm	Fielden and Holtby (1987)
	Carnation Cr. - pre-logging - post-logging	 50mm 59mm	 Scrivener and Andersen (1982)
	Chilliwack R.	57mm	Fedorenko and Cook (1982)
	upper Pitt R.	54mm	Schubert and Fedorenko (1985)
	Birkenhead R.	56mm	Schubert et al. (1985)
Alaska:	Prince of Wales Is. (mean of 4 streams)	50mm	from Dolloff (1983)
	Sashin Cr.	56mm	Crone and Bond (1976)
	Wood Cr. (an interior stream)	52mm	Raymond (1986)

Sizes are in fact remarkably consistent over a broad geographic range. Although sizes appear to decline with increasing latitude, logging at one site, Carnation Cr., caused size differences that virtually spanned the entire size range.

Like trout, coho in the tributary streams of the Cowichan were only slightly larger in the pools. Underyearling coho in this study differed between habitat types only in Clearwater Cr. where they were largest in the riffles. Condition factors of coho did not differ between habitats in either region. This preliminary indication that there is little size segregation of underyearling coho between habitats in the northern study area is not inconsistent with the Cowichan results and is similar to that found by Bisson et al. (1988) for age 0. coho in some western Washington streams. There may be segregation with larger sizes, however. Dolloff (1983) found that yearling coho in his streams on Prince of Wales Is. tended to be in deeper water than the age 0. coho. This was also the case in Lachmach R., where all 18 yearlings were found in the pools.

Only the Herman and Lachmach reaches had all three habitat types. The mean utilization coefficients for the riffles, glides and pools in these streams were: > -0.96, -0.91, and +1.68, respectively. Re-calculating Fielden and Holtby's coefficients for Cowichan tributaries to exclude the slough habitat category, the U's were -0.97, -0.28, and +0.64, indicating that the preference for pools was probably stronger in our study streams. The comparison is inexact, however, because the presence of sloughs in some of the Cowichan tributary sites would affect the utilization of the other habitat types.

The preference by coho for pools or other slow current areas is a common observation, of course (e.g. Hartman 1965, Mundie 1969 and Bisson et al. 1988). Shirvell (1990) found a strong association of coho fry with slow, dark microhabitats in Kloiya Cr., near Lachmach River. The utilization of pools in this study was as strong as Heifetz et al. (1986) found in the winter when they surveyed 18 southeastern Alaskan streams. Southern coho become more strongly associated with pools, sloughs and swamps in the winter, although not necessarily the same areas as occupied in the summer (e.g. Bustard and Narver 1975, Fielden and Holtby 1987 and Brown and Hartman 1988). On-going work at Lachmach R. will help to answer whether glides and riffles are used so little in northern streams in the summer that there is little seasonal difference in the utilization of these faster water habitats.

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Table 1. Selection criteria for a northern study stream.

Criterion	Objective
Abundance	An expectation of an annual smolt run of at least 10,000 (the original criterion was 20,000)
"Fenceability"	The stream should have: - a mean discharge of less than 10 m^3/sec - relatively moderate spring discharges - annual regimes of usually less than 2 m - relatively gradual discharge changes - relatively small loads of large and small debris; and it should have a site below the major spawning and rearing areas with: - vehicular access - a widening in the channel - well defined banks, higher than 2 m - firm substrate, e.g. cobble - little or no tidal influence - a pool immediately downstream (not essential)
Confounding	No fish enhancement activities or significant habitat alterations
Typicalness	Obviously unusual populations should be avoided
Accessibility	Vehicular access close to several stream locations throughout the study area
Residency	Streams were down-rated if there were large rearing areas of good quality located downstream from, or adjacent to, the candidate stream. Early emigration of fry or pre-smolts may be more likely in these systems.
Straying	Proximity to much larger coho populations was considered a disadvantage due to increased risk of juvenile immigration and adult straying into the study stream.
Location	Populations on the periphery of each region of interest, the north coast and north/central interior, would likely be poor samples of the region's coho, e.g. the transitional zone between the two.

Table 2. Candidate streams for intensive study and how they were evaluated.

Area	Sub-area	Stream	Spot check	Heli-copter	Ground search	Sampled smolt	Sampled Fry
Coastal	Graham Island	Honna R.	x				
		Hiellen R.		x	x	x	
		Sangan R.		x	x	x	
		Skonun R.	x	x		x	
		Hancock R.		x			
		Kumdis Cr.	x	x			
		Florence Cr.		x			
		Gold Cr.	x	x			
		King Cr.	x	x			
	Mainland	Kloiya Cr.			x		
		Hartley Bay Cr.			x		
		Lachmach R.			x		x
		McNeil(Green) R.	x				
Interior/ Coastal	Skeena	Shames Cr.	x				
		Lakelse R.			x	x	
		Herman Cr.	x			x	x
		Andalas Cr.	x				
		Clearwater Cr.	x			x	x
		Schulbuckand(Scully) Cr.	x				
		Williams Cr.				x	
		Sockeye Cr.	x			x	
		Alwyn Cr.	x			x	
		Thornhill Cr.	x				
		Singlehurst Cr.	x				
		Chimdemash Cr.	x				
		Douglas Cr.	x				
	Nass	Zolzap Cr.	x				x
		Tseax Cr.			x	x	
		Gingut Cr.	x				
		N. Seaskinnish Cr.	x			x	
Interior	Skeena	Toboggan Cr.			x		
		McDonell system (upper Zymoetz R.)			x		
		upper Bulkley R.	x				
		McQuarrie Cr.			x		x
		Owen Cr.	x				
		Lamprey Cr.			x		
		McBride Cr.			x		
	Nass	Cranberry R.			x	x	
		McKnight Cr.	x				
		upper Kwinageese R.	x				

Table 3. Description of the streams and their reaches where habitat utilization data were collected.

	Lachmach	Herman	Clearwater	McQuarrie
Date	Oct. 16	Oct. 8	Oct. 10	Oct. 17
Stream order	2	1	2	4
Discharge (m^3/sec)	0.82	0.09	0.66	0.21
Temperature (°C)	9.3	11.5	7.0	5.5
Wetted width (m)	4.9	3.3	6.0	4.0
Canopy closure	Slight	Heavy	Slight	None
Primary riffle substrate	Cobble	Cobble	Sm. gravel	Boulder

Table 4. Evaluation of the more intensively studied streams as sites for long - term research on coho in northern B.C. Streams were rated as having advantages with respect to the criterion (+), being neutral with respect to it (0), or having disadvantages (-).

		Criteria[a]							
Area	Stream	1	2	3	4	5	6	7	8
Coastal	Sangan system	+	0	+	0	-	+	+	+
	Hiellen R.	+	0	+	0	-	+	+	+
	Kloiya R.	+	0	-	-	+	+	+	+
	Hartley Bay Cr.	+	0	-	+	-	+	+	-
	Lachmach R.	+	+	+	+	+	+	+	+
Coastal/ Interior	Lakelse R.	+	-	+	0	+	+	+	-
	Herman Cr.	-	+	+	+	+	-	-	-
	Clearwater Cr.	+	-	0	-	-	-	+	-
	Williams Cr.	+	-	+	+	+	-	+	-
	Sockeye Cr.	-	+	-	0	+	-	-	-
	Alwyn Cr.	-	+	-	+	0	-	-	-
	Zolzap Cr.	+	0	+	0	-	+	+	-
	Tseax R.	+	-	+	0	+	+	+	-
Interior	McDonell system	+	0	+	0	+	+	+	+
	Toboggan Cr.	+	+	-	-	+	+	+	+
	Owen Cr.	-	0	0	+	+	-	0	+
	McQuarrie Cr.	-	+	0	+	+	-	0	+
	Cranberry R.	+	-	+	+	+	+	+	+

[a]Criteria key (see Table 1 for definitions):

1. Abundance
2. "Fenceability"
3. Confounding
4. Typicalness
5. Accessibility
6. Residency
7. Straying
8. Location

Table 5. Catches of coho in May, 1986.

Stream	Date	Catch by age[a]				Catch(C) by gear[b]			
	(May)	U/K	0	1	2	Net	Traps		
						C	No.	Hrs[c]	C[d]
Skonun R.	7	0	3	7	0	7	0	-	-
	22	9	7	14	10	33	0	-	-
Sangan R.	6	1	1	18	1	20	0	-	-
	21	0	0	40	8	24	28	12	24 (0.9)
Hiellen R.	7	1	0	3	4	-	6	22	8 (1.3)
	22	78	0	45	30	-	28	17	153 (5.5)
Lakelse R.	8	0	0	0	0	0	0	-	-
	24	0	0	6	0	-	10	24	6 (0.6)
Williams Cr.	24	5	5	25	2	-	3	24	32(10.7)
Sockeye Cr.	9	0	0	18	2	-	6	21	20 (3.3)
	24	3	0	10	1	-	2	24	14 (7.0)
Clearwater Cr.	23	1	0	2	1	-	3	24	4 (1.3)
Alwyn Cr.	24	0	0	2	1	-	2	24	3 (1.5)
Tseax R.	9	0	0	19	0	0	5	7	19 (3.8)
	25	0	0	4	0	-	9	24	4 (0.4)
N. Seaskinnish Cr.	25	0	0	0	0	-	4	24	0 (0.0)
Cranberry R.	10	1	0	19	0	8	6	8	12 (2.0)
	25	5	0	9	1	15	0	-	-

[a]When scales were missing or illegible, fork lengths were used to estimate ages whenever possible.

[b]The catch of coho other than age 0.'s in the fyke net and/or minnow traps.

[c]These soak times are approximate. All were overnight sets except the seven and eight hour sets at Tseax and Cranberry rivers where the traps were collected at late dusk.

[d]The catch per trap is in parentheses.

Table 6. Lengths and condition factors of smolts of known age that were captured in May, 1986. Fish whose ages were inferred from their lengths were excluded. The means, their standard errors and the sample sizes are shown.

	Fork length (mm)		Condition factor	
Stream	Age 1.	Age 2.	Age 1.	Age 2.
Skonun R.	84.5±17.26 (15)	107.8±10.53 (10)	1.18±0.108 (15)	1.18±0.089 (10)
Sangan R.	73.1±14.90 (37)	104.7±13.68 (9)	1.23±0.131 (37)	1.20±0.074 (9)
Hiellen R.	95.1±19.15 (42)	114.9±9.37 (34)	1.20±0.117 (42)	1.19±0.193 (34)
Alwyn Cr.	66.0±1.41 (2)	97.0 (1)	1.26±0.025 (2)	1.13 (1)
Lakelse R.	74.6±13.03 (5)		1.25±0.261 (5)	
Clearwater Cr.	95.5±10.61 (2)	113.0 (1)	1.27±0.113 (2)	1.24 (1)
Williams Cr.	60.3±13.63 (16)	95.0±2.83 (2)	1.12±0.086 (16)	1.13±0.105 (2)
Sockeye Cr.	74.9±11.06 (27)	104.3±12.50 (3)	1.25±0.097 (27)	1.29±0.112 (3)
Tseax R.	69.6±11.43 (20)		1.29±0.073 (20)	
Cranberry R.	71.6±20.17 (19)	114.0 (1)	1.23±0.159 (19)	0.90 (1)

Table 7. Dimensions and area of habitat units that were sampled in October, 1986 (by habitat type and stream).

Habitat type	Stream	Habitat unit	Length (m)	Width (m)	Area (m^2)	Depth (cm)
Riffle	Herman	rapids	3.8	1.5	5.7	19
(n = 8)		low grad.	8.4	3.5	29.4	15
		low grad.	5.3	3.5	18.5	13
	Clearwater	low grad.	12.2	5.0	61.0	26
		low grad.	13.4	3.9	52.3	21
	Lachmach	low grad.	22.4	6.2	138.9	24
	McQuarrie	cascades	6.0	4.0	24.0	21
		low grad.	11.0	4.3	47.3	23
		$\bar{X}$	10.3	4.0	47.1	20
		SD	5.97	1.35	41.45	4.4
Glide	Herman		4.6	2.5	11.5	30
(n = 4)			5.0	2.6	13.0	27
			5.0	1.6	8.0	21
	Lachmach		20.0	5.4	108.0	23
		$\bar{X}$	8.7	3.0	35.1	26
		SD	7.57	1.65	48.63	3.8
Pool	Herman	dammed	10.0	4.2	42.0	43
(n = 11)	Clearwater	2°channel	9.2	2.0	18.4	11
		plunge	0.4	2.8	1.1	38
		plunge	1.2	3.0	3.6	45
		backwater	6.7	3.1	20.8	30
		backwater	9.6	6.1	58.6	45
	Lachmach	backwater	20.5	4.3	88.1	41
		backwater	6.5	8.0	52.0	44
	McQuarrie	lat. scour	10.0	4.8	48.0	46
		lat. scour	11.0	4.1	45.1	46
		$\bar{X}$	8.5	4.2	37.8	39
		SD	5.60	1.76	26.92	11.0

Table 8. Cover characteristics of the habitat types that were sampled in each stream in October, 1986.

			Mean Score[a]						Volume(m^3)	
Habitat type	Stream	No. units	Small wood	Terrest. veg.	Undercut bank	Turbu-lence	Boulder	Max. depth	Large wood	Root wad
Riffle	Herman	3	0.6	0	0	1.3	1.3	0	0	0
	Clearwater	2	1.5	1.0	2.0	1.0	0	0	0	0
	Lachmach	1	0	0	0	2.0	2.0	0	0	0.3
	McQuarrie	2	0.5	0	0	1.0	3.0	0	0	3.0
Glide	Herman	3	0.6	0.6	2.3	0	1.7	0	0	0
	Lachmach	1	1.0	0	0	1.0	1.0	0	0	0
Pool	Herman	1	2.0	3.0	1.0	0	1.0	3.0	0	0
	Clearwater	5	1.0	1.4	2.0	1.0	0	1.4	1.4	0
	Lachmach	2	1.0	1.0	1.3	0	2.3	1.3	1.5	3.4
	McQuarrie	2	1.0	0	0.5	0.5	1.7	1.7	0	1.4

[a]All cover types except large wood and root wads were estimated by scores: 0 - absent, 1 - small amount, 2 - moderate amount, and 3 - abundant, dominant feature. The tabulated values are means of scores from the habitat units.

Table 9. Catches in the habitat utilization survey of October, 1986.[a]

		Trout							
Stream	coho	CT	RB	U/K	DV	LA	SC	ST	SU
Herman	4	92	14	13	5	14	2	0	0
Zolzap	24	0	0	0	0	0	0	8	0
Clearwater	74	24	0	36	15	4	16	0	0
Lachmach	306	1	25	167	17	0	-	1	0
McQuarrie	3	0	8	93	0	0	-	0	5

[a]Species codes:
CT - cutthroat trout (Oncorhynchus clarki)
RB - rainbow trout (Oncorhynchus mykiss)
U/K- unknown trout, either cutthroat or rainbow
DV - Dolly Varden char (Salvelinus malma)
LA - lamprey spp. (Petromyzonidae)
SC - sculpin (Cottus spp.)
ST - threespine stickleback (Gasterosteus aculeatus)
SU - longnose sucker (Catostomus catostomus)

Table 10. Statistical summary by habitat type and stream of the lengths and condition factors of underyearling coho and trout that were caught in October, 1986.

Habitat type	Stream	Fork length (mm)			Condition factor		
		N	Mean	SD	N	Mean	SD
			Coho				
Riffle	Herman	0			0		
	Clearwater	19	64.5	8.49	1	1.17	
	Lachmach	11	55.0	6.10	11	1.02	0.105
	McQuarrie	0			0		
Pool	Herman	0			0		
	Clearwater	54	57.9	14.68	25	1.15	0.213
	Lachmach	147	53.8	5.91	142	1.01	0.081
	McQuarrie	3	70.7	4.62	3	1.29	0.249
Glide	Herman	0			0		
	Clearwater	-			-		
	Lachmach	15	50.9	5.83	15	1.00	0.127
	McQuarrie	-			-		
All habitat types	Herman	0			0		
	Zolzap[a]	24	57.6	7.22	24	1.17	0.136
	Clearwater	73	59.6	13.61	26	1.15	0.209
	Lachmach	173	53.6	5.95	168	1.01	0.087
	McQuarrie	3	70.7	4.62	3	1.29	0.249
			Trout				
Riffle	Herman	32	51.0	7.49	32	0.99	0.302
	Clearwater	16	49.4	8.73	3	1.05	0.141
	Lachmach	17	47.0	5.97	17	0.98	0.102
	McQuarrie	18	46.7	6.37	18	1.14	0.142
Pool	Herman	13	51.2	7.46	13	1.02	0.131
	Clearwater	15	43.9	9.46	9	1.03	0.217
	Lachmach	58	48.0	5.66	57	0.96	0.156
	McQuarrie	51	46.0	5.15	50	1.16	0.089
Glide	Herman	31	53.3	7.78	31	0.96	0.108
	Clearwater	-			-		
	Lachmach	43	47.9	5.16	42	0.97	0.140
	McQuarrie	-			-		

Table 10 (cont'd)

Habitat type	Stream	Fork length (mm)			Condition factor		
		N	Mean	SD	N	Mean	SD
			Trout				
All habitat types	Herman	76	52.0	7.59	76	0.98	0.213
	Zolzap[a]	0			0		
	Clearwater	31	46.8	9.36	12	1.03	0.195
	Lachmach	118	47.8	5.49	116	0.97	0.142
	McQuarrie	69	46.2	5.46	68	1.15	0.105

[a]Zolzap Cr. samples were not systematically obtained by habitat type. The stream was in freshet.

Table 11. Catch of juvenile coho and trout and their estimated abundance and density. Data are by habitat types.

Habitat type	Stream	Total catch	Est'd number (N) and density N	N/m	N/m^2
			Coho		
Riffle	Herman	0	0	0	0
	Clearwater	20	22	0.9	0.2
	Lachmach[a]	11	>11	>0.5	>0.1
	McQuarrie	0	0	0	0
	Mean			>0.3	>0.1
Glide	Herman	0	0	0	0
	Clearwater	-	-	-	-
	Lachmach	15	20	1.0	0.2
	McQuarrie	-	-	-	
	Mean			0.5	0.1
Pool	Herman	4	6	0.6	0.1
	Clearwater	54	59	2.2	0.6
	Lachmach	280	369	13.7	2.6
	McQuarrie	3	3	0.1	0.03
	Mean			4.2	0.8
			Trout		
Riffle	Herman	39	40	2.3	0.7
	Clearwater	24	24	0.9	0.2
	Lachmach	22	28	1.3	0.2
	McQuarrie	33	38	2.2	0.5
	Mean			1.7	0.4
Glide	Herman	56	58	4.0	1.8
	Clearwater	-	-	-	-
	Lachmach	43	49	2.5	0.5
	McQuarrie	-	-	-	-
	Mean			3.3	1.1
Pool	Herman	24	32	3.2	0.8
	Clearwater	29	29	1.1	0.3
	Lachmach	129	163	6.0	1.2
	McQuarrie	68	73	3.5	0.8
	Mean			3.5	0.8

[a]No estimate could be made because the catch did not decline with each pass.

Table 12. Utilization coefficients using lineal and areal densities of juvenile coho and trout for each habitat type in the streams sampled in October, 1986.

Stream	Lineal density			Areal density		
	Riffle	Glide	Pool	Riffle	Glide	Pool
			Coho			
Herman	-1.00	-1.00	+3.29	-1.00	-1.00	+1.80
Clearwater	-0.44	-	+0.42	-0.50	-	+0.53
Lachmach	>-0.91	-0.83	+1.37	>-0.92	-0.82	+1.55
McQuarrie	-1.00	-	+0.75	-1.00	-	+0.50
			Trout			
Herman	-0.26	+0.28	+0.04	-0.26	+0.76	-0.25
Clearwater	-0.07	-	+0.06	-0.16	-	+0.12
Lachmach	-0.64	-0.29	+0.75	-0.68	-0.27	+0.87
McQuarrie	-0.23	-	+0.19	-0.22	-	+0.15