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COHO SALMON SMOLT AND ADULT PRODUCTION FROM GRANT LAKE (COWICHAN RIVER, VANCOUVER ISLAND, B.C.) FOLLOWING TWO YEARS OF COLONIZATION WITH HATCHERY-REARED AND SALVAGED FRY

by

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ABSTRACT

Bams, R. A. and D. G. Crabtree. 1991. Coho salmon smolt and adult production from Grant Lake (Cowichan River, Vancouver Island, B.C.) following two years of colonization with hatchery-reared and salvaged fry. Can. Tech. Rep. Fish. Aquat. Sci. 1842: 28 p.

Coho salmon underyearlings of wild and hatchery origin were transplanted in 1985 and '86 into a 52-ha lake containing native trout. Initial coho densities were 1020 and 1650 fish/ha. Overall survivals to smolt were 18.9 and 17.6%, with sub-group survivals ranging from 13% for the smallest fish at time of planting (2.25 g average weight) to 19% for the largest (5.5 and 7.3 g). Annual mean smolt weights were 38.6 and 16.3 g. CW-tagged fish of the second year contributed to the Canadian and American fisheries at 5.24% compared with 4.73% for 5 Gulf of Georgia hatcheries and 1.44% for 4 colonization projects of the same year. Several aspects of semi-natural production techniques utilizing lake habitats and relating to fish size and lake productivity are discussed.

RÉSUMÉ

Bams, R. A. and D. G. Crabtree. 1991. Coho salmon smolt and adult production from Grant Lake (Cowichan River, Vancouver Island, B.C.) following two years of colonization with hatchery-reared and salvaged fry. Can. Tech. Rep. Fish. Aquat. Sci. 1842: 28 p.

En 1985 et 1986, des saumons cohos sauvages ou d'élevage âgés de moins d'un an ont été transplantés dans un lac de 52 hectares peuplé de truites indigènes. Les densités initiales de cohos étaient de 1020 et 1650 poissons par hectare. Les taux de survie globale jusqu'à l'état de smolt se sont élevés respectivement à 18,9 % et 17,6 %, avec des taux de survie par sous-groupe allant de 13 % pour les poissons les plus petits au moment de l'ensemencement (poids moyen de 2,25 g) à 19 % pour les poissons les plus gros (5,5 et 7,4 g). Les poids moyens annuels des smolts étaient de 38,6 et 16,3 g. Les poissons de deuxième année marqués d'un fil métallique codé ont représenté 5,24 % des pêches canadiennes et américaines comparativement à 4,73 % pour cinq piscifactures du golfe de Giorgia et à 1,44 % pour 4 projets de colonisation la même année. Plusieurs aspects des techniques de production semi-naturelle utilisant les habitats lacustres et reliant la taille des poissons et la productivité des lacs sont examinés.

INTRODUCTION

Catch and escapement information on Gulf of Georgia adult coho salmon (Oncorhynchus kisutch) in the seventies and early eighties indicated a possibly substantial decline in abundance of wild stocks (Anon. 1987). This trend continued into the second half of the decade, (Farlinger et al. 1990). Recognition of this trend led to a marked acceleration in the outplanting of large quantities of young coho into various aquatic habitats that were thought to be capable of coho smolt production (Anon. 1980-85). Many of these habitats are located above barriers, such as falls, that prevent adult fish from reaching them. Such outplanting is classified locally as 'colonization' and tends to use hatchery 'surplus' fry and fingerlings, usually available in significant quantities from hatcheries that have escapements exceeding those needed for their normal smolt rearing requirements. There was local concern about the effectiveness and possible ecological consequences of these broad-brush efforts in B.C. The Canadian Department of Fisheries and Oceans, Pacific Region, in addition to its basic project evaluations, therefore, initiated a series of tests to address more specific aspects of colonization. One such test is covered by this report, some others were published in Hurst and Blackman 1988.

MATERIALS AND METHODS

The Lake and the Traps. Grant Lake is situated near the city of Duncan on the east coast of Vancouver Island B.C. It is a clear, oligotrophic mountain lake, lying at 224 m elevation in a short narrow valley, and is perched some 70 m above the Koksilah River valley floor. The watershed is about 8 square km in size, forms part of a privately owned tree farm, (B.C.T.F. licence # 45) and is mostly covered in second growth conifers. The lake is about 1850 m long and 500 m wide at its widest point, is about 52 ha in size, slopes evenly to a maximum depth of 40.5 m, and has a very limited littoral zone. During the years of experimentation it had a well-established thermocline by mid-June, with surface temperatures approaching 20 C° and a hypolimnion, at some 10 m, at less than 10 C°. By mid-August temperatures were from 20 to 24 C° in the top 8 m and the hypolimnion started at 13 to 15 m with temperatures below 10 C°. Conductivity ranged from 65 to 50 µmho in the top 10 m at this time.

Shore vegetation contains hardhack, willow, alder, Labrador tea, and various rushes and sedges. There are some marshy areas adjacent to the lake and three small but permanent feeder streams. Pond weeds and lily pads are present in narrow bands along most of the shores as is some large debris, mostly submerged tree trunks. There are substantial self-sustaining populations of rainbow (O. gairdneri) and cutthroat trout (O. clarkii), prickly sculpin (Cottus asper), and some three-spined sticklebacks (Gasterosteus aculeatus). Two trawl samples (2x2m surface net, 15 and 20 min. hauls) were obtained at about 2000 h. on Dec. 8, 1986. The catch contained no fish but the zooplankton present, in rough order of abundance, were Diaptomus (poss. 2 spp.), Cyclops (poss. 2 spp.), Chaoborus, Neomysis, Daphnia, and Bosmina (J. Candy, P.B.S., pers. com.).

The lake has a 1-m high concrete dam at the outlet to retain sufficient water for a private power plant (Pelton wheel) driven year-round via an old 12" wood-stave pipe with a screened intake in the creek some distance below the dam. The diverted water rejoins the creek just above the smolt fence site, i.e. just above the confluence of the creek with the Koksilah River, about 12 km upstream of Marble Falls. The creek is only about 700 m long and contains several falls and cascades comprising a 70 m drop, which makes the lake inaccessible to anadromous fish. Marble Falls is equipped with a poorly maintained fish-way and is believed to be passable only occasionally to steelhead and coho. Due to extensive logging in the entire Koksilah River watershed summer flows have become reduced and fall and winter floods are severe.

The first smolt run was enumerated with a simple smolt weir erected some 40 m upstream from the confluence of the creek with the Koksilah River. It consisted of two 5 m long by 0.4 m high wings, constructed of 5 by 10 cm lumber and clad with 6 mm mesh metal screen, anchored and sealed with plastic sheeting to the stream bottom, and leading into a 15 cm dia. plastic pipe (corrugated 'Big-O' pipe), which, in turn, led into a double-chambered, Marquisette-lined holding box set in a deep pool downstream of the fence. The box had a hinged lid and was secured with a lock.

The first year's operation demonstrated severe smolt damage and loss, incurred during the descent. A bypass system was built for the second smolt run (Bams 1989), which collected all the fish at the lake's outlet after they were guided over the dam and directed them into a translucent, white, 6.4-cm dia. PVC pipe, 707 m long and discharging into a box similar to the weir collecting box. Flow in the pipe was 34 LPM. It took the fish about 6 minutes to make the passage, and they arrived in excellent shape, without any visible agitation or damage. There were no problems with total gas pressure or temperature.

Sources and treatment of fish used. In 1984 eggs were collected from wild coho spawning in Glenora Creek, a tributary of the lower Koksilah River. They were incubated and the fry were reared in the Cowichan River (Salmonid) Enhancement Society's hatchery operated by the Cowichan Indian Band near the mouth of the Cowichan River. Incubation and rearing took place in aerated ground water according to standard SEP practices using Heath incubators, Capilano-type troughs, and Oregon Moist Pellet diets fed at manufacturer's recommended rates. Additional fish were obtained from fry salvage operations, carried out annually in the Cowichan watershed (Burns et al. 1987). Two groups of salvaged fry were used: an early salvaged group, obtained from the upper Cowichan, and a later group, salvaged from Glenora Creek. Both groups were fed at the hatchery prior to release. Two of the available groups were differentially marked by excising a ventral fin and the third was left unmarked. Fish were taken to the lake by truck in aerated tanks and released in the surface water. The fish were visibly stressed under this treatment because of high lake water temperatures, and a few mortalities were observed.

In 1985 eggs were taken from Glenora and Kelvin creeks, both of which are lower Koksilah tributaries, and fry were salvaged in 1986 from Glenora Creek and the lower Cowichan River, mostly from drying side channels. All fish were fed at the hatchery and two groups were marked selectively by removal of a ventral fin. Release was effected this time via a 15-cm diameter hose that started at a box situated at the lake's edge, ran along the lake bottom, and terminated just below the thermocline in water that had the same temperature as that of the hatchery rearing water. The fish were transferred easily and no stress was observed (Bams 1989).

On several occasions a few fish were collected from the lake with baited 40-cm long minnow (Gee) traps, by angling, and with graduated gill nets. One attempt was made to collect fish at night with a tow net, but this was unsuccessful. At the fence migrating smolts were collected and counted mostly daily. Fish were coded-wire tagged usually twice a week. Individual weight measurements were taken occasionally on random samples of narcotized fish. Condition factors were calculated as $K = 10^4 \cdot W(g) \cdot L(mm)^{-3}$. Most data analysis was carried out using Minitab Release 7 (DOS) software.

RESULTS

The 1984-brood year

On August 8 and 9, 1985, the following groups (in order of increasing size) of coho fingerlings were released into the lake

MARKS	AV.WGT.	NUMBER	EST.L.	REMARKS (source)
R.V.	3.6 g	12,600	67.9	Salvaged, short rearing.
N.M.	5.5 g	32,000	78.2	Salvaged, longer rearing.
L.V.	7.3 g	8,400	85.9	Glenora stock, hatch. reared.
All	5.6 g	53,000	82.5	Weighted average.

where RV = right ventral, LV = left ventral, and NM = no mark. Only average weights were available at time of planting, but assuming K-values of 1.15 for these well-fed fish the expected average lengths can be estimated as indicated on the table. Naturally rearing under-yearling coho in adjacent streams (Bams, unpublished), averaged about 52 mm in size and it is clear, therefore, that all three of the Grant Lake groups had been significantly advanced by feeding at the hatchery.

On 20 November, 1985, 50 baited minnow traps (Gee-traps with enlarged funnel openings to accommodate the large fish) were set near shore at depths of from 2 to 5 feet in several locations of the lake. The water temperature was 6.5 C° and the traps were fished overnight; the bait was not available to the fish. The following text table shows the catch that was obtained, where N = number caught, SE = standard error of the mean, and COND'N = condition factor (K).

MARK	N	LENGTH (mm) Mean	SE	WEIGHT (g) Mean	SE	COND'N (K) Mean	SE
R.V.	1	118	-	17.9	-	1.089	-
N.M.	6	136.5	8.6	27.1	4.20	1.032	0.030
L.V.	7	138.0	13.6	30.8	6.61	1.024	0.029
All	14	135.9	7.5	28.3	3.72	1.032	0.019

The fish had gained significantly in average size and displayed a very large variation in length (mostly from 110 to 170 mm). Approximate gains in average length and weight were 65 and 400%, respectively. Condition factors were high and indicated that growing conditions in the lake were good up to this date.

The 1986 smolt run. Smolts started arriving at the weir a few days prior to May 1, 1986, the first day of record (Table 1). The three groups showed similar daily fluctuations and rates, but minor differences in timing of egress. Earliest was the short-reared (R.V.), followed by the long-reared salvaged group (NM) and last was the hatchery-reared group (L.V.). The trend is in direct relation with fish size, both at release and as smolt. The median and the mid-80 % points of the three sub-runs clearly show this trend and were as follows.

Time	R.V.	N.M.	L.V.
10 %	May 20.2	May 21.7	May 23.1
50 %	May 24.8	May 27.5	May 28.1
90 %	May 30.1	June 1.2	June 1.7

Survival from planting to smolt count at the weir were as follows for the three groups and their totals.

Mark	N plant	N smolts	Surv.%
R.V.	12,600	2,198	17.4
N.M.	32,000	6,183	19.3
L.V.	8,400	1,610	19.2
All	53,000	10,026	18.9

The short-reared salvaged fish (R.V.) had sustained a slightly higher mortality than the other two groups; this, as will be demonstrated below, was likely related to the smaller average size of this group at time of release. The apparent lack of a difference in mortality between the N.M. and the L.V. groups, which had a similar size difference between them at time of release, is addressed in the Discussion.

The smolts were extensively damaged during their descent from the lake. Descaling of from 10 to 50 % of body area was common and many fish held back in calmer areas of the stream long enough to develop fungus growth on injured areas; dead fish were also observed (Bams 1989). Predation by otters and probably other mammals and birds became extensive. Smolt counts and survival figures are, therefore, underestimated. Some fish are also known to have remained in the lake after the smolt run; in the fall several specimens from 20 to 25 cm fork length were caught on sport gear.

The 1986 smolt sizes. All three groups showed increasing mean lengths and weights and decreasing condition factors (K) during the smolt run (Table 3). Table 5 relates one-way Analyses of Variance to test for significance of effects and Means and 95% Confidence Intervals for these parameters for all treatments. Differences in length are significant (P <.001) in time and among the three treatments. The same results were obtained with the weights, which also differed significantly (P <.001) both in time and among the three groups. The condition factors decreased sharply during the last part of the run, with the group of the smallest fish (R.V.) showing consistently lower values than the other two, which were similar when all available dates were summed. The unweighted means (Table 3) show a more even and consistent gradation from N.M. through R.V. to L.V., but this does not correlate with original source or fish size of these groups.

The 1985-brood year.

On 1 August 1986 the following groups of fingerlings were introduced below the thermocline of Grant Lake (abbreviations are the same as before).

Mark	Number	Avg.Wt.	Est.L.	Remarks (Source)
L.V.	10,100	2.25 g	58.9 mm	briefly reared salvaged stock
N.M.	20,350	,,	,,	same stock, partial group
R.V.	10,100	5.35 g	78.6 mm	hatchery-reared Glenora stock
N.M.	45,650	,,	,,	same stock, partial group
N.M.	66,000	4.40 g	73.7 mm	total and calculated averages for combined N.M. group
All	86,200	4.25 g	72.8 mm	total and averages of all groups

The N.M. group was made up of 31% salvaged and 69% Glenora (reared) stock. Again, the mean weights (as supplied by the hatchery) were converted to estimated mean lengths, using K = 1.10 . Variability would have been high in both groups due to the rearing and collecting methods used.

The 1987 smolt run. As in the previous year, the first few smolts appeared during the last week of April and the run covered approximately the same period, but it showed two pronounced peaks, one around the middle of May, comprising 53 %, and one at the end of May, comprising 14 % of the total run (Table 2). Fish of the three groups as distinguished by mark showed very similar fluctuations in daily migration rates with the mid-80 % and the median dates as follows. There was no appreciable influence of fry or smolt size on time or rate of egress.

Time	L.V.	N.M.	R.V.
10 %	May 12.2	May 12.6	May 12.6
50 %	May 14.9	May 14.8	May 14.8
90 %	May 27.7	May 28.5	May 28.1

Survivals (Surv. in percent) from planting to smolt count at the weir were as follows for the three groups and their totals.

Mark	N plant	N smolts	Surv.%
L.V.	10,100	1,312	13.0
N.M.	66,000	11,941	18.1
R.V.	10,100	1,874	18.6
All	86,200	15,130	17.6

On the basis of mark recoveries the hatchery-reared fish again outperformed the salvaged fish in survival. Applying the survival rates obtained on the marked populations to the known proportions of the mixed unmarked group gives a total predicted output of 11,114 smolts, which is only 7% below the observed figure. The difference would include an expected marking mortality as well as marked fish that regenerated poorly executed fin clips, a certain percentage of which always occur. Clearly neither source of bias was high and the data appear coherent. Regeneration of marks would have been more prevalent in the salvaged fry, which were significantly smaller at time of marking, and a small bias may have depressed their survival somewhat.

The 1987 smolt sizes. Mean sizes and standard errors are recorded on Table 4 for samples separated by source (marks) and date. Salvaged fish (L.V.) were again consistently smaller throughout the run and in somewhat better condition than the hatchery fish (the R.V. group, but also evident in the N.M. group, which comprised 69% R.V.). One-way Anova's for all parameters by mark and by date show these differences to be statistically significant at P <.001 (Table 6). All groups showed some growth and after an initial reduction a strong recovery in condition during the last two weeks. All groups were much smaller on average in 1987 than those of 1986 (daily means on Tables 3 and 4, total means on Tables 5 and 6).

Adult returns. Coded wire nose-tags were applied to 9303 smolts (code 082431) up to May 28, 1987, and another 1876 (code 082432) on the later fish, to June 11, 1987, for a total of 11,179 fish, i.e. 74% of the total run. These figures are adjusted for immediate (7 day) tag loss. Adult returns to the various fisheries were obtained from 1986 to 1989. Table 7 lists all estimated returns to the ten fisheries that recovered marks from marked coho releases from 17 selected sites surrounding the lower Gulf of Georgia. Recoveries were from troll, net, and sports fisheries in North and Central B.C., the West coast of Vancouver Island, the Inside Straights, and Alaska, Washington, and Oregon States sports fisheries. The releases contained standard hatchery production groups, SEP small projects efforts, and several colonization attempts, including the two Grant Lake tag groups. Calculated survival to the combined fisheries for the Grant Lake fish was 5.24% as compared to 4.73% for 5 coastal production hatcheries, and 1.44% for four other colonization attempts.

Adult recoveries were disappointingly low in both Koksilah and Cowichan River watersheds. Recovery attempts were hampered by continuing high water levels and poor seeing conditions so that, despite extensive stream surveys, only a few marked fish were recovered.

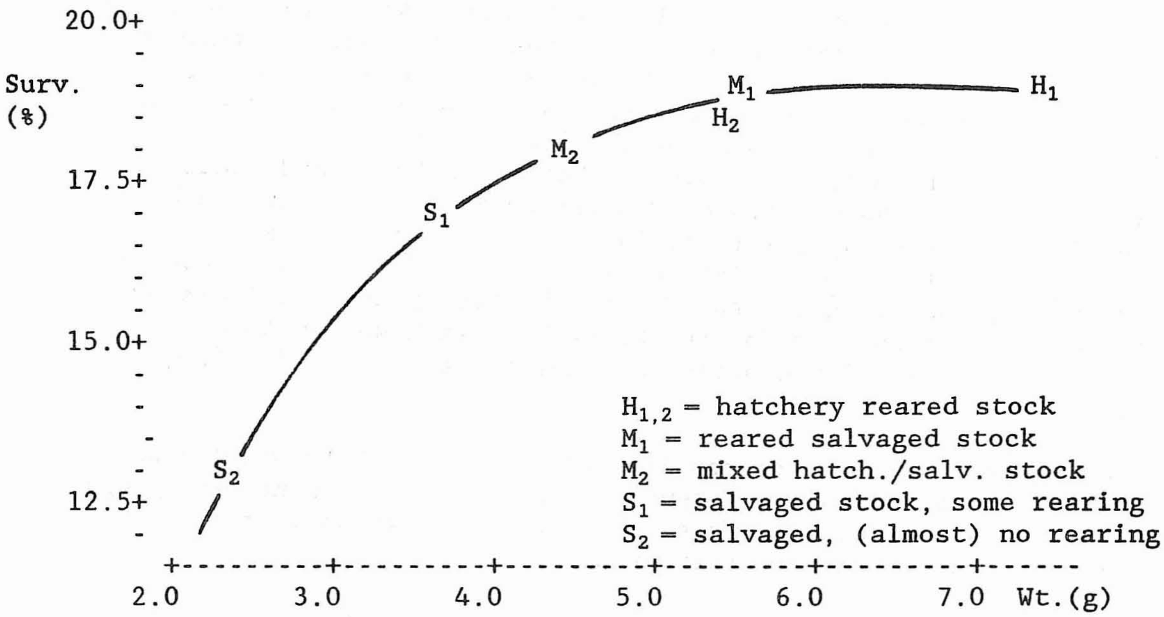
DISCUSSION

Survival.

Survivals from time of release into the lake (early August) to migrating smolt (mid-May) and weights at time of introduction for fish of the different sources in the two years were as follows.

Brood-year	Hatchery		Salvaged/reared or mixed		Salvaged short rearing	
	W(g)	S(%)				
1984	7.30	19.2	5.50	19.3	3.60	17.2
1985	5.35	18.6	4.40	18.1	2.25	13.0

When plotted a decreasingly positive relationship between fingerling size and survival to smolt is clearly demonstrated, showing little or no influence of origin of stock (letters) or year class (subscripts).



The relationship is described well by the quadratic equation

$$(\text{Survival}) = 4.39 + 4.81(\text{Wt}) - 0.384(\text{Wt})^2,\ r^2 = .97$$

and is clearly asymptotic. This suggests that coho mortality in this lake was strongly size related, probably primarily a function of size selective predation by the resident trout, which were commonly in the 25- to 30-cm size range. The coho mortality rate likely decreased gradually from a maximum at time of introduction when the fry were smallest. A weight exceeding about 5 g seems to have maximized survival at close to 20% in both years. Extrapolating the mortality curve to initial weights of 1 g or less (the typical hatchery produced 'unfed' fry commonly used for outplanting) suggests that survival of such fish would be too low to warrant stocking at any level of abundance in this lake, and, perhaps, other lakes like it. It also spells trouble for the outplanting of unfed 'salvaged' fry into lakes of this type early in the summer, because a significant proportion of such fry will be in this size group and are thus likely to be preyed upon by resident trout. Of interest here are observations by Crone (1976) on Osprey Lake (S.E. Alaska) where Dolly Varden char (*Salvelinus malma*), which were mostly spatially segregated from the introduced coho, were, nevertheless, observed to eat young coho. Even though the coho were reared prior to release to about 45 mm long to reduce predation, Dollies about 150 mm long had up to 15 fry each in their stomachs. The percentage of sampled char that were observed to have taken coho fell from 20 in July to 11 in September.

The observed survival rates agree well with results obtained elsewhere on Vancouver Island (e.g. Hurst and Blackman 1988) and are similar to natural survivals observed in the general area. Kyle (1984) reports on an extended coho colonization study in 73-ha Bear Lake in Alaska. Fluctuating populations of native sockeye compete for the available zooplankton supply (and so do sticklebacks probably), but I am not aware of sympatric predatory salmonids in the system. During the first 4 years of the program (1972/75) coho were planted at 2500/ha and average survival was 26%. During the next 5 years fish were planted at 1250/ha and survival increased to 37%. Starting in 1981 the lake was fertilized during the summer months and the production improved again to over 50% annually. There has been an accompanying change in the age at which the fish smolt: from 52 through 70 to 90% of the total run are now 1^+ age. This clearly demonstrates that food availability is a critical issue in coho production from lakes such as these. Food availability, coho density and size strongly influence ultimate production and will require monitoring and mutual adjustment to achieve the desired outcome. Crone and Koenings (1985) discuss prey selectivity of coho in lakes and demonstrate significant correlation between coho growth rates and availability of large prey items (macroplankton, primarily calanoid copepods).

Releases of hatchery salmonids in the absence of competitive or predatory fish populations generally fare much better than those in presence of such fish populations; e.g. Crone and Koenings (1985) with coho in Sea Lion Cave Lake, at 78%; and Crone (1976) coho in Tranquil Lake following two applications of Rotenone, at 57 and 48%. This should come as no surprise and indicates a need to consider carefully various options that may be available for enhancement of any body of water before any one option is initiated. Hasty choices may preempt other outcomes that later turn out to be more desirable and, then, could be difficult or impossible to effect.

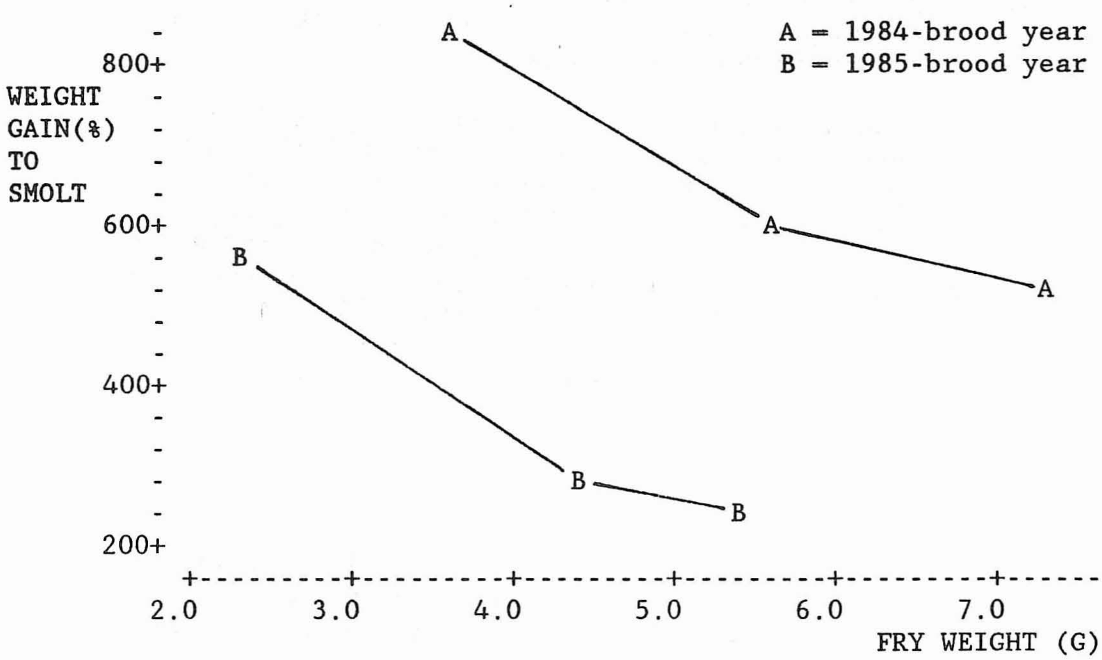
Growth.

All groups of fish gained substantially in size between time of planting and migration as smolts. The relevant measures are tabled below for Length (Ln), Weight (Wt), and Condition (K), together with the gain (in %) for the first two parameters.

		FRY		SMOLTS				
BY	Mk	Ln	Wt	Ln	Ln%	Wt	Wt%	K
84	LV	85.9	7.30	169.3	97	44.78	513	0.8437
	NM	78.2	5.60	157.9	102	39.03	597	0.9108
	RV	67.9	3.60	151.4	123	33.55	832	0.9201
85	RV	78.6	5.35	122.6	56	17.17	221	0.9210
	NM	73.7	4.40	120.5	64	16.96	285	0.9424
	LV	58.9	2.25	113.7	93	14.60	549	0.9792

Several observations obtain from these results.

Fish size at time of introduction had a strong influence on growth rate in both years, with the smaller fish growing fastest. Since growth was inversely related to survival over the same period, some of the difference in growth rate may be attributable to size selective mortality due to predation, i.e. population growth rate differed from real growth rate (Ricker 1975). However, the relative magnitude of the change in growth far exceeds that in mortality and, therefore, selective mortality alone is insufficient to explain the difference in growth rates. I conclude that growth was biased in favor of smaller fish. This could have been a consequence of limiting availability of larger food items. The following diagram clearly demonstrates the effects on weight gain achieved of 1) original fry size (parallel slopes of lines) and 2) the difference in growth levels between years (difference in origin of lines).



Growth clearly was superior in the first year in all three size groups despite their larger average size at introduction, which, as was just demonstrated, was associated with lower growth rate in this lake. Weighted mean smolt size was 38.6 g in the first year and 16.8 in the second, a decrease of more than 55%. The former size is very large, even by hatchery production standards, but the second is close to outplanted coho sizes observed in the Quinsam and Millstone rivers in 1985 and '86, and 1986 and '87, respectively (Labelle 1990).

Size alone, however, does not reflect lake productivity, because the coho population was increased from 53.0 to 86.2 thousand fish at time of planting (an increase of 63%), and this resulted in, respectively, 10.0 and 15.1 thousand smolts (increase 51%). Therefore, total calculated smolt weight is a more appropriate measure of productivity and it too decreased markedly, from 387.2 to 253.8 kg, giving a net reduction of almost 35%.

The difference in productivity is probably not associated with the trout population, which is unlikely to have changed appreciably over the two consecutive years. A more likely explanation may lie in a change in availability of preferred food taxa, which could have become reduced in the second year as a consequence of heavy cropping the first year. Such reductions have been observed repeatedly elsewhere, following introduction of a planktivorous species in a lake (Nilsson, 1972). After an initial high growth rate stocks tend to settle down at a sustainable, but much lower, level of productivity. Our tests did not last long enough to demonstrate what the maintainable level of production is in this lake, nor what the cumulative effect on the trout population would be. The answers to such questions require the commitment of long-term research and will determine the eventual success and viability of outplanting as a production strategy.

The observed average condition factors at migration (Tables 3 and 4, and text table on p. 11) indicate clearly that the smaller fish sizes of the second year were associated with higher, i.e. more normal, K-values in the smolts. The same relationship is evident among groups within years. I interpret these observations as indicating that food supply became limiting for the larger fish, which is congruent with more rewarding (larger?) food items having been in short supply. Since all K-values were near, albeit below, 1.0, there was no indication of the carrying capacity of the lake having been exceeded, as was observed in coho transplants into Burnt-out Lake (Bams 1990) and into Brannen Lake (Hurst and Blackman 1988), but the much smaller smolt size of the second year suggests that, at least in that year, there was no great excess in capacity either. The planting density of 1600 fish per hectare seems to have been a reasonable maximum for this lake, at least in the second year and at the fry size used. It is not known whether this level of productivity could have been maintained in subsequent years; it is possible that the loading level would have had to be reduced.

<u>Adult Returns</u>

As indicated in the Results section, the Grant Lake fish contributed widely to a number of fisheries. Their overall capture rate ("SURV-%" on Table 7) of 5.24% was better than that of any of five Gulf of Georgia coastal hatcheries (Big and Little Qualicum, Capilano, Puntledge, and Rosewall) in that same brood year, at a mean of 4.73%, and considerably better than four other colonization efforts in the area (the Millstone, upper Puntledge, Tenderfoot, and Vancouver rivers), at only 1.44%. The relative distribution of the catches shows the Cowichan stocks to contribute differently to the various fisheries (Table 7). The outstanding differences are a major shift to the west coast of Vancouver Island fisheries and a reduction in the (Canadian) Inside troll and sports categories. There was also a notable increase in the American ocean sports catch, which occurred mostly around the San Juan Islands and on the Washington side of the Juan de Fuca Strait. Of all the other stocks only those of a southern location, and especially the Tenderfoot Creek and the Salmon River stocks, contributed to these fisheries, but at a lesser rate.

Adult returns to the river of origin were disappointing. The presence of an essentially impassable falls on the Koksilah River (Marble Falls) may have aggravated the lack of returns to the Grant Lake outlet stream, but as far as we were able to discern fish were also lacking elsewhere in the Koksilah as well as the Cowichan systems. Field surveys in the spring of 1989 turned up a few coho fry in the immediate area of the outlet of Grant Lake where no fish had been observed in previous years. It is concluded that some fish managed to return to the area and spawned successfully, but their numbers were negligible and could not form the basis of an artificially maintained Grant Lake run. Colonization stock would have to be generated yearly from adjacent streams, e.g. Glenora Creek. Improvements to the now largely defunct Marble Falls fish-way would be advisable if returns to the general area were to occur.

Several attempts were made to obtain coho fry and/or fingerlings from Grant Lake following the smolt output of 1987. Only during the summer of 1987 were some immature fish collected and no further evidence was obtained of any coho occurring in the system after that. Mature adults have been observed following outplanting in small lakes (e.g. Bams 1990) and in larger ones, e.g. Klein and Finnel (1969) who observed 3- and 4-year old males and females in Colorado high altitude reservoirs of different sizes. In none of these cases were young coho (0^+) observed even though spawning creeks were at hand. I have no record of a run maintaining itself in such a lake and assume that any progeny would quickly be removed by coho yearlings and/or resident fish, such as cutthroat trout. These observations are reassuring to the effect that viable, self-perpetuating trout populations are unlikely to be lastingly affected negatively by limited colonization efforts. A schedule of controlled on/off colonization applications or seedings at less than maximum levels may well ensure continuing satisfactory performance of the usually desirable resident trout populations, while producing an optimum number of coho smolts as well. Crone (1976) found evidence that Dolly Varden and coho partitioned a lake spatially, at least at certain times of the year. Such mechanisms are likely to reduce dietary and, particularly, predatory competition (but see comments above) and help establish carefully controlled multi-species equilibria that make best possible use of the available resources of a promising system.

Lake fertilization, when properly controlled for quantities of nutrients, their balance, and timing of application, has resulted in the promotion of the 'right' zooplankters in several Alaskan lakes (Kyle 1984) with the desired responses from outplanted coho. Numbers of 'hold-over' fish (1^+ after smolting) have been reduced and growth and survival promoted. Clearly a variety of fish-cultural techniques are now available to initiate or enhance coho production from available natural habitats presently not utilized by the species.

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Table 1. Numbers of smolts by date (N), cumulatively (NC), and in cumulative percent (C%), for unmarked (NM), right ventral clip (RV), left ventral clip (LV), and total fish (TOTAL), for Grant Lake in 1986.

Date	NM			RV			LV			TOTAL		
	N	NC	C%	N	NC	C%	N	NC	C%	N	NC	C%
May 1	2	2	0.0	6	6	0.3	0	0	0.0	8	8	0.1
2	2	4	0.1	0	6	0.3	0	0	0.0	2	10	0.1
3	1	5	0.1	1	7	0.3	0	0	0.0	2	12	0.1
6	2	7	0.1	2	9	0.4	0	0	0.0	4	16	0.2
8	1	8	0.1	7	16	0.7	0	0	0.0	8	24	0.2
9	3	11	0.2	2	18	0.8	0	0	0.0	5	29	0.3
10	5	16	0.3	8	26	1.2	0	0	0.0	13	42	0.4
11	10	26	0.4	9	35	1.6	2	2	0.1	21	63	0.6
13	17	43	0.7	26	61	2.8	1	3	0.2	44	107	1.1
14	8	51	0.8	7	68	3.1	0	3	0.2	15	122	1.2
15	44	95	1.5	50	118	5.4	9	12	0.7	103	225	2.3
19	8	103	1.7	18	136	6.2	3	15	0.9	29	254	2.5
20	87	190	3.1	80	216	9.8	15	30	1.9	183	437	4.4
21	25	215	3.5	23	239	10.9	2	32	2.0	50	487	4.9
22	546	761	12.3	408	647	29.4	64	96	6.0	1023	1510	15.1
23	230	991	16.0	154	801	36.4	58	154	9.6	443	1953	19.5
24	312	1303	21.1	153	954	43.4	89	243	15.1	556	2509	25.0
25	373	1676	27.1	187	1141	51.9	80	323	20.1	641	3150	31.4
26	649	2325	37.6	246	1387	63.1	139	462	28.7	1037	4187	41.8
27	423	2748	44.4	92	1479	67.3	104	566	35.2	620	4807	47.9
28	712	3460	56.0	195	1674	76.2	200	766	47.6	1109	5916	59.0
29	820	4280	69.2	194	1868	85.0	267	1033	64.2	1297	7213	71.9
30	319	4599	74.4	101	1969	89.6	99	1132	70.3	519	7732	77.1
31	594	5193	84.0	91	2060	93.7	166	1298	80.6	852	8584	85.6
Jun. 1	337	5530	89.4	63	2123	96.6	109	1407	87.4	510	9094	90.7
2	222	5752	93.0	31	2154	98.0	61	1468	91.2	314	9408	93.8
3	214	5966	96.5	19	2173	98.9	65	1533	95.2	298	9706	96.8
4	79	6045	97.8	9	2182	99.3	27	1560	96.9	116	9827	98.0
6	82	6127	99.1	5	2187	99.5	29	1589	98.7	116	9938	99.1
9	53	6180	100	9	2196	99.9	20	1609	99.9	82	10020	99.9
17	3	6183	100	2	2198	100	1	1610	100	6	10026	100

Table 2. Numbers of smolts by date (N), cumulatively (NC), and in cumulative percent (C%), for unmarked (NM), right ventral clip (RV), left ventral clip (LV), and total fish (TOTAL), for Grant Lake in 1987.

	NM			RV			LV			TOTAL		
Date	N	NC	C%	N	NC	C%	N	NC	C%	N	NC	C%
Apr.20	1	1	0.0	0	0	0.0	0	0	0.0	1	1	0.0
25	3	4	0.0	0	0	0.0	0	0	0.0	3	4	0.0
26	3	7	0.1	0	0	0.0	0	0	0.0	3	7	0.0
29	3	10	0.1	0	0	0.0	1	1	0.1	4	11	0.1
May 5	3	13	0.1	1	1	0.1	1	2	0.2	5	16	0.1
8	45	58	0.5	1	2	0.1	9	11	0.8	55	71	0.5
9	125	183	1.5	17	19	1.0	32	43	3.3	174	245	1.6
10	125	308	2.6	19	38	2.0	20	63	4.8	164	409	2.7
12	178	486	4.1	14	52	2.8	32	95	7.2	224	633	4.2
13	1168	1654	13.9	220	272	14.5	168	263	20.0	1556	2189	14.5
14	291	1945	16.3	49	321	17.1	31	294	22.4	371	2560	16.9
15	4865	6810	57.0	794	1115	59.5	412	706	53.8	6071	8631	57.1
16	1485	8295	69.5	194	1309	69.9	195	901	68.7	1874	10505	69.5
17	30	8325	69.7	30	1339	71.5	30	931	71.0	90	10595	70.0
18	725	9050	75.8	87	1426	76.1	51	982	74.8	863	11458	75.8
22	210	9260	77.6	30	1456	77.7	16	998	76.1	256	11714	77.4
23	372	9632	80.7	81	1537	82.0	21	1019	77.7	474	12188	80.6
25	383	10015	83.9	46	1583	84.5	64	1083	82.5	493	12681	83.8
28	551	10566	88.5	101	1684	89.9	107	1190	90.7	759	13440	88.9
31	1158	11724	98.2	153	1837	98.0	84	1274	97.1	1395	14835	98.1
Jun. 4	214	11938	100.0	37	1874	100.0	37	1311	99.9	288	15123	100.0
15	2	11940	100.0	0	1874	100.0	0	1311	99.9	2	15125	100.0
21	1	11941	100.0	0	1874	100.0	1	1312	100.0	2	15127	100.0

Table 3. Number of fish (n), mean Length (L, in mm), Weight (W,in g), and Condition (K) and their standard errors (SE) for Coho smolts from Grant Lake, in 1986, by Date and by Mark.

Date		n	L	SE	n	W	SE	K	SE
**** NO MARK ****									
May	2	2	152.5	7.50	*	*	*	*	*
	3	1	130.0	*	*	*	*	*	*
	8	1	146.0	*	*	*	*	*	*
	9	3	147.7	6.44	*	*	*	*	*
	10	5	143.8	9.94	*	*	*	*	*
	11	10	147.8	4.89	*	*	*	*	*
	13	17	155.8	3.94	*	*	*	*	*
	14	8	154.0	7.47	*	*	*	*	*
	15	44	154.7	2.12	*	*	*	*	*
	19	8	157.6	2.21	*	*	*	*	*
	20	87	153.9	1.53	*	*	*	*	*
	21	25	156.6	2.04	25	38.6	1.46	0.996	0.021
	22	142	151.6	1.14	19	33.1	1.75	0.941	0.014
	23	29	156.0	1.57	*	*	*	*	*
	25	31	159.2	2.66	*	*	*	*	*
	27	33	159.9	1.30	33	38.8	1.07	0.942	0.011
	29	36	164.8	1.89	36	40.6	1.42	0.900	0.008
June	2	32	173.8	2.16	*	*	*	*	*
	4	32	170.2	2.03	32	40.9	1.52	0.821	0.013
	5	37	169.8	2.56	*	*	*	*	*
	17	3	171.3	6.01	3	40.4	4.18	0.798	0.019
**** RIGHT VENTRAL CLIP ****									
May	3	1	148.0	*	*	*	*	*	*
	8	7	142.6	5.11	*	*	*	*	*
	9	2	141.0	11.00	*	*	*	*	*
	10	8	141.5	4.00	*	*	*	*	*
	11	9	148.4	2.29	*	*	*	*	*
	13	26	148.2	2.39	*	*	*	*	*
	14	7	147.6	3.72	*	*	*	*	*
	15	50	150.7	2.01	*	*	*	*	*
	19	18	150.3	2.11	*	*	*	*	*
	20	80	152.3	1.22	*	*	*	*	*
	21	23	149.2	3.44	23	32.3	2.14	0.945	0.016
	22	139	151.1	0.89	27	32.0	1.23	0.935	0.008
	23	16	151.3	2.19	*	*	*	*	*
	25	10	156.4	2.26	*	*	*	*	*
	27	8	155.5	2.49	8	33.6	1.52	0.889	0.009
	29	7	165.3	2.93	7	40.0	2.27	0.881	0.010
June	2	3	168.7	5.70	*	*	*	*	*
	4	6	170.2	4.42	6	42.5	3.71	0.851	0.024
	5	1	183.0	*	*	*	*	*	*
	17	2	161.0	1.00	2	32.8	1.10	0.786	0.012

Table 3 (cont'd)

Date		n	L	SE	n	W	SE	K	SE
**** LEFT VENTRAL CLIP ****									
May	11	2	149.0	1.00	*	*	*	*	*
	13	1	168.0	*	*	*	*	*	*
	15	9	161.9	5.69	*	*	*	*	*
	19	3	153.7	10.70	*	*	*	*	*
	20	15	158.3	4.13	*	*	*	*	*
	21	2	129.5	7.50	2	19.8	3.40	0.903	0.001
	22	20	166.5	3.93	4	46.8	8.00	0.863	0.030
	23	5	184.0	7.60	*	*	*	*	*
	25	9	158.0	1.48	*	*	*	*	*
	27	9	165.9	5.29	9	41.1	3.77	0.884	0.020
	29	7	167.1	3.81	7	41.2	2.80	0.877	0.021
June	2	14	184.1	4.78	*	*	*	*	*
	4	12	190.2	3.98	12	54.1	2.77	0.783	0.018
	5	11	176.4	4.49	*	*	*	*	*
	17	1	161.0	*	1	32.8	*	0.786	*

Table 4. Number of fish (n), mean Length (L, in mm), Weight (W, in g), and Condition (K) and their standard errors (SE) for coho smolts from Grant Lake, in 1987, by Date and by Mark.

Date		n	L	SE	n	W	SE	K	SE
**** NO MARK ****									
Apr.	29	3	123.3	7.26	*	*	*	*	*
May	5	3	119.7	2.03	*	*	*	*	*
	8	45	116.5	0.98	*	*	*	*	*
	12	30	118.3	0.93	*	*	*	*	*
	14	31	121.8	1.50	*	*	*	*	*
	16	60	116.4	0.98	60	14.92	0.333	0.942	0.010
	17	30	122.9	1.53	30	16.89	0.607	0.907	0.020
	22	31	118.3	1.26	31	15.98	0.434	0.963	0.013
	28	60	123.4	0.93	60	17.50	0.359	0.926	0.008
	31	60	125.0	0.83	60	19.00	0.360	0.967	0.006
**** RIGHT VENTRAL CLIP ****									
May	5	1	130.0	*	*	*	*	*	*
	8	1	125.0	*	*	*	*	*	*
	12	14	119.6	1.68	*	*	*	*	*
	14	47	122.4	1.25	*	*	*	*	*
	15	32	121.1	1.20	32	16.41	0.561	0.916	0.013
	16	26	119.5	1.33	26	15.62	0.484	0.909	0.011
	17	30	121.1	1.45	30	15.97	0.527	0.892	0.008
	22	30	122.4	1.49	30	16.54	0.529	0.897	0.011
	28	59	122.1	0.78	59	16.91	0.340	0.925	0.010
	31	60	126.8	0.85	60	19.43	0.339	0.951	0.007
**** LEFT VENTRAL CLIP ****									
Apr.	29	1	112.0	*	*	*	*	*	*
May	5	1	115.0	*	*	*	*	*	*
	8	9	116.9	1.61	*	*	*	*	*
	12	30	115.4	1.42	*	*	*	*	*
	14	31	112.3	1.24	*	*	*	*	*
	15	64	109.9	0.98	42	12.78	0.379	0.957	0.017
	16	16	111.3	1.96	16	12.84	0.618	0.928	0.028
	17	30	112.4	1.33	30	13.02	0.358	0.918	0.019
	22	16	116.9	1.29	16	14.83	0.369	0.929	0.013
	28	60	113.3	0.83	60	14.65	0.318	1.001	0.007
	31	60	118.1	0.63	60	17.02	0.237	1.031	0.008

Table 5. One-way Anova's, Means, and 95% Confidence Intervals on mean Lengths, Weights, and Condition factors (K), by Date and by Mark, for Grant Lake coho smolts in 1986.

```
 ANALYSIS OF VARIANCE ON LENGTH BY DATE

SOURCE     DF         SS         MS         F        p

DATE       21      69912       3329     18.88    0.000
ERROR    1115     196597        176
TOTAL    1136     266509
                                    INDIVIDUAL 95 PCT CI'S FOR MEAN
                                    BASED ON POOLED STDEV
  LEVEL      N       MEAN      STDEV  --+---------+---------+---------+----
   5.01      8     150.62      14.05        (-----*------)
   5.02      2     152.50      10.61   (------------*-----------)
   5.06      2     156.50       7.78      (-----------*------------)
   5.08      8     143.00      12.57   (-----*-----)
   5.09      5     145.00      11.66   (-------*-------)
   5.10     13     142.38      15.52    (----*----)
   5.11     21     148.19      11.25         (---*---)
   5.13     44     151.57      14.31            (--*--)
   5.14     15     151.00      16.61          (----*---)
   5.15    103     153.37      14.63               (*-)
   5.19     29     152.69       9.68             (--*--)
   5.20    182     153.57      13.09               (*-)
   5.21     50     152.10      14.50             (-*--)
   5.22    301     152.38      13.06               (*)
   5.23     50     157.28      13.18                (--*-)
   5.25     50     158.42      12.17                 (--*-)
   5.27     50     160.26       9.71                  (--*-)
   5.29     50     165.20      10.60                      (-*--)
   6.02     49     176.41      14.61                             (--*-)
   6.04     50     175.00      14.56                            (--*-)
   6.06     49     171.53      15.45                          (-*--)
   6.17      6     166.17       8.70                  (------*------)
                                      --+---------+---------+---------+----
POOLED STDEV = 13.28                    135       150       165       180
```

Table 5 (cont'd)

```
ANALYSIS OF VARIANCE ON LENGTH BY MARK

SOURCE      DF          SS          MS         F          p

MARK         2       31914       15957     77.14      0.000
ERROR     1134      234594         207
TOTAL     1136      266509
                                        INDIVIDUAL 95 PCT CI'S FOR MEAN
                                        BASED ON POOLED STDEV
  LEVEL      N        MEAN       STDEV  ----------+---------+---------+------
     NM    587      157.88       14.92             (-*-)
     RV    430      151.39       11.90  (-*--)
     LV    120      169.27       19.12                              (---*---)
                                        ----------+---------+---------+------
POOLED STDEV =    14.38                         156.0     162.0     168.0

ANALYSIS OF VARIANCE ON WEIGHT BY DATE

SOURCE      DF          SS          MS         F          p

DATE         6      3959.5       659.9      8.52      0.000
ERROR      257     19910.4        77.5
TOTAL      263     23870.0
                                        INDIVIDUAL 95 PCT CI'S FOR MEAN
                                        BASED ON POOLED STDEV
   LEVEL        N        MEAN      STDEV  ------+---------+---------+---------+
    5.01        8      32.950      8.646   (---------*---------)
    5.21       50      34.934      9.676            (---*---)
    5.22       50      33.602      8.632          (---*---)
    5.27       50      38.368      7.298                  (---*---)
    5.29       50      40.594      7.944                      (---*---)
    6.04       50      44.276     10.354                            (---*---)
    6.17        6      36.600      6.224       (-----------*-----------)
                                           ------+---------+---------+---------+
POOLED STDEV = 8.802                            30.0      36.0      42.0      48.0
```

Table 5 (cont'd)

```
ANALYSIS OF VARIANCE ON WEIGHT BY MARK

SOURCE      DF         SS          MS          F         p

MARK         2     3326.3      1663.1      21.13     0.000
ERROR      261    20543.7        78.7
TOTAL      263    23870.0
                                       INDIVIDUAL 95 PCT CI'S FOR MEAN
                                       BASED ON POOLED STDEV
 LEVEL       N       MEAN       STDEV  -------+---------+---------+---------
    NM     150     39.027       7.977               (--*--)
    RV      79     33.551       8.195  (---*---)
    LV      35     44.783      13.087                          (-----*----)
                                       -------+---------+---------+---------
POOLED STDEV =      8.872                   35.0      40.0      45.0


ANALYSIS OF VARIANCE ON CONDITION FACTOR K BY DATE

SOURCE      DF         SS          MS          F         p

DATE         6    0.75732     0.12622      28.92     0.000
ERROR      257    1.12166     0.00436
TOTAL      263    1.87898
                                       INDIVIDUAL 95 PCT CI'S FOR MEAN
                                       BASED ON POOLED STDEV
  LEVEL        N       MEAN       STDEV  -----+---------+---------+---------+-
   5.01        8    0.94844     0.04088                        (-----*------)
   5.21       50    0.96886     0.09387                               (-*--)
   5.22       50    0.93135     0.05338                         (--*--)
   5.27       50    0.92339     0.06357                        (--*--)
   5.29       50    0.89088     0.04508                    (-*--)
   6.04       50    0.81556     0.06975          (--*-)
   6.17        6    0.79192     0.02280  (------*-------)
                                         -----+---------+---------+---------+-
POOLED STDEV =  0.06606                      0.770     0.840     0.910     0.980
```

Table 5 (cont'd)

ANALYSIS OF VARIANCE ON CONDITION FACTOR K BY MARK

SOURCE	DF	SS	MS	F	p
MARK	2	0.15470	0.07735	11.71	0.000
ERROR	261	1.72428	0.00661		
TOTAL	263	1.87898			

```
                                           INDIVIDUAL 95 PCT CI'S FOR MEAN
                                           BASED ON POOLED STDEV
 LEVEL      N      MEAN     STDEV   -------+---------+---------+---------
    NM    150   0.91083   0.09063                             (--*---)
    RV     79   0.92010   0.06395                              (----*----)
    LV     35   0.84368   0.07306   (-------*-------)
                                    -------+---------+---------+---------
POOLED STDEV =  0.08128                  0.840     0.875     0.910
```

Table 6. One-way Anova's, Means, and 95% Confidence Intervals on mean Lengths, Weights, and Condition factors (K), by Date and by Mark, for Grant Lake coho smolts in 1987.

```
 ANALYSIS OF VARIANCE ON LENGTH BY DATE

SOURCE      DF         SS         MS         F         p

DATE        10     7420.2      742.0     11.69     0.000
ERROR      959    60849.6       63.5
TOTAL      969    68269.7
                                      INDIVIDUAL 95 PCT CI'S FOR MEAN
                                      BASED ON POOLED STDEV
  LEVEL      N       MEAN      STDEV  ---------+---------+---------+-------
   4.29      4     120.50      11.73      (---------------*---------------)
   5.05      4     118.50       3.70  (---------------*---------------)
   5.08     55     116.69       6.34          (---*----)
   5.12     74     117.38       6.67            (---*--)
   5.14    109     119.34       9.17                 (--*--)
   5.15     96     113.60       9.17     (--*--)
   5.16    102     116.41       7.80           (--*--)
   5.17     90     118.81       9.06               (---*--)
   5.22     77     119.58       7.45                 (--*---)
   5.28    179     119.59       7.95                  (-*--)
   5.31    180     123.31       7.08                         (--*-)
                                      ---------+---------+---------+-------
POOLED STDEV = 7.97                          115.0     120.0     125.0


ANALYSIS OF VARIANCE ON LENGTH BY MARK

SOURCE      DF         SS         MS         F         p

MARK         2    13532.6     6766.3    119.54     0.000
ERROR      967    54737.1       56.6
TOTAL      969    68269.7
                                      INDIVIDUAL 95 PCT CI'S FOR MEAN
                                      BASED ON POOLED STDEV
 LEVEL       N       MEAN      STDEV  ----+---------+---------+---------+--
    NM     353     120.52       7.83                        (--*-)
    RV     299     122.57       7.43                               (--*-)
    LV     318     113.71       7.25  (--*--)
                                      ----+---------+---------+---------+--
POOLED STDEV = 7.52                      114.0     117.0     120.0     123.0
```

Table 6 (cont'd)

```
ANALYSIS OF VARIANCE ON WEIGHT BY DATE

SOURCE     DF        SS        MS         F        p

DATE        5   1476.92    295.38     36.74    0.000
ERROR     696   5596.01      8.04
TOTAL     701   7072.94
                                   INDIVIDUAL 95 PCT CI'S FOR MEAN
                                   BASED ON POOLED STDEV
 LEVEL      N      MEAN     STDEV  ---------+---------+---------+-------
   515     74    14.346     3.308  (----*---)
   516    102    14.774     2.661     (--*---)
   517     90    15.292     3.215        (---*---)
   522     77    15.958     2.516            (---*----)
   528    179    16.346     2.821                (--*--)
   531    180    18.481     2.658                             (--*--)
                                   ---------+---------+---------+-------
POOLED STDEV =    2.836                   15.0      16.5      18.0

ANALYSIS OF VARIANCE ON WEIGHT BY MARK

SOURCE     DF        SS        MS         F        p

L/R,V       2    932.97    466.49     53.11    0.000
ERROR     699   6139.96      8.78
TOTAL     701   7072.94
                                   INDIVIDUAL 95 PCT CI'S FOR MEAN
                                   BASED ON POOLED STDEV
 LEVEL      N      MEAN     STDEV  --------+---------+---------+--------
    NM    241    16.960     3.128                         (---*--)
    RV    237    17.169     3.007                           (---*--)
    LV    224    14.597     2.726  (---*---)
                                   --------+---------+---------+--------
POOLED STDEV =    2.964                  15.0      16.0      17.0

 ANALYSIS OF VARIANCE ON CONDITION FACTOR K BY DATE

SOURCE     DF        SS        MS         F        p
DATE        5   0.44432   0.08886     14.89    0.000
ERROR     696   4.15404   0.00597
TOTAL     701   4.59837
                                   INDIVIDUAL 95 PCT CI'S FOR MEAN
                                   BASED ON POOLED STDEV
  LEVEL      N      MEAN     STDEV  ----+---------+---------+---------+--
   5.15     74   0.93923   0.09672            (-----*-----)
   5.16    102   0.93096   0.08053          (----*----)
   5.17     90   0.90547   0.09133   (-----*----)
   5.22     77   0.93007   0.07124         (-----*-----)
   5.28    179   0.95098   0.07136                  (---*---)
   5.31    180   0.98302   0.06607                            (---*--)
                                    ----+---------+---------+---------+--
POOLED STDEV =  0.07726               0.900     0.930     0.960     0.990
```

Table 6 (cont'd)

ANALYSIS OF VARIANCE ON CONDITION FACTOR K BY MARK

SOURCE	DF	SS	MS	F	p
MARK	2	0.39840	0.19920	33.15	0.000
ERROR	699	4.19997	0.00601		
TOTAL	701	4.59837			

```
                                      INDIVIDUAL 95 PCT CI'S FOR MEAN
                                      BASED ON POOLED STDEV
 LEVEL      N      MEAN     STDEV    ------+---------+---------+---------+
    NM    241   0.94241   0.07467              (---*---)
    RV    237   0.92096   0.06518    (---*---)
    LV    224   0.97923   0.09131                        (---*---)
                                     ------+---------+---------+---------+
POOLED STDEV =  0.07751                  0.925     0.950     0.975     1.000
```

Table 7. Code-wire tag returns from coho salmon to Canadian and American marine fisheries and their relative composition, as estimated counts (Mark Recovery Program data base, July 1991) and in percent. Source and location codes are below.

RELEASE SITE	NR.TAGS SOURCE	WVTR	WVN	WVSP	NCTR	NCN	NCSP	INTR	INN	INSP	USSP	TOTAL	SURV-%
BQU/TOT	42689	39	0	0	52	0	18	43	97	360	7	616	1.44
BQU/%	HATCH	6.33	0	0	8.44	0	2.92	6.98	15.75	58.44	1.14	100	
BLC/TOT	35640	660	0	0	454	28	58	346	331	1483	33	3393	9.52
BLC/%	WILD	19.45	0	0	13.38	.83	1.71	10.20	9.76	43.71	.97	100	
CAP/TOT	109237	103	0	8	0	0	10	140	46	6354	145	6806	6.23
CAP/%	HATCH	1.51	0	.12	0	0	.15	2.06	.68	93.36	2.13	100	
CHE/TOT	50910	1133	14	0	165	0	18	1031	379	3247	252	6239	12.25
CHE/%	HATCH	18.16	.22	0	2.64	0	.29	16.53	6.07	52.04	4.04	100	
CHI/TOT	49957	868	13	0	86	0	51	1554	394	4372	363	7701	15.42
CHI/%	HATCH	11.27	.17	0	1.12	0	.66	20.18	5.12	56.77	4.71	100	
COW/GRT	11079	295	8	10	5	0	0	13	19	150	80	580	5.24
COW/GR%	COLN	50.86	1.38	1.72	.86	0	0	2.24	3.28	25.86	13.79	100	
COW/TOT	20791	659	16	20	16	0	0	15	55	242	154	1177	5.66
COW/%	MIX	55.99	1.36	1.70	1.36	0	0	1.27	4.67	20.56	13.08	100	
FRE/TOT	24354	110	1	0	23	5	0	181	81	870	24	1295	5.32
FRE/%	WILD	8.49	.08	0	1.78	.39	0	13.98	6.25	67.18	1.85	100	
HOR/TOT	19675	46	0	0	0	5	0	52	35	1079	35	1252	6.36
HOR/%	HATCH	3.67	0	0	0	.40	0	4.15	2.80	86.18	2.80	100	
LQU/TOT	20343	77	1	0	34	4	18	78	83	678	13	986	4.85
LQU/%	WILD	7.81	.10	0	3.45	.41	1.83	7.91	8.42	68.76	1.32	100	
MIL/TOT	95135	269	1	8	57	4	24	78	123	520	44	1128	1.19
MIL/%	COLN	23.85	.09	.71	5.05	.35	2.13	6.91	10.90	46.10	3.90	100	
PNT/PTO	58145	265	0	0	95	18	56	317	187	1041	25	2004	3.45
PNT/P%	HATCH	13.22	0	0	4.74	.90	2.79	15.82	9.33	51.95	1.25	100	
PNT/CTO	166016	83	1	0	60	0	10	152	77	506	6	895	.54
PNT/C%	COLN	9.27	.11	0	6.70	0	1.12	16.98	8.60	56.54	.67	100	
PNT/TOT	224161	348	1	0	155	18	66	469	264	1547	31	2899	1.29
PNT/T%	MIX	12.00	.03	0	5.35	.62	2.28	16.18	9.11	53.36	1.07	100	
ROS/LTO	22839	167	1	0	117	9	74	210	293	1067	16	1954	8.56
ROS/L%	TR.H	8.55	.05	0	5.99	.46	3.79	10.75	14.99	54.61	.82	100	

Table 7 (cont'd)

RELEASE SITE	NR.TAGS SOURCE	WVTR	WVN	WVSP	NCTR	NCN	NCSP	INTR	INN	INSP	USSP	TOTAL	SURV-%
ROS/BTO	18843	234	2	0	96	6	0	58	184	611	10	1201	6.37
ROS/B%	TR.H	19.48	.17	0	7.99	.50	0	4.83	15.32	50.87	.83	100	
ROS/TRTO	15900	159	0	0	72	7	37	108	197	669	7	1256	7.90
ROS/TR%	TR.H	12.66	0	0	5.73	.56	2.95	8.60	15.68	53.26	.56	100	
ROS/TOT	57582	560	3	0	285	22	111	376	674	2347	33	4411	7.66
ROS/T%	TR.H	12.70	.07	0	6.46	.50	2.52	8.52	15.28	53.21	.75	100	
SAL/W	22887	360	5	0	31	2	37	680	205	1745	211	3276	14.31
SAL/%	WILD	10.99	.15	0	.95	.06	1.13	20.76	6.26	53.27	6.44	100	
TEN/PTO	52122	636	4	0	63	17	10	427	146	4782	419	6504	12.48
TEN/P%	HATCH	9.78	.06	0	.97	.26	.15	6.57	2.24	73.52	6.44	100	
TEN/CTO	18696	76	0	0	26	3	18	34	15	275	32	479	2.56
TEN/C%	COLN	15.87	0	0	5.43	.63	3.76	7.10	3.13	57.41	6.68	100	
TEN/TOT	70818	712	4	0	89	20	28	461	161	5057	451	6983	9.86
TEN/T%	MIX	10.20	.06	0	1.27	.29	.40	6.60	2.31	72.42	6.46	100	
TRE/TOT	15690	197	0	0	94	0	68	282	251	1014	18	1924	12.26
TRE/%	WILD	10.24	0	0	4.89	0	3.53	14.66	13.05	52.70	.94	100	
VAN/VR	84245	17	0	0	26	4	0	91	25	1073	4	1240	1.47
VAN/%	COLN	1.37	0	0	2.10	.32	0	7.34	2.02	86.53	.32	100	
WVA/CYC	3186	0	0	0	0	0	0	0	4	10	0	14	.44
WVA/%	TR.H	0	0	0	0	0	0	0	28.57	71.43	0	100	

RELEASE SITE: BQU=Big Qualicum R.; BLC=Black Cr.; CAP=Capilano R.; CHE=Chehalis R.; CHI=Chilliwack R.;COW=Cowichan R., where GR= Grant Lake Colonization; FRE=French Cr.; HOR=Horseshoe Bay; INC=Inches Cr.; LQU=Little Qualicum R.; MIL=Millstone R.; PNT=Puntledge R., where P=production, C=Colonization, T=total; ROS=Rosewall Cr., where L=Little Qualicum, B=Black Creek, TR=Trent, and TOT=combined transplanted stock(s); SAL=Salmon R. Vancouver; TEN=Tenderfoot Cr., where P=production, C=Colonization, and T= total stock; TRE=Trent R. augmented; VAN=Vancouver Bay; WVA=West Vancouver Lab. Capilano stock transplant to Cypress Cr. All /TOT and /xTO designations signify multiple tag groups.

SOURCE: WILD = naturally reared to smolt; HATCH = hatchery-reared to smolt; COLN = hatchery or wild reared to fry, naturally reared to smolt; TR.H = hatchery reared to smolt, then transplanted to non-parental stream.

FISHERIES: WVTR= West Vanc. Isl., Troll; WVN= ditto, Net; WVSP= ditto, Sport; NCTR= North and Central coast, Troll; NCN= ditto, Net; NCSP= ditto, Sport; INTR= Inside Straights, Troll; INN= ditto, Net; INSP= ditto, Sport; USSP= USA (Alaska and Washington) Sport.