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Large numbers of coho salmon (Oncorhynchus kisutch) fry move downstream shortly after emergence from the gravel in many spawning tributaries. In three small coastal streams of Oregon about eight times more juveniles leave the tributaries as newly emerged fry than as smolts one year later. Because these early emigrants comprise such a large proportion of the total out-migration of juvenile coho from these streams, a study was initiated to determine their distribution and survival and to evaluate their contribution, if any, to the spawning escapements.

In spring 1972, all emigrating coho fry were marked with ventral finclips as they entered fish traps located near the mouths of the three natal streams. Coho fry were later examined for ventral marks in July and September at 19 sampling stations in downstream areas.

Emigrants generally dispersed downstream after being marked, although some upstream movement occurred once they entered larger tributaries. A few moved as far as 9.7 km downstream from the fish traps. Few, if any, migrated directly to saltwater. The proportion of emigrants in samples of coho fry was highest directly below the fish traps and decreased farther downstream. Emigrant fry were not evenly distributed in downstream areas.

About 7% of the emigrants survived to September. Survival rates of emigrant fry and of fry in downstream areas that had not emigrated from the study streams (residents) were similar from July to September, being 43% and 46%, respectively. The survival of coho that remained above the traps was 78% for the same time period. The evidence suggests emigrants were as competitive as residents in downstream areas, but that environments downstream were more adverse than those farther upstream.

Eight adult and jack coho salmon that had been marked as emigrating fry in spring 1969, returned to spawn in the natal streams in 1970-71 and 1971-72. They represented a known return of about 0.1% of the emigrants. Emigrant fry probably contributed to spawning escapements in downstream areas as well, but contributions to these areas could not be directly evaluated.

Distribution and Survival of Coho Salmon Fry after Emigration from Natal Streams

by

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TABLE OF CONTENTS

INTRODUCTION	1
Study Area	3
MATERIALS AND METHODS	7
Marking	7
Population Estimates	7
Survival	10
Contribution to Adult Returns	11
RESULTS	
Distribution	13
Survival	17
Contribution to Returns in Needle Branch	25
DISCUSSION	28
LITERATURE CITED	36
APPENDIX	39

LIST OF FIGURES

Figure		Page
1.	Map of the Drift Creek drainage showing location of sampling stations.	4
2.	Pattern of fry emigration through the fish traps in the three study streams in 1972.	14
3.	Survival rates of emigrant and resident fry in each stream from July to September (54 days).	20
4.	Daily instantaneous mortality rates for emigrant fry during three time periods in 1972.	21

LIST OF TABLES

Table		Page
1.	Distribution of emigrant fry from Deer Creek (LV), Flynn Creek (BV), and Needle Branch (RV) in July 1972 (7/4-7/24).	15
2.	Distribution of emigrant fry at the sampling stations in September (8/29-9/15).	16
3.	Estimated number of emigrant and resident fry in each stream in July and September, 1972.	18
4.	Daily instantaneous mortality rates (i) for marked and unmarked coho fry above the trap from late summer to the mid-date of the smolt migration the next spring.	23
5.	Mean lengths and weights of emigrant and resident fry in July and September.	24
6.	Summary of trap data for two spawning runs when the contribution of emigrant fry could be evaluated in the returns to Needle Branch.	26

DISTRIBUTION AND SURVIVAL OF COHO SALMON FRY AFTER EMIGRATION FROM NATAL STREAMS

INTRODUCTION

Downstream movement of coho salmon (Oncorhynchus kisutch) fry shortly after emergence from the spawning gravel is a common feature of coho life history over much of its range (Hoar, 1951; Shapovalov and Taft, 1954; Salo and Bayliff, 1958; Chapman, 1962; Crone, 1968). These fish often comprise a large proportion of the total out-migration of juvenile coho from spawning tributaries (Crone, 1968; Au, 1971). Past studies have dealt primarily with mechanisms causing this movement (Hoar, 1958; McDonald, 1970; Chapman, 1962; Au, 1971). Few have provided empirical data on the dynamics of emigrant fry populations after emigration. My study was designed to determine the distribution and survival of recently emerged coho fry that emigrated from three small coastal streams of Oregon, and to evaluate their contribution to the spawning escapements in these streams.

The project was part of the Alsea Watershed Study, a 15-year cooperative investigation of the effects of logging on water quality, fish habitat, and fish populations. In most years since the Alsea study began, several thousand fry have emigrated through fish traps located near the mouths of Deer Creek, Flynn Creek, and Needle

Branch, the three study streams. Emigrant fry comprise about 25% of the total emergence in Deer Creek and greater than 50% in Flynn Creek and Needle Branch (Au, 1971). About eight times more juveniles emigrate from these streams as newly emerged fry than as smolts. Emigration occurs from March to early summer. Its pattern corresponds closely to that of emergence (Au, 1971).

Chapman (1962) suggested the downstream drift of fry was largely due to the presence of other coho. When he placed emigrating fry in environments free of resident fish, downstream movement ceased. He concluded that aggressive behavior resulting from the territorial nature of coho fry was an important cause of emigration. Au (1971) believed the movement was a dispersal mechanism that distributed fry downstream from redd sites to nursery areas. He hypothesized that newly emerged fry were passively displaced by the current at night until a specific nocturnal resting behavior developed. This behavior consisted of fry settling to the stream bottom and remaining quiescent during hours of darkness. Development of the behavior depended on a physiological maturation sequence modified by agonistic interactions.

The downstream response of fry may have evolved as a density regulating mechanism adjusting populations in natal streams within limits of the food and space available (Chapman, 1966; McFadden, 1969; Au, 1971). It may also promote a wide distribution of fish in stream systems (Hoar, 1951).

Chapman (1961) was the first to describe the downstream movement in the Alsea study streams and called the migrants "nomads". I have called them emigrants, since the term nomad incorrectly implies that they do not establish residence. Fry remaining above the traps in the three Alsea study streams and those in the downstream areas that did not emigrate from these study streams were called residents. Work was conducted from July 1971 to October 1972 on Needle Branch, Deer, Flynn, Meadow, Horse, and Drift creeks.

Study Area

Deer Creek, Flynn Creek, and Needle Branch are located about 40 km from the central Oregon coast (Fig. 1). Deer and Flynn creeks flow into Horse and Meadow creeks, respectively. Needle Branch flows directly into Drift Creek, which empties into the Alsea Bay near Waldport, Oregon. Permanent upstream-downstream traps near the mouths of Needle Branch, Deer, and Flynn creeks provide nearly complete inventories of fish movements. Hall and Lantz (1969) give a detailed description of the Alsea Watershed Study area.

The watersheds of Deer Creek (304 ha) and Needle Branch (71 ha) were logged in 1966. Access roads were built in 1965. The Needle Branch watershed was completely clearcut. The Deer Creek

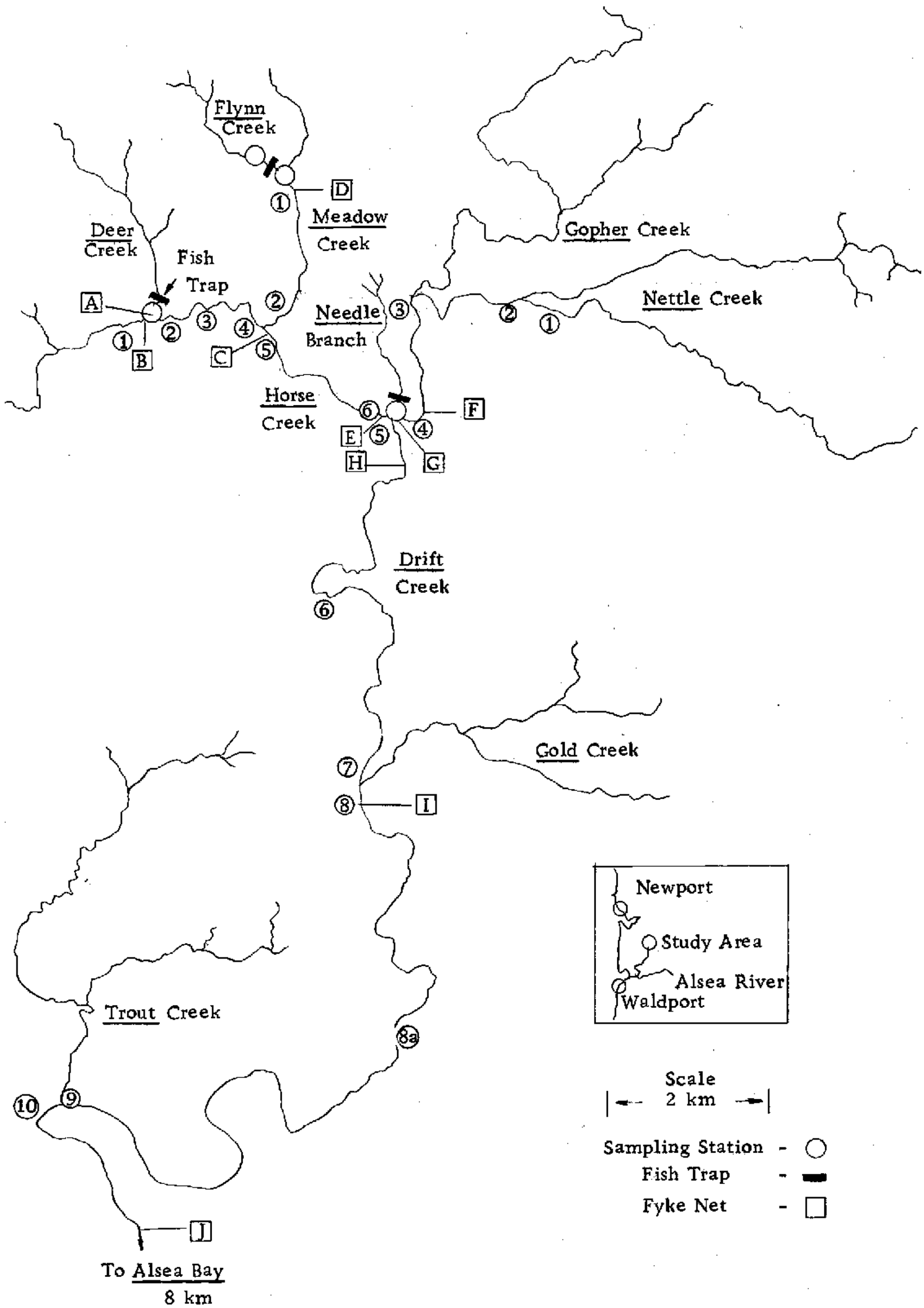

Figure 1. Map of the Drift Creek drainage showing location of sampling stations.

watershed was partially clearcut in three separate units, about 30% of the timber being harvested. A buffer strip was left along Deer Creek. The Flynn Creek watershed (203 ha) remained unlogged as a control during the study. Post-logging effects were monitored for 7 years.

Changes occurred in Needle Branch after logging. Sedimentation, water temperature, and base streamflows in summer and winter increased. Dissolved oxygen in surface and intragravel waters decreased. Cutthroat trout (Salmo clarki) decreased to about 30% of their pre-logging numbers. Numbers of newly emerged coho emigrating from Needle Branch were reduced by an average of 60%. Temperature, intragravel oxygen, trout and emigrant fry numbers have not returned to pre-logging levels 7 years after logging. Deer Creek, with the protective buffer strip, was little affected. Several authors document pre- and post-logging conditions in the study streams (Chapman, 1961; Hall and Lantz, 1969; Au, 1971; Lantz, 1972).

Morphologically, Meadow Creek and the upper areas of Horse Creek are similar to the three study streams. Drift Creek and the lower 800 m of Horse Creek, however, are characterized by streambeds of rubble or bedrock. Temperatures in Drift Creek commonly exceed 20° C during the summer, whereas the tributaries generally remain below 16° C.

Juvenile coho salmon and cutthroat trout are the predominant salmonid species present in the summer. Juvenile steelhead trout (Salmo gairdneri), the chinook salmon (Oncorhynchus tshawytscha), the reticulate sculpin (Cottus perplexus), and the longnosed dace (Rhinichthys cataractae) are found in Drift Creek.

MATERIALS AND METHODS

Marking

Emigrating coho fry received distinguishing ventral finclips as they moved into the traps from March through June 1972. Ventral finclips are permanent, easily recognized marks (Lindsay, unpublished data) and have been used for long-term identification of small salmonids (Slater, 1949; Hunter, 1959; Parker, 1968). Fry were marked with a left ventral finclip (LV) on Deer Creek, a right ventral clip (RV) on Needle Branch and a both ventral finclip (BV) on Flynn Creek. They were measured (fork length) to 0.5 mm and weighed to 1 mg. Groups of fry were held periodically during the migration period to assess short-term effects of handling. The fry were then released below the traps.

Population Estimates

Sampling stations were located to bracket the upper and lowermost limits of the dispersal of emigrant fry. Coho fry were collected at 19 stations (Fig. 1) in mid-July (7/4-7/24) and in early September (8/29-9/15) with a backpack electrofishing unit. A seine was also used in Drift Creek. Fish were anesthetized with MS-222 and examined for ventral fin marks. Emigrant and resident (unmarked) fry were measured to 0.5 mm fork length and weighed to

1 mg.

The three-catch removal method (Zippin, 1958; Seber and Whale, 1970) was used to estimate the number of fry at stations below the fish traps in Needle Branch, Deer, Flynn, Meadow, and Horse creeks. Fry were held in separate live boxes until after the third catch, counted, examined for marks, and released back into the stream.

Bailey's modification of the Petersen mark-recapture method (Ricker, 1958) was used to estimate populations at stations in Drift Creek and at a station above the trap in Flynn Creek. The area above the trap in Flynn Creek was the control during the study. Fry were marked on initial capture with an adipose finclip (AD) in July and a top-caudal clip (TC) in September. I monitored downstream movements during sampling periods with fyke nets (Fig. 1). Removal and mark-recapture methods were used together in July to provide comparative estimates at stations in Horse and Deer creeks.

Water temperatures in excess of 18° C in Drift Creek during July increased handling mortality and made it impossible to compute unbiased population estimates at every station. Procedures were modified to concentrate sampling during times of cooler temperatures. Under these conditions, I obtained reliable estimates for Stations 4 and parts of 5. By calculating a mean survival rate from July to September for these two stations and dividing the population estimates made in September at each station by this mean, I obtained estimates for each station in Drift Creek in July. Handling mortality was not significant in September.

The number of emigrant fry at some sampling stations was too small to allow direct estimation by either the mark-recapture or the removal method. Estimates were obtained for these stations by multiplying the proportion of emigrant fry by the number of total fry estimated by the mark-recapture or removal method.

The total stream area below the traps in Deer Creek, Flynn Creek, and Needle Branch was sampled. Sampling stations were established in Meadow, Horse, and Drift creeks and averaged 82 m, 74 m, and 180 m in length, respectively. Population estimates were expanded in these streams to include total emigrant and resident fry populations between the uppermost and lowermost sampling stations. The estimates were calculated in Meadow and Horse creeks by dividing the sum of the station estimates by the proportion of the total stream area that was sampled. Because riffle areas were not sampled in Drift Creek, estimates were expanded by dividing the sum of the station estimates by the proportion of the total pool area that was sampled. Underwater observations by snorkeling in 1971 had indicated relatively few coho fry inhabited riffle areas of Drift Creek and that time could be more profitably spent sampling pools. Stein et al. (1972) and Fortune and Laumen (1971) reported coho fry were found predominantly in the pools of three Oregon rivers. I believe the expanded estimates represented at least 75% of the total fry population between stations 3 and 8 in Drift Creek.

Confidence intervals for mark-recapture estimates were determined with computations and figures from Adams (1951). Intervals for removal estimates were obtained with computations from Zippin (1958).

Survival

Survival of emigrant fry was computed from estimates of daily instantaneous mortality rates for three time periods: 1) emigration to the July estimate, 2) July to the September estimate, and 3) emigration to the September estimate. From the model $N_d = \sum_{k=1}^{n} C_k e^{(-it_k)}$ mortality was calculated from the time emigrants moved past the traps to the time of population estimates in July (d=1) and in September (d=2). Fry emigrating on day k were designated as cohort C_k (n = total number of days cohorts were released). I assumed that each cohort decreased exponentially at a constant rate per day (i) from the day it was released below the trap to July and to September (t_k days). The value of i was varied in a computer program until the sum of all cohort survival (N_d) for a given mark equalled the LV, RV, or BV fry population in July or September. Median dates were used for the average time of population estimates in the six streams in July and September.

I used the time period between July and September to compare survival rates of emigrant and resident fry. Daily instantaneous rates (Ricker, 1958) were calculated to place mortality in comparable terms between streams. Survival rates were subsequently computed, based upon the average number of days between stream estimates in July and September.

Survival rates through the winter were estimated for coho populations above the traps in Deer Creek, Flynn Creek, and Needle Branch. These were used to approximate overwinter survival below the traps. The estimates also provided a means of evaluating differential mortality as a result of finclips applied in the summer. Survival was computed for a period that began in late August and ended on the mid-date of the smolt migration the next spring. Data used to obtain these estimates were collected by the Oregon Wildlife Commission (unpublished).

Contribution to Adult Returns

The contribution provided by emigrant fry to returns of adult and jack (2-year-old precocial male) salmon could be directly evaluated only in Needle Branch. During spring 1969, Oregon Wildlife Commission personnel marked all emigrating fry (6,935) with left-ventral finclips at the Needle Branch trap. Smolts of the same year class (emigrating spring 1970) received left-ventral-adipose combination marks (LVAD). The number of LV marks on mature fish returning to Needle Branch provided a way of assessing the contribution of emigrant fry. Trap records from Deer and Flynn creeks were also examined for the number of LV marks on adults and jacks entering these streams. There were no direct means of evaluating contributions to areas below the traps.

RESULTS

Distribution

Emigrating coho fry moved into the fish traps from mid-March to mid-July. Peak emigration occurred in May (Fig. 2). Totals of 3,375, 3,666 and 7,895 fry were marked and released from the Deer Creek, Flynn Creek, and Needle Branch traps, respectively. Their mean fork lengths were 40, 39, and 40 mm. Short-term mortality due to marking was less than 1% in Deer Creek and Needle Branch and 2% in Flynn Creek. I felt I was able to recognize ventral marks as finclips in July and September with less than 5% error.

Emigrant fry dispersed downstream after being released below the traps. The proportion of emigrants in samples of coho was highest directly below the traps and decreased farther downstream (Tables 1 and 2). A few marked on Deer Creek (LV) moved as far as 9.7 km downstream from the trap and were found at Station 8 in Drift Creek.

Some emigrant fry moved upstream after leaving the three study streams. A few marked on Needle Branch (RV) were found 1.7 km upstream in Drift Creek in September. Some RV fry moved from Drift Creek upstream into Horse Creek and subsequently into Meadow Creek. Emigrants from Needle Branch moved farther upstream than those from either Deer or Flynn creeks.

There were no significant changes ($P < .05$; χ^2 test) in the

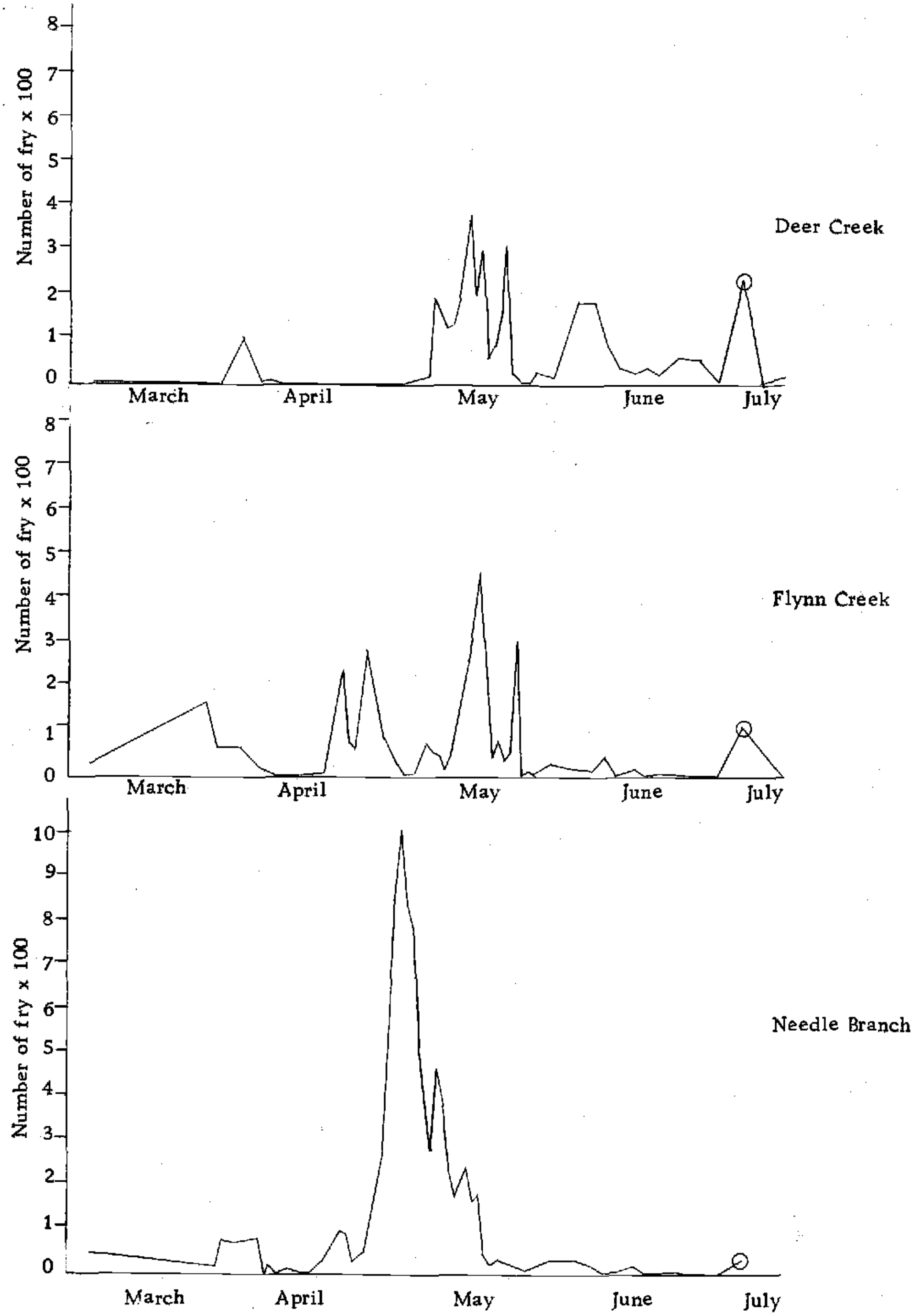

Figure 2. Pattern of fry emigration through the fish traps in the three study streams in 1972. Circled points represent releases of residual emigrant fry that had passed through the fine mesh of the fry enclosure but had remained in the trapping facilities.

Table 1. Distribution of emigrant fry from Deer Creek (LV), Flynn Creek (BV), and Needle Branch (RV) in July 1972 (7/4-7/24).

Stream	Station	Fin marks	Number of marks	Sample size	Percentage marked
Deer Creek	Below trap	LV	195	602	32.4
Flynn Creek	Below trap	BV	32	81	39.5
Needle Branch	Below trap	RV	182	197	92.4
Meadow Creek	1	BV	8	182	4.4
	2	LV	1	227	0.4
		RV	1	227	0.4
		BV	2	227	0.9
Horse Creek	1	No marks		106	--
	2	LV	17	287	5.9
	3	LV	3	227	1.3
		RV	1	227	0.4
	4	RV	1	118	0.8
	5	No marks		167	--
	6	LV	5	199	2.5
		RV	1	199	0.5
Drift Creek	3	No marks		234	--
	4	LV	1	612	0.2
		RV	3	612	0.5
		BV	1	612	0.2
	5	LV	12	1233	1.0
		RV	34	1233	2.8
		BV	8	1233	0.6
	6	RV	2	206	1.0
		BV	2	206	1.0
	7	LV	2	358	0.6
		RV	6	358	1.7
	8	LV	1	170	0.6
		RV	2	170	1.2
	8a	No marks		49	--
	10	Not sampled in July			

Table 2. Distribution of emigrant fry at the sampling stations in September 1972 (8/29-9/15). Significant changes (P <.05, 1 df) in the proportion of marks in each stream from July to September are indicated by an asterisk on the Chi-square value.

Stream	Station	Fin marks	Number of marks	Sample size	Percentage marked	Chi-square	
Deer Creek	Below trap	LV	107	421	25.4	LV	5.80*
Flynn Creek	Below trap	BV	23	53	43.4	BV	0.20
Needle Branch	Below trap	RV	131	141	92.9	RV	0.01
Meadow Creek	1	BV	4	137	2.9	BV	0.55
	2	RV	1	167	0.6		
		BV	1	167	0.6	RV	0.04
Horse Creek	1	No marks	--	102	--		
	2	LV	14	242	5.8		
		BV	1	242	0.4		
	3	LV	3	202	1.5	LV	1.27
		RV	1	202	0.5	RV	1.33
	4	RV	1	132	0.8		
	5	LV	2	234	0.8		
		RV	3	234	1.3		
	6	RV	2	258	0.8		
Drift Creek	3	RV	2	286	0.7		
	4	LV	1	442	0.2		
		RV	2	442	0.4		
		BV	1	442	0.2	LV	0.05
	5	LV	9	865	1.0	BV	0.28
		RV	23	865	2.7		
		BV	4	865	0.5	RV	0.03
	6	LV	1	313	0.3		
		RV	6	313	1.9		
		BV	2	313	0.6		
	7	RV	4	258	1.6		
	8	LV	1	138	0.7		
	8a	Not sampled in Sept.					
	10	No marks		20	--		

proportions of emigrant fry in each stream from July to September, except in Deer Creek (Table 2). This suggests that significant differential movement or mortality did not occur during this period. The decrease observed in Deer Creek was probably due to the large release of residual LV fry from the Deer Creek trap just prior to sampling in July (Fig. 2).

More emigrant fry established residence in Drift Creek than in the other five streams (Table 3). Those marked on Flynn Creek tended to concentrate in Meadow and Drift creeks, moving through the lower part of Horse Creek without establishing residence. Downstream movement of fry during sampling periods was negligible. Fyke nets caught an average of 2.2 coho per day in July and 0.1 per day in September (Appendix 1). Estimates made with the mark-recapture method generally yielded larger values than those made with the removal method, but the differences were not statistically significant (P= .09, n=9; randomization test for matched pairs in Siegel, 1956).

Survival

Approximately 3% (1,051) of all coho fry in the downstream areas in September were emigrants from the three study streams (Table 3). Their contribution to the coho populations ranged from 93.9% below the trap in Needle Branch to 1.9% in Meadow Creek.

Table 3. Estimated number of emigrant and resident fry in each stream in July and September, 1972. Confidence limits (95%) are in parentheses.[a]

	July					September				
	LV	RV	BV	Resident	Total	LV	RV	BV	Resident	Total
Deer Creek	170 (158-182)	0	0	392 (378-406)	562	113 (106-120)	0	0	323 (315-331)	436
Flynn Creek	0	0	34 (28-40)	35 (33-39)	69	0	0	24 (22-26)	30 (28-32)	54
Needle Branch	0	210 (185-250)	0	24 b	234	0	138 (131-145)	0	9 b	147
Meadow Creek	21	21	224	8, 917	9, 183	0	13	69	4, 141	4, 223
Horse Creek	539	64	0	19, 590	20, 193	209	77	10	12, 591	12, 887
Drift Creek	249	731	170	42,741	43, 741	85	264	49	16, 020	16, 418
Total	979	1, 026	428	71, 549	73, 982	407	492	152	33, 114	34, 165

[a] Total estimates in Meadow, Horse, and Drift creeks were expanded from estimates at sampling stations on each stream. Confidence limits for these stations are given in Appendix 2.

[b] Sample size was too small to compute confidence limits.

Average survival rates of all emigrant fry were 16% from the median date of emigration to July (66 days) and 7% from emigration to September (120 days). Those from Flynn Creek had lower survival rates than those from either Deer Creek or Needle Branch. Consequently, BV fry comprised 24% of the emigrant fry at the end of the downstream migration, but only 14% of the population in September. Emigrants marked with LV and RV finclips comprised 23 and 53%, respectively, at the end of migration and 39 and 47% by September.

Forty-three percent of the emigrant fry survived from July to September (54 days). Survival of resident fry was 46%. Although these rates were similar, emigrants had lower survivals than residents in the five streams sampled (Fig. 3). Survival above the trap in Flynn Creek was 78% during this period. Combined survival rates of emigrant and resident fry ranged from 84% below the trap in Flynn Creek, to 29% in Drift Creek. To show mortality in comparable terms between time periods, daily instantaneous mortality rates are given in Figure 4.

Handling coho fry when water temperatures exceeded 18° C greatly increased mortality in samples from Drift Creek in July. These deaths may have contributed to the decrease in fry numbers from July to September. Assuming this observed mortality was in addition to natural mortality, 2.6% of the deaths in Drift Creek during this period can be attributed to handling. Survival rates from

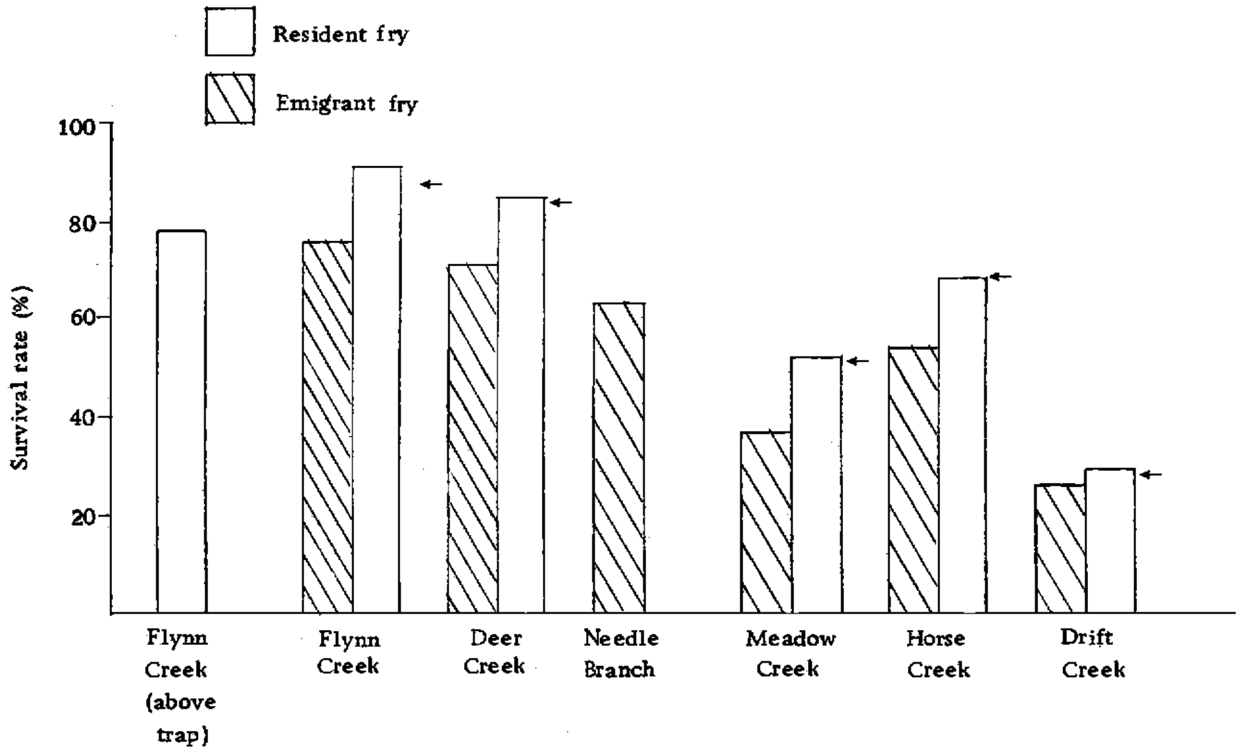

Figure 3. Survival rates of emigrant and resident fry in each stream from July to September (54 days). Arrows indicate combined survivals of emigrant and resident fry. Sample size was too small to compute survival estimates for residents in Needle Branch.

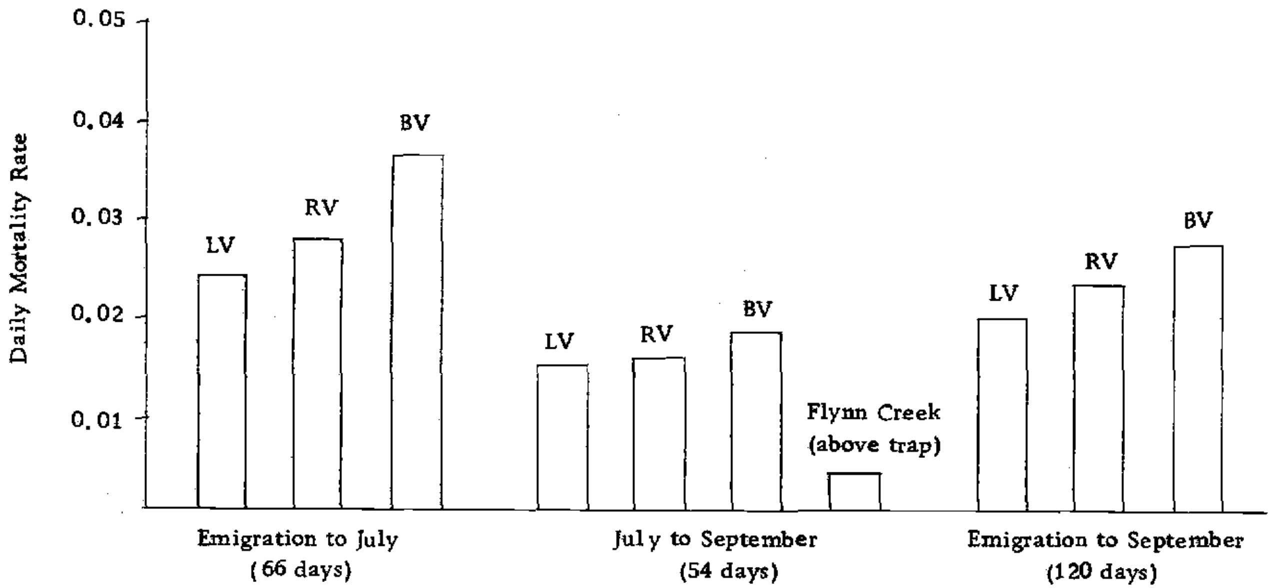

Figure 4. Daily instantaneous mortality rates for emigrant fry during three time periods in 1972.

July to September were computed on the basis of estimates made at cooler temperatures in Drift Creek and were not affected by handling mortality.

Overwinter survival of marked and unmarked coho above the study stream traps was 40% from late August 1972 to smoltification in mid-March 1973 (206 days). Fry marked with top caudal finclips (TC) during population estimates in August experienced lower survivals than fry not marked (19% vs. 58%) (Table 4). The differences were statistically significant ($P < .05$; sign test in Siegel, 1956). At least 90% of the TC marks were still recognizable when the smolts emigrated in the spring (Pohl, personal communication, Oregon Wildlife Commission). The survival rate of 58% may approximate that in areas below the traps through winter with the exception of Drift Creek. Here, winter conditions are probably more rigorous and survivals probably lower than in the smaller tributary streams.

On the average, the mean fork length of emigrant fry was 5 mm less than resident fry in both July and September. Differences in September ranged from 3 mm in Drift Creek to 12 mm in Deer Creek (Table 5). In July, emigrants were heavier for given lengths than residents in Flynn, Meadow and Horse creeks, but lighter than residents in Deer Creek. By September, resident fry were heavier than emigrants in each stream over the range of the lengths examined (4.1-9.7 cm). Slopes of regressions of log weight on log length

Table 4. Daily instantaneous mortality rates (i) for marked and unmarked coho fry above the trap from late summer to the mid-date of the smolt migration the next spring.[a] Survival rates, adjusted for 206 days, are in parentheses.

	Deer Creek	Flynn Creek	Needle Branch		
	1972	1972	1970	1971	1972
Days to mid-date of smolt migration	211	203	207	219	204
Finclip	TC	TC	LV	TC	TC
i_m (marked fry)	.0072 (18%)	.0061 (24%)	.0060 (24%)	.0047 (33%)	.0108 (8%)
i_u (unmarked fry)	.0031 (48%)	.0023 (58%)	.0024 (57%)	.0003 (93%)	.0026 (54%)
Ratio i_m/i_u	2.3	2.6	2.5	15.7	4.2

[a]Oregon Wildlife Commission, unpublished data.

Table 5. Mean lengths and weights of emigrant and resident fry in July and September. Significant differences (P <.05) between emigrant and resident lengths are indicated by an asterisk on the t value.

Stream	Fry type	July N	July Length (mm)	July Weight (gms)	July Difference in length	July t	September N	September Length (mm)	September Weight (gms)	September Difference in length	September t
Deer Creek	Emigrant	31	49.2	1.87	-2.6	0.99	36	50.4	1.60	-11.8	5.35*
	Resident	23	51.8	2.33			32	62.2	3.01		
Flynn Creek	Emigrant	31	46.5	1.63	-7.9	2.48*	23	54.6	2.02	- 5.5	1.59
	Resident	33	54.4	2.74			30	60.1	2.86		
Needle Branch	Emigrant	a	a	a			31	62.1	2.76		
	Resident	a	a	a			a	a	a		
Meadow Creek	Emigrant	5	41.8	0.80	-6.2	2.19*	6	51.6	1.80	- 4.0	0.79
	Resident	21	48.0	1.52			32	55.6	2.23		
Horse Creek	Emigrant	17	44.4	1.12	-11.0	4.82*	27	50.5	1.52	- 8.3	3.70*
	Resident	60	55.4	2.25			74	58.8	2.58		
Drift Creek	Emigrant	16	60.2	2.98	+3.8	1.85	31	63.6	3.05	- 2.6	1.94
	Resident	108	56.4	2.40			288	66.2	3.47		
Flynn Creek (above trap)	Resident	54	51.8	1.95			58	56.6	2.22		

[a]No data were taken.

differed significantly ($P < .05$; covariance tests) between emigrant and resident fry in each stream except Drift Creek in July (Appendix 3). Data from Needle Branch were incomplete and excluded from the analyses.

Contribution to Returns in Needle Branch

Eight adult and jack coho salmon marked with LV finclips as emigrating coho fry from Needle Branch entered the study streams in 1970-71 and 1971-72 (Table 6). They represented a known return of about 0.1% of the emigrants. Four jacks with LV clips contributed approximately 6% to the Needle Branch run in 1970-71. In 1971-72, one female and two male adults with LV clips contributed 4% to the run. One LV adult male entered Deer Creek in 1971-72. Returns could not be evaluated in areas below the traps.

Escapements in 1971-72 indicated that a large proportion of the coho entering Needle Branch were straying from other streams. All returning coho in this run year should have carried marks. Of 62 fish entering the stream, however, only 11% were returning coho marked as either emigrant fry or smolts. Fifty-five (89%) were fish with no marks or with marks not put on at Needle Branch. Straying of this magnitude invalidated comparisons of numbers of unmarked juveniles with numbers of unmarked adults of the same year class. The contribution of emigrant fry to returns in Deer and Flynn

Table 6. Summary of trap data for two spawning runs when the contribution of emigrant fry could be evaluated in the returns to Needle Branch.[a]

Year	Marks observed on returning coho				Marks expected on returning coho			
	Mark	Male	Female	Jack	Mark	Year applied	Age at marking	Age at return[b]
1970-71	No mark	16	2	40	No mark	1968	Fry	Adult
	LV	0	0	4[c]	LVAD	1968-69	Smolts	Adult
	LVAD	1	0	0	LV	1969	Fry	Jack
	Other	0	0	2[d]	LVAD	1969-70	Smolts	Jack
1971-72	No mark	36	15	3	LV	1969	Fry	Adult
	LV	2	1	0	LVAD	1969-70	Smolts	Adult
	LVAD	2[d]	2	0	e	1970	Fry	Jack
	Other	1	0	0	BV	1970-71	Smolt	Jack

[a] Oregon Wildlife Commission, unpublished data.

[b] Adult and jack coho in Needle Branch are 3 and 2-year-old fish, respectively.

[c] Count includes a fish (460 mm) whose scale was presumably misread as an adult and one with a missing maxillary bone. Missing maxillaries were not considered marks.

[d] One fish entered the Deer or Flynn creek trap before entering Needle Branch.

[e] Only 10 emigrant fry passed the trap in 1970. They were not marked.

creeks could not be evaluated because emigrants from these streams were not marked prior to 1972.

DISCUSSION

Coho salmon fry that emigrated from the three study streams survived in downstream areas and contributed to the spawning escapements. Many of them established residence in each of the six streams sampled and were not nomadic as Chapman (1962) had suggested.

Fry released below the traps did not evenly disperse and colonize the six streams, although the proportion in samples generally decreased downstream. Au (1971) hypothesized that the distribution of any group of coho fry depended on their "dispersiveness"--a function of their physiological readiness to settle to the stream bottom at night, modified by competitive interactions. The combined dispersal patterns of groups scattered spatially and temporally may result in a patchy distribution. The decrease in the proportion of emigrant fry downstream from the traps suggests that downstream movement of newly emerged coho simply represents a dispersal from redd sites above the traps.

Some emigrant and presumably resident fry moved upstream into Horse and Meadow creeks from Drift Creek during the summer. This response may have negatively biased estimates of survival in Drift Creek and positively biased them in Horse Creek. They probably immigrated to escape high summer temperatures in Drift Creek. Coho fry were no longer found in the Sixes River of Oregon as temperatures increased during the summer (Stein _et al._, 1972). Coho there were thought to have moved into cooler tributaries or to have died in the main river.

There was little evidence to suggest that fry emigrating from the study streams moved directly to saltwater. The farthest downstream any emigrants were found was about 10 km from the Deer Creek trap, although only small numbers of coho were collected below that point. I saw very few coho in the tidal waters of Drift Creek during observations with snorkeling gear in summers 1971 and 1972. Coho fry comprised less than 0.5% of 3,000 salmonids seined from Alsea Bay (Giger, personal communication, Oregon Wildlife Commission). One of Giger's sampling stations was near the mouth of Drift Creek. Very few underyearling coho were captured in several years of extensive seining in the estuary and fyke-net sampling in the Sixes River where it enters the estuary (Stein _et al._, 1972).

Pre-smolt coho are poorly equipped physiologically to survive emigration to undiluted saltwater, but survival may be possible in estuarine areas (Otto, 1971). Crone (1968) reported as many as 44,000 coho moved into Chatham Strait shortly after emergence from Sashin Creek in southeastern Alaska. On the basis of scales from returning adults, he concluded that none survived to return. Only 0.4% of 6,313 adult coho from streams in British Columbia had migrated to the sea as fry (Pritchard, 1940). Garrison (1971) reared coho fry to smolts in 90 days in a brackish water impoundment on Alsea Bay. His findings and those of Otto (1971) indicate the need for further research on the survival of coho fry that enter estuaries soon after emergence.

Seven percent of the fry emigrating to areas below the fish traps survived to September. About 20% of the coho remaining in the natal streams (above the traps) survive this period (Au, 1971). The difference in survival in the two areas is probably a real one, but the estimates were undoubtedly influenced to some degree by study procedures.

Causes for this diffference are difficult to assign. Fry emigrating downstream were probably more vulnerable to predation than residents with established territories. Continued movement would increase predator-prey contacts and result in higher mortality rates in emigrating fish. Cutthroat trout and large coho juveniles were probably the more important predators.

Differences in the size of emigrant and resident fry may have affected survival. Chapman (1962) found that emigrating coho were smaller on the average than those that did not migrate. Emigrants were also smaller than residents below the traps in July and September. Because size often governs position in social hierarchies (Chapman, 1962), more emigrating coho may have been displaced into exposed environments and those less suitable for growth. This would have increased predation and explained why residents were heavier than emigrants over the range of lengths examined in September. However, it may not be appropriate to compare the length-weight relationships of two groups of fish with different mean lengths since differences in conformation may be a normal consequence of allometric growth.

Stream environments in downstream areas were apparently more adverse than those farther upstream. Consequently, emigrant and resident fry in Meadow, Horse, and Drift creeks had lower survival rates from July to September than those in Flynn and Deer creeks. Downstream areas may have had higher water temperatures, more predators (McFadden, 1969), less cover and/or less food than areas upstream. The similarity in survival rates of emigrant and resident fry below the traps from July to September suggests that any differential mortality in these groups occurred before July.

Fin removal may have affected survival and growth of emigrants. Nicola and Cordone (1973) found that removal of a single ventral fin reduced survival of fingerling rainbow trout in Castle Lake by 60 to 70%. Marked pink salmon fry experienced an average survival rate to adulthood about 5.7 times lower than that of unmarked fry (Parker *et al.*, 1961). Data from my study indicated overwinter survival was considerably lower for fish finclipped in the summer than for those left unmarked (19 vs. 58%). From data given by Au

(1971), I computed an overwinter survival rate for marked fry in the three study streams and found a similar low average (22%) for 1963-68. Physical damage from handling, increased vulnerability to predators and a higher incidence of disease have been suggested as possible mechanisms of mortality in marked fish (Parker et al., 1961; Nicola and Cordone, 1973). Finclips on emigrant fry may have affected growth by lessening their ability to compete directly for the food resource or by altering their social position. Several authors have shown, however, that growth is generally not affected or affected only slightly by finclips (Shetter, 1952; Parker et al., 1961; Nicola and Cordone, 1973). Work needs to continue on better methods of marking large numbers of small salmonids.

Survival estimates would have been negatively biased if concentrations of emigrant fry had been missed in July and September. This may have occurred, since emigrants were not evenly distributed in downstream areas. The exclusion of a section of Meadow Creek directly below the mouth of Flynn Creek probably reduced survival estimates from emigration to July and to September for BV fry and for the total emigrant fry population. Samples from areas directly below the mouths of Deer Creek and Needle Branch in Horse and Drift creeks showed that these areas held relatively large numbers of emigrant fry.

A few adult and jack salmon marked as emigrating fry in 1969 on Needle Branch contributed to the spawning escapements in the study streams. This finding indicates some emigrant fry survived after September and suggests they contributed to spawning escapements in areas below the traps as well.

The return of emigrant fry as adults to a particular stream depends on the stage in their freshwater life when imprinting occurs and on their homing ability. Donaldson and Allen (1958) found that coho fingerlings transferred to Issaquah Creek after one year in Green River hatchery returned not to their natal stream to spawn, but to their point of release. Ricker (1972) suggested that coho fry rearing to smolts would home to nursery and not natal streams to spawn. On these bases, I speculate that emigrants imprint and home to streams in which they establish residence.

Straying in Needle Branch (89% in 1971-72) was much greater than that reported in other streams. Shapovalov and Taft (1954) found that 85% of all returning adults marked as smolts in Waddell Creek returned there to spawn. Fifteen percent strayed to Scott Creek. Of the returning adults marked as smolts in Scott Creek, 27% strayed to Waddell Creek and 73% returned to spawn. The percentage of straying in coho was considerably higher than in steelhead. Donaldson and Allen (1958) reported straying to be less than 1% (1 to 194 correct choices) in transferred coho fingerlings returning as adults to their point of release. Salo and Bayliff (1958), however, felt returns of unmarked coho to Minter Creek, in years when all juveniles of that year class were marked, were large enough to invalidate comparisons with earlier years when juveniles were not marked. Little detailed work has been done to determine the degree of precision of homing in coho salmon (Ricker, 1972).

The large number of strays observed in Needle Branch is not inconsistent with concepts of imprinting and homing in salmon. I believe the straying is a direct result of two factors present in Drift Creek: 1) a large population of coho fry rearing to smolts and 2) the small amount of spawning habitat available to returning adults (Lindsay, unpublished data). Fish returning to spawn in Drift Creek are confronted with a situation not unlike that of an impassable obstruction in a stream (Ricker, 1972). Since they are unable to find suitable habitat, coho may search out and ascend tributary streams to spawn. In these terms, straying in Needle Branch would be quite unlike that observed by Shapavolov and Taft (1954) and Donaldson and Allen (1958). This type of "forced" movement would have adaptive value for a species dependent upon small watersheds, historically susceptible to fires and, more recently, to logging.

It may be impossible to fully evaluate the effects of logging on spawning escapements in Needle Branch because large numbers of stray coho enter that stream. However, clearcut logging of the Needle Branch watershed may have reduced the number of coho fry that normally emigrate in spring soon after emergence. Because some of these fish survive in downstream areas and later contribute to spawning escapements, a reduction in their numbers could have a deleterious effect on coho stocks in the Drift Creek system. Results of this study emphasize the importance of maintaining water quality and spawning habitat in small tributary streams.

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APPENDIX

Table A-1. Summary of fyke net catches during summer 1972.[a]

Fyke net	Dates fished	Percent of stream width fished	Total hours fished	Total coho caught	Average catch/ day[b]	Marks	Fork length (mm)		
							n	$\bar{x}$	Range
A (Mouth of Deer Creek)	7/9-7/13	100	99	3	0.7	2 LV	2	42	40-44
B	7/9-7/13	100	99	0	0	--	--	--	--
C	6/27-7/9	95	285	15	1.2	0	14	40	36-49
D	7/4-7/7	100	78	1	0.3	--	1	38	--
E (Mouth of Horse Creek)	6/25-7/25	95	485	101	5.0	2 LV, 1 RV	97	54	39-100
	8/29-9/7	100	214	3	0.3	0	2	51	50-52
F	6/27-6/30	40	67	0	0	--	--	--	--
G	6/28-7/9	45	210	19	2.2	0	16	48	41-64
	8/29-9/7	70	214	0	0	--	--	--	--
H	6/27-7/9	35	207	11	1.2	0	11	50	38-98
	8/29-9/7	40	213	2	0.2	0	1	67	--
I	7/3-7/10	30	168	3	0.4	0	3	54	43-68
	8/29-9/5	40	169	0	0	--	--	--	--
J	6/30-7/1	20	19	0	0	--	--	--	--

[a] See Figure 1 for the location of the fyke nets.

[b] Catch adjusted for a 24 hour period.

Table A-2. Population estimates at stations in Meadow, Horse and Drift creeks in July and September.

Stream	Station	July N	July 0.95 Confidence Limit Lower	July 0.95 Confidence Limit Upper	September N	September 0.95 Confidence Limit Lower	September 0.95 Confidence Limit Upper
Meadow Creek	1	228	198	279	139	136	142
	2	459	346	651	177	167	187
Horse Creek	1	136	105	167	105	100	110
	2	281	232	330	276	252	300
	3	453	356	655	218	205	231
	4	226	157	390	135	130	140
	5	214	174	254	239	233	245
	6	672	460	1138	292	269	315
Drift Creek	3	1240[a]			466	367	596
	4	1980	1603	2680	730	612	890
	5	4202[a]			1584	1398	1851
	6	1948[a]			734	561	1022
	7	910[a]			343	299	424
	8	645[a]			243	187	351

[a]Estimates were back calculated from those made in September by using the survival rate (0.377) from July to September at Station 4 and parts of 5.

Table A-3. Statistics for the relationship between length (l) in mm and weight (w) in gms of the form: $w = al^b$. Significant differences ($P < 0.05$) between regression coefficients (b) for emigrant and resident fry are indicated by an asterisk on the t statistic (Sokal and Rohlf, 1969).

Stream	Type	July 1972				September 1972			
		Date	a+	b	t	Date	a+	b	t
Deer Creek	Emigrant	7/9-11	1.841	2.6613	-14.55*	9/14	0.110	3.0663	+18.32*
	Resident		3.072	2.8052			5.113	2.8697	
Flynn Creek	Emigrant	7/4	3.408	2.8278	+ 9.76*	9/15	0.144	3.1267	+30.74*
	Resident		2.280	2.7146			3.889	2.8005	
Needle Branch	Emigrant		++	++		9/12	1.293	2.5276	
	Resident		++	++			++	++	
Meadow Creek	Emigrant	7/4-18	9.066	2.9925	+ 7.76*	9/15	0.149	3.1361	+12.27*
	Resident		2.984	2.7590			5.388	2.8798	
Horse Creek	Emigrant	7/5-18	5.262	2.8860	+17.25*	9/11-15	0.415	3.3869	+29.55*
	Resident		1.860	2.6355			8.245	2.9846	
Drift Creek	Emigrant	7/19-23	9.528	3.0492	+ 0.92	8/31-9/6	5.184	2.8735	- 9.52*
	Resident		9.258	3.0398			7.124	2.9531	
Flynn Creek (above trap)	Resident	7/18	0.150	3.1743		8/21-22	0.237	3.2504	

+ Multiply these by 10^{-4}.

++ No data.