

Kalama River Studies Final Report
Part II. Juvenile Downstream Migrant Studies

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by

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Preface

This report is the second in a series of final reports which detail major aspects of Kalama River research. These are essentially summaries of data previously presented in annual progress reports Crawford et al. 1977 through Chilcote et al. 1984.

Presentation of results in this manner is intended to provide convenient access to salient study findings. Although additional detail may be found within individual annual reports, data presented here supersedes that in annual reports where discrepancies between the two exist. A listing of previously presented Kalama River Final Reports is shown below.

Part I. Leider S.A., M.W. Chilcote, and J.J. Loch. 1984.
Watershed spawning studies. Wash. Dept. Game Fish. Mgmt. Div.
Rept. 84-6.

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Introduction

Between 1974 and 1984, the Washington Department of Game conducted an investigation of hatchery and wild fish interactions within the Kalama River, Washington. A segment of this study was to investigate the downstream migration of juvenile steelhead and cutthroat trout. With the development of hatchery programs to enhance populations of wild salmonids, it has been shown that certain characteristics of the natural life history of wild salmonids must be duplicated if the program is to be successful (Royal 1972). Furthermore, information regarding the migrational behavior and population structure of salmonids are useful in the management of streams having wild populations. We collected basic life history data regarding run-size, migrational timing and age-length composition of juvenile outmigrants from 1978 to 1984. The purpose of this report is to summarize these data and highlight important findings.

Methods

Gobar Creek, a tributary of the Kalama River (Figure 1), was fished with a stationary fyke net trap, designed to block off the entire stream. From 1978 to 1981 the trap was located 500 meters up from the mouth of Gobar Creek (Crawford et al. 1978). However, the trap was relocated one kilometer further upstream following a severe channel change in the spring of 1982. The net measured 1.2 m X 1.2 m at the opening and had 6.0 m X 1.2 m wings with 6.4 mm mesh. The Gobar Creek trap was fished from sunset to sunrise each sampling night. From our preliminary

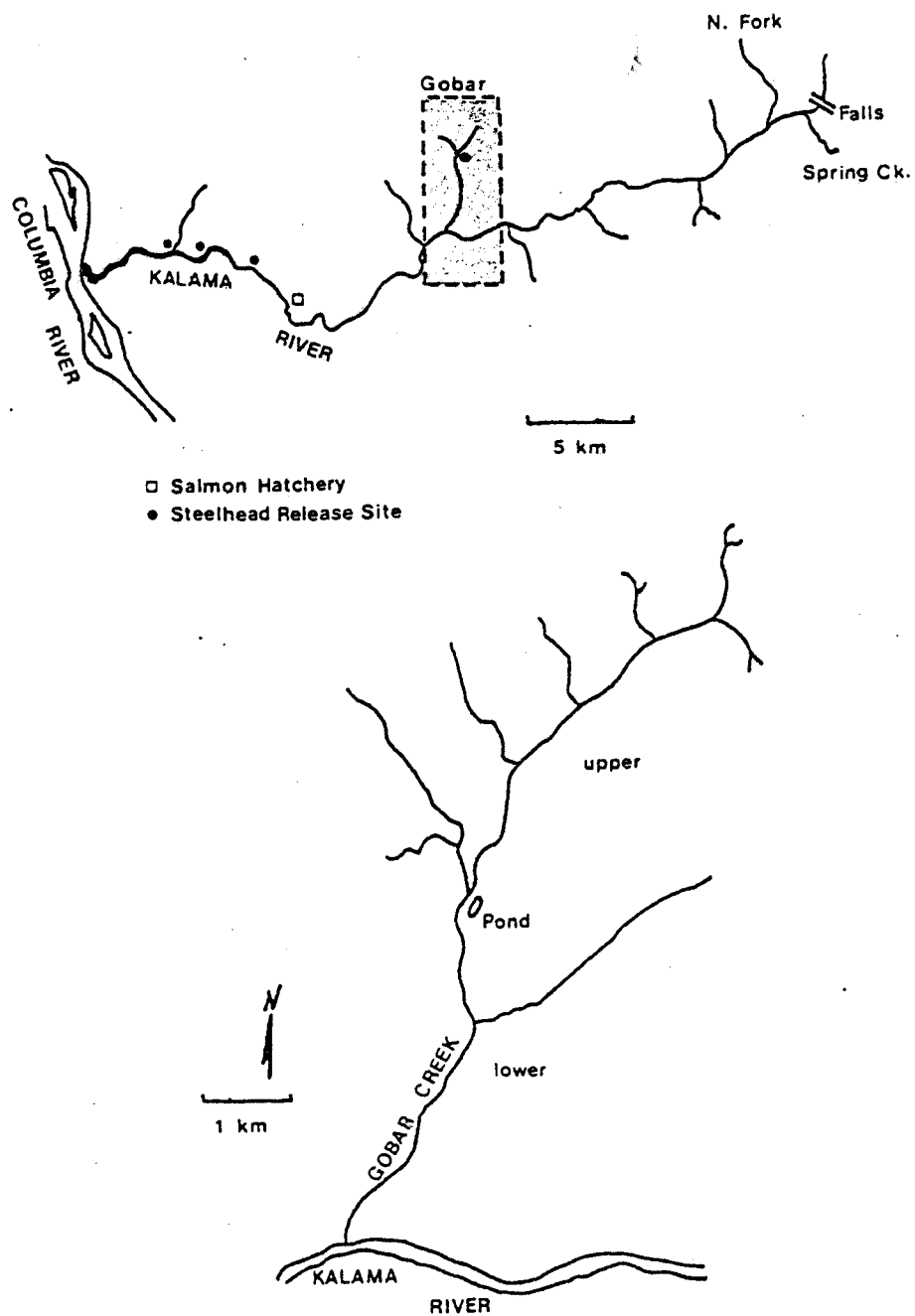


Figure 1. Map of the Kalama River drainage with enlargement of Gobar Creek, Washington.

sampling in 1977, it was determined that few juvenile steelhead and cutthroat trout migrated during the daylight hours. Sampling was conducted two to five nights each week. The fyke net was tended as frequently as dictated by flow conditions and migration intensity in order to minimize handling stress to the fish.

A traversing fyke net similar to that described by Tyler (1979) and Davis et al. (1980) was used to capture downstream migrants from the Kalama River at the Kalama Falls Salmon Hatchery (located 17 Km from the mouth of the Kalama River). The fyke net was constructed of 18 mm mesh knotless nylon with a 1.8 m X 1.8 m opening (Crawford et al. 1979). Gear efficiencies were developed from the recapture proportion of a known number of hatchery steelhead smolts released each year 19 Km above the Kalama River trap site. These recapture proportions were related to a corresponding river discharge (flow) from which a model was developed such that gear efficiency for any night could be estimated from the river flow observed for that particular night. Methodology for the estimation of the downstream migrant run-size and associated variance for both Gobar Creek and the Kalama River is described in Appendix 1.

All fish captured in the traps were separated by species and migrant group (i.e. parr or smolt). Smolts were "silvery", had loose scales, minimal parr markings, and usually greater than 110 mm in fork length, and were assumed to be migrating to the ocean. Parr were non-silvery, had non-loose scales and distinct parr marks, were generally less than 110 mm in fork length, and were not assumed to be ocean migrants. Fork length and weight measurements were taken from a sub-sample of migrants.

Additionally, scales were collected from a portion of the migrants for age determination. Condition factors were calculated for smolts using the method described by Bagenal and Tesch (1978). Water flow measurements were estimated by methods described in Appendix 2. Temperatures were recorded at the Kalama Falls Salmon Hatchery.

Beginning in 1981, watershed movement of Gobar Creek juvenile steelhead was examined by marking migrant juveniles with an identifiable fin clip (Chilcote et al. 1982).

Results and Discussion

Steelhead Migrants

Migration Timing

The downstream migration of juvenile steelhead smolts from Gobar Creek and Kalama River usually began early each March, and peaked during the first week of May (Table 1). Their emigration was essentially over by mid-June (Figure 2). Pautzke and Meigs (1940), Gudjonsson (1946), and Phillips et al. (1981) have reported similar timing for steelhead juveniles within other Washington streams.

In the Kalama River, smolt movement appeared to increase with decreasing water flow and increasing water temperature (Appendix 3). The average flow during the two week interval of maximum smolt outmigration (May 1-15) ranged from 760 cfs (1980) to 1268 cfs (1983) with a mean flow of 1067 cfs. Water temperature ranged between 6.7 °C (1980) and 12.8 °C (1979) with a mean of 9.3 °C. Similar patterns have been observed by

Table 1. Migration of wild steelhead smolts expressed as a percentage of total run size for Gobar Creek and Kalama River, 1978 through 1984.

Sampling Interval	Site ^a	Year							Average
		1978	1979	1980 ^b	1981 ^c	1982	1983	1984	
3/16-3/31	GB	7.5	1.9	0.0	0.0	9.9	4.5	0.0	3.4
	KR	2.1	3.3	2.0	0.0	7.8	0.0	6.6	3.1
4/01-4/15	GB	9.7	5.8	15.0	7.3	0.0	7.1	4.4	7.0
	KR	5.3	16.3	9.1	9.8	5.4	6.8	9.6	8.9
4/16-4/30	GB	24.6	24.5	27.6	61.7	15.3	26.3	36.7	31.0
	KR	3.5	28.5	27.4	17.2	13.3	56.8	33.1	25.7
5/01-5/15	GB	37.8	53.6	31.2	9.2	36.5	47.5	12.2	32.6
	KR	56.9	19.7	36.8	52.5	48.1	25.4	8.1	35.4
5/16-5/31	GB	11.5	9.3	17.2	19.3	24.8	12.0	21.1	16.5
	KR	29.9	21.9	20.4	13.0	25.4	11.0	39.9	23.1
6/01-6/15	GB	8.9	4.9	9.0	2.5	13.5	2.4	25.6	9.5
	KR	2.3	10.1	4.3	7.5	0.0	0.0	2.7	3.8

a

GB = Gobar Creek; KR = Kalama River

b

Values adjusted for comparison with entire time series; sampling terminated May 1980.

c

Trap relocated one kilometer upstream following severe channel change in spring of 1981.

Armstrong (1971) and Manion (1977) for other salmonids.

Gobar Creek steelhead parr migrants began their downstream migration early in March, peaked within the second week of May, and ended by early June (Figure 2). The timing of migrant steelhead parr from the Kalama River was significantly earlier than that of Gobar Creek juvenile migrant parr ($P < 0.05$; t-Test).

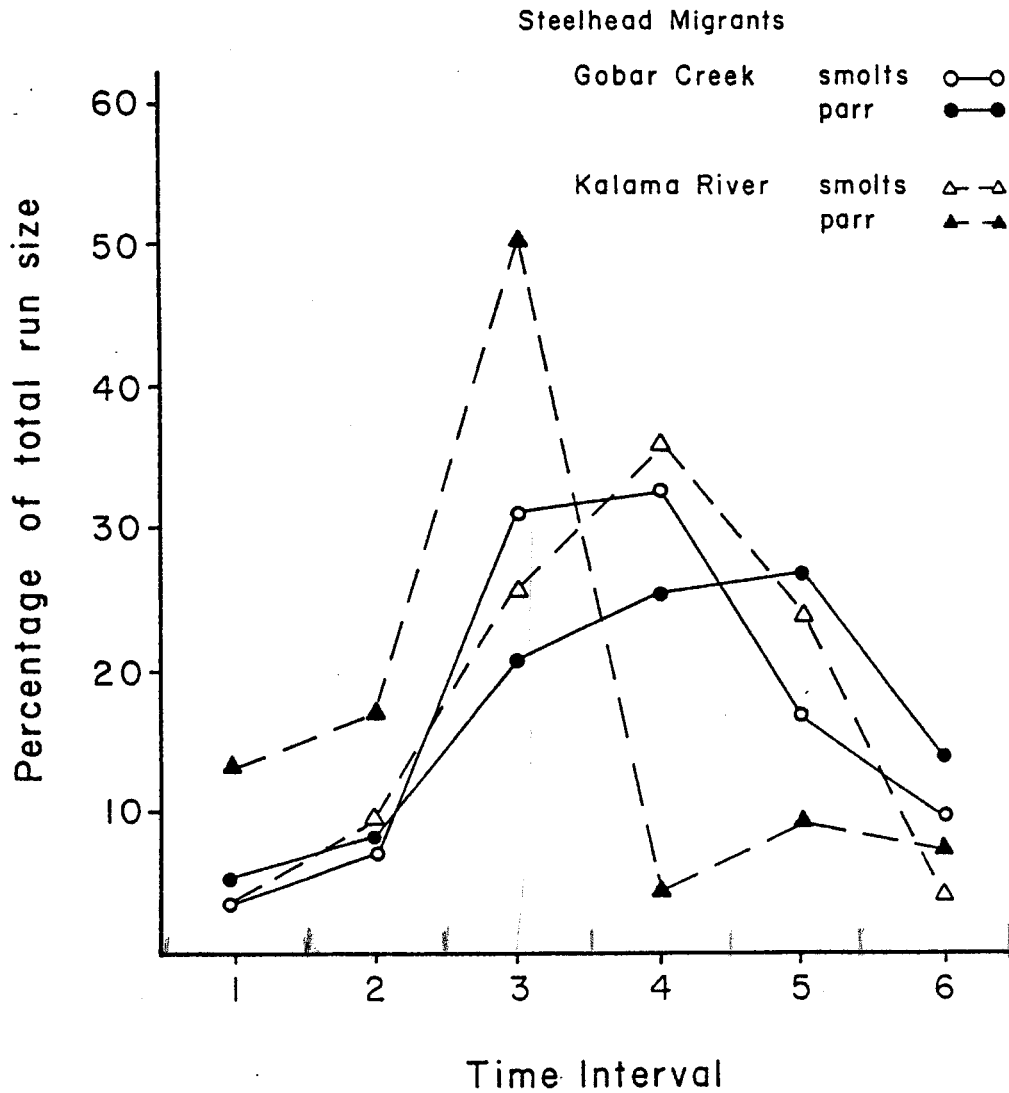


Figure 2. Average time of downstream migration (two week intervals) of steelhead smolts and parr from Gobar Creek and the Kalama River, 1978-84 (interval 1= 3/16-3/31; interval 2= 4/01-4/15; interval 3= 4/16-4/30; interval 4=5/01-5/15; interval 5=5/16-5/31; interval 6= 6/01-6/15).

Generally, Kalama River steelhead parr started their downstream migration in early March, peaked by late April and ended by early June (Figure 2). Interestingly, the Kalama River parr migration significantly preceded the peak smolt outmigration ($P \leq 0.01$; t-Test), whereas for Gobar Creek, the parr migration lagged slightly behind that of smolt migrants suggesting that different conditions may exist between the two sites.

Run Size

The average run size of steelhead smolts captured from Gobar Creek was 331 for the seven seasons with a low of 90 in 1984 and a high of 571 in 1979 (Table 2). For the same time period, the average number of smolts from the Kalama River was 28,259 with a low of 10,953 in 1982, and a high of 43,336 in 1983 (Table 2).

Steelhead parr comprised an average of 86.1 percent of all juvenile steelhead migrants (smolts and parr) for Gobar Creek. Steelhead parr in the Kalama River comprised only 44.1 percent of the total juvenile migrant run size (Table 2).

Daily captures of downstream migrant steelhead from Gobar Creek and the Kalama River are presented in Appendix 4.

For Gobar Creek, the association between the number of outmigrating steelhead parr and the number of outmigrating steelhead smolts of the following year was examined. A significant positive correlation existed between steelhead parr and associated smolts of the following year ($P \leq 0.05$; t-Test). However, no significant ($P > 0.05$) relationship was found for a similar test between Kalama River steelhead parr and

Table 2. Estimated yield of wild downstream migrant steelhead juveniles from Gobar Creek and Kalama River, 1978 through 1984.

Migrant Group	Year							Average + 95 % CI ^a
	1978	1979	1980	1981	1982	1983	1984	
Gobar Creek								
Smolt	349	571	301	316	222	465	90	331 ± 116
Parr	933	3,034	2,201	1,966	1,908	3,323	975	2,049 ± 679
Kalama River								
Smolt	35,166	34,356	23,804	37,082	10,953	43,336	12,113	28,259 ± 9,491
Parr	19,404	23,405	35,302	22,502	11,845	38,063	5,804	22,332 ± 8,600

^a

Confidence interval

smolts. These data suggest Gobar Creek smolt yield is related to density of yearlings, whereas Kalama River smolt yield is not.

Steelhead parr were marked to examine whether or not migrant steelhead parr were utilizing downstream areas for rearing. As reported by Chilcote et al. (1983) in some years marked parr moved back into pools, above the trap site, only to move back

downstream again at a later date. Recapture of marked and tagged parr indicated substantial instream movement. It was determined that approximately 82 percent of the fish originating from Gobar Creek and emigrating as smolts down the Kalama River, may have reared below Gobar Creek before smolting (Chilcote et al. 1984). Possible reasons for this instream movement behavior range from limited available rearing space, to displacement from periodic freshets. Additionally, as the growth of juveniles continues, their feeding requirement may also change, resulting in their relocation to downstream areas.

Age, Size, and Condition

The average age composition of Gobar Creek steelhead smolts was 15.8 percent age 1, 76.7 percent age 2, and 7.5 percent age 3. Their associated average fork lengths were 128.1 mm, 158.9 mm, and 178.0 mm, respectively. Similarly, the average age composition for Kalama River smolts was 6.1 percent age 1, 80.6 percent age 2, and 13.3 percent age 3. The average fork length of each age group was 141.6 mm, 160.8 mm, and 171.6 mm, respectively. Gobar Creek steelhead smolt production averaged 366 for the 1977-1981 brood years (Appendix 5), whereas for the same time period Kalama River production averaged 27,910.

Steelhead parr migrants from Gobar Creek averaged 85.8 mm in fork length with a range from 50.0 mm to 150.0 mm. Kalama River steelhead parr averaged 85.4 mm in fork length with a range from 53.0 mm to 153.0 mm (Appendix 6).

Little change in the relative percentage of age 1, 2, and 3 smolts were observed for Gobar Creek outmigrants over the seven

seasons. However, although not significant ($P > 0.05$), we found a decrease in the percentage of age 3 steelhead smolts captured in the Kalama Rivers, whereas age groups 1 and 2 slightly increased over the same period (Figure 3).

Gobar Creek smolts (all ages) were generally not as large as those from the Kalama River. Overall, mean fork lengths of Gobar Creek and Kalama River smolts were 154 mm and 161 mm, respectively.

The average weight of steelhead smolts migrating from Gobar Creek was 39.2 g and ranged from 27.6 g in 1984 to 47.1 g in 1978 (Appendix 5). Kalama River smolts ranged from 37.0 g in 1981 to 43.3 g in 1983 with an average weight of 39.6 g (Appendix 7). The average condition factor for Gobar Creek and Kalama River steelhead smolts was 1.05 and 0.94, respectively (Appendix 7).

Sex Composition

In 1983 and 1984, we sexed a sample of smolts from both Gobar Creek and the Kalama River. We found no significant ($P > 0.05$) size difference between male and female migrants between or within the two sampling locations for both years. For Gobar Creek, the male to female ratio for all ages was 1:1.21 in 1983 and 1:4.33 in 1984 (Appendix 8). The difference may be related to limited sample sizes in 1984. For Kalama River migrants, the male to female ratio was 1:1.19 and 1:1.36 for all ages in 1983 and 1984, respectively (Appendix 8). These findings appear to agree with other published studies. Shapovalov and Taft (1954) estimated sex ratios of downstream migrating steelhead to be close to 1:1 for steelhead age 2 and younger. Sex determination

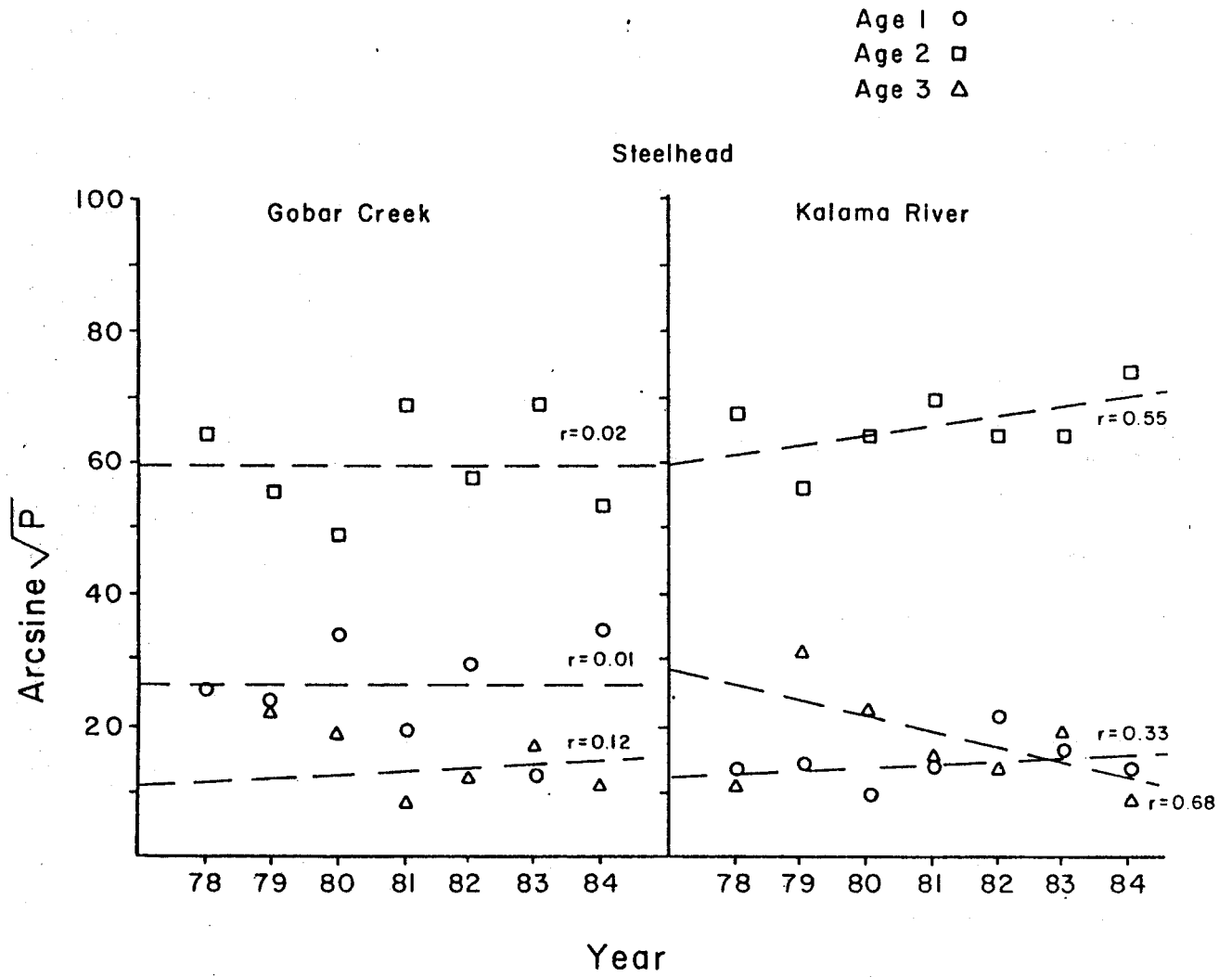


Figure 3. The proportion (P) of each migrant steelhead smolt age group observed emigrating from Gobar Creek and the Kalama River, 1978-1984.

was not conducted for juvenile steelhead migrants by Gudjonsson (1946), however, he calculated lengths up to first seaward migration from adult scale data. Gudjonsson (1946) found no significant difference in size between female and male smolts. Parker and Larkin (1959) demonstrated that in fresh water both sexes of winter-run steelhead grow at approximately the same rate.

Hatchery Steelhead Migrants

Migration Timing, Duration, and Size

The downstream movement of hatchery smolts after release into the Kalama River was rapid. The average elapsed time to first observation at the Kalama River trap was one day (Appendix 9). The peak outmigration for hatchery fish usually occurred three days following release. The mean duration of the migration interval was 16 days.

We compared the time for which hatchery fish peaked on their outmigration with the peak of wild fish and found that hatchery fish were significantly later than wild fish ($P \leq 0.05$; paired t-Test). However, when we excluded 1984 from our test, no differences were found in peak timing between the two groups.

Woodin et al. (1976) reported that residualism of hatchery fish released into Gobar Creek was minimal. Crawford et al. (1977) found that following release, as many as five percent (1,075) hatchery smolts remained in Gobar Creek after two months. However, Crawford et al. (1977) also indicated that the survival of hatchery residuals was poor, with few fish present by the fall of the same year. Trapping information suggested that no more

than 0.9 percent of the residual smolts remained in Gobar Creek to emigrate after two years in fresh water (Crawford et al. 1977). Natural mortality was stated as the principle cause of decline in numbers of residuals (Crawford et al. 1978). Additionally, a sport fishery for trout, size selective for the larger residuals, increased their stream mortality.

Hatchery-reared steelhead planted into Gobar Creek averaged 2.5 Kg^{-1} (5.4/lb). Fork lengths in 1978 and 1979 averaged 196.5 mm and 187.7 mm, respectively.

Cutthroat Migrants

Migration Timing

Juvenile cutthroat smolts from Gobar Creek and the Kalama River usually began their emigration in late March of each year. The emigration of Gobar Creek cutthroat smolts usually peaked during the middle of May whereas Kalama River cutthroat smolts peaked earlier (Table 3). The cutthroat smolt migration appeared to be nearly complete by mid-June at both locations (Figure 4). In the Kalama River, as shown for steelhead smolts, the period of greatest emigration for cutthroat smolts appeared to be associated with decreasing water flows and increasing water temperatures (Appendix 10). The mean water flow for the two week interval (May 1-15) of maximum smolt outmigration was 1135 cfs with a low of 760 cfs in 1980 and a high of 1611 cfs in 1982. The associated average water temperatures ranged from 6.7 C (1984) to 12.6 C (1979) with a mean of 9.1 C.

Cutthroat parr generally migrated from Gobar Creek beginning

Table 3. Migration of wild cutthroat smolts expressed as a percentage of total run size for Gobar Creek and Kalama River, 1978 through 1984.

Sampling Interval	Site ^a	Year							Average
		1978	1979	1980 ^b	1981 ^c	1982	1983	1984	
3/16-3/31	GB	4.8	0.9	0.0	4.1	2.6	0.8	0.0	1.9
	KR	1.7	1.2	0.0	10.2	13.2	6.4	0.0	4.7
4/01-4/15	GB	2.8	3.1	1.5	2.0	0.0	0.8	7.4	2.5
	KR	2.0	8.1	0.0	5.0	20.0	6.0	0.0	5.9
4/16-4/30	GB	8.4	23.8	15.1	11.5	4.1	13.6	10.1	12.4
	KR	18.1	18.3	0.0	23.5	13.0	33.3	27.0	19.0
5/01-5/15	GB	27.8	33.7	28.5	33.8	26.9	34.5	17.6	29.0
	KR	31.2	26.9	34.7	34.7	17.1	31.6	14.9	27.3
5/16-5/31	GB	45.3	25.4	44.1	38.1	53.0	43.6	47.3	42.4
	KR	42.8	36.2	64.5	7.1	36.7	22.7	53.3	37.6
6/01-6/15	GB	10.9	13.1	10.8	10.5	13.4	6.7	17.6	11.9
	KR	4.2	9.3	0.8	19.5	0.0	0.0	4.8	5.5

a

GB = Gobar Creek; KR = Kalama River

b

Values adjusted for comparison with entire time series; sampling terminated May 1980.

c

Trap relocated one kilometer upstream following severe channel change in spring of 1981.

in late March of each year, peaked by the latter part of May, and were finished by early June (Figure 4). Few cutthroat parr were ever captured at the Kalama River site, precluding comparison of timing with other migrant groups.

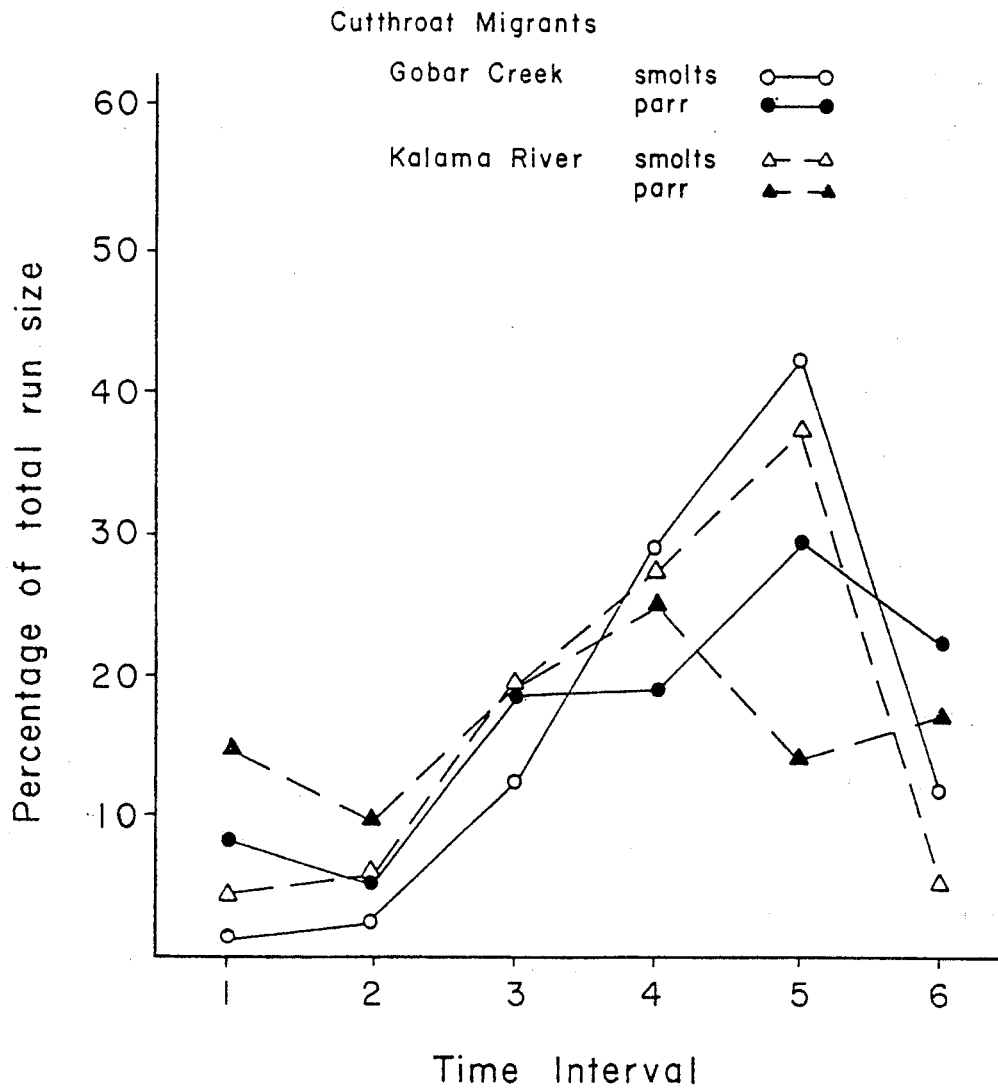


Figure 4. Magnitude of downstream migration (two week intervals) of cutthroat smolt and parr from Gobar Creek and the Kalama River, 1978-84 (interval 1= 3/16-3/31; interval 2= 4/01-4/15; interval 3= 4/16-4/30; interval 4= 5/01-5/15; interval 5= 5/16-5/31; interval 6= 6/01-6/15).

Run Size

The average run size for cutthroat smolts from Gobar Creek was 454 with a high of 610 in 1983 and a low of 148 in 1984 (Table 4).

For the Kalama River, cutthroat smolts had an average run size of 7,737 with a low of 163 in 1980 and a high of 16,229 in 1983 (Table 4).

The run size of cutthroat parr averaged approximately 17 percent of all cutthroat migrants sampled from Gobar Creek and only 11 percent for Kalama River cutthroat migrants (Table 4).

Daily captures of cutthroat downstream migrants for Gobar Creek and the Kalama River are presented in Appendix 4.

Age, Size, and Condition of Migrants

The average age composite of Gobar Creek and Kalama River cutthroat smolts was similar. The mean age composition of Gobar Creek cutthroat smolts was 6.5 percent age 1, 69.6 percent age 2, and 23.9 percent age 3. Their associated fork lengths were 126.3 mm, 155.0 mm, and 175.1 mm, respectively. Kalama River cutthroat smolts were comprised of 2.2 percent age 1, 73.1 percent age 2, and 24.7 percent age 3 and were of 123.0 mm, 163.0 mm, and 199.0 mm, respectively. Average production of cutthroat in Gobar Creek and the Kalama River for the 1977 to 1981 brood years was 465 and 7,865, respectively (Appendix 11).

Cutthroat parr migrants from Gobar Creek averaged 99.8 mm in fork length and ranged from 60.0 mm to 168.0 mm. Kalama River cutthroat parr averaged 118.4 mm with a range of 90.0 mm to 143.0 mm (Appendix 12).

Table 4. Estimated yield of wild downstream migrant cutthroat juveniles from Gobar Creek and Kalama River, 1978 through 1984.

Migrant Group	Year							Average \pm
	1978	1979	1980	1981	1982	1983	1984	95% CI ^a
Gobar Creek								
Smolt	539	587	397	391	509	610	148	454 \pm 118
Parr	143	50	59	40	134	173	47	92 \pm 41
Kalama River								
Smolt	8,296	7,535	163	14,704	2,943	16,229	4,286	7,737 \pm 4,417
Parr	146	1,100	3,235	466	45	248	1,048	898 \pm 824

a

Confidence interval

Over the seven year period the percentage of age 3 cutthroat from Gobar Creek decreased significantly ($P \leq 0.05$; t-Test) whereas age 2 smolts significantly increased ($P \leq 0.05$; t-Test). Although not significant, the percentage of age 1 cutthroat smolts, beginning in 1981, declined (Figure 5). Similar to steelhead smolts, Gobar Creek cutthroat smolts generally were smaller than Kalama River smolts. Overall, the average length of Gobar Creek and Kalama River cutthroat smolt (all ages) was 157 mm and 166 mm, respectively. The average weight of cutthroat

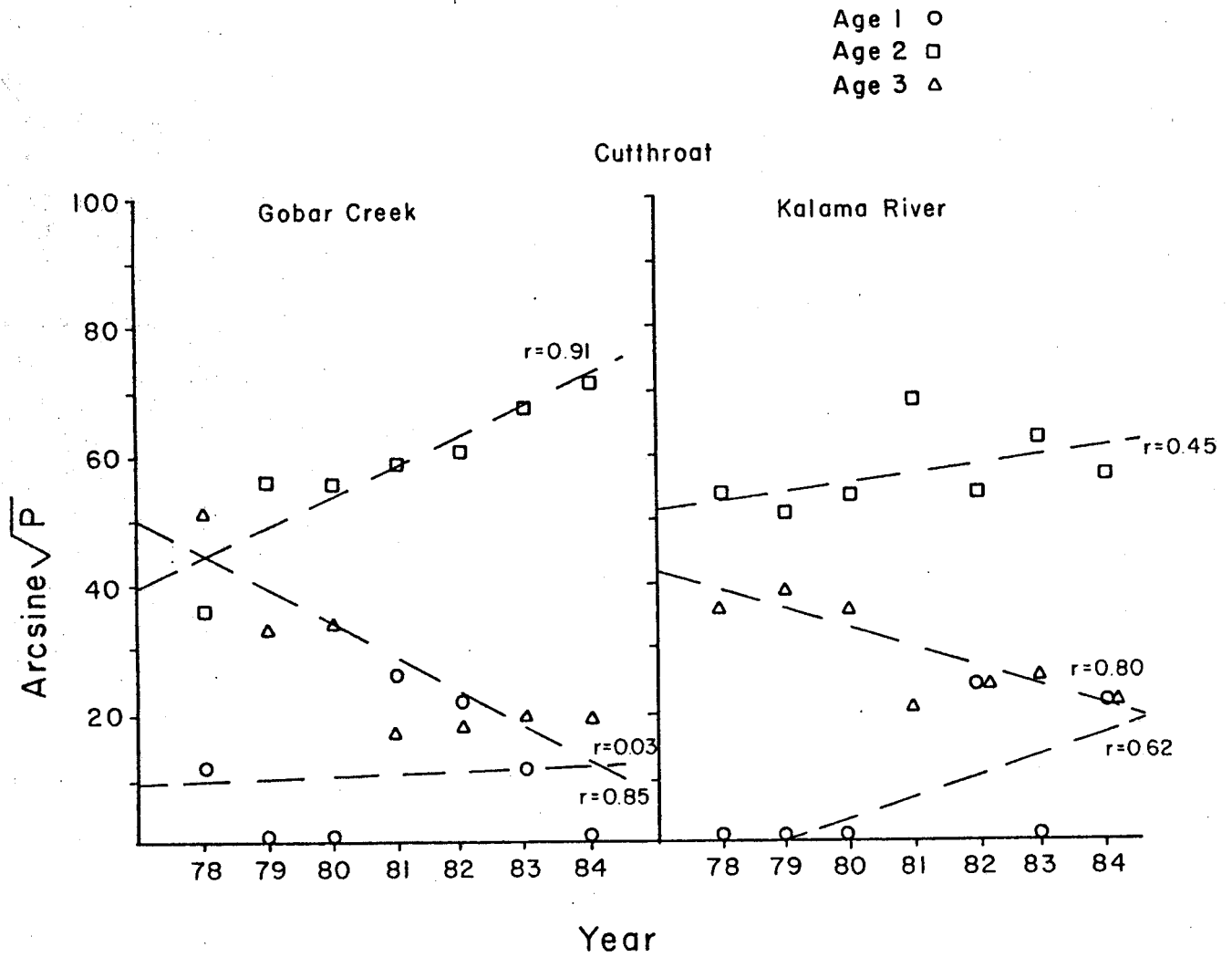


Figure 5. The proportion (P) of each migrant cutthroat smolt age group observed emigrating from Gobar Creek and the Kalama River, 1978-1984.

smolts from Gobar Creek was 37.4 g and ranged from 29.9 g in 1981 to 42.3 g in 1983 while Kalama River cutthroat smolts ranged from 35.9 g in 1979 to 48.7 g in 1982 with a mean of 41.7 g (Appendix 13). The average condition factor for Gobar Creek and Kalama River cutthroat smolts was 0.95 and 0.91, respectively (Appendix 13).

Inter-species Comparisons

The downstream timing of Gobar Creek cutthroat smolt migrants was significantly later than that of steelhead migrants ($P \leq 0.01$; paired t-Test). Steelhead and cutthroat smolt timing within the Kalama River was essentially the same.

The average run-size for Gobar Creek steelhead smolts was not significantly different from cutthroat smolts ($P > 0.05$; t-Test). However, the average run-size for Kalama River steelhead smolts was significantly greater than for cutthroat smolts ($P \leq 0.01$; t-Test). Furthermore, the average run-size for steelhead parr was significantly greater than that of cutthroat parr for both Gobar Creek and Kalama River ($P \leq 0.01$; t-Test).

The mean parr-to-smolt ratio of steelhead emigrating from Gobar Creek was 6:1 whereas the parr-to-smolt ratios for cutthroat averaged 1:5. For Kalama River migrants, the mean parr-to-smolt ratios were 1:1 and 1:9 for steelhead and cutthroat, respectively. The mean ratio of steelhead smolts to cutthroat smolts was 1:1 for Gobar Creek and 4:1 for the Kalama River.

The age composition of steelhead was comprised of more age

1 and 2 smolts than for cutthroat at either sampling location, cutthroat trout smolt consistently had a greater percentage of age 3's than steelhead smolts.

Applications to Management

The importance of a tributary to steelhead production can not be evaluated solely on the basis of smolts produced. Migrant parr are a substantial part of the production that complete their freshwater cycle in the mainstem (become smolts), yet depend on tributaries for a critical portion of their life. Destruction of tributary habitat destroys more in terms of smolt production (system wide) than the number of smolts which actually migrate out of the creek. Regulating the alteration of stream side habitat to minimize negative impacts would provide protection to rearing habitat for juvenile salmonids. Tributaries are even more critical to cutthroat trout as indicated by our parr to smolt ratios for cutthroat and steelhead, Gobar Creek vs. Kalama River. It appears cutthroat parr do not utilize mainstem rearing areas to the same extent as do steelhead. Therefore, cutthroat smolt yield depends heavily on the availability of quality tributary habitat.

Although cutthroat smolts (all ages) are similar in size to steelhead smolts at the time of emigration, an examination of the age composition of cutthroat and steelhead smolts suggests that cutthroat tend to be comprised of a greater proportion of older smolts than steelhead. Given this extended rearing time within tributaries, cutthroat are more subject to increased mortality

from fishing pressure.

It is critical that several years of run-size data are collected when attempting to determine "average" smolt yield or production for a given stream. Smolt run-size varies greatly from year to year and this variation should not be ignored.

Our data provides baseline information useful in measuring the response of wild juvenile steelhead and cutthroat populations to potential changes in harvesting regulations and management strategies.

In addition, the setting of opening dates and size limits by management biologists to ensure protection of both juvenile steelhead and cutthroat rearing within tributary streams, should consider the data provided by our studies.

Future Research Needs

To provide a better understanding of wild steelhead and cutthroat trout within the Kalama River watershed, basic life history information regarding run-size, migrational patterns, and production of smolts has been collected. We suggest future work involve a more detailed examination of size of specific age groups, migrational behavior patterns of specific age groups, and relative survival rates of specific age groups. By having baseline information regarding wild populations, a means for evaluating future management strategies is possible. The downstream migration of parr to mainstem areas has been reported for other areas (Bjornn 1978; Tredger 1980). Habitat selection and interspecific interaction for food and rearing

areas are possible reasons migrant parr utilize mainstems for rearing (Everest and Chapman 1972). A number of questions remain to be investigated regarding migrant parr. How successful are these migrant parr relocating (selecting a micro-habitat) within the mainstem? What is the smolt-to-adult survival rate of these parr? Are some of these migrants emigrating as far as the estuary as Chapman (1958) suggested for Alsea River age 0+ steelhead migrants? Why and to what degree do the number of parr migrants from tributaries change each year? Evaluation of the relationship of carrying capacity of a natal stream with respect to the number of migrant parr migrating in a given year should be one of the objectives of future juvenile life history studies in addition to those stated previously. We recommend that mainstem production of salmonids and their relative contribution to returning adults be investigated.

Over the seven years that our juvenile migrant study was conducted, both Beaver Creek and Skamania hatchery stocks of steelhead smolts have been planted into the Kalama River watershed. Earlier plants of Gobar pond conditioned fish consisted of summer-run smolts only. However, in recent years a 50-50 mix of both winter- and summer-run steelhead smolts have been planted into Gobar Creek and the mainstem Kalama River after rearing in Gobar Pond. Although residualism is often minimal (Woodin et al. 1976 ; Crawford et al. 1977; and Crawford et al. 1978), evaluation of the rate of outmigration of these different steelhead groups would provide valuable information for managers regarding the degree to which one race tended to remain within a stream following planting. Additional questions include: what

size smolt should be planted? What are the smolt-to-adult survival rates for hatchery fish released into rivers vs. tributaries? Do large releases into streams influence the movement of other salmonids (i.e. wild) to migrate abnormally? The recapture proportion of a known number of hatchery smolts released above the Kalama River trap site was used to develop a model for gear efficiency of the traversing fyke net.

These hatchery smolt releases were usually completed within a one week period. We recommend that investigations using traversing fyke systems use several multispecies release groups (i.e. coho and steelhead) over wider time frames and flow levels. This would increase the accuracy of gear efficiency estimates and model development for each species and age group captured. We further recommend that a live box be attached to the cod end of the fyke net to reduce impingement and scaling of captured fish, and reduce handling and subsequent mortality. Although more costly and labor intensive, two traversing fyke nets located a distance from one another could further improve gear efficiency estimates. Actively migrating fish captured in the upper trap could be marked and released, and then be re-sampled at the lower trap site. This method would allow a mark recapture population estimate and would avoid the problem of determining gear efficiency based only upon hatchery fish recaptured from single releases. Opportunities would exist to obtain gear efficiency estimates for all species and age (size) groups observed. In general, our traversing fyke net system was relatively inexpensive, required minimal maintenance, was

operated by a single individual, and allowed access to a substantial number of emigrating fish. Providing gear efficiency can be effectively determined as outlined above, we recommend its use to anyone interested in sampling large river systems.

Summary

Steelhead

The smolt outmigration for both Gobar Creek and Kalama River began early March of each year, peaked during the first week of May and ended by mid June.

The period of maximum outmigration for wild smolts appeared related to that time period for which water flow levels were declining and water temperature were increasing.

The average smolt run size for Gobar Creek was 331 smolts with a range of 90 to 571 for the seven year period. An average of 28,259 smolts with a range of 10,953 to 43,336 migrated from the Kalama River over the seven year period. Parr comprised an average of 86.1 percent and 44.1 percent of the total number of outmigrants (smolts and parr) observed in Gobar Creek and Kalama River, respectively.

A significant ($P \leq 0.05$; t-Test) relationship existed between the number of migrant parr migrating and the number of smolts of the following year.

The majority of smolts for both Gobar Creek and the Kalama River were 2 years old, 76.7 percent and 80.6 percent, respectively.

The average fork length of age 2 smolts was 159 mm and 161 mm for both Gobar Creek and Kalama River, respectively.

No significant size difference existed between male and female migrant smolts within or between locations. Male to female

ratios indicated the smolt populations were typically composed of slightly more females than males.

Hatchery-reared released into Gobar Creek moved downstream rapidly. The average number of days to peak migration at the Kalama River trap occurred three days following release with an average duration of 16 days.

Cutthroat

The outmigration of both Gobar Creek and Kalama River smolts began in late March of each year. Gobar Creek smolts peaked during the second week of May, Kalama River smolts usually peaked slightly earlier. Both migrations ended their migration by mid-June.

Average run size for smolts emigrating from Gobar Creek (1978-1984) was 454 with a range of 148 to 610. For the Kalama River, smolt run size averaged 7,737 between 1978 and 1984 with a range of 163 to 16,229.

Parr averaged approximately 17 and 11 percent of all migrants (smolts and parr) sampled from Gobar Creek and the Kalama River, respectively.

The majority of smolts from both Gobar Creek and Kalama River were age 2, 69.6 % and 73.1%, respectively.

The average length of age 2 smolts was 155 mm and 163 mm for Gobar Creek and Kalama River, respectively.

Steelhead and Cutthroat Comparisons

For Gobar Creek and the Kalama River, the mean time of migration for cutthroat smolts was 1-2 weeks later than for steelhead smolts.

The ratio of steelhead smolts to cutthroat smolts was approximately 1:1 for Gobar Creek. However, for the Kalama River it was nearly 4:1, suggesting significant differences existed in the degree to which steelhead and cutthroat utilized the mainstem and tributary for smolt production.

The proportion of age 3 smolts was greater for cutthroat than it was for steelhead.

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(APPENDICES)

Appendix 1. Downstream migrant run-size estimate procedure for Gobar Creek and the Kalama River.

The following general equation was used to estimate run-size:

$$1) \hat{N} = \sum_{j=1}^6 A_j / a_j (\sum n_{ij})$$

where,

\hat{N} = Total estimated run-size,

A_j = Total number of days in the j^{th} sampling interval
(season was divided into 6 of approximately the same number of days),

a_j = Number of days in the j^{th} interval actually sampled,

n_{ij} = Number of individuals captured on the i^{th} night of the j^{th} interval.

Equation 1 was used to compute run-size estimates for Gobar Creek. However, for the Kalama River the estimator differed from that of Gobar Creek. Because it was not possible to fish the entire width of the Kalama river it was necessary to expand actual captures by the gear efficiency (sampling proportion) of our fyke net, to obtain n_{ij} 's for use in equation 1. The following equation was used to estimate n_{ij} 's for the Kalama River:

$$2) \hat{n}_{ij} = c_{ij}/(GE_{ij})$$

where,

\hat{n}_{ij} = The estimated number of fish which would have been captured on the i^{th} night of the j^{th} interval if it had been possible to block and trap the entire river,

c_{ij} = The number of fish caught on the i^{th} night of the j^{th} interval,

GE_{ij} = The gear efficiency for the net on the i^{th} night of the j^{th} interval.

Preliminary data indicated that an inverse relationship existed between gear efficiency and river discharge (flow). Therefore, to determine n_{ij} , we set out to develop a model whereby for any known flow (in cfs), a gear efficiency could be estimated and be used in equation 2. We constructed this model from the recapture proportion of a known number of hatchery fish released above the trap site and river discharge on the night of peak recaptures. For each year we estimated gear efficiency (GE_k) on hatchery steelhead from:

$$3) GE_k = A_k/a_k (c_{ik})/R_k$$

where,

GE_k = The gear efficiency for the k^{th} year of hatchery smolts,

A_k = The interval length (in nights) between the first and last observed recapture of hatchery smolts for the k^{th} year,

a_k = Number of nights in the k^{th} interval
actually sampled,

c_{ik} = Number of hatchery smolts recaptured on the
 i^{th} night of the k^{th} year,

R_k = Number of hatchery smolts released upstream
for the k^{th} year.

To complete our model development we needed to obtain flow rates for the Kalama River that corresponded to the night of peak hatchery smolt captures for each year of trapping. In addition, once this model was developed, we ultimately needed flow rates for the entire sampling season (92 nights/year) so that they could be used in computing n_{ij} 's (see equation 2). Unfortunately, USGS river discharge records do not exist for the Kalama River after 1975 (our years of interest were 1978 to 1984). However, we were able to develop a significant ($P < 0.05$) relationship between Kalama River flows and flows of an adjacent river, the Coweeman, during a 15 year period (1960 - 1975) when coincident measurements were made on both systems (Appendix 2). When the appropriate GE_k 's (equation 3) and flows were regressed, a significant ($P < 0.05$) exponential relationship was determined, from which the following equation was developed for estimating gear efficiencies:

$$4) \hat{GE}_{ij} = 1.694 e^{-0.004 F_{ij}}$$

where,

\hat{GE}_{ij} = The estimated gear efficiency for the i^{th}
night of the j^{th} interval,

F_{ij} = The estimated flow (cfs) for the Kalama River on the i^{th} night of the j^{th} interval (Appendix 1).

Because of the range of points (flows) used to develop equation 4, the following limits were put on the values which could be substituted for F_{ij} :

If $F_{ij} > 1451$ cfs, then $F_{ij} = 1451$ cfs, and

If $F_{ij} < 772$ cfs, then $F_{ij} = 772$ cfs.

Run-size estimates for the Kalama River were made by preceding from equation 4, to equation 2 and finally to equation 1; substituting the appropriate values at each step. We computed the run-size variance for both Gobar Creek and Kalama River from:

$$5) \hat{V}(\hat{N}) = \sum_{j=1} (A_j^2 - a_j A_j / a_j) (a_j \sum_{i=1} n_{ij}^2 - (\sum_{i=1} n_{ij})^2 / a_j (a_j - 1))$$

where,

$\hat{V}(\hat{N})$ = The variance associated with the run-size estimate, \hat{N} ;

A_{ij} , a_j , and n_{ij} = as defined in equation 1.

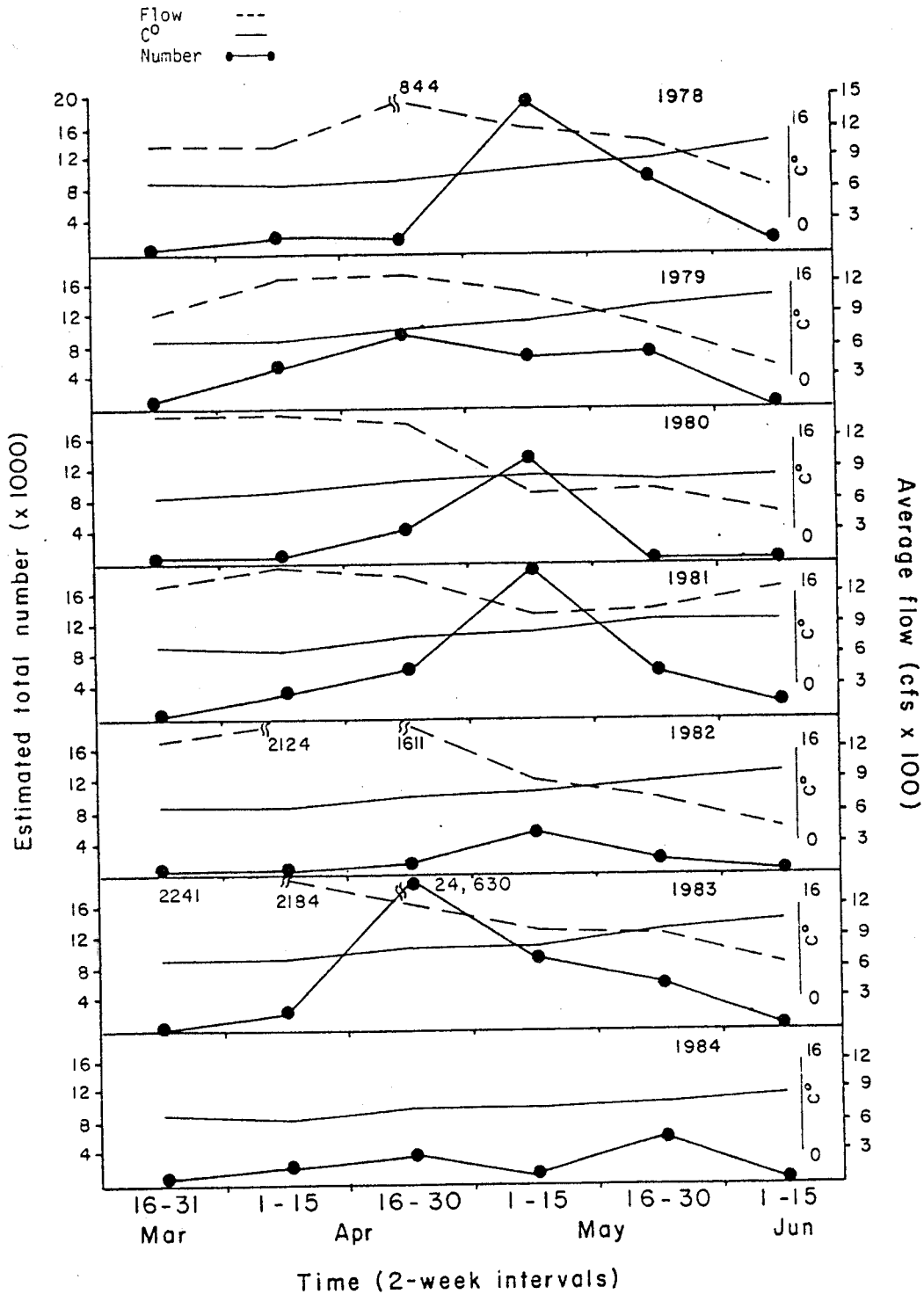
Appendix 2. Method used to estimate flows for the Kalama River, 1978-1984.

River flow data (USGS) does not exist for the Kalama River prior to 1975. It was necessary to develop a model to predict daily flows based upon a relationship between the Kalama River and adjacent river system with complete flow data records. Information was obtained for the Coweeman River for 1960 through 1984. Daily flows were correlated between the Coweeman River and the Kalama River from mid March through mid June of each year from 1960 through 1975. A statistically significant ($P \leq 0.05$) regression resulted. To increase the precision of the estimator model, the sampling period was divided into six time intervals. For each of the six time intervals, significant correlations were found ($P \leq 0.05$). Regression equations, with the appropriate Coweeman River flow data, were used to estimate daily flows between mid-March and mid-June for the Kalama River from 1978 through 1984 and are shown in the following table:

Interval	Date	Days	Model	r^a
1	3/16-31	16	$F = 453.80 + 2.08x$	0.92*
2	4/01-15	15	$F = 438.39 + 1.91x$	0.92*
3	4/16-30	15	$F = 536.64 + 1.83x$	0.88*
4	5/01-15	15	$F = 429.63 + 2.26x$	0.85*
5	5/16-31	16	$F = 518.70 + 2.23x$	0.88*
6	6/01-15	15	$F = 250.70 + 2.89x$	0.95*

^a

r = correlation coefficient; * = significant at 95% level



Appendix 3. Estimated total number of steelhead smolts, average water flow, and average water temperature by sampling interval, Kalama River, 1978-1984.

Appendix 4a-n. Gobar Creek and Kalama River nightly captures of juvenile steelhead and cutthroat migrants, 1978-84.

Appendix 4a. Daily downstream migrant count for Gobar Creek, 1978.

Date	Steelhead		Cutthroat	
	Parr	Smolt	Parr	Smolt
3-16	0	0	1	0
3-20	1	2	0	2
3-23	4	3	0	3
3-27	6	3	0	1
3-30	0	0	4	2
4-03	1	0	0	1
4-06	11	4	1	0
4-10	7	4	0	3
4-13	6	1	0	0
4-17	3	8	0	2
4-20	2	3	0	0
4-24	12	6	1	2
4-27	22	6	2	8
5-01	28	12	3	3
5-04	5	8	2	3
5-08	27	2	1	5
5-11	16	16	3	27
5-15	40	6	2	12
5-18	22	5	7	14
5-22	4	2	1	12
5-25	11	1	3	20
5-29	13	2	2	15
Total	241	94	33	135

Appendix 4b. Daily downstream migrant count and estimated flow data for the Kalama River, 1978.

Date	Steelhead		Cutthroat		Estimated Flow (cfs)
	Parr	Smolt	Parr	Smolt	
3-23	1	1	0	1	947
3-27	1	2	0	0	1,140
3-30	1	0	0	0	1,082
4-03	0	0	0	1	1,023
4-06	5	1	0	0	1,397
4-10	5	6	0	0	988
4-13	1	7	1	0	925
4-17	0	1	0	0	1,219
4-20	2	0	0	0	1,662
4-24	4	0	0	0	2,028
4-27	4	1	0	2	1,570
5-01	5	14	0	2	1,264
5-04	1	36	0	1	1,112
5-08	3	48	0	3	927
5-09	7	43	0	6	916
5-10	0	42	0	11	916
5-11	0	52	0	11	1,105
5-15	0	3	0	0	2,712
5-18	2	5	0	2	1,487
5-22	1	15	0	3	1,121
5-25	1	17	0	1	1,027
5-29	2	10	0	6	1,114
6-01	9	10	0	11	829
Total	55	314	1	62	

Appendix 4c. Daily captures of downstream migrants for Gobar Creek, 1979.

Date	Steelhead		Cutthroat	
	Parr	Smolt	Parr	Smolt
3-19	9	1	0	0
3-21	11	1	1	0
3-23	18	0	0	0
3-26	6	1	0	2
3-28	7	0	0	0
3-30	3	1	2	0
4-02	7	2	0	1
4-04	7	0	0	1
4-06	25	4	0	0
4-09	7	2	1	2
4-11	17	3	0	2
4-16	25	4	1	0
4-18	17	2	1	2
4-20	20	4	0	4
4-25	108	19	3	20
4-27	89	11	3	12
4-30	85	16	1	18
5-02	30	8	0	2
5-04	104	72	0	28
5-09	34	5	0	5
5-11	29	10	0	13
5-14	61	7	1	18
5-16	47	2	0	7
5-18	57	2	0	8
5-21	37	5	0	11
5-23	47	4	0	4
5-25	49	7	1	13
5-30	26	0	1	13
6-01	50	1	0	12
Total	1032	194	16	198

Appendix 4d. Daily downstream migrant count and estimated flow for the Kalama River, 1979.

Date	Steelhead		Cutthroat		Estimated Flow (cfs)
	Parr	Smolt	Parr	Smolt	
3-19	10	2	0	0	1,009
3-21	18	1	2	0	959
3-23	22	1	1	1	895
3-26	9	6	0	1	859
3-28	4	2	0	0	911
3-30	3	1	0	0	859
4-02	3	7	0	1	977
4-04	6	0	0	0	1,009
4-06	23	5	1	2	983
4-09	3	9	0	0	1,042
4-11	2	3	1	1	1,458
4-12	0	4	0	0	1,565
4-13	1	0	0	0	2,142
4-16	1	1	0	0	1,589
4-18	1	1	0	0	1,514
4-20	8	2	1	1	1,316
4-23	0	36	0	4	1,148
4-25	12	4	0	0	1,089
4-27	11	10	0	3	1,025
4-30	9	11	0	1	956
5-02	5	24	0	0	938
5-04	4	19	0	0	1,019
5-07	2	3	0	0	1,910
5-08	1	0	0	0	1,636
5-09	0	0	0	1	1,410
5-10	4	2	0	4	1,268
5-11	3	4	0	9	1,166
5-14	4	7	0	10	995
5-16	9	40	0	10	1,000
5-18	2	10	0	2	945
5-21	8	40	0	10	887
5-23	12	19	0	7	876
5-25	10	27	0	13	842
5-30	9	10	0	9	818
6-01	3	5	0	13	598
Total	222	316	6	103	

Appendix 4e. Daily captures of downstream migrants for Gobar Creek, 1980.

Date	Steelhead		Cutthroat	
	Parr	Smolt	Parr	Smolt
3-24	2	0	1	0
3-31	2	0	0	0
4-03	6	1	0	0
4-07	12	5	0	2
4-14	41	9	4	0
4-17	50	1	1	1
4-21	57	9	1	6
4-24	18	3	0	2
4-28	26	9	0	7
5-01	34	6	1	1
5-08	24	4	1	3
5-12	42	3	1	13
5-15	35	12	0	13
Total	349	62	10	48

Appendix 4f. Daily captures of migrants and estimated flow for the Kalama River, 1980.

Date	Steelhead		Cutthroat		Estimated Flow (cfs)
	Parr	Smolt	Parr	Smolt	
3-17	1	0	0	0	1,941
3-20	1	0	0	0	1,972
3-24	0	1	0	0	1,569
3-31	2	0	0	0	1,294
4-04	0	0	0	0	1,057
4-07	0	1	0	0	1,842
4-10	0	0	0	0	2,539
4-17	3	0	0	0	1,291
4-21	0	1	0	0	2,129
4-24	6	4	0	1	1,364
4-28	37	7	0	1	1,086
5-01	0	25	0	0	972
5-05	2	52	9	0	864
5-06	0	57	0	2	852
5-08	2	66	0	8	814
5-12	5	86	0	18	780
5-15	2	36	0	11	762
Total	61	336	9	41	

Appendix 4g. Daily captures of downstream migrants from Gobar Creek, 1981.

Date	Steelhead		Cutthroat	
	Parr	Smolt	Parr	Smolt
3-30	3	0	0	1
4-06	7	0	0	0
4-13	7	3	0	1
4-20	12	2	0	2
4-23	31	7	0	1
4-27	29	16	1	5
4-30	90	27	1	4
5-04	18	4	1	3
5-06	31	0	2	1
5-11	45	7	0	11
5-13	81	12	0	14
5-14	36	6	0	15
5-18	56	10	0	22
5-20	24	3	2	10
5-21	19	6	3	7
5-25	20	2	0	8
5-27	23	2	2	3
5-28	26	0	0	6
6-01	10	2	0	4
6-03	14	0	1	4
6-04	9	0	0	2
6-11	0	0	0	1
Total	591	109	13	125

Appendix 4h. Daily captures of downstream migrants and estimated flow for the Kalama River, 1981.

Date	Steelhead		Cutthroat		Estimated Flow (cfs)
	Parr	Smolt	Parr	Smolt	
3-30	1	0	0	1	1,201
4-02	0	1	0	0	1,477
4-06	5	0	0	1	1,569
4-09	1	2	0	0	1,237
4-13	0	1	0	0	2,807
4-16	4	1	0	0	1,547
4-20	4	0	0	2	1,225
4-23	2	2	0	1	1,239
4-27	5	7	1	5	1,113
4-30	7	12	0	3	1,102
5-04	2	34	0	7	1,053
5-07	0	13	0	4	1,209
5-11	0	31	0	12	1,053
5-14	1	53	0	9	931
5-18	2	22	1	17	1,107
5-21	0	21	0	11	1,141
5-25	0	14	0	8	1,322
5-28	0	11	0	7	1,081
6-01	1	16	0	7	771
6-04	2	26	0	7	837
6-11	1	0	0	2	2,375
Total	38	267	2	104	

Appendix 4i. Daily captures of downstream migrants from Gobar Creek, 1982.

Date	Steelhead		Cutthroat	
	Parr	Smolt	Parr	Smolt
3-19	7	4	1	0
3-24	0	0	1	2
3-25	16	3	2	1
3-29	2	0	0	1
3-31	2	0	2	0
4-01	0	0	1	0
4-05	2	0	1	0
4-07	1	0	0	0
4-08	1	0	0	0
4-19	0	0	0	0
4-21	5	0	0	1
4-22	11	2	0	1
4-26	25	6	1	1
4-27	9	4	0	1
4-28	5	3	1	3
4-29	0	0	0	1
4-30	8	3	1	3
5-03	8	0	1	4
5-04	4	2	0	0
5-06	15	15	1	8
5-07	13	6	0	6
5-12	52	5	9	13
5-13	44	4	1	12
5-14	93	6	2	21
5-17	27	7	1	11
5-18	56	6	7	20
5-20	62	5	2	22
5-24	87	5	3	29
5-25	41	1	3	19
5-27	27	0	0	3
5-31	32	0	0	14
6-01	6	1	2	3
6-03	22	0	1	4
6-08	45	1	5	9
6-10	44	6	1	2
Total	772	95	50	215

Appendix 4j. Daily captures of downstream migrants and estimated flow for the Kalama River, 1982.

Date	Steelhead		Cutthroat		Estimated Flow (cfs)
	Parr	Smolt	Parr	Smolt	
3-22	2	1	0	1	1,153
3-25	6	2	0	0	1,036
3-29	0	0	0	0	1,261
4-01	1	1	0	1	1,372
4-05	1	0	0	0	1,720
4-08	1	0	0	0	1,372
4-12	1	0	0	0	2,348
4-15	2	0	0	0	2,482
4-19	0	0	0	0	1,576
4-22	3	0	0	0	1,362
4-26	2	3	0	1	1,152
4-29	4	1	0	0	1,113
5-06	4	2	0	0	943
5-13	3	36	0	4	841
5-17	7	27	0	6	931
5-20	3	9	0	7	862
5-24	1	5	1	3	811
5-27	1	0	0	0	806
5-31	0	0	0	3	751
6-03	0	0	0	0	566
6-07	0	0	0	0	566
Total	42	87	1	26	

Appendix 4k. Daily captures of downstream migrants from Gobar Creek, 1983.

Date	Steelhead		Cutthroat	
	Parr	Smolt	Parr	Smolt
3-16	0	0	0	0
3-17	0	0	1	2
3-21	18	4	0	0
3-22	15	2	3	0
3-24	12	6	0	1
3-28	3	0	0	0
3-29	0	0	0	0
3-30	0	0	0	0
3-31	0	0	0	0
4-01	0	0	0	0
4-04	0	0	0	0
4-05	21	0	0	0
4-06	37	1	1	0
4-07	0	0	0	0
4-08	44	2	0	1
4-11	0	0	0	0
4-13	18	1	0	0
4-14	72	7	0	1
4-15	116	11	0	1
4-18	106	9	2	5
4-19	57	4	4	4
4-20	77	8	2	3
4-21	26	5	2	4
4-22	67	8	2	2
4-25	11	2	0	1
4-26	32	11	4	6
4-27	10	4	1	2
4-28	40	14	0	12
4-29	68	17	1	16
5-02	60	19	4	11
5-03	61	16	0	7
5-04	126	31	6	17
5-05	63	13	1	23
5-06	44	14	4	9
5-09	26	6	0	4
5-10	32	6	1	9
5-11	80	13	10	32
5-17	108	8	7	32
5-18	65	3	5	22
5-20	118	13	8	39
5-23	38	0	1	8
5-24	108	4	5	21
5-25	79	4	9	21

Appendix 4k (continued)

5-26	18	0	3	2
5-27	33	2	5	14
5-30	15	1	7	5
5-31	17	0	0	2
6-02	13	3	0	2
6-03	20	0	2	8
6-07	3	0	0	0
6-10	5	0	0	1

Total	1,982	272	101	350
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Appendix 41. Daily captures of downstream migrants and estimated flow for the Kalama River, 1983.

Date	Steelhead		Cutthroat		Estimated Flow (cfs)
	Parr	Smolt	Parr	Smolt	
3-17	5	0	0	0	1,775
3-21	5	0	0	1	1,203
3-31	0	0	0	0	3,199
4-04	0	1	0	0	2,043
4-07	3	1	0	0	1,388
4-14	6	1	0	1	1,124
4-18	28	14	0	6	1,031
4-21	13	28	0	3	967
4-25	2	6	0	2	1,027
4-28	7	33	0	7	926
5-02	1	0	0	0	832
5-05	1	0	0	0	789
5-09	2	7	1	7	1,019
5-12	2	51	1	22	873
5-13	1	34	0	12	843
5-14	3	32	0	12	834
5-16	2	19	0	13	996
5-20	0	0	0	0	889
5-23	0	0	0	0	844
5-26	0	1	0	4	806
6-02	0	0	0	0	664
Total	81	228	2	90	

Appendix 4m. Daily captures of downstream migrants from Gobar Creek, 1984.

Date	Steelhead		Cutthroat	
	Parr	Smolt	Parr	Smolt
3-29	11	0	0	2
4-02	21	1	0	1
4-05	5	0	0	0
4-09	0	0	0	0
4-12	0	0	0	0
4-16	13	3	0	3
4-19	8	2	0	0
4-23	18	3	0	2
4-26	8	3	0	0
4-30	10	0	1	0
5-03	0	0	0	0
5-07	9	2	0	3
5-10	0	0	0	0
5-15	9	1	1	4
5-17	20	4	0	9
5-21	4	0	1	2
5-24	9	0	0	0
5-29	31	1	2	8
5-31	6	1	0	3
6-04	18	2	1	4
6-07	15	2	5	3
6-11	11	1	0	0
6-14	20	1	2	0
Total	246	27	13	44

Appendix 4n. Daily captures of downstream migrants and estimated flow for the Kalama River, 1984.

Date	Steelhead		Cutthroat		Estimated Flow (cfs)
	Parr	Smolt	Parr	Smolt	
3-19	0	0	0	0	2,213
3-22	0	0	1	0	3,366
3-26	1	1	0	0	2,328
3-29	0	0	0	0	2,070
4-02	3	1	0	0	1,304
4-05	2	0	0	0	1,176
4-09	0	1	0	0	1,951
4-12	0	0	0	0	2,807
4-16	1	0	0	1	1,677
4-19	1	1	0	0	1,340
4-23	2	13	0	2	1,155
4-26	1	4	0	1	1,053
4-30	0	3	0	0	1,236
5-03	0	0	0	0	- - -
5-07	0	0	0	0	- - -
5-10	0	1	0	0	1,340
5-13	0	0	0	0	- - -
5-14	1	1	0	1	1,505
5-15	0	0	0	0	- - -
5-17	0	3	0	2	1,455
5-21	2	12	1	4	1,281
5-24	1	0	0	0	1,669
5-29	0	0	0	0	- - -
5-30	0	0	0	0	- - -
5-31	2	2	0	3	1,311
6-04	0	1	0	1	1,112
6-07	0	1	0	0	1,037
6-11	0	0	0	0	- - -
6-14	0	0	0	0	- - -
Total	17	45	2	15	

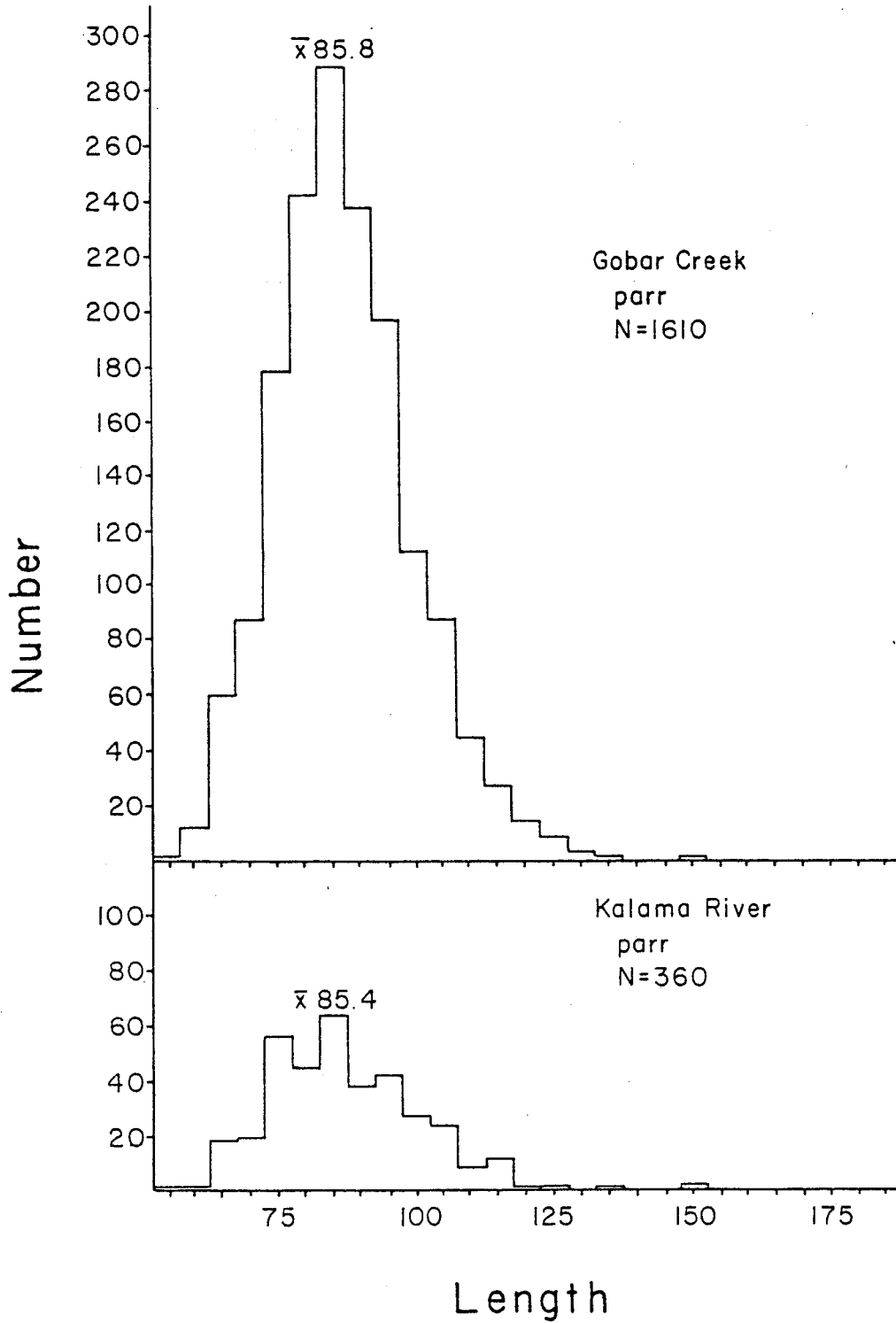
Appendix 5a. Steelhead smolt run-size, age composition, and production for Gobar Creek, 1978-1984.

Year Captured	Brood Year									Estimated Yield
	1975	1976	1977	1978	1979	1980	1981	1982	1983	
Age Group	<u>3</u>	<u>2</u>	<u>1</u>							
1978 (n)	0	285	64							349
(%)	(0.0)	(81.8)	(18.2)							
Age Group		<u>3</u>	<u>2</u>	<u>1</u>						
1979 (n)		90	391	90						571
(%)		(15.7)	(68.6)	(15.7)						
Age Group			<u>3</u>	<u>2</u>	<u>1</u>					
1980 (n)			32	172	97					301
(%)			(10.7)	(57.1)	(32.1)					
Age Group				<u>3</u>	<u>2</u>	<u>1</u>				
1981 (n)				7	273	36				316
(%)				(2.0)	(86.5)	(11.5)				
Age Group					<u>3</u>	<u>2</u>	<u>1</u>			
1982 (n)					11	158	53			222
(%)					(4.8)	(71.0)	(24.2)			
Age Group						<u>3</u>	<u>2</u>	<u>1</u>		
1983 (n)						36	410	19		465
(%)						(7.7)	(88.1)	(4.2)		
Age Group							<u>3</u>	<u>2</u>	<u>1</u>	
1984 (n)							3	58	29	90
(%)							(3.6)	(64.3)	(32.1)	
Production			487	269	381	230	466			

Appendix 5b. Cutthroat smolt run-size, age composition, and production for Gobar Creek, 1978-1984.

Year Captured	Brood Year								Estimated Yield	
	1975	1976	1977	1978	1979	1980	1981	1982		1983
Age Group	<u>3</u>	<u>2</u>	<u>1</u>							
1978 (n)	342	179	18							539
(%)	(63.4)	(33.3)	(3.3)							
Age Group		<u>3</u>	<u>2</u>	<u>1</u>						
1979 (n)		182	405	0						587
(%)		(31.0)	(69.0)	(0.0)						
Age Group			<u>3</u>	<u>2</u>	<u>1</u>					
1980 (n)			124	273	0					397
(%)			(31.2)	(68.8)	(0.0)					
Age Group				<u>3</u>	<u>2</u>	<u>1</u>				
1981 (n)				32	289	70				391
(%)				(8.3)	(73.8)	(17.9)				
Age Group					<u>3</u>	<u>2</u>	<u>1</u>			
1982 (n)					51	389	69			509
(%)					(10.1)	(76.4)	(13.5)			
Age Group						<u>3</u>	<u>2</u>	<u>1</u>		
1983 (n)						73	517	20		610
(%)						(12.0)	(84.8)	(3.3)		
Age Group							<u>3</u>	<u>2</u>	<u>1</u>	
1984 (n)							16	132	0	148
(%)							(10.8)	(89.2)	(0.0)	
Production			547	305	340	532	602			

Steelhead



Appendix 6. Length frequency of migrant steelhead parr from Gobar Creek and the Kalama River, 1978-1984.

Appendix 7. Average fork length, weight, and condition factor (all ages) for steelhead smolts sampled from Gobar Creek and Kalama River, 1978-1984.

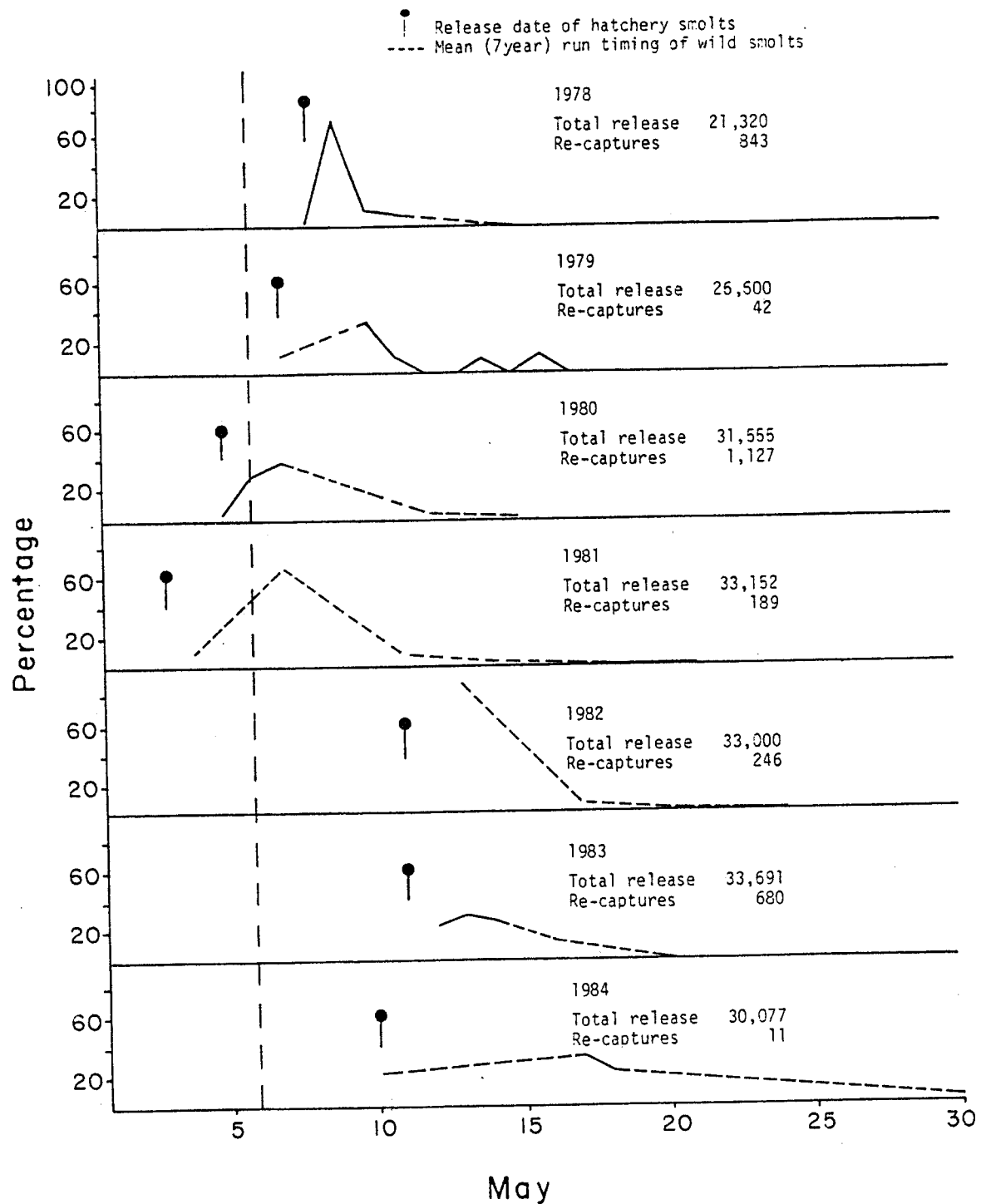
Year	n	Average Length (mm) \pm CI ^a	n	Average Weight (g) \pm CI ^a	Average K ^b
Gobar Creek					
1978	44	137.1 \pm 17.9	38	47.08 \pm 8.33	1.83
1979	52	156.2 \pm 05.5	50	35.76 \pm 4.12	0.94
1980	34	159.3 \pm 07.2	33	42.07 \pm 6.74	1.04
1981	52	161.0 \pm 06.0	50	39.21 \pm 3.57	0.94
1982	62	158.1 \pm 04.5	51	40.88 \pm 3.55	1.03
1983	118	162.3 \pm 03.6	115	41.75 \pm 2.79	0.97
1984	28	142.0 \pm 07.6	24	27.64 \pm 4.85	0.97
Mean		153.7		39.20	1.05
Kalama River					
1978	64	164.0 \pm 05.0	58	41.45 \pm 4.07	0.94
1979	122	158.8 \pm 02.9	120	40.22 \pm 2.38	1.00
1980	68	158.3 \pm 03.4	68	38.55 \pm 2.48	0.97
1981	108	161.0 \pm 02.8	105	37.02 \pm 2.41	0.89
1982	63	160.8 \pm 02.8	61	39.51 \pm 1.61	0.95
1983	89	167.8 \pm 03.7	88	43.25 \pm 2.60	0.92
1984	40	158.9 \pm 05.1	37	37.21 \pm 3.43	0.93
Mean		161.4		39.60	0.94

a Confidence interval; $\alpha = 0.05$

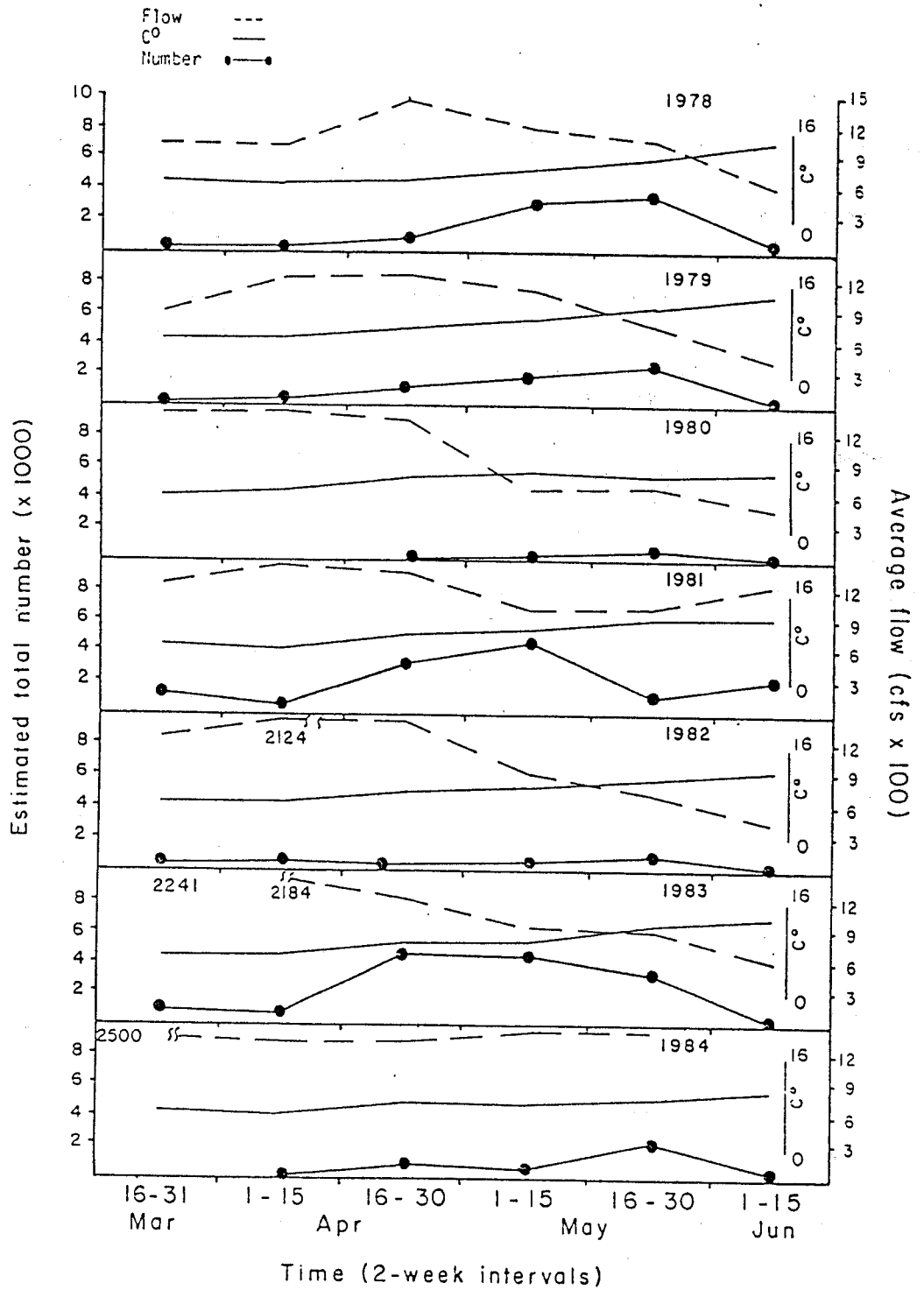
b Condition factor

Appendix B. Number, fork length and weight of male and female steelhead smolts sampled from Gobar Creek and the Kalama River, 1983 and 1984.

Age	Male				Female			
	n	Average Length (mm)	n	Average Weight (g)	n	Average Length (mm)	n	Average Weight (g)
Gobar Creek								
<u>1983</u>								
1	1	130.0	1	21.0	1	117.0	1	16.6
2	25	164.2	25	41.0	32	161.7	30	40.7
3	3	181.0	3	56.5	2	178.0	2	49.4
<u>1984</u>								
1	0	---	0	---	4	123.8	3	18.5
2	3	158.3	2	36.5	9	150.9	7	31.6
3	0	---	0	---	1	190.0	1	58.5
Kalama River								
<u>1983</u>								
1	2	114.0	2	15.7	1	117.0	1	16.6
2	28	164.4	28	41.7	35	160.7	34	39.7
3	2	181.0	2	57.4	2	178.0	2	4.4
<u>1984</u>								
1	0	---	0	---	1	160.0	1	39.0
2	11	154.5	10	34.2	14	160.4	13	37.8
3	0	---	0	---	0	---	0	---



Appendix 9. The migration rate of hatchery steelhead smolts expressed in percentage of total recaptures by night, 1978-1984; Dotted vertical line indicating peak migration (7 year mean) for wild steelhead smolts.



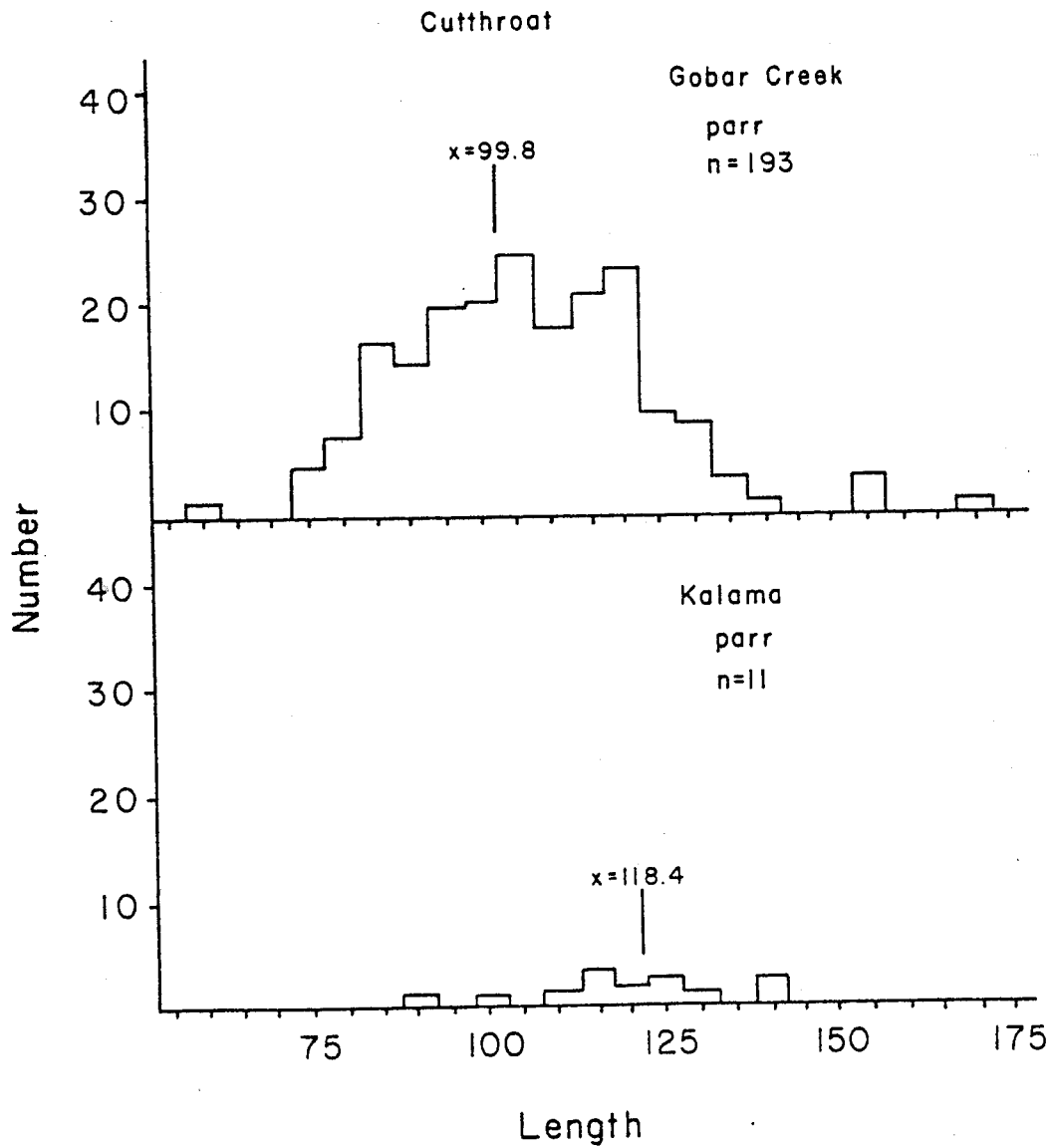
Appendix 10. Estimated total number of cutthroat smolts, average water flow, and average water temperature by sampling interval, Kalama River, 1978-1984.

Appendix 11a. Steelhead smolt run-size, age composition, and production for the Kalama River, 1978-84.

Year Captured	Brood Year									Estimated Yield
	1975	1976	1977	1978	1979	1980	1981	1982	1983	
Age Group	<u>3</u>	<u>2</u>	<u>1</u>							
1978 (n)	3,942	30,524	1,700							36,166
(%)	(10.9)	(84.4)	(4.7)							
Age Group		<u>3</u>	<u>2</u>	<u>1</u>						
1979 (n)		9,036	23,362	1,958						34,356
(%)		(26.3)	(68.0)	(5.7)						
Age Group			<u>3</u>	<u>2</u>	<u>1</u>					
1980 (n)			3,856	19,258	690					23,804
(%)			(16.2)	(80.9)	(2.9)					
Age Group				<u>3</u>	<u>2</u>	<u>1</u>				
1981 (n)				2,373	32,632	2,077				37,082
(%)				(6.4)	(88.0)	(5.6)				
Age Group					<u>3</u>	<u>2</u>	<u>1</u>			
1982 (n)					690	8,872	1,391			10,953
(%)					(6.3)	(81.0)	(12.7)			
Age Group						<u>3</u>	<u>2</u>	<u>1</u>		
1983 (n)						4,940	35,449	2,947		43,336
(%)						(11.4)	(81.8)	(6.8)		
Age group							<u>3</u>	<u>2</u>	<u>1</u>	
1984 (n)							302	11,205	606	12,113
(%)							(2.5)	(92.5)	(5.0)	
Production		28,918	23,589	34,012	15,889	37,142				

Appendix 11b. Cutthroat smolt run-size, age composition, and production for the Kalama River, 1978-84.

Year Captured	Brood Year							Estimated Yield		
	1975	1976	1977	1978	1979	1980	1981		1982	1983
Age Group	<u>3</u>	<u>2</u>	<u>1</u>							
1978 (n)	2,791	5,321	0							8,112
(%)	(34.4)	(65.6)	(0.0)							
Age Group		<u>3</u>	<u>2</u>	<u>1</u>						
1979 (n)		3,042	4,487	0						7,529
(%)		(40.4)	(59.6)	(0.0)						
Age Group			<u>3</u>	<u>2</u>	<u>1</u>					
1980 (n)			126	223	0					349
(%)			(36.1)	(63.9)	(0.0)					
Age Group				<u>3</u>	<u>2</u>	<u>1</u>				
1981 (n)				1,867	12,837	0				14,704
(%)				(12.7)	(87.3)	(0.0)				
Age Group					<u>3</u>	<u>2</u>	<u>1</u>			
1982 (n)					489	1,963	491			2,943
(%)					(16.6)	(66.7)	(16.7)			
Age Group						<u>3</u>	<u>2</u>	<u>1</u>		
1983 (n)						3,181	13,048	0		16,229
(%)						(19.6)	(80.4)	(0.0)		
Age Group							<u>3</u>	<u>2</u>	<u>1</u>	
1984 (n)							613	3,060	613	4,266
(%)							(14.3)	(71.4)	(14.3)	
Production			4,613	2,090	13,326	5,144	14,152			



Appendix 12. Length frequency of migrant cutthroat parr from Gobar Creek and the Kalama River, 1978-1984.

Appendix 13. Average fork length, weight, and condition factor (all ages) for cutthroat trout smolts sampled from Gobar Creek and Kalama River, 1978 through 1984.

Year	n	Average Length (mm) \pm CI ^a	n	Average Weight (g) \pm CI ^a	Average K ^b
Gobar Creek					
1978	31	150.8 \pm 12.4	31	35.89 \pm 4.74	1.05
1979	54	158.2 \pm 07.4	52	37.46 \pm 6.05	0.95
1980	31	162.7 \pm 08.9	31	41.41 \pm 7.89	0.96
1981	84	146.6 \pm 04.3	82	29.91 \pm 2.54	0.95
1982	88	159.2 \pm 03.4	86	38.63 \pm 2.34	0.96
1983	92	166.6 \pm 04.0	92	43.27 \pm 3.21	0.94
1984	37	157.5 \pm 05.0	36	35.15 \pm 3.63	0.90
Mean		157.4		37.39	0.96
Kalama River					
1978	32	165.4 \pm 7.28	32	42.98 \pm 5.52	0.95
1979	47	155.8 \pm 4.25	46	35.94 \pm 2.93	0.95
1980	36	168.1 \pm 4.61	36	42.46 \pm 3.79	0.89
1981	71	166.2 \pm 3.41	69	38.79 \pm 2.75	0.84
1982	24	170.0 \pm 7.81	22	48.69 \pm 4.90	0.99
1983	47	173.2 \pm 5.28	47	46.76 \pm 3.79	0.90
1984	14	160.7 \pm 5.44	13	36.03 \pm 6.21	0.87
Mean		165.6		41.70	0.91

a Confidence interval; $\alpha = 0.05$

b Condition factor