STUDY 4.

LIFE-HISTORY OF OCEAN-TYPE JUVENILE CHINOOK SALMON IN THE SITUK RIVER

Rationale

Unique stocks in the Situk River, such as ocean-type chinook, may be lost as a result of flooding. Therefore, freshwater life-history information on juvenile chinook is critical in any effort to conserve this stock.

Objectives

The objectives of this study were to document the existence and describe the life history of ocean-type chinook in the Situk River by examining the distribution, abundance, habitat use, migration and residence timing, seawater tolerance, and size of juveniles before seaward migration.

Summary of Results

Most (>95%) chinook in the Situk River migrate to sea at age 0. Chinook primarily occupied main-stem habitats (channel edges in spring, pools and willow edges in summer) in 1989. Peak density in the upper and lower main stem was 96 and 76 fish/100 m^2, respectively. Chinook migrated downstream in two phases: a spring dispersal of emergent fry, and a summer migration of presmolts. Chinook marked in the upper river in late June and July were recaptured 20 km downstream in the lower river in late July. Marked chinook remained in the lower river for up to 34 days. Mean fork length of chinook in the lower river increased from 40 mm in May to 80 mm in early August. By late August, chinook had emigrated from the lower river at a size of about 80 mm. Fish of this size could tolerate seawater and had the physical appearance of smolts. The results of this study have been reported elsewhere (Johnson et al. 1992).

METHODS

Juvenile chinook were sampled at 55 sites in the Situk River and neighboring watersheds (Fig. 4.1). Sites were either repetitive (8) or distribution (47) sites; repetitive sites were sampled several times in 1988-89 to determine seasonal changes in chinook size and abundance, whereas distribution sites were usually sampled only once (March-October) from 1987 to 1989 to document presence or absence of chinook. In 1988, repetitive sites included four in the lower river and one in the upper river; sites were sampled about every 3 weeks from 13 April to 1 September (sampling at the upper river site did not begin until mid-May). In 1989, repetitive sites included two in the lower river and two in the upper river; sites were sampled about every 2 weeks from 10 May to 22 September, and once in late November. Repetitive sites were different in 1988 and 1989, except for one site in the lower river. Similar habitats were sampled and comparable methods (e.g., seines, minnow traps) were used at both repetitive and distribution sites.

In 1988 at repetitive sites, relative abundance was determined from total catch of chinook by habitat type. At least one channel edge and one debris pool (habitats defined in Study 2) and one main-stem channel pool (deep area of main-river flow, usually void of LWD) were usually sampled at each of the five sites. Chinook in channel edges were captured with a pole seine (Study 2). Chinook in debris pools were captured with minnow traps: 5-10 traps spaced 3-5 m apart throughout a pool and set for 30 min. Chinook in main-stem channel pools were captured with a beach seine: 28 m long, 3 m deep, with 13-mm stretch mesh on the wings, and a central bag of 6-mm stretch mesh. Researchers on foot set the seine parallel to and 3-4 m from shore and retrieved it from shore. Only one pass with a seine was made at channel edges and main-stem channel pools.

We sampled more intensively at repetitive sites in 1989 than in 1988 primarily to 1) determine population density, 2) determine seasonal changes in density in the upper and lower river, and 3) document the emigration of chinook from the river. During each sampling period in 1989, three channel edges, one debris pool, and one willow edge were usually sampled at each of the four repetitive sites. Fish were captured, populations estimated, and habitat was measured as described in Studies 2 and 3. Differences in habitat characteristics (water depth, etc.) among habitat types in the upper and lower river are described in Study 3.

To assess fish residence time and movement between the upper and lower river in 1989, some juvenile chinook were tattoo marked with a Panjet medical instrument (Fig. 4.2). A dye (Alcian Blue at a concentration of 65 mg/ml) was injected under pressure into the caudal fin rays of anesthetized fish from a distance of about 3 mm. After injection, each fish was dipped in water and the mark was checked; if the mark was not clear, the fish was remarked. Fish from upper-river sites were marked in the upper lobe of the caudal fin (UC = upper caudal), whereas fish from lower-river sites were marked in the lower lobe (LC = lower caudal) (Fig. 4.3). All marked fish were released at their capture site. Downstream movement of juvenile chinook was also monitored by periodically placing a fyke net (1.2 m x 1.2 m; 6-mm mesh) in the main-stem Situk River from April to late June 1989. The fyke net was set overnight (12 h) in the upper river (17 km upstream from the mouth, Fig. 4.1), about every fifth night.

The osmocompetence of chinook was tested with salinity tolerance bioassays. From May to July 1988, chinook were collected in the lower and upper river and placed in 60-L plastic containers filled with aerated water at 0, 26, 28, and 30‰ salinity at ambient temperature for 96 h. Ocean water was mixed with fresh water to obtain desired salinity. To avoid overcrowding, fewer than 20 fish were placed in each container. Dead fish were removed every 12 h.

A random sample of juvenile chinook captured during each sampling period was measured for FL. Scale samples for ageing were taken from a range of sizes in the catch.

In mid-July 1989, over 10,000 juvenile chinook were captured in the lower river, coded-wire tagged (Fig. 4.4), adipose (AD)-clipped, and released. Mean growth was determined from recaptured AD-clipped fish in the lower river in early August 1989.

RESULTS

Distribution

Juvenile chinook were captured in only 22 of 55 sites sampled in the Situk River and neighboring watersheds (Fig. 4.1). Most sites with chinook were restricted to or near larger streams: 16 were on the main-stem Situk River (average width 27 m), and 3 of the 6 remaining sites were on tributaries approximately 200 m upstream of the main-stem Situk River. Chinook were not captured in two main-stem distribution sites (Fig. 4.1), probably because these sites were sampled after late July and most chinook had already migrated to sea. Other distribution sites were accessible and contained numerous juvenile salmonids; however, chinook were probably absent from most because of small stream size (average width 8 m).

Seasonal Abundance in Upper and Lower River

In 1988, juvenile chinook were present at the upper river site from mid-May to 1 September. Chinook catch was greatest in mid-May, when nearly 50 fish were captured. In 1989, chinook were present at the upper river sites from mid-May to late September; peak density was 96 fish/100 m^2 in late June (Fig. 4.5).

In 1988, juvenile chinook were present at the lower river sites from mid-April to early August. Total catch of chinook was greatest in late June, when nearly 300 fish were captured. In 1989, chinook were present at the lower river sites from late May to late September, except for a few newly emerged chinook captured in mid-March during distribution sampling. In 1989, density of chinook peaked in lower river sites in late July (76 chinook/100 m^2; Fig. 4.5).

Chinook abundance declined by late summer: catches declined to zero in the lower river sites and one in the upper river site on 1 September 1988. Density declined to only 0.03 fish/100 m^2 in the lower river and 0.55 fish/100 m^2 in the upper river on 20 September 1989 (Fig. 4.5). In November 1989, no chinook were found in either the upper or lower river.

Habitat Utilization

Chinook density did not differ significantly ($P > 0.05$; Friedman's test) between lower-river habitat types, but did differ significantly ($P < 0.05$) between upper-river habitat types. Few chinook were in the lower river in May, June, August, and September 1989. However, chinook were abundant in July; mean density ranged from 43 fish/100 m^2 in debris pools to 141 fish/100 m^2 in willow edges (Fig. 4.6). Recently emerged chinook (mean FL 43 mm), captured primarily along channel edges in May 1989, indicated that populations had not yet reached equilibrium among habitat types in the upper river (Fig. 4.6). Beginning in June, however, as chinook grew (mean FL 56 mm) in the upper river, most occupied pool or willow-edge habitats, and few were found in channel edges (Fig. 4.6). In the upper river, the highest chinook density observed was in debris pools in July (mean 164 fish/100 m^2).

Migration and Residence Timing

After emergence, chinook either dispersed downstream or remained in the upper river until July. Juveniles (mean FL 43 mm) dispersing downstream were captured by fyke net from April through June 1989, with peak catches in May (Fig. 4.7)—however, most juveniles remained in the upper river. In July, a major downstream migration of chinook presmolts to the lower river occurred: density in the lower river increased sharply from 3 fish/100 m^2 to 76 fish/100 m^2 (21 June-25 July 1989) while density in the upper river decreased from 96 fish/100 m^2 to 40 fish/100 m^2 (Fig. 4.5). Further evidence of the downstream migration was the recapture of marked fish—37 of 882 chinook that were Panjet marked (UC) 19 June-7 July 1989 in the upper river were recaptured. Most (30) were recaptured approximately 20 km downstream in the lower river on 16-20 July (Table 4.1); the rest (7) were recovered in the upper river.

Chinook were present in the lower river in substantial numbers for about 48 days (21 June-9 August 1989; Fig. 4.5). Recovery of Panjet-marked fish indicated that some chinook reared in the lower river for at least 8 days and possibly as long as 34 days—69 of 229 chinook marked in the lower river on 22 June and 8 July 1989 were recaptured in the lower river between 8 and 26 July (Table 4.1). Chinook did not migrate from the lower river to other areas in the Situk River watershed. Sampling of several distribution sites (including Situk Lake), and repetitive sites after mid-August, captured few chinook. Most chinook captured in the lower river in summer appeared to be smolts.

Seawater Tolerance

Chinook from the lower river tolerated seawater earlier in the year than chinook from the upper river. Survival in 26-30‰ salinity seawater was 91% in mid-May and 100% in early June for chinook from the lower river, versus 31% and 62%, respectively, for chinook from the upper river. By mid-July, however, survival was 100% from both the upper and lower river. Survival of fish of similar length from the upper and lower river differed significantly ($P < 0.05$; Chi-square). In early June, survival in 26-30‰ salinity seawater for 40-49 mm FL chinook was 100% for fish from the lower river compared to only 64% for fish from the upper river (Table 4.2). Survival of ≥50 mm FL chinook did not differ significantly ($P > 0.05$) between the upper (90%) and lower (100%) river; in mid-July, most chinook in the river were >60 mm FL, and survival was 100%.

Age and Size

Of the 250 chinook aged in 1988 and 1989, 98% were age 0 and 2% were age 1 (Table 4.3). Two of the five age-1 chinook were captured in June and three in July.

Chinook were larger in the lower river than in the upper river (Fig. 4.8). Most chinook reared in the upper river to about 60 mm FL before migrating to the lower river. For example, some larger chinook in the upper river in May 1989 apparently migrated to the lower river in June (range 56-76 mm FL; Fig. 4.8). Most chinook captured in the lower river were ≥60 mm FL (99% in 1989; 77% in 1988). Chinook reared in the lower river until they were approximately 70-80 mm FL.

Mean size of chinook doubled in the lower river from nearly 40 mm in May to about 80 mm in early August; mean size in the upper river was less than 70 mm in early August (Fig. 4.9). Within most sampling periods, chinook in the lower river were 5-17 mm longer than chinook in the upper river. Mean size in the lower river, just before abundance declined, was 70 mm in late June 1988 and approximately 80 mm in late July 1989.

In late July 1989, chinook in the lower river grew approximately 0.57 mm/day. Based on the recapture of AD-clipped fish, mean FL in the lower river increased from 80 mm ($n = 423$) on 16-20 July (18 July; median release date) to 88 mm ($n = 103$) on 1 August.

DISCUSSION

Because of the apparent presence of a freshwater annulus on adult scales—which can be difficult to identify (Koo and Isarankura 1967)—most (>97%) chinook in the Situk River have been classified by fishery workers as stream-type fish (McBride 1986; Riffe et al. 1987). Based on our study of juveniles in the river, we believe that most adult Situk chinook have been misidentified as stream-type. It could be argued that the disparity in freshwater age could result from only age-1 smolts (2% of the population) surviving to adulthood and poor survival of ocean-type fish (98% of the population). Recent studies, however, indicate that the total chinook smolt yield from the Situk River is approximately 67,000 fish (Study 7) and the approximate 2,500 annual adult run could not possibly be produced by 2% of the smolt yield, even with 100% survival. The ocean-type chinook we captured in the lower Situk River had the morphological appearance of smolts, could tolerate seawater, and eventually disappeared from the river; presumably they migrated to sea. Most chinook apparently do not winter within the Situk River watershed, because few age-1 fish were present in 1988 or 1989. Kissner (1986) suggested a similar seaward migration of ocean-type chinook from the Situk River in 1983 and 1984 based on juvenile sampling.

Chinook primarily occupied main-stem habitats until they apparently emigrated from the Situk River, similar to fall chinook in Sixes River, Oregon, which occupy main-stem habitats until early summer, when they migrate to the estuary (Reimers 1971; Stein et al. 1972). In spring in the upper Situk River, recently emerged chinook were often present along channel edges. By June, as fish increased in size, they moved into deeper, faster water with more cover (willow edges and debris pools). Lister and Genoe (1970) and Stein et al. (1972) also observed the shift in habitat utilization of juvenile chinook salmon from stream margins in spring to midstream or areas of faster water in summer. Chinook in the Situk River occupied areas with water velocity (range, 4-26 cm/s) and depth (range, 0.3-1.5 m) similar to areas utilized by chinook in other studies (Everest and Chapman 1972; Reiser and Bjornn 1979; Hillman et al. 1987).

Peak densities of chinook in the upper (96 fish/100 m^2) and lower (76 fish/100 m^2) river were similar to density in other studies. Murray and Rosenau (1989) reported maximum chinook density of 6-68 fish/100 m^2 from May to June in tributaries of the Fraser River, British Columbia. Chinook density in summer of 10-75 fish/100 m^2 were reported in some Idaho rivers (Everest and Chapman 1972; Hillman et al. 1987). In the Stikine River, Alaska, chinook density was 2-95 fish/100 m^2 from May to October[18]. In the glacial Taku River, Alaska, however, chinook density (0-8 fish/100 m^2; Murphy et al. 1989) was much lower than in the Situk River.

Chinook in the Situk River migrated downstream in two phases: a dispersal in spring after emergence followed by a mid-summer migration. The fyke net site was in mid-upper river, and catches probably were emergent fry redistributing to suitable rearing areas. Most chinook did not enter the lower river, however, until July, which suggests that fish remained in the upper river or migrated slowly downstream. Rearing migrations where chinook move slowly downstream throughout the summer have been reported by Ewing and Birks (1982) and Beauchamp et al. (1983). Once chinook start downstream, they either migrate directly to the estuary or stop and rear in the stream for a few weeks to a year or more (Healey 1991). The rapid increase in chinook abundance during July in the lower river with a concurrent decrease in the upper river, and the recapture of marked (UC) fish in the lower river, documents a major downstream migration. After reaching the lower river, some marked (LC) chinook remained there at least 8 days to nearly a month. Residence of 1-4 weeks in the lower river offers benefits of additional food similar to estuarine conditions (Levy and Northcote 1982) and a period of seawater acclimation.

Most ocean-type chinook disappeared from the Situk River by September and apparently emigrated to sea. Just before seaward migration (late June to late July), chinook mean size was 70-80 mm FL; for fish ≥60 mm FL from both the upper and lower river, survival in seawater was 100%. Weisbart (1967) reported that 70 mm FL was the approximate size at which juvenile chinook can tolerate full-strength seawater. Thus, ocean-type chinook in the Situk River were of sufficient size to tolerate seawater and probably migrated seaward. Similarly, along the Pacific coast of the United States and British Columbia, ocean-type chinook migrate to sea at approximately 70-80 mm FL (Healey 1980; Healey and Groot 1987).

Migration of ocean-type chinook from the Situk River was slightly later (July-August) than in more southerly British Columbia streams (June-July; Healey and Groot 1987) and may vary annually depending upon the severity of winter and spring. In years with a cold winter and late spring, time of emergence and growth may be retarded and time of emigration delayed. The colder winter and spring of 1989 versus 1988 probably accounts for the later start of emigration observed in 1989 (late July) than in 1988 (late June); average monthly air temperature from

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[18]Unpubl. data. J. Edgington and J. Lynch, Alaska Dep. Fish and Game, P.O. Box 667, Petersburg, AK 99833.

January through March 1989 was 2.6-6.5°C cooler than during the same period in 1988 (NOAA 1988, 1989). Kissner and Hubartt (1987) also reported a later out-migration of ocean-type chinook in the Situk River in 1985 (August) than in 1984 (July) and attributed the later migration in 1985 to an extremely cold and late spring.

Growth of chinook in the Situk River was similar to that reported in some estuaries. Chinook rearing in the lower Situk River increased from 40 to 80 mm FL from May to early August. In some British Columbia estuaries, chinook fry increased from 40 to 70 mm FL from March to June (Healey 1980; Levy and Northcote 1982). Changes in average length of fish (over time) from the general population probably underestimate the true growth rate because of fish emigration and immigration in study areas (Healey 1991). Actual short-term (late July) growth rate, however, of marked chinook in the lower Situk River (0.57 mm/day) was similar to rates reported for chinook fry in the Campbell River estuary, British Columbia (0.46-0.70 mm/day; Levings et al. 1986), and in Coos Bay, Oregon (0.29-0.54 mm/day; Fisher and Pearcy 1990), but lower than reported by Healey (1980) for fry in the Nanaimo River estuary, British Columbia (1.32 mm/day).

Chinook in the Situk River are capable of migrating to sea at age 0 possibly because of an extended growing season. Peak spawning of chinook in the Situk River occurs the first week of September (Study 1); therefore, based on mean daily water temperature (Fig. H.6), peak emergence of fry (calculated from heating units—900°C days to emergence; Russell et al. 1983) would occur the first week of April. Peak emergence of chinook is in mid- to late April or May in other streams: Big Qualicum River (Lister and Genoe 1970), Sixes River (Reimers 1971), and Taku River (Kissner 1978). Early emergence and a longer growing season probably allow ocean-type chinook in the Situk River to reach the minimum size (60-70 mm) necessary to adapt to seawater as age-0 fish.

Situk River chinook appear to be unique because they have life-history characteristics intermediate between typical stream- and ocean-type populations. Most juvenile chinook out-migrate from the Situk River at age-0, at a size and time very similar to ocean-type populations in the Pacific Northwest. Adult freshwater entry (June-July) and spawning timing (mid-August to mid-September), however, is more similar to stream-type populations than ocean-type[19]. Some advantages of the ocean-type life history compared to the stream-type are lower mortality because of less time rearing in fresh water and quicker availability for recruitment into fisheries.

This study documented for the first time that ocean-type life history dominates a stream population of chinook north of 56°N latitude. Taylor (1990) had previously shown that ocean-type chinook were rare north of British Columbia, Canada. The only other river in Alaska with an apparent emigration of substantial numbers of ocean-type chinook smolts is the Deshka River in Southcentral Alaska (Delaney et al. 1982). In the Situk River, peak emergence of chinook appears to be in early April. Chinook migrate downstream in two phases: 1) a spring dispersion of emergent fry to suitable rearing areas in mid-upper river, and 2) a summer migration of presmolts to the lower river. Juveniles rear in and acclimate to seawater in the lower river for 1-4 weeks (late June and July) before entering the main estuary by early August at about 80 mm FL.

Future tag recoveries of adults returning from juveniles coded-wire tagged in July 1989 should provide valuable information on the ocean distribution, survival, and exploitation rate of this unique stock. In-stream recoveries of adult coded-wire tagged chinook will also substantiate our age designations.

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[19]S. McPherson, Alaska Dep. Fish and Game, Div. Commercial Fish, Southeast Region, 802 Third St., Douglas, AK 99824-0020. Pers. commun., 1992.

Table 4.1—Release and recovery of marked (Panjet and adipose clip) juvenile chinook salmon in the lower and upper Situk River, 1989. (LC = lower caudal Panjet mark; UC = upper caudal Panjet mark; AD = adipose clip).

Date	River location	Total marks released			Marks recaptured		
		LC	UC	AD	LC	UC	AD
6/19-20	upper		720				
6/22	lower	40					
7/7	upper		162			6	
7/8	lower	189			1		
7/16-20	lower			10,191*	64	30	
7/25-26	lower				4		155
7/27	upper					1	
7/31	lower						13
8/1	lower						103
Total		229	882	10,191	69	37	271

*Coded-wire tagged.

Table 4.2—Percent survival of juvenile chinook salmon of similar size from the upper and lower Situk River, June-July 1988, after 96 h in 26-30‰ salinity seawater. Significance based on Chi-square test.

Fork length (mm)	Percent survival				*P*
	Upper river		Lower river		
	%	Sample size	%	Sample size	
35-39[a]	0	5		0	
40-49[a]	64	39	100	12	<0.05
50-59[b]	90	10	100	24	NS
≥60[c]	100	15	100	36	NS

[a]Fish from June sampling.

[b]Predominately fish from June sampling.

[c]Predominately fish from July sampling.

Table 4.3—Percent age composition of juvenile chinook salmon measured in the Situk River, 1988-89.

Year	Period	Number aged	Percent	
			Age 0	Age 1
1988	Apr.-Sept.	136	97.8	2.2
1989	May -Sept.	114	98.2	1.8

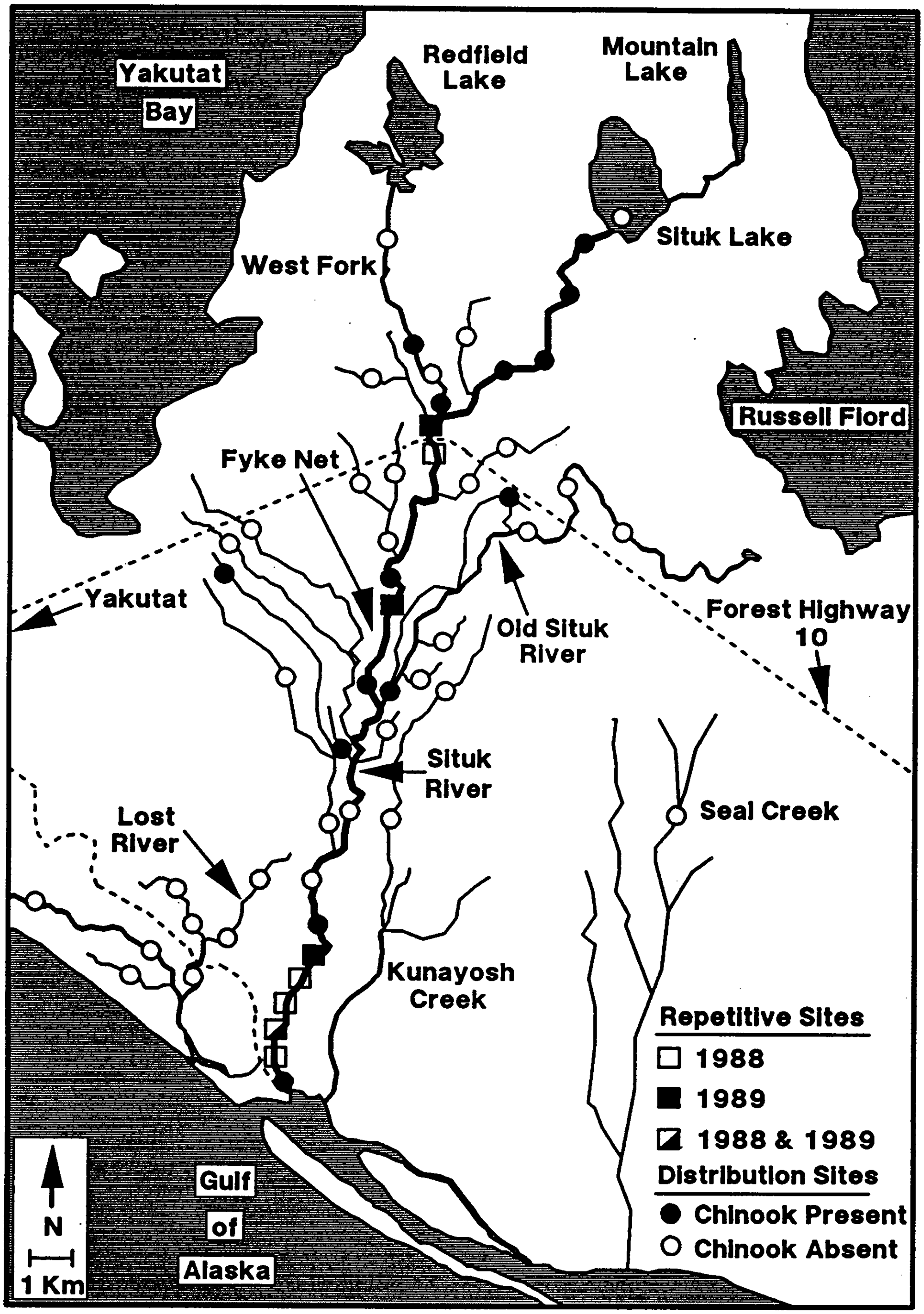

Figure 4.1—Sites sampled for juvenile chinook salmon in the Situk River and neighboring watersheds, 1987-89. Sites were either repetitively sampled in a given year (repetitive sites) or were sampled only once (distribution sites). Chinook were present in all repetitive sites.

Figure 4.2—Tattoo-marking juvenile chinook salmon on caudal fin.

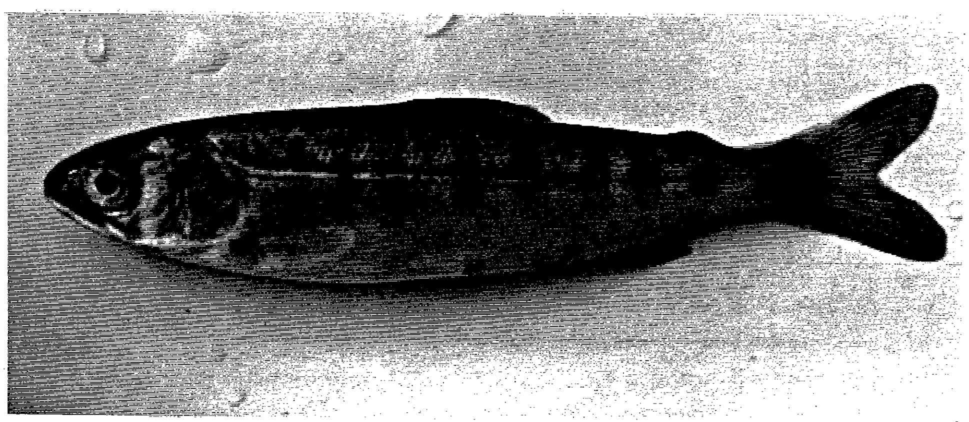

Figure 4.3—Juvenile chinook salmon with tattoo on lower caudal fin.

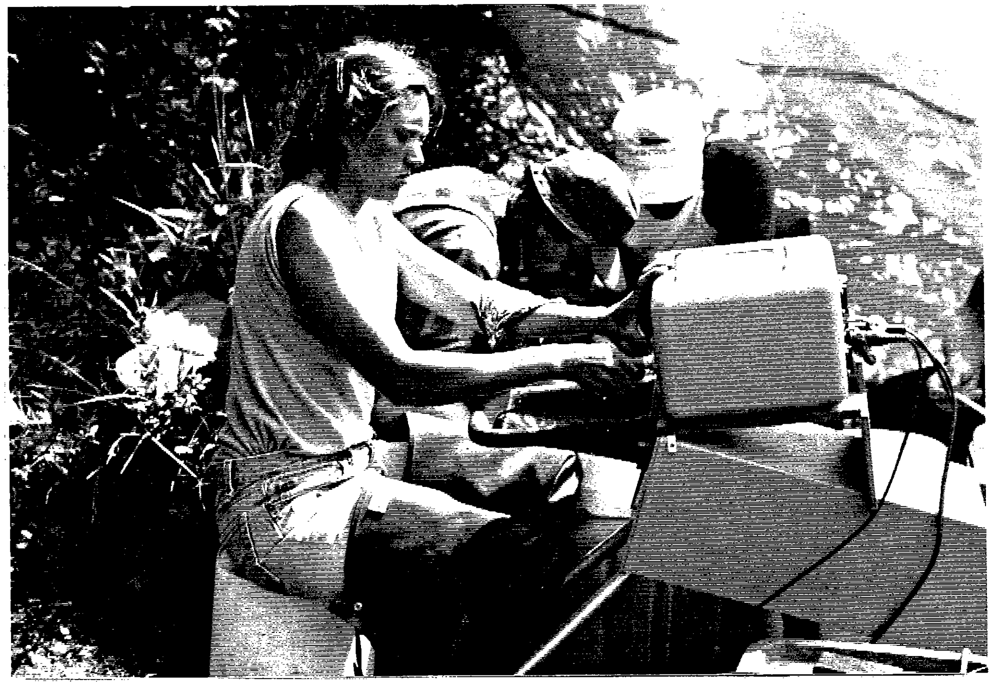

Figure 4.4—Coded-wire tagging juvenile chinook salmon in the lower Situk River, 1989.

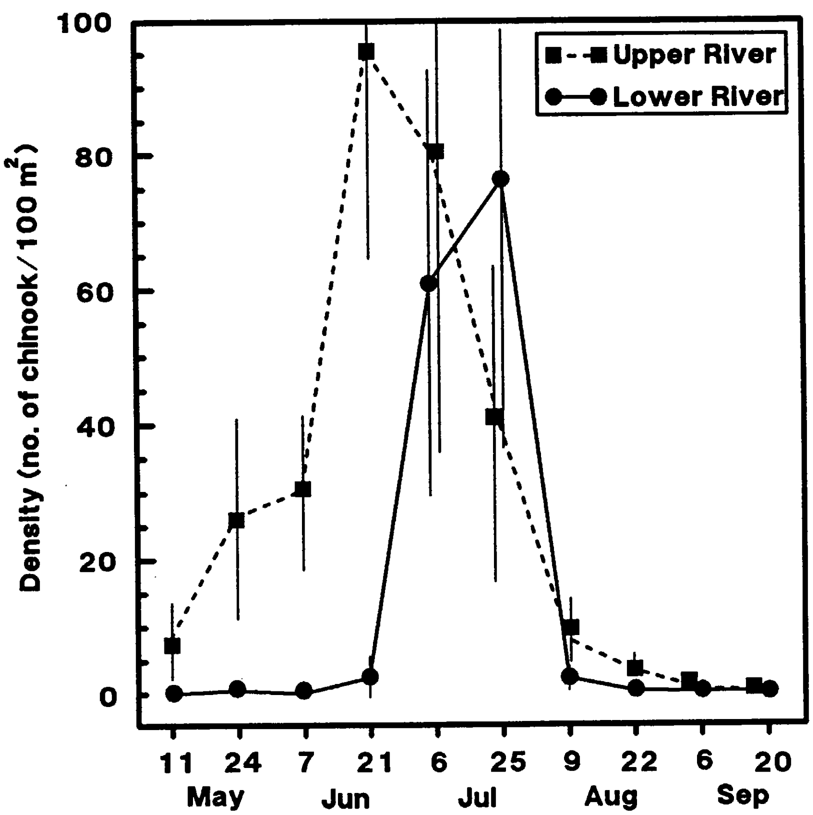

Figure 4.5—Mean density (±SE) of juvenile chinook salmon by sampling period in repetitive sites in the upper and lower Situk River, 1989. For each data point, n = 10 (2 sites x 3 channel edges, 1 willow edge, and 1 debris pool per site).

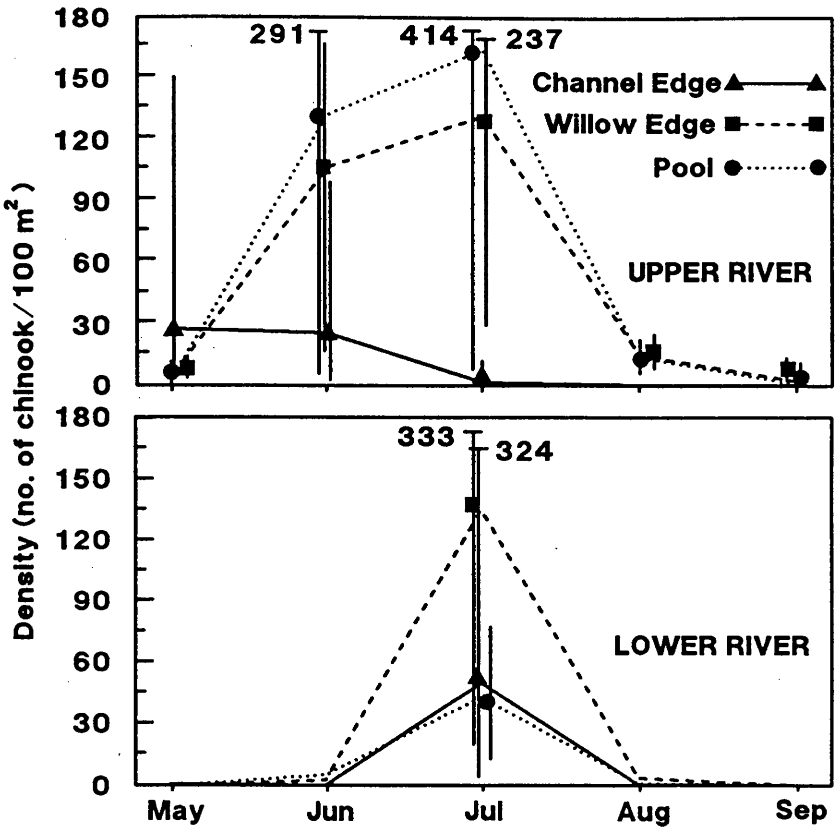

Figure 4.6—Mean density (±range) of juvenile chinook salmon by month and habitat type in repetitive sites in the upper and lower Situk River, 1989. Channel edges, $n = 12$; willow edges, $n = 4$; pools with large woody debris, $n = 4$. (2 sampling periods x 2 sites x 3 channel edges or 1 willow edge or 1 pool per site).

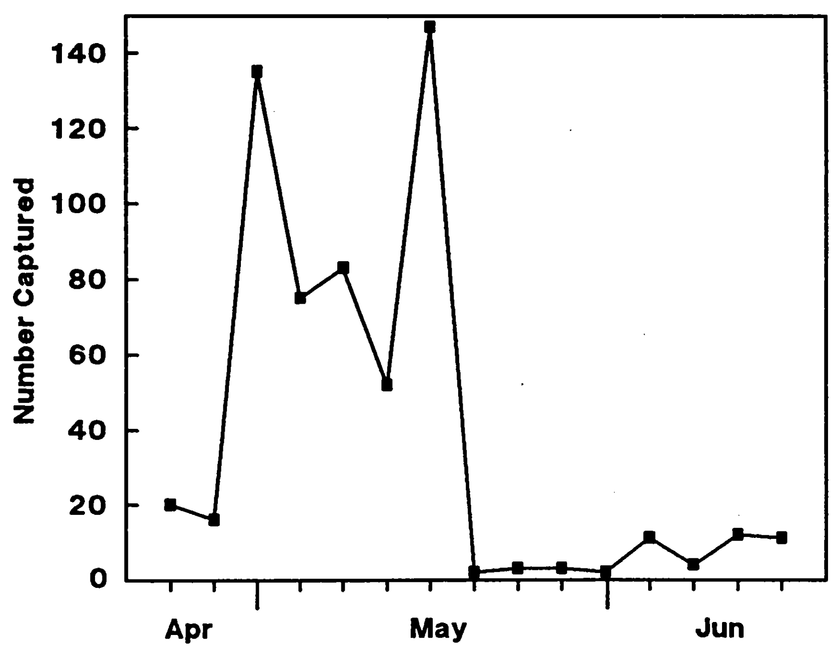

Figure 4.7—Number of juvenile chinook salmon captured by fyke net in the upper Situk River, 1989.

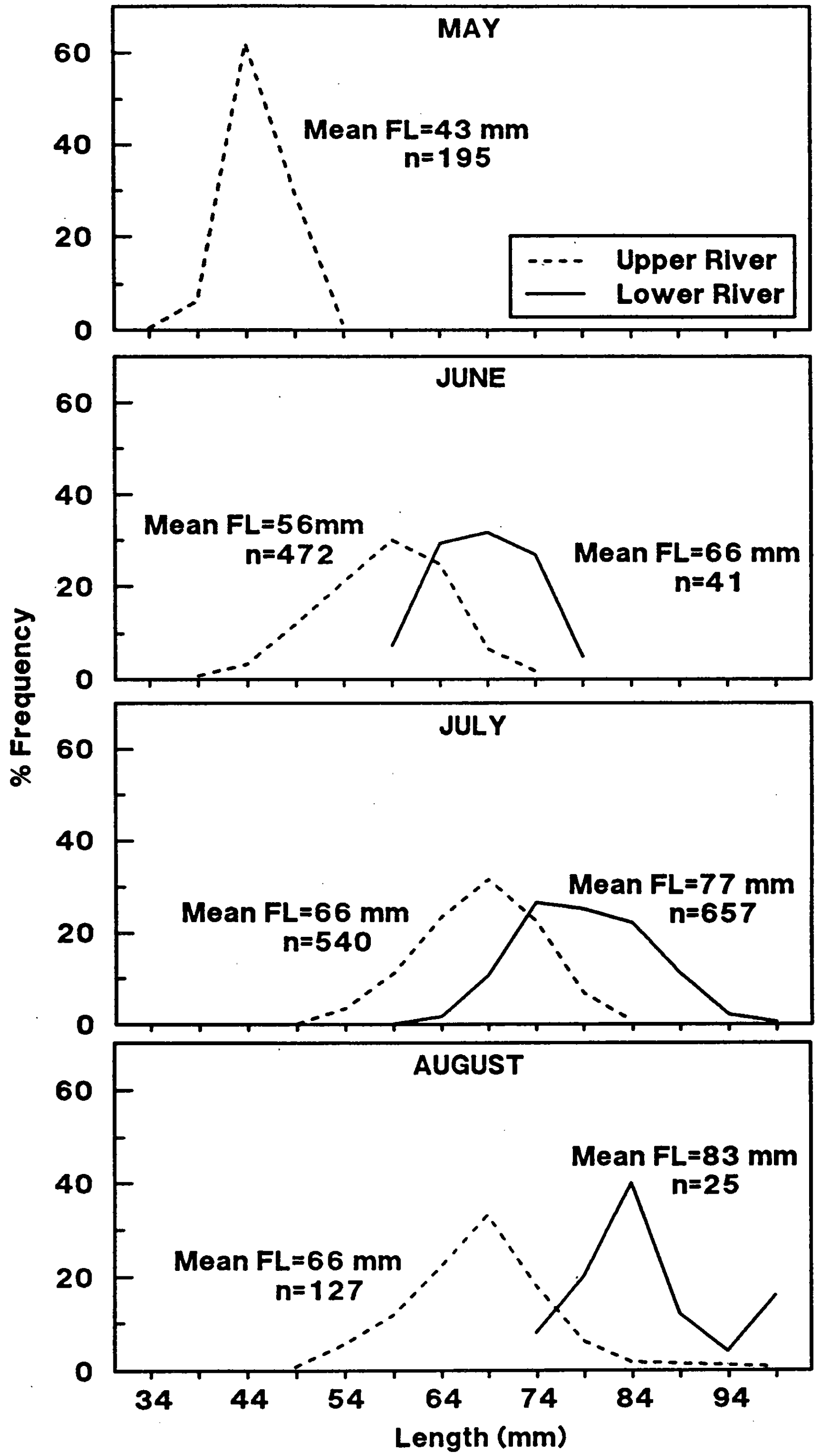

Figure 4.8—Length frequency distributions of juvenile chinook salmon by month in the upper and lower Situk River, 1989. Length frequencies are not shown when <15 chinook were measured. X-axis represents upper limit of 5-mm interval.

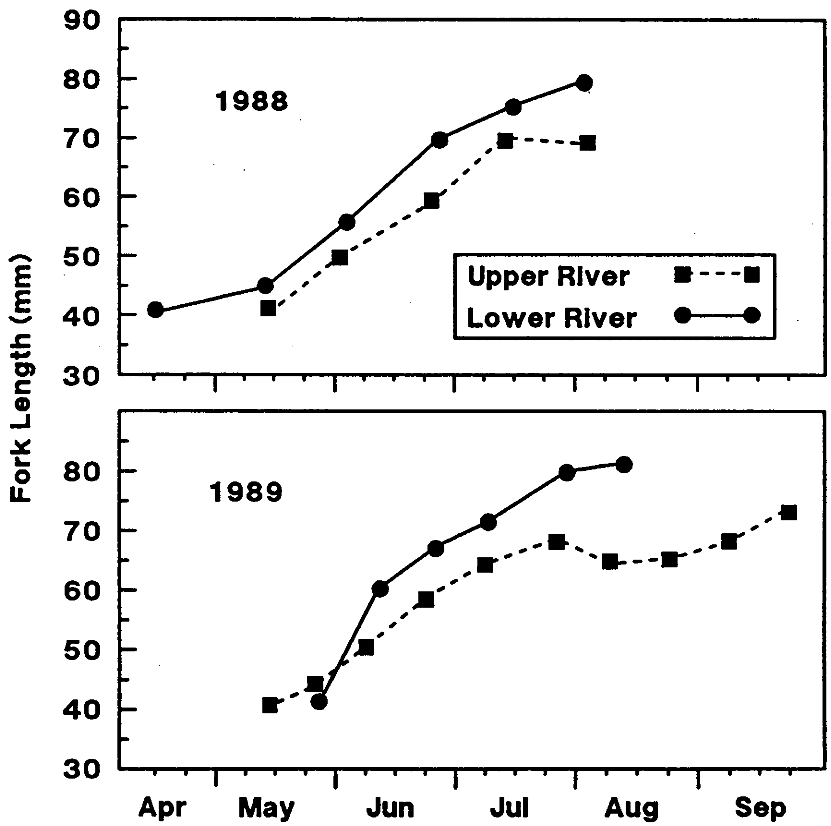

Figure 4.9—Mean fork length of juvenile chinook salmon in the upper and lower Situk River, 1988 and 1989. Each data point represents a minimum of four (range 4-381) fish measured.