Abundance and Run Timing of Adult Salmon in the Kateel River, Koyukuk National Wildlife Refuge, Alaska, 2001-2003

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Abstract

A 3-year study was initiated in 2001 to collect biological information on Chinook *Oncorhynchus tshawytscha* and summer chum salmon *O. keta* migrating into the Kateel River to spawn, a tributary of the Koyukuk River, Alaska. A resistance board weir was used to assess passage rates and collect biological data. Additionally, passage information was recorded for whitefish (Coregoninae), longnose sucker *Catostomus catostomus*, Arctic grayling *Thymallus arcticus*, and northern pike *Esox lucius*. Due to unforeseen delays in transporting the weir material and field supplies to this remote site, the weir was not fully operational in 2001. In 2002, the weir was installed and operated from June 23 to July 27. A total of 73 Chinook and 2,853 summer chum salmon passed through the weir. The most abundant resident species passing through the weir were whitefish (N=13), followed by longnose sucker (N=6), Arctic grayling (N=4), and northern pike (N=3). The median passage date for Chinook salmon was July 12. Females comprised 29% of the Chinook salmon run, with age class 1.2 dominating (50%). The mean MEL length of female Chinook salmon was 710 mm, ranging from 515 to 865 mm, and male length averaged 596 mm, ranging from 410 to 845 mm. The median passage date for summer chum salmon was July 11. Females comprised 45% of the summer chum salmon run, with age class 0.3 dominating (58%). The mean MEL length of female summer chum salmon was 555 mm, ranging from 380 to 650 mm, and male length averaged 587 mm, ranging from 450 to 670 mm. In 2003, budget constraints forced the cancellation of operations in the Kateel River. It is recommended that tributary streams containing small salmon stocks, like the Kateel River, be monitored on a periodic basis.

Introduction

Chinook *Oncorhynchus tshawytscha* and chum *O. keta* salmon from the Kateel River contribute to the subsistence and commercial fisheries within the Yukon River drainage. Chinook salmon enter the Yukon River in mid-June and continue through early July. Summer chum salmon enter the Yukon River in mid-June, while fall chum salmon enter in late July or early August. Spawning Chinook salmon utilize tributaries along the entire Yukon River, while summer chum salmon utilize those tributaries along the lower and middle areas of the Yukon River. Recent declines of Yukon River salmon stocks, particularly summer and fall chum salmon (Bergstrom et al. 1995; Kruse 1998; JTC 2001), have led to harvest restrictions, subsistence fishery closures, and spawning escapements below management goals. Accurate escapement estimates are required to determine exploitation rates, marine survival rates, and spawner/recruit relations of Pacific salmon stocks (Labelle 1994). In addition, healthy salmon escapements to individual tributary spawning areas are required to maintain genetic diversity and sustainable harvests. Management of salmon populations within the Yukon River is complicated due to the mixed stock nature of this fishery (Tobin and Harper 1998).

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In an effort to understand the mixed stock fishery within the Yukon River, numerous tributary and main stem escapement studies are conducted each year to provide fishery managers with an indication of run strength for Chinook and chum salmon stocks. Historically, the Alaska Department of Fish and Game, Division of Commercial Fisheries (ADF&G-DCF) has conducted and compiled a data base on relative abundance of salmon stocks from many tributaries in interior Alaska. This database is primarily made up of aerial surveys (Barton 1984), which are highly variable and are used to estimate spawning strength. More in-depth studies along the lower Yukon River provide managers with information required to assess the in-season run (Vania and Golembeski 2000). These studies include the Emmonak test fishery, subsistence and commercial harvest reports, Pilot Station sonar, and the East Fork Andreafsky River weir. In addition, there are studies along the middle portion of the Yukon River that record stock status and trends of salmon populations. These studies include the pilot radio telemetry study on the Innoko River, the Anvik River sonar, the Nulato River counting tower, the Gisasa River weir, the Clear Creek-Hogatza River counting tower, and the Henshaw Creek weir.

On the Koyukuk River, a main tributary of the Yukon River, various salmon escapement projects have been conducted using weirs and counting towers (Figure 1; VanHatten 2004). The information gathered from these studies provides in-season escapement data to federal and state fisheries managers. These projects include the Gisasa River weir study (1994-2003), the South Fork Koyukuk River weir study (1996-1997), the Clear Creek-Hogatza River counting tower study (1995-2003), the Henshaw Creek counting tower study (1999), and the Henshaw Creek weir study (2000-2003).

To increase the understanding of Koyukuk River salmon resources, a 3-year resistance board weir project was initiated on the Kateel River in 2001. The Kateel River is one of many tributaries flowing into the Koyukuk River drainage on the Koyukuk National Wildlife Refuge (Koyukuk Refuge). The Koyukuk Refuge is located on the lower Koyukuk River near the villages of Koyukuk, Galena, Huslia, and Hughes. The communities located down river of the potential project site depend on both salmon species for subsistence use. In accordance with the Alaska National Interests Lands Conservation Act of 1980, Alaska Refuges were established to fulfill many goals and objectives. As part of these goals, the Refuges are responsible to conserve fish and wildlife populations, maintain habitats in their natural diversity, and provide the opportunity for continued subsistence use by local residents (USFWS 1993). Obtaining accurate escapement and stock assessment estimates from adult salmon are important components in refining fishery management practices and fulfilling Congressional mandates.

The upper reaches of the Kateel River, as well as other tributaries of the Koyukuk River, provide spawning and rearing habitat for Chinook and chum salmon (USFWS 1993). Aerial survey estimates of salmon escapement in the Kateel River have been conducted intermittently since 1960 (Appendix 1; Barton 1984; ADF&G, unpublished data). The Kateel River has been classified as a secondary index stream for Chinook and chum salmon (ADF&G 1998). With the use of a resistance board weir, biological information can be collected from both salmon species. The information collected will be used to meet issues identified by the Regional Advisory Councils and specific actions stated in the Yukon River Comprehensive Management Plan for Alaska.

The 2001-2003 objectives of the Kateel River weir study were to: 1) determine daily escapement and run timing of adult salmon; 2) gather age, sex, and length composition data from passing adult salmon; and 3) monitor non-salmon species movement through the weir.

Study Area

The Kateel River is a small, clear water tributary of the Koyukuk River located in north-central Alaska (Figure 1). The headwaters of the Kateel River originate in the Nulato Hills; drain the northwestern areas of the Koyukuk Refuge. The climate characteristics of this area are cold and continental, which is characterized by extreme seasonal temperature variations and very low precipitation. There is an extreme range in air temperature, with recorded temperatures ranging from 32 ^{o} C in summer to lows of -59 ^{o} C in winter (USFWS 1993). Stream flows are highest during the spring in response to snowmelt with sporadic high discharge periods throughout the summer in response to local rain showers.

The Kateel River channel configuration is typically meandering with alternating cut banks and gravel bars. The substrate varies from gravel and cobble in high velocity areas to mud and silt in lower velocity areas. The lower sections of the system are more uniform in appearance with gradual sloping mud banks and emergent shoreline vegetation. The weir site is located approximately 47 km upstream from the mouth of the Kateel River, with channel width averaging 31m and depth averaging 0.6 m. The substrate composition at this site consists of large gravel to small cobble (50-150 mm).

Methods

Weir Construction

A resistance board weir was used to collect biological information from adult salmon and resident fish species as they migrated up the Kateel River. Construction and installation methods for operating a resistance board weir were described by Tobin (1994). Each picket of the weir was schedule 40 polyvinyl chloride (PVC) electrical conduit with 2.5 cm inside diameter and individual pickets spaced 3.2 cm apart, gap between pickets (Wiswar 2001). Visual inspection of the weir was conducted on a daily basis for holes and structural integrity. During visual inspection, the weir was cleaned of debris and fish carcasses. A live trap installed near mid-channel allowed migrating salmon and resident fish species to pass through the weir.

Biological Data

Data were collected on daily passage rates for all passing fish; and age, length, and sex ratios of adult salmon. Salmon run timing was described by quartiles, i.e. first quartile represents the first 25th percentile of the run passing through the weir, middle quartile as the 50th percentile, and the third quartile as the 75th percentile. Daily counts began at 0800 hour and ended at 2400 hour, with the trap being closed from 2400 to 0800 hour to prevent upstream passage during unmonitored times. The counting schedule was divided into two 8-hour periods with two crewmembers recording biological information during each period.

A stratified random sampling scheme was used to collect age, length, and sex ratio information from both adult salmon species. Sampling for age, length, and sex started at the beginning of each week and generally was conducted over a 3-4 day period, targeting 160 salmon/species/ week. Scale samples were used for aging salmon and reported using the European technique

(Foerster 1968). Three scales were collected from Chinook salmon and one scale from chum salmon. Scales were sampled from the area located on the left side of the fish and two rows above the lateral line on a diagonal line from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin. Scales from both adult salmon species were sent to ADF&G-DCF for processing. Lengths of Chinook and chum salmon were measured to the nearest 5 mm from mid-eye to fork in the caudal fin (MEL). Sex ratio data were collected during age and length sampling. Sex of each fish was determined by secondary sex characteristics.

Data Analysis

Calculations for age and sex information were treated as a stratified random sample (Cochran 1977) with statistical weeks as the strata. Each statistical week was defined as beginning on Monday and ending on Sunday. Within a week, the proportion of the samples composed of a given sex or age, $\hat{p}_{ij}$, were calculated as

$$\hat{p}_{ij} = \frac{n_{ij}}{n_j},$$

where n_{ij} is the number of fish by sex i or age i sampled in week j, and n_j is the total number of fish sampled in week j. The variance of $\hat{p}_{ij}$ was calculated as

$$\hat{v}(\hat{p}_{ij}) = \frac{\hat{p}_{ij}(1-\hat{p}_{ij})}{n_j - 1}.$$

Sex and age compositions for the total run of Chinook and chum salmon of a given sex/age, $\hat{p}_i$ were calculated as

$$\hat{p}_i = \sum_{j-1} \hat{W}_j \hat{p}_{ij},$$

where the stratum weight $\hat{W}_j$ was calculated as

$$\hat{W}_j = \frac{N_j}{N},$$

and N_j equals the total number of fish of a given species passing through the weir during week j, and N is the total number of fish of a given species passing through the weir during the run. Variance, $\hat{v}(\hat{p}_i)$ of sex and age compositions for the run was calculated as

$$\hat{v}(\hat{p}_i) = \sum_{j-1} \hat{W}_j^2 \hat{v}(\hat{p}_{ij}).$$

Results and Discussion

Weir Operation

In 2001, the weir was not operated due to unforeseen delays in transporting the weir material and field supplies to the Kateel River site (VanHatten 2002). The remote location of the project and the large amount of weir materials required transportation to the site using a combination of Yukon River barge service and helicopter support. A late ice breakup on the Yukon River in 2001, severe flooding, and wild fires caused the barge and helicopter schedule to be delayed. Because of these unanticipated problems, weir construction was not competed until July 18. It was decided at this time that the project was too far behind schedule to be successful. Historic passage dates from other Koyukuk River salmon escapement projects, Gisasa River and Henshaw Creek (VanHatten 2002), suggested that over 50% of the Chinook and summer chum salmon runs would have likely passed the site by this date. Additional efforts were redirected toward preparing the weir site for operation in 2002.

In 2002, operation of the Kateel River weir began on June 23 and continued through July 27. During the field season the weir performed quite well and was effective in both passing fish and collecting biological information. The spacing between each weir pickets (3.2 cm) was close enough to prevent adult Chinook and summer chum salmon from passing through the weir panels. However, some small non-salmon species, such as Arctic grayling *Thymallus arcticus*, northern pike *Esox lucius*, and whitefish (Coregoninae), likely passed undetected through the weir. Multiple rain events during the 2002 season raised the water level high enough to potentially jeopardize the weir's integrity. High water levels can temporarily submerge weir panels (Tobin 1994), causing fish to migrate over and around the weir. At the start of the season, the water level (initially 35 cm) did not affect the counting schedule. From July 5-27 the water level rose above 53 cm, requiring the crew to make adjustments to keep fish from passing around and over the weir. These adjustments included constructing and installing additional weir panels and filling sandbags for placement around the trap, base rails, and bulkheads. By July 28 the water levels were high enough to submerge the weir panels, allowing fish to pass by undetected. Due to the high water and low escapement counts (daily passage <1% of seasonal passage to date) the study was terminated on July 28.

In 2003, budget constraints forced the cancellation of operations in the Kateel River. During summer, the weir and camp supplies were transported by helicopter and boat to the Gisasa River (an existing weir project site) and the village of Galena for storage. Because of the logistical difficulties in running a weir in such a remote location, it is recommended that if the Kateel River project becomes re-instated in the future, the weir be located closer to the confluence with the Koyukuk River. Potential sites located further downstream were identified in 2001 (K. VanHatten, U.S. Fish and Wildlife Service, personal communication). Although removal of the Kateel River weir reduced the amount of salmon escapement monitoring on the Koyukuk River, three projects did count salmon passage to Koyukuk River tributaries in 2003, i.e., Gisasa River weir, Clear Creek counting tower, and Henshaw Creek weir (Figure 1).

Biological Data

In 2002, summer chum salmon was the most abundant salmon species counted migrating through the Kateel River weir (N=2,853), followed by Chinook salmon (N=73; Table 1; Figure 2). Of the four non-salmon species migrating through the weir, whitefish species (N=13) were the most abundant, followed by longnose sucker *Catostomus catostomus* (N=6), Arctic grayling (N=4), and northern pike (N=3). The Kateel River weir counted fewer salmon than the other two weir projects operated on the Koyukuk River in 2002. The Gisasa River weir counted 33,125 summer chum salmon and 1,931 Chinook salmon, and Henshaw Creek weir recorded 25,249 summer chum salmon and 649 Chinook salmon (K. VanHatten, U.S. Fish and Wildlife Service, personal communication).

Chinook Salmon—Chinook salmon were first counted on July 5 and the last Chinook salmon passed on July 25. The first quartile migrated through the weir by July 10 and the median migration date was July 12 (Table 1; Figure 2). The Chinook salmon seasonal sex composition consisted of 29% females (N=66), with weekly female sex composition ranging from 25 to 40% (Table 2). Sixty-nine Chinook salmon were sampled for ageing, with three age samples classified as unreadable. Age composition consisted of three age groups: age 1.4 (14%), age 1.3 (36%), and age 1.2 (50%; Table 3). The average female Chinook salmon length was 710 mm with a range from 515 to 865 mm MEL (Table 4). The average male Chinook salmon length was 596 mm with a range from 410 to 845 mm MEL.

Summer Chum Salmon—Summer chum salmon were first counted on June 26, and the last summer chum was counted on July 27. The first quartile migrated through the weir by July 9, and the median migration date was July 11 (Table 1; Figure 2). The summer chum salmon seasonal sex ratio consisted of 45% females (N=524), with weekly female sex ratios ranging from 30 to 59% (Table 2). Of the 590 summer chum salmon samples used for age composition, 66 were classified as unreadable. Age composition for the remaining 524 sampled summer chum salmon consisted of three age groups: age 0.5 (4%), age 0.4 (38%), and age 0.3 (58%; Table 3). The average female summer chum salmon length was 555 mm, with a range from 380 to 650 mm MEL (Table 4). The average male summer chum salmon length was 587 mm with a range from 450 to 670 mm MEL.

Though data collection was limited to one year, the Kateel River was shown to support small stocks of Chinook and summer chum salmon. Because of the nature of the mixed-stock salmon fishery on the main stem Yukon River, small stocks can be susceptible to over-harvest (Vania et al. 2002). It is important that fisheries managers and funding sources recognize this threat to the health of these small populations. Projects that periodically assess run sizes of these small stocks, such as the Kateel River weir, should continue to be supported.

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Table 1. Daily and cumulative (Chinook and summer chum salmon only) counts of fish passing through the Kateel River weir, Alaska, 2002. (Cum=cumulative). * indicate first, middle, and third quartile of run.

	Chinook salmon		Summer chum salmon		Whitefish spp.	Longnose sucker	Arctic grayling	Northern pike
Date	Daily	Cum	Daily	Cum	Daily	Daily	Daily	Daily
23-Jun	0	0	0	0	0	0	0	0
24-Jun	0	0	0	0	0	0	0	0
25-Jun	0	0	0	0	0	0	0	0
26-Jun	0	0	2	2	0	0	0	0
27-Jun	0	0	1	3	0	0	0	0
28-Jun	0	0	5	8	0	0	0	0
29-Jun	0	0	2	10	0	0	0	0
30-Jun	0	0	2	12	0	0	0	0
1-Jul	0	0	7	19	0	1	0	1
2-Jul	0	0	11	30	0	0	0	0
3-Jul	0	0	8	38	0	0	0	0
4-Jul	0	0	51	89	0	0	0	0
5-Jul	3	3	94	183	2	0	1	0
6-Jul	0	3	58	241	0	0	0	0
7-Jul	2	5	137	378	0	0	0	0
8-Jul	5	10	269	647	1	1	0	1
9-Jul	7	17	296	*943	0	0	1	0
10-Jul	5	*22	258	1,201	2	1	0	0
11-Jul	10	32	305	*1,506	1	0	0	0
12-Jul	7	*39	221	1,727	0	0	0	0
13-Jul	4	43	211	1,938	1	2	2	0
14-Jul	4	47	196	2,134	0	0	0	0
15-Jul	3	50	91	*2,225	1	0	0	0
16-Jul	0	50	140	2,365	0	0	0	0
17-Jul	4	54	84	2,449	3	1	0	0
18-Jul	3	*57	74	2,523	2	0	0	0
19-Jul	2	59	65	2,588	0	0	0	0
20-Jul	1	60	49	2,637	0	0	0	0
21-Jul	5	65	58	2,695	0	0	0	0
22-Jul	4	69	44	2,739	0	0	0	0
23-Jul	1	70	51	2,790	0	0	0	0
24-Jul	2	72	19	2,809	0	0	0	0
25-Jul	1	73	17	2,826	0	0	0	0
26-Jul	0	73	11	2,837	0	0	0	1
27-Jul	0	73	16	2,853	0	0	0	0
Total	73		2,853		13	6	4	3

Table 2. Sex ratios of Chinook and summer chum salmon sampled at Kateel River weir, Alaska, 2002. Standard errors are in parentheses. Season total is calculated from weighted weekly estimates.

Time period	Run size	N	Percent female	Estimated number of females
		Chinook salmon		
Jun 23-30	0			
Jul 1-7	5	5	40 (24.5)	2
Jul 8-14	42	36	25 (7.3)	11
Jul 15-21	18	17	35 (11.9)	6
Jul 22-27	8	8	25 (16.4)	2
Season total	73	66	29 (5.7)	21
		Summer chum salmon		
Jun 23-30	12	10	50 (16.7)	6
Jul 1-7	366	152	38 (4.0)	140
Jul 8-14	1,756	137	30 (3.9)	526
Jul 15-21	561	116	59 (4.6)	329
Jul 22-27	158	109	59 (4.7)	93
Season total	2,853	524	45 (2.6)	1,093

Table 3. Percent weekly age estimates of Chinook and summer chum salmon sampled at Kateel River weir, Alaska, 2002. Standard errors are in parentheses. Season total is calculated from weighted weekly estimates.

Chinook salmon

				Brood year and age		
				1996	1997	1998
Time period	Run size	N	Unknown	1.4	1.3	1.2
June 23-30	0	0				
July 1-7	5	5	0	0 (0.0)	60 (24.5)	40 (24.5)
July 8-14	42	36	2	17 (6.3)	33 (8.0)	50 (8.5)
July 15-21	18	17	1	12 (8.1)	35 (11.9)	53 (12.5)
July 22-27	8	8	0	13 (12.5)	38 (18.3)	50 (18.9)
Season total	73	66	3	14 (4.4)	36 (6.0)	50 (6.3)

Summer chum salmon

				Brood year and age		
				1996	1997	1998
Time period	Run size	N	Unknown	0.5	0.4	0.3
Jun 23-30	12	10	1	0 (0.0)	50 (16.7)	50 (16.7)
Jul 1-7	366	152	11	6 (1.9)	41 (4.0)	53 (4.1)
Jul 8-14	1,756	137	25	4 (1.6)	41 (4.2)	55 (4.3)
Jul 15-21	561	116	16	3 (1.5)	33 (4.4)	65 (4.5)
Jul 22-27	158	109	13	3 (1.6)	37 (4.6)	61 (4.7)
Season total	2,853	524	66	4 (1.1)	38 (2.8)	58 (2.8)

Table 4. Length at age of female and male Chinook and summer chum salmon sampled at Kateel River weir, Alaska, 2002.

	Female				Male			
		Mid-eye to fork length (mm)				Mid-eye to fork length (mm)		
Age	N	Mean	Median	Range	N	Mean	Median	Range
Chinook salmon								
1.2	4	549	550	515-580	29	539	540	410-625
1.3	9	695	685	590-790	15	673	670	565-730
1.4	6	839	833	820-865	3	765	740	710-845
Total	19	710	740	515-865	47	596	575	410-845
Summer chum salmon								
0.3	143	549	550	480-650	160	578	575	450-665
0.4	86	562	560	380-625	115	596	600	530-670
0.5	7	581	590	520-630	13	618	615	560-670
Total	236	555	555	380-650	288	587	585	450-670

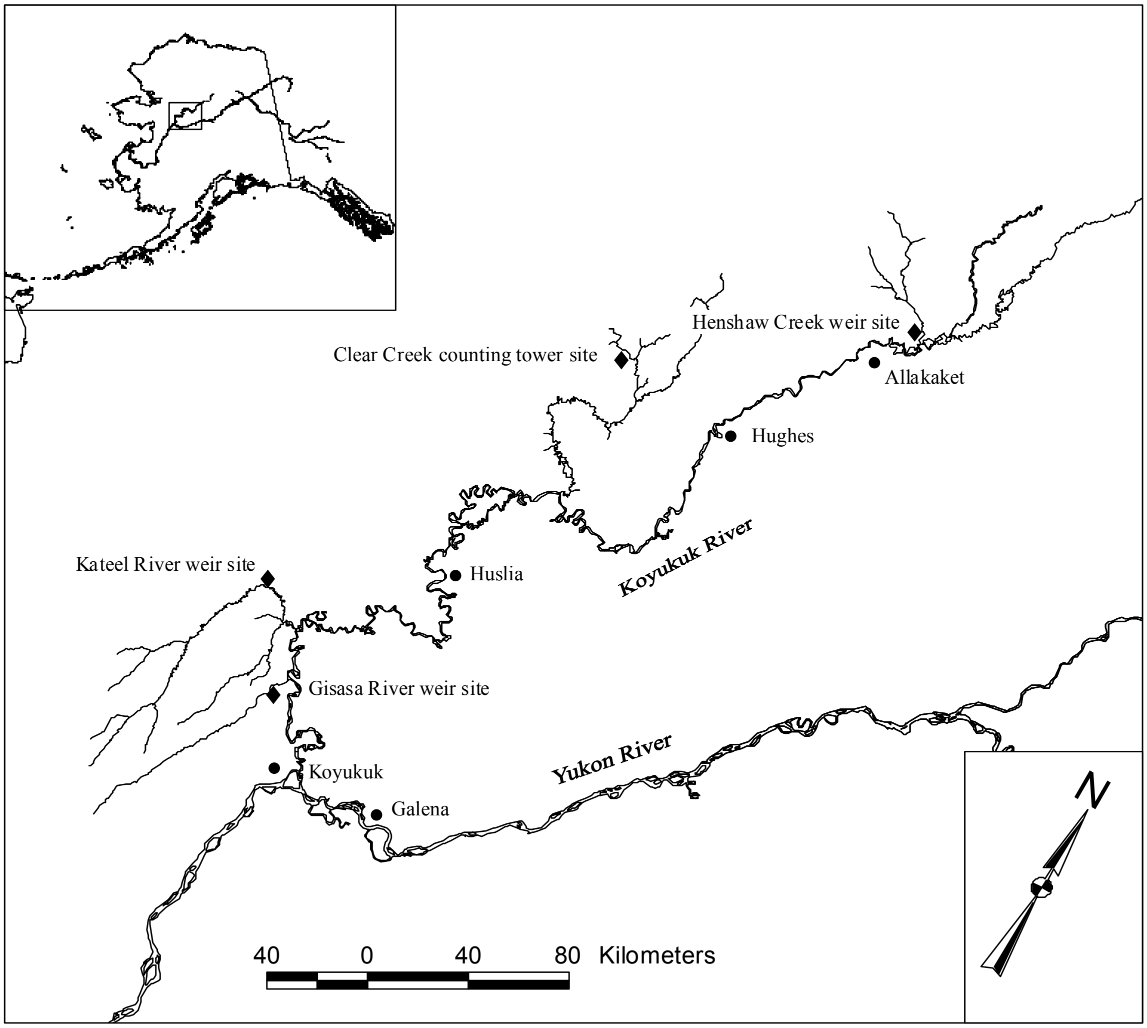

Figure 1. The Koyukuk River and tributary escapement study sites (♦), Alaska, 2001-2003.

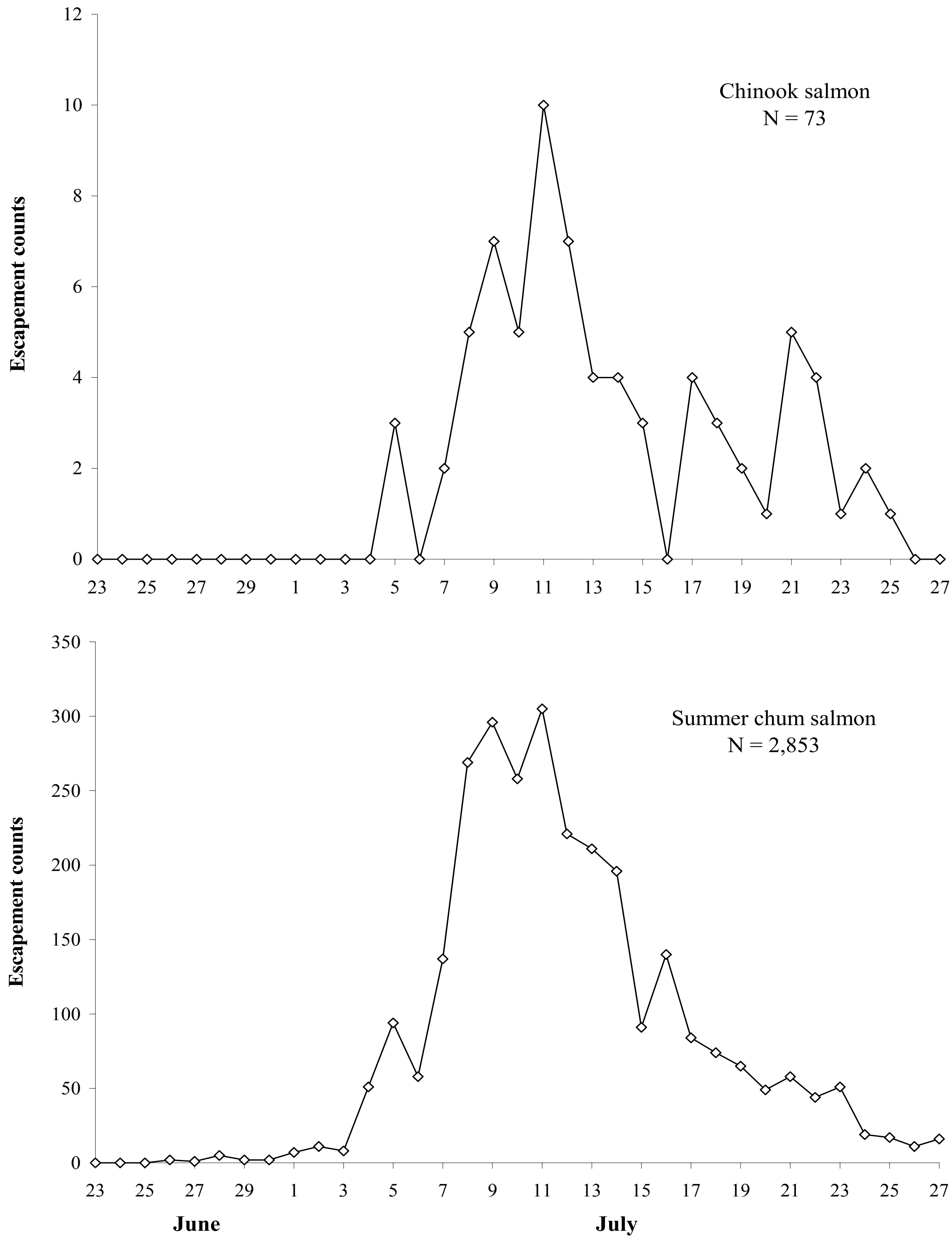

Figure 2. Daily Chinook and summer chum salmon escapement counts recorded at Kateel River weir site, Alaska, 2002.

Appendix 1. Historical Chinook and summer chum salmon escapements for Kateel River, Alaska, 1960-2003. All data except floating weir are from Barton (1984) and ADF&G, unpublished data. Aerial index estimates are surveys that are rated at poor, fair, good, or any combination.

	Aerial index estimates			Floating weir	
Year	Chinook salmon	Summer chum salmon	Rating	Chinook salmon	Summer chum salmon
1960	4	46	Fair		
1974	14	1,661	Fair		
1975	60	8,552	Fair/past peak		
1976	8	238	Fair/at peak		
1980	0	6	Good/before peak		
1990	185	338	Poor		
1992	65	800	Incomplete		
1993	0	0	Poor		
2002				73	2,853