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Abundance and run timing of adult salmon in Henshaw Creek, Kanuti National Wildlife Refuge, Alaska, 2000-2003

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Abstract

Chinook and summer chum salmon escapement counts assist managers in making decisions during in-season run activity, provide post season evaluation of various management practices, and assist in developing future run projections. From 2000 to 2003 a resistance board weir was used to record escapement information from Chinook and summer chum salmon on Henshaw Creek, within the Koyukuk River drainage, Alaska. The four-year average escapement for Chinook salmon was estimated at 670 fish with a range from 193 in 2000 to 1,091 in 2001. The average median date of passage occurred on July 16. The average Chinook salmon sex ratio was 38% females. The proportion of females generally increased as the season progressed in 2000 and 2001, but declined earlier in the run in 2002 and 2003. The 1.4 age class predominated only in 2001, while the 1.3 age class prevailed in the remaining years. The four-year average escapement for summer chum salmon was estimated at 26,458 fish with a range from 21,400 in 2003 to 34,777 in 2001. The average median date of passage occurred on July 19. The average summer chum salmon sex ratio was 57% females. The proportion of females increased in a consistent manner as each season progressed. The yearly dominant age class varied between age classes 0.3 and 0.4. Escapement fluctuations for Chinook and summer chum salmon did not describe any patterns, given the short observation period. The information collected established a database for Chinook and summer chum salmon populations in the upper Koyukuk River basin. Due to the complexity of the Yukon River fishery and the difficulty in managing specific stocks, it is vital to continue collecting information from individual salmon populations from the Koyukuk River drainage.

Introduction

In accordance with the Alaska National Interest Lands Conservation Act of 1980, the U.S. Fish and Wildlife Service (USFWS) is obligated to conserve the natural diversity of fish and wildlife resources on National Wildlife Refuge lands. As part of these goals, USFWS is responsible for conserving fish and wildlife populations, maintaining habitats in their natural diversity, and providing the opportunity for continued subsistence use by local residents (USFWS 1993). Due to recent declines of many Yukon River salmon runs, particularly summer and fall chum salmon, there have been harvest restrictions, complete subsistence fishery closures, and spawning escapement below management goals on many tributaries in the Yukon River drainage (Bergstrom et al. 1995; Kruse 1998). The need to collect accurate escapement estimates from these tributaries is required to determine exploitation rate, and spawner recruit relationships (Labelle 1994). In addition, monitoring salmon escapements into spawning areas is required if

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genetic diversity and sustainable harvests of those salmon stocks are to be maintained. Unfortunately, due to the mixed stock nature of the Yukon River fishery, management is complex (Tobin and Harper 1998). In an attempt to understand this mixed stock fishery, several studies are being conducted within the Yukon River drainage that provide managers with information required to assess the in-season run of Chinook and summer chum salmon (Vania and Golembeski 2000).

The Yukon River drainage, encompassing 854,700 km^2, is among the largest producers of wild Chinook *Oncorhynchus tshawytscha* and chum salmon *O. keta* stocks in North America (Daum and Osborne 1999). In addition to Chinook and chum salmon, coho *O. kisutsh*, sockeye salmon *O. nerka,* and pink salmon *O. gorbusha* are found in the drainage (Buklis and Barton 1984, Bergstrom et al. 1995). The Yukon River is the only North American drainage that has two distinct races of chum salmon (Bergstrom et al. 1995). Genetic studies reported by Wilmot et al. (1992) show that these two runs are genotypically distinct and differ in life history and phenotypic characteristics, e.g., run timing, spawning locations, and morphology. The run of Chinook and summer chum salmon in the Yukon River starts in early June and continues through mid-July (Wiswar 2000). Chinook salmon spawn throughout the Yukon River drainage, whereas summer chum salmon spawning mainly in the lower and middle reaches (Minard 1996). Fall chum salmon spawn in the upper Yukon River tributaries from mid August to late October (Buklis and Barton 1984).

The Koyukuk River is located 818 km upriver from the mouth of the Yukon River in west central Alaska (Figure 1). The headwaters of the Koyukuk River originate in the Brooks Range and the river flows southeasterly passing through the Kanuti (Kanuti Refuge) and Koyukuk (Koyukuk Refuge) National Wildlife refuges before entering the Yukon River. The Koyukuk Refuge is located on the lower Koyukuk River, near the villages of Koyukuk, Galena, Huslia, and Hughes, and the Kanuti Refuge is located on the upper Koyukuk River near the villages of Allakaket, Alatna, and Bettles.

It is important to monitor salmon escapements into tributaries within both refuges for many reasons. This information: (1) provides vital data to federal and state fishery managers for in-season management decisions, (2) tracks and compares individual salmon stocks within the Koyukuk River drainage, and (3) meets requirements of Alaska National Interests Lands Conservation Act of 1980 (USFWS 1993). Historically, the Alaska Department of Fish and Game, Division of Commercial Fisheries (ADF&G-DCF) has conducted aerial surveys on several index tributaries to collect escapement information since 1960 (Barton 1984). These surveys have not been conducted on a continuous basis, and the surveys are highly variable, only representing an index of escapements. To record total escapements, aerial survey methods have been replaced with more accurate population assessment methods like counting towers, floating weirs, and sonar. Obtaining accurate escapement and stock assessment estimates from adult salmon are important components in refining fishery management practices and fulfilling Congressional mandates. In order to meet these practices and goals, assessment and monitoring projects have been conducted on four different Koyukuk River tributaries (Figure 1) by U.S. Fish and Wildlife Service-Fairbanks Fish and Wildlife Field Office (USFWS-FFWFO). These projects use floating weirs to enumerate passing fish. A floating weir has been operated on the Gisasa River since 1994 (Wiswar 2001), on Henshaw Creek since 2000 (USFWS 2005), and on the South Fork Koyukuk River in 1996 and 1997 (Wiswar 1997; 1998). The South Fork Koyukuk River weir study was discontinued in 1997 due to persistent high water conditions

(Wiswar 1998). A fourth project was planned for 2001-2003, but only operated in 2002, on the Kateel River. Also, a counting tower has been operated on Clear Creek, Hogatza River, since 1995 by the Bureau of Land Management (C. Kretsinger, Bureau of Land Management, Fairbanks, personal communication).

Because the South Fork weir project was canceled due to persistent high water conditions, and in an effort to continue collecting salmon data from the upper Koyukuk River, Henshaw Creek was picked as a potential site for estimating Chinook and summer chum salmon. A counting tower was operated in 1999 on Henshaw Creek. However, due to high water conditions during a three-week time period, the study only estimated 12 Chinook and 1,510 summer chum salmon (VanHatten 1999). It was determined that a resistance board weir would be more effective in counting upstream migrating fish during high water conditions. In 2000, the weir material from the South Fork Koyukuk River was moved to the Henshaw Creek weir site, and operated fore its first season.

This report describes the 2000-2003 Henshaw Creek escapement project conducted by USFWS-FFWFO (Figure 1). The objectives of the project were to: (1) determine daily escapement and run timing of adult salmon; (2) determine sex and size composition of adult salmon; and (3) determine the presence and movement of resident fish.

Study Area

Climate conditions of the Koyukuk River drainage are characteristically continental with seasonal temperature variations and very low precipitation. The air temperature ranges from 18^{o} C in summer to -57^{o} C in winter (USFWS 1993). The hydrology of this area is very dynamic with high water levels during spring and low water levels in summer. The river sections near Henshaw Creek are characteristically more uniform in appearance with gradual sloping mud banks and emergent shoreline vegetation (USFWS 1993). The substrate composition along the river varies from gravel and cobble in high velocity sections to mud and silt in eddies and sloughs.

Henshaw Creek (66^{o} 33' N latitude, 152^{o} 13' W longitude, USGS 1:63,360 series, Bettles C-5 quadrangle) is located 721 km upriver from the mouth of the Koyukuk River (Figure 1). The headwaters originate in the Alatna Hills and the river flows 144 km southeast, passing through the Kanuti Refuge, before entering the Koyukuk River.

The location of the weir site is approximately 1.5 km upriver from the mouth of Henshaw Creek. This site was selected for its optimal width (29 m), depth (0.6 m), and substrate composition (small cobble of 50-150 mm in diameter).

Methods

Weir operation

A resistance board weir was operated to obtain escapement counts and collect biological information from adult salmon as they migrated into Henshaw Creek. Construction and installation of the weir is described by Tobin (1994). Each picket of the weir was made of 2.5 cm (inside diameter) schedule-40, polyvinyl chloride (PVC) electrical conduit which was spaced 6.7 cm apart, from center to center (Wiswar 2001). During visual inspection, the weir was cleaned of debris and fish carcasses. A live trap, installed near mid-channel allowed salmon and resident species to be recorded as they migrated upstream. The criterion for selecting the end date of the project was based on when the daily count was less than 1% of the run for two or more consecutive days.

Biological data

Run timing and abundance of adult salmon were estimated by recording and plotting the number of each species of fish migrating through the weir each day. Non-salmon species were not handled as they migrated through the weir. Because the non-salmon species were not handled, it was difficult to identify different whitefish species; therefore all whitefish species were grouped under the subfamily Coregoninae.

The counting schedule was designed to count migrating fish species 24 hours a day, 7 days a week for the duration of the project. The daily counting schedule began at 0001 hours and ended at 2400 hours. During high water events when the counting schedule was interrupted, missing daily salmon estimates were generated by linear interpolation. However, if the count for the day prior to the high water event was zero, no interpolation was performed.

A stratified random sampling scheme was used to collect age, length, and sex ratio information from both adult salmon species. Calculations for age and sex information were treated as a stratified random sample (Cochran 1977) with single statistical weeks being defined as the strata. Each statistical week was defined as beginning on Monday and ending on Sunday. Sampling began at the beginning of each week and, generally was conducted over a 3-4 day period. A goal of 160 fish per species per week was set for each sample period for collecting scales for age, sex ratios, and length distribution data.

Scales were used for aging salmon with age class information being reported using the European technique (Foerster 1968). Three scales were collected from Chinook salmon and one scale from summer 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 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. Daily sex ratios were collected using two methods: (1) sex of each fish was recorded when sampling for age and length; and (2) sex of other fish were identified throughout the day. For identifying fish throughout the day, the sexes of fish were opportunistically identified. Crew members physically handled and identified sex of the fish as they migrated into the trap. Sex of each fish was determined by secondary sex characteristics. The daily escapement count and sex ratios were reported to the USFWS-FFWFO. Lengths of Chinook and summer chum salmon were measured to the nearest 5 mm from mid eye to fork of the caudal fin (MEL).

Data analysis

Within a week, the proportion of the samples composed of a given sex or age, 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 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 summer chum salmon of a given sex/age, p_i, were calculated as:

$$\hat{p}_i = \sum \left(\frac{N_j}{N} \right) \hat{p}_{ij} ,$$

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. Variances of sex and age compositions for the run were calculated as:

$$\hat{v}(\hat{p}_i) = \sum_{j=1} \left(\frac{N_j}{N} \right)^2_j \hat{v}(\hat{p}_{ij}) .$$

Results and Discussion

Weir operation

Chinook and summer chum salmon escapements were estimated using a resistance board weir. Depending on break-up conditions, the starting date for weir operations ranged from June 28 in 2003 to July 8 in 2000 (Table 1). The end date of the project varied each year and ranged from August 2 in 2002 to August 12 in 2001. During operation of the weir spawning activity of summer chum salmon immediately upstream of the weir resulted in areas where gravel accumulated on the weir panels. These areas and floating debris were cleaned off the weir on a daily basis.

The weir on Henshaw Creek was operational throughout the field season in 2001 and 2002, but was operational for only part of the season in 2000 and 2003. During the 2000 and 2003 field season there was high water for most of the season, which caused the counting schedule to be interrupted at times. On those occasions when water level rose high enough to impede the counting schedule the weir remained intact but weir panels were submerged allowing fish to pass undetected (Tobin 1994). When the weir was operational the picket spacing within the trap and weir panels were spaced far enough apart to prevent adult Chinook and summer chum salmon from passing through the weir. However, some of the smaller fish species, e.g., Arctic grayling *Thymallus arcticus* and whitefish spp. Coregoninae, likely passed through the weir without being counted.

Biological data

Longnose sucker *Catostomus catostomus* was the most abundant resident species passing through the weir with an annual average of 1,806 fish counted over the four year period. This species was followed by Arctic grayling with an average of 134 fish, northern pike *Esox lucius* with an average of 5 fish, and whitefish with an average of 3 fish (Appendix 1 and 2).

Chinook salmon—From 2000 to 2003 the largest recorded Chinook salmon escapement count was 1,091 fish in 2001 and the lowest recorded escapement count was 193 fish in 2000 (Table 1; Figure 2). The average annual estimate for the four-year period was 670 fish. Run timing varied from year to year, with the average annual median date of passage being July 16 (Table 1; Figure 3). Five age classes were represented in Chinook salmon escapements with age class 1.4 more abundant in only the escapement for 2001. Age class 1.3 was more abundant in the remaining years (Table 2; Figure 4). The seasonal Chinook salmon sex ratio ranged from 20% female in 2000 to 40% in 2001 (Table 3). The average seasonal female Chinook salmon length ranged from 818 in 2002 to 833 mm in 2003 (Table 4; Figure 5). The average seasonal male Chinook salmon length ranged from 616 in 2000 to 686 mm in 2001.

Summer chum salmon—From 2000 to 2003 the largest recorded summer chum salmon escapement count was 34,777 fish in 2001 and the lowest recorded escapement count was 21,400 fish in 2003 (Table 5, Figure 6). The average annual estimated escapement for the four-year period was 26,458 fish. Run timing varied from year to year, with the average annual median date of passage being July 19 (Table 5, Figure 7). Four age classes were represented in summer chum salmon escapements, with age class 0.3 more abundant in the escapements of 2000 and 2003, with age class 0.4 more abundant in 2001 and 2002 (Table 6, Figure 8). The seasonal summer chum salmon sex ratio ranged from 50% female in 2003 to 61% in 2001 (Table 7). The average seasonal female summer chum salmon length ranged from 537 in 2000 to 556 mm in 2002 (Table 8, Figure 9). The average seasonal male summer chum salmon length ranged from 570 in 2000 and 2003 to 592 mm in 2002.

Escapement and run timing

In general, the abundance of Yukon River Chinook and summer chum salmon has improved in recent years. However, the short time frame for operation of Henshaw Creek weir did not allow a long term comparison with other stocks other than to observe that the abundance of Henshaw Creek and Gisasa River Chinook salmon stocks has fluctuated over the past four-years. On Henshaw Creek the Chinook salmon escapement counts increased 465% between 2000 (N=193) and 2001 (N=1,091), then decreased 41% between 2001 and 2002 (N=649), and then increased 15% between 2002 and 2003 (N=748). This fluctuating trend was also noticed on the Gisasa River where the Chinook salmon escapement increased 46% between 2000 (N=2,089) and 2001 (N=3,052), then decreased 34% between 2001 and 2002 (N=2,025), and again decreased another 6% between 2002 and 2003 (N=1,899; Figure 10). While the variation between years at both sites appeared realistic, the low count in 2000 on Henshaw Creek was most likely due to under-estimation of passage for six of seven days during a main part (July 13-19) of the run.

On Henshaw Creek, the summer chum salmon escapement count in 2000 was 24,406, and in 2001 the escapement count increased 42% to 34,777 (Table 5, Figure 7). However, from 2001 to 2002 the escapement count decreased 27% (25,249) and further decreased by 15% in 2003 (21,400). By comparison the Gisasa River summer chum salmon escapement counts have fluctuated also. The Gisasa River summer chum salmon count in 2000 (N=11,410) increased 57% to 17,936 in 2001 (Figure 11). From 2001 to 2002 the summer chum salmon count increased by 84% to 33,125, and from the 2002 to 2003 the count decreased by 26% to 24,507.

Given the short time observation period for these projects, the fluctuations in abundance and comparisons cannot describe meaningful patterns for either species.

Age distribution

Chinook salmon populations are generally made up of six different age classes, with older fish dominating (Groot and Margolis 1998). Age class 1.3 was the more abundant class for the Chinook salmon escapements from Henshaw Creek for every year of observation with the exception of 2001 when age class 1.4 prevailed (Table 2, Figure 4). Age class 1.3 constituted 63%, 36% and 44% of the escapements for 2000, 2002, and 2003, respectively, while age class 1.4 represented 45% of the run in 2001. Similarly and by comparison, age class 1.3 of the Gisasa River Chinook salmon escapements was also more abundant in every year observed, again with the exception of 2001, when age class 1.4 prevailed (Figure 12).

Summer chum salmon populations are generally comprised of 0.2, 0.3, and 0.4 age classes with older fish dominating (Groot and Margolis 1998). However, no single age class was consistently more abundant in the 2000-2003 Henshaw Creek summer chum salmon escapements (Table 6, Figure 8). Age class 0.3 was more abundant in the escapements of 2000 (57%) and 2003 (86%), while age class 0.4 prevailed in 2001 (63%) and 2002 (80%). By comparison, age class 0.4 was more abundant in the Gisasa River summer chum salmon escapement in 2000 (61%) and 2001 (73%) while age class 0.3 prevailed in 2002 (60%) and 2003 (70%) (Figure 13). Due to the many marine and freshwater variables that salmon are exposed to during their life cycles, it is not clear why different age classes are more abundant during any given year for specific tributaries.

Sex ratio

During the salmon spawning period, there are typically higher proportions of males in early stages of the run while females dominate later stages (Beacham and Starr 1982). In 2000 and 2001 the Henshaw Creek Chinook salmon escapements followed this trend, with female ratios starting low during the first week and generally increasing past the mid point of the run. However, the female ratios for escapements in 2002 and 2003 declined earlier in the season (Figure 14). The ratio started a gradual decline after the second week of the 2002 escapement, and a steeper decline after the fourth week of the 2003 escapement.

By comparison, the female ratios of the Gisasa River Chinook salmon escapements also followed the typical trend in 2000 and 2001. However, the female ratio for escapements in 2002 and 2003 failed to confirm the trend by declining more during the early segments of the escapements in 2002 and 2003.

By comparison with Chinook salmon escapements, summer chum salmon in both Henshaw Creek and Gisasa River exhibited a more consistent increase in the female ratio throughout the seasons, with the exception of the 2003 escapement to the Gisasa River. In this year, a gradual decline in the female ratio began after the second week of the run (Figure 15).

The operation of weirs on tributaries within the Koyukuk River drainage is an important management tool. Both federal and state managers rely upon inseason weir data to understand population dynamics of Chinook and summer chum salmon as fisheries are occurring. The information collected has also established databases for Koyukuk River Chinook and summer chum salmon populations that allow postseason evaluation of management actions.

Due to the complexity of the Yukon River fishery, the difficulty in managing specific stocks, and the variability of escapement characteristics, it is vital to continue collecting information from individual salmon populations. Comparison of four years of data showed that the Henshaw Creek and Gisasa River systems can be quite different in run timing, sex ratios, age distributions, and escapement numbers of returning salmon. With this in mind, it is recommended that both these projects be continued for the long-term, so that population trends in both systems can be identified.

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Table 1.—Daily and cumulative count of Chinook salmon migrating through Henshaw Creek weir, Alaska, 2000-2003. cum = cumulative. Asterisk indicates first, middle, and third quartile of run. Bold numbers indicated interpolated estimates.

	2000		2001		2002		2003	
Date	Daily	cum	Daily	cum	Daily	cum	Daily	cum
28-Jun							1	1
29-Jun							1	2
30-Jun							2	4
1-Jul					1	1	3	7
2-Jul					0	1	3	10
3-Jul					2	3	**8**	**18**
4-Jul					0	3	**13**	**31**
5-Jul					1	4	**18**	**49**
6-Jul					9	13	**23**	**72**
7-Jul			1	1	10	23	**28**	**100**
8-Jul	0	0	0	1	29	52	**33**	**133**
9-Jul	0	0	0	1	62	114	38	171
10-Jul	5	5	0	1	51	*165	47	*218
11-Jul	2	7	6	7	65	230	31	249
12-Jul	25	32	24	31	64	294	33	282
13-Jul	**22**	***54**	46	77	30	324	27	309
14-Jul	**19**	**73**	92	169	58	*382	29	338
15-Jul	**16**	**89**	117	*286	31	413	30	368
16-Jul	**13**	***102**	38	324	44	457	36	*404
17-Jul	10	112	57	381	37	*494	45	449
18-Jul	**10**	**122**	83	464	29	523	72	521
19-Jul	**10**	**132**	95	*559	33	556	64	*585
20-Jul	11	143	144	703	20	576	20	605
21-Jul	10	*153	135	*838	12	588	22	627
22-Jul	11	164	32	870	20	608	29	656
23-Jul	3	167	69	939	8	616	9	665
24-Jul	6	173	32	971	8	624	10	675
25-Jul	5	178	27	998	1	625	15	690
26-Jul	0	178	16	1,014	4	629	16	706
27-Jul	3	181	17	1,031	4	633	**13**	**719**
28-Jul	2	183	6	1,037	1	634	**10**	**729**
29-Jul	**2**	**185**	12	1,049	5	639	**7**	**736**
30-Jul	**2**	**187**	10	1,059	4	643	**4**	**740**
31-Jul	2	189	4	1,063	2	645	1	741
1-Aug	1	190	7	1,070	3	648	3	744
2-Aug	1	191	4	1,074	1	649	0	744
3-Aug	0	191	4	1,078			2	746
4-Aug	0	191	3	1,081			0	746
5-Aug	1	192	2	1,083			2	748
6-Aug	1	193	3	1,086			0	748
7-Aug	0	193	2	1,088				
8-Aug	0	193	1	1,089				
9-Aug	0	193	1	1,090				
10-Aug	0	193	0	1,090				
11-Aug	0	193	0	1,090				
12-Aug	0	193	1	1,091				
Total	193		1,091		649		748	

Table 2.—Brood year and age class distribution of Chinook salmon sampled at Henshaw Creek weir, Alaska, 2000-2003.

			Brood year and age class							
Population (N)	Sample (n)	Unknown Age	1993	1994	1995	1996	1997	1998	1999	2000
				2000						
			1.5	1.4	1.3	1.2	1.1			
193	38	0	0%	18%	63%	18%	0%			
				2001						
				1.5	1.4	1.3	1.2	1.1		
1,091	377	53		1%	45%	42%	12%	0%		
				2002						
					1.5	1.4	1.3	1.2	1.1	
649	347	39			2%	31%	36%	30%	0%	
				2003						
						1.5	1.4	1.3	1.2	1.1
748	304	17				2%	33%	44%	19%	2%

Table 3.—Sex ratios and sample size of Chinook salmon sampled at Henshaw Creek weir, Alaska, 2000-2003. Standard errors are in parentheses.

Year	Total number of salmon estimated	Sample size (n)	Percent female of sample	Estimated number of females
2000	193	94	20	39
2001	1,091	975	40	436
2002	649	347	31	201
2003	748	580	38	284

Table 4.—Mean length at age of female and male Chinook salmon sampled at Henshaw Creek weir, Alaska, 2000-20003.

	Female				Male			
Age	N	Percent per sample	Mean (SE)	Range	N	Percent per sample	Mean (SE)	Range
				2000				
1.1	0				0			
1.2	0				7	27%	492 (14.0)	460-550
1.3	5	42%	812 (9.3)	790-840	19	73%	661 (12.9)	545-750
1.4	7	58%	830 (17.0)	795-915	0			
1.5	0				0			
Total	12		823 (10.6)	790-915	26		616 (18.0)	460-750
				2001				
1.1	0				0			
1.2	0				44	17%	534 (8.9)	450-740
1.3	24	21%	787 (17.3)	605-905	142	59%	697 (5.6)	490-860
1.4	108	79%	830 (4.8)	620-835	55	23%	778 (7.2)	640-885
1.5	4		842	770-915	4	1%	843 (37.8)	770-915
Total	136		826 (5.2)	605-915	241		686 (6.5)	450-915
				2002				
1.1	0				0			
1.2	1	1%	540 (0.0)	-	104	43%	521 (7.2)	410-860
1.3	24	22%	784 (13.4)	610-890	101	42%	699 (6.2)	545-930
1.4	75	70%	832 (6.3)	715-975	34	15%	797 (10.5)	685-950
1.5	7	7%	853 (22.0)	740-920	1	0%	895 (0.0)	-
Total	107		818 (6.4)	540-975	240		637 (8.1)	410-950
				2003				
1.1	0				5	3%	376 (4.9)	365-390
1.2	0				59	32%	508 (6.2)	410-695
1.3	26	22%	764 (10.1)	695-875	108	58%	690 (5.4)	425-780
1.4	88	74%	851 (6.4)	580-955	13	7%	830 (21.3)	700-940
1.5	5	4%	894 (10.4)	860-915	0			
Total	119		833 (6.3)	580-955	185		633 (8.8)	365-940

Table 5.—Daily and cumulative count of summer chum salmon migrating through Henshaw Creek weir, Alaska, 2000-2003. cum = cumulative. Asterisk indicates first, middle, and third quartile of run. Bold numbers indicate interpolated estimates.

	2000		2001		2002		2003	
Date	Daily	cum	Daily	Cum	Daily	cum	Daily	cum
28-Jun							3	3
29-Jun					35	35	0	3
30-Jun					22	57	3	6
1-Jul					55	112	5	11
2-Jul					187	299	29	40
3-Jul					237	536	**74**	**114**
4-Jul					321	857	**119**	**233**
5-Jul					285	1,142	**164**	**397**
6-Jul					585	1,727	**209**	**606**
7-Jul					1,362	3,089	**254**	**860**
8-Jul	101	101			1,380	4,469	**299**	**1,159**
9-Jul	75	176	1	1	1,646	6,115	344	1,503
10-Jul	141	317	41	42	1,079	*7,194	481	1,984
11-Jul	229	546	335	377	741	7,935	638	2,622
12-Jul	514	1,060	1,420	1,797	779	8,714	785	3,407
13-Jul	**626**	1,686	1,972	3,769	982	9,696	536	3,943
14-Jul	**737**	2,423	1,602	5,371	1,480	11,176	591	4,534
15-Jul	**849**	3,272	1,530	6,901	1,839	*13,015	574	5,108
16-Jul	**960**	4,232	1,438	8,339	1,870	14,885	591	*5,699
17-Jul	1,072	5,304	1,791	*10,130	1,796	16,681	813	6,512
18-Jul	**1,276**	*6,580	2,048	12,178	1,501	18,182	1,000	7,512
19-Jul	**1,479**	8,059	2,452	14,630	1,309	*19,491	1,104	8,616
20-Jul	1,683	9,742	3,259	*17,889	1,055	20,546	1,105	9,721
21-Jul	1,306	11,048	2,793	20,682	879	21,425	1,059	*10,780
22-Jul	1,903	*12,951	1,725	22,407	567	21,992	1,259	12,039
23-Jul	2,189	15,140	2,541	24,948	547	22,539	1,524	13,563
24-Jul	2,167	17,307	1,988	*26,936	585	23,124	1,556	15,119
25-Jul	1,619	*18,926	1,312	28,248	384	23,508	1,339	*16,458
26-Jul	1,054	19,980	1,022	29,270	233	23,741	1,143	17,601
27-Jul	775	20,755	681	29,951	377	24,118	**944**	**18,545**
28-Jul	402	21,157	634	30,585	338	24,456	**745**	**19,290**
29-Jul	342	21,499	614	31,199	302	24,758	**546**	**19,836**
30-Jul	281	21,780	681	31,880	135	24,893	**347**	**20,183**
31-Jul	221	22,001	652	32,532	174	25,067	149	20,332
1-Aug	394	22,395	598	33,130	106	25,173	248	20,580
2-Aug	307	22,702	353	33,483	76	25,249	189	20,769
3-Aug	325	23,027	288	33,771			236	21,005
4-Aug	293	23,320	203	33,974			164	21,169
5-Aug	232	23,552	188	34,162			162	21,331
6-Aug	184	23,736	117	34,279			69	21,400
7-Aug	186	23,922	84	34,363				
8-Aug	121	24,043	80	34,443				
9-Aug	131	24,174	90	34,533				
10-Aug	75	24,249	94	34,627				
11-Aug	47	24,296	73	34,700				
12-Aug	68	24,364	77	34,777				
13-Aug	42	24,406						
Total	24,406		34,777		25,249		21,400	

Table 6.—Brood year and age class distribution of summer chum salmon sampled at Henshaw Creek weir, Alaska, 2000-2003.

			Brood year and age						
Population (N)	Sample (n)	Unknown age	1994	1995	1996	1997	1998	1999	2000
			2000						
			0.5	0.4	0.3	0.2			
24,406	519	61	0%	42%	57%	1%			
			2001						
				0.5	0.4	0.3	0.2		
34,777	627	162		2%	63%	34%	0%		
			2002						
					0.5	0.4	0.3	0.2	
25,249	732	142			4%	80%	16%	0%	
			2003						
						0.5	0.4	0.3	0.2
21,400	696	86				1%	9%	86%	4%

Table 7.—Sex ratios and sample size of summer chum salmon sampled at Henshaw Creek weir, Alaska, 2000-2003. Standard errors are in parentheses.

Year	Total number of salmon estimated	Sample size (n)	Percent female of sample	Estimated number of females
2000	24,406	1,649	57%	14,445
2001	34,777	1,557	61%	21,214
2002	25,249	21,727	60%	15,149
2003	21,400	14,266	50%	10,700

Table 8.—Mean length at age of female and male summer chum salmon sampled at Henshaw Creek weir, Alaska, 2000-2003.

	Female				Male			
Age	N	Percent per sample	Mean (SE)	Range	N	Percent per sample	Mean (SE)	Range
				2000				
0.2	3	2%	525 (8.7)	510-540	1	1%	535 (0.0)	
0.3	196	59%	531 (1.7)	445-600	104	55%	561 (2.7)	515-655
0.4	134	40%	545 (2.4)	430-615	80	43%	581 (3.7)	500-655
0.5	0				1	1%	570 (0.0)	-
Total	333		537 (1.4)	430-615	186		570 (2.3)	500-655
				2001				
0.2	1	0%	480 (0.0)	-	0	0%		
0.3	149	36%	532 (2.4)	430-640	64	30%	560 (4.5)	480-650
0.4	254	62%	559 (2.1)	450-665	144	67%	594 (3.6)	520-725
0.5	8	2%	547 (11.4)	500-595	7	3%	577 (8.4)	550-620
Total	412		549 (1.7)	430-665	215		583 (2.9)	480-725
				2002				
0.2	1	1%	520		0			
0.3	79	18%	543 (3.5)	450-630	35	12%	577 (5.1)	540-690
0.4	348	79%	559 (1.3)	465-635	241	83%	594 (2.3)	515-805
0.5	14	3%	570 (6.0)	540-600	14	5%	589 (7.6)	540-640
Total	442		556 (1.3)	450-635	290		592 (2.1)	515-805
				2003				
0.2	6	2%	526 (11.9)	495-570	2	1%	585 (25.0)	560-610
0.3	317	87%	537 (1.5)	465-625	281	84%	563 (1.7)	490-660
0.4	24	7%	567 (5.9)	495-615	35	10%	596 (6.7)	510-660
0.5	14	4%	580 (6.0)	530-610	17	5%	633 (6.0)	595-680
Total	361		540 (1.5)	465-625	335		570 (1.9)	490-680

Table 9.—Yearly percent female and percent of population sampled of Chinook salmon recorded from Henshaw Creek and Gisasa River weirs, Alaska, 2000-2003.

Year	Population size (N)	Sample size (n)	Percent sampled	Percent Female
Henshaw Creek				
2000	193	94	49%	20%
2001	1,091	975	89%	40%
2002	649	347	53%	31%
2003	748	580	78%	38%
Gisasa River				
2000	2,089	946	45%	36%
2001	3,052	781	26%	49%
2002	2,025	526	26%	21%
2003	1,899	631	33%	37%

Table 10.—Yearly percent female and percent of population sampled of summer chum salmon recorded from Henshaw Creek and Gisasa River weirs, Alaska, 2000-2003.

Year	Population size (N)	Sample Size (n)	Percent sampled	Percent female
Henshaw Creek				
2000	24,406	1,649	7%	57%
2001	34,777	1,557	4%	61%
2002	25,249	732	3%	60%
2003	21,400	14,266	67%	50%
Gisasa River				
2000	11,410	952	8%	49%
2001	17,936	1,233	7%	51%
2002	33,481	777	3%	48%
2003	24,507	14,731	60%	48%

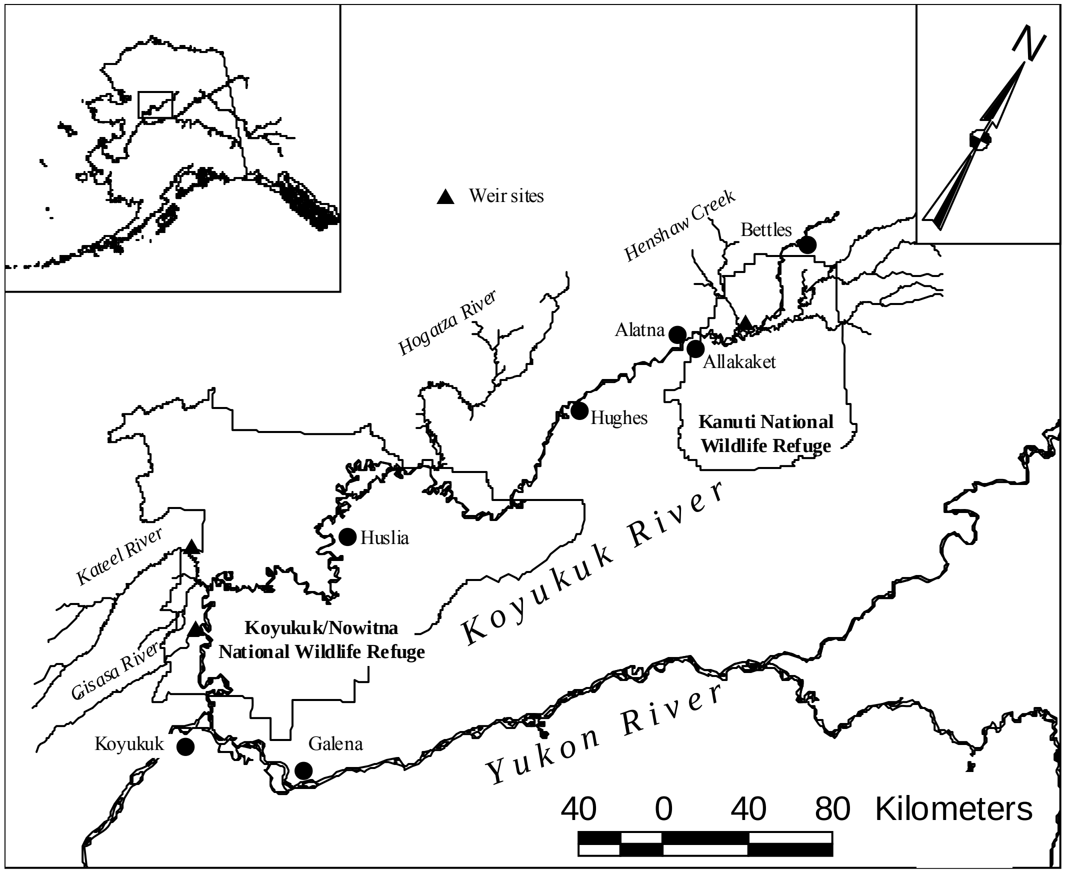

Figure 1.--Koyukuk River, major tributaries, and resistance board study sites(▲), Alaska, 2003. (The Kateel River weir was not in operation in 2003.)

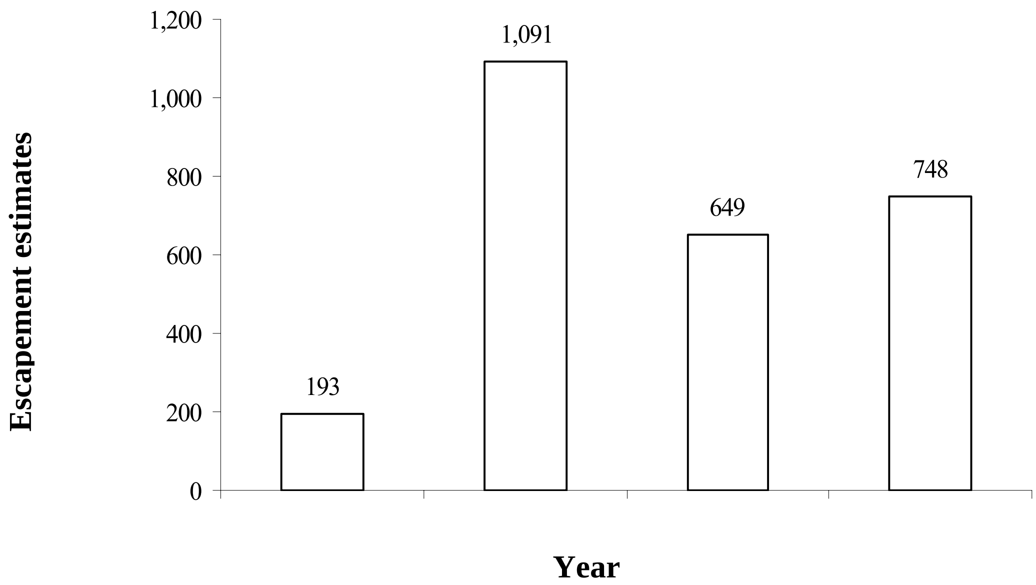

Figure 2.—Seasonal escapement estimates of Chinook salmon recorded at Henshaw Creek weir, Alaska, 2000-2003.

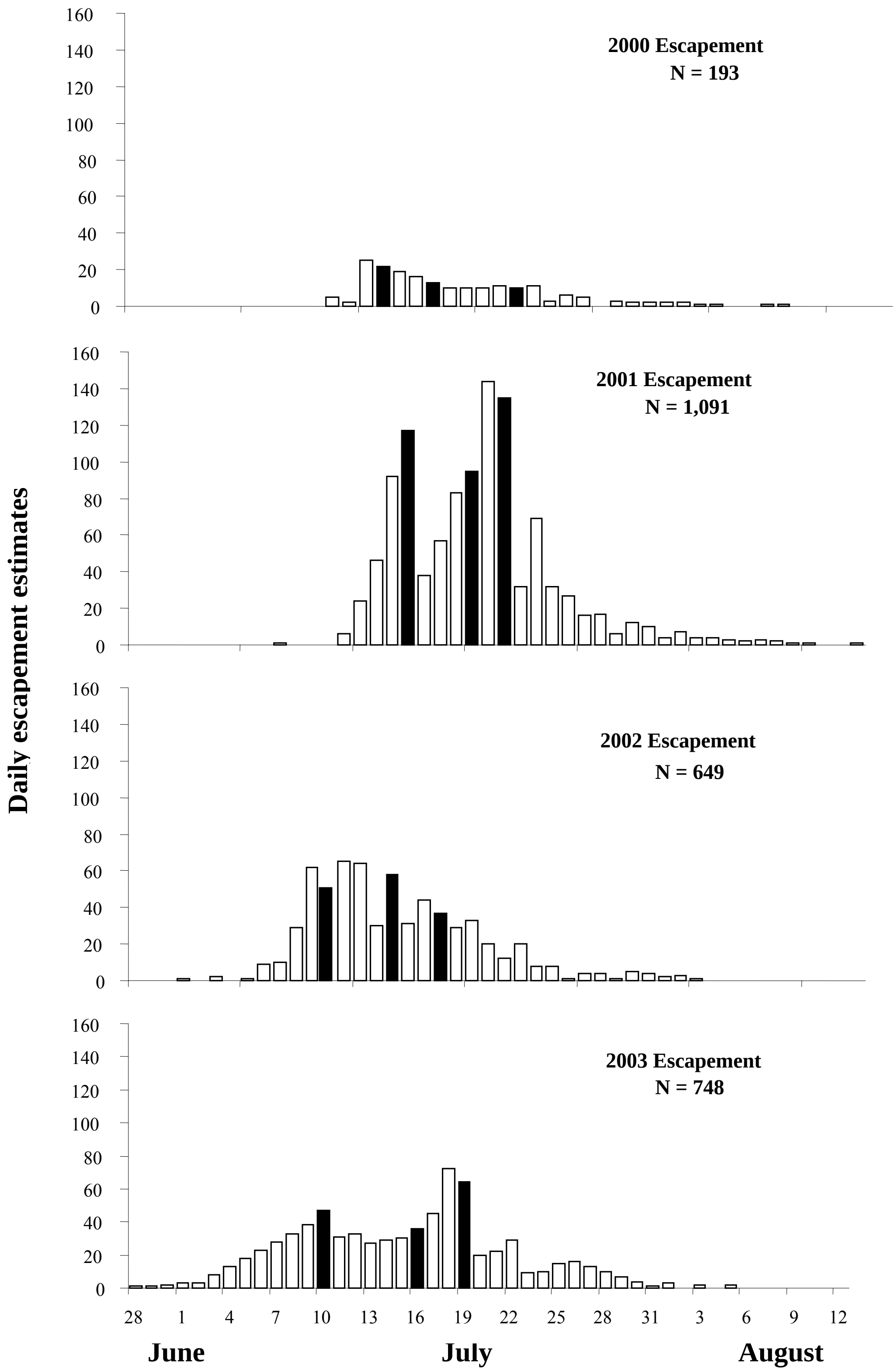

Figure 3.—Daily escapement estimates and run timing of Chinook salmon migrating through Henshaw Creek weir, 2000-2003. Shaded areas represent first, second, and third quartiles of run.

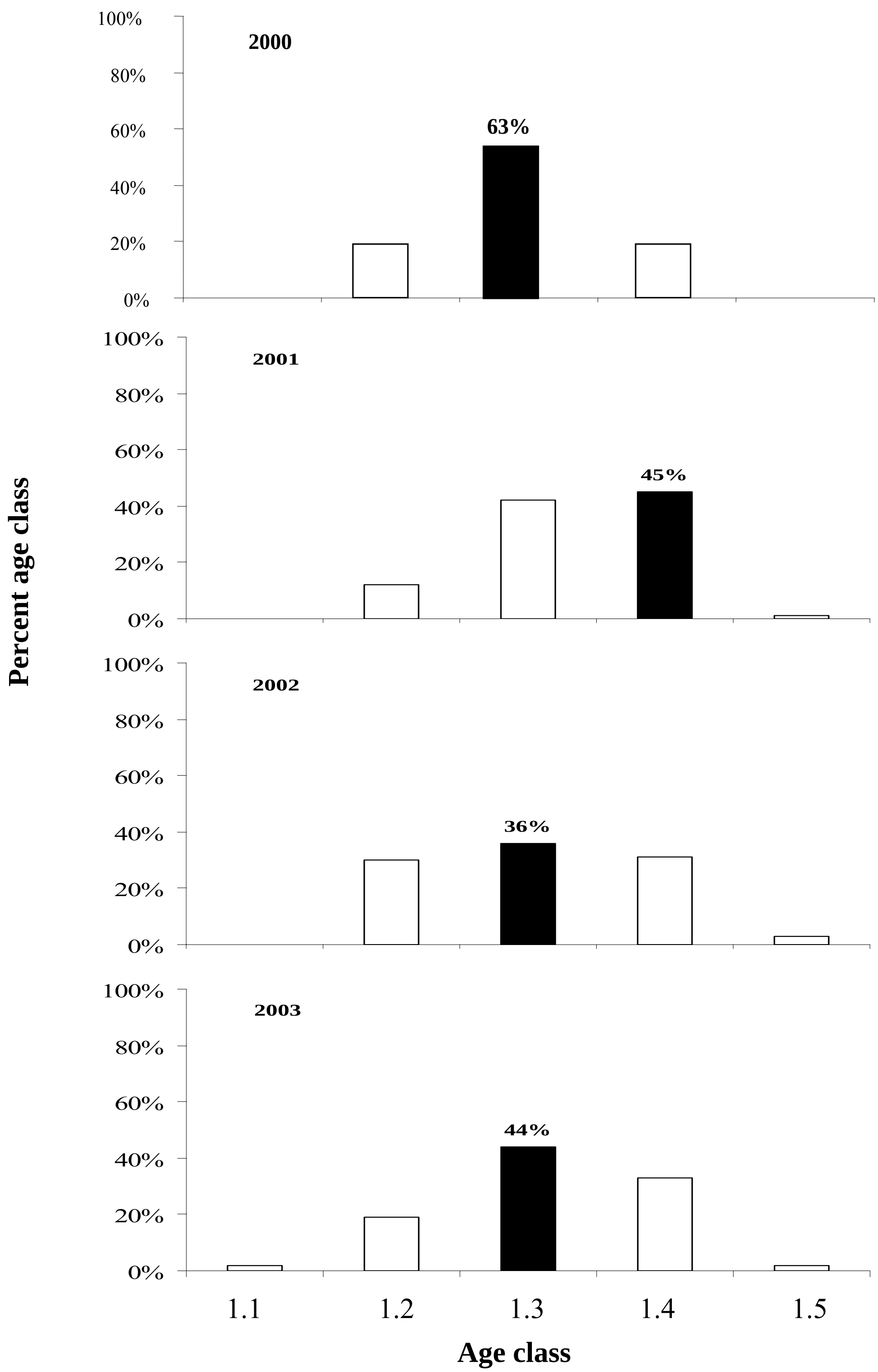

Figure 4.—Age class distribution of Chinook salmon sampled at Henshaw Creek weir, Alaska, 2000-2003.

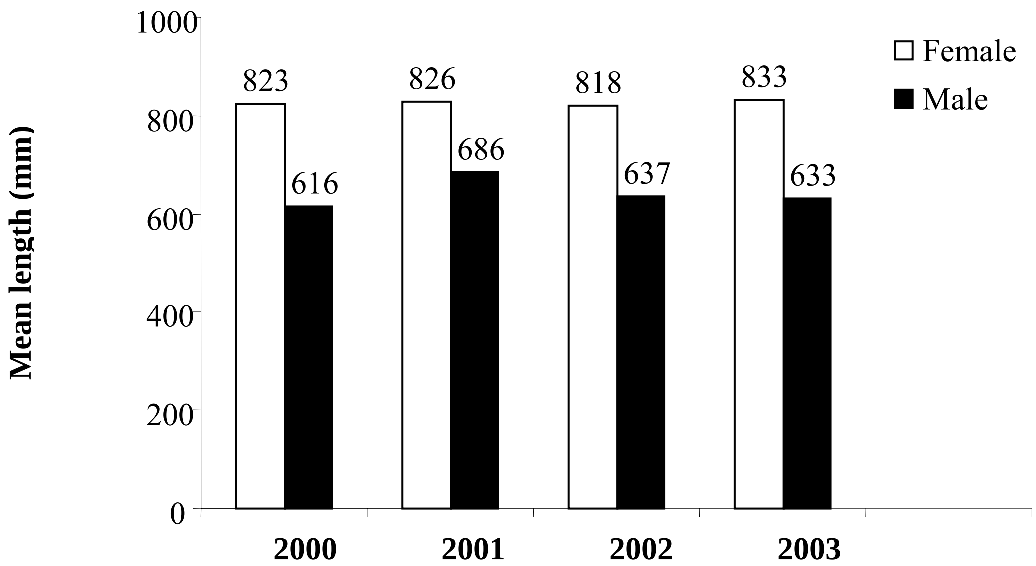

Figure 5.—Mean length distribution of Chinook salmon sampled at Henshaw Creek weir, Alaska, 2000-2003.

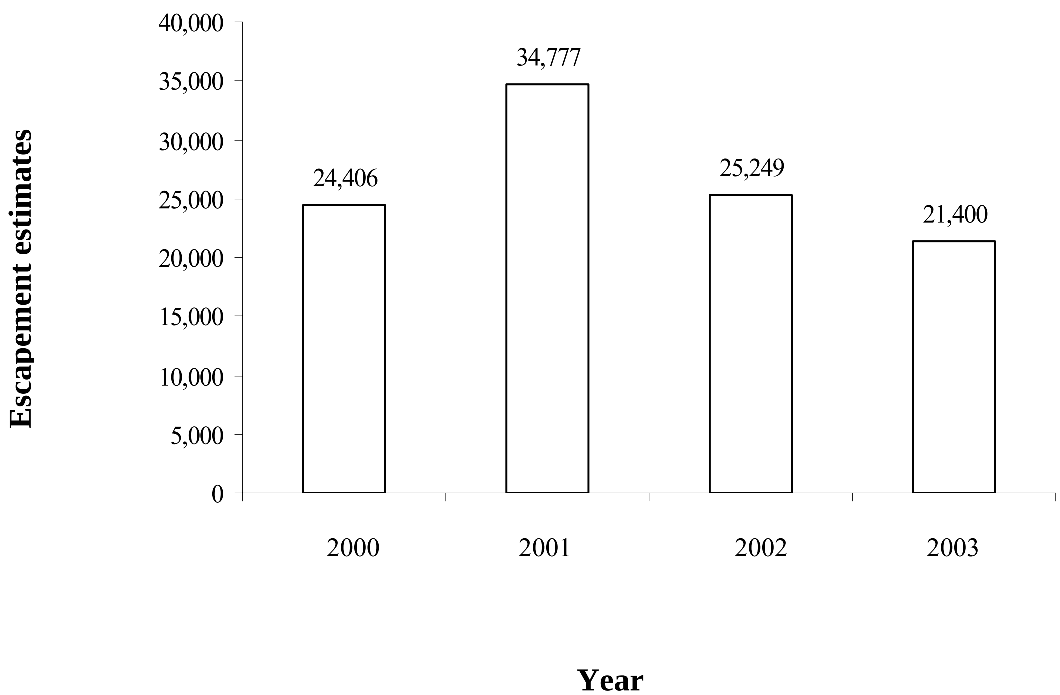

Figure 6.—Seasonal escapement estimates of summer chum salmon recorded at Henshaw Creek weir, Alaska, 2000-2003.

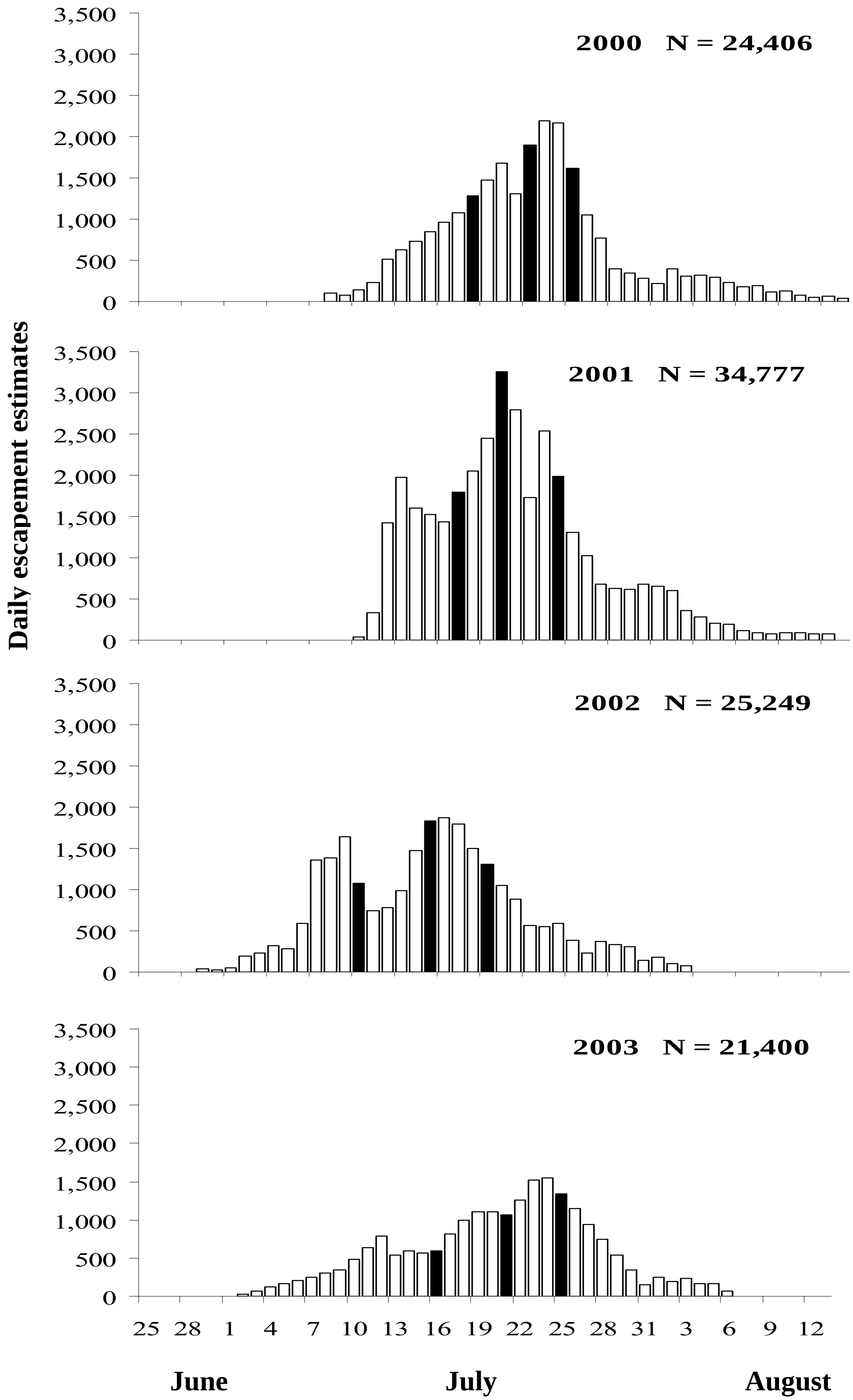

Figure 7.—Daily escapement estimates and run timing of summer chum salmon migrating through Henshaw Creek weir, Alaska, 2000-2003. Shaded areas represent first, second, and third quartiles of run.

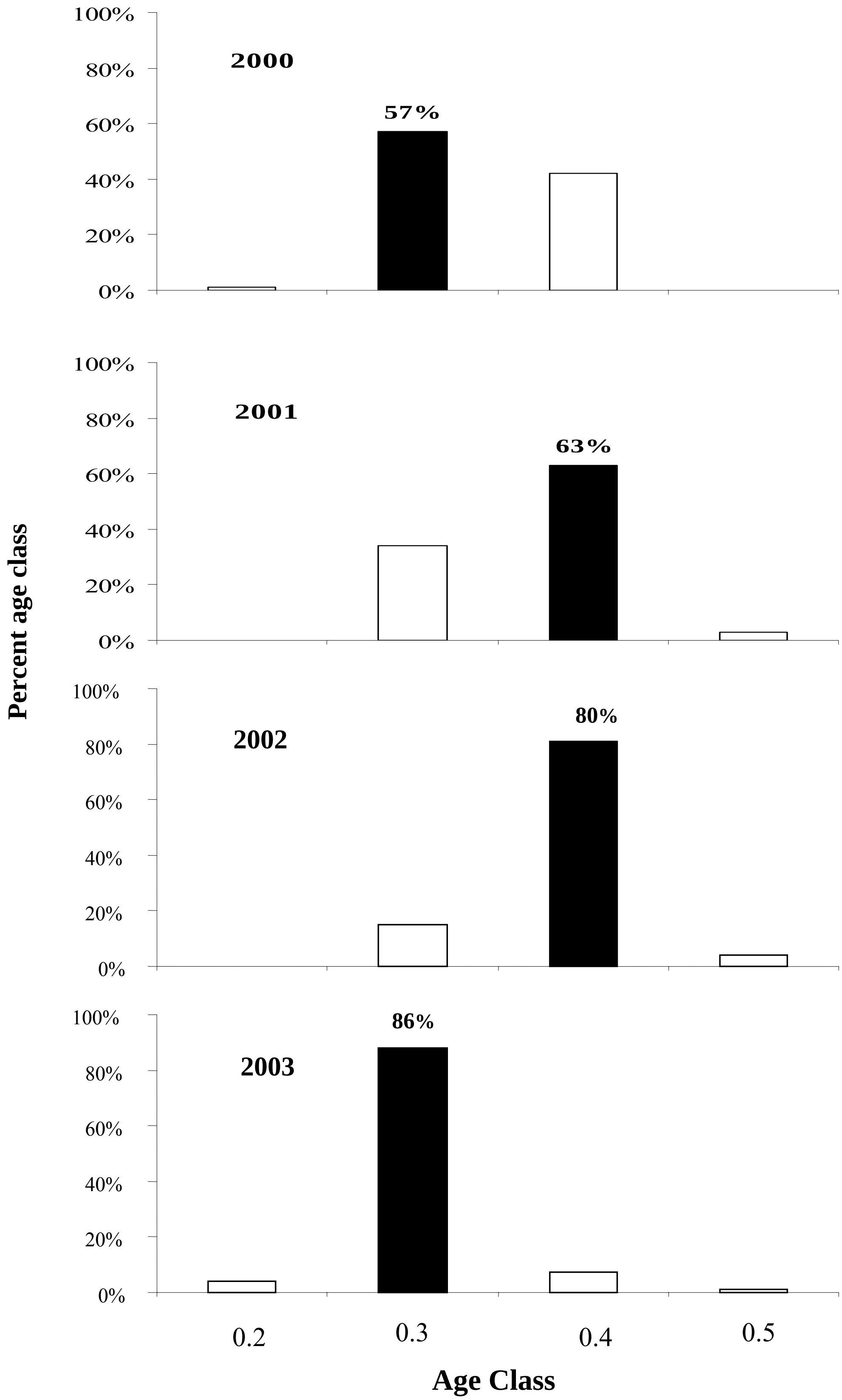

Figure 8.—Age class distribution of summer chum salmon sampled at Henshaw Creek weir, Alaska, 2000-2003.

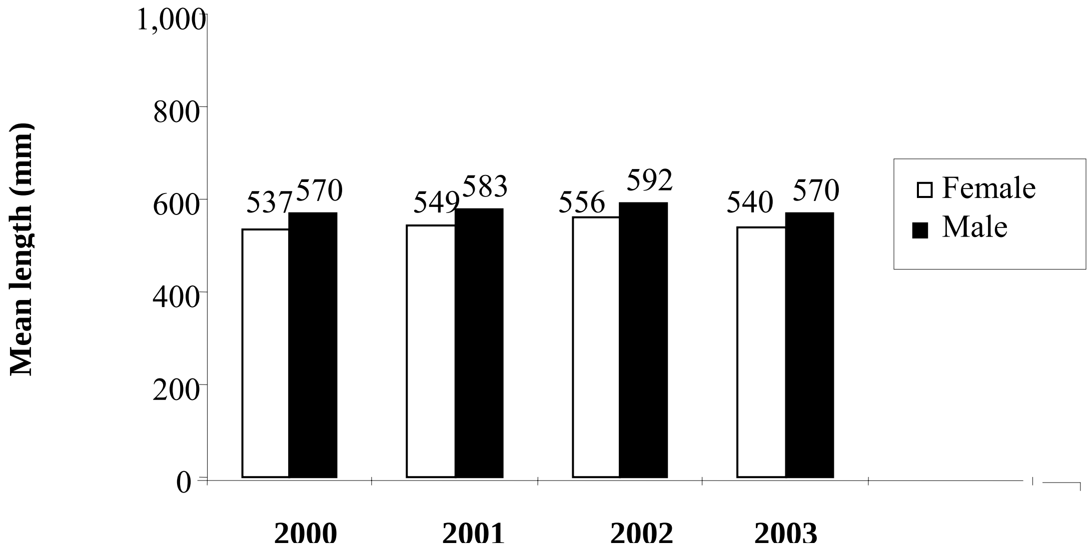

Figure 9.—Average mean length distribution of summer chum salmon recorded at Henshaw Creek weir, Alaska, 2000-2003.

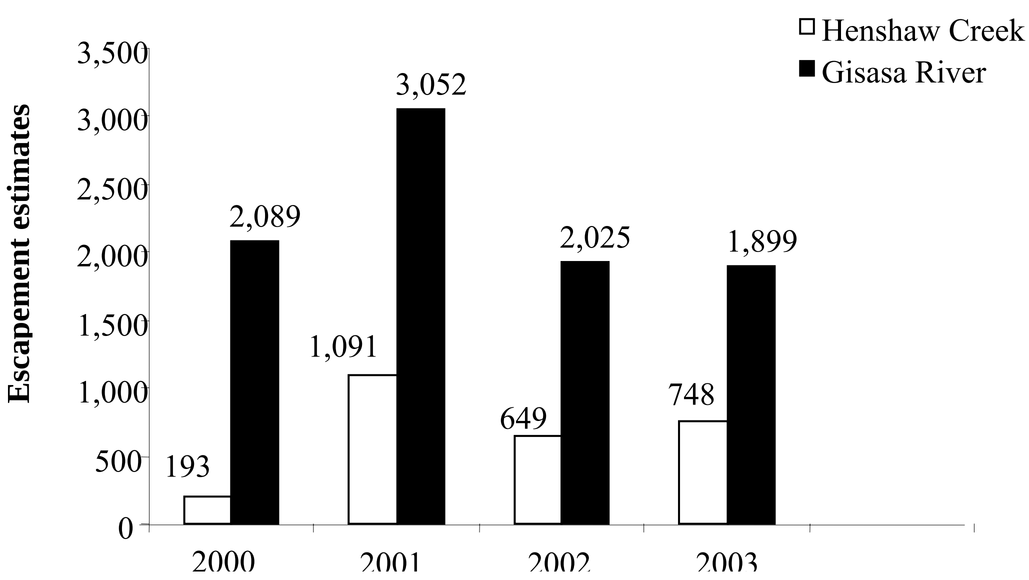

Figure 10.—Seasonal Chinook salmon escapement counts recorded at Henshaw Creek and Gisasa River weirs, Alaska, 2000-2003.

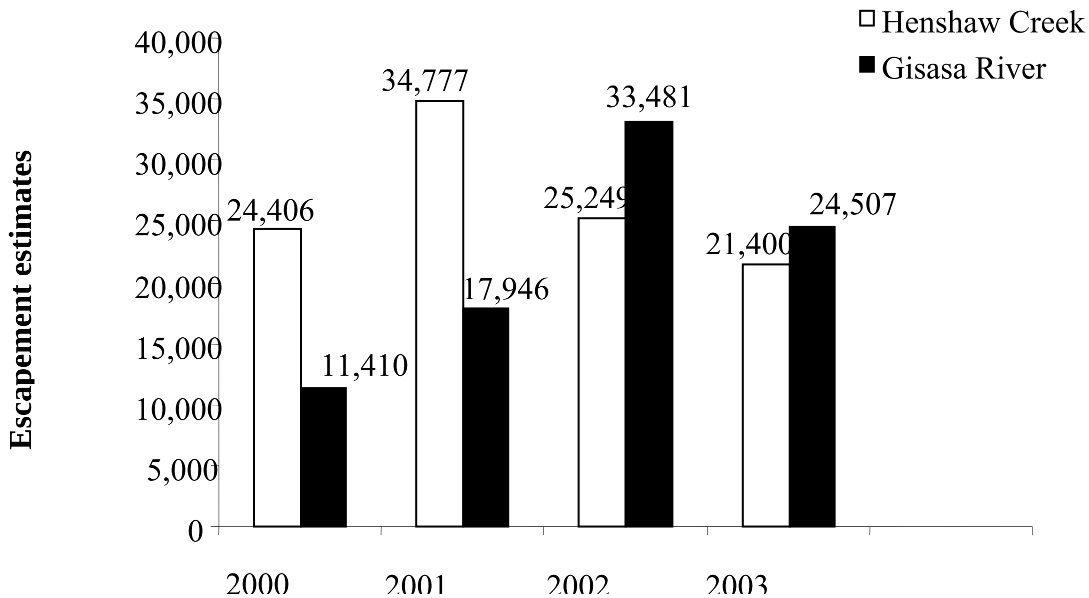

Figure 11.—Seasonal summer chum salmon escapement counts recorded at Henshaw Creek and Gisasa River weirs, Alaska, 2000-2003.

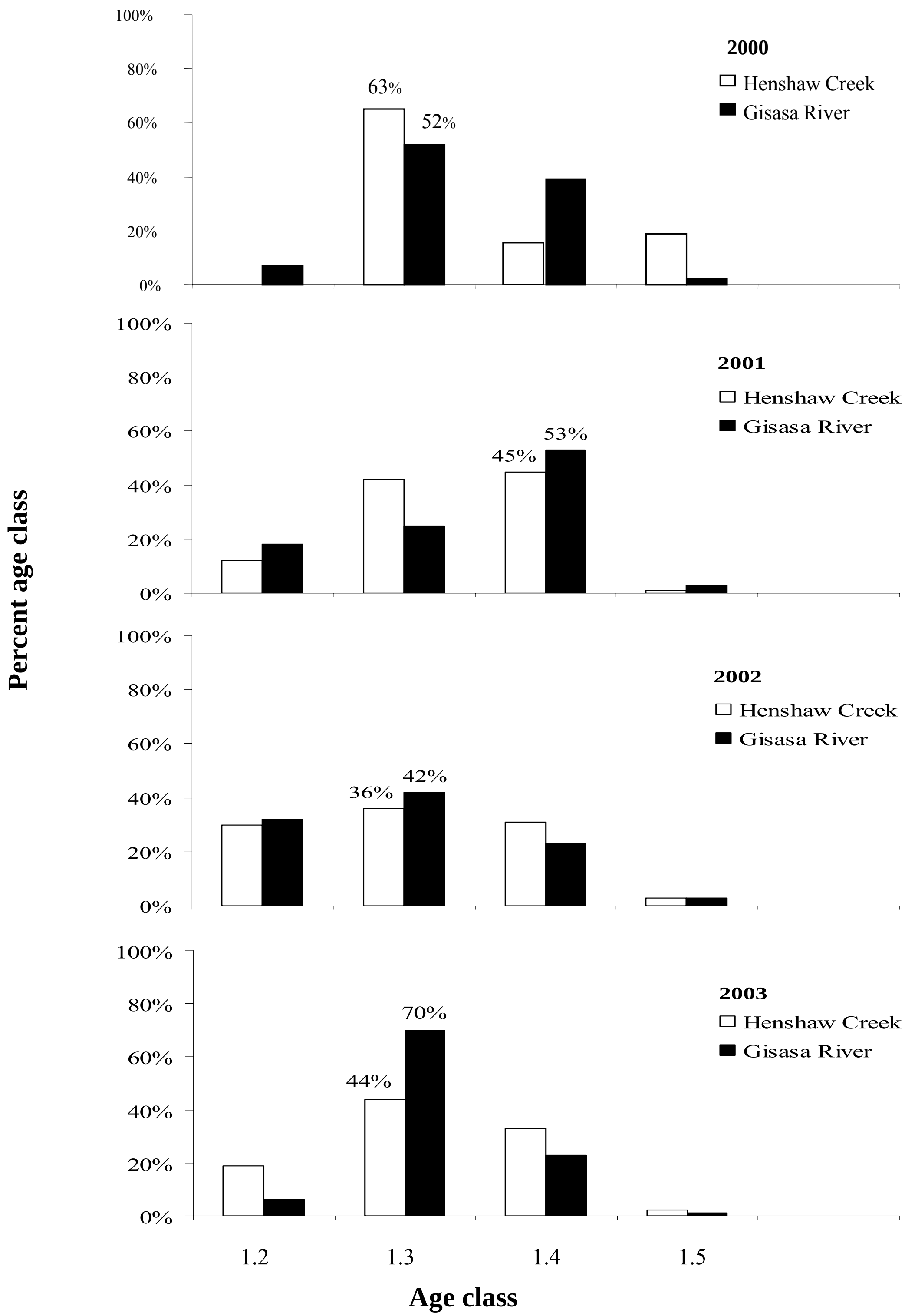

Figure 12—Age class distribution of Chinook salmon sampled at Henshaw Creek and Gisasa River weirs, Alaska, 2000-2003. Percentages represent dominant age classes for that year.

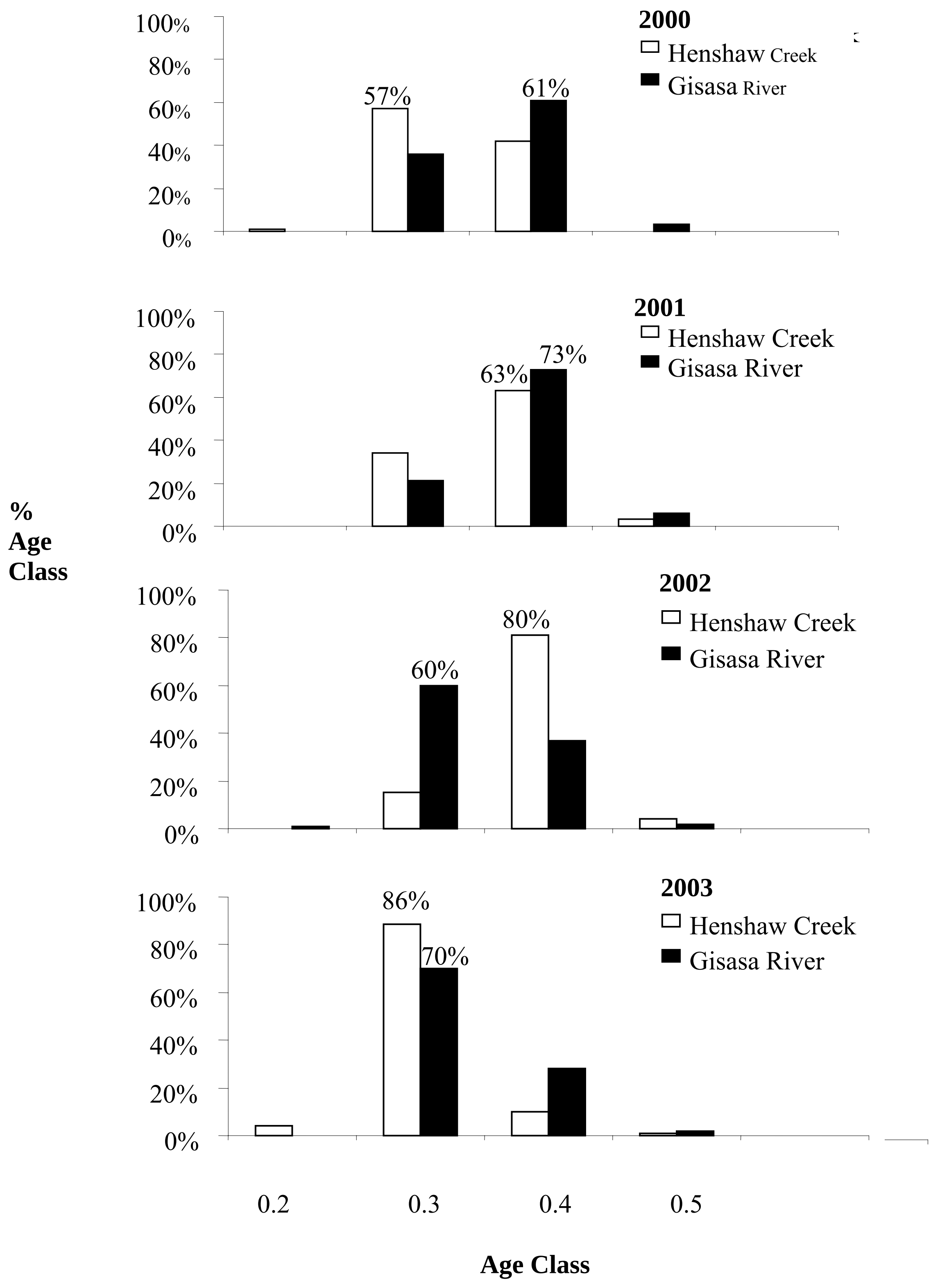

Figure 13.—Age class distribution of summer chum salmon sampled at Henshaw Creek and Gisasa River weirs, Alaska, 2000-2003. Percentages represent dominant age classes for that year.

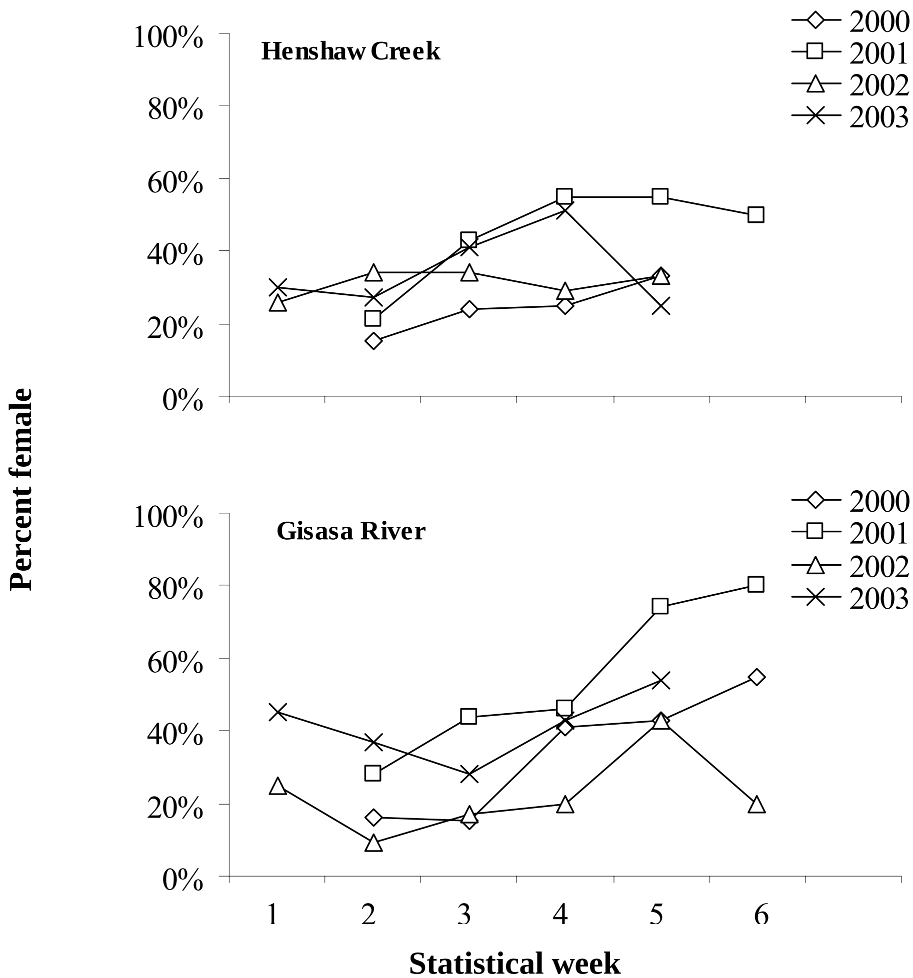

Figure 14.—Chinook salmon female sex ratios, by statistical week, sampled at Henshaw Creek and Gisasa River weirs, Alaska, 2000-2003.

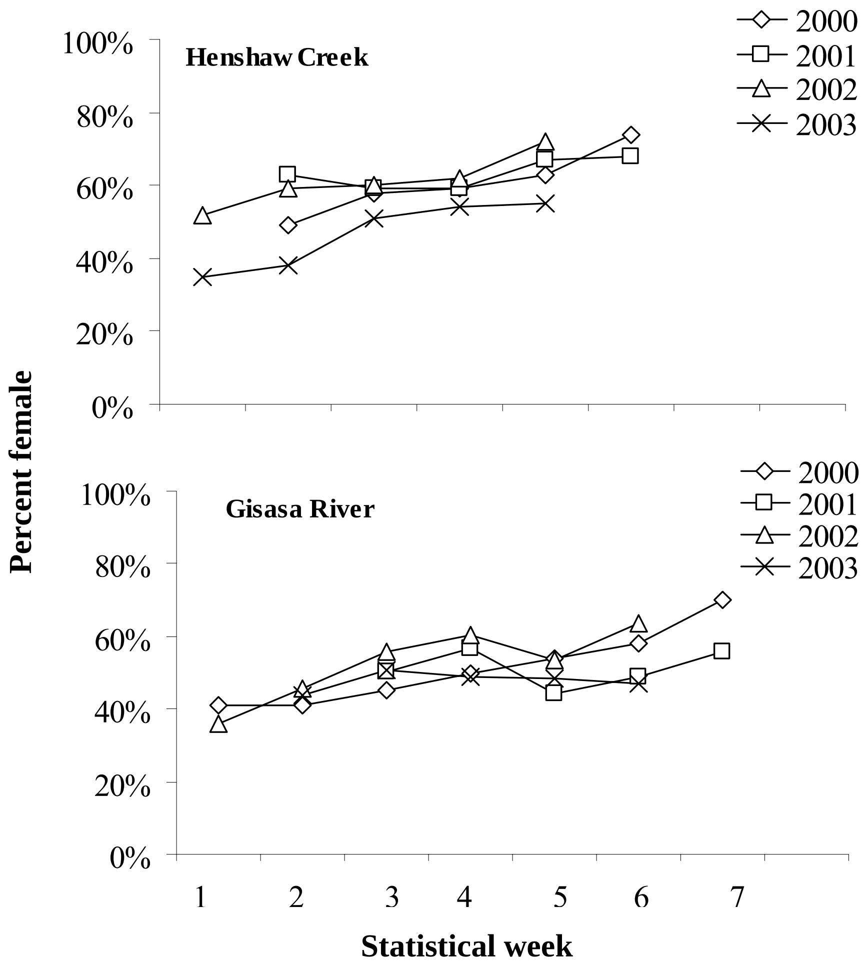

Figure 15.—Summer chum salmon female sex ratios, by statistical week, sampled at Henshaw Creek and Gisasa River weirs, Alaska, 2000-2003.

Appendix 1.—**Daily passage count of longnose sucker and Arctic grayling passing the Henshaw Creek weir, Alaska, 2000-2003.**

	Longnose sucker				Arctic grayling			
Date	2000	2001	2002	2003	2000	2001	2002	2003
26-Jun		0		25		0		9
27-Jun		0		54		0		13
28-Jun		1		106		3		16
29-Jun		18	30	43		3	2	12
30-Jun		52	3	94		1	10	1
1-Jul		18	5	4		3	12	0
2-Jul		19	5	0		45	9	0
3-Jul		9	0	0		27	13	0
4-Jul		47	0	0		27	6	0
5-Jul		5	13	0		6	9	0
6-Jul		3	13	0		2	5	0
7-Jul		0	32	0		10	7	0
8-Jul	51	3	51	0	3	6	5	0
9-Jul	175	36	85	167	2	6	5	15
10-Jul	20	166	605	157	3	4	6	9
11-Jul	11	78	582	29	2	0	2	8
12-Jul	21	15	86	27	1	1	0	2
13-Jul	17	50	2	10	1	0	0	0
14-Jul	13	39	0	1	1	4	0	3
15-Jul	9	445	0	0	1	1	3	1
16-Jul	5	515	146	3	1	3	2	2
17-Jul	2	110	297	0	1	0	0	2
18-Jul	1	34	68	0	1	1	0	2
19-Jul	0	61	19	3	0	0	4	3
20-Jul	0	20	0	68	0	3	1	5
21-Jul	0	0	2	169	1	2	2	11
22-Jul	0	7	81	161	0	15	0	5
23-Jul	0	170	31	9	1	0	0	2
24-Jul	0	235	85	10	0	0	0	1
25-Jul	0	0	191	17	0	51	1	0
26-Jul	0	9	59	73	0	0	0	1
27-Jul	0	1	24	58	0	0	6	0
28-Jul	0	10	78	43	0	1	0	0
29-Jul	0	0	427	28	0	0	28	0
30-Jul	0	0	50	13	0	0	2	0
31-Jul	0	1	51	0	0	0	1	2
1-Aug	0	52	4	3	0	3	0	0
2-Aug	0	31	0	3	0	0	1	2
3-Aug	0	5	3,125	0	0	1		1
4-Aug	0	0		0	0	0		0
5-Aug	0	24		8	0	1		5
6-Aug	0	83		8	0	1		0
7-Aug	0	0			0	2		
8-Aug	0	0			0	1		
9-Aug	0	0			1	1		
10-Aug	0	0			0	4		
11-Aug	0	0			0	0		
12-Aug	0	6			1	0		
13-Aug	0				0			
Season Total	325	2,378	3,125	1,394	21	239	142	133

Appendix 2.—Daily passage count of northern pike and whitefish spp. passing the Henshaw Creek weir, Alaska, 2000-2003.

	Northern pike				Whitefish spp.			
Date	2000	2001	2002	2003	2000	2001	2002	2003
26-Jun		0		0		0		1
27-Jun		0		0		0		0
28-Jun		0		1		0		0
29-Jun		0	0	0		0	0	0
30-Jun		0	0	0		0	0	0
1-Jul		2	0	0		0	0	0
2-Jul		0	0	0		0	0	0
3-Jul		1	0	0		1	0	0
4-Jul		0	0	0		0	0	0
5-Jul		0	0	0		1	2	0
6-Jul		0	0	0		0	0	0
7-Jul		0	0	0		0	1	0
8-Jul	0	2	0	0	0	0	0	0
9-Jul	0	1	1	0	0	0	0	0
10-Jul	0	0	0	1	0	0	0	0
11-Jul	0	1	0	0	0	0	1	0
12-Jul	0	0	0	0	0	0	0	0
13-Jul	0	0	0	0	0	0	0	0
14-Jul	0	0	0	1	0	0	0	0
15-Jul	1	0	0	0	0	0	0	0
16-Jul	1	1	0	0	0	0	0	0
17-Jul	1	0	0	0	0	0	0	0
18-Jul	1	0	0	0	0	0	0	0
19-Jul	0	0	0	0	0	0	1	0
20-Jul	0	0	0	2	0	0	0	0
21-Jul	0	0	0	0	0	0	0	0
22-Jul	0	0	0	0	0	0	0	0
23-Jul	0	0	0	0	0	0	0	0
24-Jul	0	0	0	1	0	0	1	0
25-Jul	0	0	0	0	0	0	0	0
26-Jul	0	0	0	1	0	0	0	0
27-Jul	0	0	0	0	0	0	0	0
28-Jul	0	0	0	0	0	0	0	0
29-Jul	0	0	0	0	0	0	0	0
30-Jul	0	0	0	0	0	0	1	0
31-Jul	0	0	0	0	0	0	0	0
1-Aug	0	0	0	0	0	0	1	0
2-Aug	0	0	0	0	0	0	0	0
3-Aug	0	0		0	0	0		0
4-Aug	0	0		0	0	0		0
5-Aug	0	0		0	0	0		1
6-Aug	0	0		0	0	0		0
7-Aug	0	0			0	0		
8-Aug	0	0			1	0		
9-Aug	0	0			0	0		
10-Aug	0	0			0	0		
11-Aug	0	0			0	0		
12-Aug	0	0			0	0		
13-Aug	0				0			
Season Total	4	8	1	7	1	2	8	2