Fishery Data Series Number 95-1

Abundance and Run Timing of Adult Salmon in the Gisasa River, Koyukuk National Wildlife Refuge, Alaska, 1994

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and
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February 1995

United States Department of the Interior
Fish and Wildlife Service
Region 7
Fishery Resources

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Abstract.— From July 11 to August 10, 1994 a resistance board weir was operated on the Gisasa River, a tributary to the Koyukuk River in west central Alaska. A total of 51,116 summer chum salmon *Oncorhynchus keta* and 2,888 chinook salmon *O. tschawytscha* were counted. Pink salmon *O. gorbuscha* (N=200) and sockeye salmon *O. nerka* (N=3) were also enumerated. The most abundant resident species were northern pike *Esox lucius* (N=16) and longnose sucker *Catostomus catostomus* (N=14). Installation of the weir was later than scheduled, resulting in portions of the salmon runs being missed. Females comprised 64% of the chum salmon sampled. Average mid-eye to fork length (MEL) was 54 cm (N=193, SD=2.4) for females and 56 cm (N=107, SD=2.9) for males. Chinook salmon samples were 39% females and averaged 75 cm MEL (N=80, SD=10.0) for females and 72 cm MEL (N=126, SD=10.0) for males.

Introduction

Accurate salmon escapement data are critical to evaluating harvest management strategies, particularly in mixed stock fisheries. Chum salmon *Oncorhynchus keta* and chinook salmon *O. tschawytscha* stocks from the Gisasa River, located on the Koyukuk National Wildlife Refuge (Refuge), have been identified as important contributors to subsistence and commercial fisheries in the middle Yukon River drainage (USFWS 1993). Alaska National Interest Lands Conservation Act mandates that salmon populations within the Refuge be conserved in their natural diversity, international treaty obligations be fulfilled and subsistence opportunities for local residents be maintained.

Aerial survey escapement counts in the Yukon River drainage have been highly variable (Schultz et al. 1993), and are only an index of relative strength of a salmon run (Barton 1984). Summer chum salmon escapement counts from aerial surveys of the Gisasa River were highest from 1974 to 1976 averaging 33,423 (range = 21,342 to 56,904). From 1985 to 1993, when survey conditions were rated fair to good, summer chum escapement counts averaged 7,805 (range = 1,581 to 13,232) (Schultz et al. 1993; Alaska Department of Fish and Game, unpublished data).

A resistance board weir (Booth 1993; Tobin 1994) was installed by the U.S. Fish and Wildlife Service on the lower Gisasa River during July 1994. This was the first year of a five year study designed to: (1) determine daily escapement and run timing of salmon into the Gisasa River; (2) determine sex and size composition of chinook and chum salmon in the Gisasa River; (3) evaluate the effectiveness of aerial surveys as a method for salmon escapement estimation in the Gisasa River; (4) determine presence, movement, and abundance of resident fish in the Gisasa River.

Study Area

The Gisasa River is a tributary of the Koyukuk River located in west central interior Alaska (Figure 1). Climate of the region is continental subarctic with extreme seasonal variations of temperature. The town of Galena, approximately 64 km by air southeast of the mouth of the Gisasa River, has a mean annual temperature of 3.8° C. Extremes range from 32° C to -59° C. Rivers in the area generally begin to freeze during October and breakup occurs sometime in May (USFWS 1993).

The Gisasa River flows northeast 112 km from it's origin in the Nulato Hills to the Koyukuk River (65° 16'N latitude, 157° 40'W longitude, USGS. 1:63,360 series, Kateel River B-4 quadrangle). The lower third of the Gisasa River flows through the Refuge. Peak flows of area streams generally occur during snow melt and breakup, or during summer high precipitation events (USFWS 1993).

The weir site was approximately 4 km upriver from the mouth of the Gisasa River. This section of the river was straight and flow was generally laminar. The river channel sloped gradually from the stream banks and maximum depth was approximately 0.7 m. Substrate at the weir site consisted primarily of medium sized gravel.

Materials and Methods

Weir Construction and Installation

Construction of the main components of the weir began during March and continued through June 1994. Additional components, the trap and passing chute, were constructed at the site on the Gisasa River. The pickets for the weir panels were 6.1 m long, 2.5 cm inside diameter schedule 40 polyvinyl chloride (PVC) conduit. Pickets were sealed at both ends and joined together with polyethylene and aluminum stringers with steel conduit hangers. Each panel was 1.2 m wide. Eighteen pickets were used per panel and were spaced 6.8 cm center to center. Resistance boards measured 0.6 m high and 1.2 m wide and were constructed with laminated plywood and styrofoam. The resistance boards were hinged to the last aluminum stringer at the downstream end of the panels. Attachment of the panels to the rail cable was accomplished by placing hooks located on the upstream end of the panels over the cable (Figure 2).

The substrate rail consisted of 3 m long sections of 7.6 cm x 7.6 cm, 6 mm structural steel angle. Sections of rail were joined by means of a male/female connection created by welding pieces of different sized square steel tubing to the ends of the rail sections. Steel pins and Duckbill® anchors secured the rail to the substrate. Sandbags were lined along the upstream edge of the rail to prevent the washout of gravel beneath the rail. An apron of 90 cm-wide chain link fencing was attached to the downstream side of the substrate rail. Steel rods were woven through the lengths of fencing to help insure the fencing remained flat. The apron prevented fish from digging under the rail, and assisted in preventing washout beneath the rail. A 10 mm cable was anchored at one end of the substrate rail with Duckbill® anchors and threaded through guides welded to the substrate rail. The other end was attached to a winch that applied tension to the cable.

Bulkheads were constructed at the ends of the substrate rail near each bank to prevent stream bank erosion. The bulkheads also maintain a fish tight connection with the weir panels. Bulkheads were pined to the stream bottom and struts extended from the top of the bulkhead to the stream bank. A section of rigid weir blocked the area between the bulkheads and the stream bank (Figure 3).

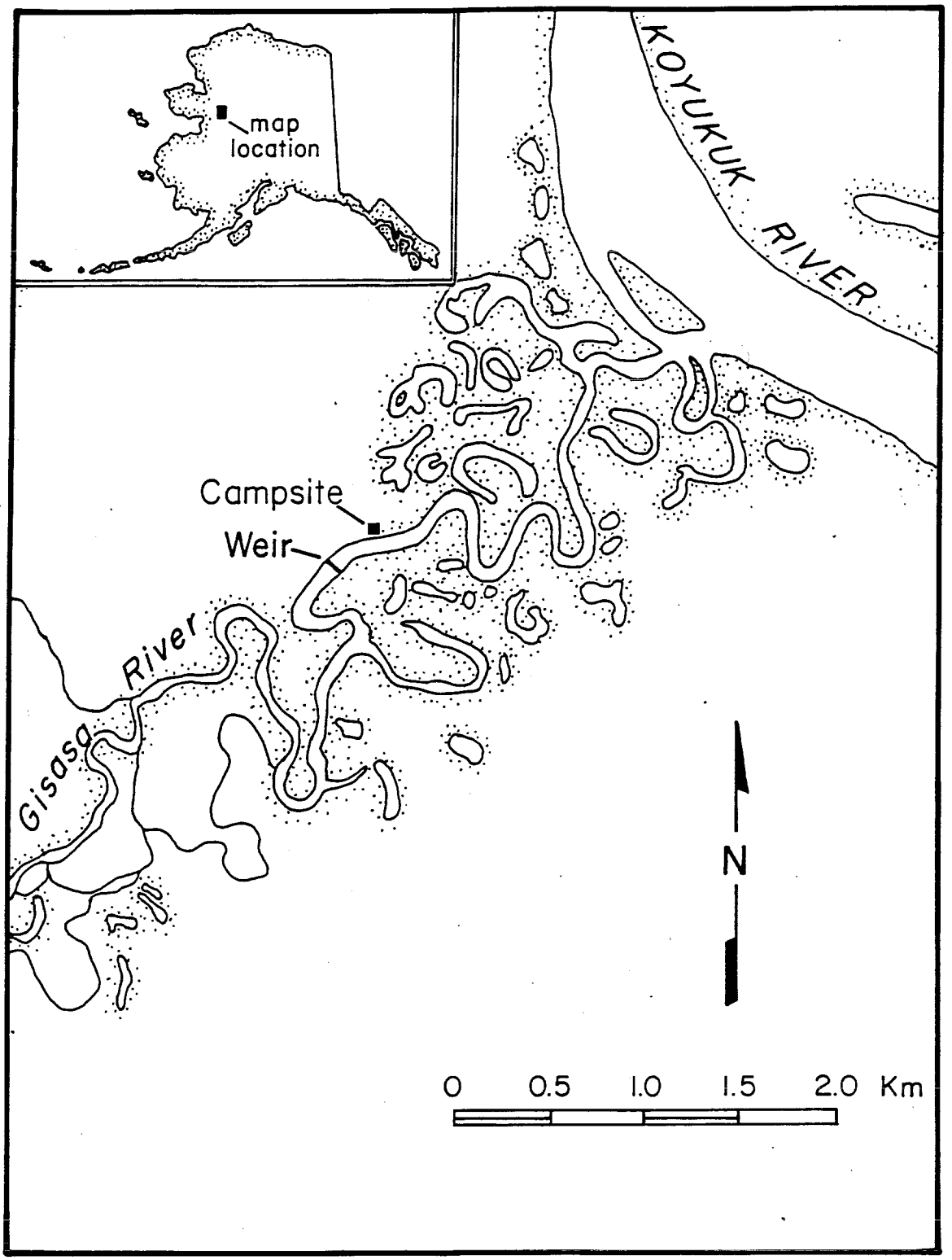

FIGURE 1.— Map of Gisasa River weir location, Koyukuk National Wildlife Refuge, Alaska.

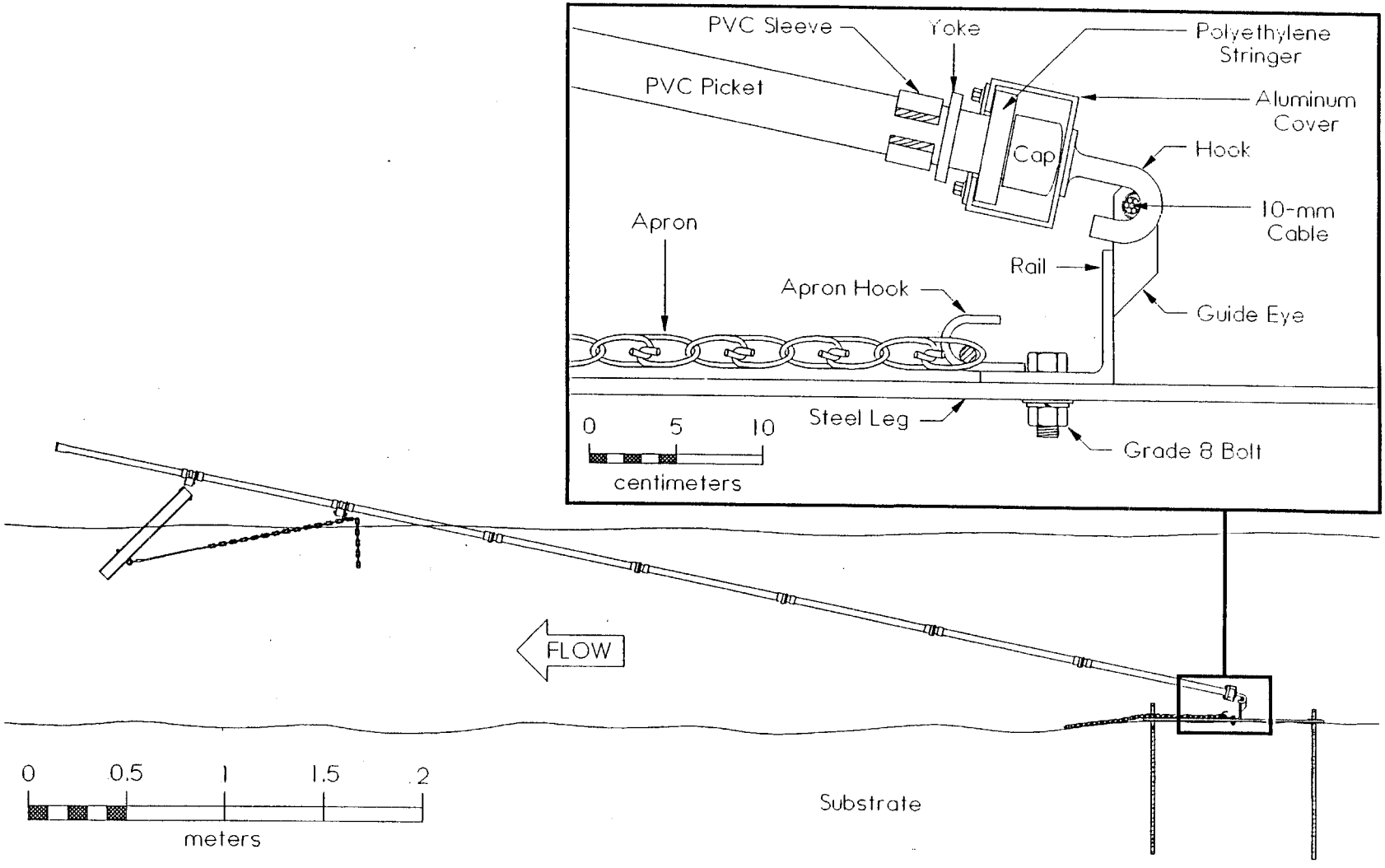

FIGURE 2.— Lateral view of installed weir panal. Inset shows details of the substrate rail, panel attachment, and the apron. (From Tobin 1994).

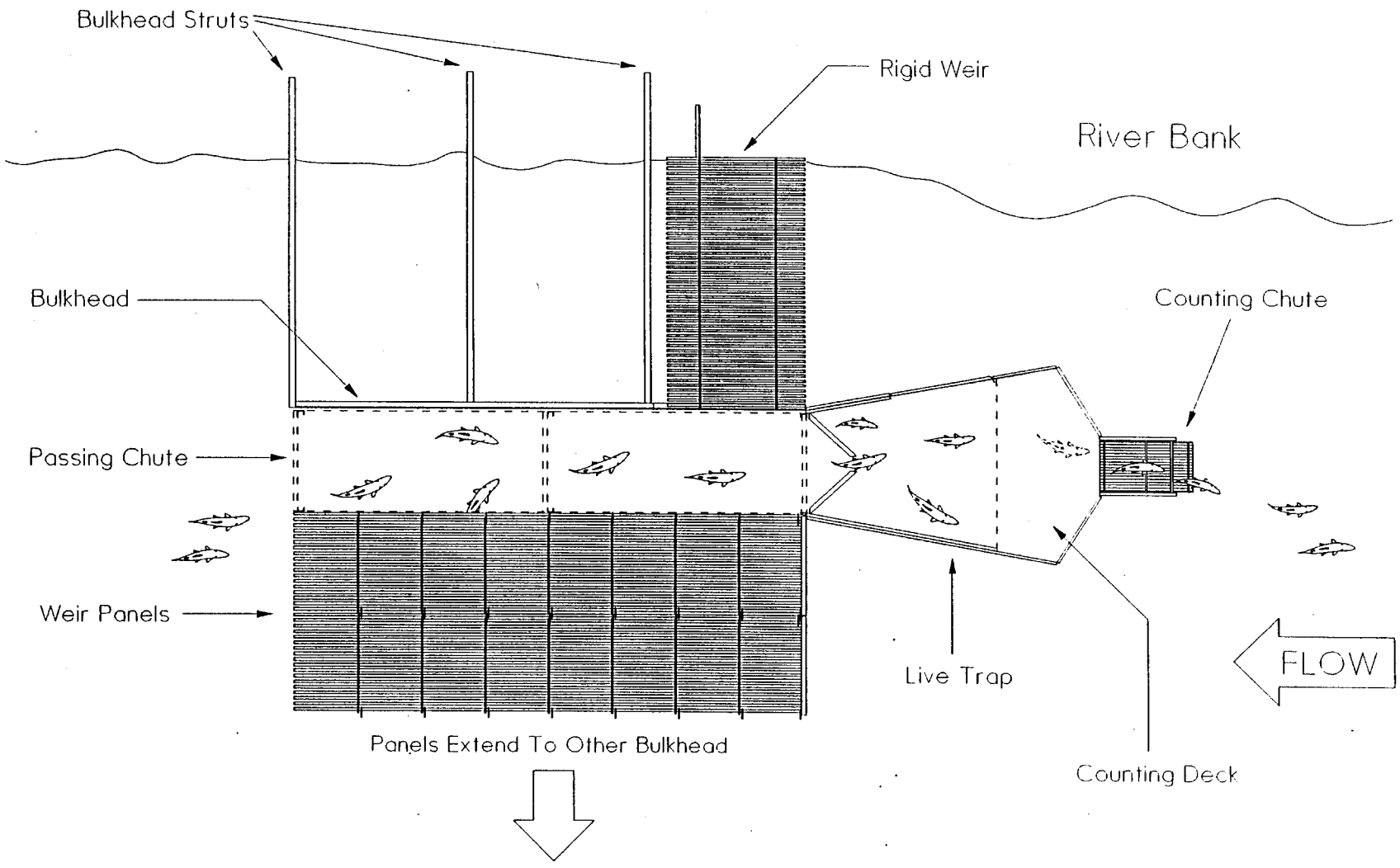

Figure 3.— Overhead view of weir section depicting fish passage through passing chute and live trap, bulkhead, and rigid weir section. (From Tobin 1994).

A passing chute was incorporated into one of the weir panels. The chute was made by heating and bending ten of the PVC pickets upward at the second aluminum stringer. These pickets formed the top of the chute. Additional pickets were added to complete the sides. This created a 57 cm x 56 cm passing chute that allowed fish to pass through the weir into a live trap where they could be counted or biological samples could be taken.

The live trap (Figure 3), which is 1.8 m high, 3.5 m long and 1.2 to 2.4 m wide, was constructed of an aluminum frame and panels of aluminum angle and PVC pickets. The front of the trap was covered with plywood and served as a counting deck. A counting chute and an adjustable door on the upstream end of the trap forced fish up near the surface of the water as they exited the trap to facilitate identification and counting.

The weir was visually inspected daily for holes and structural integrity. Fish carcasses and debris were cleaned from the weir as they accumulated, often several times a day. Cleaning usually involved walking on the weir panels until they were partially submerged and allowing the current to flush the debris off. Occasionally larger debris would have to be physically pushed off the weir.

Biological Data

Fish passing through the weir were counted and identified to species. *Coregonus* and *Prosopium* spp. were grouped together as whitefish. Daily counts began at 0001 hours and ended at midnight. Samples of chum and chinook salmon were sexed using external characteristics, and measured to the nearest cm mid-eye to fork length (MEL). Samples were to include the first 100 fish each week; however, due to logistics problems complete samples were not always obtained. Sampling periods ranged from one to three days, and the reported sample date indicates the last day of sampling for that period. A students t-test ($P < 0.05$; Zar 1984) was used to compare mean length of males and females.

Weir counts were compared to aerial survey counts from Alaska Department of Fish and Game to determine if the aerial surveys provide an effective index of spawning escapement.

Results

Biological Data

Summer chum salmon (N=51,116) were the most abundant species counted through the weir, followed by chinook (N=2,888) and pink salmon *O. gorbuscha* (N=200). Six resident species were counted through the weir. The most abundant were northern pike *Esox lucius* (N=16) and longnose sucker *Catostomus catostomus* (N=14). Other species were encountered in low abundance (Table 1).

Chum salmon were observed in the river on June 27, two weeks before the weir began operation on July 11. Daily counts began declining four days after the weir was installed (Figure 4). The peak of migration occurred on July 15. A total of 300 chum salmon were sampled for sex and length. Females comprised 64% of the total sample, and increased from 58% of the first sample to 69% of the third sample (Figure 5). Lengths of sampled chum salmon ranged from 47 cm to 64 cm MEL. The average length of females (54 cm MEL) was significantly less ($P<.0005$) than males (56 cm MEL).

Chinook salmon were observed in the river approximately 10 days before the weir was operating. Daily chinook counts showed an increasing trend, reaching a peak on July 16 then began declining

TABLE 1— Total counts of fish, by species, passing through the Gisasa River weir, July 11 - Aug. 10, 1994.

Common name	Scientific name	Count
Chum salmon	*Oncorhynchus keta*	51,116
Chinook salmon	*Oncorhynchus tschawytscha*	2,888
Pink salmon	*Oncorhynchus gorbuscha*	200
Sockeye salmon	*Oncorhynchus nerka*	3
Northern pike	*Esox lucius*	16
Longnose sucker	*Catostomus catostomus*	14
Whitefish	*Coregonus & Prosopium* spp.	3
Dolly Varden char	*Salvalinus malma*	2
Burbot	*Lota lota*	1
Arctic grayling	*Thymallus arcticus*	1

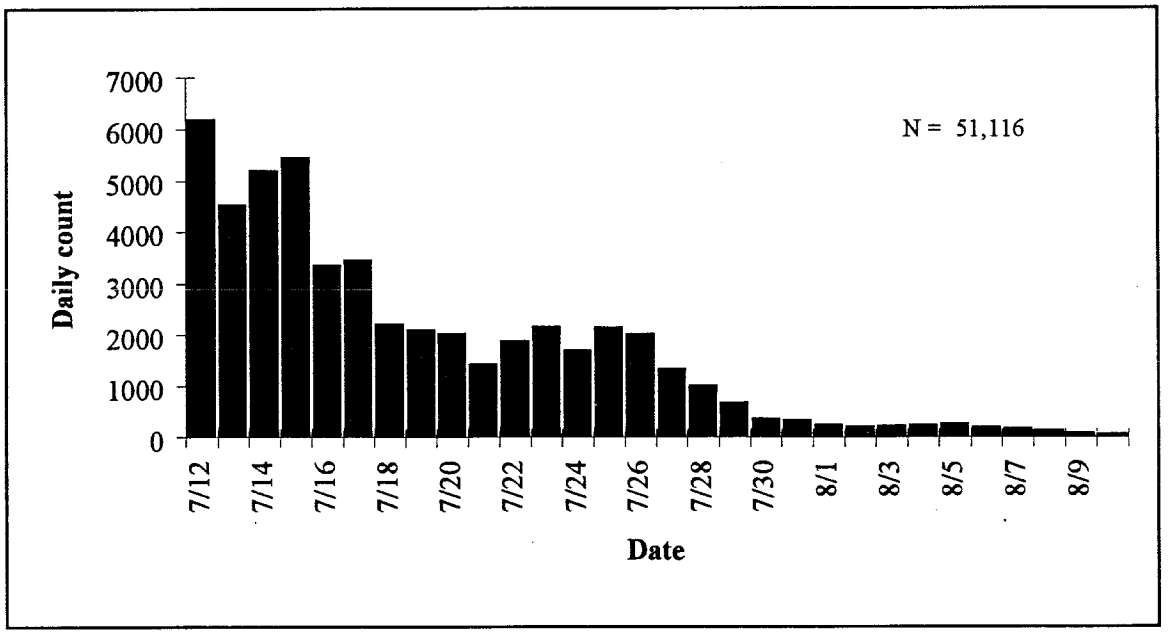

FIGURE 4.— Daily counts of summer chum salmon passing through the Gisasa River weir, 1994. The count for 7/12 began at 1800 hours on 7/11. The gate to the trap was left open for approximately two to three hours on 7/30 and 8/10, fish passing during these times were not counted.

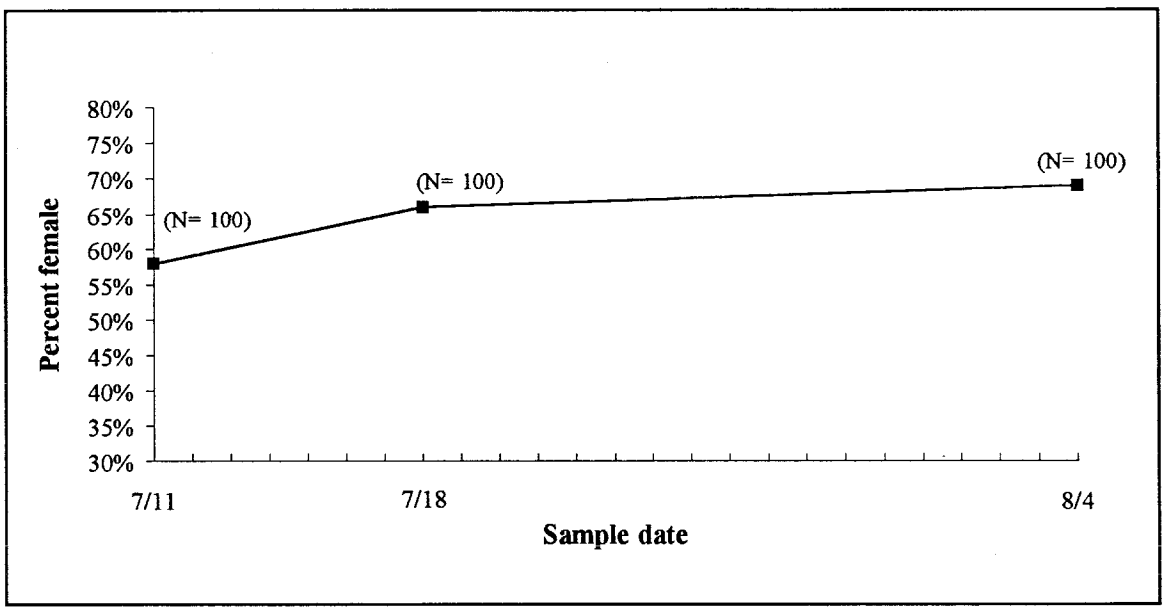

FIGURE 5.— Sex composition (percent female) of samples of summer chum salmon from the Gisasa River weir, 1994.

(Figure 6). A total of 206 chinook were sampled for length and sex. Females accounted for 39% of the total sample, and ranged from 40% of the first sample to 31% of the third sample (Figure 7). Lengths of chinooks sampled ranged from 40 cm to 106 cm MEL. Average length of females (75 cm MEL) was significantly larger ($P=.035$) than males (72 cm MEL).

A total of 200 pink salmon were counted through the weir. The first pink was counted on July 15. The majority of the pink salmon (N=157) were counted between July 29 to Aug. 3. Counts before and after this time period were intermittent and sporadic (Appendix 1).

Weir performance

Construction and logistics delayed installation of the weir by approximately three weeks. The weir was operational (fish tight) from July 11 to August 10. Water levels fluctuated approximately 0.3 m, estimated from the water level on the bulkhead, during operation of the weir. Picket spacing was adequate to prevent the passage of adult chum and chinook salmon. However, a pink salmon and a small longnose sucker were observed to escape from the trap between the pickets. Spawning activity immediately upstream of the weir resulted in areas where gravel accumulated on the lower ends of the weir panels. No major problems that affected the performance of the weir were encountered.

Discussion

Biological data

Observations of both chum and chinook salmon in the river prior to weir installation, and the trends of the daily counts, indicate that considerable proportions of the runs were not counted. Because of this the weir counts are conservative, and size and sex data from the samples may not be representative of the entire run. Peak migration of chum salmon and chinook salmon occurred on July 15 and July 16 respectively. However, it is possible that additional peaks may have occurred before the weir was installed.

The number of summer chum salmon counted through the weir (N=51,116) was greater than recent aerial survey counts (Table 2). An aerial survey was flown by Alaska Department of Fish and Game personnel on July 26, 11 days after the estimated peak of migration. The number of chum salmon counted through the weir was 7.5 times greater than the aerial survey of 6,827. The cumulative count of chum salmon passing through the weir by the date of the aerial survey was 45,644, 6.7 times greater than the aerial survey. Since a portion of the run was missed by the weir count the difference between actual escapement and the aerial survey would be even greater.

The average length of male chum salmon was larger than females. McBride et al. (1983) reported average lengths, from carcass samples of chum salmon on the Gisasa River, of 605 mm (N=9, SE=7.7) for males and 540 mm (N=22, SE=9.3) for females. Size differences between sexes of summer chum salmon have been documented on other tributaries in the Yukon River drainage. Average length was 581 mm (N=163, SE=3.8) for males and 534 mm (N=298, SE=2.4) for females in the Andreafsky River, and in the Anvik River averages were 592 mm (N=117, SE=3.8) and 545 mm (N=265, SE=2.5) for males and females, respectively (McBride et al. 1983). During 1982 at a Yukon River test fishery near Kaltag, approximately 97 km below the mouth of the Koyukuk River, average lengths were 591 mm (N=185, SE=4.3) for males and 555 mm (N=317,

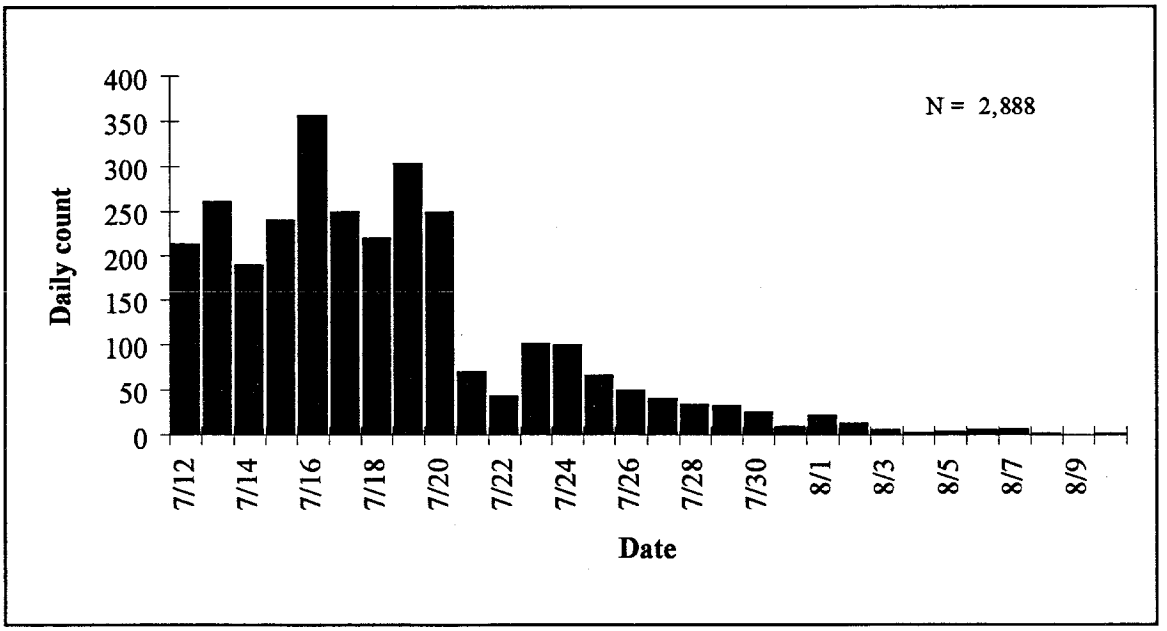

FIGURE 6.— Daily counts of chinook salmon passing through the Gisasa River weir, 1994. The count for 7/12 began at 1800 hours on 7/11. The gate to the trap was left open for approximately two to three hours on 7/30 and 8/10, fish passing during these times were not counted.

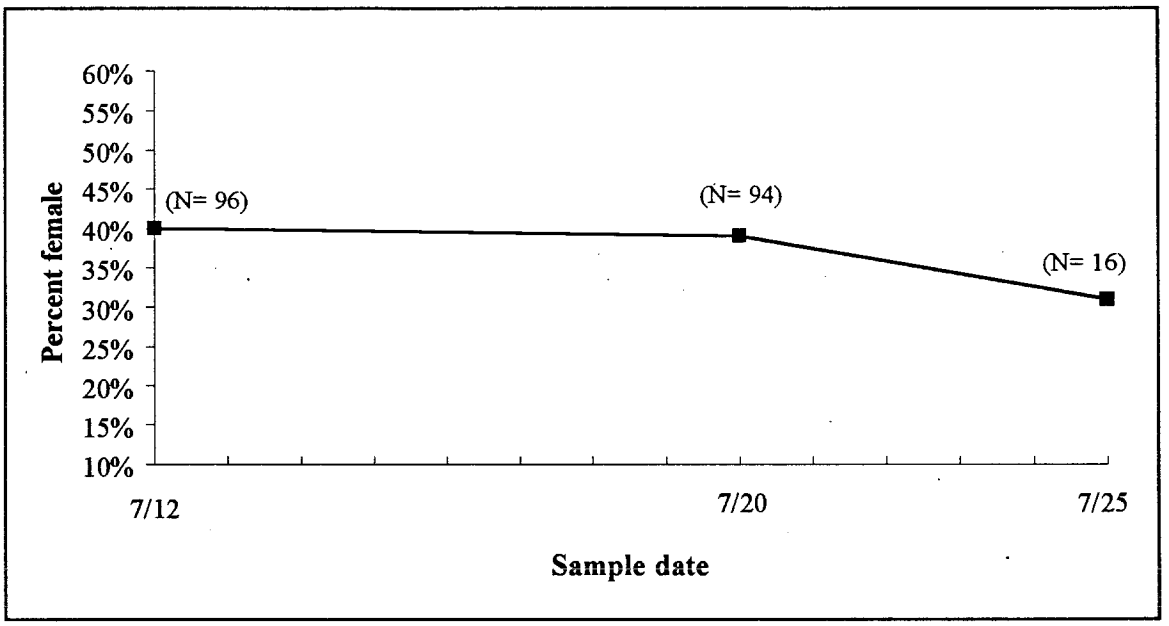

FIGURE 7.— Sex composition (percent female) of samples of chinook salmon from the Gisasa River weir, 1994.

TABLE 2.— Escapement counts from aerial surveys of the Gisasa River, 1974-1994. (Schultz et al. 1993; Alaska Department of Fish and Game, unpublished data).

	Escapement counts	
Year	Chum	Chinook
1974	22,022	161
1975	56,904	385
1976	21,342	332
1977	2,204[a]	255
1978	9,280[a]	45[a]
1979	10,962	484
1980	10,388	951
1981	-	-
1982	334[a]	421
1983	2,356[a]	572
1984	-	-
1985	13,232	735
1986	12,114	1,346
1987	2,123	731
1988	9,284	797
1989	-	-
1990	450[a]	884[a]
1991	7,003	1,690
1992	9,300	910
1993[b]	1,581	1,573
1994[b]	6,827	2,775

[a] Inaccurate counts due to incomplete surveys or poor survey timing or conditions.

[b] 1993 & 1994, unpublished data, Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Anchorage Alaska.

SE=2.4) for females (Anderson 1983).

Suitable chum salmon spawning habitat is present below the weir site and chum were observed spawning below the weir. While the number of spawners below the weir is likely to be insignificant relative to the total run, a more complete survey could be conducted to determine the extent of spawning activity below the weir.

The number of chinook salmon counted through the weir (N=2,888) was greater than any past aerial survey count (Table 2). The count from the aerial survey on July 26 (N=2,775) was the highest recorded (Schultz et al. 1993), and was slightly larger than the cumulative count (N = 2,695) of chinook passing through the weir by that date. However, the early portion of the run was missed in the weir count.

Average length of female chinook salmon was significantly larger than males. McBride et al. (1983) reported average lengths of chinook salmon from Gisasa River escapement samples of 657 mm (N=21, SE=11.9) for males and 830 mm (N=11, SE=16.6) for females. Size differences between sexes of chinook salmon in other Yukon River drainages have also been documented. Chinook salmon samples from the Andreafsky River averaged 643 mm (N=200, SE=6.0) for males and 741 mm (N=37, SE=16.0) for females (McBride et al. 1983). Skaugstad (1994) reported that 71% of males were less than 750 mm and 92% of females were 750 mm or larger in the Salcha River. Samples from the Anvik River averaged 631 mm (N=100, SE=10.9) for males and 829 mm (N=38, SE=11.9) for females (McBride et al. 1983).

Pink salmon had not been previously documented in the Gisasa River. Pink salmon were generally thought to be limited to the lower Yukon drainage below the village of Grayling, nearly 370 kilometers downstream of the mouth of the Gisasa River (Barton 1984).

Weir performance

The use of resistance board weirs in Alaska is relatively new (Tobin 1994). Resistance board weirs are less likely to be damaged or washed-out by high flows and debris than conventional rigid weir designs. When compared to sonar enumeration, resistance board weirs provide more accurate identification of species, eliminate the need for test fisheries, do not require expensive electronics equipment, and require less time spent interpreting data after field work is completed.

Aerial surveys are less costly than sonar or weirs, however the data provided are highly variable and are of limited use. Daum et al. (1992) reported expansion factors for aerial surveys to sonar counts of fall chum salmon that ranged from 2.70 to 6.17 on the Chandalar River from 1988 to 1990. Aerial survey conditions for all three years were rated fair to good. Additionally, population estimates from mark and recovery studies of chinook salmon from 1986 to 1990 on the Chena River were 1.7 to 4.9 times greater than the corresponding aerial surveys (Schultz et al. 1993). Much of the variability of aerial surveys is due to uncontrollable factors such as weather, variable run timing, and changing river conditions. Comparatively, the effects of these factors on the performance of a resistance board weir are minimal.

The weir performed well and was effective in allowing accurate counts of migrating salmon. Picket spacing of the trap and the weir panels was adequate to prevent adult chum and chinook salmon from passing between the pickets; however, smaller pink salmon and resident species may have passed through the weir undetected. High water levels can temporarily submerge weir panels (Booth 1993;

Tobin 1994), resulting in the need to estimate escapement over the submerged panels. The absence of any high water event on the Gisasa River during weir operation precluded this need.

Recommendations

The weir should be installed during early June and operated through late August to decrease the potential of missing a portion of the run. A better defined sampling schedule, which includes collection of scales for aging, should be developed. Additionally, tagging fish as they pass the weir and recovering the tags from carcasses could be used to determine residency time. Other data that may be useful and could be collected include: more accurate measurements of river stage (height); discharge; and water temperature.

Acknowledgments

Special thanks are extended to everyone who assisted with this project. Arnold Brown, Paul Erhardt, Jeremy Esmailka, Donald Hall, Denali Henderson, Keith Kimbrell, Patrick Lovely, Edward Sommer and Tim Walker all participated in construction and/or operation of the weir. Rod Simmons provided many helpful editorial comments. Logistics support, including air support, storage space, and more, was provided by the staff of Koyukuk/Nowitna National Wildlife Refuge. Betsy Sturm provided the map figure. Valuable technical assistance was provided by John Tobin during construction of the weir.

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APPENDIX 1.- Daily and total fish counts from Gisasa River weir, 1994.

Date	Chum	Chinook	Pink	Sockeye	N.pike	Sucker	Whitefish spp.	Burbot	Dolly Varden	Arctic grayling
*7/12/94	6178	212	0	0	1	1	0	0	0	0
7/13/94	4528	259	0	0	1	1	0	0	0	0
7/14/94	5195	189	0	0	1	0	1	0	0	0
7/15/94	5449	239	1	0	0	2	0	0	0	0
7/16/94	3347	355	0	0	0	0	0	0	1	0
7/17/94	3450	248	3	0	0	1	0	0	1	0
7/18/94	2193	219	3	0	0	1	0	0	0	0
7/19/94	2089	302	7	0	0	0	0	0	0	0
7/20/94	2007	248	0	0	0	0	1	0	0	0
7/21/94	1416	70	0	0	0	0	0	0	0	0
7/22/94	1864	42	1	0	0	0	0	1	0	0
7/23/94	2138	100	0	0	0	0	1	0	0	0
7/24/94	1676	99	0	0	0	0	0	0	0	0
7/25/94	2120	65	6	0	1	0	0	0	0	0
7/26/94	1994	48	5	0	1	0	0	0	0	0
7/27/94	1325	39	0	0	0	0	0	0	0	0
7/28/94	994	33	0	0	0	0	0	0	0	0
7/29/94	671	32	41	0	1	0	0	0	0	0
**7/30/94	360	24	39	0	0	0	0	0	0	0
7/31/94	321	9	31	0	2	0	0	0	0	0
8/1/94	247	21	14	0	2	0	0	0	0	1
8/2/94	205	12	15	1	2	1	0	0	0	0
8/3/94	225	5	17	1	0	0	0	0	0	0
8/4/94	238	2	6	0	0	1	0	0	0	0
8/5/94	259	3	1	0	1	0	0	0	0	0
8/6/94	194	5	6	0	1	0	0	0	0	0
8/7/94	169	6	2	0	0	0	0	0	0	0
8/8/94	130	1	1	0	0	3	0	0	0	0
8/9/94	81	0	0	1	1	2	0	0	0	0
**8/10/94	53	1	1	0	1	1	0	0	0	0
TOTAL	51116	2888	200	3	16	14	3	1	2	1

* Count for 7-12 began at 1800 hrs. on 7-11.

** Trap gate was left open for two to three hours, fish passing during these times wer not counted.