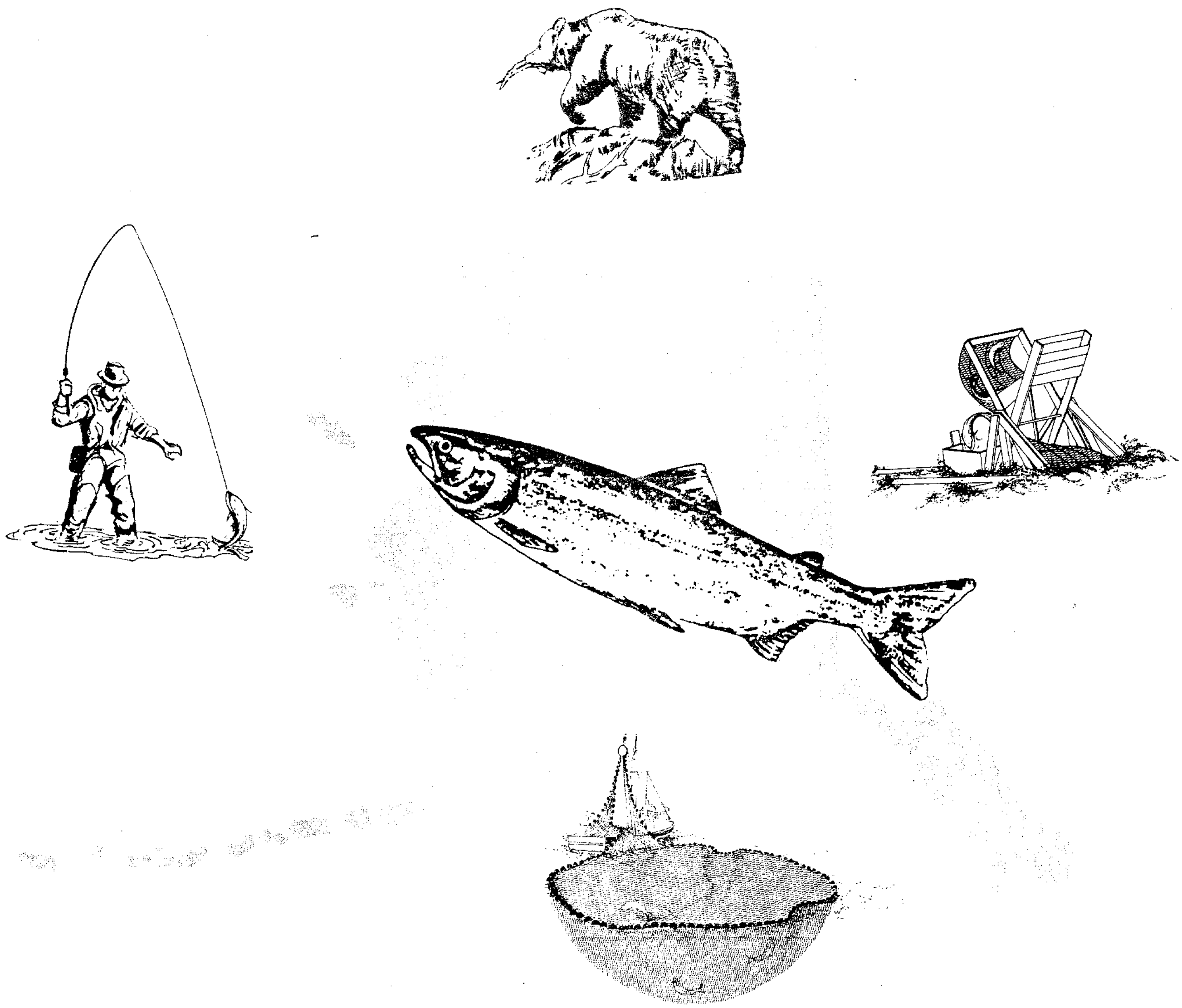
Alaska Fisheries Technical Report Number 41

RUN TIMING AND ABUNDANCE OF ADULT SALMON IN THE TULUKSAK RIVER, YUKON DELTA NATIONAL WILDLIFE REFUGE, 1994



June 1997

Region 7
U.S. Fish and Wildlife Service • Department of the Interior

Alaska Fisheries Technical Report Number 41
June 1997

Run Timing and Abundance of Adult Salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 1994

Ken C. Harper

Key Words: Weir
Oncorhynchus keta
O. tshawaytscha
O. nerka
O. kisutch
Migrational rates
Sex ratios
Gill net marks
Carcasses
Stream-life

U.S. Fish and Wildlife Service
Kenai Fishery Resource Office
P.O. Box 1670
Kenai, Alaska 99611

Disclaimer

The mention of trade names or commercial products in this report does not constitute endorsement or recommendation for use by the federal government.

The U.S. Department of Interior prohibits discrimination in Department Federally Conducted Programs based on race, color, national origin, sex, age, or disability. If you believe that you have been discriminated against in any program, activity, or facility operated by the U.S. Fish and Wildlife Service or if you desire further information please write to:

U.S. Department of Interior
Office for Equal Opportunity
1849 C Street, N.W.
Washington, D.C. 20240

The correct citation for this report is:

Harper, K.C. 1997. Run timing and abundance of adult salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 1994. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Technical Report 41, Anchorage, Alaska.

Run Timing and Abundance of Adult Salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 1994

KEN C. HARPER

U.S. Fish and Wildlife Service, Kenai Fishery Resource Office
P.O. Box 1670, Kenai, Alaska 99611, (907) 262-9863

Abstract.—A resistance board weir was used to collect run timing, abundance, and biological data from salmon in the Tuluksak River, June 29-September 11, 1994. The weir escapement of 15,724 chum *Oncorhynchus keta*, 2,917 chinook *O. tshawytscha*, 3,488 pink *O. gorbuscha*, 82 sockeye *O. nerka*, and 7,953 coho salmon *O. kisutch* were all higher than 1991 to 1993 weir escapements for all species except coho and sockeye salmon. Peaks in weekly passage occurred July 10-16 for chinook, July 17-18 for chum and sockeye, and August 9-15 for pink salmon. The weir was submerged for an estimated 40% of the coho salmon run, and the total escapement was estimated.

Other species counted included 478 Dolly Varden *Salvelinus malma*, 272 whitefish (*Coregonus* and *Prosopium* spp.), 110 Arctic grayling *Thymallus arcticus*, and nine northern pike *Esox lucius*. Whitefish moved primarily in September while Dolly Varden and Arctic grayling moved in July.

Sex composition in the chum salmon escapement shifted from predominately males to females as the run progressed. Females composed 51% of the chum salmon escapement; 24% of the chinook salmon escapement, and 38% of the sampled coho salmon escapement. Coho salmon were not sampled during the peak of the run due to high water.

Gill net marks ranged from 0.5% on chum salmon to 16% on female chinook salmon sampled at the weir.

Travel times from the Bethel test fishery to the weir were estimated to be 10 and 12 days for chum and chinook salmon, respectively.

Table of Contents

List of Tables

List of Figures

List of Figures (continued)

List of Appendices

Appendix Page

Introduction

The Tuluksak River is a tributary of the lower Kuskokwim River located on the Yukon Delta National Wildlife Refuge (Refuge). The Tuluksak River provides important spawning and rearing habitat for chum *Oncorhynchus keta*, chinook *O. tshawytscha,* pink *O. gorbuscha*, sockeye *O. nerka*, and coho salmon *O. kisutch* (Figure 1)(Alt 1977; U.S. Fish and Wildlife Service 1992). Salmon returning to the Tuluksak River migrate 218 rkm in the lower Kuskokwim River before reaching the Tuluksak River. These salmon then migrate up the Tuluksak River as far as 130 rkm to reach spawning grounds. Salmon bound for the Tuluksak River are commercially harvested in the lower 218 rkm of the Kuskokwim River. The Kuskokwim River also supports one of Alaska's most intense subsistence salmon fisheries (Francisco et al. 1995). Subsistence fishing occurs in the Kuskokwim River main stem and its tributaries, including the Tuluksak River. Salmon in the Tuluksak and other rivers provide food for brown bears *Ursus arctos* and other carnivores, raptors, and scavengers. In addition, resident fish and salmon fry rely heavily on the nutrient base provided by salmon carcasses (U.S. Fish and Wildlife Service 1992).

The Alaska National Interest Lands Conservation Act (ANILCA) mandates that, within the Refuge, salmon populations and their habitats be conserved in their natural diversity. However, ANILCA mandates may not be met, because reliable escapement data on lower Kuskokwim River tributary fish stocks are missing. The Alaska Department of Fish and Game's (Department) management objective for chum, chinook, sockeye, and coho salmon in the Kuskokwim River is "to achieve desired escapement objectives and allow for the orderly harvest of fish surplus to spawning requirements" (Francisco et al. 1995). Escapement goals have not been established for sockeye and pink salmon which are not actively managed in the Kuskokwim River. Commercial and subsistence catches of these species are considered incidental by the Department.

The Department changed from a harvest-guideline-based salmon management strategy to an escapement-objective-based strategy in the Kuskokwim River during 1983. During 1985, restrictions on the commercial chinook salmon fishery were initiated to reverse a decline in spawning escapements. These restrictions included eliminating large mesh nets (>20.3 cm) that were selective toward female chinook salmon and eliminating a directed commercial harvest for chinook salmon. Prior to these restrictions, chinook salmon were targeted as the primary commercial species, and chum salmon were exploited incidentally.

Commercial fishing periods that allowed the use of large mesh gill nets caught an average of 42.8% female chinook salmon while commercial fishing periods that restricted the mesh size to ≤ 15.2 cm only caught an average of 29.0% female chinook salmon (Francisco et al. 1995). As a result of this management action, an increased percentage of gill net marked females was noted at the Department's escapement monitoring project on the Kogrukluk River. This indicated females were escaping from nets and reaching the spawning grounds (Francisco et al. 1995).

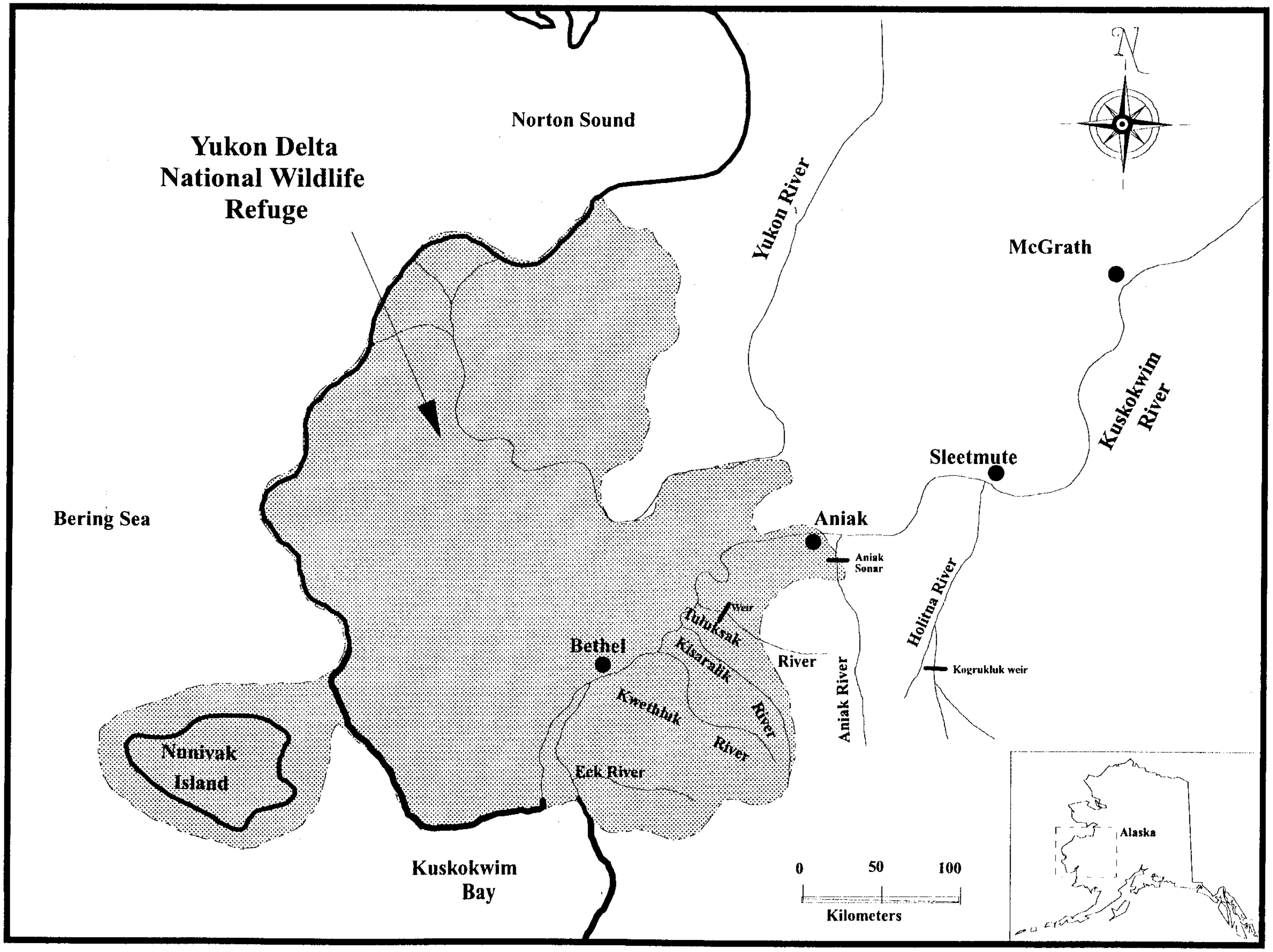


FIGURE 1.-Lower Kuskokwim River tributaries on the Yukon Delta National Wildlife Refuge, Alaska.

The Department presently determines commercial openings by evaluating salmon abundance indexes and monitoring selected escapements. Abundance indexes include one to three drift gill net test fisheries and the use of commercial fishery catch statistics. These test fisheries are located in the lower and middle stretches of the Kuskokwim River. Escapement monitoring occurs at two fish-counting sonars and a weir (Francisco et al. 1995). One sonar is located in the lower Kuskokwim main stem near Bethel, and the other is in the Aniak River, a major tributary to the middle Kuskokwim River. The weir is located in the Kogrukluk River, a major tributary to the upper Kuskokwim River.

Using an escapement-objective-based management strategy is complicated by the presence of mixed stocks in the lower Kuskokwim River. Department managers try to avoid over-harvesting species and stocks returning to each of 11 major and numerous minor tributaries to the Kuskokwim River by distributing catch over time and area. Distribution of the catch over time is important, because each stock may have characteristic migratory timing (Mundy 1982). However, stocks or species returning in low numbers, or during the early or late portion of the runs, may be incidentally over-harvested during extended harvesting of abundant stocks. Protection of smaller stocks, such as those returning to the Tuluksak River, requires run timing and escapement information.

Escapements to lower Kuskokwim River tributaries on the Refuge have been monitored sporadically between 1960 and 1994 using aerial index surveys. These surveys generally occur when salmon abundance peaks on the spawning grounds (Schneiderhan 1983, 1988; Francisco et. al. 1995). Recognizing a need for more precise monitoring, the Department established a fish-counting sonar in the Kwethluk River during 1978 (Schneiderhan 1979). However, the sonar project was abandoned after the first year due to inaccurate counts caused by organic debris in the water.

Aerial index surveys have been used to estimate relative abundances of salmon in the Tuluksak River since 1965. An aerial index objective of 5,000 chum salmon and 400 chinook salmon has been established using historical data (Francisco et al. 1995). Estimates have ranged from <100 to >56,000 chum salmon and <20 to >1,000 chinook salmon (Appendix 1). Only two aerial index surveys have been conducted for coho salmon.

Aerial index estimates are infrequently used for current-year management because they are: (1) conducted when most of the salmon are on the spawning grounds, which is after most of the commercial fishery occurs; (2) highly variable due to inconsistencies in run timing, water conditions, climatic conditions, and surveyor experience; (3) generally an underestimate of actual abundance; and (4) limited to an 'index area' which may represent only a fraction of the total spawning area. Additionally, aerial index surveys do not provide age, sex, and size composition data used to detect escapement quality and brood year production.

Salmon escapements have been monitored using a weir in the Tuluksak River since 1991 (Harper 1995a, b, c). Weir escapements for chum salmon were at least five times greater than aerial index surveys during 1991 and 1992. Weir escapements for chinook salmon were two and six times greater than respective aerial index surveys during 1991 and 1992. Aerial index surveys were not conducted for the Tuluksak River in 1993.

Salmon escapement monitoring projects in lower Kuskokwim River tributaries occurring on the Refuge are ranked as priorities in the Refuge Fishery Management Plan by the U.S. Fish and

Wildlife Service (Service) and the Department (U.S. Fish and Wildlife Service 1992). In 1991, a multi-year study was started by the Service to: (1) estimate daily salmon escapements in the Tuluksak River; (2) quantify the salmon age, sex, and length composition; (3) estimate migration time from the test or commercial fishery to the weir; (4) monitor gill net marks on salmon to establish a baseline; (5) estimate optimal timing for aerial index surveys; and (6) count other species passing through the weir.

Study Area

The Tuluksak River is in the lower Kuskokwim River drainage (Figures 1 and 2). The regions' subarctic climate is characterized by extreme temperatures. Summer temperatures average a high of 15°C, and average winter lows are near -12°C (Alt 1977). Average yearly precipitation is about 50 cm with the majority falling between June and October. Break-up of the Kuskokwim River occurs in early May, and freeze-up occurs in late November.

The Tuluksak River originates in the Kilbuck Mountains, flows northwest approximately 137 km, and drains an area of about 2,098 km^2 (Figure 2). The Tuluksak River is slow moving and meanders over most of its length. Gravel bottoms and cut banks with overhanging vegetation predominate in the upper sections of the river where water clarity is 1-2 m during low water. The lower section is characterized by deep channels that are mud lined, and the water is turbid. In the lower section, the river cuts through several tundra areas (Alt 1977). The Fog River is the only major tributary to the Tuluksak River and enters the lower section. Gold dredging operations near the mining camp of Nyac since the early 1900's have extensively changed the drainage above the refuge boundary (Francisco and Sundberg 1983; Crayton 1990). Dredging activity is now confined to Bear Creek, a tributary to the Tuluksak River above the Refuge boundary, but may be expanded.

Methods

Weir Operation

A resistance board weir (Tobin 1994) was installed at rkm 76 (60° 59' N 160° 33' W) in the Tuluksak River during June 1994 in the same location it was operated in 1991-1993 (Harper 1995a, b, c). The weir spanned 48 meters of river, and the picket spacing was 3.5 cm. A staff gauge was installed on the shore side of the bulkhead, and daily water levels were recorded at 0800 hours. River discharges were estimated using the method described by Hamilton and Bergersen (1984) with a Marsh-McBirney (Model 201-D) flow meter and top setting wading rod. Water temperatures were recorded daily between 1600 and 1800 hours. During high water, flow measurements were taken from a boat using a long, calibrated pole instead of the top setting wading rod.

The weir was operated from June 29 to September 11, 1994. All salmon were identified to species, counted, and noted for gill net marks as they passed through the weir. On days when the weir was submerged, salmon passage was estimated using the average percent passage for the corresponding day from the three previous years. Estimates of coho salmon passage were obtained using average proportions from daily counts during 1992 and 1993 (Harper 1995b, c). Data from all years was plotted, and the 1991 coho salmon weir escapement was considered later than those in 1992 or 1993.

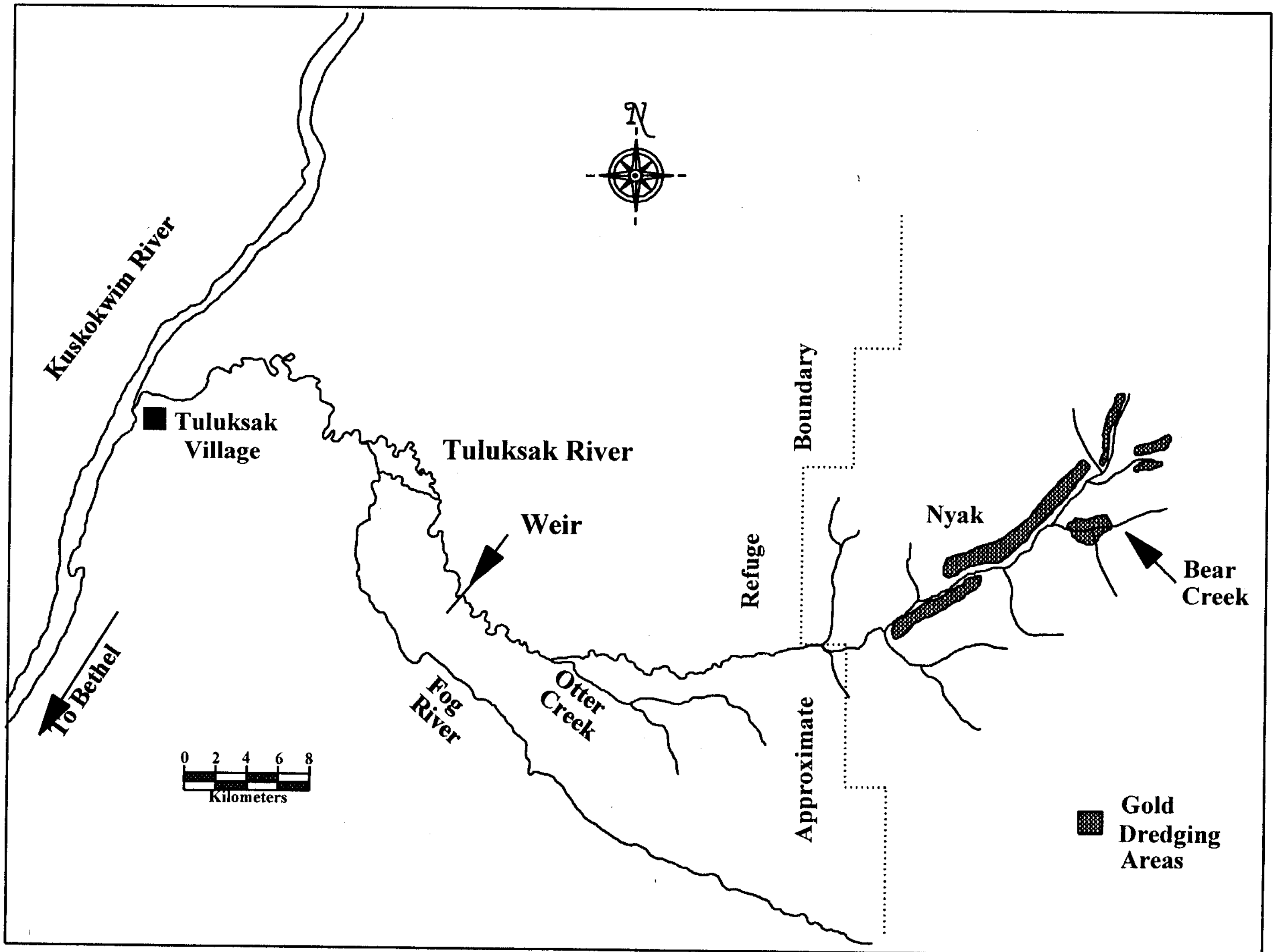


FIGURE 2.-Fish weir location in the Tuluksak River, Alaska, 1994.

The trap was usually opened at 0700 hours and closed at midnight or earlier depending on hours of daylight. Maintenance to clean and check for holes was performed daily before 0900 hours. Snorkeling was used to check weir integrity and substrate conditions. Cleaning consisted of walking across each panel to submerge it partially and allow the current to wash accumulated debris downstream. Algal growths were removed by scrubbing with long handled brooms. Spawned-out salmon and dead fish (carcasses) washing up on the weir were identified to species, counted, and passed downstream at 4-h intervals during routine cleaning operations.

Biological Data

Sample weeks started on Sunday and ended the following Saturday. A weekly quota of 160 chum, 140 chinook, and 110 coho salmon were sampled at the beginning of each week. Samples were collected in as short a period (1-3 d) as possible to approximate a pulse or snapshot sample (Geiger et al. 1990). All fish within the trap were sampled to prevent bias. A quota of 40 pink salmon was set for the season. Once weekly quotas were obtained, the trap was opened, and fish were passed until the next sampling period.

Fish sampling consisted of measuring length, determining sex, collecting scales, and then releasing the fish upstream of the weir. Each fish was also examined for gill net marks. Length was measured to the nearest 5 mm from mid-eye to fork-of-caudal-fin for salmon. Sex was determined by observing external characteristics. Scales were removed from the preferred area for age determination (Koo 1962; Mosher 1968). One scale was taken from each chum, sockeye, and pink salmon, and four scales were taken from each chinook and coho salmon. Scale impressions were made on cellulose acetate cards using a heated scale press and examined with a microfiche reader. Ages were then interpreted by a Department biologist and verified through comparison to commercial catch samples. Ages for salmon were reported according to the European Method (Koo 1962) where numerals preceding the decimal denote freshwater annuli, and numerals following the decimal refer to marine annuli. Total years of life at maturity is determined by adding one year to the sum of the two digits on either side of the decimal of the European designation. Therefore, age 1.4 and 2.3 fish are both 6-year-old fish from the same brood year (1.4=1+4+1=6 and 2.3=2+3+1=6). This number is then subtracted from the year of capture to determine brood year.

Age and sex composition of the weekly escapement were expanded directly from age and sex composition in the weekly sample using a stratified sampling design (Cochran 1977). Weekly samples were pooled into a single stratum when sample sizes were insufficient. Proportions of each strata and associated variances were calculated as:

$$\hat{p}_{hi} = \frac{a_{hi}}{n_h}; \quad \textbf{(1)}$$

$$\hat{V}(\hat{p}_{hi}) = \frac{\hat{p}_{hi}(1 - \hat{p}_{hi})}{n_h - 1}; \quad \textbf{(2)}$$

Where;

$a_{..}$ = the number of fish sampled of a given age *I* during stratum *h*,

N_h = the number of fish passing in stratum *h*;

$\hat{p}_{hi}$ = the estimated proportion of the sample in stratum *h* of a given age *I* and sex j; and,

n_h = the number of fish in sample for stratum *h*.

The proportion for the entire season was calculated as:

$$\hat{p}_i = \Sigma w_h \hat{p}_{hi}; \tag{4}$$

Where:

$w_h = \frac{N_h}{N}$ and N = The total number of fish going through the weir and the variance as;

$$\hat{V}(\hat{p}_i) = \Sigma w_h^2 \hat{V}(\hat{p}_{hi}). \tag{5}$$

The age composition and associated variance for each stratum was calculated as:

$$\hat{A}_{hi} = N_h \hat{p}_{hi}; \tag{6}$$

$$\hat{V}(\hat{A}_{hi}) = N_h^2 \hat{V}(\hat{p}_{hi}). \tag{7}$$

Stratum abundance estimates and their variances were summed to obtain age *I* and sex *j* composition estimates for the season as follows:

$$\hat{A}_i = \sum \hat{A}_{hi}; \tag{8}$$

$$\hat{V}[\hat{A}_i] = \sum \hat{V}(\hat{A}_{hi}); \tag{9}$$

where:

$\hat{A}_i$ = estimated number of fish at age I

Because lengths- (L) at-age changed during the season, and numbers of fish passing the weir varied by sampling stratum, weighted mean lengths $\hat{L}$ for the season were calculated. Average lengths from each stratum for each age and sex were weighted by the number of fish passing during that stratum.

$$\hat{L}_{ij} = \frac{\Sigma \hat{L}_{hij} \hat{A}_{hij}}{\hat{A}_{ij}}; \qquad \textbf{(10)}$$

Where: j= the given sex

Chi-square contingency table analysis was used to test for differences in age composition between the sexes. Because the standard test only applies to data collected under simple random sampling, adjustments were made to the test statistic, following Rao and Thomas (1989), to account for the impact of a stratified sampling design on the results. The $\mathbf{X}^2$ statistic, hereafter referred to as $\mathbf{X}^2(\hat{\delta}.)$, was divided by the mean generalized design effect, $\hat{\delta}.$, as a first-order correction to the standard test (Rao and Thomas 1989). Estimated design effects for the cells and marginals are presented in the results.

Migration Rates

Test fishery information was collected by the Department and consists of daily catch per unit of effort (CPUE). The CPUE is the number of fish captured per hour with a 180-m long net. Cumulative passage at the Bethel test fishery was considered to be equal to the cumulative CPUE. Cumulative proportion passage is equal to the sum of the daily percent passage to that day.

Migration rates from the Bethel test fishery to the Tuluksak River weir was estimated to the nearest day for each species and divided by the distance between the weir and the Bethel test fishery. I assumed that fish bound for the Tuluksak River were not temporally separated from other stocks but equally represented in test fishery sampling. Migration rates were compared to tagging data from the Kuskokwim River drainage (Francisco et al. 1993; Parker and Howard 1995) to estimate the possible timing of the Tuluksak River fish through the Bethel test fishery.

Stream-Life

The amount of time each salmon species remains alive above the weir before washing downstream (stream-life) was estimated. Stream-life was assumed to be the difference between the median cumulative passage dates of upstream migration and downstream passage of carcasses.

Results

Weir Operation

Water levels during 1994 started out low during weir installation, and other than a brief high water period in late June water levels remained low until late August when rains swelled the river to flood stage. Starting on August 26, high water submerged the weir until September 1. The weir submerged again on September 9 and 10 (Appendix 2). Fish passage was estimated for those days the weir was submerged. Discharge was measured on June 26 at 53.19 m^3/s, June 28 at 41.37 m^3/s, June 29 at 36.26 m^3/s and July 9 at 22.64 m^3/s. The design limitations of weir panels with 19 pickets was estimated at approximately 1 m^3/s/panel based upon rough estimates of water flows when the weir was submerged. During 1994, daytime temperatures averaged 12°C, (SD 4°C) between June 24 and September 14. The maximum temperature was 15°C on August 8 (Appendix 2).

Some damage occurred to the weir from the high water event in September. Several boats passed the weir during the flooding, and propeller strikes broke several pickets on one weir panel. Ten other panels had one to three pickets broken at the downstream end from vibrating in the high water while submerged. Several pickets also separated from the two most downstream stringers on some panels, because plastic fasteners broke.

Biological Data

A total of 15,724 chum, 2,917 chinook, 3,488 pink, 82 sockeye, and 7,953 coho salmon were estimated to have passed the weir between June 29 and September 11, 1994 (Figure 3; Appendices 3, 4, and 5). The number of salmon carcasses passed downstream over the weir were 4,286 chum, 432 chinook, 1,682 pink, five sockeye, and seven coho salmon (Appendix 6). Other species passing the weir included 478 Dolly Varden *Salvelinus malma*, 272 whitefish *Coregonus* and *Prosopium spp.*, 110 Arctic grayling *Thymallus arcticus*, and nine northern pike *Esox lucius* (Appendices 3 and 11). Estimated passage during periods when the weir was submerged were 73 chum, five chinook, two sockeye, 113 pink, and 3,143 coho salmon (Appendix 4).

Chum salmon.—Chum salmon was the first salmon species counted and passed through the weir on June 29, the first day the weir was operational. Peak weekly passage (N=5,610) was July 17-23 (Figure 3; Appendix 8). The median cumulative passage date at the weir was July 21 (Appendix 5).

Age, sex, and length data were collected from 851 chum salmon (Table 1, Appendix 8). Four age classes were identified (0.2, 0.3, 0.4, and 0.5). The bulk of the chum salmon escapement were ages 0.3 (49.6%) and 0.4 (45.1%). Age 0.4 fish predominated during the first half of the season while

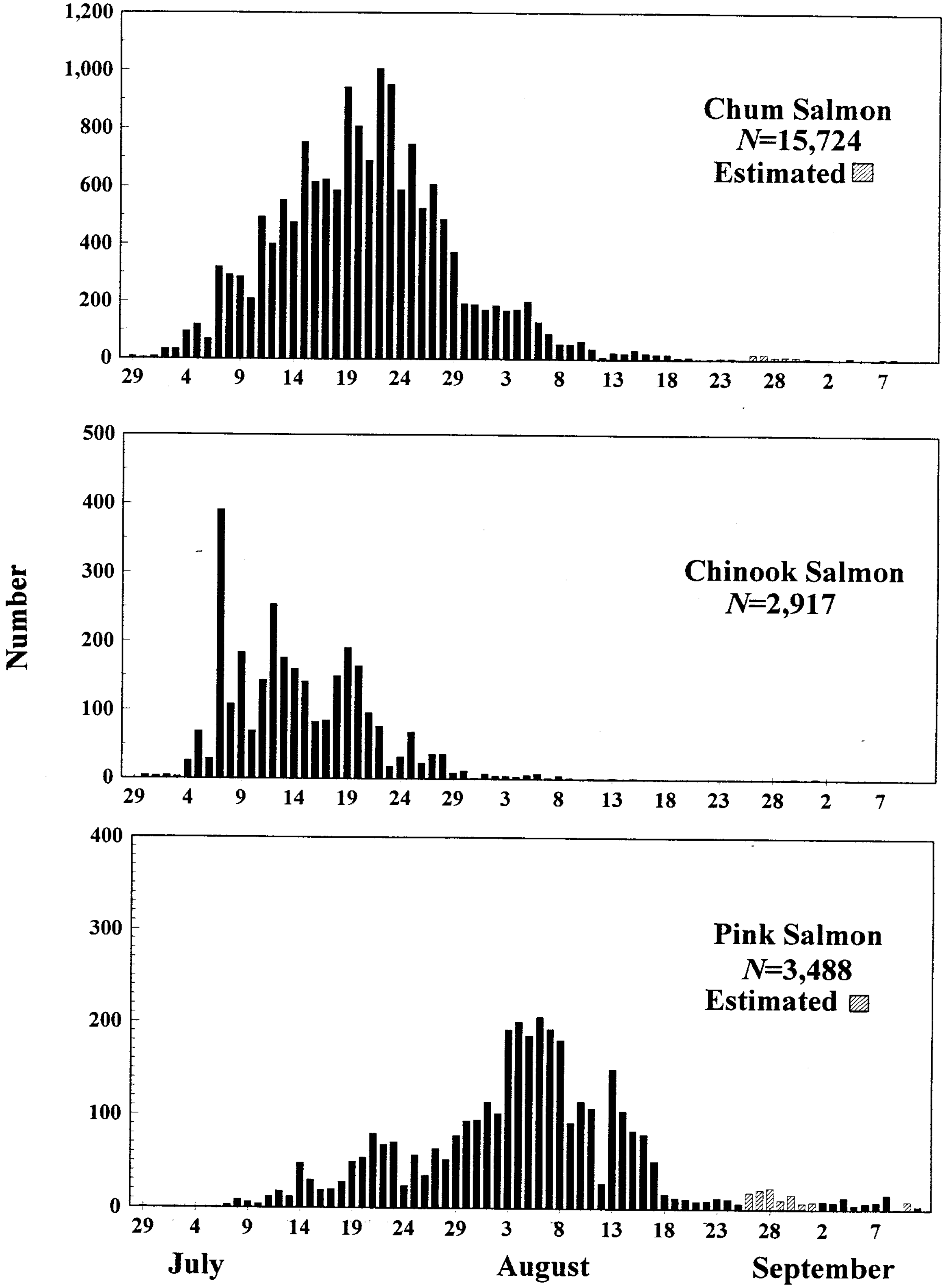


Figure 3.-Daily escapement counts for the five species of salmon passing the Tuluksak River weir from June 29 to September 11, 1994.

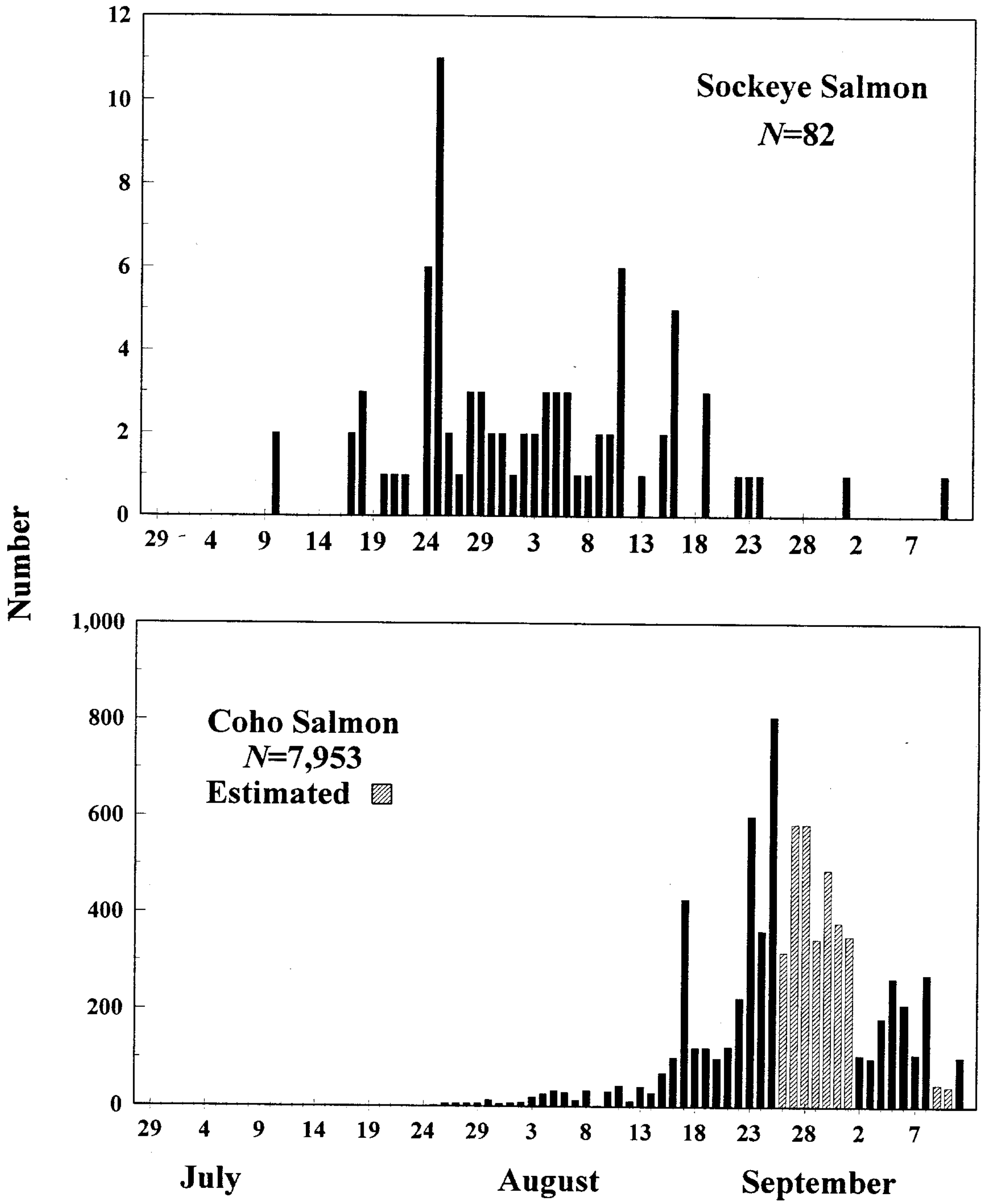


Figure 3.-(Continued).

age 0.3 fish predominated during the second half. Throughout the season, the proportion of age 0.4 fish steadily declined as the proportion of age 0.3 fish steadily increased.

Sex composition in the chum salmon escapement shifted from predominately males to females after the week of July 5-11. Males were primarily age 0.4 while females were primarily age 0.3. Age composition did not differ between the sexes ($X^2(\hat{\delta}.)$=2.32, df=2, *P*=0.31). As the season progressed, mean length-at-age decreased for both sexes.

Gill net marks (*N*=84) were observed on 0.5% of the chum salmon passing the weir in 1994 (Appendix 3). Gill net marks were noted almost every day through the end of July.

TABLE 1.-Lengths-at-age for chum salmon sampled at the Tuluksak River weir, Alaska, 1994.

		Mid-eye to fork length (mm)	
Age	*N*	Weighted Mean	Range
		Male	
0.2	2	543	525 - 560
0.3	180	567	475 - 655
0.4	206	561	490 - 665
0.5	22	584	525 - 655
Total	410		
		Female	
0.2	12	501	465 - 540
0.3	246	530	430 - 605
0.4	168	558	485 - 625
0.5	15	561	515 - 590
Total	441		

Chinook salmon.—Chinook salmon passed the weir starting June 30, one day after the first chum salmon. Peak weekly passage (*N*=1,029) was July 10-16 (Figure 3, Appendix 9). The median passage date at the weir was July 13, only 13 days after chinook salmon first passed (Appendix 5).

Ten age classes were identified from 475 chinook salmon scale samples. Males occurred in nine age classes, but females occurred primarily in the six oldest age classes (Table 2). Females composed only 23.7% of the weir escapement (Appendix 9), and were primarily ages 1.4 (10.6%) and 1.3 (8.5%). Males were primarily ages 1.2 (16.7%) and 1.3 (44.5%) (Appendix 8). Males were predominate in all age classes except 1.4, 1.5, and 2.4 (Appendix 9). Age composition of chinook salmon differed between the sexes ($X^2(\hat{\delta}.)$=100.76, df=3, *P*=0.001).

TABLE 2.–Lengths-at-age for chinook salmon sampled at the Tuluksak River weir, Alaska, 1994.

Age	N	Mid-eye to fork length (mm) Weighted Mean	Range
Male			
0.2	1	535	N/A
1.1	8	415	340 - 535
1.2	80	567	440 - 920
1.3	198	704	495 -1010
1.4	34	826	560 -1045
2.1	2	467	460 - 480
2.2	6	574	515 - 645
2.3	15	712	600 - 870
2.4	5	814	705 - 920
Total	349		
Female			
1.2	9	565	472 - 785
1.3	47	777	605 - 900
1.4	57	861	740 - 995
1.5	3	855	770 - 940
2.3	2	820	805 - 835
2.4	8	838	795 - 905
Total	126		

The passage for June 29-July 9 was 825 with 172 females (20.9%). During the week of July 10-16, 1,029 chinook salmon passed the weir of which only 152 were females (14.8%). Female numbers rebounded during the week of July 17-23 when 782 chinook salmon passed the weir and 226 (28.9%) were females (Appendix 9). A total of only 691 female chinook salmon were estimated in the weir escapement.

Gill net marks (N=173) were observed throughout the season on chinook salmon passing the weir (Appendix 3). The number of gill net marks observed on sampled females (16.0%) differed from the number observed on sampled males (5.9%) (X^2=14.49, df=1, P=0.00014).

Pink salmon.—The first pink salmon passed the weir on June 29. Pink salmon were not seen again until July 7 and continued to pass daily through September 11 (Figure 3). Peak passage (N=896) occurred the week of July 31-August 6. The median cumulative passage date was August 9, 33 days after the first pink salmon was passed.

Thirty-four pink salmon were measured and sexed (Table 3). Lengths ranged from 360 to 495 mm. Females (*N*=15) averaged 417 mm, and males (*N*=19) averaged 442 mm. Only one pink salmon passing the weir was observed with a gill net mark. Ages of three pink salmon were classified as age 1.1 due to what appears as an annulus or fresh water check (Table 3).

TABLE 3.-Lengths-at-age for pink salmon sampled at the Tuluksak River weir, Alaska, 1994.

		Mid-eye to fork length (mm)	
Age	*N*	Weighted Mean	Range
		Male	
0.1	17	437	360 - 495
1.1	2	490	490 - 490
Total	19		
		Female	
0.1	14	415	370 - 460
1.1	1	495	-
Total	15		

Sockeye salmon.—Sockeye salmon passed the weir in small numbers from July 3 to September 10 (Figure 3). Peak passage (*N*=28) occurred the week of July 24-30. The median cumulative passage date was August 2, 23 days after the first sockeye salmon passed upstream (Appendix 5).

Ages were determined from 18 sockeye salmon sampled at the weir. Females composed 83% of the sample, and both sexes were represented in ages 1.2, 1.3, and 2.3 (Table 4). Gill net marks were observed on only two sockeye salmon (2.0%) passing the weir.

Coho salmon.—Coho salmon passed the weir from July 26 to September 11, 1994 when the weir was pulled. Counts of passage were made each day except the period of August 26-September 1 and September 9 and 10, when the weir was submerged, and passage was estimated. Coho salmon were still passing the weir at the daily rate of 103 fish on September 11, the last day before the weir was removed. Peak passage occurred sometime between August 28 and September 2 when 5,382 were estimated to have passed (Figure 3). The median cumulative passage date at the weir was estimated to be August 27, 32 days after the first coho salmon was passed (Appendix 5).

TABLE 4.–Lengths-at-age for sockeye salmon sampled at the Tuluksak River weir, Alaska, 1994.

Age	N	Mid-eye to fork length (mm) Weighted Mean	Range
		Male	
1.2	2	445	480 - 610
2.3	1	435	-
Total	3		
		Female	
1.2	3	497	410 - 550
1.3	10	522	490 - 550
2.3	2	528	515 - 540
Total	15		

Age and sex composition in the weir escapements was estimated from weekly samples. Four age classes were obtained from 331 coho salmon sampled during the season (Table 5). Coho salmon were primarily ages 2.1 (85.4%) and 3.1 (12%) with representatives in age classes 1.1 and 0.3. Females composed an estimated 38.0% of the escapement and made up less than 50% of the weekly passage throughout the season (Appendix 10).

Gill net marks (N=274) were observed on 3.4% of the estimated coho salmon escapement (Appendix 3). Gill net marks on coho salmon were noted throughout the season.

Migration Rates

The distance between the Bethel test fishery and the weir is 168 rkm. The differences between the median cumulative passage dates at the Bethel test fishery and the weir were 15 days for chum; 24 days for chinook; 16 days for coho; and 32 days for sockeye salmon (Appendices 6 and 7). Estimated migration rates based on median cumulative passage dates at both sites are 11 km/d for chum and coho; 7 km/d for chinook; and 5 km/d for sockeye salmon. Pink salmon data were not plotted. The 25-75 and 10-90 percentile ranges for each salmon species to pass the weir during 1994 were 10 and 28 days for chum; 10 and 19 days for chinook; 18 and 40 days for sockeye; 12 and 36 days for pink; and 9 and 33 days for coho salmon.

Stream-Life

Chum salmon carcasses were first observed at the weir on July 2, followed by chinook on July 18; pink on July 19; sockeye on July 28; and coho salmon on August 17.

TABLE 5.-Lengths-at-age for coho salmon sampled at the Tuluksak River weir, Alaska, 1994.

		Mid-eye to fork length (mm)	
Age	N	Weighted Mean	Range
		Male	
1.1	8	522	355 - 590
2.1	171	501	395 - 655
3.1	23	538	375 - 625
Total	202		
		Female	
0.3	1	598	-
2.1	110	501	365 - 620
3.1	18	592	530 - 615
Total	129		

The median cumulative passage dates for salmon carcasses were July 28 for chum, August 7 for chinook, and August 12 for pink salmon (Appendix 6). Only seven coho salmon carcasses were passed downstream, and the median cumulative passage date was not estimated for this species. Stream-life, estimated from cumulative upstream passage and downstream passage of carcasses, was seven days for chum, 25 days for chinook, and 16 days for pink salmon (Appendices 5 and 6).

Discussion

Smaller fish may have passed undetected through the weir and the trap due to the picket spacing of 3.5 cm. Some resident fish in the trap escaped between the pickets when attempts were made to net them. Smaller pink salmon may also have passed between the pickets undetected, although none were seen. Identification of whitefish to species required individual examination, therefore, most were only classified as whitefish. Escapement data do not include salmon returning to the Fog River or several small tributaries located downstream of the weir.

Biological Data

Chum salmon.—The 1994 chum salmon weir escapement (N=15,724) was the highest on record and 13% larger than the next highest year, 1993, and 100% more than in 1991 (Appendix 4)(Harper 1995a, b, c). Several factors probably influenced this increase in Tuluksak River chum salmon during 1993 and 1994. First, during 1993, the commercial and subsistence fishery opportunities in the lower Kuskokwim River were limited due to below-average Kuskokwim River test fishery indicators and the lowest commercial catch per unit of effort recorded on that date (Francisco et al. 1994). Low catch and test fishery indicators were probably the result of a weak return to one or several Kuskokwim River tributaries. For example, the Aniak River, with an escapement goal of 250,000, had an escapement of only 13,870 fish during 1993 (Francisco et al. 1994). This was a major shortfall for that system and the Kuskokwim River commercial fishery. Second, the first commercial opening during 1994 was June 24, and subsequent openings were postponed until July 14. The median cumulative passage date for chum salmon at the Tuluksak River weir was July 21 from 1991 to 1994 (Figure 4). The median cumulative passage date at the test fishery was around July 6 in 1994. Therefore, most of the early portions of the return would have been past the commercial fishery district in the lower Kuskokwim River when the fishery resumed. Third, a strong return of 1989 and 1990 brood-year fish helped push the 1994 Tuluksak River escapement to its highest count during the four years of weir operations.

Chum salmon age composition followed a yearly pattern of changing from predominately age 0.4 fish to age 0.3 fish later in the run with age 0.3 comprising the escapement majority (Harper 1995a, b, c)(Figure 5).

Age composition in the Tuluksak River chum salmon escapement followed a yearly pattern of changing from predominately age 0.4 fish to age 0.3 fish as the run progressed, with age 0.3 fish predominating the overall escapement (Harper 1995a, b, c)(Figure 5). The sex composition also followed a similar pattern with males predominating for the first half of the season followed by females. Equal sex representation in the escapement always occurred within one week of peak weir passage (Figure 5).

Higher proportions of gill-net-marked fish in the escapement followed the timing of commercial harvests with the highest proportions observed when commercial harvests occurred in late June and early July (Table 6). For example, in 1991, three commercial openings occurred prior to July 6, and the percent marked was 4.7%. In 1994, only one opening occurred prior to July 14, and only 0.5% of the fish passing the weir were observed to have gill net marks.

Between 1991 and 1994, the median cumulative passage date for carcasses occurred between July 28 and August 5 (Figure 4; Appendix 6). The number of carcasses washing up on the weir for those years were 4,376; 3,801; 4,678; and 4,286, respectively.

Chinook salmon.—The weir escapement of 2,917 chinook salmon in 1994 was larger than in 1993 (*N*=2,218), 1992 (*N*=1,083), and 1991 (*N*=691)(Harper 1995a, b, c). The median cumulative passage date at the weir occurred around July 11 of each year and varied only three days between 1991 and 1994 (Figure 4). Cumulative passage at the Bethel test fishery varied by as much as eight days during the same years.

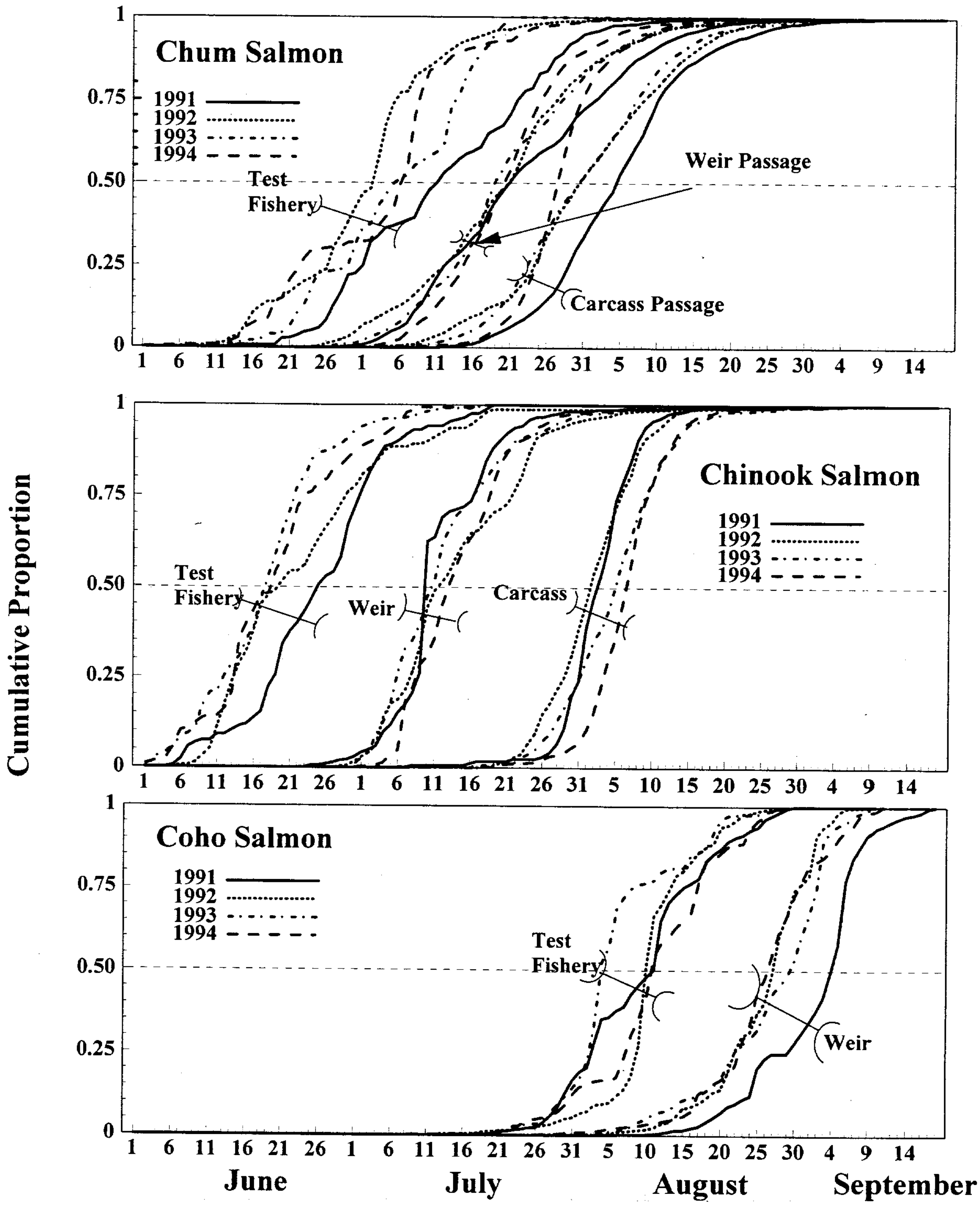


FIGURE 4.-Comparison of cumulative catch per unit of effort in the Bethel test fishery and cumulative escapement and carcass counts for chum, chinook, and coho salmon at the Tuluksak River weir, 1991-1994.

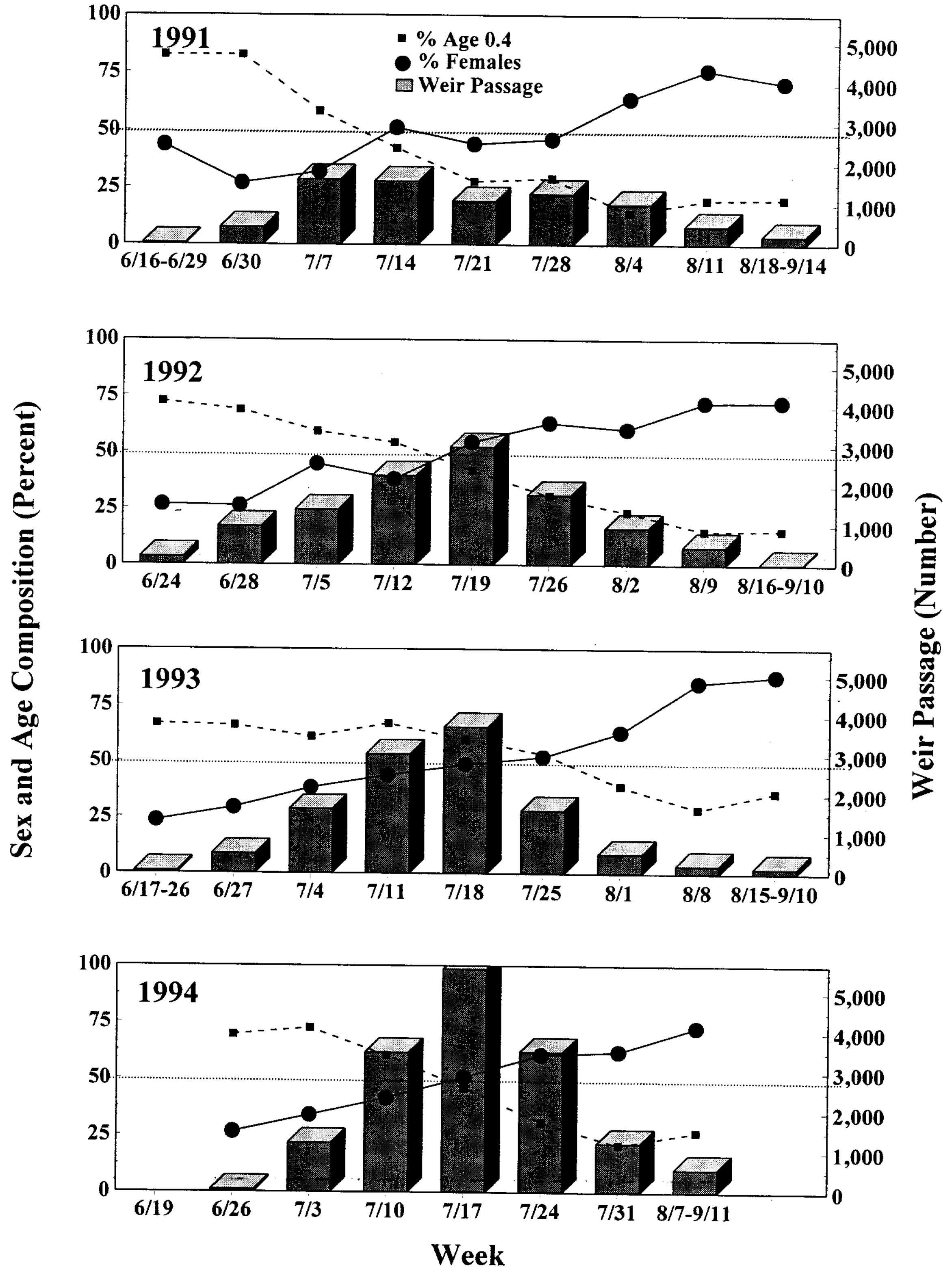


FIGURE 5.-Changes in sex and age composition in the chum salmon escapement relative to run progression at the Tuluksak River weir, 1991-1994. (Data source: Francisco et al. 1995).

TABLE 6.-Comparative chum and chinook salmon catches in the commercial fishery by year in the lower Kuskokwim River, 1991-1994 (Francisco et al. 1995).

		Catch		CPUE	
Year	Date	Chum	Chinook	Chum	Chinook
1991					
	June 20	13,266	13,813	3.68	3.83
	June 24	30,632	12,612	8.29	3.41
	July 01	50,121	5,966	13.28	1.58
	July 06	40,060	2,102	11.34	0.59
	July 13	52,552	904	15.34	0.26
	July 18	78,798	452	23.12	0.13
	July 22	49,788		15.28	
	July 25	30,083		7.06	
Total		345,300	35,849		
1992	June 18	32,695	9,756	7.21	2.15
	June 22	74,429	14,578	15.03	2.94
	June 25	55,114	8,984	10.99	1.79
	June 29	80,213	7,323	22.21	2.03
	July 06	84,196	3,250	17.93	0.69
Total		326,647	43,891		
1993	June 25	34,123	8,184	6.86	1.64
1994	June 24	87,214	14,221	18.93	3.09
	July 14	43,585	578	21.97	0.29
	July 19	60,104	441	20.03	0.15
	July 23	38,149		12.57	
	July 26	22,460		6.78	
Total		251,512	15,240		

Four-year-old (ages 1.2 and 2.1) and 5-year-old (ages 2.2 and 1.3) fish were predominate among males in the chinook salmon escapements during all years except 1991 (Figure 6). In 1991, 6-year-old (ages 1.4, 2.3) fish from 1985 brood year predominated among males. Six-year-old fish were predominate among females in all years except 1994 (Figure 6). During 1994, 5-year-old fish from the 1989 brood year were predominate among females.

Weir escapement data from 1992 to 1994 suggests the 1989 brood year was stronger than the 1990 brood year (Figure 6). This is evidenced by the strong contribution of 1989-brood-year fish as 5-year-old males in 1994, 4-year-old males in 1993, and 3-year-old males in 1992. Potentially poor 1990 brood year production may result in reduced returns of Tuluksak River chinook salmon in 1996 as contributions from the 1989 brood year diminish.

Estimates of female chinook salmon in the weir escapement increased each year from 1991 to 1994 and were 160, 201, 307, and 695 fish, respectively (Harper 1995a, b, c). Female composition in the 1991, 1992, and 1994 chinook salmon escapements was proportionally related. During 1994, the chinook salmon escapement was 4.2 times greater than in 1991, and the number of females was 4.3 times greater. During 1992, the escapement was 1.5 times greater than in 1991, and the number of females was 1.2 times greater. However, the 1993 escapement was 3.2 times greater than in 1991, but the number of females was only 1.9 times greater. The disproportionate number of females in the 1993 weir escapement can probably be attributed to a strong 1989 brood component of 4-year-old males (Figure 6).

The proportion of female chinook salmon in the weir escapement has characteristically dipped each year during the peak of the run (Figure 7). During 1991 and 1994, female proportions in the escapement continued to increase after peak passage occurred, but during 1992 and 1993, the proportion of females increased only slightly, then began to decrease. Commercial fishery restrictions in 1993, and the delayed timing of the commercial openings in 1994, reduced the number of chinook salmon that were commercially harvested in those years (Table 6). The reduced commercial harvest in 1993 did not appear to affect the percentage of females that started out low and remained low for the year.

The number of female chinook salmon in the Tuluksak River weir escapement was proportionally smaller than in the Kogrukluk River weir escapement. From 1991 to 1994, female composition in the Tuluksak River chinook salmon escapement averaged only 20.3% and was 28.8, 14.8, 13.9, and 23.7% for each year, respectively (Figure 7). During the same period, female composition in the Kogrukluk River chinook salmon escapement averaged 33.2% and was 46.6, 33.4, 28.2, and 24.6% for each year, respectively (Francisco et al. 1995). When female composition in the Tuluksak River escapement dropped below 15% during 1992 and 1993, there were not corresponding decreases in female composition on the Kogrukluk River.

The proportions of gill net marked females in the Tuluksak River chinook salmon escapements were 8.6, 21.0, 12.8, and 16.0% for 1991 through 1994, respectively. These proportions were lower than the Kogrukluk River weir escapements during all respective years except 1992 (Francisco et al. 1995). The higher incidence of gill net marks on Tuluksak River fish during 1992 may have resulted from more commercial openings prior to June 30 (Table 6) or a subsistence harvest that

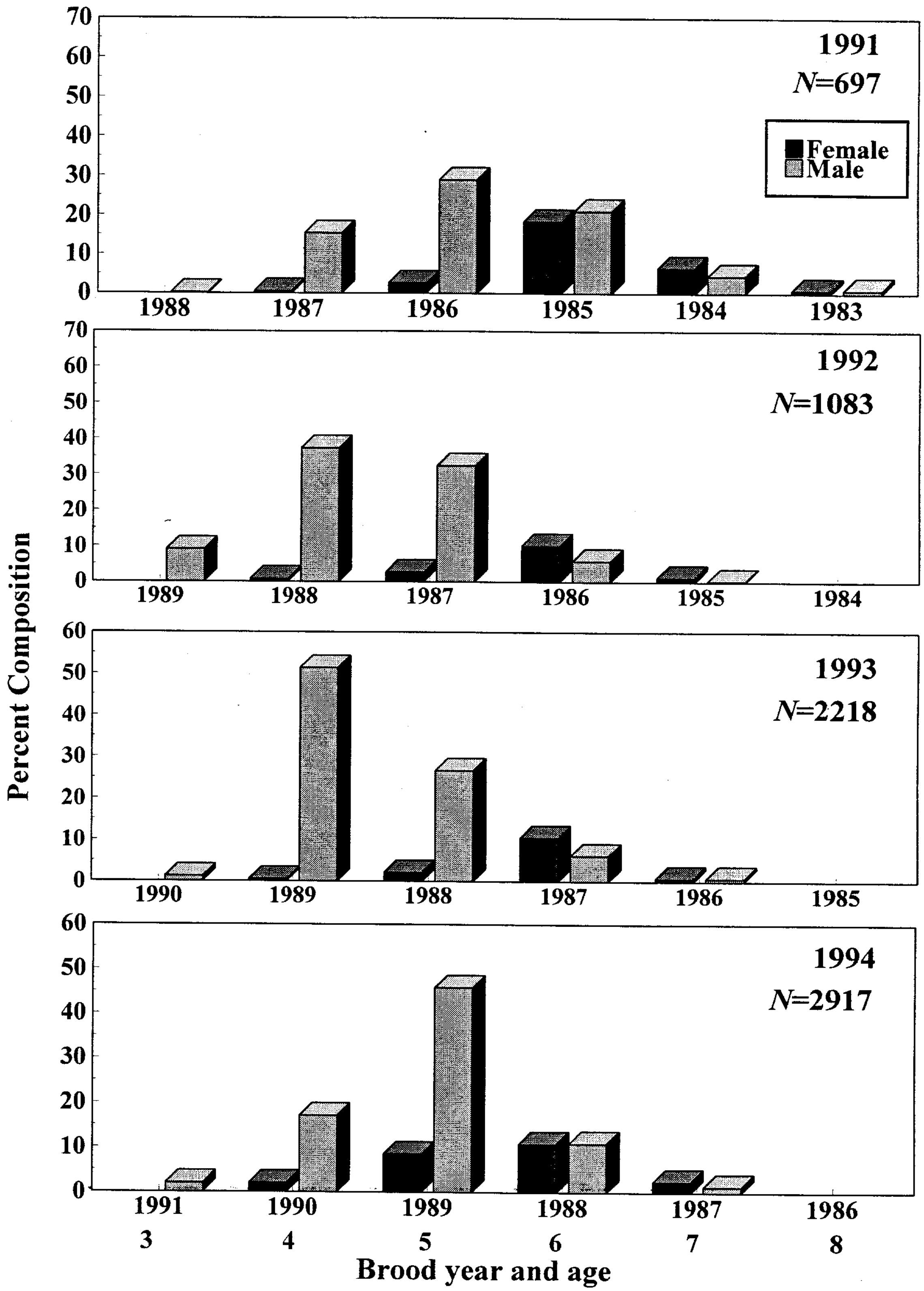


Figure 6.-Comparison of sex and age composition in chinook salmon escapements at the Tuluksak River weir, 1991-1994.

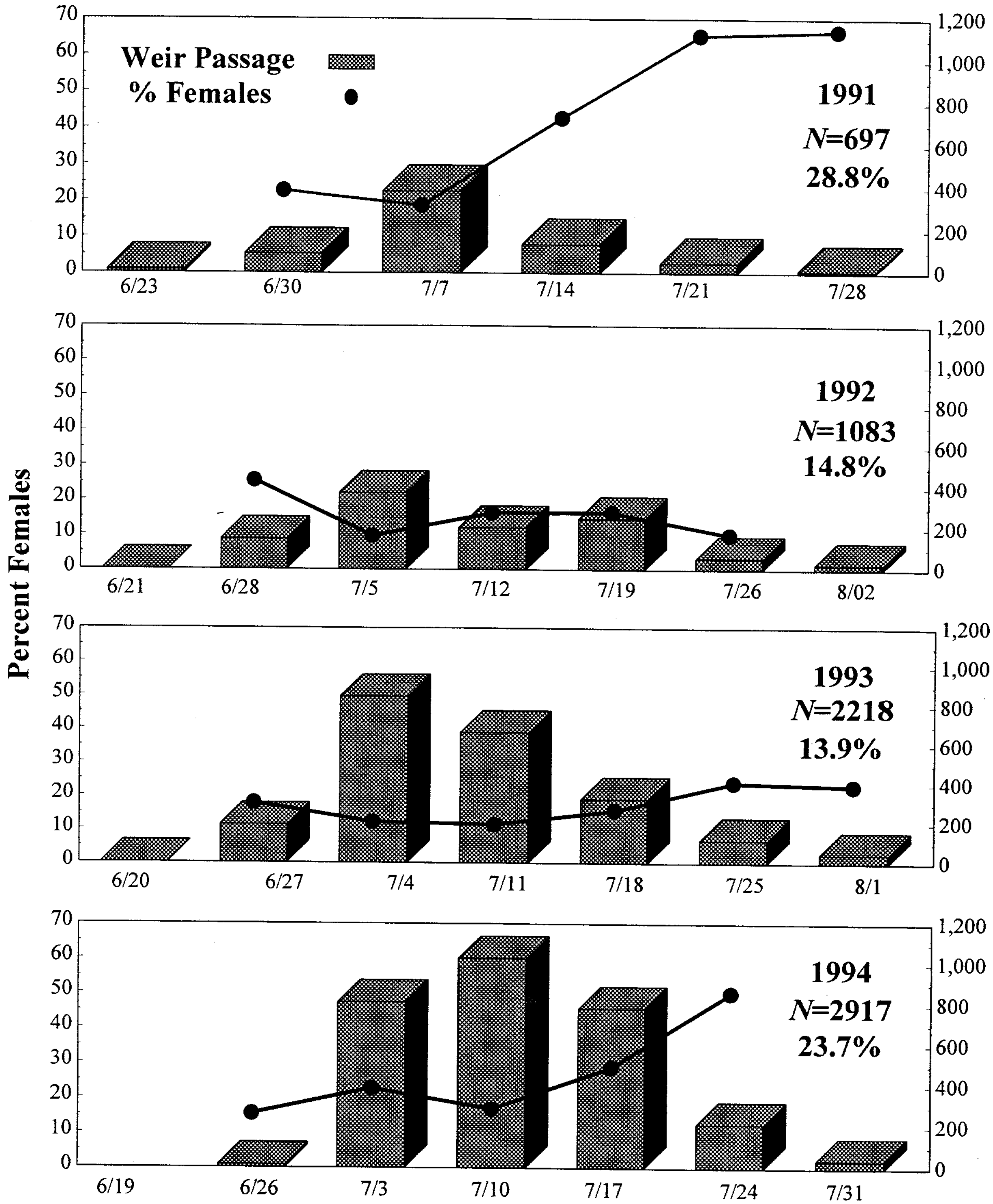


Figure 7.-Comparison of weekly chinook salmon passage and percent female composition at the Tuluksak River weir, 1991-1994.

coincided with the run timing of Tuluksak River chinook salmon. Four commercial openings for chum salmon occurred before June 30 in 1992, two in 1991, and one in both 1993 and 1994 (Table 6).

Tuluksak River chinook salmon are more susceptible to harvest in June than in July, because the bulk of the run is in the lower Kuskokwim River during June (Figure 4). During mid to late June, some chinook salmon that encounter smaller mesh nets in the commercial and subsistence fisheries will be harvested, and some will escape and resume their migration. Other chinook salmon, including the larger females, will be harvested in larger mesh nets used in the subsistence fishery. Additional information needs to be gathered on the subsistence fishery, including mesh sizes used and age and sex in the harvest.

The low percentage of female chinook salmon returning to the spawning grounds is of concern and may be due to several factors. First, females return at older ages than males and consequently incur additional years of ocean mortality (Hankin and Healy 1986). Second, as mentioned above, large mesh gill nets are selective toward the larger-sized females. The percentage of females in the commercial catch averaged 43% during years when unrestricted mesh sizes were allowed and 29% when mesh size was restricted to <20 cm (Francisco et al. 1995). Therefore, the subsistence fishery where mesh size is unrestricted, may harvest a larger proportion of females than the commercial fishery. A reduction in female chinook salmon to the Tuluksak River would be expected if intensive commercial and subsistence fishing, and the use of large mesh nets in the subsistence fishery, coincided with the run timing of this particular stock.

Escapement goals should take into consideration the sex ratios in the escapement and not simply consider the overall abundance as a measure of success, because a low proportion of females may have long term consequences. Waples (1990) suggests that a loss of genetic variability may occur with reductions in population size. Because effective population size is dependent upon females in the escapement, a reduction in females will lead to the elimination of some rare traits or low frequency alleles. The loss of these alleles may compromise their survival and limit their ability to respond to selection in future environments. Maintaining the genetic diversity that these populations represent is important for the long term health of the collective populations and the use by future fishers.

From 1991 to 1994, the difference between the median cumulative passage dates for upstream migrants and downstream carcass passage at the weir ranged from 21 to 25 days (Figure 4). During all years, the median cumulative passage dates for carcasses occurred between August 2 and August 8.

Pink salmon.—Kuskokwim River pink salmon have strong even-year runs (Francisco et al. 1992). Since 1980, commercial catches in the Kuskokwim River have averaged 3,948 fish during even years and 217 fish during odd years (Francisco et al. 1992). No escapement goals have been established for pink salmon in the Kuskokwim River drainage. The 1994 weir escapement of 3,488 pink salmon was 33% larger than the 1992 weir escapement of 2,470 fish. During 1991 and 1993, weir escapements were 392 and 210 pink salmon, respectively. The median cumulative passage dates occurred between August 5 and 9, except during 1991, when it occurred earlier in July.

Several age 1.1 fish were identified from the scale samples. This type of life cycle has been observed in other pink salmon populations (Heard 1991). It is not known if the second age check is salt water or freshwater in origin.

Sockeye salmon.—The number of sockeye salmon passing the Tuluksak River weir was small with less than 150 fish in all years between 1991-1994. The Holitna River, a tributary to the upper Kuskokwim River, is the only system that has an escapement objective for sockeye salmon (Francisco et al. 1992). The escapement objectives for that system are 2,000 fish at the Kogrukluk River weir and an aerial index estimate of 1,000 fish below the weir (Burkey 1991; Francisco et al. 1992). Commercial sockeye salmon harvests from the Kuskokwim River have ranged from 27,003 to 105,420 between the years of 1991 and 1994. The lake habitat that typically supports large numbers of juvenile sockeye salmon is not available in the Tuluksak River drainage, and actual spawning and rearing locations have not been determined. Additional data, including genetic stock identification, are needed from the Tuluksak River to determine population stability and fidelity to the system. Because the sockeye salmon population is small in the Tuluksak River, over-fishing could be detrimental to this stock.

From 1991 to 1994, the median cumulative passage dates occurred between July 21 and 27. Age 1.3 fish were predominate in the sample during all years. The number of females returning in 1994 (83.4%) was considerably higher than 1991 (33.3%), 1992 (56.8%), or 1993 (48.5%)(Harper 1995a, b, c). However, the small number of fish sampled during all years may have resulted in inaccurate composition data.

Coho salmon.—Run timing of coho salmon during the early part of the run during 1994 was similar to returns in 1992 and 1993, therefore, daily escapements from 1992-1993 were averaged and used to estimate daily passage for coho salmon when the weir was submerged during 1994 (Figure 4). This method biased estimated portions of the 1994 escapement toward resembling run timing during previous years. Because the 1994 flooding occurred during the normal run peak, a large number of coho salmon may have cued to the rising water (Holtby et al. 1984) and passed upstream before the weir was submerged. If fish passage peaked just prior to the weir being submerged, then the estimated numbers of fish passing during the flood event would be an overestimate. Alternatively, if fish passage increased during the flood event an underestimate would occur. Because there was a serge in numbers just prior to the weir being submerged, the latter probably occurred.

The estimated weir escapement of 7,953 coho salmon in 1994 was larger than in 1991 (N=4,565) but smaller than in 1993 (N=8,328)(Harper 1995c). An estimated 40% of the weir escapement was missed due to high water in 1994. By comparison, the estimated coho salmon escapement in the Kogrukluk River was 34,695 fish in 1994 and 9,964 fish in 1991. Commercial harvests of coho salmon in the lower Kuskokwim River were 477,726 fish in 1991; 631,592 fish in 1992; 586,330 fish in 1993; and 658,336 fish in 1994. If commercial catches of coho salmon in lower Kuskokwim River can be an indicator of run strength in the Tuluksak River, then the estimated of escapement during 1994 probably resembles the actual escapement.

The estimated proportion of female coho salmon in the weir escapement ranged from 52.5% during 1991 to 38.0% during 1994. Additional sampling during the period the weir was submerged may have revealed a change in the female proportion during 1994. However, the estimated sex composition for the 1994 weir escapement was similar to that in lower Kuskokwim River commercial harvests where females composed 39.5% of coho salmon catch during 1994 (Francisco et al. 1995).

Only age 1.1, 2.1, and 3.1 were consistently present in the coho salmon escapement each year. Age 3.2 was observed only during 1993, and age 2.2 was observed during 1991 and 1993. Age 2.1 fish were predominate in the sampled weir escapement during all years and females composed the majority of this age class only during 1991 (Figure 8).

The median cumulative passage dates occurred between August 28 and September 5, with 1991 being the latest (Figure 4). Coho salmon were still passing the weir each year on the last day of operation and probably continued to pass the weir site in small numbers until the end of September or later. During 1991, when the weir was operated until September 15, only 132 coho salmon were passed between September 5 and September 15 (Harper 1995a).

The decision to pull the weir each year was based on the daily escapement falling below 1% of the cumulative passage.

The percentagē of gill net marked coho salmon was lower in the 1994 weir escapement (3.4%) than in previous years, because approximately 40% of the escapement was estimated rather than visually counted. In comparison, gill net marks were observed on 9.4, 5.4, and 4.6% of the coho salmon from 1991 to 1993, respectively.

Migration Rates

Migration rates of salmon passing through the commercial or a test fishery can play an important role in management decisions. Management can spread the harvest across several fishing periods to prevent the over-harvest of individual stocks. Based on median cumulative passage dates at the Bethel test fishery and the Tuluksak River weir, estimated migration rates for salmon returning to the Tuluksak River from 1991 to 1994 were 6.5-16.9 km/d for chum; 7.0-11.3 km/d for chinook; 5.1-9.9 km/d for sockeye; and 7.7-10.6 km/d for coho salmon. These migration rates assume that the abundance of salmon bound for the Tuluksak River is normally distributed in the Bethel test fishery.

Estimating migration rates from median cumulative passage data is probably unreliable due to inconsistencies in run timing between monitoring locations and the assumption of similar timing. From 1991 to 1994, the median cumulative passage date for chum salmon varied by only four days at the Tuluksak River weir (Figure 4) but varied by as much as 10 days at the Bethel test fishery. This variability was possibly a result of commercial harvests during the middle of the run, the strength of early versus late runs or stocks, or the influence of water flows on run timing.

Tagging studies on chum, chinook, sockeye, and coho salmon are a better indicator of migration rates. Faster migration rates have been documented from tagging studies in the Kuskokwim River than from median cumulative passage dates at the Bethel test fishery and the Tuluksk River weir (Table 7). Estimated travel time between the Bethel test fishery and the Tuluksak River weir would be 9-10 days for chum and 12 days for chinook salmon if tagging data is used. If this migration rate

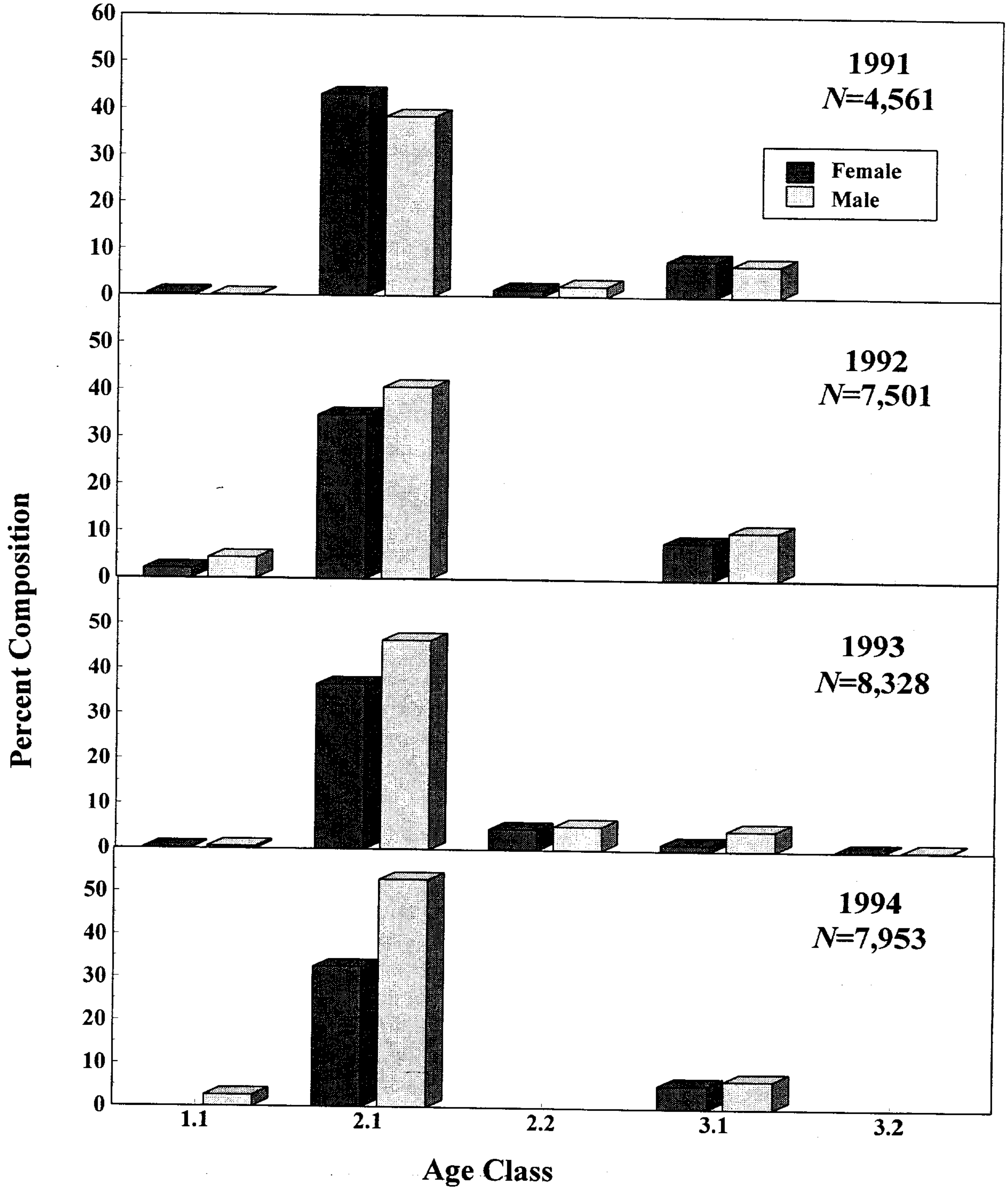


Figure 8.-Comparison of age compositions in coho salmon escapements at the Tuluksak River weir, 1991-1994.

TABLE 7.-Comparison of swimming speeds of tagged salmon on the Kuskokwim River and estimates based upon median cumulative passage at the Bethel test fishery and the Tuluksak River weir.

		Migration Rate (km/d)			
Date	Kuskokwim River Tagging Location	Chum	Chinook	Sockeye	Coho
1961	Tuluksak[a]	19.6	18.5	12.3	15.6
1962	Tuluksak[a]	21.9	11.4	17.9	N/A
1963	Enarayak 11 km up-stream of Eek Island[a]	10.5	12.4	11.3	N/A
1989	Eek, Bethel test fishery, and Bethel vicinity[b]		13.5		
1995	Upstream from Steamboat slough (*N*=297)[c]	22.0			
1995	Upstream from Steamboat slough (*N*=5)[c]	17.5			
1991-1994	Migration rate based on median passage dates at both the Bethel test fishery and the Tuluksak River weir	**6.5-16.9**	**7-11.3**	**5.1-9.9**	**7.7-10.6**

[a] Francisco et al. 1993
[b] Marino and Otis 1989
[c] Parker and Howard 1995

were representative, fishing periods after the peak in abundance of fish at the Bethel test fishery would harvest a higher percentage of Tuluksak-River-bound chum and chinook salmon (Figures 9 and 10). Additionally, tagging information suggests that sockeye and coho salmon returning to the Tuluksak River would also pass the Bethel test fishery after the peak in CPUE.

Stream-Life

Salmon stream-life can be used to determine when peak numbers of salmon are present on the spawning grounds and used as a guide for timing aerial index surveys. Stream-life estimates based on the difference between the median cumulative passage dates for chum and chinook salmon were similar for all years (Figure 4). However, using this method to estimate stream-life may result in a biased estimate. Nielson and Geen (1981), reports that residence time on redds varied throughout the season. Salmon arriving early generally occupied a redd longer than late arrivals. Rising water levels may also wash carcasses and spawned-out fish downstream faster than normal, or receding water levels might slow carcass wash-out or strand them on river banks. Spawning also occurs at varying distances above the weir, and carcasses may sink to the bottom before reaching the weir. A tagging study would provide additional information on stream-life above the weir.

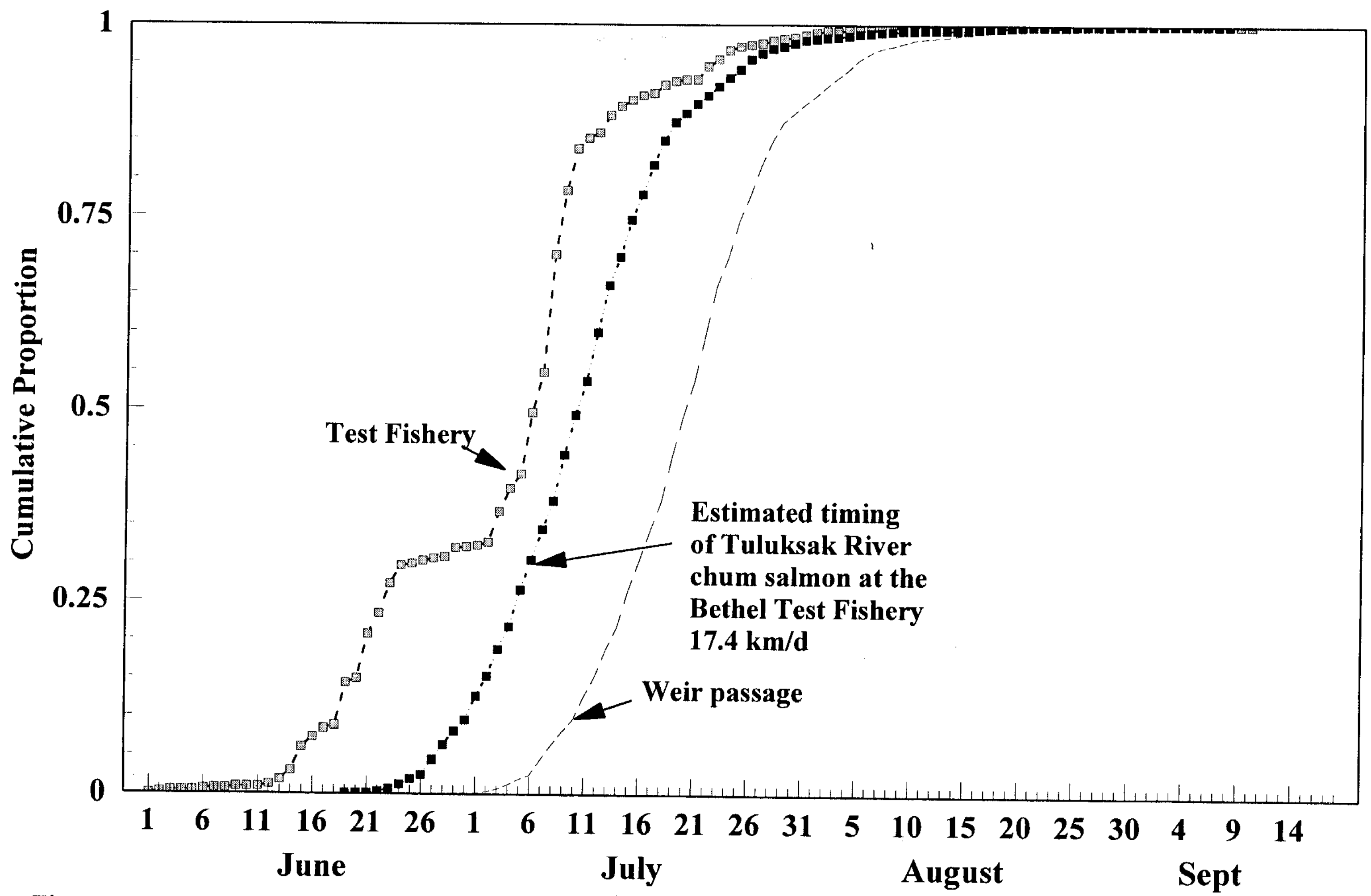


Figure 9.-Estimated run timing of Tuluksak-River-bound chum salmon at the Bethel test fishery during 1994 based on run timing at the Tuluksak River weir and radio telemetry tracking results (Bering Sea Fishermen's Association, unpublished data).

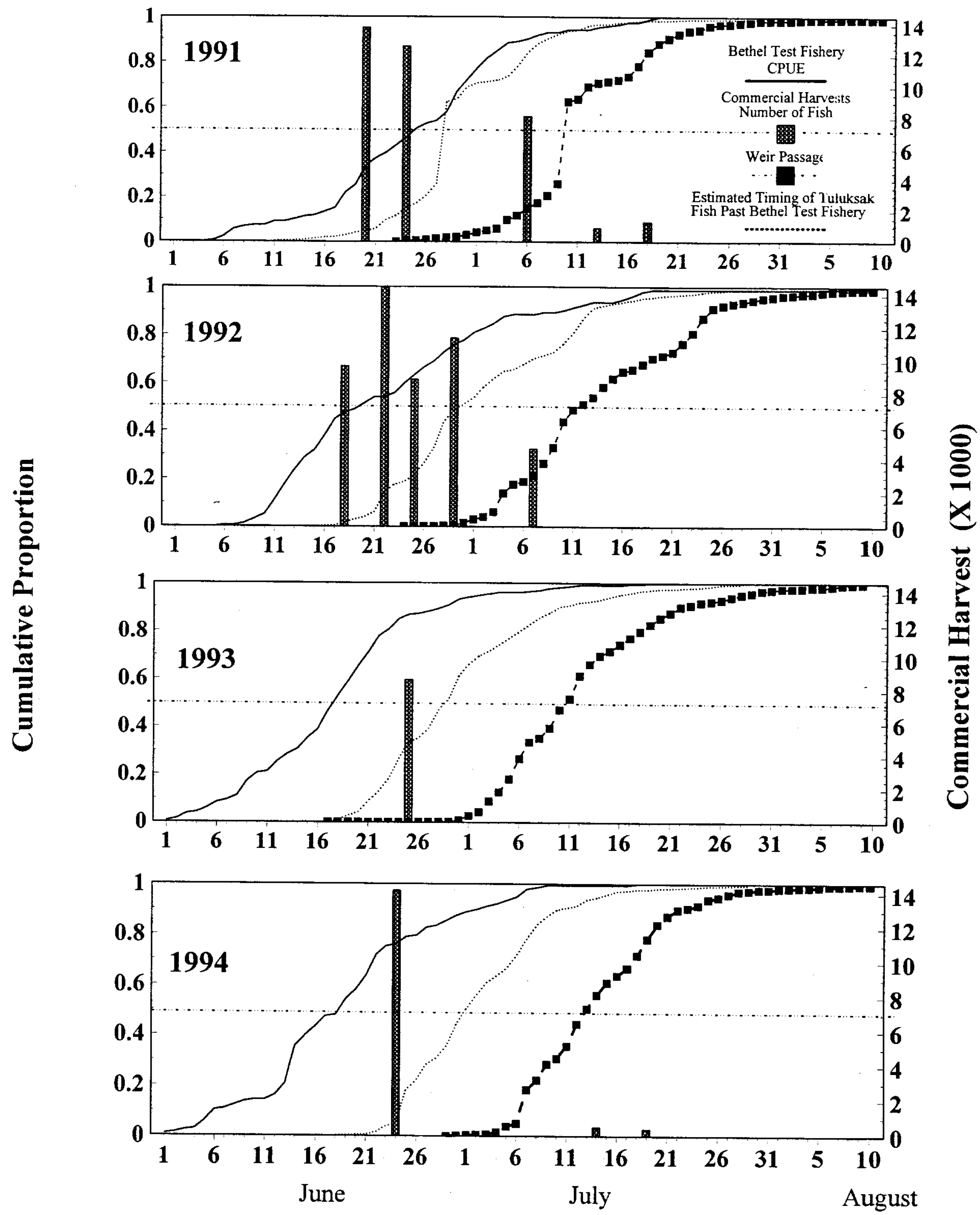


Figure 10.-Susceptibility of Tuluksak-River-bound chinook salmon to commercial exploitation based on estimated run timing of Tuluksak-River-bound chinook salmon at the Bethel test fishery and commercial harvests of this species in the Kuskokwim River below Tuluksak,1991-1994.

Aerial index estimates must account for stream-life and run timing to provide useful data. Species with a short stream-life and protracted escapements, such as chum salmon, should be surveyed more than once, and the "Factor 5" or "Area Under the Curve" methods described by Cousins et al. (1982) should be used to estimate total abundance. When 90% of the chum salmon had passed the weir, over 60% of the carcasses had been passed downstream. Conversely, a large percentage of spawners can be observed during a single survey for species, such as chinook salmon, that has a long stream-life and relatively short run duration. During 1994, approximately 91% of the chinook salmon had passed the weir by July 25, and only 1% of the carcasses had been passed downstream. Fewer spawners were present for aerial index surveys after July 25 due to carcass wash-out. For example, 94% of the weir escapement, minus 25% of the carcasses, was available for enumeration when an aerial index survey was conducted on July 29, 1994. Chinook salmon timing was relatively consistent from 1991 to 1994 which suggests the optimal timing to conduct aerial index surveys for chinook salmon in the Tuluksak River is the last week of July.

Escapement data from 1991-1994 suggest the optimal time to conduct aerial index surveys for coho salmon is the first week of September. Seventy to 90% of the coho salmon had entered the river by this date, and few carcasses were counted downstream during that time.

The lack of funding, adverse weather conditions, and poor observation conditions on the Tuluksak River, made it impossible to conduct aerial index surveys for chum, chinook, and coho salmon in some years. Therefore, better methods are needed for estimating escapement.

Recommendations

Based on the data in this report and personal observations, the following is recommended:

1. Weir operation or escapement monitoring projects should continue for at least one full life cycle of chinook salmon because of the life history. This should be the minimal amount of data used to determine if the low sex ratios for chinook salmon are cyclical. Low numbers of female chinook salmon entering the river indicate a need for a monitoring program and a change in regulations if females continue to return in low numbers. The development of a biological escapement goal that accounts for sex composition should be a high priority for the river.

2. Additional tagging studies in the lower Kuskokwim River are needed to gather information on salmon migration timing. Additional data may refine estimates of temporal or spacial separation of various stocks and estimate migration rates that are important in management of chum salmon stocks.

3. Collect spawning and rearing habitat data to quantify the river's carrying capacity, and establish biological escapement goals for chinook, chum, and coho salmon.

Acknowledgments

Special appreciation is extended to those people who contributed to this project: Ruth Post and John Crye as crew leaders for data collection and daily weir operation. Co-workers John Tobin and Henry Ivanoff, Student Conservation Volunteer Anna Maria Mueller, and local hires James Allain Jr. and Andrew Liskey from Tuluksak, Alaska, all contributed to the success of the project. Thanks also to Anne Barrett for preparation of the manuscript and figures for publication and Steve Klosiewski for invaluable biometric support and review.

I thank the many personnel of the Yukon Delta National Wildlife Refuge staff, for their assistance. The U.S. Fish and Wildlife Service also appreciates the help and assistance of the Alaska Department of Fish and Game (Commercial Fish Division, Bethel Office) and to Doug Molyneaux for pressing and aging of salmon scales.

References

Alt, K. 1977. Inventory and cataloging in western Alaska waters. Alaska Department of Fish and Game, Federal Aid in Fish Restoration Completion Report, Study G-I-P, Volume 18, Juneau, Alaska.

Burkey, C. 1991. Kogrukluk weir escapement report, 1990. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYC Region, Regional Information Report No. 3B91-19, Anchorage, Alaska.

Cochran, W.G. 1977. Sampling techniques, third edition. John Wiley and Sons, New York.

Cousins, N.B.F., G.A. Thomas, C.G. Swann, and M.C. Healey. 1982. A review of salmon escapement estimation techniques. Department of Fisheries and Oceans, Fisheries Research Branch, Pacific Biological Station, Nanaimo, British Columbia.

Crayton, W.M. 1990. Report of findings, placer mining impacts - Tuluksak River, fiscal years 1987, 1988 and 1989. U.S. Fish and Wildlife Service, Ecological Services, Anchorage, Alaska.

Francisco, K.R., C. Anderson, C. Burkey, M. Coffing, K. Hyer, D. Molyneaux, and C. Utermohle. 1992. Annual management report for the subsistence and commercial fishery of the Kuskokwim area, 1991. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Regional Information Report 3A92-06, Anchorage, Alaska.

Francisco, K.R., C. Burkey, D. Molyneaux, C. Anderson, H. Hamner, K. Hyer, M. Coffing, and Charles Utermohle. 1993. Annual management report for the subsistence and commercial fisheries of the Kuskokwim area, 1992. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Regional Information Report Number 3B93-11, Anchorage, Alaska.

Francisco, K.R., C. Anderson, C. Burkey, Jr., M. Coffing, K. Hyer, D. Molyneaux and C.Utermohle. 1994. Annual management report for the subsistence and commercial fisheries of the Kuskokwim Area, 1993. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, AYK Region, Regional information Report Number 3A94-21, Anchorage, Alaska.

Francisco, K.R., C. Anderson, M. Fogarty, C. Burkey, D. Molyneaux, C. Utermohle and K. Vaught. 1995. Annual management report for the subsistence and commercial fisheries of the Kuskokwim area, 1995. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Regional Information Report 3A95-15, Anchorage, Alaska.

Francisco, K.R., and K.A. Sundberg. 1983. Tuluksak River fisheries reconnaissance survey with special emphasis on the effects of gold dredging. Alaska Department of Fish and Game, Arctic-Yukon-Kuskokwim Region, Kuskokwim Inventory Report Number 6, Bethel, Alaska.

Geiger, J.H., J.E. Clark., B. Cross, and S. McPherson. 1990. Report from the work group on sampling. Pages 3-12 *in* H.J. Geiger, and R.L. Wilbur, editors. Proceedings of the 1990 Alaska Stock Separation Workshop. Alaska Department of Fish and Game, Division of Commercial Fisheries. Special Fisheries Report No. 2, Juneau, Alaska.

Hamilton, K., and E.P. Bergersen. 1984. Methods to estimate aquatic habitat variables. Colorado State University, Colorado Cooperative Fishery Research Unit, Ft. Collins, Colorado.

Hankin D.G., and M.C. Healy. 1986. Dependence of exploitation rates for maximum yield and stock collapse of age and sex structures of chinook salmon (*Oncorhynchus tshawytscha*) stocks. Canadian Journal of Fisheries and Aquatic Sciences Vol. 43:1746-1759.

Harper, K.C. 1995a. Run timing and abundance of adult salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 1991. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Progress Report, 95-1, Kenai, Alaska.

Harper, K.C. 1995b. Run timing and abundance of adult salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 1992. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Progress Report, 95-3, Kenai, Alaska.

Harper, K.C. 1995c. Run timing and abundance of adult salmon in the Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 1993. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Progress Report, 95-2, Kenai, Alaska.

Heard, William 1991. Life History of Pink Salmon Pages 121-230 *in* C. Groot and L. Margolis, editors. Pacific Salmon Life Histories. Department of Fisheries and Oceans, Biological Sciences Branch. University of British Columbia Press. Vancouver, British Columbia.

Holtby, L.B., G.F. Hartman, and J.L. Scrivener. 1984. Stream indexing from the prospective of the Carnation Creek experience. Pages 87-111 *in* P.E.K. Symons and M. Waldichuk, editors. Procedings of the workshop on stream indexing for salmon excapement estimation, West Vancouver, British Columbia, 2-3 Feb, 1984. Canadian Technical Report, Fish and Aquatic Science: 1326.

Koo, T.S.Y. 1962. Age determination in salmon. Pages 37-48 *in* T.S.Y. Koo, editor. Studies of Alaska red salmon. University of Washington Press, Seattle, Washington.

Marino, T., and T. Otis. 1989. Pilot inventory of the chinook salmon (*Oncorhynchus tshawytscha*) stocks of the Kuskokwim River basin, Yukon Delta National Wildlife Refuge, 1989. U.S. Fish and Wildlife Service, unpublished manuscript, Bethel, Alaska.

Mosher, K.H. 1968. Photographic atlas of sockeye salmon scales. U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Fishery Bulletin 2:243-274.

Mundy, P.R. 1982. Computation of migratory timing statistics for adult chinook salmon in the Yukon River, Alaska, and their relevance to fishery management. North American Journal of Fisheries Management 4:359-370.

Nielson, J.D., and G.H. Geen. 1981. Enumeration of spawning salmon from spawner residence time and aerial counts. Transactions of the American Fisheries Society 110: 554-556.

Parker, S.J., and R.L. Howard. 1995. Migratory behavior of Adult Chum Salmon in the Kuskokwim River. Bering Sea Fishermen's Association, 1995 Final Report, Anchorage, Alaska

Rao, J.N.K., and D.R. Thomas. 1989. Chi-squared test for contingency tables. Pages 89-114. *In* C.J. Skinner, D. Holt, and T.M.F. Smith editors. Analysis of complex surveys. John Wiley & Sons, New York, New York.

Schneiderhan, D. 1979. 1978 Kuskokwim River sonar studies. Alaska Yukon-Kuskokwim Region. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kuskokwim River Escapement Report Number 16, Anchorage, Alaska.

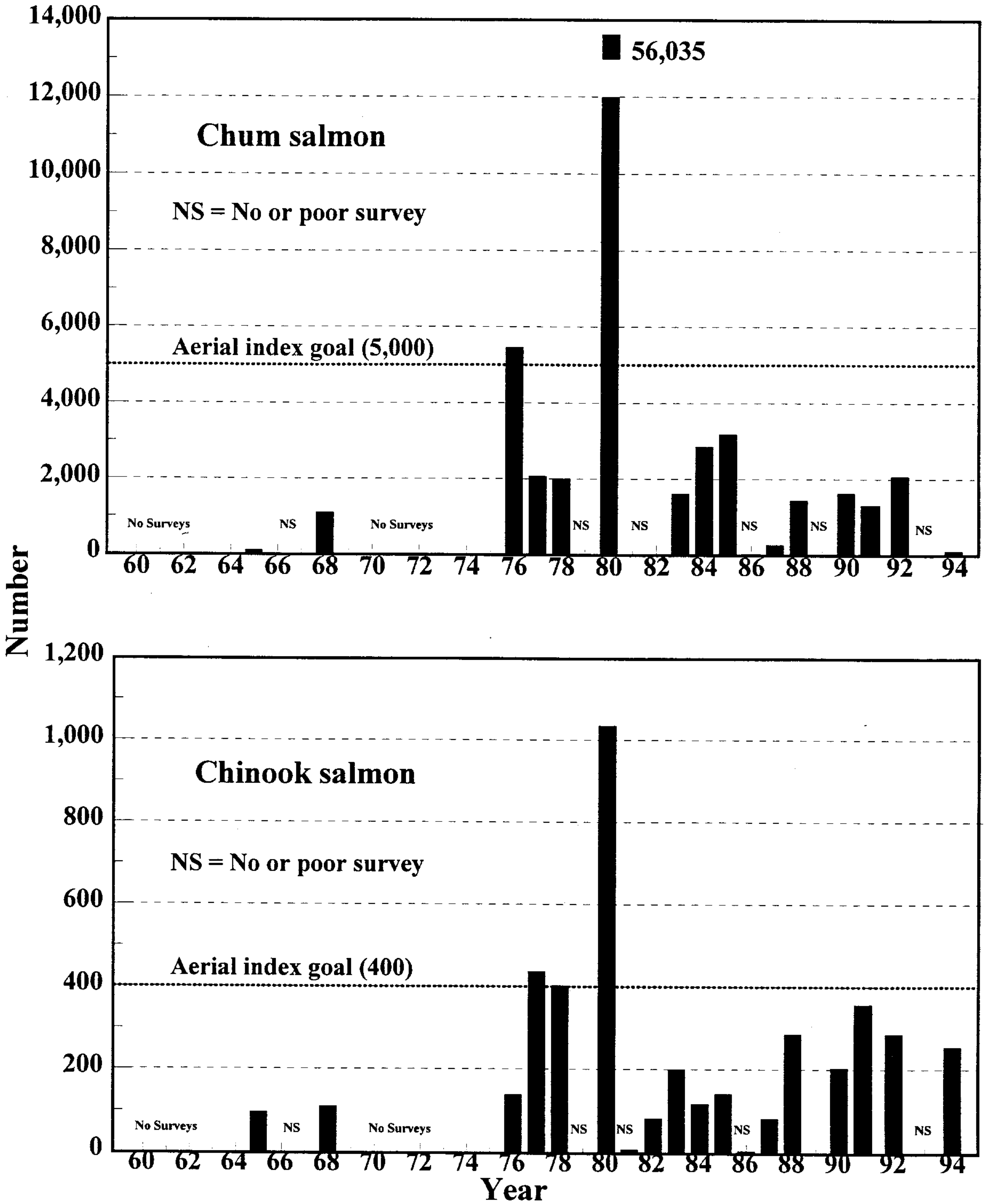
Schneiderhan, D. 1983. Kuskokwim stream catalog, 1954-1983. Alaska Department of Fish and Game, unpublished annotated database report, Anchorage, Alaska.

Schneiderhan, D. 1988. Kuskokwim area salmon escapement observation catalog, 1984-1988. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Regional Informational Report Number 3B88-29, Anchorage, Alaska.

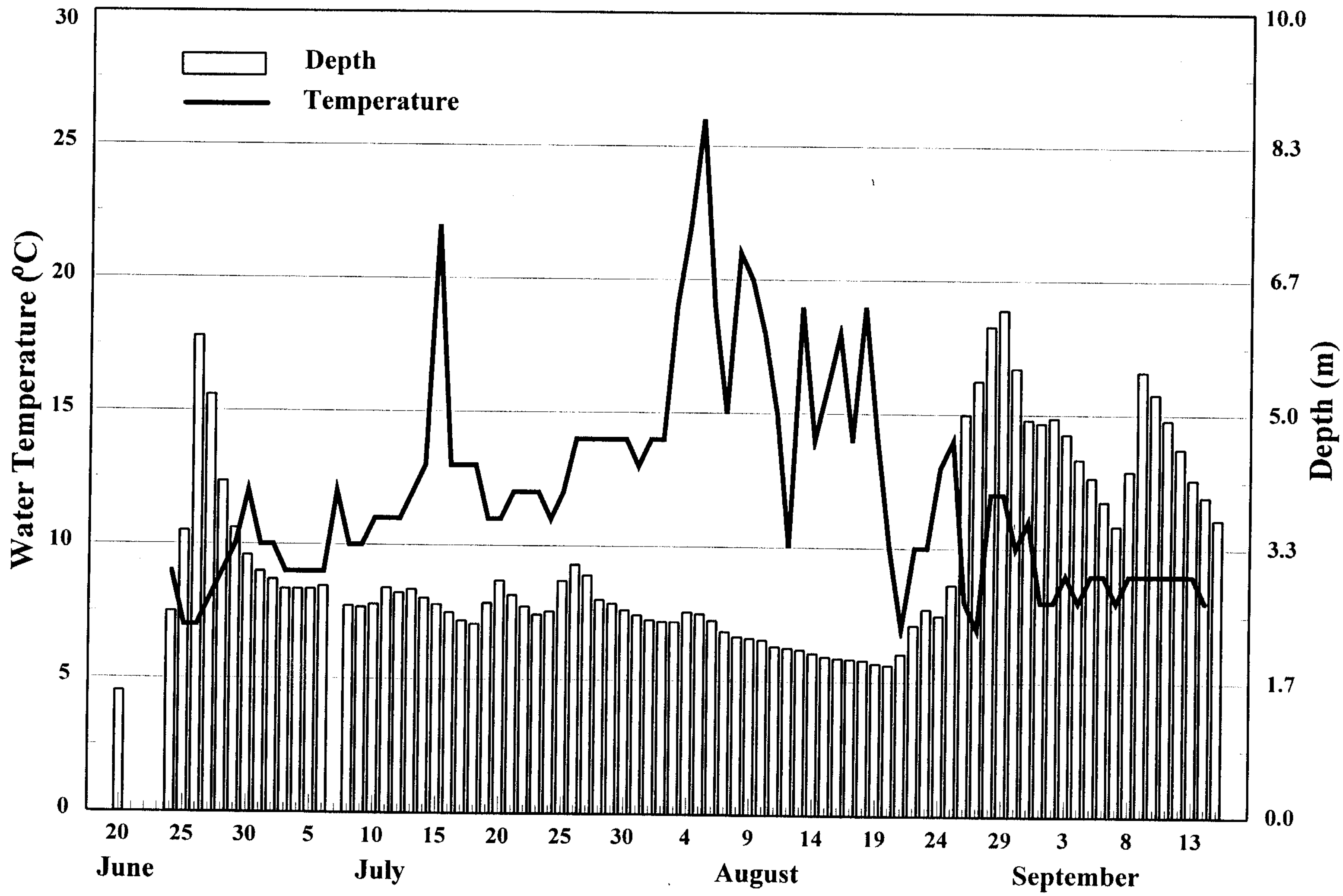
Tobin, J.H. 1994. Construction and performance of a portable resistance board weir for counting migrating adult salmon in rivers. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Technical Report Number 22, Kenai, Alaska.

U.S. Fish and Wildlife Service. 1992. Fishery management plan for the Yukon Delta National Wildlife Refuge. U.S. Fish and Wildlife Service, Anchorage, Alaska.

Waples, R.S. 1990. Conservation genetics of Pacific salmon II. Effective population size and the rate of loss of genetic variability. The Journal of Heredity 81:267-276.



Appendix 1.-Aerial index estimates for chum and chinook salmon in the Tuluksak River, 1960-1994.



Appendix 2.-Water levels and temperatures in the Tuluksak River, Alaska,1994.

Appendix 3.-Daily weir counts of salmon, gill net marked salmon and other fish species, Tuluksak River weir, 1994.

						Gill Net Marked Salmon								
Date	Chum Salmon	Chinook Salmon	Sockeye Salmon	Pink Salmon	Coho Salmon	Chum Salmon	Chinook Salmon	Sockeye Salmon	Pink Salmon	Coho Salmon	Dolly Varden	Whitefish	Arctic Grayling	Northern Pike
06/29	8	0	0	1	0	2	0	0	0	0	0	0	0	0
06/30	4	5	0	0	0	1	1	0	0	0	0	0	0	0
07/01	8	4	0	0	0	2	1	0	0	0	0	0	0	0
07/02	34	5	0	0	0	6	0	0	0	0	0	0	0	0
07/03	35	3	0	0	0	3	0	0	0	0	1	0	0	0
07/04	96	26	0	0	0	7	2	0	0	0	0	0	0	0
07/05	121	69	0	0	0	0	6	0	0	0	0	0	0	0
07/06	70	29	0	0	0	1	1	0	0	0	0	2	0	1
07/07	321	391	0	3	0	6	25	0	0	0	10	1	1	0
07/08	294	109	0	9	0	5	4	0	0	0	17	1	3	1
07/09	288	184	0	6	0	2	9	0	0	0	1	0	1	0
07/10	211	70	2	4	0	2	9	0	0	0	2	0	0	0
07/11	495	144	0	12	0	3	6	0	0	0	1	0	1	0
07/12	401	254	0	18	0	0	8	0	0	0	3	0	0	0
07/13	553	176	0	12	0	4	13	0	0	0	10	0	3	0
07/14	476	160	0	48	0	5	8	0	0	0	53	1	2	0
07/15	754	142	0	30	0	2	13	0	0	0	23	2	8	0
07/16	615	83	0	19	0	1	5	0	0	0	31	2	1	0
07/17	625	85	2	20	0	1	7	0	0	0	15	2	0	0
07/18	587	150	3	28	0	2	12	0	0	0	12	2	1	0
07/19	942	191	0	50	0	0	5	0	0	0	30	2	1	0
07/20	808	165	1	54	0	2	10	0	0	0	10	1	4	0
07/21	690	96	1	80	0	2	7	0	0	0	8	0	1	0
07/22	1006	77	1	68	0	2	5	0	0	0	11	1	2	0
07/23	952	18	0	71	0	0	0	0	0	0	10	0	0	0
07/24	589	32	6	24	0	1	6	0	0	0	2	0	0	0
07/25	747	68	11	57	3	2	3	1	0	0	0	1	1	0
07/26	525	23	2	35	7	1	2	0	0	0	3	0	0	1
07/27	609	36	1	64	7	3	1	0	0	0	4	4	0	0
07/28	487	36	3	52	7	0	1	0	0	0	2	9	2	0
07/29	374	9	3	78	7	1	0	0	0	0	4	7	1	0
07/30	194	12	2	94	14	1	2	0	0	0	3	5	4	0
07/31	191	2	2	95	7	4	0	0	0	0	0	2	0	0

-continued-

Appendix 3.-(continued)

DATE	Chum Salmon	Chinook Salmon	Sockeye Salmon	Pink Salmon	Coho Salmon	Gill Net Marked Chum Salmon	Gill Net Marked Chinook Salmon	Gill Net Marked Sockeye Salmon	Gill Net Marked Pink Salmon	Gill Net Marked Coho Salmon	Dolly Varden	Whitefish	Arctic Grayling	Northern Pike
08/01	173	8	1	114	8	3	0	0	0	0	8	0	0	0
08/02	188	5	2	102	10	1	0	1	0	0	2	1	1	1
08/03	170	5	2	192	20	1	0	0	0	2	8	0	5	0
08/04	175	4	3	201	27	0	0	0	0	1	12	0	9	0
08/05	202	6	3	186	33	0	0	0	0	0	29	7	10	1
08/06	130	8	3	206	30	0	0	0	0	1	30	0	16	0
08/07	89	2	1	193	14	0	0	0	0	0	13	1	5	0
08/08	54	5	1	181	34	1	1	0	1	2	16	3	2	0
08/09	53	2	2	92	2	0	0	0	0	1	8	2	0	0
08/10	63	1	2	115	32	1	0	0	0	2	16	8	5	0
08/11	37	2	6	108	44	1	0	0	0	2	7	7	1	0
08/12	7	0	0	27	12	0	0	0	0	0	5	4	1	0
08/13	23	2	1	150	42	0	0	0	0	0	10	2	1	0
08/14	22	1	0	105	29	0	0	0	0	3	4	10	1	0
08/15	33	2	2	84	70	0	0	0	0	3	7	0	2	0
08/16	22	1	5	80	102	0	0	0	0	5	3	1	2	0
08/17	19	0	0	51	429	1	0	0	0	10	3	4	0	0
08/18	18	1	0	16	122	0	0	0	0	4	3	1	0	0
08/19	7	0	3	12	122	0	0	0	0	3	1	4	1	0
08/20	9	1	0	11	101	0	0	0	0	4	3	3	0	0
08/21	2	1	0	8	124	0	0	0	0	3	3	3	0	0
08/22	3	0	1	9	225	0	0	0	0	11	3	4	1	0
08/23	6	0	1	12	601	1	0	0	0	18	5	8	2	0
08/24	5	0	1	11	363	0	0	0	0	21	2	7	0	0
08/25	1	0	0	6	807	0	0	0	0	37	1	16	2	0
08/26	18	0	0	18	319	0	0	0	0	0	0	0	0	0
08/27	18	0	0	21	584	0	0	0	0	0	0	0	0	0
08/28	9	1	0	23	584	0	0	0	0	0	0	0	0	0
08/29	10	0	0	10	346	0	0	0	0	0	0	0	0	0
08/30	9	2	0	16	489	0	0	0	0	0	0	0	0	0
08/31	5	0	0	7	380	0	0	0	0	0	0	0	0	0
09/01	3	2	1	8	352	0	0	0	0	2	2	5	2	0
09/02	3	0	0	9	107	0	0	0	0	9	1	9	2	2
09/03	1	0	0	8	101	0	0	0	0	4	1	11	1	1
09/04	8	1	0	13	183	0	0	0	0	15	2	14	0	1
09/05	3	0	0	5	266	0	0	0	0	37	0	17	0	0
09/06	2	0	0	7	212	0	0	0	0	17	1	9	0	0
09/07	4	0	0	8	109	0	0	0	0	19	0	4	0	0
09/08	5	0	0	16	273	0	0	0	0	26	3	37	0	0
09/09	1	0	0	1	47	0	0	0	0	0	0	0	0	0
09/10	0	0	1	9	42	0	0	0	0	0	0	10	1	0
09/11	3	1	0	4	103	0	0	0	0	12	0	15	0	0
	15724	2917	82	3488	7953	84	173	2	1	274	478	272	110	9

[shaded box] =estimated counts during flood events when weir was submerged

Appendix 4.-Daily salmon counts at the Tuluksak River weir, 1991-1994.

DATE	Chum Salmon				(% passage) (91-93a)	Chinook Salmon				(%passage) (91-93a)	Sockeye Salmon				(%passage) (91-93a)	Pink Salmon				(%passage) (91-93a)	Coho Salmon				(%passage) (92-93a)
	1991	1992	1993	1994		1991	1992	1993	1994		1991	1992	1993	1994		1991	1992	1993	1994		1991	1992	1993	1994a	
06/12	0					0			0		0			0		0			0		0				
06/13	0					0			0		0			0		0			0		0				
06/14	0					0			0		0			0		0			0		0				
06/15	0					0			0		0			0		0			0		0				
06/16	0					0			0		0			0		0			0		0				
06/17	0					0		0	0		0			0		0			0		0				
06/18	0		1			0		0	0		0		0	0		0		0	0		0		0		
06/19	1		1			0		0	0		0		0	0		0		0	0		0		0		
06/20	0		0			0		0	0		0		0	0		0		0	0		0		0		
06/21	0		10			0		0	0		0		0	0		0		0	0		0		0		
06/22	0		2			0		1	0		0		0	0		0		0	0		0		0		
06/23	1		1			1		0	0		0		0	0		0		0	0		0		0		
06/24	0	1	7			3	0	0	0		0	0	0	0		0	0	0	0		0	0	0		
06/25	0	39	18			0	0	1	0		0	0	0	0		0	0	0	0		0	0	0		
06/26	3	80	17			3	1	0	0		0	0	0	0		0	0	0	0		0	0	0		
06/27	6	75	22			3	0	2	0		0	0	0	0		0	0	0	0		0	0	0		
06/28	2	71	42			4	2	1	0		0	0	0	0		0	0	0	0		0	0	0		
06/29	11	93	26	8		1	4	0	0		0	0	0	0		0	0	0	0		0	0	0	0	
06/30	20	170	37	4		6	10	14	5		0	0	0	0		0	0	0	1		0	0	0	0	
07/01	23	242	101	8		8	15	40	4		0	0	0	0		0	0	0	0		0	0	0	0	
07/02	50	96	146	34		6	12	35	5		0	0	0	0		0	0	0	0		0	0	0	0	
07/03	64	155	119	35		6	22	102	3		0	0	1	0		0	1	0	0		0	0	0	0	
07/04	113	140	154	96		28	85	84	26		0	0	0	0		0	0	0	0		0	0	0	0	
07/05	97	150	149	121		13	40	120	69		0	0	0	0		0	1	0	0		0	0	0	0	
07/06	59	107	205	70		24	13	187	29		0	0	0	0		1	1	0	0		0	0	0	0	
07/07	115	158	313	321		15	28	157	391		0	0	0	0		0	1	0	3		0	0	0	0	
07/08	279	229	312	294		23	55	37	109		0	0	0	0		0	2	0	9		0	0	0	0	
07/09	161	228	242	288		37	71	93	184		0	0	0	0		1	2	0	6		0	0	0	0	
07/10	326	280	255	211		254	117	171	70		0	2	4	2		3	3	0	4		0	0	0	0	
07/11	296	241	379	495		8	53	100	144		1	1	4	0		1	2	0	12		0	0	0	0	
07/12	276	202	215	401		38	25	215	254		2	0	2	0		5	3	0	18		0	0	0	0	
07/13	169	254	341	553		12	32	107	176		0	0	2	0		1	3	3	12		0	0	0	0	
07/14	120	307	467	476		4	47	80	160		0	2	4	0		2	4	1	48		0	0	0	0	
07/15	169	418	413	754		5	38	43	142		0	0	1	0		2	5	0	30		0	0	0	0	
07/16	210	387	402	615		11	32	58	83		0	4	1	0		2	9	1	19		0	0	0	0	
07/17	158	174	816	625		32	8	63	85		1	1	4	2		5	3	5	20		0	0	0	0	
07/18	390	510	1010	587		43	24	60	150		5	1	3	3		54	33	3	28		0	0	0	0	
07/19	298	318	745	942		27	27	64	191		1	2	5	0		65	21	2	50		0	0	0	0	
07/20	234	265	534	808		15	12	61	165		3	2	7	1		59	10	3	54		0	0	0	0	
07/21	219	260	563	690		14	16	47	96		2	2	8	1		28	19	4	80		0	0	0	0	
07/22	232	483	377	1006		10	40	54	77		1	5	0	1		39	17	3	68		0	0	0	0	
07/23	154	559	250	952		3	46	18	18		0	20	2	0		11	21	1	71		0	1	3	0	
07/24	124	664	243	589		12	67	23	32		0	22	7	6		7	67	3	24		0	1	1	0	
07/25	155	430	255	747		5	44	10	68		2	8	0	11		8	60	3	57		0	0	1	3	
07/26	107	230	324	525		1	12	15	23		0	3	3	2		9	46	9	35		0	1	0	7	
07/27	94	263	451	609		4	9	24	36		0	1	2	1		7	57	9	64		0	0	1	7	
07/28	142	330	387	487		2	8	24	36		0	6	1	3		1	43	4	52		0	1	1	7	
07/29	260	313	301	374		4	7	14	9		3	4	6	3		6	83	5	78		0	1	7	7	
07/30	250	200	322	194		1	9	21	12		1	4	2	2		12	101	8	94		0	4	3	14	
07/31	158	238	387	191		0	5	10	2		0	1	4	2		2	126	18	95		0	1	2	7	

-continued-

Appendix 4.-(continued)

DATE	Chum Salmon 1991	Chum Salmon 1992	Chum Salmon 1993	Chum Salmon 1994	(%passage) (91-93a)	Chinook Salmon 1991	Chinook Salmon 1992	Chinook Salmon 1993	Chinook Salmon 1994	(%passage) (91-93a)	Sockeye Salmon 1991	Sockeye Salmon 1992	Sockeye Salmon 1993	Sockeye Salmon 1994	(%passage) (91-93a)	Pink Salmon 1991	Pink Salmon 1992	Pink Salmon 1993	Pink Salmon 1994	(%passage) (91-93a)	Coho Salmon 1991	Coho Salmon 1992	Coho Salmon 1993	Coho Salmon 1994	(%passage) (92,93a)
08/01	131	196	334	173		0	6	10	8		0	4	5	1		3	50	6	114		0	3	4	8	
08/02	139	211	248	188		2	3	2	5		0	3	0	2		4	79	7	102		0	3	4	10	
08/03	190	143	184	170		1	4	1	5		0	1	0	2		3	43	4	192		0	2	7	20	
08/04	168	119	234	175		0	2	7	4		1	0	0	3		1	49	3	201		1	3	25	27	
08/05	159	137	213	202		0	7	4	6		3	1	2	3		5	94	1	186		2	20	22	33	
08/06	208	135	194	130		1	4	9	8		0	2	1	3		7	104	7	206		0	28	21	30	
08/07	153	70	193	89		0	3	13	2		0	2	1	1		1	82	10	193		4	21	66	14	
08/08	92	117	148	54		0	2	3	5		1	0	1	1		6	100	4	181		0	11	50	34	
08/09	107	103	83	53		0	1	5	2		0	0	0	2		5	145	4	92		3	16	111	2	
08/10	118	80	63	63		0	0	1	1		0	2	1	2		3	98	1	115		4	17	83	32	
08/11	99	97	54	37		0	2	5	2		0	1	1	6		3	92	3	108		4	42	129	44	
08/12	73	82	48	7		1	0	1	0		1	0	0	0		3	201	5	27		16	81	42	12	
08/13	78	32	53	23		3	0	0	2		1	0	0	1		0	65	6	150		19	44	42	42	
08/14	61	33	50	22		1	1	0	1		1	0	0	0		1	86	4	105		20	121	149	29	
08/15	38	28	31	33		1	1	0	2		0	0	0	2		0	46	4	84		2	186	117	70	
08/16	53	16	23	22		0	0	0	1		0	1	1	5		1	28	2	80		25	43	46	102	
08/17	55	30	15	19		0	0	0	0		0	2	0	0		2	39	4	51		26	80	67	429	
08/18	31	22	30	18		0	1	1	1		0	1	0	0		3	47	5	16		55	93	105	122	
08/19	29	20	27	7		0	0	0	0		0	1	0	3		0	64	5	12		66	154	137	122	
08/20	27	22	55	9		0	0	0	1		1	6	0	0		0	16	3	11		70	64	166	101	
08/21	16	25	26	2		1	2	0	1		0	1	0	0		1	36	8	8		89	367	358	124	
08/22	9	13	9	3		0	1	0	0		0	2	0	1		0	15	2	9		42	529	342	225	
08/23	17	18	16	6		0	0	0	0		0	0	0	1		0	7	8	12		59	318	199	601	
08/24	11	4	9	5		0	0	0	0		0	0	0	1		0	6	1	11		52	101	143	363	
08/25	13	9	22	1		0	1	0	0		1	1	0	0		1	8	4	6		380	420	211	807	
08/26	7	8	24	18	0.001	0	0	0	0	0.000	0	0	0	0	0.000	0	3	3	18	0.005	139	246	396	319	0.040
08/27	6	15	19	18	0.001	0	0	0	0	0.000	0	0	1	0	0.004	0	21	2	21	0.006	79	647	504	584	0.073
08/28	2	9	8	9	0.001	0	1	0	1	0.000	0	0	1	0	0.004	0	26	2	23	0.007	0	902	221	584	0.073
08/29	7	6	6	10	0.001	0	0	0	0	0.000	0	1	0	0	0.003	0	10	1	10	0.003	1	448	227	346	0.043
08/30	11	1	3	9	0.001	0	2	0	2	0.001	0	0	0	0	0.000	0	10	2	16	0.005	135	557	406	489	0.062
08/31	6	1	2	5	0.000	0	0	0	0	0.000	0	0	0	0	0.000	0	4	1	7	0.002	150	161	617	380	0.048
09/01	0	2	6	3	0.000	0	2	0	2	0.001	0	3	0	1	0.008	2	4	0	8	0.002	149	174	545	352	0.044
09/02	6	8	2	3		0	1	0	0		0	0	0	0		0	14	2	9		165	922	620	107	
09/03	1	2	2	1		0	0	0	0		0	1	0	0		0	8	1	8		193	199	1274	101	
09/04	4	0	1	8		0	0	0	1		0	1	0	0		0	5	0	13		356	105	247	183	
09/05	2	3	2	3		0	0	0	0		0	0	0	0		0	7	0	5		389	236	134	266	
09/06	1	2	0	2		0	0	0	0		0	1	0	0		0	7	0	7		898	84	70	212	
09/07	0	1	2	4		0	0	0	0		0	0	0	0		0	1	0	8		312	18	171	109	
09/08	0	1	1	5		0	0	0	0		0	0	0	0		0	3	0	16		180	1	70	273	
09/09	0	2	1	1	0.000	0	0	0	0	0.000	0	0	0	0	0.000	0	2	0	1	0.000	157	8	90	47	0.006
09/10	0	0	1	0	0.000	0	0	0	0	0.000	1	0	0	1	0.010	3	1	0	9	0.003	98	16	71	42	0.005
09/11	0			3		0			1		0			0		0			4		40			103	
09/12	0					0					0					1					59				
09/13	1					0					0					1					45				
09/14	0					0					0					0					35				
09/15	0					0					0					0					20				
09/16	0					0					1					0					29				
09/17	0					0					0					0					59				
09/18	0					0					0					1					24				
	7675	11183	13804	15724	% Missed 0.005	697	1083	2218	2917	% Missed 0.002	34	129	88	82	% Missed 0.028	392	2470	210	3488	% Missed 0.033	4651	7501	8328	7953	%Missed 0.40

= estimated escapement

a = Proportions for days missed = ((daily number for 1991 /yearly total for 1991)+(1992 daily total / 1992 total)+(1993 daily total / 1993 total))/3) for all species except coho which was calculated using 92-93 passage data.
The estimated 1994 total was the sum of the cells with daily counts ie 6/29-8/25 and 9/2-9/8 and 9/11 to 9/18 divided by 1 minus the quantity of the sum of the proportion of the daily runs missed in 1994 calculated by using the above formulas. Cross hatched numbers in 1994 are estimates.

Appendix 5.-Daily cumulative proportion of chum, chinook, sockeye, pink, and coho salmon counted through the Tuluksak River weir, 1991-1994.

	Chum Salmon				Chinook Salmon				Sockeye Salmon				Pink Salmon				Coho Salmon			
Date	1991	1992	1993	1994	1991	1992	1993	1994	1991	1992	1993	1994	1991	1992	1993	1994	1991	1992	1993	1994
06/12	0.000		0.000		0.000		0.000		0.000				0.000				0.000			
06/13	0.000		0.000		0.000		0.000		0.000				0.000				0.000			
06/14	0.000		0.000		0.000		0.000		0.000				0.000				0.000			
06/15	0.000		0.000		0.000		0.000		0.000				0.000				0.000			
06/16	0.000		0.000		0.000		0.000		0.000				0.000				0.000			
06/17	0.000		0.000		0.000		0.000		0.000				0.000				0.000			
06/18	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
06/19	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
06/20	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
06/21	0.000		0.001		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
06/22	0.000		0.001		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
06/23	0.000		0.001		0.001		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
06/24	0.000	0.000	0.002		0.006	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000	
06/25	0.000	0.004	0.003		0.006	0.000	0.001		0.000	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000	
06/26	0.001	0.011	0.004		0.010	0.001	0.001		0.000	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000	
06/27	0.001	0.017	0.006		0.014	0.001	0.002		0.000	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000	
06/28	0.002	0.024	0.009		0.020	0.003	0.002		0.000	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000	
06/29	0.003	0.032	0.011	0.001	0.022	0.006	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/30	0.006	0.047	0.013	0.001	0.030	0.016	0.009	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/01	0.009	0.069	0.021	0.001	0.042	0.030	0.027	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/02	0.015	0.078	0.031	0.003	0.050	0.041	0.042	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/03	0.024	0.091	0.040	0.006	0.059	0.061	0.088	0.006	0.000	0.000	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/04	0.038	0.104	0.051	0.012	0.099	0.139	0.126	0.015	0.000	0.000	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/05	0.051	0.117	0.062	0.019	0.118	0.176	0.180	0.038	0.000	0.000	0.011	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
07/06	0.059	0.127	0.077	0.024	0.152	0.188	0.265	0.048	0.000	0.000	0.011	0.000	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000
07/07	0.074	0.141	0.099	0.044	0.174	0.214	0.335	0.182	0.000	0.000	0.011	0.000	0.003	0.002	0.000	0.001	0.000	0.000	0.000	0.000
07/08	0.110	0.161	0.122	0.063	0.207	0.265	0.352	0.220	0.000	0.000	0.011	0.000	0.003	0.002	0.000	0.004	0.000	0.000	0.000	0.000
07/09	0.131	0.182	0.139	0.081	0.260	0.331	0.394	0.283	0.000	0.000	0.011	0.000	0.005	0.003	0.000	0.005	0.000	0.000	0.000	0.000
07/10	0.173	0.207	0.158	0.095	0.624	0.439	0.471	0.307	0.000	0.016	0.057	0.024	0.013	0.004	0.000	0.007	0.000	0.000	0.000	0.000
07/11	0.212	0.228	0.185	0.126	0.636	0.488	0.516	0.356	0.029	0.023	0.102	0.024	0.015	0.005	0.000	0.010	0.000	0.000	0.000	0.000
07/12	0.248	0.247	0.201	0.152	0.690	0.511	0.613	0.443	0.088	0.023	0.125	0.024	0.028	0.006	0.000	0.015	0.000	0.000	0.000	0.000
07/13	0.270	0.269	0.226	0.187	0.707	0.540	0.661	0.504	0.088	0.023	0.148	0.024	0.031	0.008	0.014	0.019	0.000	0.000	0.000	0.000
07/14	0.286	0.297	0.259	0.217	0.713	0.584	0.697	0.558	0.088	0.039	0.193	0.024	0.036	0.009	0.019	0.032	0.000	0.000	0.000	0.000
07/15	0.308	0.334	0.289	0.265	0.720	0.619	0.717	0.607	0.088	0.039	0.205	0.024	0.041	0.011	0.019	0.041	0.000	0.000	0.000	0.000
07/16	0.335	0.369	0.319	0.304	0.736	0.648	0.743	0.635	0.088	0.070	0.216	0.024	0.046	0.015	0.024	0.046	0.000	0.000	0.000	0.000
07/17	0.356	0.384	0.378	0.344	0.782	0.656	0.771	0.665	0.118	0.078	0.261	0.049	0.059	0.016	0.048	0.052	0.000	0.000	0.000	0.000
07/18	0.406	0.430	0.451	0.381	0.844	0.678	0.798	0.716	0.265	0.085	0.295	0.085	0.196	0.030	0.062	0.060	0.000	0.000	0.000	0.000
07/19	0.445	0.458	0.505	0.441	0.882	0.703	0.827	0.781	0.294	0.101	0.352	0.085	0.362	0.038	0.071	0.075	0.000	0.000	0.000	0.000
07/20	0.476	0.482	0.543	0.493	0.904	0.714	0.855	0.838	0.382	0.116	0.432	0.097	0.513	0.042	0.086	0.090	0.000	0.000	0.000	0.000
07/21	0.504	0.505	0.584	0.537	0.924	0.729	0.876	0.871	0.441	0.132	0.523	0.109	0.584	0.050	0.105	0.113	0.000	0.000	0.000	0.000
07/22	0.534	0.548	0.612	0.600	0.938	0.765	0.900	0.897	0.471	0.171	0.523	0.122	0.684	0.057	0.119	0.132	0.000	0.000	0.000	0.000
07/23	0.555	0.598	0.630	0.661	0.943	0.808	0.908	0.904	0.471	0.326	0.545	0.122	0.712	0.065	0.124	0.153	0.000	0.000	0.000	0.000
07/24	0.571	0.658	0.647	0.698	0.960	0.870	0.919	0.914	0.471	0.496	0.625	0.194	0.730	0.092	0.138	0.160	0.000	0.000	0.000	0.000
07/25	0.591	0.696	0.666	0.746	0.967	0.910	0.923	0.938	0.529	0.558	0.625	0.328	0.750	0.117	0.152	0.176	0.000	0.000	0.001	0.000
07/26	0.605	0.717	0.689	0.779	0.968	0.922	0.930	0.946	0.529	0.581	0.659	0.352	0.773	0.135	0.195	0.186	0.000	0.000	0.001	0.001
07/27	0.617	0.740	0.722	0.818	0.974	0.930	0.941	0.958	0.529	0.589	0.682	0.365	0.791	0.158	0.238	0.204	0.000	0.000	0.001	0.002
07/28	0.636	0.770	0.750	0.849	0.977	0.937	0.952	0.970	0.529	0.636	0.693	0.401	0.793	0.176	0.257	0.219	0.000	0.001	0.001	0.003
07/29	0.669	0.798	0.772	0.873	0.983	0.944	0.958	0.973	0.618	0.667	0.761	0.438	0.809	0.209	0.281	0.242	0.000	0.001	0.002	0.004
07/30	0.702	0.816	0.795	0.885	0.984	0.952	0.968	0.978	0.647	0.698	0.784	0.462	0.839	0.250	0.319	0.269	0.000	0.001	0.002	0.006
07/31	0.723	0.837	0.823	0.897	0.984	0.957	0.972	0.978	0.647	0.705	0.830	0.486	0.844	0.301	0.405	0.296	0.000	0.001	0.002	0.007

- continued -

Appendix 5.- (continued)

Date	Chum				Chinook Salmon				Sockeye Salmon				Pink Salmon				Coho Salmon			
	1991	1992	1993	1994	1991	1992	1993	1994	1991	1992	1993	1994	1991	1992	1993	1994	1991	1992	1993	1994
08/01	0.740	0.855	0.847	0.908	0.984	0.962	0.977	0.981	0.647	0.736	0.886	0.498	0.852	0.321	0.433	0.329	0.000	0.002	0.003	0.008
08/02	0.758	0.873	0.865	0.920	0.987	0.965	0.977	0.983	0.647	0.760	0.886	0.523	0.862	0.353	0.467	0.358	0.000	0.002	0.003	0.009
08/03	0.783	0.886	0.879	0.931	0.989	0.969	0.978	0.984	0.647	0.767	0.886	0.547	0.870	0.371	0.486	0.413	0.000	0.002	0.004	0.011
08/04	0.804	0.897	0.896	0.942	0.989	0.970	0.981	0.986	0.676	0.767	0.886	0.583	0.872	0.391	0.500	0.470	0.000	0.003	0.007	0.015
08/05	0.825	0.909	0.911	0.955	0.989	0.977	0.983	0.988	0.765	0.775	0.909	0.620	0.885	0.429	0.505	0.524	0.001	0.005	0.010	0.019
08/06	0.852	0.921	0.925	0.963	0.990	0.981	0.987	0.991	0.765	0.791	0.920	0.656	0.903	0.471	0.538	0.583	0.001	0.009	0.012	0.023
08/07	0.872	0.927	0.939	0.969	0.990	0.983	0.993	0.991	0.765	0.806	0.932	0.668	0.906	0.504	0.586	0.638	0.002	0.012	0.020	0.024
08/08	0.884	0.938	0.950	0.972	0.990	0.985	0.994	0.993	0.794	0.806	0.943	0.681	0.921	0.545	0.605	0.690	0.002	0.013	0.026	0.029
08/09	0.898	0.947	0.956	0.976	0.990	0.986	0.996	0.994	0.794	0.806	0.943	0.705	0.934	0.603	0.624	0.716	0.002	0.016	0.040	0.029
08/10	0.913	0.954	0.960	0.980	0.990	0.986	0.997	0.994	0.794	0.822	0.955	0.729	0.941	0.643	0.629	0.749	0.003	0.018	0.049	0.033
08/11	0.926	0.963	0.964	0.982	0.990	0.988	0.999	0.995	0.794	0.829	0.966	0.802	0.949	0.680	0.643	0.780	0.004	0.023	0.065	0.038
08/12	0.936	0.970	0.968	0.983	0.991	0.988	1.000	0.995	0.824	0.829	0.966	0.802	0.957	0.762	0.667	0.788	0.007	0.034	0.070	0.040
08/13	0.946	0.973	0.972	0.984	0.996	0.988	1.000	0.995	0.853	0.829	0.966	0.814	0.957	0.788	0.695	0.831	0.011	0.040	0.075	0.045
08/14	0.954	0.976	0.975	0.986	0.997	0.989	1.000	0.996	0.882	0.829	0.966	0.814	0.959	0.823	0.714	0.861	0.016	0.056	0.093	0.049
08/15	0.959	0.979	0.977	0.988	0.999	0.990	1.000	0.996	0.882	0.829	0.966	0.839	0.959	0.841	0.733	0.885	0.016	0.081	0.107	0.058
08/16	0.966	0.980	0.979	0.989	0.999	0.990	1.000	0.997	0.882	0.837	0.977	0.899	0.962	0.853	0.743	0.908	0.022	0.087	0.113	0.071
08/17	0.973	0.983	0.980	0.990	0.999	0.990	1.000	0.997	0.882	0.853	0.977	0.899	0.967	0.868	0.762	0.923	0.027	0.097	0.121	0.124
08/18	0.977	0.985	0.982	0.991	0.999	0.991	1.000	0.997	0.882	0.860	0.977	0.899	0.974	0.887	0.786	0.928	0.039	0.110	0.133	0.140
08/19	0.981	0.986	0.984	0.992	0.999	0.991	1.000	0.997	0.882	0.868	0.977	0.936	0.974	0.913	0.810	0.931	0.053	0.130	0.150	0.155
08/20	0.984	0.988	0.988	0.992	0.999	0.991	1.000	0.997	0.912	0.915	0.977	0.936	0.974	0.920	0.824	0.934	0.068	0.139	0.170	0.168
08/21	0.986	0.991	0.990	0.993	1.000	0.993	1.000	0.998	0.912	0.922	0.977	0.936	0.977	0.934	0.862	0.936	0.087	0.188	0.213	0.183
08/22	0.988	0.992	0.991	0.993	1.000	0.994	1.000	0.998	0.912	0.938	0.977	0.948	0.977	0.940	0.871	0.939	0.096	0.258	0.254	0.212
08/23	0.990	0.993	0.992	0.993	1.000	0.994	1.000	0.998	0.912	0.938	0.977	0.960	0.977	0.943	0.910	0.942	0.109	0.301	0.277	0.287
08/24	0.991	0.994	0.993	0.993	1.000	0.994	1.000	0.998	0.912	0.938	0.977	0.972	0.977	0.946	0.914	0.946	0.120	0.314	0.295	0.333
08/25	0.993	0.995	0.994	0.993	1.000	0.994	1.000	0.998	0.941	0.946	0.977	0.972	0.980	0.949	0.933	0.947	0.202	0.370	0.320	0.434
08/26	0.994	0.995	0.996	0.995	1.000	0.994	1.000	0.998	0.941	0.946	0.977	0.972	0.980	0.950	0.948	0.952	0.232	0.403	0.368	0.475
08/27	0.995	0.997	0.997	0.996	1.000	0.994	1.000	0.998	0.941	0.946	0.989	0.976	0.980	0.959	0.957	0.958	0.249	0.489	0.428	0.548
08/28	0.995	0.997	0.998	0.996	1.000	0.995	1.000	0.998	0.941	0.946	1.000	0.980	0.980	0.969	0.967	0.965	0.249	0.610	0.455	0.621
08/29	0.996	0.998	0.998	0.997	1.000	0.995	1.000	0.998	0.941	0.953	1.000	0.982	0.980	0.973	0.971	0.968	0.249	0.669	0.482	0.665
08/30	0.997	0.998	0.999	0.998	1.000	0.997	1.000	0.999	0.941	0.953	1.000	0.982	0.980	0.977	0.981	0.973	0.278	0.744	0.531	0.726
08/31	0.998	0.998	0.999	0.998	1.000	0.997	1.000	0.999	0.941	0.953	1.000	0.982	0.980	0.979	0.986	0.975	0.310	0.765	0.605	0.774
09/01	0.998	0.998	0.999	0.998	1.000	0.999	1.000	0.999	0.941	0.977	1.000	0.990	0.985	0.981	0.986	0.977	0.342	0.788	0.670	0.818
09/02	0.999	0.999	0.999	0.998	1.000	1.000	1.000	0.999	0.941	0.977	1.000	0.990	0.985	0.986	0.995	0.980	0.378	0.911	0.745	0.832
09/03	0.999	0.999	0.999	0.998	1.000	1.000	1.000	0.999	0.941	0.984	1.000	0.990	0.985	0.989	1.000	0.982	0.419	0.938	0.898	0.845
09/04	0.999	0.999	0.999	0.999	1.000	1.000	1.000	1.000	0.941	0.992	1.000	0.990	0.985	0.991	1.000	0.986	0.496	0.952	0.927	0.868
09/05	1.000	0.999	1.000	0.999	1.000	1.000	1.000	1.000	0.941	0.992	1.000	0.990	0.985	0.994	1.000	0.987	0.579	0.983	0.943	0.901
09/06	1.000	1.000	1.000	0.999	1.000	1.000	1.000	1.000	0.941	1.000	1.000	0.990	0.985	0.997	1.000	0.989	0.773	0.994	0.952	0.928
09/07	1.000	1.000	1.000	0.999	1.000	1.000	1.000	1.000	0.941	1.000	1.000	0.990	0.985	0.998	1.000	0.991	0.840	0.997	0.972	0.941
09/08	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.941	1.000	1.000	0.990	0.985	0.999	1.000	0.996	0.878	0.997	0.981	0.976
09/09	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.941	1.000	1.000	0.990	0.985	1.000	1.000	0.996	0.912	0.998	0.991	0.982
09/10	1.000		1.000	1.000	1.000		1.000	1.000	0.971		1.000	1.000	0.992		1.000	0.999	0.933		1.000	0.987
09/11	1.000			1.000	1.000			1.000	0.971			1.000	0.992			1.000	0.942			1.000
09/12	1.000				1.000				0.971				0.995				0.954			
09/13	1.000				1.000				0.971				0.997				0.964			
09/14	1.000				1.000				0.971				0.997				0.972			
09/15	1.000				1.000				0.971				0.997				0.976			
09/16	1.000				1.000				1.000				0.997				0.982			
09/17	1.000				1.000				1.000				0.997				0.995			
09/18	1.000				1.000				1.000				1.000				1.000			

Appendix 6.-Daily cumulative proportion of salmon spawnouts and carcasses counted on the upstream side of the Tuluksak River weir, 1991-1994.

Date	Chum Salmon				Chinook Salmon				Sockeye Salmon				Pink Salmon				Coho Salmon			
	1991	1992	1993	1994	1991	1992	1993	1994	1991	1992	1993	1994	1991	1992	1993	1994	1991	1992	1993	1994
06/12	0.000				0.000				0.000				0.000				0.000			
06/13	0.000				0.000				0.000				0.000				0.000			
06/14	0.000				0.000				0.000				0.000				0.000			
06/15	0.000				0.000				0.000				0.000				0.000			
06/16	0.000				0.000				0.000				0.000				0.000			
06/17	0.000				0.000				0.000				0.000				0.000			
06/18	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
06/19	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
06/20	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
06/21	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
06/22	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
06/23	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
06/24	0.000	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000	
06/25	0.000	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000	
06/26	0.000	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000	
06/27	0.000	0.001	0.000		0.000	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000	
06/28	0.000	0.001	0.001		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/29	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/30	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/01	0.000	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/02	0.000	0.001	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/03	0.000	0.002	0.003	0.001	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/04	0.000	0.003	0.003	0.001	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/05	0.000	0.004	0.004	0.002	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/06	0.000	0.005	0.005	0.002	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/07	0.000	0.008	0.006	0.002	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/08	0.000	0.009	0.007	0.003	0.006	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/09	0.000	0.019	0.009	0.003	0.006	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/10	0.000	0.026	0.010	0.004	0.006	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/11	0.000	0.035	0.015	0.006	0.006	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/12	0.002	0.043	0.019	0.007	0.006	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/13	0.003	0.058	0.027	0.009	0.006	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/14	0.006	0.072	0.033	0.011	0.006	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/15	0.008	0.083	0.043	0.014	0.006	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/16	0.011	0.095	0.053	0.019	0.012	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/17	0.018	0.102	0.065	0.025	0.018	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/18	0.029	0.120	0.086	0.039	0.018	0.003	0.007	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/19	0.040	0.129	0.105	0.055	0.018	0.003	0.009	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
07/20	0.051	0.139	0.130	0.073	0.018	0.012	0.009	0.007	0.000	0.000	0.037	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
07/21	0.062	0.147	0.157	0.093	0.018	0.012	0.009	0.012	0.000	0.000	0.037	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
07/22	0.075	0.177	0.196	0.116	0.024	0.028	0.011	0.012	0.000	0.000	0.037	0.000	0.000	0.001	0.000	0.003	0.000	0.000	0.000	0.000
07/23	0.087	0.199	0.232	0.163	0.024	0.037	0.027	0.012	0.000	0.000	0.037	0.000	0.000	0.001	0.000	0.004	0.000	0.000	0.000	0.000
07/24	0.104	0.232	0.275	0.214	0.024	0.067	0.038	0.014	0.000	0.000	0.037	0.000	0.000	0.001	0.000	0.005	0.000	0.000	0.000	0.000
07/25	0.122	0.283	0.316	0.272	0.024	0.095	0.049	0.014	0.000	0.000	0.037	0.000	0.003	0.006	0.000	0.009	0.000	0.000	0.000	0.000
07/26	0.144	0.336	0.354	0.364	0.030	0.147	0.073	0.023	0.000	0.000	0.037	0.000	0.008	0.012	0.007	0.015	0.000	0.000	0.000	0.000
07/27	0.167	0.372	0.393	0.454	0.042	0.177	0.093	0.032	0.000	0.000	0.037	0.000	0.016	0.017	0.007	0.022	0.000	0.000	0.000	0.000
07/28	0.203	0.419	0.431	0.552	0.066	0.217	0.128	0.035	0.000	0.000	0.037	0.200	0.030	0.028	0.021	0.033	0.000	0.000	0.000	0.000
07/29	0.249	0.449	0.459	0.640	0.108	0.251	0.166	0.042	0.000	0.000	0.037	0.200	0.077	0.042	0.036	0.043	0.000	0.000	0.000	0.000
07/30	0.298	0.486	0.488	0.714	0.198	0.312	0.203	0.056	0.000	0.000	0.037	0.200	0.134	0.060	0.050	0.064	0.000	0.000	0.000	0.000
07/31	0.333	0.519	0.517	0.762	0.240	0.385	0.243	0.067	0.000	0.053	0.037	0.200	0.235	0.077	0.079	0.105	0.000	0.000	0.000	0.000

-continued-

Appendix 6.- (continued)

Date	Chum Salmon				Chinook Salmon				Sockeye Salmon				Pink Salmon				Coho Salmon			
	1991	1992	1993	1994	1991	1992	1993	1994	1991	1992	1993	1994	1991	1992	1993	1994	1991	1992	1993	1994
08/01	0.375	0.548	0.549	0.807	0.389	0.459	0.296	0.102	0.000	0.053	0.037	0.200	0.318	0.092	0.086	0.139	0.000	0.000	0.000	0.000
08/02	0.409	0.575	0.578	0.839	0.467	0.535	0.350	0.146	0.000	0.053	0.037	0.200	0.401	0.106	0.121	0.173	0.000	0.000	0.000	0.000
08/03	0.445	0.608	0.604	0.862	0.533	0.593	0.381	0.220	0.000	0.053	0.074	0.200	0.477	0.130	0.157	0.209	0.000	0.000	0.000	0.000
08/04	0.474	0.637	0.640	0.882	0.611	0.657	0.429	0.294	0.000	0.053	0.074	0.200	0.520	0.147	0.186	0.247	0.000	0.000	0.000	0.000
08/05	0.529	0.666	0.664	0.902	0.737	0.716	0.500	0.356	0.000	0.053	0.074	0.200	0.616	0.170	0.207	0.269	0.000	0.000	0.000	0.000
08/06	0.569	0.694	0.702	0.915	0.790	0.768	0.578	0.451	0.000	0.053	0.148	0.200	0.687	0.195	0.250	0.307	0.000	0.000	0.000	0.000
08/07	0.608	0.722	0.749	0.925	0.844	0.807	0.631	0.553	0.000	0.105	0.185	0.200	0.735	0.223	0.314	0.345	0.000	0.000	0.000	0.000
08/08	0.645	0.748	0.778	0.936	0.904	0.875	0.695	0.660	0.000	0.105	0.259	0.200	0.757	0.259	0.364	0.381	0.000	0.000	0.000	0.000
08/09	0.696	0.770	0.812	0.952	0.940	0.908	0.745	0.734	0.059	0.105	0.259	0.400	0.796	0.288	0.450	0.407	0.000	0.000	0.000	0.000
08/10	0.749	0.792	0.841	0.962	0.958	0.924	0.792	0.785	0.059	0.132	0.259	0.600	0.833	0.323	0.529	0.436	0.000	0.000	0.000	0.000
08/11	0.787	0.818	0.864	0.971	0.964	0.939	0.836	0.845	0.059	0.132	0.333	0.600	0.852	0.362	0.550	0.466	0.000	0.000	0.000	0.000
08/12	0.811	0.843	0.882	0.977	0.976	0.960	0.869	0.870	0.059	0.211	0.333	0.600	0.875	0.402	0.571	0.505	0.000	0.000	0.000	0.000
08/13	0.836	0.866	0.897	0.981	0.982	0.976	0.894	0.907	0.059	0.211	0.370	0.600	0.897	0.422	0.586	0.562	0.000	0.000	0.000	0.000
08/14	0.856	0.883	0.912	0.984	0.982	0.985	0.927	0.942	0.176	0.263	0.370	0.600	0.908	0.452	0.621	0.617	0.000	0.000	0.000	0.000
08/15	0.867	0.901	0.927	0.987	0.988	0.988	0.949	0.954	0.176	0.289	0.370	0.600	0.915	0.489	0.629	0.661	0.000	0.000	0.000	0.000
08/16	0.883	0.918	0.940	0.991	0.994	0.991	0.954	0.968	0.294	0.316	0.407	0.600	0.926	0.533	0.664	0.714	0.000	0.000	0.000	0.000
08/17	0.897	0.931	0.950	0.993	0.994	0.997	0.962	0.975	0.353	0.316	0.444	0.600	0.938	0.586	0.679	0.762	0.000	0.000	0.000	0.143
08/18	0.909	0.946	0.957	0.996	0.994	0.997	0.973	0.977	0.412	0.368	0.481	0.600	0.944	0.643	0.714	0.813	0.000	0.000	0.000	0.143
08/19	0.920	0.956	0.962	0.998	0.994	0.997	0.974	0.986	0.529	0.526	0.556	0.600	0.951	0.701	0.729	0.859	0.000	0.000	0.000	0.286
08/20	0.929	0.964	0.966	1.000	0.994	0.997	0.982	0.986	0.588	0.605	0.630	0.600	0.953	0.748	0.757	0.903	0.000	0.000	0.000	0.429
08/21	0.938	0.969	0.970	1.000	0.994	0.997	0.984	0.988	0.588	0.605	0.630	0.600	0.959	0.795	0.779	0.935	0.000	0.000	0.500	0.429
08/22	0.942	0.976	0.972	1.000	0.994	0.997	0.984	0.988	0.588	0.711	0.667	0.600	0.960	0.843	0.793	0.963	0.000	0.000	0.500	0.571
08/23	0.951	0.980	0.976	1.000	0.994	0.997	0.984	0.991	0.588	0.789	0.667	0.600	0.966	0.883	0.793	0.984	0.000	0.000	0.500	0.571
08/24	0.959	0.985	0.978	1.000	0.994	0.997	0.987	0.995	0.647	0.816	0.704	0.600	0.975	0.922	0.800	0.996	0.000	0.000	0.500	0.714
08/25	0.967	0.990	0.981	1.000	0.994	0.997	0.989	0.995	0.765	0.842	0.741	0.600	0.985	0.950	0.829	0.996	0.000	0.000	0.500	0.857
08/26	0.973	0.991	0.983	1.000	0.994	0.997	0.989	0.995	0.765	0.868	0.778	0.600	0.986	0.966	0.857	0.996	0.000	0.000	0.500	0.857
08/27	0.977	0.992	0.984	1.000	1.000	0.997	0.989	0.995	0.765	0.868	0.852	0.600	0.989	0.968	0.879	0.996	0.000	0.000	0.500	0.857
08/28	0.981	0.993	0.986	1.000	1.000	0.997	0.993	0.995	0.765	0.868	0.889	0.600	0.992	0.972	0.893	0.996	0.000	0.000	0.500	0.857
08/29	0.982	0.994	0.989	1.000	1.000	0.997	0.995	0.995	0.765	0.895	0.889	0.600	0.992	0.975	0.900	0.996	0.000	0.250	0.500	0.857
08/30	0.984	0.994	0.991	1.000	1.000	0.997	0.996	0.995	0.882	0.895	0.889	0.600	0.992	0.980	0.929	0.996	0.000	0.250	0.500	0.857
08/31	0.987	0.996	0.993	1.000	1.000	0.997	0.996	0.995	0.882	0.921	0.889	0.600	0.992	0.988	0.943	0.996	0.000	0.250	0.500	0.857
09/01	0.990	0.997	0.995	1.000	1.000	0.997	0.996	0.995	0.882	0.947	0.889	0.600	0.997	0.991	0.957	0.996	0.000	0.500	0.500	0.857
09/02	0.992	0.998	0.996	1.000	1.000	0.997	0.996	0.995	0.882	0.947	0.889	0.600	0.997	0.995	0.971	0.996	0.000	0.750	0.500	0.857
09/03	0.994	0.999	0.997	1.000	1.000	0.997	0.996	0.995	0.882	0.947	0.926	0.600	0.997	0.998	0.979	0.996	0.154	1.000	0.500	0.857
09/04	0.995	1.000	0.998	1.000	1.000	1.000	0.998	0.998	0.882	0.974	1.000	0.600	0.997	1.000	0.993	0.997	0.154	1.000	1.000	0.857
09/05	0.995	1.000	0.998	1.000	1.000	1.000	0.998	0.998	0.941	1.000	1.000	0.600	0.997	1.000	0.993	0.998	0.154	1.000	1.000	1.000
09/06	0.996	1.000	0.999	1.000	1.000	1.000	0.998	1.000	0.941	1.000	1.000	0.800	0.997	1.000	0.993	0.999	0.154	1.000	1.000	1.000
09/07	0.997	1.000	0.999	1.000	1.000	1.000	1.000	1.000	0.941	1.000	1.000	1.000	0.997	1.000	0.993	1.000	0.154	1.000	1.000	1.000
09/08	0.997	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.941	1.000	1.000	1.000	0.997	1.000	0.993	1.000	0.154	1.000	1.000	1.000
09/09	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.941	1.000	1.000	1.000	0.997	1.000	0.993	1.000	0.154	1.000	1.000	1.000
09/10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.941	1.000	1.000	1.000	0.999	1.000	1.000	1.000	0.154	1.000	1.000	1.000
09/11	1.000			1.000	1.000			1.000	0.941			1.000	0.999			1.000	0.231			1.000
09/12	1.000				1.000				0.941				0.999				0.308			
09/13	1.000				1.000				0.941				1.000				0.385			
09/14	1.000				1.000				0.941				1.000				0.385			
09/15	1.000				1.000				1.000				1.000				0.538			
09/16	1.000				1.000				1.000				1.000				0.692			
09/17	1.000				1.000				1.000				1.000				0.846			
09/18	1.000				1.000				1.000				1.000				1.000			

Appendix 7.-Daily cumulative proportion of salmon captured in the Bethel test fishery, 1991-1994 (Francisco et al. 1995).

	Chum Salmon				Chinook Salmon				Sockeye Salmon				Coho Salmon			
Date	1991	1992	1993	1994	1991	1992	1993	1994	1991	1992	1993	1994	1991	1992	1993	1994
06/01	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/02	0.000	0.000	0.000	0.002	0.000	0.000	0.015	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/03	0.000	0.000	0.000	0.004	0.000	0.000	0.036	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/04	0.000	0.000	0.000	0.004	0.000	0.000	0.042	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/05	0.000	0.000	0.000	0.004	0.006	0.000	0.059	0.060	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/06	0.000	0.002	0.001	0.006	0.023	0.006	0.083	0.102	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/07	0.000	0.003	0.001	0.007	0.057	0.006	0.093	0.108	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/08	0.000	0.004	0.001	0.007	0.068	0.014	0.110	0.122	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000
06/09	0.000	0.005	0.001	0.009	0.074	0.032	0.172	0.136	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000
06/10	0.000	0.007	0.004	0.009	0.074	0.052	0.206	0.142	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000
06/11	0.000	0.011	0.007	0.009	0.091	0.112	0.212	0.142	0.000	0.000	0.008	0.002	0.000	0.000	0.000	0.000
06/12	0.002	0.014	0.007	0.012	0.091	0.176	0.255	0.162	0.000	0.000	0.011	0.004	0.000	0.000	0.000	0.000
06/13	0.002	0.028	0.011	0.018	0.102	0.236	0.285	0.207	0.005	0.008	0.029	0.004	0.000	0.000	0.000	0.000
06/14	0.007	0.035	0.014	0.030	0.114	0.288	0.306	0.355	0.010	0.020	0.033	0.012	0.000	0.000	0.000	0.000
06/15	0.007	0.070	0.020	0.060	0.119	0.320	0.352	0.398	0.015	0.032	0.035	0.012	0.000	0.000	0.000	0.000
06/16	0.007	0.107	0.021	0.073	0.136	0.380	0.389	0.435	0.015	0.044	0.049	0.051	0.000	0.000	0.000	0.000
06/17	0.007	0.125	0.025	0.084	0.153	0.450	0.467	0.474	0.036	0.087	0.087	0.058	0.000	0.000	0.000	0.000
06/18	0.007	0.139	0.040	0.088	0.222	0.476	0.531	0.480	0.123	0.128	0.111	0.113	0.000	0.000	0.000	0.000
06/19	0.007	0.139	0.040	0.143	0.256	0.490	0.592	0.543	0.142	0.136	0.121	0.134	0.000	0.000	0.000	0.000
06/20	0.027	0.150	0.045	0.149	0.341	0.516	0.656	0.580	0.209	0.150	0.158	0.186	0.000	0.000	0.000	0.000
06/21	0.029	0.169	0.063	0.207	0.375	0.542	0.713	0.636	0.224	0.175	0.238	0.265	0.000	0.000	0.000	0.000
06/22	0.036	0.185	0.104	0.234	0.398	0.542	0.779	0.719	0.298	0.207	0.265	0.291	0.000	0.000	0.000	0.000
06/23	0.047	0.202	0.131	0.273	0.432	0.559	0.807	0.753	0.327	0.242	0.296	0.320	0.000	0.000	0.000	0.000
06/24	0.052	0.212	0.185	0.297	0.466	0.599	0.851	0.761	0.337	0.303	0.349	0.338	0.000	0.000	0.000	0.000
06/25	0.059	0.225	0.231	0.299	0.506	0.634	0.868	0.790	0.353	0.389	0.413	0.355	0.000	0.000	0.000	0.000
06/26	0.084	0.239	0.231	0.303	0.528	0.666	0.873	0.795	0.363	0.406	0.427	0.428	0.000	0.000	0.000	0.000
06/27	0.130	0.308	0.234	0.306	0.540	0.692	0.883	0.827	0.399	0.450	0.439	0.442	0.000	0.000	0.000	0.000
06/28	0.169	0.343	0.239	0.308	0.580	0.729	0.894	0.835	0.466	0.577	0.454	0.451	0.000	0.000	0.000	0.000
06/29	0.220	0.385	0.252	0.320	0.670	0.761	0.909	0.855	0.509	0.675	0.490	0.472	0.000	0.000	0.000	0.000
06/30	0.226	0.430	0.317	0.321	0.722	0.778	0.934	0.875	0.543	0.739	0.741	0.609	0.000	0.000	0.000	0.000
07/01	0.250	0.470	0.368	0.323	0.773	0.810	0.941	0.889	0.591	0.770	0.810	0.676	0.000	0.000	0.000	0.000
07/02	0.322	0.484	0.376	0.327	0.818	0.827	0.949	0.898	0.651	0.803	0.842	0.729	0.000	0.000	0.000	0.000
07/03	0.339	0.571	0.429	0.367	0.852	0.847	0.955	0.912	0.757	0.873	0.850	0.844	0.000	0.000	0.000	0.000
07/04	0.365	0.676	0.464	0.397	0.886	0.876	0.962	0.920	0.818	0.893	0.884	0.869	0.000	0.000	0.000	0.000
07/05	0.370	0.738	0.497	0.416	0.892	0.885	0.962	0.935	0.884	0.898	0.890	0.901	0.000	0.000	0.000	0.000
07/06	0.379	0.772	0.514	0.496	0.903	0.885	0.962	0.949	0.896	0.909	0.909	0.963	0.000	0.000	0.000	0.000
07/07	0.388	0.776	0.524	0.548	0.920	0.885	0.966	0.980	0.908	0.909	0.920	0.983	0.000	0.000	0.000	0.000
07/08	0.396	0.822	0.554	0.701	0.932	0.893	0.970	0.986	0.908	0.921	0.954	0.988	0.000	0.000	0.000	0.000
07/09	0.443	0.837	0.567	0.784	0.932	0.893	0.979	0.994	0.954	0.923	0.958	0.991	0.000	0.000	0.000	0.001
07/10	0.479	0.852	0.579	0.838	0.943	0.902	0.983	0.994	0.964	0.927	0.960	0.991	0.000	0.000	0.000	0.001
07/11	0.500	0.868	0.595	0.852	0.943	0.914	0.987	0.994	0.969	0.933	0.962	0.992	0.000	0.000	0.000	0.001
07/12	0.533	0.887	0.621	0.859	0.943	0.925	0.992	0.994	0.974	0.939	0.962	0.992	0.000	0.000	0.000	0.001
07/13	0.550	0.904	0.736	0.882	0.955	0.937	0.992	0.994	0.979	0.956	0.975	0.992	0.000	0.002	0.003	0.001
07/14	0.572	0.920	0.765	0.894	0.960	0.937	0.992	0.994	0.985	0.977	0.992	0.994	0.000	0.003	0.003	0.001
07/15	0.588	0.929	0.824	0.902	0.966	0.937	0.992	0.994	0.990	0.980	0.998	0.995	0.000	0.003	0.003	0.002
07/16	0.597	0.936	0.862	0.908	0.977	0.948	0.992	0.994	0.990	0.989	0.999	0.995	0.000	0.004	0.003	0.002
07/17	0.610	0.943	0.894	0.911	0.977	0.963	0.996	0.994	0.993	0.993	0.999	0.995	0.000	0.004	0.003	0.002
07/18	0.650	0.951	0.916	0.922	0.989	0.980	0.996	1.000	0.993	0.998	0.999	0.996	0.000	0.007	0.003	0.003
07/19	0.663	0.961	0.956	0.927	1.000	0.988	1.000	1.000	0.993	0.998	0.999	0.997	0.001	0.010	0.006	0.006

-continued-

Appendix 7.-(continued)

Date	Chum Salmon 1991	Chum Salmon 1992	Chum Salmon 1993	Chum Salmon 1994	Chinook 1991	Chinook 1992	Chinook 1993	Chinook 1994	Sockeye Salmon 1991	Sockeye Salmon 1992	Sockeye Salmon 1993	Sockeye Salmon 1994	Coho Salmon 1991	Coho Salmon 1992	Coho Salmon 1993	Coho Salmon 1994
07/20	0.675	0.962	0.978	0.929	1.000	0.988	1.000	1.000	0.993	0.998	0.999	0.997	0.005	0.012	0.007	0.006
07/21	0.707	0.962	1.000	0.929	1.000	0.988	1.000	1.000	0.993	0.998	1.000	0.999	0.009	0.013	0.008	0.006
07/22	0.752	0.970	1.000	0.946	1.000	0.988	1.000	1.000	0.997	0.998	1.000	0.999	0.012	0.015	0.017	0.013
07/23	0.778	0.975	1.000	0.955	1.000	0.988	1.000	1.000	1.000	0.998	1.000	0.999	0.015	0.016	0.027	0.017
07/24	0.787	0.978	1.000	0.967	1.000	0.988	1.000	1.000	1.000	0.998	1.000	0.999	0.018	0.017	0.030	0.032
07/25	0.831	0.980	1.000	0.972	1.000	0.988	1.000	1.000	1.000	0.998	1.000	0.999	0.022	0.021	0.033	0.044
07/26	0.838	0.983	1.000	0.974	1.000	0.988	1.000	1.000	1.000	0.998	1.000	0.999	0.023	0.025	0.034	0.048
07/27	0.876	0.986	1.000	0.976	1.000	0.988	1.000	1.000	1.000	0.998	1.000	0.999	0.037	0.028	0.041	0.052
07/28	0.890	0.987	1.000	0.980	1.000	0.988	1.000	1.000	1.000	0.998	1.000	0.999	0.058	0.032	0.067	0.061
07/29	0.919	0.989	1.000	0.982	1.000	0.988	1.000	1.000	1.000	0.998	1.000	0.999	0.083	0.040	0.091	0.069
07/30	0.930	0.989	1.000	0.984	1.000	0.988	1.000	1.000	1.000	0.998	1.000	0.999	0.126	0.049	0.116	0.090
07/31	0.949	0.989	1.000	0.987	1.000	0.988	1.000	1.000	1.000	0.998	1.000	0.999	0.165	0.054	0.142	0.122
08/01	0.955	0.994	1.000	0.990	1.000	0.988	1.000	1.000	1.000	0.998	1.000	0.999	0.191	0.066	0.169	0.145
08/02	0.960	0.994	1.000	0.992	1.000	0.988	1.000	1.000	1.000	0.998	1.000	0.999	0.205	0.072	0.222	0.156
08/03	0.969	0.994	1.000	0.992	1.000	0.988	1.000	1.000	1.000	0.998	1.000	0.999	0.277	0.090	0.332	0.163
08/04	0.977	0.994	1.000	0.993	1.000	0.988	1.000	1.000	1.000	0.998	1.000	0.999	0.352	0.094	0.526	0.167
08/05	0.977	0.996	1.000	0.993	1.000	0.988	1.000	1.000	1.000	0.998	1.000	0.999	0.358	0.098	0.572	0.167
08/06	0.979	0.996	1.000	0.993	1.000	0.988	1.000	1.000	1.000	0.998	1.000	0.999	0.378	0.118	0.687	0.175
08/07	0.980	0.996	1.000	0.994	1.000	0.994	1.000	1.000	1.000	0.998	1.000	0.999	0.390	0.139	0.724	0.231
08/08	0.984	0.997	1.000	0.996	1.000	0.994	1.000	1.000	1.000	0.998	1.000	0.999	0.429	0.180	0.750	0.304
08/09	0.987	0.997	1.000	0.997	1.000	0.994	1.000	1.000	1.000	0.998	1.000	0.999	0.455	0.270	0.762	0.354
08/10	0.989	0.998	1.000	0.998	1.000	0.994	1.000	1.000	1.000	0.998	1.000	0.999	0.480	0.514	0.766	0.414
08/11	0.991	1.000	1.000	0.999	1.000	0.994	1.000	1.000	1.000	0.998	1.000	1.000	0.502	0.666	0.775	0.538
08/12	0.994	1.000	1.000	0.999	1.000	0.994	1.000	1.000	1.000	0.998	1.000	1.000	0.652	0.699	0.799	0.581
08/13	0.994	1.000	1.000	0.999	1.000	0.994	1.000	1.000	1.000	1.000	1.000	1.000	0.707	0.743	0.811	0.602
08/14	0.994	1.000	1.000	0.999	1.000	0.994	1.000	1.000	1.000	1.000	1.000	1.000	0.732	0.789	0.811	0.631
08/15	0.995	1.000	1.000	0.999	1.000	0.994	1.000	1.000	1.000	1.000	1.000	1.000	0.753	0.804	0.814	0.652
08/16	0.997	1.000	1.000	1.000	1.000	0.994	1.000	1.000	1.000	1.000	1.000	1.000	0.766	0.833	0.854	0.675
08/17	0.997	1.000	1.000	1.000	1.000	0.994	1.000	1.000	1.000	1.000	1.000	1.000	0.781	0.861	0.860	0.772
08/18	0.997	1.000	1.000	1.000	1.000	0.994	1.000	1.000	1.000	1.000	1.000	1.000	0.834	0.876	0.872	0.832
08/19	0.997	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.855	0.888	0.921	0.839
08/20	0.997	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.871	0.937	0.962	0.858
08/21	0.997	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.894	0.943	0.972	0.878
08/22	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.906	0.958	0.974	0.884
08/23	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.913	0.978	0.974	0.888
08/24	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.928	0.979	0.975	0.933
08/25	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.937	0.987	0.978	0.958
08/26	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.962	0.991	0.985	0.972
08/27	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.973	0.995	0.988	0.990
08/28	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.984	0.996	0.993	0.997
08/29	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.995	0.997	0.997	0.997
08/30	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999	0.999	1.000
08/31	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Appendix 8.- Estimated age and sex composition of weekly chum salmon passage and estimated design effects used in computing first order correction chi square statistics from the Tuluksak River, 1994.

		Brood Year and Age Class				
		1991	1990	1989	1988	
		0.2	0.3	0.4	0.5	Total
Stratum Dates:	June 29-July 2					
Sampling Dates:	June 29-July 2					
Sample Size:	49					
Female	Percent of Sample	0.0	6.1	20.4	0.0	26.5
	Number in Passage	0	3	11	0	14
Male	Percent of Sample	0.0	16.3	49.0	8.2	73.5
	Number in Passage	0	9	26	4	40
Total	Percent of Sample	0.0	22.4	69.4	8.2	100.0
	Number in Passage	0	12	37	4	54
	Standard Error	0	3	4	2	
Stratum Dates:	July 3-9					
Sampling Dates:	July 3,4,5					
Sample Size:	127					
Female	Percent of Sample	0.0	6.3	22.8	4.7	33.9
	Number in Passage	0	77	280	58	415
Male	Percent of Sample	0.0	11.8	49.6	4.7	66.1
	Number in Passage	0	145	608	58	810
Total	Percent of Sample	0.0	18.1	72.4	9.4	100.0
	Number in Passage	0	222	887	116	1,225
	Standard Error	0	42	49	32	
Stratum Dates:	July 10-16					
Sampling Dates:	July 10-11					
Sample Size:	133					
Female	Percent of Sample	0.0	12.8	24.8	3.8	41.4
	Number in Passage	0	448	870	132	1,449
Male	Percent of Sample	0.0	18.1	35.3	5.3	58.7
	Number in Passage	0	633	1,239	184	2,056
Total	Percent of Sample	0.0	30.8	60.2	9.0	100.0
	Number in Passage	0	1,081	2,108	316	3,505
	Standard Error	0	141	149	87	
Stratum Dates:	July 17-23					
Sampling Dates:	July 17-18					
Sample Size:	142					
Female	Percent of Sample	0.0	23.2	24.7	2.8	50.7
	Number in Passage	0	1,304	1,383	158	2,845
Male	Percent of Sample	0.0	26.1	21.1	2.1	49.3
	Number in Passage	0	1,462	1,185	118	2,765
Total	Percent of Sample	0.0	49.3	45.8	4.9	100.0
	Number in Passage	0	2,766	2,568	276	5,610
	Standard Error	0	236	235	102	

-continued-

Appendix 8.-(continued).

		1991 0.2	1990 0.3	1989 0.4	1988 0.5	Total
Stratum Dates:	July 24-30					
Sampling Dates:	July 24					
Sample Size:	137					
Female	Percent of Sample	0.0	42.3	18.3	0.0	60.6
	Number in Passage	0	1,492	643	0	2,136
Male	Percent of Sample	0.0	26.3	12.4	0.7	39.4
	Number in Passage	0	926	437	26	1,390
Total	Percent of Sample	0.0	68.6	30.7	0.7	100.0
	Number in Passage	0	2,419	1,081	26	3,525
	Standard Error	0	140	139	26	
Stratum Dates:	July 31 - August 6					
Sampling Dates:	July 31-August 2					
Sample Size:	150					
Female	Percent of Sample	3.3	46.7	12.0	0.0	62.0
	Number in Passage	41	574	147	0	762
Male	Percent of Sample	1.3	27.3	8.7	0.7	38.0
	Number in Passage	16	336	107	8	467
Total	Percent of Sample	4.7	74.0	20.7	0.7	100.0
	Number in Passage	57	910	254	8	1,229
	Standard Error	21	44	41	8	
Stratum Dates:	August 7 - September 11					
Sampling Dates:	August 7-10, 14-17, 21, 4,5,7					
Sample Size:	113					
Female	Percent of Sample	6.2	50.4	15.9	0.0	72.6
	Number in Passage	36	291	92	0	418
Male	Percent of Sample	0.0	16.8	10.6	0.0	27.4
	Number in Passage	0	97	61	0	158
Total	Percent of Sample	6.2	67.3	26.5	0.0	100.0
	Number in Passage	36	387	153	0	576
	Standard Error	13	26	24	0	
Stratum Dates:	Season					
Sampling Dates:	6/17-9/10					
Sample Size:	851					
Female	Percent of Sample	0.5	26.6	21.8	2.2	51.1
	Number in Passage	77	4,189	3,426	348	8,039
	Estimated design effect	0.353	1.345	1.534	1.592	1.456
Male	Percent of Sample	0.1	22.9	23.3	2.5	48.9
	Number in Passage	16	3,607	3,663	398	7,685
	Estimated design effect	0.440	1.520	1.394	1.461	1.456
Total	Percent of Sample	0.6	49.6	45.1	4.7	100.0
	Number in Passage	93	7,796	7,089	746	15,724
	Standard Error	25	316	319	141	
	Estimated design effect	0.364	1.371	1.413	1.508	

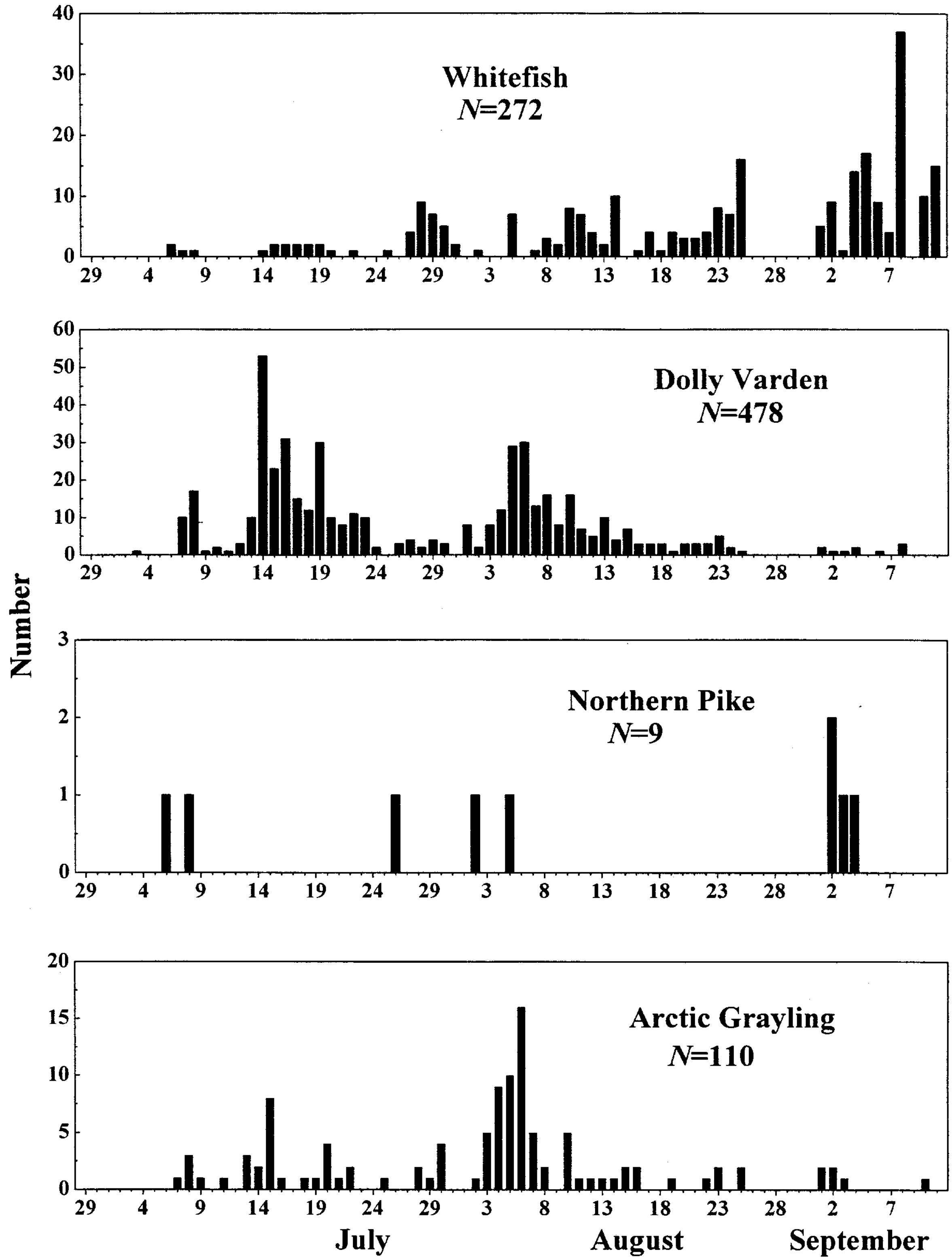
Column header: Brood Year and Age Class

Appendix 9.- Estimated age and sex composition of weekly chinook salmon passage and estimated design effects used in computing first order correction chi square statistics from the Tuluksak River, 1994.

		Brood Year and Age Class									
		1991	1990		1989		1988		1987		
		1.1	1.2	2.1	1.3	2.2	1.4	2.3	1.5	2.4	Total
Stratum Dates:	June 29- July 9										
Sampling Dates	June 30-July 7										
Sample Size:	115										
Female	Percent of Sample	0.0	5.2	0.0	6.1	0.0	7.8	0.0	0.9	0.9	20.9
	Number in Passage	0	43	0	50	0	65	0	7	7	172
Male	Percent of Sample	0.9	10.4	0.0	54.8	0.0	5.2	5.2	0.0	2.6	79.1
	Number in Passage	7	86	0	452	0	43	43	0	22	653
Total	Percent of Sample	0.9	15.7	0.0	60.9	0.0	13.1	5.2	0.9	3.5	100.0
	Number in Passage	7	129	0.0	502	0	108	43	7	29	825
	Standard Error	7	28	0	38	0	26	17	7	14	
Stratum Dates:	July 10-16										
Sampling Dates	7/10 - 16										
Sample Size:	135										
Female	Percent of Sample	0.0	0.0	0.0	4.4	0.0	7.4	0.0	0.0	3.0	14.8
	Number in Passage	0	0	0	46	0	76	0	0	30	152
Male	Percent of Sample	0.0	20.0	0.7	48.9	1.5	8.9	3.7	0.0	1.5	85.2
	Number in Passage	0	206	8	503	15	91	38	0	15	877
Total	Percent of Sample	0.0	20.0	0.7	53.3	1.5	16.3	3.7	0.0	4.4	100.0
	Number in Passage	0	206	8	549	15	168	38	0	30	1,029
	Standard Error	0	36	8	0	11	33	17	0	18	
Stratum Dates:	July 17 - 23										
Sampling Dates	7/17 - 23										
Sample Size:	142										
Female	Percent of Sample	0.0	1.4	0.0	12.0	0.0	13.4	0.0	0.7	1.4	28.9
	Number in Passage	0	11	0	94	0	105	0	5	11	226
Male	Percent of Sample	1.4	19.0	0.7	35.9	2.8	9.2	2.1	0.0	0.0	71.1
	Number in Passage	11	149	5	281	22	72	17	0	0	556
Total	Percent of Sample	1.4	20.4	0.7	47.9	2.8	22.5	2.1	0.7	1.4	100.0
	Number in Passage	11	160	5	374	22	176	17	5	11	782
	Standard Error	8	27	5	33	11	28	9	5	8	
Stratum Dates:	July 24- Sept 11										
Sampling Dates	7/24 - Sept 11										
Sample Size:	88										
Female	Percent of Sample	0.0	1.2	0.0	20.7	0.0	23.2	2.4	1.2	1.2	50.0
	Number in Passage	0	3	0	58	0	65	7	3	3	141
Male	Percent of Sample	6.1	17.1	0.0	22.0	0.0	3.7	1.2	0.0	0.0	50.0
	Number in Passage	17	48	0	62	0	10	3	0	0	141
Total	Percent of Sample	6.1	18.3	0.0	42.7	0.0	26.8	3.7	1.2	1.2	100.0
	Number in Passage	17	51	0	120	0	75	10	3	3	281
	Standard Error	7	12	0	15	0	13	6	3	3	
Stratum Dates:	Season										
Sampling Dates	6/30-8/18										
Sample Size:	480										
Female	Percent of Sample	0.0	2.0	0.0	8.5	0.0	10.6	0.2	0.6	1.8	23.7
	Number in Passage	0	58	0	248	0	311	7	16	52	691
	Estimated design effect	1.000	1.068		0.929		0.957		1.086		0.966
Male	Percent of Sample	1.2	16.7	0.4	44.5	1.3	7.4	3.5	0.0	1.3	76.3
	Number in Passage	35	488	13	1,298	37	216	101	0	37	2,226
	Estimated design effect	0.770	1.056		1.052		1.105		1.208		0.966
Total	Percent of Sample	1.2	18.7	0.4	53.0	1.3	18.1	3.7	0.6	3.0	100.0
	Number in Passage	35	546	13	1,545	37	527	108	16	89	2,917
	Standard Error	13	54	9	52	15	52	26	10	25	0
	Estimated design effect	0.770	1.070		1.063		1.043		1.128		

Appendix 10.- Estimated age and sex composition of weekly coho salmon passage and estimated design effects used in computing first order correction chi square statistics from the Tuluksak River, 1994.

		Brood Year and Age Class			
		1991	1990	1989	
		1.1	2.1	3.1	Total
Stratum Dates:	June 29-August 20				
Sampling Dates:	July 25-26,Aug1,2,8,10,14,17				
Sample Size:	152				
Female	Percent of Sample	0.0	32.9	6.6	39.5
	Number in Passage	0	439	88	527
Male	Percent of Sample	2.6	50.0	7.9	60.5
	Number in Passage	35	668	105	808
Total	Percent of Sample	2.6	82.9	14.5	100.0
	Number in Passage	35	1107	194	1,335
	Standard Error	17	41	38	
Stratum Dates:	August 21-September 3				
Sampling Dates:	August 21-22				
Sample Size:	125				
Female	Percent of Sample	0.0	30.4	6.4	36.8
	Number in Passage	0	1,636	344	1,981
Male	Percent of Sample	3.2	53.6	6.4	63.2
	Number in Passage	172	2,885	344	3,401
Total	Percent of Sample	3.2	84.0	12.8	100.0
	Number in Passage	172	4,521	689	5,382
	Standard Error	85	177	161	
Stratum Dates:	September 4-11				
Sampling Dates:	September 4-7				
Sample Size:	53				
Female	Percent of Sample	0.0	41.5	0.0	41.5
	Number in Passage	0	513	0	513
Male	Percent of Sample	0.0	52.8	5.7	58.5
	Number in Passage	0	653	70	723
Total	Percent of Sample	0.0	94.3	5.7	100.0
	Number in Passage	0	1,166	70	1,236
	Standard Error	0	40	40	
Stratum Dates:	Season				
Sampling Dates:	6/29-9/11				
Sample Size:	330				
Female	Percent of Sample	0.0	32.5	5.4	38.0
	Number in Passage	0	2,588	433	3,021
	Estimated design effect	1.0000	1.4018	1.4888	1.4194
Male	Percent of Sample	2.6	52.9	6.5	62.0
	Number in Passage	207	4,205	520	4,932
	Estimated design effect	1.5465	1.4272	1.3977	1.4194
Total	Percent of Sample	2.6	85.4	12.0	100.0
	Number in Passage	207	6,793	953	7,953
	Standard Error	87	186	171	
	Estimated design effect	1.5465	1.4468	1.4360	



Appendix 11.-Passage of whitefish, Dolly Varden, northern pike and Arctic grayling through the Tuluksak River weir, June 29-September 11, 1994.