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NULATO RIVER SALMON ESCAPEMENT STUDY, 1994

By

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OEO/ADA STATEMENT

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ABSTRACT

Daily passage of summer chum salmon *Oncorhynchus keta* and chinook salmon *O. tshawytscha* were estimated from visual observations from towers situated on each bank of the mainstem Nulato River. During the period 29 June through 23 July 1994, an estimated 148,762 summer chum salmon and 1,795 chinook salmon passed the tower site. Note that these escapement estimates are only for the operational period. High, turbid water prohibited the observation of salmon passage from the towers during the period 20-28 June. Salmon passage during that time was not estimated. However, these escapement estimates are considered conservative estimates of salmon escapement for the entire season. Based on these estimates, it was concluded that minimum escapement objectives for summer chum and chinook salmon for this tributary were achieved. Timing of the Nulato River summer chum salmon run was very similar to the timing of the summer chum salmon run into nearby Kaltag Creek and into the relatively distant Anvik and Andreafsky Rivers. Quartile days of passage occurred on 4, 9, and 13 July. The middle 50% of the run passed the tower site in 9 days. Female chum salmon comprised an estimated 41.8% of the summer chum salmon passage. Age-4 fish comprised an estimated 35.8% of the passage; age-5 fish accounted for 63.0%. Male chum salmon dominated all four sampling stratum. Age-5 salmon dominated the first three sampling strata. Salmon counts during the period 20 - 28 June were unavailable because of poor observation conditions. Based on the timing of the summer chum salmon run into nearby Kaltag Creek, it is speculated that approximately 36,000 uncounted summer chum salmon may have passed the tower site during this time.

INTRODUCTION

Two distinct runs of chum salmon *Oncorhynchus keta*, summer and fall, spawn in the Yukon River drainage. The Anvik River (river km [rkm] 512) is the largest producer of summer chum salmon in the Yukon River drainage. Buklis (1982) estimated that the Anvik River alone accounted for 35% of the total drainage production. In 1993, 55% of the estimated summer chum salmon passage at the Yukon River sonar site was also estimated to have passed the Anvik River sonar site (Sandone 1994). In 1994, this percentage was very similar, 57% (Sandone 1995). Post-season aerial surveys conducted by the department during recent years suggests that summer chum salmon spawning escapements to other tributary spawning stocks have been generally declining and, for the most part, considered below escapement goals. Other known major summer chum spawning populations occur in the Andreafsky (rkm 167), Chulinak, or Atcheulinguk (rkm 203), Rodo (rkm 719), Nulato (rkm 777), Melozitna (rkm 938), and the Tozitna (rkm 1,096) Rivers, which drain directly into the Yukon River, the Gisasa (rkm 907) and Hogatza (rkm 1,255) Rivers, which drain into the Koyukuk River, and the Chena (rkm 1,480) and Salcha Rivers (rkm 1,553), which drain into the Tanana River (Figure 1). Summer chum salmon spawn in lesser numbers in most other tributaries of the Yukon River drainage below the confluence of the Tanana and Yukon Rivers (rkm 1,118), and within the Tanana River drainage.

In February, 1990, a Yukon River-wide guideline harvest range (GHR) for summer chum salmon of 400,000 - 1,200,000 was established by the Alaska Board of Fisheries (ADF&G 1990). This overall guideline was distributed by district and subdistrict based on previous 15-year average harvests. In some years a substantial number of salmon destined to the Anvik River were available for harvest in the lower Yukon Area and the extreme lower portion of Subdistrict 4-A (Figure 1). Attempts to more fully exploit the Anvik River stock in the mixed stock lower river commercial fishery in 1988 and 1989 probably contributed to the over-exploitation of the less abundant stocks above the Anvik River. Additionally, attempts by the Department to maintain fishing period length in District 4, while targeting the annual harvest of summer chum salmon at the same proportional level of the GHR for all districts, including those above the confluence of the Anvik River, directly resulted in the over-exploitation of these stocks. This problem was exacerbated by the disappointing Yukon River summer chum salmon runs during 1990-1993.

Prior to 1994, in conjunction with the Lower Yukon River test fish CPUE estimates, in-season passage estimates of summer chum salmon from the Yukon River (rkm 198) and Anvik River sonar projects provided much of the available information used to make management decisions concerning the commercial harvest of summer chum salmon in District 4 (Figure 1), or between the confluences of the Anvik and Tanana Rivers. Escapements were typically assessed by aerial surveys conducted after the commercial fishing season had been terminated. Although the escapement goal was generally met in the Anvik River, escapement to most other tributary streams declined to unacceptable levels. Operation of an inseason escapement-monitoring project for summer chum salmon within the upper portion of District 4 would serve as an index for the middle Yukon River area and provide fishery managers additional information concerning the size and quality of spawning escapement in this area. This information would be used in conjunction with the Yukon River and Anvik River sonar passage estimates to make more informed management decisions regarding the summer chum salmon-directed commercial fishery in District 4. Additionally, genetic stock identification (GSI) sampling of escapements could contribute to attempts to apportion summer chum salmon fishery harvests to stock of origin. Therefore, there is a real need to monitor and sample summer chum salmon escapement, not only to the Anvik River, which is the major producer in the Yukon River drainage, but to a representative secondary producer in the middle Yukon area, like the Nulato River, as well.

The Nulato River is believed to be the largest producer of summer chum salmon above the confluence of the Anvik and Yukon Rivers. Chinook *O. tshawytscha* occur in the Nulato River coincidentally with summer chum salmon. Coho salmon *O. kisutch* have been reported to spawn in the Nulato River drainage during the fall (Holder and Hamner *In Prep*). Very few pink salmon are thought to spawn in the Nulato River.

Stock Identification Studies

Two stock identification studies have been conducted on Yukon River chum salmon stocks, and additional research is ongoing. Initially, a small-scale stock identification investigation using scale pattern analysis was conducted by the Alaska Department of Fish and Game (ADF&G). Results of this pilot study indicated that separation of chum salmon stocks by scale pattern analysis was probably not feasible (Wilcock 1988).

A more recent stock identification study (Wilmot et al. 1992) reported success in separating Yukon River chum salmon stocks using protein electrophoresis techniques. This study was initiated in 1987 by the United States Fish and Wildlife Service (USFWS) and continued through the 1991 season. Preliminary results indicated that among all represented chum salmon stocks of the Yukon River, two major groups were apparent, a summer-run group and a fall-run group. These investigators also reported that within the summer-run group, two major subdivisions were apparent, those of the lower river below rkm 800 and those of the mid river (rkm 800-1,150). A more recent study by ADF&G indicated that the major split was based more on geographic lines between upper and lower Yukon River stocks (Crane et al. 1994). Summer chum salmon samples collected during the 1988 field season from the North and South Forks of the Nulato River were grouped with the lower summer run group by Wilmot et al (1992). Wilmot et al. (1992) also reported that estimated stock compositions of samples collected from District 1 commercial and test net fisheries during 1987 to 1990 indicated that the lower river summer-run chum salmon stocks contributed substantially to the catch until mid-July.

Recent GSI research conducted by ADF&G Genetics Laboratory has been designed to improve the existing allozyme-based data set by: 1) adding new populations to the baseline and resampling populations of special concern, and 2) identifying additional genetic markers (Crane et al. 1994). More recently, ADF&G, USFWS, and the National Biological Service (NBS) have agreed to conduct a coordinated pilot study designed to investigate the utility of mtDNA, microsatellite and intron markers in separating U.S.\Canada fall chum salmon.

Harvest of Nulato River Salmon

Commercial and subsistence harvests of Nulato River summer chum salmon occur throughout the mainstem Yukon River from the coast of the delta to the mouth of the Nulato River. This section of river includes Districts 1, 2, 3 and approximately 86% of Subdistrict 4-A, by length (Figure 1). Set and drift gillnets are the legal fishing gear in Districts 1, 2, and 3; set gillnets and fish wheels are allowed in District 4. Fish taken commercially in the lower three districts are sold in the round; District 4 is primarily a roe fishery because of poor flesh quality, distance from market, and high quality salmon roe product. Subsistence fishers in Districts 1, 2, and 3 take summer chum salmon primarily for human consumption. Subsistence harvest of summer chum salmon in District 4 is primarily for sled dog food.

Prior to the season, the 1994 run-strength outlook for Yukon River summer chum was for a below average run. This was based on evaluation of parent-year escapements in 1990, and an assumed poor return of age-5 fish from the 1989 brood year. A poor return of the age-5 component was anticipated in the 1994 run because of the very poor return of sibling, age-4 salmon in the 1993 run. It was also noted that if the return of age-4 salmon in the 1994 run was similar to the very poor return of age-4 salmon in the 1993 run, the 1994 summer chum salmon run could be critically low (ADF&G 1994a). Accordingly, no commercial harvest of summer chum salmon was expected. Additionally, it was further noted that if the 1994 run appeared critically low, more stringent conservation management actions would be necessary to assure that escapement goals were met (ADF&G 1994a).

Escapement Assessment

Accurate salmon escapement assessment on Yukon River tributaries is important for regulating fishery harvests, setting escapement goals, evaluating the effectiveness of management programs, and providing information for use in projecting subsequent returns. However, because of the vast size of the Yukon River drainage, 853,000 km^2, low-level aerial surveys conducted from single-engine, fixed-wing aircraft have been used to provide indices of escapement for selected spawning areas. The counts obtained are only indices of abundance because the entire escapement is not present on the day of the survey and not all the fish present are seen and counted. Additionally, the quality of the survey count may vary because of weather and stream conditions, timing of the survey relative to spawning stage, number of other species of salmon present, and observer subjectivity and experience. Attempts to standardize the conditions under which these indices are conducted improves their usefulness in monitoring the relative abundance of spawning escapements.

Chinook salmon escapements to the major spawning areas in the Yukon River drainage have been estimated by aerial survey from fixed-wing aircraft on a consistent basis since the early 1960s. Chum salmon escapements have been estimated by aerial survey since the early 1970s. Escapement goals based on aerial surveys have been established for both summer chum and chinook salmon in selected tributary streams for which there is a sufficient historical database (Schultz et al. 1993; Tables 1 and 2, respectively).

The Nulato River is one of the department's primary aerial survey index areas for assessment of the relative magnitude of summer chum and chinook salmon spawning escapement. All escapement goals pertaining to the Nulato River were, and are presently, based on aerial survey counts of salmon.

An escapement goal range of 33,700 to 78,400 aerial survey counts of summer chum salmon was initially proposed for the entire Nulato River in 1981 (Buklis 1993). In April 1982, a single goal of 75,000 aerial survey counts was proposed for both the North Fork and South Fork combined (Buklis 1993). In April 1984, an escapement goal range of 37,00 to 53,000 aerial survey counts of summer chum salmon was established for the North Fork only. No escapement goal was established for the South Fork (Geiger et al. 1984). In 1989, the high end of the escapement goal range (53,000) was established as the aerial survey-based goal for the North Fork (Bergstrom et al. 1991). In 1990, a minimum of the 53,000 summer chum salmon aerial survey counts was targeted as the escapement goal (Bergstrom et al. 1992). The various aerial survey-based escapement goals, which were effective for different time periods, have been met only once since initially established. In 1986 the aerial survey count of 47,417 summer chum salmon exceeded the low end of the aerial survey escapement goal range of 37,000 - 53,000 salmon (Table 1). However, survey conditions have not been acceptable in some years.

A chinook salmon aerial survey escapement goal range of 400 to 1,100 was proposed in 1981 for the entire Nulato River (Buklis 1993). In April 1982, a single goal of 1,200 aerial survey counts of chinook salmon was proposed for both the North and South Forks combined (Buklis 1993). In April 1984 an escapement goal of 500 aerial survey counts of chinook salmon for each fork was established (Geiger et al 1984). In 1990, a minimum number of 500 aerial survey counts of chinook salmon was targeted as the escapement goals each fork of the Nulato River (Bergstrom et al. 1992). Chinook salmon escapement goals for the Yukon River were reevaluated in the spring of 1991 and were made effective for the 1992 season (Buklis 1993). At that time, minimum interim escapement goals for chinook salmon, based on aerial survey counts, were established for both forks: 800 for the North Fork and 500 for the South Fork (Buklis 1993; Table 2). Since 1984, chinook salmon escapement to the Nulato River, as observed under fair or good aerial survey conditions, has exceeded the established, effective escapement goals for each fork, except for 1987 in the South Fork and for 1992 in both the North Fork and South Fork (Table 2).

Comprehensive escapement assessment studies have been conducted on only a few selected spawning streams for summer chum salmon in the Yukon River drainage prior to 1994. The Anvik River was chosen for summer chum salmon research studies in 1972 and the Andreafsky and Melozitna Rivers in 1981. However, because of budget restrictions, the Melozitna River project was discontinued in 1984; the Andreafsky River project was discontinued in 1989. During 1993, counting towers for chinook and summer chum assessment were operated by Sport Fish Division on the Chena and Salcha Rivers of the Tanana River drainage. During the 1994 season, in addition to the Anvik River sonar and Chena and Salcha Rivers counting-tower projects, the USFWS operated salmon-counting weirs on the East Fork Andreafsky and Gisasa Rivers. Additionally, counting towers were operated on the mainstem Nulato River and Kaltag Creek (rkm 724). The Nulato River salmon-counting tower project was cooperatively funded by Bering Sea Fishermen's Association (BSFA), Tanana Chiefs Conference, Inc. (TCC) and ADF&G. The Kaltag counting-tower project was funded by Alaska Cooperative Extension 4-H Program, and partially funded by BSFA.

Study Area

The Nulato River is a narrow runoff stream with a substrate mainly of gravel and cobble. The Nulato River divides into two main forks, the North and South Fork, approximately 9 km above its mouth. Both forks of the Nulato River originate at an elevation of approximately 600 m. From its source, the South Fork flows in a northeasterly and easterly direction for its entire length, approximately 98 km, to the confluence with the North Fork. From its source the North Fork, for the most part, also flows in a northeasterly and easterly direction. However, the direction of flow abruptly changes to south approximately 16 km upstream from its confluence with the South Fork. The length of the North Fork is approximately 114 km. However, the North Fork drainage also includes the Kalasik Creek (Figure 2) drainage. This tributary stream is approximately 54 km long. The mainstem Nulato River joins the Yukon River at rkm 777 at an approximate elevation of 33 m

The Nulato River tower site is located approximately 5 km upstream of the confluence of the Nulato and Yukon Rivers (Figure 2). The water is typically clear but stained brown by peat-land leachates. Practically all chum salmon spawning areas appear to be upstream of the tower site.

Objectives

The objectives of this study were to:

1. estimate total escapement of summer chum and chinook salmon into the Nulato River from mid-June through the end of July using tower-counting methodology;

2. estimate the age and sex composition of the summer chum spawning population;

3. monitor climatological and hydrological conditions at the tower-counting site; and

4. collect and preserve tissue samples from 100 adult summer chum salmon for GSI analysis.

METHODS

Site Selection and Preparation

A 2-d reconnaissance of the mainstem Nulato River below the confluence of the two main forks was conducted 16-17 June 1994 to select a tower site. The criteria used for tower site selection included: 1. location well below most, if not all, chum salmon spawning areas, 2. single, relatively narrow, river channel, and 3. relatively shallow river depth so that migrating salmon could be observed from counting towers. The south (right) bank consisted of a gradual sloping gravel bar; the north (left) bank was a cut bank. Stream width at the tower site was approximately 49 m.

One tower, approximately 3 m high, of iron scaffolding material was erected on each bank of the mainstem Nulato River to observe migrating salmon. An approximate 15-m weir, constructed of chain-link fencing material, secured by T-stakes was installed perpendicular to the south (right) bank shoreline to concentrate the fish near the south-bank tower. The south (right) bank tower was placed and secured with sandbags and ropes in the river, approximately 15 meters from the shore and in approximately 1.2 meters of water. The north (left) bank tower was erected on a man-made pad, consisting of rock, dirt, and sandbags, immediately next to the north (left) bank shore. To provide contrast for fish species identification and enumeration, four white canvas tarp sections, approximately 3 m wide and 1 m long, were secured onto a cable which was strung across the river. The tarps were to be placed on the bottom of the river so that tower observers could easily see, identify, and count the salmon migrating over them. However, the crew was not able to secure the tarps to the bottom of the river because of the relatively swift current and deep water at the tower site during this season. Consequently, salmon were observed to pass under these canvas sections. These flash panels were subsequently replaced by a single line of sandbags, secured onto the wire cable with bailing wire. This line of sandbags, which extended from the north (left) bank, covered approximately 60%-70% of the transect counting line between the two towers. Additionally, a narrow piece of white canvass, secured along the length of the middle portion of a 15-m section of chain-link fence, served as a flash panel for the remainder of the counting transect adjacent to the south (right) bank tower. This portion of the flash panel was held in position by sandbags which were placed on top of the fencing material. Polaroid sunglasses were worn by the observer to reduce glare. During hours of darkness, several 120-volt lights, suspended by a rope across the river, were used to illuminate the counting area.

Tower-Count Sampling

Tower counting operations were conducted 7 days a week, 24 hours a day, for a 15-minute count interval each hour on each bank. The tower observer counted fish passage by species and direction (i.e. upstream or downstream). Counts were initially recorded on hand-held tally counters, and subsequently transcribed onto data forms immediately after the 15-minute counting session. Counts were expanded for each hour, for each bank, by dividing the raw count by the proportion of the hour counted. Missing counts were estimated by averaging the counts for the hour before and after the missing hourly count. When salmon were not counted for a portion of a day, the expanded daily count total for that day was estimated by dividing the expanded partial daily count by the mean proportion of expanded counts for the corresponding hours for the first day before and after having full 24-h counts. When counting was not conducted for a full day the salmon passage estimate for that day was calculated as the mean salmon passage for the day before and after. When counting was not conducted for more than one full day, the passage estimate for those days was estimated by interpolating between the last full day of counts and first full day after resumption of counts.

The daily passage for each bank was calculated by simply summing the expanded hourly counts for each species, for each bank. The total daily passage estimate for each species was simply the sum of the expanded count for each bank.

Age-Sex-Size Sampling

Historic timing information of the summer chum salmon escapement into the Nulato River was lacking this season because 1994 was the first season an escapement project was operated on the Nulato River. However, because the recommended days for optimal aerial survey conditions for the Nulato River, July 25-31, overlap that of the optimal time for aerial surveys on the Anvik River, July 20-31, it was suspected that the timing of the summer chum salmon escapement may be similar. Therefore, season strata used for the comparison of hourly and sector sonar passage data for the Anvik River were also used to define the Nulato River sampling strata. These strata were defined by the early, early middle, late middle and late strata for age-sex-size sampling goals. Each stratum was determined preseason based on historical run timing data of the Anvik River chum salmon escapement at the Anvik River sonar site. Sampling by stratum attempts to sample the escapement for age-sex-size information in relative proportion to the total run. Strata were defined as: 20 June-3 July; 4-8 July; 9-13 July; and 14-26 July.

A beach seine (31 m long, 66 meshes deep, 6.35-cm mesh) was used to capture chum and chinook salmon for age, sex, and size measurements. Captured chum and chinook salmon were identified by sex, and measured in millimeters from mid-eye to fork-of-tail. One scale was taken for age determination from chum salmon. Scales were removed from an area posterior to the base of the dorsal fin and above the lateral line on the left side of the fish (Clutter and Whitesel 1956). The adipose fin was clipped on each fish before release to prevent resampling. Three scales were taken from each chinook salmon sampled for determination of age. Scale samples were later pressed on acetate cards and the resulting impressions viewed on a microfiche reader for age determination.

Sample size goals for each species were based on 95% precision with a 10% accuracy for each time stratum. A sample size of 138 fish per stratum (early, early middle, late middle, and late) was needed to describe the age composition of the chum salmon escapement by stratum (Bromaghin 1993). However, the sample size goal was increased to 152 per stratum to account for a 10% unageable rate. A sample size of 198 for the season (1 stratum) was needed to describe the age and sex composition of the chinook salmon escapement based on the number of expected age classes and an assumed 10% unageable rate (Bromaghin 1993). The chum salmon sample goal was expected to be attained. However because few chinook salmon are usually captured by beach seining, the sample goal for chinook salmon was not expected to be achieved.

Hydrological and Climatological Sampling

Climatological data were collected at approximately 1800 hours each day at the campsite. Relative river depth was monitored by staff gauge marked in 0.01-ft increments. Change in water depth was converted to centimeters and presented as negative or positive increments from the initial reading of 0.0 cm. Water temperature was measured in degrees centigrade near shore at a depth of about 0.5 m. Daily maximum and minimum air temperatures were recorded in degrees centigrade. Subjective notes were kept by the crew describing wind speed and direction, cloud cover, and precipitation.

GSI Sampling

Procedures for the collection and preservation of tissue samples from chum salmon for GSI analysis were provided by the Genetics Laboratory of the ADF&G Division of Commercial Fisheries Management and Development (CFM&D).

Run Timing

Since 1986, except for 1992, run timing of summer chum salmon within the Yukon River drainage was monitored at three locations: the lower Yukon River test fishery (rkm 32), Yukon River sonar site (rkm 198), and Anvik River sonar site, located approximately 576 km from the mouth of the Yukon River (Figure 1). In 1992, the Yukon sonar project was conducted in an experimental mode, and complete timing statistics are not available. Prior to the 1994 season, comprehensive, daily, run timing information for the summer chum salmon migration above the confluence of the Anvik River was unavailable. For 1994, run timing statistics, quartile days, were calculated and compared for chum salmon passage at the lower Yukon River test fishing site, Yukon River and Anvik River sonar sites, and the Kaltag Creek and Nulato River tower sites. As previously stated, because the timing of the peak aerial survey period for observing summer chum salmon in the Anvik and Nulato Rivers overlapped, run timing was expected to be similar.

RESULTS AND DISCUSSION

Escapement Estimation

One salmon-counting tower on each bank of the Nulato River was operated from 29 June through 23 July at a site located approximately 5 km upstream from the mouth. Poor visibility, resulting from high, turbid river water, prohibited the counting of salmon from towers during the period 20-28 June, and interfered with counting on six separate days during the operational period (Tables 3 and 4). Additionally, only a partial count was available for the first day of tower operations, 29 June. Salmon passage was not estimated for the period 20-28 June. Counts were not expanded for the uncounted portion of the day on 29 June. However, passage estimates were calculated for the six days when high water interfered with counting operations during the season.

Passage estimates for both summer chum and chinook salmon are conservative because counts do not include fish passage prior to initiation of counting operations and after counting ceased. The delay in counting operations probably affected the season passage estimate of summer chum salmon more so than chinook salmon because it appears from the data collected this season that summer chum salmon enter into the river earlier than chinook salmon (Figure 3). Therefore, a delay in counting operations probably resulted a higher proportion of summer chum salmon to pass uncounted than chinook salmon. After 29 June, however, poor visibility from the tower probably affected the counting of chinook salmon more so than summer chum salmon. Most chum salmon migrated along the banks where visibility from the tower was optimal. Most chinook salmon, however, migrated farther offshore in locations where visibility was poor. These conditions persisted for much of the operational period. Therefore, during the operational period, 29 June - 23 July, the difference in the spatial migration of the species, in conjunction with the poor observation conditions offshore, most likely resulted in a fairly accurate estimate of summer chum salmon passage but a substantial underestimate of the chinook salmon passage.

Summer Chum Salmon

The estimated escapement count for the period 29 June through 23 July was 148,762 summer chum salmon (Table 3). The first quartile day of summer chum salmon passage occurred on 4 July; the median day of passage occurred on 9 July; and the third quartile day of passage occurred on 13 July. The duration of the mid-50% portion of the 1994 run lasted 9 d. The historical average for the duration of the mid-50% passage is 13 d for the lower Yukon River test fishery passage (1980-1993), 12 d for Yukon River sonar passage (1986-1991, 1993), and 10 d for Anvik River sonar passage (1979-1993).

Daily expanded passage estimates of summer chum salmon ranged from 1,208 on 21 July to 10,744 on 10 July. A similarly high passage estimate of 10,188 summer chum salmon was recorded on 5 July. Estimated passage was greatest during the 7-d period, 5-11 July. This peak passage period included the median-day of passage, 9 July, and was contained within the estimated mid-50% portion of the run. During this 7-d period, 58,744 chum salmon, or 39% of the total season run, were estimated to have passed the tower site. Interestingly, the greatest estimated summer chum salmon passage at the Anvik River sonar site was also 5-11 July. Estimated passage during the same 7-d period at the Anvik River sonar site comprised a similar 41% of total season passage estimate (Sandone 1995). Expanded hourly tower counts of summer chum salmon for the south (right) and north (left) banks are provided in Appendices A and B, respectively.

Because summer chum salmon counts were initially high, in excess of 8,000 salmon on the first full day of counting, 30 June, and remained relatively high for the following 12 days, except for 8 July (Figure 4), it is suspected that the delay in counting operations resulted in a substantial underestimate of the summer chum salmon passage. Because of this delay in the initiation of counting operations, it is suspected that the estimated Nulato River tower counts reflect not more than 80% of the actual passage. This is based on the run timing of summer chum salmon into nearby Kaltag Creek, as documented by the salmon-counting tower project located on that creek (unpublished data; Table 5). Although river water conditions interfered with counting operations on six days after counting was initiated, it is believed that the calculated chum salmon passage during these days represent a fairly accurate estimate of the actual passage. Therefore, the chum salmon escapement estimate for the period 29 June - 23 July is believed to be fairly accurate.

Quartile-days of summer chum salmon escapement into Kaltag Creek were approximately 2 to 4 days earlier than the observed run timing of the escapement into the Nulato River. Interestingly, the run timing of Kaltag Creek summer chum salmon escapement was very similar to that of the Anvik River escapement (Table 5). Calculated quartile days for the 1994 Nulato River summer chum escapement were nearly identical to the long-term average timing statistics of the Anvik River summer chum salmon escapement (Sandone 1994b).

During the 1994 season a higher proportion of summer chum salmon migrated past the tower site during the evening hours than during the daytime hours (Figure 5). The Anvik River summer chum salmon escapement has also displayed a distinct diurnal pattern (Buklis 1982b 1985, 1986, 1987; Sandone 1989, 1990a, 1990b, 1993, 1994a, 1994b, 1995). Based upon the total expanded counts for days with at least 20 h of counting time, salmon passage was lowest, less than 4.0% of the total passage, from 0300 to 1600 hours (averaging 2.6% of total daily passage per hour) and greatest, greater than 5.0% of the total passage, from 1900-0200 (averaging 7.1% of total daily passage per hour). Chum salmon passage for hours ending 1700 and 1800 was intermediate, averaging 4.5% of the total daily passage per hour. This pattern was consistent throughout the season on the south (right) bank (Figure 6), but less so on the north (left) bank (Figure 7), especially during the final sampling stratum. These inconsistencies, however, may be partially attributed to the relatively low number of salmon migrating along the north (left) bank.

Approximately 80.2% of the summer chum salmon escapement was counted migrating along the south (right) bank (Table 3). The percentage varied little throughout the season, ranging from 72.5% to 88.0%. A dominant-bank migrational pattern has also been identified for the Anvik River. Typically, a majority of the annual summer chum salmon escapement to the Anvik River has been associated with the west bank at the sonar site (Mauney and Buklis 1980; Buklis 1981, 1982b, 1983, 1984a, 1984b, 1985, 1986, 1987; Sandone 1989, 1990a, 1990b, 1993, 1994b, 1995). In both cases, the majority of the chum salmon passage occurs along the gradually sloping bar, opposite a cut bank. Chum salmon probably migrate along this type of shoreline, or inside of a river bend, because of substantially lower water velocities than along the cut bank.

Management Implications Inseason Nulato River passage estimates, in conjunction with the Yukon River and Anvik River sonar passage estimates, played a major role in the management of the Upper Yukon Area fisheries in 1994. Passage estimates from the Yukon River and Anvik River sonar projects were used to assess summer chum salmon run size in the mainstem Yukon River above the confluence of the Anvik River. The Nulato River summer chum passage estimate was used as an indicator of chum salmon escapement size and quality in the middle portion of the Yukon River Management Area.

During the 1994 season, inseason run assessment, based on data collected from the above-mentioned projects, indicated that a harvestable surplus of summer chum salmon was available. Consequently, four commercial fishing periods were scheduled in Subdistrict 4-A for a total fishing time of 90 hours. During these four periods approximately 136,345 summer chum salmon were harvested to produce the 65,496 pounds of summer chum salmon roe sold (ADF&G 1994b). The 90 hours of commercial fishing time allowed in Subdistrict 4-A was over four times the amount of fishing time allowed during the 1993 season. The 1994 commercial harvest of 136,345 summer chum salmon in the Subdistrict 4-A fishery was at the 10%-point of the guideline harvest range of 113,000 to 338,000 summer chum salmon. The summer chum salmon harvest in Subdistricts 4-B and 4-C, 15,960 salmon, was slightly below the low end of the guideline harvest range of 16,000 - 47,000 fish.

Based on a preliminary Yukon River sonar passage estimate of approximately 2.0 million summer chum salmon, reported commercial and estimated subsistence harvest statistics, and the estimated escapement to the Anvik River, approximately 600,000 summer chum salmon escaped to tributaries above the Yukon River sonar site, other than to the Anvik River. This escapement level is nearly double the estimated 1993 escapement level. Consequently, unlike 1993, escapement goals appear to have been achieved throughout the drainage in 1994 (ADF&G 1994b). An aerial survey of the Nulato River to estimate escapement was not conducted this year because of poor survey conditions. However, based on in-season data from the Nulato River tower project, it was assumed that the minimum aerial survey escapement goal of 53,000 salmon for the North Fork Nulato River would probably be achieved. The tower-based escapement estimate of 148,762 summer chum salmon on the mainstem Nulato River (Table 3), under less than optimal viewing conditions, suggested that the aerial survey escapement goal for the North Fork Nulato River, of 53,000 chum salmon, was probably achieved. A tower-based escapement estimate of 39,343 summer chum salmon on the Salcha River (Table 1) indicated that the aerial survey escapement goal of 3,500 for that tributary was also achieved. Escapement surveys of the two other tributaries which have established escapement goals, Clear and Caribou Creeks of the Hogatza River, were not conducted during 1994. Aerial surveys, tower, and weir counts of escapements to other upper river tributaries, which do not have established escapement goals

(Table 1), indicated that summer chum salmon escapement was very good. Further, a weir count of 200,981 summer chum salmon on the East Fork of the Andreafsky River (Table 1) indicated that escapement to lower river tributaries was also good. This evaluation of good river-wide summer chum salmon escapement is much improved from the poor escapements observed for spawning stocks, other than the Anvik River, in recent years. However, the effect on the quality, or sex ratio, of the escapement in Upper Yukon Area tributary streams, from the catch and release of male salmon by commercial fishers, particularly in Subdistrict 4-A, is unknown.

Chinook Salmon

The estimated chinook salmon escapement for the period 29 June through 23 July was 1,795 salmon (Table 4). This estimate of chinook salmon escapement is believed to be conservative because of the poor visibility encountered during most of the season for the middle section of the observation transect at the tower site.

The first quartile day of passage for the chinook salmon escapement occurred on 6 July; the median day of passage occurred on 9 July; and the third quartile day of passage occurred on 14 July. The duration of the mid-50% portion of the 1994 run was 8 days. Although the first quartile day of passage of the two runs differed by two days, the timing of the chinook and summer chum salmon runs into the Nulato River were very similar (Figure 3). However, because of the high turbid water, which precluded observation of salmon during the first part of the migrations, the actual timing of the two runs were probably more different than observed.

Daily expanded passage estimates of chinook salmon ranged from 0 on 29 June to 216 on 5 July. A similarly high passage estimate of 208 chinook salmon was also recorded on 6 July. Except for those two days with estimated passage counts in excess of 200 chinook salmon, total daily passage was relatively stable throughout the mid-50% portion of the run (Figure 4). Expanded hourly counts of chinook salmon passage by bank are provided in Appendices C and D.

During the 1994 season a higher proportion of chinook salmon migrated past the tower site during the mid-afternoon and evening hours (Figure 5). However, the pattern was not as consistent for chinook salmon as observed for chum salmon (Figure 5). This inconsistency was probably caused, at least in part, by the relatively low number of chinook salmon observed passing the tower site, as compared to summer chum salmon passage. Generally, chinook salmon passage was lowest in the morning hours and greatest in the mid-afternoon and evening hours (Figure 5). No obvious bank orientation was observed for chinook salmon passing the towers (Table 4).

Although the tower-based chinook salmon escapement estimate for the Nulato River was only 38% above the combined aerial survey-based escapement goal for both forks of the Nulato River, the poor visibility within the middle section of the observation transect at the Nulato tower site, which persisted much of the season, probably resulted in a substantial, but unknown, number of chinook salmon to pass the tower site uncounted. Primarily because the tower estimate is conservative, and secondarily because of very good chinook salmon escapements observed in the rest of the drainage, it is believed that the aerial survey goals of the North Fork, 800 salmon, and South Fork, 500 salmon, of the Nulato River were achieved.

Age and Sex Composition

Summer Chum Salmon

Beach seine sets were made from 23 June to 19 July on 12 individual days. During the early portion of the run, when chum salmon were not abundant, as many as eight individual sets were made in one day. During the season, a total of 828 chum salmon, ten chinook, and a number of non-salmon species were captured during beach seining operations (Appendix E). One pink salmon was captured on 12 July. Number of chum salmon sampled by the field crew by stratum were 152, 156, 152, and 153 for the four sampling strata, respectively. The sampling goal of 138 ageable scales per stratum was achieved for the first and second stratum. Ageable scales totaled 134, or 97% of the sampling goal, for the third stratum, and 129, or 93% of the sampling goal, for the final stratum (Appendix E). Overall, of the 613 chum salmon sampled for age-sex-size data, 551 (90%) had ageable scales. The 1994 percentage of ageable scales was as anticipated, 90%. However, it appears that percentage of ageable scales declined over the season from a high of 96%, during the first stratum, to a low of 84% during the final stratum. Because of this decline in ageable scales during the season, it is recommend that the sample goal be increased in the 1995 operational plan to 160 chum salmon per stratum to compensate for the decline in the number of ageable scales during the season. A similar chum salmon sample goal for each stratum has been established for Anvik River chum salmon sampling.

Sex composition from beach seine samples was used to apportion chum salmon passage by sex by stratum. Male chum salmon dominated all sampling strata (Figure 8), ranging from 53.4% in the first stratum to 63.9% in the third stratum. Overall, female chum salmon accounted for an estimated 41.8% of the total escapement. Male to female sex ratio was 1.37:1.00. Conversely, female chum salmon dominated every sampling stratum during the 1994 summer chum escapement into the Anvik River. Typically, female chum salmon dominated at least the last two sampling strata of the Anvik River escapement since 1989 (Sandone 1995).

In the Nulato River, age-5 chum salmon dominated the first three sampling strata (Figure 8), ranging from 89.7% in the first to 58.2% in the third stratum. The proportion of age-4 salmon, however, increased from 7.5% during the first stratum to 58.9% in the final stratum (Figure 8). A similar pattern has been observed in the Anvik River escapement in 1994 (Sandone 1995), as well as in previous years. Age composition of the Nulato River escapement, weighted by strata escapement estimates, was 0.4% age 3, 35.8% age 4, 63.0% age 5, and 0.9% age 6. This age composition is remarkably similar to the age composition of the 1994 Anvik River summer chum salmon escapement: 0.0% age 3, 34.9% age 4, 63.9% age 5, and 1.2% age 6 (Sandone 1995). However, two operational problems may have affected the accuracy of the Nulato River age composition estimates. In 1994, proportionally more male chum salmon were sampled and aged than captured during beach seining operations (Appendix E). Usually, a majority of age-5 chum salmon are male. Therefore, because proportionally more male salmon were sampled and aged than actually captured, and most of the age-5 chum salmon are male, the estimated age-5 composition of the escapement may be biased slightly higher than actual. However, the age-5 component may have also been substantially underestimated because of the late initiation of observations from the tower. Note that during the first stratum, 29 June - 3 July, age-5 chum salmon accounted for 89.7% of captured salmon. However, because counting operations were not initiated until 29 June, a substantial portion of the summer chum salmon escapement may have passed the tower site without being observed. This inability to observe the migrating salmon during this stratum probably resulted in a substantial underestimate of the total passage of age-5 summer chum salmon.

Approximately 80% of the Subdistrict 4-A summer chum salmon harvest was apportioned by age based on ASL samples collected by period, statistical area, and gear type. Female chum salmon accounted for 81% of this harvest. However, this percentage of females was considered to be erroneously high because fishers frequently sorted their catch by sex, disposing of, or releasing, male chum salmon before department personnel sampled the catch. As a result, sex ratio of the harvest was not determined from ASL samples. Sex ratio was determined from samples of salmon collected from unsorted boxes, or from counts, by sex, of fish as they were captured by fish wheels. Using these samples, the estimated percent female composition of Subdistrict 4-A summer chum salmon was 59%.

Age-class and sex composition of the Subdistrict 4-A harvest differed substantially from the Nulato River escapement. Although both escapement and harvest samples contained few age-3 and age-6 salmon, the escapement was dominated by age-5 salmon, whereas the harvest was dominated by age-4 salmon. The weighted age-class composition estimate of the sampled Subdistrict 4-A summer chum salmon harvest was 0.0% age 3, 61.8% age 4, 36.5% age 5, and 1.7% age 6. Additionally, female salmon dominated the sex ratio in three of the four commercial samples for sex ratio. For all periods, percent female ranged from 50% during the second commercial period to 70% during the third period. However, male chum salmon dominated all escapement sampling strata (Figure 8).

The timing of the commercial fishery, in conjunction with the observed age-class composition shift from age-5 in the earlier portion to age-4 salmon in the latter portion of the escapement (Figure 8) may account for a large part of the apparent age-composition differences. In 1994, the first commercial opening occurred in Subdistrict 4-A on 7-8 July. By 8 July, the ending date of the second escapement sampling stratum, nearly half of the observed escapement had passed the Nulato River tower site and was unavailable for harvest. Age-5 salmon dominated this portion of the escapement (Figure 8). Additionally, the age composition of the remaining portion of the escapement was represented by nearly equal numbers of age-4 and age-5 chum salmon. Approximately 68% of the Subdistrict 4-A summer chum salmon harvest was taken after 11 July, or well after the first half of the Nulato River escapement had passed the tower. Additionally, most of this harvest was taken from that portion of the Nulato River run which would have passed the tower site during the last couple days of the third, 9 - 13 July, and during the fourth, 13 - 23 July, sampling strata. Because the proportion of age-4 salmon dominated the final sampling stratum, most salmon passing the tower site during this time were probably age-4 fish. Additional factors which may contribute to the explanation of these age-class differences include differences in run strengths, run timing, and age-class compositions of the various summer chum salmon stocks of the Yukon River drainage which pass through Subdistrict 4-A, and a possible sampling bias introduced because a vast majority (80%) of the commercial ASL samples were obtained from female salmon. Because the sex composition of individual age classes may be dominated by a particular sex, sampling one sex disproportionately, would tend to bias the sample in favor of the dominant age of that sex.

Differences in sex composition between the commercial harvest and the Nulato River escapement are more difficult to explain. Possible explanations may include: 1) differences in run strengths, sex compositions, and run timing of the various summer chum salmon stocks of the Yukon River drainage which pass through Subdistrict 4-A; 2) the return of large numbers of live male salmon to the river by fishers who use fish wheels; 3) a sampling bias because of the small sample sizes used for determination of the sex composition of the commercial harvest; and 4) a sampling bias toward male chum salmon in the escapement sample. Additionally, another inconsistency was observed in the Nulato River escapement samples which may be related to the Subdistrict 4-A harvest. In the escapement samples the proportion of female salmon decreased while the age-4 component increased during the first three sampling strata (Figure 8). For the Anvik River escapement, the proportion of female salmon and the age-4 component generally increase during the season (Sandone 1990a, 1990b, 1993, 1994a, 1994b, 1995). This trend is thought to occur because: 1) a majority of age-5 summer chum salmon are male, while the majority of age-4 summer chum salmon are female; and 2) male chum salmon, within an age class, usually arrive on the spawning grounds earlier than the female component. If, however, the harvest and escapement sex ratio samples, collected during the 1994 season, actually represent the harvest and escapement, the selective nature of the Subdistrict 4-A summer chum fishery may have a substantial impact on the quality of the escapement, not only to the Nulato River, but possibly to other Upper Yukon Area tributaries, as well. To determine the impact of this fishery on the quality of summer chum salmon escapement in tributaries above the Anvik River, it is recommended that a more rigorous sampling program for sex composition be established for both the commercial fishery and escapement-monitoring projects.

Chinook Salmon

Only ten chinook salmon were captured by beach seine. Unlike on the Anvik River, chinook salmon carcass samples were not collected. Therefore, age composition of the chinook salmon escapement is unavailable.

Hydrologic and Climatological Sampling

Maximum river depth, and probably maximum river width, during project operations occurred on the evening of 25 June, or the early morning hours of 26 June (Appendix F). An observation during the evening hours of 25 June or the morning hours of 26 June indicated that the river crested at 1.5 cm (0.05 ft; Appendix F) above the initial relative reading of 0.0 cm. River water level dropped approximately 40.2 cm between 26 June and 8 July in a relatively consistent and regular manner (Figure 9). However, during the 5-d period, from 9 July to 13 July, river water level increased 32.0 cm because of frequent, heavy rains. After this freshet, river water level declined, with only one minor interruption (Figure 9).

Instantaneous water temperature ranged from a low of 7° C recorded on the first two days of record, 22 and 23 June, to a high of 13° C recorded on 17 and 19 July. Because a min/max thermometer was not available prior to 12 July, instantaneous air temperatures were collected daily at the time when weather was observed. During this time instantaneous air temperatures ranged from 10° C, observed on 8 July, to a high of 22° C on 30 June and 1 July (Figure 9). Daily minimum and maximum air temperatures were available only after 11 July. During this time daily minimum and maximum air temperatures ranged from a minimum low of 8° C, observed on 21 July, to a maximum high of 27° C, observed on 14 and 17 July (Figure 9). Although the daily minimum low air temperature probably occurred prior to 12 July, during the time when minimum and maximum temperatures were not recorded, it is uncertain if the maximum air temperature occurred prior to 12 July.

GSI Sampling

Heart, liver, eye, and muscle tissues were collected and preserved in liquid nitrogen from 100 adult summer chum salmon collected at the Nulato River tower site during the 1994 season. Samples were transported to the Anchorage-based genetics laboratory of the CFM&D Division, ADF&G, where they were analyzed. Preliminary results from ongoing Yukon River chum salmon research indicates that as many as eight potential genetic groups have been identified for Yukon River chum salmon stock. Additionally, this research indicates that Nulato River chum salmon are most genetically similar to the group identified as the lower summer run group. In addition to the Nulato River summer chum salmon, this group is also composed of summer chum salmon from the Andreafsky, Chulinak, or Atcheulinguk, Innoko (rkm 441), Anvik, Rodo, Kaltag, and Melozitna Rivers which drain into the Yukon River, and the Gisasa, Huslia (rkm 1,144), and Dakli (rkm 1,215) Rivers, which drain into the Koyukuk River (Lisa Seeb, ADF&G, Anchorage, personal communication).

Run Timing

Summer chum salmon run timing at the lower Yukon River set gillnet test fishery site (rkm 32), the Yukon River (rkm 198) and Anvik River (576 rkm) sonar sites, and Katlag River (724 rkm) and Nulato River (782 rkm) tower sites were compared to provide a qualitative assessment of summer chum salmon migration through the lower and middle Yukon River areas, up to the Koyukuk River. As previously stated, because the timing of the peak aerial survey period for observing summer chum salmon in the Anvik and Nulato Rivers overlap, run timing was expected to be similar. Run timing of summer chum salmon escapement into Kaltag Creek and

Nulato River were anticipated to be identical because of their close proximity to each other, 58 km. However, because Kaltag Creek and the Nulato River project sites are approximately 214 km and 232 km, respectively, upriver of the mouth of the Anvik River, it was also assumed that escapement timing into these rivers would be slightly later than that at the Anvik River sonar site. However, the comparison of timing statistics between the Anvik River and Kaltag Creek escapement resulted in a surprising degree of similarity (Table 5). The first quartile and median day of passage for the Kaltag Creek escapement was 1 day earlier than the Anvik River escapement, while the third quartile days of passage were identical. Because it is suspected that a substantial portion of the summer chum salmon escapement was not observed during the first portion of the escapement into the Nulato River, the calculated timing statistics for this tributary was probably later than actual. Therefore, it is assumed that the timing statistics of the Kaltag Creek escapement also represented the timing statistics of the escapement into the Nulato River for purposes of this comparison.

As in previous years, Sandone (1995) assumed a 10-d travel period for summer chum salmon passage between the Yukon River sonar and the Anvik River sonar sites for the 1994 season. This travel time was primarily based on the run timing differences between these two sonar sites from 1986-1994, excluding 1992, and from the periodicity of Yukon River and Anvik River sonar passage estimates (Paul Skvorc, ADF&G, Anchorage, personal communication). Therefore, because of the similarity between the Anvik River and Kaltag Creek run timing statistics (Table 5), and the assumed similarity between Kaltag Creek and Nulato River escapement timing, a 10-day lag period from Yukon River sonar to all three tributary escapement project sites was employed (Figure 10).

The distance from the Yukon River sonar site to the various escapement projects varies by as much as 584 km. This distance translates into approximately 14 days chum salmon travel time, based on the estimated mean (1986-1993) travel time between the Yukon River and Anvik River sonar sites of 42 km/d (Sandone 1995). Two scenarios are plausible which would provide for the arrival of these different summer chum salmon stocks on the spawning grounds at basically the same time. If the Anvik River, Kaltag Creek and Nulato River-bound summer chum salmon pass the Yukon River sonar site at the same time, swimming speeds must vary because of the differences in distance among the sites. Calculated swimming speeds of chum salmon between the Yukon River sonar site and the Kaltag Creek and Nulato River tower sites, based on distance and the number of days between median days of passage at the three sites, are 58 km/d and 49 km/d, respectively. Note that these swimming speeds are much faster than the estimated speed the chum salmon travel between the Yukon River and Anvik River sonar sites, based on the same assumptions.

The more plausible scenario assumes that chum salmon stocks migrate throughout the Yukon River drainage at relatively similar speeds, and that chum salmon stocks destined to spawn in more distant tributaries enter the Yukon River earlier than chum salmon stocks destined to spawn in tributaries closer to the mouth of the Yukon River. This scenario is supported by information presented by Sandone (1995), who compared East Fork Andreafsky and Anvik River summer chum run timing. He found that, although the mouth of the Andreafsky River is approximately

400 km down river of the Anvik River sonar site, run timing statistics for these stocks were very similar. He speculated that the middle portion of the chum salmon run which passed the weir site on the East Fork Andreafsky River probably passed the lower Yukon River test net sites during the latter half of the total Yukon River summer chum salmon migration. It appears that chum salmon passing the Andreafsky River weir site, the Anvik River sonar site, and the Kaltag Creek and Nulato River tower sites all pass the project sites on these rivers at relatively the same time. This occurs even though some of these tributary river escapement projects are separated by over 600 km. However, this relationship does not appear to be true for chum salmon spawning in the Chena and Salcha Rivers in the Tanana River drainage. The median day of summer chum salmon passage for these two rivers in 1994 was no earlier than 27 and 28 July, respectively.

The duration of the mid-50% of the summer chum run passing the Nulato River tower site lasted 9 days, 4-13 July. Although the duration of the passage of this mid-50% portion of the run is similar to the Anvik River run, 10 days, the timing of the passage was 2 to 3 days later than for the Anvik River escapement, which occurred from 1-11 July (Figure 10). However, run timing past the tower site on Kaltag Creek, which is only 53 km down river of the mouth of the Nulato River, indicated that the timing was very similar to the Anvik River escapement (Figure 10). Because high, turbid river water prohibited the counting of salmon from the tower on the Nulato River during the early portion of the escapement, the actual timing statistics for the Nulato River escapement may be earlier than calculated. Based on the assumption that the timing of summer chum escapement into Kaltag Creek and the Nulato River were similar, it can be speculated as to the number of salmon which were not counted during the early portion of the Nulato River escapement. Assuming that the first quartile day of passage for the Nulato River escapement was the same as for Kaltag Creek, 30 June, it is estimated that approximately 36,000 chum salmon passed the Nulato River tower prior to the initiation of counting operations. The addition of this estimate to the estimate obtained during the operational period would result in a summer chum salmon escapement estimate of approximately 185,000 salmon. Additionally, the median day of passage would be the same for both the Kaltag and Nulato escapements, 6 July. However, the third quartile day of passage would occur one day later in the Nulato River. Consequently, the duration of the mid-50% of the escapement would be one day more than for Kaltag Creek.

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TABLES

Table 1. Summer chum salmon escapement counts for selected spawning areas in the Yukon River drainage, 1973-1994.

	Andreafsky River							Nulato River					Hogatza River[a]					
	East Fork			Anvik River			Kaltag Cr.	Aerial		Mainstem	Gisasa River		(Clear &		Chena River		Salcha River	
Year	Aerial[a]	Sonar, Tower, or Weir Cnts	West Fork[a]	Tower & Aerial[b]	Sonar	Rodo River[a]	Tower Counts	South Fork	North Fork[c]	Tower Counts	Aerial	Weir	Caribou Creeks)	Tozitna River[a]	Aerial	Tower	Aerial	Tower
1973	10,149 [d]		51,835	249,015											79 [d]		290	
1974	3,215 [d]		33,578	411,133		16,137		29,016	29,334		22,022			1,823	4,349		3,510	
1975	223,485		235,954	900,967		25,335		51,215	87,280		56,904		22,355	3,512	1,670		7,573	
1976	105,347		118,420	511,475		38,258		9,230 [d]	30,771		21,342		20,744	725 [d]	685		6,484	
1977	112,722		63,120	358,771		16,118		11,385	58,275		2,204 [d]		10,734	761 [d]	610		677 [d]	
1978	127,050		57,321	307,270		17,845		12,821	41,659		9,280 [d]		5,102	2,262	1,609		5,405	
1979	66,471		43,391		280,537			1,506	35,598		10,962		14,221		1,025 [d]		3,060	
1980	36,823 [d]		114,759		492,676			3,702 [d]	11,244 [d]		10,388		19,786	580	338		4,140	
1981	81,555	147,312 [g]			1,486,182			14,348							3,500		8,500	
1982	7,501 [d]	181,352 [g]	7,267 [d]		444,581						334 [d]		4,984 [d]	874	1,509		3,756	
1983		110,608 [g]			362,912			1,263 [d]	19,749		2,356 [d]		28,141	1,604	1,097		716 [d]	
1984	95,200 [d]	70,125 [g]	238,565		891,028								184 [d]		1,861		9,810	
1985	66,146		52,750		1,080,243	24,576		10,494	19,344		13,232		22,566	1,030	1,005		3,178	
1986	83,931	167,614 [h]	99,373		1,189,602			16,848	47,417		12,114			1,778	1,509		8,028	
1987	6,687 [d]	45,221 [h]	35,535		455,876			4,094	7,163		2,123		5,669 [d]		333		3,657	
1988	43,056	68,937 [h]	45,432		1,125,449	13,872		15,132	26,951		9,284		6,890	2,983	432		2,889 [d]	
1989	21,460 [d]				636,906										714 [d]		1,574 [d]	
1990	11,519 [d]		20,426 [d]		403,627	1,941 [d]		3,196 [d, j]	1,419 [d]		450 [d]		2,177 [d]	36	245 [d]		450 [d]	
1991	31,886		46,657		847,772	3,977		13,150	12,491		7,003		9,947	93	115 [d]		154 [d]	
1992	11,308 [d]		37,808 [d]		775,626	4,465		5,322	12,358		9,300		2,986	794	848 [d]		3,222	
1993	10,935 [d]		9,111 [d]		517,409	7,867		5,486	7,698		1,581			970	168	5,487	212	5,563
1994 [y]		200,981 [n, p]			1,124,689		47,295			148,762 [r]	6,827	51,116 [s]			1,137	10,108	4,679	39,343
E.O.[t]	>109,000		>116,000		>500,000[v]				>53,000[x]				>17,000[x]				>3,500	

[a] Data obtained by aerial survey unless otherwise noted. Only peak counts are listed. Latest table revision April 3, 1995.
[b] From 1972-1979 counting tower operated; escapement estimate listed is the tower counts plus expanded aerial survey counts below the tower (see Buklis 1982).
[c] Includes mainstem counts below the confluence of the North and South Forks, unless otherwise noted.
[d] Incomplete survey and/or poor survey timing or conditions resulted in minimal or inaccurate count.
[f] Boat survey
[g] Sonar count.
[h] Tower count.
[j] Mainstem counts below the confluence of the North and South Forks Nulato River included in the South Fork counts.
[k] Tower Count
[n] Weir Count
[p] Weir installed on June 29. First full day of counts occurred on June 30.
[r] Tower counts delayed until June 29 because of high, turbid water. First full day of counts occurred on June30.
[s] Weir installed on July 11. First full day of counts occurred on July 12.
[t] Interim escapement objective.
[v] The Anvik River Escapement Objective was rounded upward to 500,000 from 487,000 in March, 1992.
[w] Interim escapement objective for North Fork Nulato River only.
[x] Consists of Clear and Caribou Creeks interim escapement objectives of 9,000 and 8,000, respectively.
[y] Preliminary.

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Table 2. Chinook salmon escapement counts for selected Alaskan spawning stocks in the Yukon River drainage, 1961-1994 [a]

Year	Andreafsky River East Fork Aerial	Andreafsky River East Fork Tower or Weir Cnt	Andreafsky River West Fork Aerial	Anvik River Aerial River[b]	Anvik River Aerial Index Area[b]	Nulato River Aerial North Fork[c]	Nulato River Aerial South Fork	Nulato River Mainstem Tower Counts	Gisasa River Aerial	Gisasa River Weir	Chena River Pop. Est. or Tower Counts	Chena River Aerial River	Chena River Aerial Index Area[d]	Salcha River Pop. Est. or Tower Counts	Salcha River Aerial River	Salcha River Aerial Index Area[f]
1961	1,003			1,226		376 [g]	167		266 [g]						2,878	
1962	675 [g]		762 [g]									61 [g,h]			937	
1963												137 [g]				
1964	867		705												450	
1965			344 [g]	650 [g]											408	
1966	361		303	638											800	
1967			276 [g]	336 [g]												
1968	380		383	310 [g]											739	
1969	274 [g]		231 [g]	296 [g]											461 [g]	
1970	665		574 [g]	368								6 [g]			1,882	
1971	1,904		1,682									193 [g,h]			158 [g]	
1972	798		582 [g]	1,198								138 [g,h]			1,193	1,034
1973	825		788	613								21 [g]			391	352 [j]
1974			285	471 [g]		55 [g]	23 [g]		161			1,016 [h]	959 [h]		1,857	1,620
1975	993		301	730		123	81		385			316 [h]	262 [h]		1,055	950 [j]
1976	818		643	1,053		471	177		332			531	496		1,641	1,473
1977	2,008		1,499	1,371		286	201		255			563			1,202	1,052
1978	2,487		1,062	1,324		498	422		45 [g]			1,726			3,499	3,258
1979	1,180		1,134	1,484		1,093	414		484			1,159 [g]			4,789	4,310 [j]
1980	958 [g]		1,500	1,330	1,192	954 [g]	369 [g]		951			2,541			6,757	6,126
1981	2,146 [g]		231 [g]	807 [g]	577 [g]		791					600 [g]			1,237	1,121
1982	1,274		851						421			2,073			2,534	2,346
1983				653 [g]	376 [g]	526	480		572			2,553	2,336		1,961	1,803
1984	1,573 [g]		1,993	641 [g]	574 [g]							501	494		1,031	906
1985	1,617		2,248	1,051	720	1,600	1,180		735			2,553	2,262		2,035	1,860
1986	1,954	1,530 [k]	3,158	1,118	918	1,452	1,522		1,346		9,065 [m]	2,031	1,935		3,368	3,031 [j]
1987	1,608	2,011 [k]	3,281	1,174	879	1,145	493		731		6,404 [m]	1,312	1,209	4,771 [m]	1,898	1,671
1988	1,020	1,339 [k]	1,448	1,805	1,449	1,061	714		797		3,346 [m]	1,966	1,760	4,562 [m]	2,761	2,553
1989	1,399		1,089	442 [g]	212 [g]						2,666 [m]	1,280	1,185	3,294 [m]	2,333	2,136
1990	2,503		1,545	2,347	1,595	568 [g]	430 [g,n]		884 [g]		5,603 [m]	1,436	1,402	10,728 [m]	3,744	3,429
1991	1,938		2,544	875 [g]	625 [g]	767	1,253		1,690		3,025 [m]	1,277 [g]	1,277 [g]	5,608 [m]	2,212 [g]	1,925 [g]
1992	1,030 [g]		2,002 [g]	1,536	931	348	231		910		5,230 [m]	825 [g]	799 [g]	7,862 [m]	1,484 [g]	1,436 [g]
1993	5,855		2,765	1,720	1,526	1,844	1,181		1,573		12,241 [k]	2,943	2,660	10,007 [k]	3,636	3,562
1994 [v]	300 [g]	7,801 [p,r]	213 [g]		913 [g]			1,795 [s]	2,775	2,888 [p,t]	12,006 [k]	1,570	1,570	18,376 [k]	11,823	11,189
E.O.[w]	>1,500		>1,400	>1,300[x]	>500[x]	>800	>500		>600				>1,700			>2,500

[a] Data obtained by aerial survey unless otherwise noted. Only peak counts are listed. Survey rating is fair to good, unless otherwise noted. Latest table revision: April 5, 1995.
[b] From 1961-1970, river count data are from aerial surveys of various segments of the mainstem Anvik River. From 1972-1979, counting tower operated; mainstem aerial survey counts below the tower were added to tower counts. From 1980-present, aerial survey counts for the river are best available minimal estimates for the entire Anvik River drainage. Index area counts are from the mainstem Anvik River between the Yellow River and McDonald Creek.
[c] Includes mainstem counts below the confluence of the North and South Forks, unless otherwise noted.
[d] Chena River index area for assessing the escapement objective is from Moose Creek Dam to Middle Fork River.
[f] Salcha River index area for assessing the escapement objective is from the TAPS crossing to Caribou Creek.
[g] Incomplete and/or poor survey conditions resulting in minimal or inaccurate counts.
[h] Boat survey.
[j] Data unavailable for index area. Calculated from historic (1972-91) average ratio of index area counts to total river counts (0.90:1.0).
[k] Tower Counts
[m] Population estimate
[n] Manistem counts below the confluence of the North and South Forks Nulato River included in the South Fork counts.
[p] Weir Counts
[r] Weir installed on June 29; first full day of counts June 30.
[s] Tower counts delayed until June 29 because of high, turbid water. First full day of counts occurred on June 30.
[t] Weir installed on July 11; first full day of counts July 12.
[v] Preliminary.
[w] Interim escapement objectives. Established March, 1992.
[x] Interim escapement objective for the entire Anvik River drainage is 1,300 salmon. Interim escapement objective for mainstem Anvik River between the Yellow River and McDonald Creek is 500 salmon.

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Table 3. Nulato River expanded summer chum salmon tower counts by date, 1994.

Date	North (left) Bank				South (right) Bank				Entire River				
	Raw Daily Count	Minutes Counted	Expanded Daily Count	Percentage of Daily Total	Raw Daily Count	Minutes Counted	Expanded Daily Count	Percentage of Daily Total	Raw Daily Count	Expanded Daily Count	Expanded Season Total	Daily Prop.	Season Prop.
20-Jun		0 [a]				0 [a]							
21-Jun		0 [a]				0 [a]							
22-Jun		0 [a]				0 [a]							
23-Jun		0 [a]				0 [a]							
24-Jun		0 [a]				0 [a]							
25-Jun		0 [a]				0 [a]							
26-Jun		0 [a]				0 [a]							
27-Jun		0 [a]				0 [a]							
28-Jun	\	0 [a]				0 [a]							
29-Jun	117	120 [a]	351 [b]	17.5	550	120 [a]	1,650 [b]	82.5	667 [b]	2,001 [b]	2,001	0.01	0.01
30-Jun	658	480	1,974	23.6	2,127	480	6,381	76.4	2,785	8,355	10,356	0.06	0.07
01-Jul	541	445	1,767	22.4	1,769	445	6,131	77.6	2,310	7,898	18,254	0.05	0.12
02-Jul	465	360	1,860	19.4	1,936	360	7,744	80.6	2,401	9,604	27,858	0.06	0.19
03-Jul	105	150 [a]	1,664 [c]	21.9	1,557	370	5,937	78.1	1,662	7,601 [d]	35,459	0.05	0.24
04-Jul	367	360	1,468	21.9	1,310	360	5,240	78.1	1,677	6,708	42,167	0.05	0.28
05-Jul	387	360	1,548	15.2	2,160	360	8,640	84.8	2,547	10,188	52,355	0.07	0.35
06-Jul	372	360	1,488	18.4	1,651	360	6,604	81.6	2,023	8,092	60,447	0.05	0.41
07-Jul	359	360	1,436	20.5	1,393	360	5,572	79.5	1,752	7,008	67,455	0.05	0.45
08-Jul	247	360	988	21.0	929	360	3,716	79.0	1,176	4,704	72,159	0.03	0.49
09-Jul	467	360	1,868	20.2	1,841	360	7,364	79.8	2,308	9,232	81,391	0.06	0.55
10-Jul	616	360	2,464	22.9	2,070	360	8,280	77.1	2,686	10,744	92,135	0.07	0.62
11-Jul	549	360	2,196	25.0	1,645	360	6,580	75.0	2,194	8,776	100,911	0.06	0.68
12-Jul	314	390	1,124	15.3	0	0 [a]	6,203 [g]	84.7	314	7,327 [d]	108,238	0.05	0.73
13-Jul	0	0 [a]	1,105 [h]	15.9	0	0 [a]	5,826 [g]	84.1	0	6,931 [d]	115,169	0.05	0.77
14-Jul	138	120 [a]	1,086 [h]	16.6	693	120 [a]	5,449 [g]	83.4	831	6,535 [d]	121,704	0.04	0.82
15-Jul	267	360	1,068	17.4	1,268	360	5,072	82.6	1,535	6,140	127,844	0.04	0.86
16-Jul	212	360	848	19.1	898	360	3,592	80.9	1,110	4,440	132,284	0.03	0.89
17-Jul	85	255	483 [h]	15.0	707	385	2,728	85.0	792	3,211	135,495	0.02	0.91
18-Jul	253	360	1,012	30.4	580	360	2,320	69.6	833	3,332	138,827	0.02	0.93
19-Jul	94	345 [a]	376 [k]	17.0	120	150 [a]	1,839 [m]	83.0	214	2,215 [d]	141,042	0.01	0.95
20-Jul	0	15 [a]	354 [k]	20.7	15	15 [a]	1,358 [m]	79.3	15	1,712 [d]	142,754	0.01	0.96
21-Jul	83	360	332	27.5	219	360	876	72.5	302	1,208	143,962	0.01	0.97
22-Jul	84	360	336	12.0	618	360	2,472	88.0	702	2,808	146,770	0.02	0.99
23-Jul	85	360	340	17.1	413	360	1,652	82.9	498	1,992	148,762	0.01	1.00
Total	6,865	7,720	29,536		26,469	7,485	119,226		33,334	148,762			
Mean				19.8				80.2	980	4,375		0.04	

[a] Poor visibility, resulting from high, turbid river water, interfered with or prohibited visual counting of salmon from towers.
[b] Partial count. Counting initiated on 29 June at 18:00 h on both banks.
[c] Total daily count unavailable. Total daily count was estimated by interpolating between expanded counts on 2 and 4 July.
[d] Includes an estimate of salmon passage for the portion of, or the whole day when counts were not possible.These estimates were based on hourly passage proportions or interpolated values.
[f] Total daily count unavailable. Total daily count was estimated by interpolating between the expanded counts on 11 and 15 July.
[g] Total daily count unavailable. Total daily count was estimated by interpolating between the expanded counts on 12 and 15 July.
[h] Daily count unavailable for period with hours ending 4:00 - 10:00 on 17 July. Daily count for 17 July was estimated by dividing the sum of the 11:00- 24:00 counts on 17 July by the mean passage proportion on 16 and 18 for the same time period.
[j] Daily count unavailable for period with hours ending 22:00 - 24:00 on 19 July. Daily count for 19 July was estimated by dividing the sum of the 1:00- 21:00 counts on 19 July by the mean passage proportion on 18 and 21 July for the same time period.
[k] Total daily count unavailable. Total daily count was estimated by interpolating between expanded counts on 19 and 21 July.
[m] Total daily count unavailable. Total daily count was estimated by interpolating between the expanded counts on 18 and 21 July.

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Table 4. Nulato River expanded chinook salmon tower counts by date, 1994.

Date	North (left) Bank				South (right) Bank				Entire River				
	Raw Daily Count	Minutes Counted	Expanded Daily Count	Percentage of Daily Total	Raw Daily Count	Minutes Counted	Expanded Daily Count	Percentage of Daily Total	Raw Daily Count	Expanded Daily Count	Expanded Season Total	Daily Prop.	Season Prop.
20-Jun		0 [a]				0 [a]							
21-Jun		0 [a]				0 [a]							
22-Jun		0 [a]				0 [a]							
23-Jun		0 [a]				0 [a]							
24-Jun		0 [a]				0 [a]							
25-Jun		0 [a]				0 [a]							
26-Jun		0 [a]				0 [a]							
27-Jun		0 [a]				0 [a]							
28-Jun		0 [a]				0 [a]							
29-Jun	0	120 [a]	0 [b]		0	120 [a]	0 [b]		0 [b]	0 [b]	0	0.00	0.00
30-Jun	0	480	0	0.0	1	480	3	100.0	1	3	3	0.00	0.00
01-Jul	0	445	0	0.0	2	445	6	100.0	2	6	9	0.00	0.01
02-Jul	9	360	36	50.0	9	360	36	50.0	18	72	81	0.04	0.05
03-Jul	1	150 [a]	36 [c]	50.0	9	370	36	50.0	10	72 [d]	153	0.04	0.09
04-Jul	9	360	36	60.0	6	360	24	40.0	15	60	213	0.03	0.12
05-Jul	10	360	40	18.5	44	360	176	81.5	54	216	429	0.12	0.24
06-Jul	25	360	100	48.1	27	360	108	51.9	52	208	637	0.12	0.35
07-Jul	22	360	88	73.3	8	360	32	26.7	30	120	757	0.07	0.42
08-Jul	18	360	72	85.7	3	360	12	14.3	21	84	841	0.05	0.47
09-Jul	20	360	80	87.0	3	360	12	13.0	23	92	933	0.05	0.52
10-Jul	16	360	64	64.0	9	360	36	36.0	25	100	1,033	0.06	0.58
11-Jul	5	360	20	17.9	23	360	92	82.1	28	112	1,145	0.06	0.64
12-Jul	3	390	10	10.9	0	0 [a]	82 [g]	89.1	3	92 [d]	1,237	0.05	0.69
13-Jul	0	0 [a]	24 [h]	25.0	0	0 [a]	72 [g]	75.0	0	96 [d]	1,333	0.05	0.74
14-Jul	4	120 [a]	38 [h]	38.0	6	120 [a]	62 [g]	62.0	10	100 [d]	1,433	0.06	0.80
15-Jul	13	360	52	50.0	13	360	52	50.0	26	104	1,537	0.06	0.86
16-Jul	6	360	24	54.5	5	360	20	45.5	11	44	1,581	0.02	0.88
17-Jul	6	255	29 [h]	56.9	6	385	22	43.1	12	51	1,632	0.03	0.91
18-Jul	4	360	16	40.0	6	360	24	60.0	10	40	1,672	0.02	0.93
19-Jul	6	345 [a]	24 [k]	55.8	2	150 [a]	19 [m]	44.2	8	43 [d]	1,715	0.02	0.96
20-Jul	0	15 [a]	14 [k]	50.0	0	15 [a]	14 [m]	50.0	0	28 [d]	1,743	0.02	0.97
21-Jul	1	360	4	33.3	2	360	8	66.7	3	12	1,755	0.01	0.98
22-Jul	1	360	4	50.0	1	360	4	50.0	2	8	1,763	0.00	0.98
23-Jul	8	360	32	100.0	0	360	0	0.0	8	32	1,795	0.02	1.00
Total	187	7,720	843		185	7,485	952		372	1,795			
Mean				46.6				53.4	11	53		0.04	

[a] Poor visibility, resulting from high, turbid river water, interfered with or prohibited visual counting of salmon from towers.
[b] Partial count. Counting initiated on 29 June at 18:00 h on both banks.
[c] Total daily count unavailable. Total daily count was estimated by interpolating between expanded counts on 2 and 4 July.
[d] Includes an estimate of the salmon passage which was not counted because of poor visibility. Salmon passage estimates when visibility was poor were based on hourly passage proportions or interpolated values.
[f] Total daily count unavailable. Total daily count was estimated by interpolating between the expanded counts on 11 and 15 July.
[g] Total daily count unavailable. Total daily count was estimated by interpolating between the expanded counts on 12 and 15 July.
[h] Daily count unavailable for period with hours ending 4:00 - 10:00 on 17 July. Daily count for 17 July was estimated by dividing the sum of the 11:00- 24:00 counts on 17 July by the mean passage proportion on 16 and 18 July for the same time period.
[j] Daily count unavailable for period with hours ending 22:00 - 24:00 on 19 July. Daily count for 19 July was estimated by dividing the sum of the 1:00- 21:00 counts on 19 July by the mean passage proportion on 18 and 21 July for the same time period.
[k] Total daily count unavailable. Total daily count was estimated by interpolating between expanded counts on 19 and 21 July.
[m] Total daily count unavailable. Total daily count was estimated by interpolating between the expanded counts on 18 and 21 July.

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Table 5. Comparison of run timing statistics of the Anvik River, Kaltag Creek, and Nulato River summer chum salmon escapements, 1994

Escapement Project Site	Yukon River km	Summer Chum Salmon Passage Estimate	Day of First Salmon Counts	First Quartile Day	Median Day	Third Quartile Day	Days between Quartile Days		
							First and Median	Median and Third	First and Third
Anvik River	576	1,124,689	19-Jun	01-Jul	07-Jul	11-Jul	6	4	10
Kaltag Creek	724	47,295	20-Jun	30-Jun	06-Jul	11-Jul	6	5	11
Nulato River [a]	782	148,762	29-Jun	04-Jul	09-Jul	13-Jul	5	4	9

[a] Initiation of counting operations delayed because of poor visibilty resulting from high, turbid river water.

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FIGURES

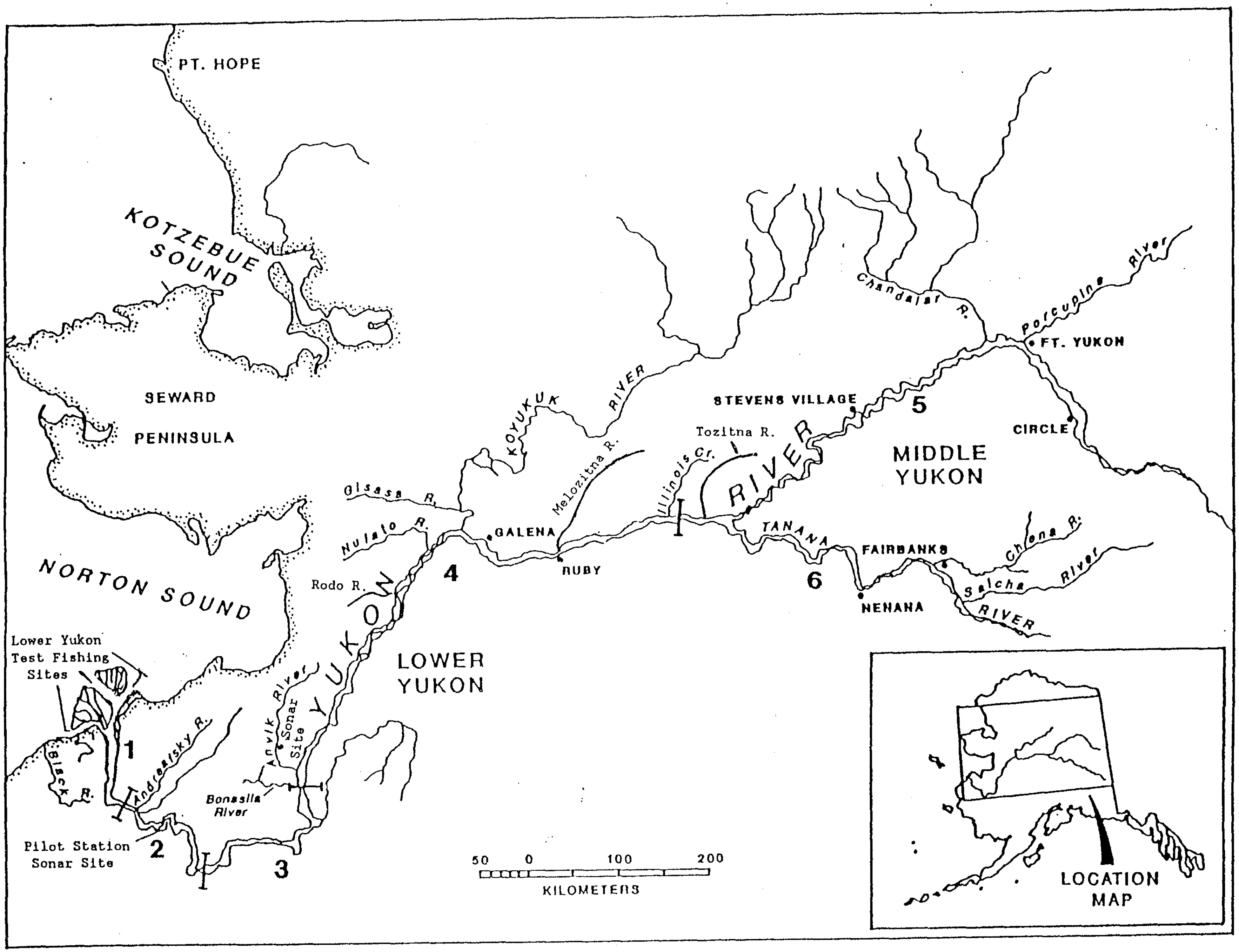

Figure 1. Alaskan portion of the Yukon River showing fishing district boundaries.

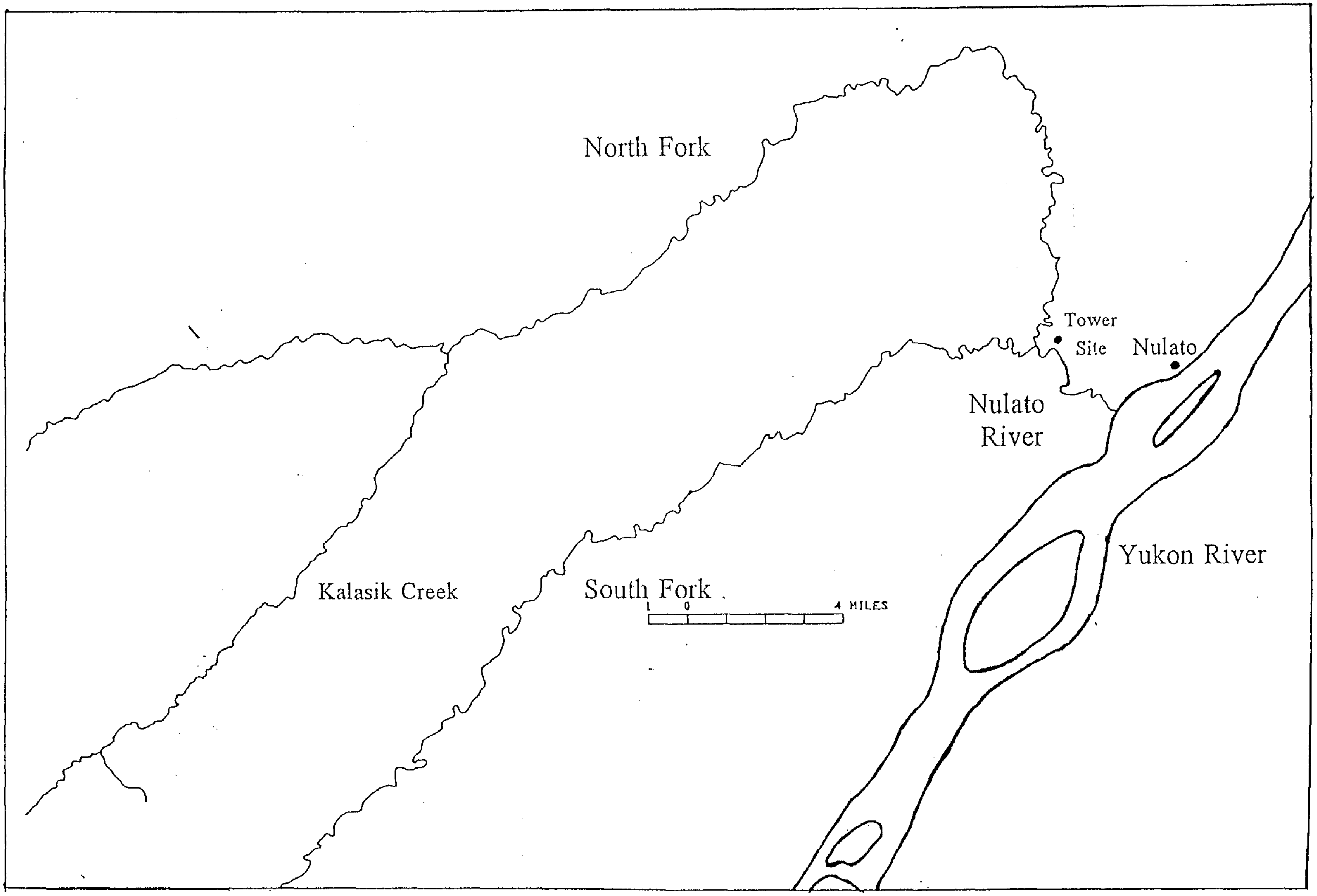

Figure 2. The Nulato River drainage showing the counting tower site

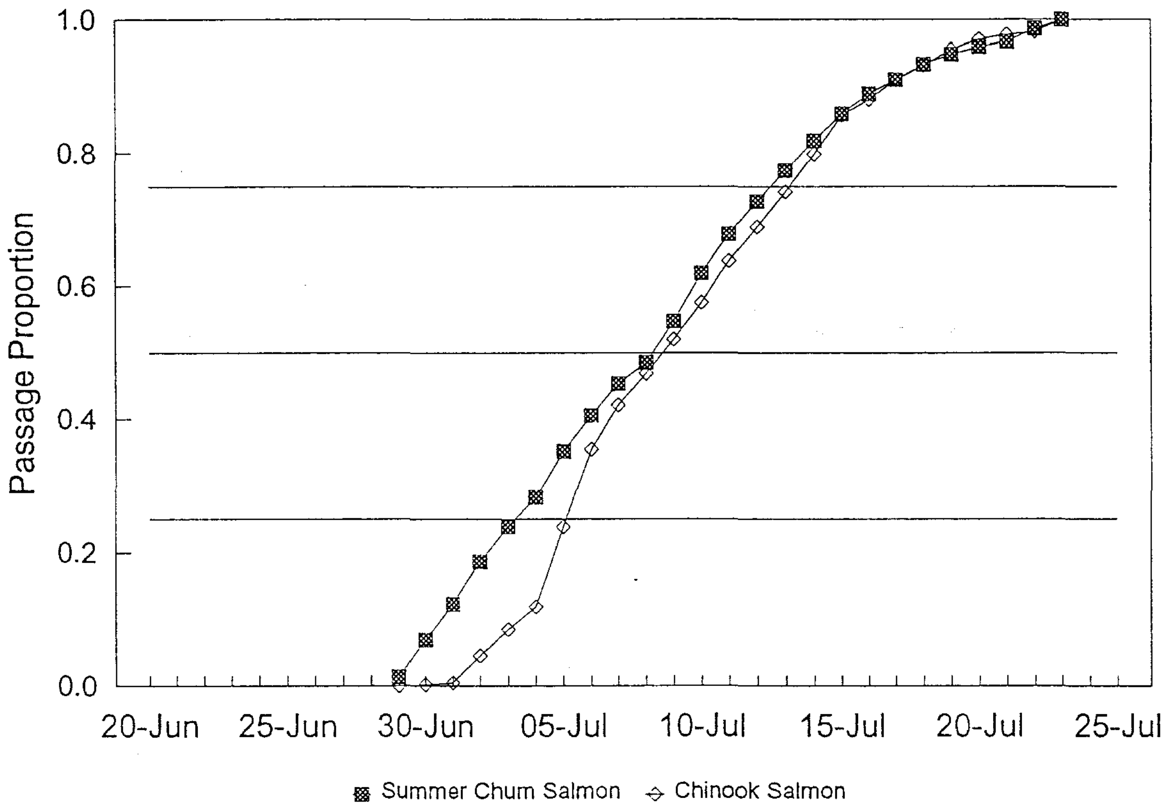

Figure 3. Run timing comparison of summer chum and chinook salmon escapement, Nulato River expanded tower counts, 29 June - 23 July, 1994. Horizontal lines indicate quartile proportions.

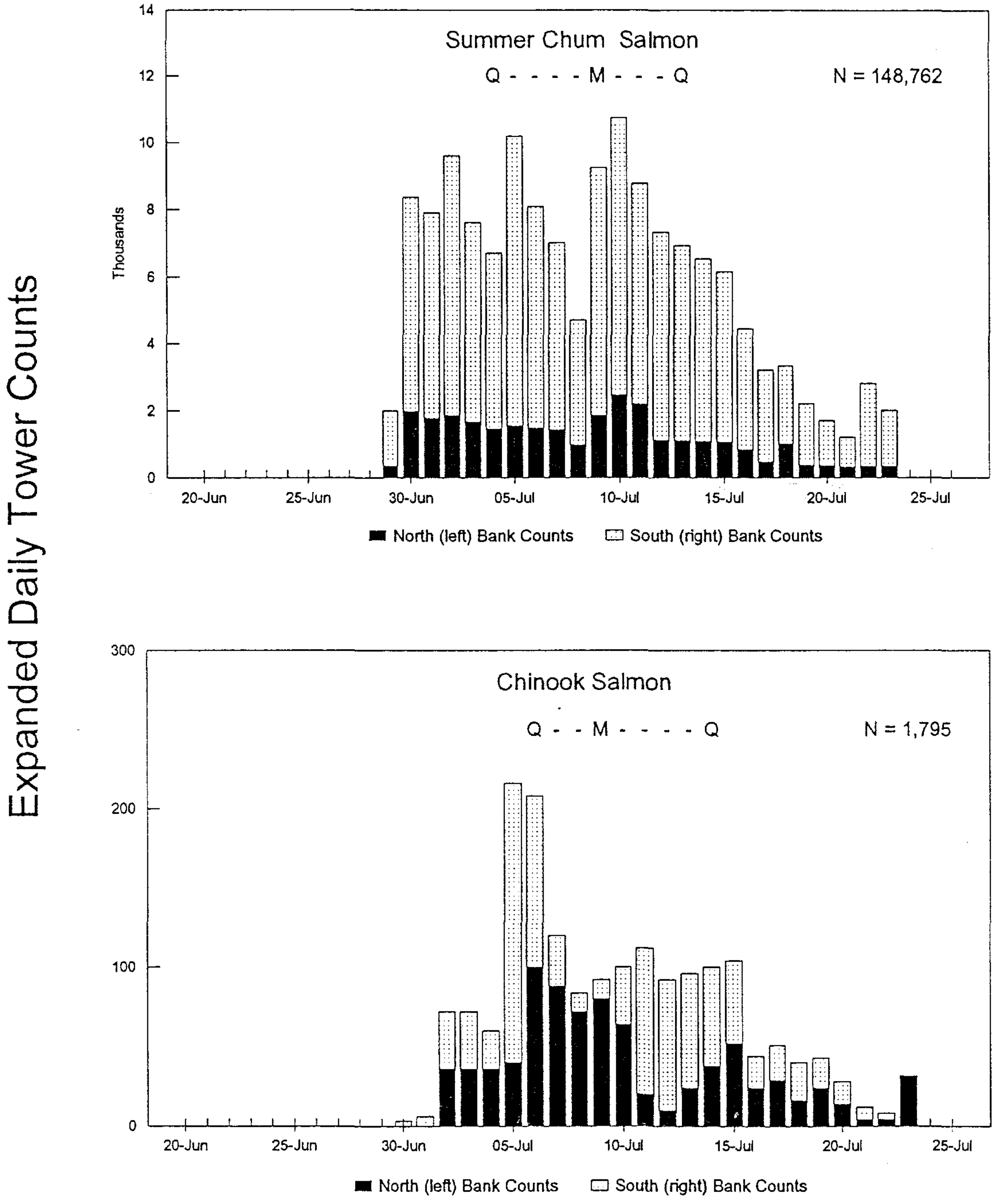

Figure 4. Nulato River expanded tower counts for summer chum (above) and chinook (below) salmon by day, 1994. Poor visibility, resulting from high, turbid river water, prohibited the counting of salmon from towers during the period 20 - 28 June and occasionally interfered with counting throughout the season.

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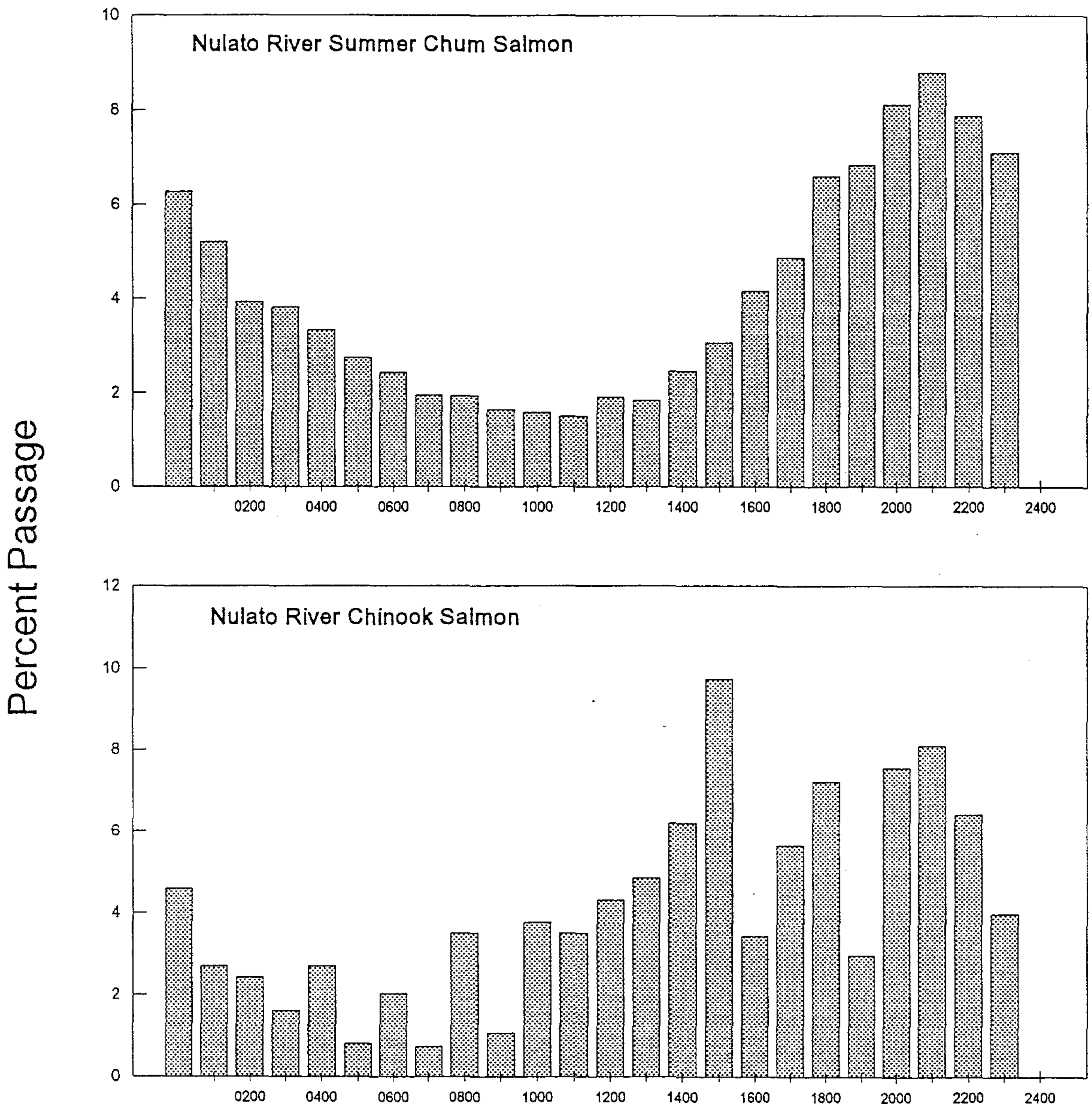

Figure 5. Estimated percent of summer chum (above) and chinook (below) salmon passage by hour of the day, Nulato River, 1994. Only days with at least 20 hours of counts were included.

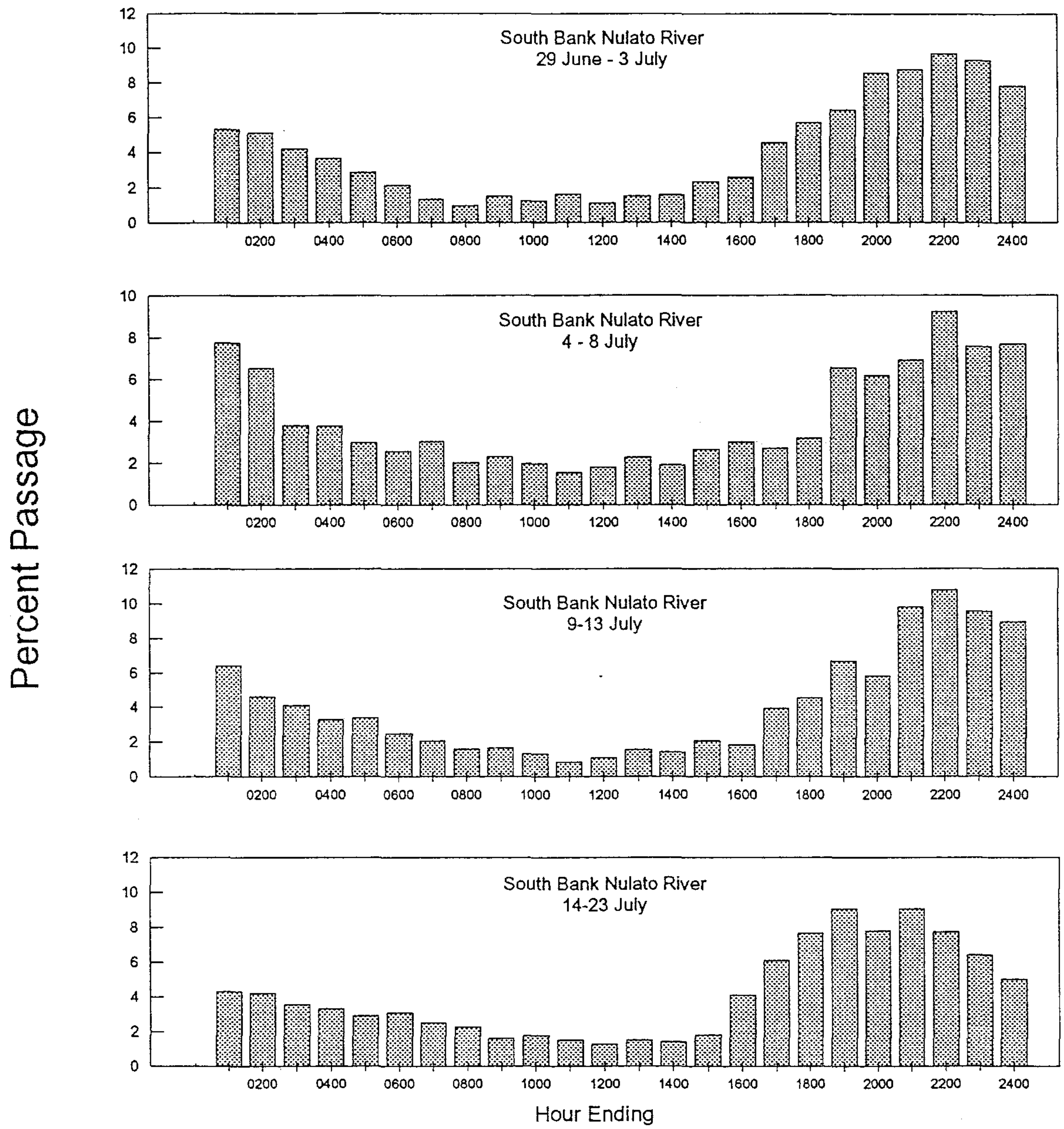

Figure 6. Estimated percent of summer chum salmon passage by sampling stratum and hour of the day, South (right) bank Nulato River, 1994. Only days with at least 20 hours of counts were included.

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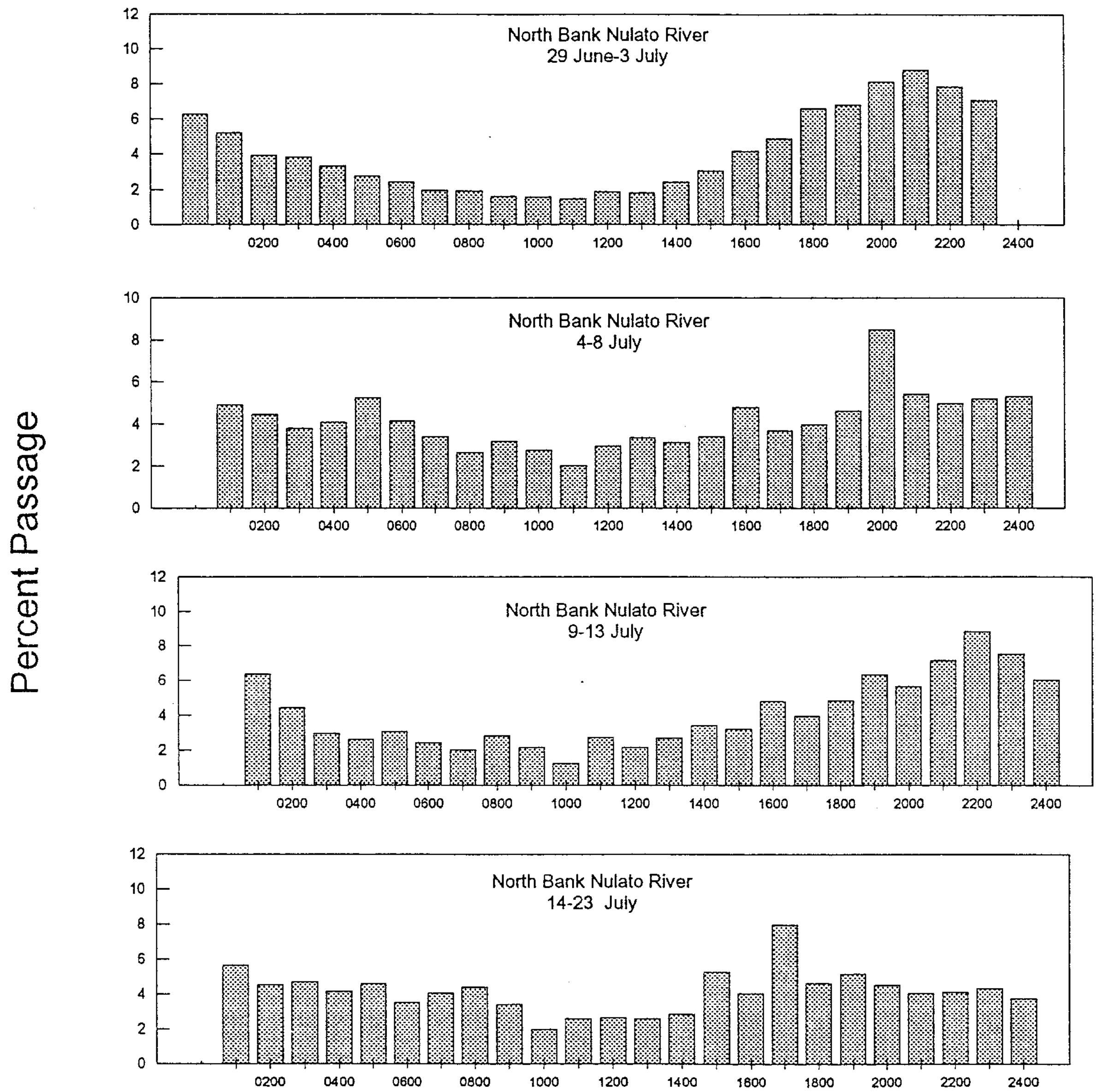

Figure 7. Estimated percent of summer chum salmon passage by sampling stratum and hour of the day, North (left) bank Nulato River, 1994. Only days with at least 20 hours of counts were included.

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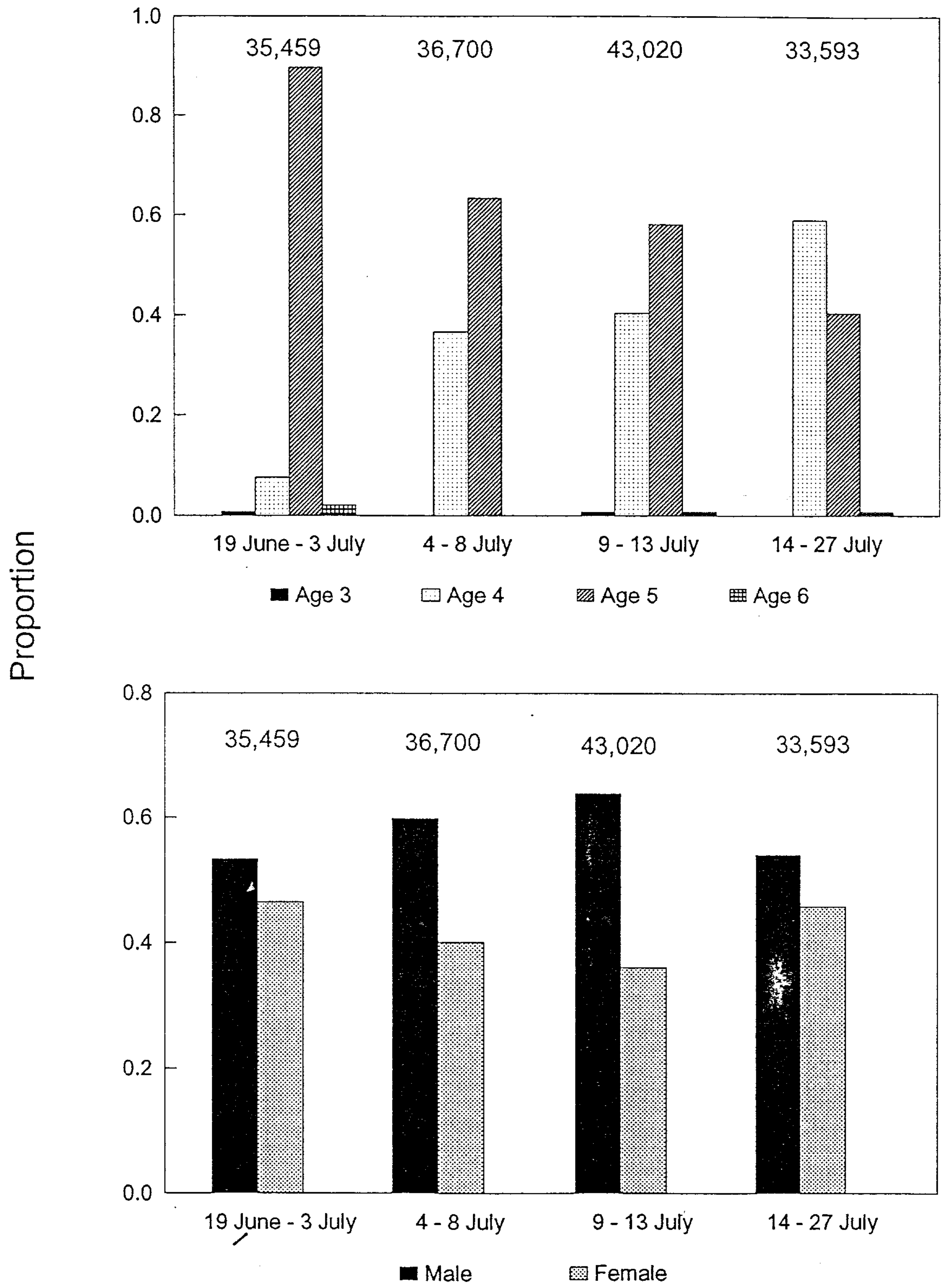

Figure 8. Age and sex compositon of sampled Nulato River summer chum salmon by sampling stratum, 1994. Numbers above bars indicate estimated passage during that stratum.

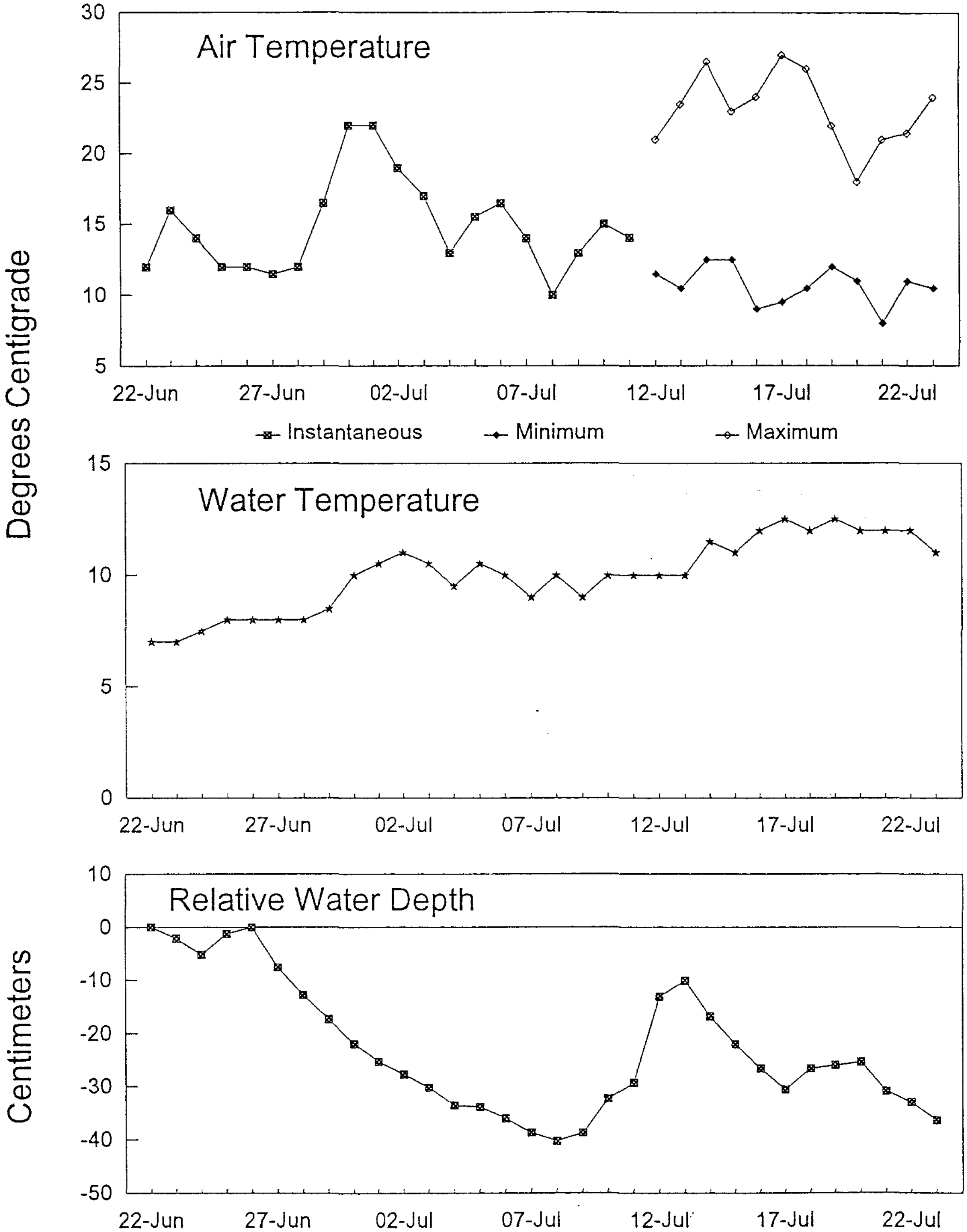

Figure 9. Available instantaneous, minimum, and maximum air temperatures, instantaneous water temperature, and relative water depth measured at approximately 1800 hours daily at the Nulato River tower site, 1994.

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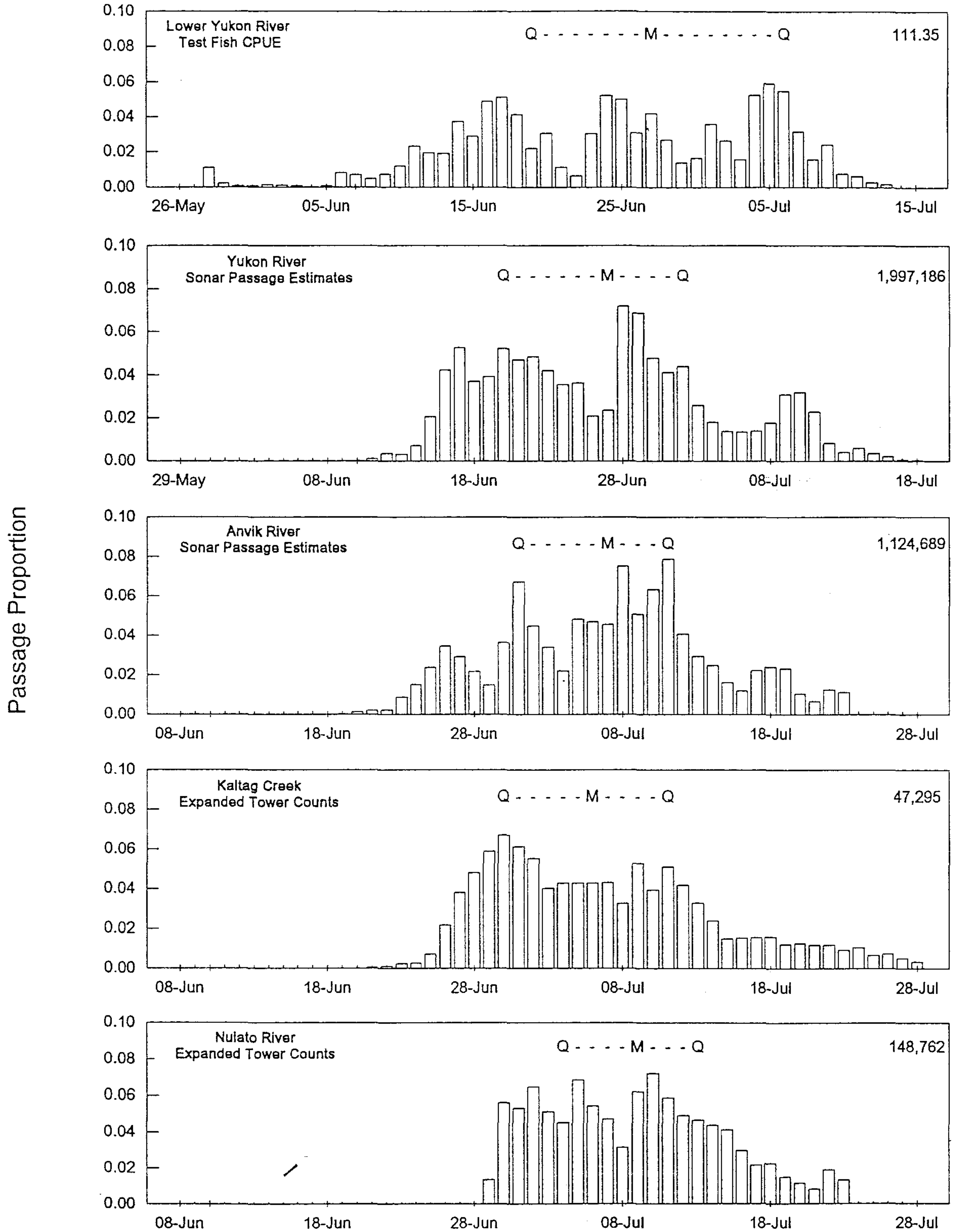

Figure 10. Run timing of the 1994 Yukon River summer chum salmon run, as indicated by daily passage proportions of Lower Yukon River test fish CPUE, Yukon River and Anvik River sonar passage estimates, and Kaltag Creek and Nulato River expanded tower counts. First and third quartiles are indicated by the "Q"s, while the median day of passage is indicated by the "M". Note that the Yukon River sonar graph is time lagged from the Lower Yukon River test fish CPUE graph by 3 days, while the rest of the graphs are time lagged by 13 days.

APPENDIX

Appendix A. South (right) bank Nulato River expanded summer chum salmon tower counts by hour and date, 20 June - 23 July, 1994.

Ending	20-Jun [a]	21-Jun [a]	22-Jun [a]	23-Jun [a]	24-Jun [a]	25-Jun [a]	26-Jun [a]	27-Jun [a]	28-Jun [a]	29-Jun [b]	30-Jun	01-Jul	02-Jul	03-Jul	04-Jul	05-Jul	06-Jul	07-Jul
01:00											177	498	304	416	460	340	372	748
02:00											294	465	288	292	416	416	304	432
03:00											336	294	296	176	196	212	232	196
04:00											318	144	204	292	176	244	240	200
05:00											276	198	128	140	196	176	260	188
06:00											150	165	132	116	116	140	180	172
07:00											72	102	152	28	260	208	192	88
08:00											63	90	84	20	136	124	112	152
09:00											57	144	92	104	104	176	152	120
10:00											27	90	104	104	132	132	164	76
11:00											48	84	160	136	80	124	160	48
12:00											48	42	64	136	140	184	124	24
13:00											108	90	76	128	212	144	172	68
14:00											66	69	108	176	200	92	148	72
15:00											138	126	184	164	224	240	200	68
16:00											126	57	348	140	196	400	168	56
17:00											300	177	492	216	172	248	124	176
18:00											201	492	460	340	204	256	188	196
19:00										165	396	492	324	476	292	816	360	340
20:00										159	624	412	640	568	268	540	420	472
21:00										366	729	564	552	456	272	936	332	296
22:00										249	579	460	1,060	440	232	1,204	628	488
23:00										366	549	428	936	528	340	580	636	532
24:00										345	699	448	556	345	216	708	736	364
Total										1,650	6,381	6,131	7,744	5,937	5,240	8,640	6,604	5,572

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Appendix A. (page 2 of 2).

Hour Ending	08-Jul	09-Jul	10-Jul	11-Jul	12-Jul [c]	13-Jul [c]	14-Jul [c]	15-Jul	16-Jul	17-Jul	18-Jul	19-Jul [d]	20-Jul [d]	21-Jul	22-Jul	23-Jul
01:00	392	376	724	324				140	156	116	168	80		60	72	96
02:00	384	380	512	136				68	268	176	132	92		32	28	80
03:00	296	248	452	212				80	284	84	108	72		20	20	68
04:00	264	164	356	216				56	252	72	100			4	28	112
05:00	68	216	360	180				60	236	44	132			4	4	64
06:00	152	152	268	136				52	172	72	116			24	32	108
07:00	156	140	208	116				40	156	75	88			16	28	64
08:00	76	112	116	132				64	120	69	88	32		8	48	24
09:00	136	136	92	148				76	64	42	48			12	24	40
10:00	84	104	96	100				132	88	42	28	4		20	12	16
11:00	52	64	72	52				88	60	20	40	16		20	32	28
12:00	64	104	64	76				56	88	24	12	40		24	20	16
13:00	80	116	132	104				76	40	28	36	16		12	28	68
14:00	60	80	120	116				76	68	24	16	64		16	40	24
15:00	56	132	160	168				76	76	0	48	28		8	104	28
16:00	80	88	180	144				212	92	80	260			12	68	40
17:00	88	140	176	564			220	336	140	140	204			44	216	64
18:00	100	208	324	484			236	548	176	120	284			44	152	112
19:00	140	520	420	540			408	408	220	444	120			68	340	92
20:00	140	360	564	372			516	392	296	244	68			76	280	100
21:00	224	920	804	448			524	672	176	264	76			80	264	160
22:00	196	928	748	716			372	564	100	268	44			112	244	112
23:00	164	712	728	680			304	504	120	172	56			48	192	104
24:00	264	964	604	416			192	296	144	108	48		60	112	196	32
Total	3,716	7,364	8,280	6,580	6,203	5,826	5,449	5,072	3,592	2,728	2,320	1,839 [g]	1,358 [h]	876	2,472	1,652

[a] Poor visibility resulting from high, turbid waters prohibited visual counting of salmon from towers.
[b] Counting initiated on 29 June at 18:00 h.
[c] Total daily count unavailable. Total daily count was estimated by interpolating between the expanded counts on 11 and 15 July.
[d] Total daily count unavailable. Total daily count was estimated by interpolating between the expanded counts on 18 and 21 July.

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Appendix B. North (left) bank Nulato River expanded summer chum salmon tower counts by hour and date, 20 June - 23 July, 1994.

Hour Ending	20-Jun [a]	21-Jun [a]	22-Jun [a]	23-Jun [a]	24-Jun [a]	25-Jun [a]	26-Jun [a]	27-Jun [a]	28-Jun [a]	29-Jun [a]	30-Jun [b]	01-Jul	02-Jul	03-Jul [c]	04-Jul	05-Jul	06-Jul	07-Jul
01:00											252	237	112	32	132	56	60	60
02:00											207	144	36	44	84	60	72	68
03:00											66	144	52	60	64	52	72	36
04:00											264	198	64	36	64	40	64	40
05:00											135	90	88	12	64	48	80	68
06:00											96	108	52	20	44	48	68	84
07:00											72	69	56	24	72	44	56	32
08:00											24	48	60	20	56	40	32	32
09:00											9	12	24	84	60	44	68	36
10:00											18	9	36	88	48	44	40	32
11:00											3	18	60		48	12	40	24
12:00											6	6	12		44	64	40	40
13:00											3	12	28		96	56	40	12
14:00											9	18	32		56	40	56	40
15:00											18	27	20		100	36	52	4
16:00											30	15	44		40	140	88	20
17:00											72	36	24		52	48	48	68
18:00											57	104	32		64	48	44	84
19:00										3	39	72	72		52	72	68	76
20:00										9	21	48	168		44	184	48	244
21:00										0	42	152	348		32	100	96	80
22:00										0	96	60	212		44	88	92	88
23:00										42	261	68	104		56	80	60	116
24:00										297	174	72	124		52	104	104	52
Total										351	1,974	1,767	1,860	1,664	1,468	1,548	1,488	1,436

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Appendix B. (page 2 of 2).

Hour Ending	08-Jul	09-Jul	10-Jul	11-Jul	12-Jul	13-Jul [d]	14-Jul [d]	15-Jul	16-Jul	17-Jul [f]	18-Jul	19-Jul [g]	20-Jul [h]	21-Jul	22-Jul	23-Jul
01:00	32	40	244	168	36			48	60	36	60	36		16	4	20
02:00	24	64	152	68	56			56	52	32	24	36		4	12	12
03:00	40	44	100	36	48			32	56	16	68	32		0	12	4
04:00	76	44	72	56	32			36	52		52	12		8	8	12
05:00	104	28	112	44	52			40	64		68	15		0	12	0
06:00	44	32	60	52	44			24	44		40	36		12	0	(4)
07:00	32	24	60	40	32			32	52		44	24		4	16	4
08:00	24	36	84	64	36			40	36		56	30		8	8	12
09:00	12	24	48	52	44			80	16		8	0		4	4	36
10:00	28	12	36	36	12			32	4		12	6		12	8	12
11:00	16	20	80	68	44			40	32	24	4	9		4	8	16
12:00	16	20	100	28	20			52	28	20	4	12		8	4	8
13:00	28	36	92	48	32			32	24	20	16	0		12	16	12
14:00	24	28	104	76	56			32	28	(4)	12	8		16	12	16
15:00	44	40	72	64	72			48	24	20	72	28		12	20	24
16:00	44	28	88	224	28			48	12	20	40	8		28	16	24
17:00	40	56	64	140	44		72	36	56	24	140	12		44	20	36
18:00	36	136	52	144	40		60	28	36	40	56	8		40	20	12
19:00	52	64	104	184	135		52	56	52	40	52	8		12	24	20
20:00	68	56	112	160	105		92	52	28	20	44	4		28	20	20
21:00	68	144	180	176	48		104	24	28	12	60	12		16	12	24
22:00	32	404	168	56	48		64	72	24	8	28	14		16	24	0
23:00	48	248	160	140	30		52	56	28	(4)	20	15		20	32	16
24:00	56	240	120	72	30		56	72	12	16	32	10	0	8	24	4
Total	988	1,868	2,464	2,196	1,124	1,105	1,086	1,068	848	483	1,012	375	354	332	336	340

[a] Poor visibility from high turbid waters prohibited visual counting of salmon from towers.
[b] Counting initiated on 30 June at 0000 h.
[c] Total daily count unavailable. Total daily count was estimated by interpolating between expanded counts on 2 and 4 July.
[d] Total daily count unavailable. Total daily count was estimated by interpolating between expanded counts on 12 and 15 July.
[f] Daily count unavailable for period with hours ending 4:00 - 10:00 on 17 July. Daily count for 17 July was estimated by dividing the sum of the 11:00- 24:00 counts on 17 July by the mean passage proportion on 16 and 18 July for the same time period.
[g] Daily count unavailable for period with hours ending 22:00 - 24:00 on 19 July. Daily count for 19 July was estimated by dividing the sum of the 1:00- 21:00 counts on 19 July by the mean passage proportion on 18 and 21 July for the same time period.
[h] Total daily count unavailable. Total daily count was estimated by interpolating between expanded counts on 19 and 21 July.

Appendix C. South (right) bank Nulato River expanded chinook salmon tower counts by hour and date, 20 June - 23 July, 1994.

Ending	20-Jun [a]	21-Jun [a]	22-Jun [a]	23-Jun [a]	24-Jun [a]	25-Jun [a]	26-Jun [a]	27-Jun [a]	28-Jun [a]	29-Jun [b]	30-Jun	01-Jul	02-Jul	03-Jul	04-Jul	05-Jul	06-Jul	07-Jul
01:00											0	0	0	0	0	0	8	4
02:00											0	0	0	0	8	0	0	0
03:00											0	0	0	0	4	0	4	0
04:00											0	0	0	0	0	0	0	0
05:00											0	0	0	0	0	0	0	0
06:00											0	0	0	0	0	4	0	0
07:00											0	0	0	0	0	0	0	0
08:00											0	3	0	0	0	0	0	0
09:00											0	0	0	0	0	4	8	0
10:00											0	0	0	0	0	0	0	4
11:00											0	0	0	0	0	4	0	8
12:00											0	0	0	0	0	8	0	0
13:00											0	0	0	0	0	12	4	0
14:00											0	0	0	0	4	0	4	0
15:00											0	0	4	4	0	20	4	0
16:00											0	0	4	4	0	12	0	0
17:00											0	3	4	4	0	0	4	4
18:00											0	0	0	8	0	8	4	4
19:00										0	0	0	0	12	0	4	12	0
20:00										0	0	0	8	0	4	0	4	8
21:00										0	0	0	0	0	4	20	8	0
22:00										0	0	0	12	4	0	16	20	0
23:00										0	3	0	4	0	0	36	12	0
24:00										0	0	0	0	0	0	28	12	0
Total										0	3	6	36	36	24	176	108	32

continued

Appendix C. (page 2 of 2).

Hour Ending	08-Jul	09-Jul	10-Jul	11-Jul	12-Jul [c]	13-Jul [c]	14-Jul [c]	15-Jul	16-Jul	17-Jul	18-Jul	19-Jul [d]	20-Jul [d]	21-Jul	22-Jul	23-Jul
01:00	8	0	4	0				4	0	0	0	0		0	0	0
02:00	\ 0	0	8	0				0	0	0	0	4		0	0	0
03:00	0	0	0	4				4	0	0	0	0		0	0	0
04:00	0	0	4	0				0	8	0	4			0	0	0
05:00	0	0	0	0				0	0	0	0			0	0	0
06:00	(4)	0	0	0				0	0	0	0			0	0	0
07:00	4	0	0	0				4	0	6	0			0	0	0
08:00	0	0	0	4				0	0	0	0	0		0	0	0
09:00	0	0	0	0				0	0	0	0			4	0	0
10:00	0	4	0	4				0	0	0	0	0		0	0	0
11:00	0	0	4	0				0	0	4	0	0		0	0	0
12:00	0	0	0	0				0	0	0	0	0		0	0	0
13:00	4	0	0	4				0	0	0	4	4		0	0	0
14:00	0	0	0	0				8	0	4	8	0		0	0	0
15:00	0	0	4	0				0	4	0	0	0		0	0	0
16:00	0	4	0	4				0	8	0	4			0	4	0
17:00	0	0	0	8			4	0	0	4	0			0	0	0
18:00	0	0	0	4			8	0	0	0	0			0	0	0
19:00	0	0	0	4			4	8	0	0	0			0	0	0
20:00	0	0	0	4			0	0	0	0	0			0	0	0
21:00	0	4	12	4			4	12	0	0	0			4	0	0
22:00	0	0	0	28			0	0	0	4	0			0	0	0
23:00	0	0	0	20			4	4	0	0	4			0	0	0
24:00	0	0	0	0			0	8	0	0	0		0	0	0	0
Total	12	12	36	92	82	72	62	52	20	22	24	19 [g]	14 [h]	8	4	0

[a] Poor visibility resulting from high, turbid waters prohibited visual counting of salmon from towers.
[b] Counting initiated on 29 June at 18:00 h.
[c] Total daily count unavailable. Total daily count was estimated by interpolating between the expanded counts on 11 and 15 July.
[d] Total daily count unavailable. Total daily count was estimated by interpolating between the expanded counts on 18 and 21 July.

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Appendix D. North (left) bank Nulato River expanded chinook salmon tower counts by hour and date, 20 June - 23 July, 1994.

Hour Ending	20-Jun [a]	21-Jun [a]	22-Jun [a]	23-Jun [a]	24-Jun [a]	25-Jun [a]	26-Jun [a]	27-Jun [a]	28-Jun [a]	29-Jun [b]	30-Jun	01-Jul	02-Jul	03-Jul [c]	04-Jul	05-Jul	06-Jul	07-Jul
01:00											0	0	0	0	4	0	4	8
02:00											0	0	0	4	4	0	0	0
03:00											0	0	0	0	0	0	0	0
04:00											0	0	0	0	0	0	0	0
05:00											0	0	0	0	0	0	12	4
06:00											0	0	0	0	0	0	0	8
07:00											0	0	0	0	4	0	0	0
08:00											0	0	0	0	0	0	0	0
09:00											0	0	0		0	4	0	0
10:00											0	0	0		0	0	0	0
11:00											0	0	0		0	0	0	4
12:00											0	0	0		0	0	4	4
13:00											0	0	0		0	16	4	4
14:00											0	0	4		0	0	0	4
15:00											0	0	8		4	0	16	0
16:00											0	0	20		0	12	8	8
17:00											0	0	0		0	0	8	4
18:00											0	0	0		8	0	0	12
19:00											0	0	4		4	8	8	4
20:00											0	0	0		4	0	4	4
21:00											0	0	0		4	0	12	4
22:00											0	0	0		0	0	12	8
23:00											0	0	0		0	0	8	0
24:00											0	0	0		0	0	0	8
Total											0	0	36	36	36	40	100	88

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Appendix D. (page 2 of 2).

Hour Ending	08-Jul	09-Jul	10-Jul	11-Jul	12-Jul	13-Jul [d]	14-Jul [d]	15-Jul	16-Jul	17-Jul [f]	18-Jul	19-Jul [g]	20-Jul [h]	21-Jul	22-Jul	23-Jul
01:00	12	4	8	0	0			0	0	0	0	0		0	0	0
02:00	4	0	4	8	0			0	0	0	4	0		0	0	0
03:00	0	8	12	0	0			0	0	0	0	0		0	0	0
04:00	0	4	0	0	0			0	0		0	4		0	0	0
05:00	12	4	0	0	0			0	4		0	0		0	0	0
06:00	0	4	0	0	0			0	0		0	0		0	0	0
07:00	8	0	4	0	0			0	0		0	0		0	0	0
08:00	0	0	4	0	0			0	0		0	0		0	0	0
09:00	4	0	0	0	0			8	4		0	4		0	0	0
10:00	0	0	4	0	0			0	0		0	0		0	0	0
11:00	0	4	4	0	0			4	4	0	0	0		0	0	8
12:00	0	4	8	8	0			8	0	4	0	0		0	0	0
13:00	0	4	0	0	4			0	0	0	0	4		0	0	0
14:00	4	0	4	0	0			8	0	0	4	8		0	0	0
15:00	8	4	4	0	0			0	0	8	4	4		0	0	0
16:00	4	4	4	4	0			16	0	0	0	0		0	4	0
17:00	0	8	0	0	0		4	0	0	0	0	0		0	0	0
18:00	0	8	0	0	0		4	8	4	0	0	0		4	0	0
19:00	4	16	4	0	3		4	0	4	12	4	0		0	0	0
20:00	0	0	0	0	0		0	0	0	0	0	0		0	0	4
21:00	0	0	0	0	0		4	0	4	0	0	0		0	0	16
22:00	12	0	0	0	0		0	0	0	0	0	0		0	0	4
23:00	0	4	0	0	0		0	0	0	0	0	0		0	0	0
24:00	0	0	0	0	3		0	0	0	0	0	0	0	0	0	0
Total	72	80	64	20	10	24	38	52	24	29	16	24	14	4	4	32

[a] Poor visibility from high turbid waters prohibited visual counting of salmon from towers.
[b] Counting initiated on 29 June at 1800 h.
[c] Total daily count unavailable. Total daily count was estimated by interpolating between expanded counts on 2 and 4 July.
[d] Total daily count unavailable. Total daily count was estimated by interpolating between expanded counts on 12 and 15 July.
[f] Daily count unavailable for period with hours ending 4:00 - 10:00 on 17 July. Daily count for 17 July was estimated by dividing the sum of the 11:00- 24:00 counts on 17 July by the mean passage proportion on 16 and 18 July for the same time period.
[g] Daily count unavailable for period with hours ending 22:00 - 24:00 on 19 July. Daily count for 19 July was estimated by dividing the sum of the 1:00- 21:00 counts on 19 July by the mean passage proportion on 18 and 21 July for the same time period.
[h] Total daily count unavailable. Total daily count was estimated by interpolating between expanded counts on 19 and 21 July.

Appendix E. Nulato River salmon beach seine catch by species; salmon catch by sex, date, and stratum; and number of chum salmon sampled for age, sex, size information, by sex, date and stratum, 1994.

		Chum Salmon									Chinook Salmon			Non-salmon Species			
	Number	Number Captured			Number Sampled			Number Aged			Number Captured			Number Captured			
Date	of Sets	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	suckers	char	whitefish	grayling
20-Jun																	
21-Jun																	
22-Jun																	
23-Jun	3	0	0	0	0	0	0	0	0	0	0	0	0	5	3	3	0
24-Jun																	
25-Jun	4	4	3	7	4	3	7	4	3	7	0	0	0	3	4	0	0
26-Jun	8	27	25	52	26	23	49	24	24	48	0	0	0	4	9	1	4
27-Jun	6	30	31	61	29	27	56	29	26	55	0	1	1	7	2	2	0
28-Jun	5	32	22	54	20	20	40	16	20	36	0	0	0	6	5	1	2
29-Jun																	
30-Jun																	
01-Jul																	
02-Jul																	
03-Jul																	
04-Jul																	
05-Jul	2	50	26	76	50	26	76	45	24	69	1	1	2	42	0	0	0
06-Jul																	
07-Jul	2	53	43	96	43	37	80	41	32	73	1	1	2	18	0	0	0
08-Jul																	
09-Jul																	
10-Jul	1	51	13	64	28	12	40	28	9	37	0	0	0	18	2	0	2
11-Jul																	
12-Jul	1	39	36	75	38	34	72	33	30	63	3	1	4	16	2	1	2
13-Jul	3	55	33	88	22	18	40	18	16	34	0	0	0	20	2	3	4
14-Jul																	
15-Jul																	
16-Jul																	
17-Jul																	
18-Jul	1	80	59	139	33	40	73	26	35	61	1	0	1	28	2	0	4
19-Jul	1	58	58	116	27	53	80	24	44	68	0	0	0	23	2	0	3
20-Jul																	
21-Jul																	
22-Jul																	
23-Jul																	
24-Jul																	
25-Jul																	
26-Jul																	
27-Jul																	
Stratum Totals																	
19 June - 3 July	26	93	81	174	79	73	152	73	73	146	0	1	1	25	23	7	6
Percent		53.4	46.6		52.0	48.0		50.0	50.0								
4 June - 8 July	4	103	69	172	93	63	156	86	56	142	2	2	4	60	0	0	0
Percent		59.9	40.1		59.6	40.4		60.6	39.4								
9 June -13 July	5	145	82	227	88	64	152	79	55	134	3	1	4	54	6	4	8
Percent		63.9	36.1		57.9	42.1		59.0	41.0								
14 June -23 July	2	138	117	255	60	93	153	50	79	129	1	0	1	51	4	0	7
Percent		54.1	45.9		39.2	60.8		38.8	61.2								
Season Totals	37	479	349	828	320	293	613	288	263	551	6	4	10	190	33	11	21
Percent		57.9	42.1		52.2	47.8		52.3	47.7								

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Appendix F. Climatological and hydrological observations, Nulato River counting- tower site, 1994.

Date	Time	Precip. (Code) [a]	Wind (Direction and Velocity)	Cloud Cover (Code) [b]	Temperature: Air Instant. [d] °C	Temperature: Air Min. °C	Temperature: Air Max. °C	Temperature: Instant. Water °C	Water Gauge: Actual (ft.)	Water Gauge: Relative (ft.)	Water Gauge: Relative (cm)	Water Color (code) [c]	
22-Jun	23:00	I	SW 5	3	12			7	2.92	0.00	0.0	Tr	water level rising; heavy rains yesterday
23-Jun	18:00	I	S 5	3	16			7	2.85	-0.07	-2.1	Tr	water level dropping; clearer
24-Jun	15:00	I	S 0-5	4	14			8	2.75	-0.17	-5.2	Dk	water level dropping; clearer
25-Jun	18:00	I	S 5	4	12			8	2.88	-0.04	-1.2	Br	water level rising; turbid; rain off and on for 24 h
26-Jun	18:00	N	S 5	3	12			8	2.92	0.00	0.0	Br	water level dropping; crested at 2.97 last night
27-Jun	18:00	I	N 0-5	3	12			8	2.67	-0.25	-7.6	Br	some sun
28-Jun	18:00	I	NW 0- 5	3	12			8	2.50	-0.42	-12.8	Br	water level dropping; can see chum salmon in shallows
29-Jun	18:00	N	W 10	1	17			9	2.35	-0.57	-17.4	Lt	counted first chum salmon
30-Jun	18:00	N	SW 0-5	2	22			10	2.20	-0.72	-21.9	Br	
01-Jul	18:25	N	calm	4	22			11	2.09	-0.83	-25.3	Br	high thin overcast
02-Jul	17:55	N	S 10	3	19			11	2.01	-0.91	-27.7	Br	milky colored water; less clear than yesterday
03-Jul	18:00	N	S10	4	17			11	1.93	-0.99	-30.2	Br	more turbid than yesterday
04-Jul	18:20	I	SE 5-15	4	13			10	1.82	-1.10	-33.5	Br	overcast and windy; reduced visibility in water
05-Jul	18:00	I	W 5	3	16			11	1.81	-1.11	-33.8	Br	
06-Jul	18:00	I	S 15	2	17			10	1.74	-1.18	-36.0	Br	wind riffling water surface; visibility problems
07-Jul	21:50	I	SE 15	3	14			9	1.65	-1.27	-38.7	Br	windy; water clarity improved
08-Jul	18:00	I	S 10	4	10			10	1.60	-1.32	-40.2	Br	dreary
09-Jul	19:00	I	SE 10	4	13			9	1.65	-1.27	-38.7	Br	windy and rainy
10-Jul	18:00	I	S 5	3	15			10	1.86	-1.06	-32.3	Tr	more turbid than yesterday
11-Jul	18:00	I	SE 5	4	14			10	1.96	-0.96	-29.3	Tr	difficult to see bottom of river 20 ft from shore.
12-Jul	18:00	I	SE 5	3		12	21	10	2.49	-0.43	-13.1	Tr	very muddy; cannot count from right bank
13-Jul	18:00	I	NW 5	3		11	24	10	2.59	-0.33	-10.1	Dk	water level crested at 2.65 ft; cannot count at all
14-Jul	18:00	I	calm	1		13	27	12	2.37	-0.55	-16.8	Dk	gorgeous day; resumed counts at 1600 h
15-Jul	18:00	N	SE 10	1		13	23	11	2.20	-0.72	-21.9	Dk	water is clearing up
16-Jul	18:00	N	E 5	2		9	24	12	2.05	-0.87	-26.5	Br	nice day; good visibility
17-Jul	18:00	N	E 5	4		10	27	13	1.92	-1.00	-30.5	Br	clear, then overcast, thunderstorms in area
18-Jul	21:00	I	NE 10	3		11	26	12	2.05	-0.87	-26.5	Br	thunderstorms; water level rising; more turbid
19-Jul	20:00	I	S 10	3		12	22	13	2.07	-0.85	-25.9	Tr	water level steady; too turbid to count without sunlight
20-Jul	18:00	I	S 5	3		11	18	12	2.09	-0.83	-25.3	Br	too turbid to count; water level crested at 2.17 ft last night
21-Jul	18:00	I	S 0-5	4		8	21	12	1.91	-1.01	-30.8	Br	water much clearer; good visibility
22-Jul	18:00	N	SW 15	3		11	22	12	1.84	-1.08	-32.9	Br	very good visibility despite wind
23-Jul	18:00	I	S 15	4		11	24	11	1.73	-1.19	-36.3	Br	good clarity; windy

[a] Precipitation code for the preceding 24-h period: N = No precipitation; I = Intermittent rain; R = Continuous rain; S = Snow; S&R = Snow and rain mixed H = Hail; and T = Thunder showers.
[b] Instantaneous cloud cover code: 0 = No observation; 1 = Clear sky, cloud cover not more than 10% of sky; 2 = Cloud cover not more than 50% of sky; 3 = Cloud cover more than 50% but less than 100% of sky; 4 = Completely overcast; and 5 = Fog or thick haze.
[c] Instantaneous water color code: Cl = Clear; Lt = Light brown; Br = Brown; Dk = Dark brown; and Tr = Turbid: murky or glacial.
[d] Minimum/Maximum thermometer unavailable. Instantaneous air temperature taken with hand-held thermometer.

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