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Alaska Department of Fish and Game
Commercial Fisheries Division
P.O. Box 25526
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June 1993

Anvik River Salmon
Escapement Study, 1991

by

Gene J. Sandone

State of Alaska Walter J. Hickel, Governor

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF APPENDICES

Page

Appendix A:

ABSTRACT

The Anvik River sonar project has estimated daily passage of summer chum salmon *Oncorhynchus keta* since 1979 using side-scanning sonar counters. During the period 21 June through 26 July 1991, an estimated 847,772 summer chum salmon passed the sonar site on the Anvik River. This estimate is 74% above the minimum escapement objective of 487,000 salmon. Timing of the 1991 run was mixed in relation to the long-term mean (1979–1990 excluding 1986) timing statistics of the run. Although the first quartile passage day of the run was 1 d earlier than the long-term first quartile day, the median passage day was 2 d later, and the third quartile passage day was 3 d later than the corresponding long-term mean quartile day of passage. Female chum salmon comprised an estimated 57.9% of the summer chum salmon passage. Age-5 fish comprised an estimated 55.6% of the passage; age-4 fish accounted for 44.2%. Older-age, male salmon dominated the first sampling stratum, 21–30 June. A total of 628 chinook salmon *O. tshawytscha* were enumerated on an aerial survey of the index area within Anvik River drainage. This count is 26% above escapement objective of 500 chinook salmon for this index area. Age-5 salmon accounted for 52.9% of the escapement; age-6 salmon accounted for 31.7% based on carcass samples. Male chinook salmon dominated the escapement, accounting for 59.0% of the sample.

INTRODUCTION

The Anvik River (Figure 1) is the largest producer of summer chum salmon *Onchorynchus keta* in the Yukon River drainage. Buklis (1982a) estimated that the Anvik River alone accounts for 35% of the total production. Other known major spawning populations occur in the Andreafsky, Rodo, Nulato, Gisasa, Hogatza, Melozitna, Tozitna, Chena, and Salcha Rivers (Figure 1). Summer chum salmon spawn in lesser numbers in other tributaries of the Yukon River. Chinook *O. tshawyscha* and pink *O. gorbuscha* salmon occur in the Anvik River coincidentally with summer chum salmon. Coho salmon *O. kisutch* spawn in the Anvik River drainage during the fall.

Two stock identification studies have been conducted on Yukon River chum salmon stocks. 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 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 (Wilmont et al. 1992). These investigators also reported that within the summer-run group, two major subdivisions were apparent, those of the lower river below river-kilometer (rkm) 800 and those of the midriver (rkm 800 to 1,150).

During the 1987 and 1988 field season, chum salmon genetic stock identification (GSI) collections were obtained at the mainstem Anvik River sonar site. Interestingly, these two collections were significantly different genetically (Wilmot et al. 1992). Although the collection obtained in 1987 was genetically similar to the lower river summer-run group, the collection obtained in 1988 was reported to be a separate group within the summer-run group, genetically distinct from the lower and midriver groups (Wilmot et al. 1992). These investigators speculated that because the Anvik River is a large, productive river system that probably supports numerous spawning stocks, the mainstem collections at the sonar site in 1987 and 1988 most likely included different combinations of upriver, genetically distinct stocks. This apparent under-representation of Anvik River subpopulations in the genetic baseline data set was identified as one of the limitations of the study (Wilmot et al. 1992). Future studies will attempt to sample tributary populations of chum salmon within the Anvik River drainage in order to expand the chum salmon baseline.

Commercial and subsistence harvests of Anvik River summer chum salmon occur throughout the mainstem Yukon River from the coast of the delta to the mouth of this tributary stream (rkm 513). This section of river includes Districts 1, 2, and 3 in total and the extreme lower portion of District 4 (Figure 1). Set and drift gillnets are the legal fishing gear in Districts 1, 2, and 3; set gillnets and fish wheels are used in District 4. Most of the effort and harvest on the Anvik River stock occurs in Districts 1 and 2 and in the extreme lower portion of District 4 below the confluence of the Anvik and Yukon Rivers. Fish taken commercially in the lower three districts are sold in the round; District 4 is primarily a roe fishery due to poor flesh quality and distance from market. Commercial and subsistence summer chum salmon fisheries in the remainder of District 4 and in District 6 are supported by stocks other than the Anvik

River stock. Very few summer chum salmon are harvested in District 5 due to the lack of spawning populations in that portion of the drainage. Wilmot et al. (1992) 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 75–100% of the catch until mid-July.

In the lower portion of the Yukon River (Districts 1, 2, 3), run timing of chinook and summer chum salmon greatly overlap from river-ice breakup through June or early July. During this period, management of the lower Yukon River has traditionally been directed at chinook salmon. The District 4 commercial fishery has been directed primarily at chum salmon. Subsistence fisheries in all four districts take summer chum salmon primarily for sled dog food. In the Lower Yukon Area, large-mesh gillnets (stretch mesh greater than 6 in) were employed to harvest chinook salmon. Although these were very efficient, the associated harvest of summer chum salmon through 1984 was small in relation to the size of the run. Therefore, prior to the 1985 season, the Alaska Board of Fisheries, in an attempt to increase the harvest of summer chum salmon in the lower river, directed that special small-mesh (stretch mesh maximum of 6 in) fishing periods be allowed during the chinook salmon season provided that (1) the summer chum salmon run was of sufficient size to support the additional exploitation, and (2) the incidental harvest of chinook salmon during these small-mesh fishing periods did not adversely affect conservation of that species.

A poor summer chum salmon run to the Yukon River in 1987 prompted fishery managers to consider the summer chum salmon fishery as fully developed (Sandone 1991). However, strong runs during 1988 and 1989 resulted in record commercial harvests of 1,620,269 summer chum salmon in 1988 and 1,456,928 in 1989 (Bergstrom et al. 1992). Distribution of the summer chum salmon resource available for harvest reflected market demand and scheduled fishing time. Without harvest guidelines, increased market demand prompted allocation disputes between district fishermen. Additionally, fishery managers were perceived by some of the public as making resource-allocation decisions by scheduling fishing time. To address these problems the Alaska Board of Fisheries, in February 1990, established a riverwide guideline harvest range of 400,000–1,200,000 summer chum salmon (ADF&G 1990). This overall guideline was distributed by district and subdistrict based on the previous 15-year average harvests.

In 1991, because of an anticipated below-average run size, restricted mesh size periods were not initiated until late June to conserve summer chum salmon. The summer commercial fishing season was closed after a total of four restricted fishing periods in the lower river fisheries. The 1991 harvest of summer chum salmon in the lower Yukon River fisheries was approximately 25% above the lower end of the guideline harvest level.

Accurate salmon escapement counts on Yukon River tributaries are important for regulating fishery harvests, determining escapement objectives, evaluating the effectiveness of management programs, and providing information for use in projecting subsequent returns. However, because of the size of the Yukon River drainage, 853,000 km^2, enumerating escapements to more than a few tributaries is economically infeasible. Consequently, most escapements are instead assessed using low-level aerial surveys conducted from single-engine, fixed-wing aircraft. These aerial surveys are subject to counting errors and year-to-year variability associated with weather, stream conditions, timing of the survey relative to spawning stage, and observer subjectivity and experience. 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. 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 and chum salmon since the early 1970s. Escapement objectives based on aerial surveys have been established for both chinook and chum salmon in selected tributary streams for which there is a sufficient historical database (Bergstrom et al. 1991).

Two distinct runs of chum salmon, summer and fall, spawn in the Yukon River drainage; comprehensive enumeration studies have been conducted on only a few selected spawning streams for each run. The Anvik River was chosen for summer chum salmon research studies in 1972, the Andreafsky River (Figure 1) in 1981. However, because of budget restrictions, the Andreafsky River project was discontinued in 1989.

The Anvik River originates at an elevation of 400 m and flows in a southerly direction approximately 200 km to its mouth at rkm 513 of the Yukon River. It is a narrow runoff stream with a substrate mainly of gravel and cobble. However, bedrock is exposed in some of the upper reaches. The Yellow River (Figure 2), a major tributary of the Anvik, is located approximately 100 km upstream from the mouth of the Anvik River. Downstream of the confluence of the Yellow and Anvik Rivers, the Anvik River changes from a moderate gradient system to a low gradient system meandering through a much broader flood plain. Turbid waters from the Yellow River also greatly reduce the water clarity of the Anvik River below this confluence. Numerous oxbows, old channel, cutoffs, and sloughs are found throughout the lower river.

Anvik River salmon escapement was enumerated from two counting tower sites from 1972 to 1979 above the confluence of the Anvik and Yellow Rivers (Figure 2). A site 8.9 km above the Yellow River on the mainstem Anvik River was used from 1972 to 1975 (Lebida 1973; Trasky 1974, 1976; Mauney 1977). From 1976 to 1979 a site on the mainstem Anvik River near the confluence of Robinhood Creek and the Anvik River was used (Figure 2; Mauney 1979, 1980; Mauney and Geiger 1977). Other than 1974, aerial surveys were flown each year in fixed-wing aircraft to estimate salmon abundance below the tower site. High and turbid water often affected the accuracy of visual salmon enumeration from counting towers, as well as from aircraft on the Anvik River.

The Electrodynamics Division of the Bendix Corporation[1] developed a side-scanning sonar counter during the 1970s capable of detecting and counting salmon migrating along the banks of streams. A pilot study using side-scanning sonar to estimate chum salmon escapement to the Anvik River was conducted in 1979. Results of this study indicated that sonar enumeration of chum salmon escapements to the Anvik River

[1]Use of a company's name does not constitute endorsement.

was superior to the counting tower method (Mauney and Buklis 1980). Therefore, in 1980, sonar enumeration replaced the tower counting method for estimating summer chum salmon escapement.

The Anvik River sonar site is located approximately 76 km upstream of the confluence of the Anvik and Yukon Rivers (Figure 2). Project results for escapement studies using sonar technology on the Anvik River from 1979 to 1990 have been reported by Mauney and Buklis (1980), Buklis (1981, 1982b, 1983, 1984a, 1984b, 1985, 1986, 1987), and Sandone (1989, 1990a, 1990b). This report presents results of the Anvik River summer chum salmon escapement study for the 1991 field season.

Because the majority of the subsistence harvest and some of the commercial summer chum salmon harvest occurs in the Yukon River drainage above the mouth of the Anvik River, it is important to accurately assess the strength of the upriver run so that escapement and harvest needs can be met. The information derived from this project, in conjunction with Yukon River sonar passage estimates and subsistence and commercial catch rates, is used by the Upper Yukon Area staff to assess the strength of the Yukon River summer chum salmon run above the mouth of the Anvik. The timely and accurate reporting of information from the Anvik River sonar project is a critical component of Yukon River summer chum salmon management. The primary purpose of this study is to monitor the escapement of summer chum salmon to the Anvik River. The two primary objectives of this study are to:

1. estimate the daily summer chum salmon escapement passing the Anvik River sonar site; and

2. estimate the age and sex composition of the summer chum and chinook salmon spawning escapements.

METHODS

Sonar Deployment and Operation

A sonar counter has been installed and operated on each bank of the Anvik River near Theodore Creek (Figure 2) each year since 1979. The sonar counter operates by transmitting a sonic beam along an 18-m aluminum tube, or substrate. Echoes from salmon passing through the beam are reflected back to the transducer. The system electronics interpret the strength and number of the echoes, and tally salmon counts. Criteria for strength and frequency of the echoes are designed to optimize counting of salmon and minimize any non-salmon counts (i.e., debris or other fish species). Aerial survey data indicate that virtually all summer chum salmon spawning activity is located upstream of this site.

During the 1991 season, a 1981 model sonar counter was deployed and operated according to guidelines described by Bendix Corporation (1981) on each bank of the Anvik River to enumerate summer chum salmon passage. Sonar counters were operated without the prescribed artificial aluminum substrate tubes throughout the season. This practice of operation without an artificial substrate has been in effect since 1986. The east and west bank sites used in previous years were probed to locate uniform river bottom gradients that would provide optimum surfaces for ensonification. Each sonar transducer was mounted on a rectangular aluminum frame. Two steel pipes were set into the river bottom on each side of the river, onto which the transducer frames were guided by side-mounted steel sleeves. Sonic beams emitted from each transducer were aimed perpendicular to shore; transducers were offset to prevent interference between units. Weirs constructed of T-stakes and rectangular mesh fencing extended perpendicular from the shoreline downstream of the transducer to approximately 1 m beyond the transducer to prevent fish passage inshore of the transducers. Counting towers of aluminum scaffolding material approximately 3m in height were placed near the transducers on each bank for visual observation of salmon when water conditions permitted. As required by fluctuating water levels, transducers were moved inshore or offshore. Consequently, depth at the transducer varied throughout the season. Transducers were aimed and counting range lengths were adjusted so that echoes resulting from the stream bottom or surface interface did not register as counts by the sonar electronics.

The 1981 model counters used on the Anvik River sonar project divided the counting range, or ensonified zone, in 16 sectors of equal length. Sector length was dependent on the length of the counting range. Sectors were consecutively numbered from the west (right) to east (left) bank. Therefore, sectors 1–16 were associated with the west bank counter; sectors 17–32 were associated with the east bank counter. Sector number 1 and 32 corresponded to the near-shore sector on each respective bank.

The east bank transducer was located along a cutbank approximately 60 m above the field camp site. Initial placement of the east bank transducer was approximately 1.0 m offshore and at a depth of 0.5–1.5 m. The west bank transducer was located along a gradually sloping gravel bar, approximately 3 m downstream of the east bank transducer. Initial placement of the west bank transducer was approximately 9.0 m offshore and at depth similar to the placement of the east bank transducer.

Sonar Calibration and Sampling

Each sonar counter was usually calibrated five times daily by observing fish passage using an oscilloscope integrated with each sonar unit. Salmon passing through the sonar beam produce a distinctive oscilloscope trace or spike. During each calibration period counts of salmon enumerated by the observer using the oscilloscope were compared to counts recorded by the sonar electronics. The fish velocity control setting on the sonar counter was adjusted immediately after a calibration if the ratio of sonar counts to oscilloscope counts varied from 1.0 by 15% or more. The existing fish velocity setting was multiplied by this ratio to obtain the correct new setting. If adjustments were made to the sonar unit, an additional calibration was made to initialize the counting period and to ensure that the oscilloscope-to-sonar count ratio was within accepted limits, plus or minus 15%. Each calibration lasted for at least 15 min, or until 30 salmon were counted by the observer, whichever was less. As a further check on sonar accuracy and to train operators in oscilloscope monitoring, attempts were also made to visually enumerate fish passage from 3 m counting towers during sonar calibration times. Polaroid sunglasses were worn to reduce water surface glare. However, attempts to visually enumerate salmon during calibration times were discontinued from the west bank when it became apparent that the presence of the observer on the tower interfered with the normal passage of salmon past the sonar site. Salmon passed farther offshore when the observer was on the tower.

Five daily calibration times were deemed adequate to monitor the diel timing pattern of the salmon migration. Calibrations were normally conducted during 0400, 0800, 1300, 1800, and 2400 hours. However, during the initial and last days of the project when fish passage was low, calibrations were conducted during 0800, 1300, 1800, and 2400 hours.

Bank-specific calibration periods were defined by the time between individual calibrations on each bank. An associated adjustment factor, specific to each calibration period and to each bank was derived from the following formula:

$$A_{b,n}=\frac{(OC_{b,ts}+OC_{b,te})}{(SC_{b,ts}+SC_{b,te})}$$

where .... A = periodic adjustment factor,
.... b = west or east bank,
.... n = calibration period,
.... ts = time at beginning of calibration period ,
.... te = time at end of calibration period,
.... OC = oscilloscope counts, and
.... SS = sonar counts.

The periodic adjustment factor was applied to the unadjusted sonar counts for each hour within the associated calibration period for each bank. The resulting corrected sonar counts for each hour within a day were summed, yielding the estimated summer chum salmon passage for that day for that bank.

Corrected hourly counts were calculated and totaled for each day, for each bank using a portable computer. The daily passage of salmon was determined by summing the daily bank estimates. Daily adjustment factors for each bank and for both banks were calculated by dividing the daily corrected counts by the sonar counts. Daily sector counts were corrected by using the overall daily correction factor. Corrected hourly and sector counts were used to determine the temporal and spatial distribution of the summer chum salmon run.

Counters do not distinguish between species of salmon. However, a separate escapement estimate for chinook salmon was obtained by aerial survey. This count was not subtracted from the chum salmon sonar count because we assumed that most chinook salmon were not counted by the sonar counters. This assumption was based on tower observations which indicated that most chinook salmon migrated up the middle of the stream channel beyond the ensonified zones. Additionally, the relative small numbers of chinook salmon observed during aerial survey flights have averaged less than 0.2% of the estimated sonar counts of summer chum salmon escapement from 1979–1991. Therefore, the small numbers of chinook salmon, which may have been counted as summer chum salmon during 1991, were considered insignificant. During the 1991 season pink salmon were not observed either from the tower or in beach seine samples collected for age-sex-size sampling. Accordingly, we assumed that no pink salmon passed the sonar site. Therefore, we contributed all sonar counts to summer chum salmon during 1991.

Missing hourly sector counts, not recorded as a result of debris or printer malfunction, were estimated by averaging the counts in the same sector for the hour before and after the count in question. When salmon were not counted for a large portion of a day, or a large portion of the counting range within a day, the corrected daily count total for that day was estimated. This was done by dividing the corrected partial daily count by the mean proportion of corrected counts for the corresponding hours or sectors for the first day before and after which full 24-h counts were recorded. The estimated counts for the sectors or hours for which counts were not recorded were distributed by sector or hour based on the mean count-distribution pattern of the corresponding sectors or hours on the day before and day after. When counting was not conducted for a full day, the salmon passage for that day was estimated as the mean of the salmon passage for the day before and after. The estimated daily counts were distributed by hour and sector based on the mean distribution pattern of corrected counts for the day before and after the missing count.

Age-Sex-Size Sampling

Season strata used for the comparison of hourly and sector passage data were defined by the early, early middle, late middle and late strata for age-sex-size sampling goals. Each terminal stratum was initially defined by an approximate 2-week interval with the two middle strata defined by a 1-week period. These strata were determined preseason, based on historical run timing data; they represent an attempt to sample the escapement for age-sex-size information in relative proportion to the total run. During 1991, the early and late strata were adjusted inseason. Initiation of the early stratum was delayed until salmon passed the sonar site; the final stratum ended with the termination of sonar enumeration. For 1991, the strata were specifically defined as: 21–30 June; 1–7 July; 8–15 July; and 16–26 July.

A beach seine (31 m long, 66 meshes deep, 6.35-cm mesh) was set approximately 100 m above the sonar site to capture chum and chinook salmon for age, sex, and size measurements. Chum and chinook salmon were placed in a holding pen, 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. Additionally, chinook salmon carcasses were sampled in August to supplement the beach seine sample. Three scales were taken from each chinook salmon sampled for determination of age and stock-of-origin analysis.

Scale samples were later pressed on acetate cards and the resulting impressions viewed on a microfiche reader for age determination. Sample size goals were based on 95% precision with a 10% accuracy for each time stratum. A sample size of 152 fish per stratum (early, early middle, late middle, and late) was needed to describe the age composition of the chum salmon escapement by stratum (J. Bromaghin, Alaska Department of Fish and Game, Anchorage, personal communication). This sample size accounts for a 10% unageable rate when one scale per fish is collected. Assuming a 10% scale rejection rate, a sample size of 198 was needed to describe the age and sex composition of the chinook salmon population of the Anvik River, with 95% precision and 10% accuracy, considering only one stratum (J. Bromaghin, Alaska Department of Fish and Game, Anchorage, personal communication). However, a sample size of 400 chinook salmon per stratum (entire season) was deemed necessary for the scale pattern analysis baseline for the Anvik River chinook salmon stock .

Hydrological and Climatological Sampling

A water-depth profile was measured at 3-m intervals from established headpins across the width of the river by probing with a pole marked in 1-cm increments. Because the east bank sonar site was situated approximately 10 m upriver from the west bank site, one transect situated between the sites served to describe profile. Transect profile data were collected twice during the season.

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.

Run Timing

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 sonar at Pilot Station (rkm 197), and at the Anvik River sonar site (approximately 589 km from the mouth of the Yukon River; (Figure 1). Run timing statistics, quartile days, were calculated for chum salmon passage at each site and compared. Because the Anvik River is the major producer of summer chum salmon in the Yukon River drainage, comparison of run timing statistics allowed a calculation of estimated migratory rate of the salmon.

RESULTS AND DISCUSSION

Sonar Enumeration

Two sonar counters were operated on the Anvik River from 21 June through 26 July at the same sites used in previous years. Only a small portion, approximately 16 m, of the central river channel was not ensonified on 7 July (Figure 3). Because of decreasing river water level (Figure 4) and, consequently, cross-sectional area throughout the season, the central river channel not ensonified on 24 July decreased to 13 m. Similar river ensonification was achieved during the initial placement of the transducers on 21 June and throughout the season. Because most of the historical chum salmon passage has been close to each shore, it was assumed that very few chum salmon migrated past the sonar site beyond the ensonified zone. Because sonar beam width and height increased with distance from the transducer, the ensonified zone also encompassed most of the vertical water column within the counting range. Therefore, it was assumed that only a very small portion of the total summer chum salmon passage was not counted during the operational period.

The escapement count for the period 21 June through 26 July was 847,772 summer chum salmon (Table 1). The 5-d period around the median day of passage, 8 July through 12 July accounted 26% of the total salmon passage, or 220,500 salmon (Figure 5). Information concerning escapement timing was mixed. Although the first quartile-day of passage, 2 July, was 1 day earlier than the overall mean, the median day of passage, 10 July, indicated a slightly late run timing (Table 2). Comparison of the 1991 run timing with the overall mean run timing (Figure 6) indicates that the first quartile of the run was slightly early, whereas the last two quartiles were late. Therefore, it appears that the median day of the 1991 escapement passage was a good indicator of the central estimate of run timing.

Although the preseason expectation for 1991 was for a below-average summer chum salmon run, inseason assessment of the Anvik River escapement in late June, in conjunction with lower Yukon River test fish CPUE and Yukon sonar passage estimates, indicated that the run may have been average in abundance. In response, commercial fishing time with restricted mesh size gillnet was allowed in the lower Yukon River management area during the latter portion of the summer season. One fishing period with restricted mesh size was allowed in District 1 on 4 July; two were allowed in District 2 on 30 June and 7 July; and one was allowed in District 3 on 30 June. Commercial fishing time in these districts with restricted mesh size totaled 42 h for the 1991 season. This limited fishing opportunity with restricted mesh size gillnets in the Lower Yukon Area fisheries allowed more summer chum salmon to pass to the Anvik River spawning grounds.

Buklis (1982a) expanded the season escapement estimates for 1972 through 1978, making it possible to more directly compare visual count estimates to more recent annual sonar count estimates (Figure 7). Assuming average contributions of 4% age-3, 64% age-4, 31% age-5, and 1% age-6 summer chum salmon, the 1991 escapement estimate of 847,772 summer chum salmon was 20% greater than the weighted parent-year escapement from years 1985–1988 of 705,103 fish; it was also 33% greater than the long-term (1972–1990) average of 636,700 fish.

A total of 26.47 h of sonar calibration was conducted over a 36-d period at the west bank site. West bank sonar accuracy (sonar count/oscilloscope count) averaged 1.06 (Table 3). Sonar accuracy averaged 1.09 for 27.17 h of oscilloscope calibration at the east bank site over a 32-d period (Table 3).

Temporal distribution of the west and east bank adjusted sonar counts by hour (Appendix A.1 and A.2, respectively) indicates a distinct diel pattern of salmon passage (Figure 8). Based upon adjusted counts salmon passage was lowest from 0700 to 1800 hours (averaging 3.1% of total daily passage per hour) and greatest from 2100–0300 (averaging 5.7% of total daily passage per hour). This pattern was relatively consistent throughout the season (Figure 9) and similar to the historical temporal distribution pattern of the migration.

In 1991, 72% of the total adjusted counts were observed on the west bank. This percentage is very similar to the 1986–90 average on the west bank of 74% (SE = 12%). In all years that sonar has been used to estimate Anvik River summer chum salmon escapement, a majority of the escapement passage has been associated with the west bank (Mauney and Buklis 1980; Buklis 1981, 1982b, 1983, 1984a, 1984b, 1985, 1986, 1987; Sandone 1989, 1990a, 1990b). Spatial distribution of the adjusted sonar counts by sector (Figure 8) indicates that most of the salmon passage occurred near shore on the west bank: sonar sectors 2, 3, and 4. These nearshore west bank sectors accounted for 53% of all adjusted sonar counts (Appendix A.3); east bank near-shore sectors 29 through 32 accounted for 11% of the total passage (Appendix A.4). The remaining 36% of the counts were distributed across the other 26 sonar counting sectors. The sonar sector nearest the shoreline of the west bank, sonar sector 1 was low, probably due to the salmon avoiding the nearby weir and transducer. These sector passage rates are remarkably similar to passage rates observed for similar sectors for the 1989 and 1990 escapement migration (Sandone 1990a, 1990b). This general trend of spatial distribution of salmon passage varied little throughout the season (Figure 10). However, salmon passage along the west bank generally declined throughout the season from a high of 92% during the first stratum to 63% during the third and 64% during the final stratum.

Age and Sex Composition

Summer Chum Salmon

Beach seine sets were made from 27 June to 24 July on 12 individual days. A total of 596 chum salmon were captured (Appendix A.5). Stratum sampling sizes were 75, 187, 154, and 168 for the four sampling strata. Although the sampling goal of 138 ageable scales per stratum was not achieved for the first stratum, the sampling goal was achieved for the last three strata. Of the 596 chum salmon sampled for age-sex-size data, 552 (93%) later proved to have ageable scales. Age of the escapement passing the sonar site varied through time (Figure 11). Age-5 chum salmon dominated the first sampling stratum, and age-4 salmon dominated the final stratum. Age composition of the escapement, weighted by strata escapement counts, was 0.0% age 3, 44.2% age 4, 55.6% age 5, and 0.2% age 6 (Appendix A.6). Age-5 chum salmon dominated the escapement in 1972, 1976, 1981, 1986, 1989, and 1991, but in all other years since 1972 the 4-year-old age class has dominated (Figure 12).

As in 1989 and 1990 (Sandone 1990a, 1990b), male chum salmon dominated during the first stratum. As in 1990 (Sandone 1990b), female chum salmon dominated during the final two strata (Figure 11). During 1989 female chum salmon dominated only the final stratum (Sandone 1990a). Overall, female chum salmon accounted for 57.9% of the 1991 escapement to the Anvik River. Females have contributed more than 50% to the escapement sample of summer chum salmon in 16 of the 19 years of record (Appendix A.6). Overall, the range of female contribution has ranged from 39.1% in 1974 to 69.4% in 1982.

Except for 1990, age class compositions of both the Anvik River escapement and the District 1 summer chum salmon harvest have been very similar (Figure 13). In 1991 both escapement and harvest samples contained no age-3 salmon and few age-6 salmon and were dominated by the age-5 component. Estimated age composition of the Anvik River escapement was 0.0% age 3, 44.2% age 4, 55.6% age 5, and 0.2% age 6 (Appendix A.6). Similarly, the preliminary age-class composition estimate of the total District 1 summer chum salmon harvest was 0.0% age 3, 41.4% age 4, 57.1% age 5, and 1.5% age 6 (D. Schneiderhan, Alaska Department of Fish and Game, Anchorage, personal communication). Also, similar to previous years, the sex composition of the 1991 Anvik River summer chum salmon escapement was dominated by females, whereas male salmon composed the majority of the District 1 commercial catch in every year since 1982, except for 1983 (Figure 14). Male chum salmon accounted for 60.6% of the District 1 harvest (D.Schneiderhan, Alaska Department of Fish and Game, Anchorage, personal communication) but accounted for only 42.1% of the Anvik River escapement. The difference in the sex composition between the 1991 District 1 harvest and Anvik River escapement is thought to have occurred because of (1) male selectivity of large-mesh gillnets almost exclusively used in the lower river fisheries during the 1991 summer season, and (2) the number of small-mesh District 1 commercial fishing periods. Only one small-mesh fishing period was allowed in District 1 during the 1991 summer season.

Chinook and Pink Salmon

No chinook or pink salmon were captured by beach seine. However, 411 chinook salmon carcass samples were collected by boat survey in August. Of the Anvik River chinook salmon sampled for age-sex-size data, 378 (92%) provided ageable scales. Age composition was 9.8% age 4, 52.9% age 5, 31.7% age 6, and 2.9% age 7 (Figure 15). Females accounted for 41.0% of the sample (Appendix A.7), slightly greater than the 40.1% long-term average (1972–1990, excluding 1974 when no samples were obtained).

Age composition of the District 1 commercial harvest was approximately 1.4% age 4, 36.3% age 5, 51.8% age 6, 10.2% age 7, and 0.3% age 8. Female chinook salmon accounted for 48.0% of the harvest

(D. Schneiderhan, Alaska Department of Fish and Game, Anchorage, personal communication). The District 1 commercial catch and Anvik River escapement age composition samples of chinook salmon are usually quite dissimilar (Figure 16). The Anvik River escapement has been usually composed of younger-age salmon than the District 1 commercial harvest (Figure 16). This difference is most likely due to the differences in age compositions and run strengths of the various chinook stocks present in the lower river during the harvest period, and secondarily, to the size-selective nature of the commercial gillnets.

An aerial survey of the Anvik River drainage, including Beaver Creek, Swift River, Canyon Creek, Otter Creek, and McDonald River, was flown on 23 July under poor survey conditions. A total of 875 chinook salmon were enumerated. The count of 628 chinook salmon in the mainstem Anvik River between the Yellow River and McDonald Creek (Figure 2) met the aerial survey count objective of at least 500 chinook salmon for this index area. A total of 170,000 chum salmon were also counted on this survey. No pink salmon were observed and they were assumed not present.

Hydrologic and Climatological Sampling

River transect data collected on 7 and 24 July indicated that the bottom gradient was relatively smooth on both banks, and without major obstructions to the sonar beam (Figure 3). River width data collected in conjunction with the transect profiles varied from a high on 7 July of approximately 55 m to a low of 49 m on 24 July. Although overall maximum river width and river depth recorded during project operations occurred during the first full day of field operations, 21 June (Appendix A.8), maximum river width and depth probably occurred prior to initiation of field operations. River water level dropped approximately 88 cm between 21 June and 27 July (Figure 4). After a slight increase in water level on 26 June, river level dropped in a consistent and regular manner through out the remainder of the season.

Instantaneous water temperature ranged from a low of 12° C on 24 June to a high of 22° C on 30 June. Instantaneous air temperature ranged from a low daily minimum of 2° C on 13 July to a high daily maximum of 32° C observed on 29 June (Figure 4).

Run Timing

Summer chum salmon run timing at the lower Yukon River set gillnet test fishery (rkm 32), at the Yukon River sonar site (rkm 197), and at the Anvik River sonar site located 589 km from the mouth of the Yukon River (Figure 1), were compared to provide a qualitative assessment of summer chum salmon migration through the lower river fisheries (Figure 17). In 1991, 69% of the estimated summer chum salmon which passed the mainstem Yukon River sonar site also passed the Anvik River sonar site. Although there is a major spawning tributary, the Andreafsky River (Figure 1), between the lower Yukon River test fishery and the mainstem Yukon River sonar site, it is assumed that most of the unharvested salmon migrating passed the lower Yukon River test fishing sites also pass the Yukon sonar site. This assumption is probably met because of the difference in magnitude between the Andreafsky and Anvik River summer chum runs. The Anvik River summer chum salmon run is thought to be at least 5 times greater in size than the Andreafsky River run. Whereas summer chum salmon escapements have averaged over 700,000 for the period 1979–1990, aerial survey estimates and tower counts of Andreafsky River escapements have rarely exceeded 200,000 (Bergstrom et al. 1991). In 1991 the peak aerial survey estimate of summer chum salmon escapement to the Andreafsky River was only 78,543 salmon; the Anvik River escapement was 874,772 salmon.

Because we assumed that a majority of the summer chum passed all three sites, we could subjectively assess run timing of the summer chum salmon run among these sites. The median date of the 1991 summer chum salmon passage was 28 June at the lower river test fishing sites, 2 July at the Yukon sonar site, and 10 July at the Anvik River sonar site. Based on these data, the difference or lag time between the lower river test fishery and the Anvik River sonar site in 1991 was 16 d (1986–90 average = 14.8 days, SE=4.1), whereas the lag time between the Yukon River and Anvik River sonar sites was 8 d (1986–1990 average = 10.0 days, SE 1.6). Based on distance and time between median days of passage, the calculated swimming speed of summer chum salmon in 1991 was approximately 35 km/d from the lower river test fishery to the Anvik River sonar site, and 42 k/day between the two sonar sites. The 1986–90 average swimming speed, based on similar calculations, between the lower Yukon River test fishing sites and the Anvik River sonar site was 38 km/d; between the Yukon and Anvik River sonar sites, it was 39 km/d. These calculations, however, may be affected by test net efficiency, sonar accuracy, and run timing differences of the various summer chum salmon stocks.

Inspection of the daily test fishing catch per unit effort in the lower river test fishery and the Anvik River sonar counts indicates that a large pulse of fish passed these two sites during the first portion of the run (Figure 17). However, this pulse was not apparent in the Yukon River sonar counts (Figure 17). In 1991 the apparent fast swimming speed between the Yukon and Anvik River sonar sites, 42 km/d, could be partially attributed to the actual median day of passage being earlier than that observed at the Yukon River sonar site because this large pulse of salmon early in the run was not detected. The pulse may not have been detected at the Yukon River sonar because of sonar signal attenuation and salmon passing outside the sonar range at the mainstem Yukon River sonar site. Salmon passing outside the sonar range has been identified as a potentially significant sampling problem at that site (Fleischman et al. 1992).

Side-scanning sonar proved to be an effective method for monitoring summer chum salmon escapement in the Anvik River. Escapement to the Anvik River estimated by side-scanning sonar was 842,772 summer chum salmon in 1991. Although the preseason outlook for the 1991 Anvik River summer chum salmon run was below average, the escapement exceeded the minimum escapement objective by 74%. A revised inseason assessment of run size, in relation to the Anvik River escapement objective, resulted in the scheduling of additional restricted mesh-size fishing periods in the Lower Yukon Management Area.

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Table 1. Anvik River summer chum salmon sonar counts by date, 1991.

	West Bank				East Bank				Entire River				
Date	Raw Daily Count	Adjust Factor[a]	Corrected Daily Count	Percentage of Daily Total	Raw Daily Count	Adjust Factor[a]	Corrected Daily Count	Percentage of Daily Total	Raw Daily Count	Corrected Daily Count	Corrected Season Count	Daily Prop.	Season Prop.
21–Jun	22	1.00	22	100.0	–	–	–	0.0	22	22	22	0.00	0.00
22–Jun	875	0.13	112	100.0	0	–	0	0.0	875	112	134	0.00	0.00
23–Jun	2,276	0.73	1,652	100.0	0	–	0	0.0	2,276	1,652	1,786	0.00	0.00
24–Jun	2,536	0.90	2,279	100.0	0	–	0	0.0	2,536	2,279	4,065	0.00	0.00
25–Jun	9,338	0.88	8,263	100.0	0	–	0	0.0	9,338	8,263	12,328	0.01	0.01
26–Jun	26,588	0.83	22,045	99.3	269	0.61	164	0.7	26,857	22,209	34,537	0.03	0.04
27–Jun	30,976	0.88	27,294	98.5	410	1.00	410	1.5	31,385	27,704	62,241	0.03	0.07
28–Jun	43,405	0.92	39,984	89.0	4,935	1.00	4,935	11.0	48,340	44,919	107,160	0.05	0.13
29–Jun	37,338	0.93	34,645	85.8	5,321	1.08	5,739	14.2	42,659	40,384	147,544	0.05	0.17
30–Jun	22,890	0.99	22,618	84.6	4,001	1.03	4,111	15.4	26,891	26,729	174,273	0.03	0.21
01–Jul	25,025	0.92	23,119	82.7	4,827	1.00	4,827	17.3	29,852	27,946	202,219	0.03	0.24
02–Jul	20,488	0.93	19,135	74.7	6,599	0.98	6,472	25.3	27,087	25,607	227,826	0.03	0.27
03–Jul	18,674	0.95	17,671	86.2	2,347	1.20	2,828	13.8	21,021	20,499	248,325	0.02	0.29
04–Jul	15,876	0.98	15,560	69.3	8,190	0.84	6,878	30.7	24,066	22,438	270,763	0.03	0.32
05–Jul	14,353	1.00	14,317	77.1	4,630	0.92	4,261	22.9	18,983	18,578	289,341	0.02	0.34
06–Jul	11,502	1.02	11,698	83.9	2,702	0.83	2,241	16.1	14,204	13,939	303,280	0.02	0.36
07–Jul	13,105	0.94	12,350	88.9	1,561	0.98	1,537	11.1	14,666	13,887	317,167	0.02	0.37
08–Jul	27,038	0.96	25,894	67.7	12,614	0.98	12,366	32.3	39,652	38,260	355,427	0.05	0.42
09–Jul	29,270	0.99	28,913	49.8	29,974	0.97	29,155	50.2	59,244	58,068	413,495	0.07	0.49
10–Jul	27,763	0.97	26,898	58.8	20,273	0.93	18,841	41.2	48,036	45,739	459,234	0.05	0.54
11–Jul	26,377	0.96	25,217	55.7	19,473	1.03	20,078	44.3	45,850	45,295	504,529	0.05	0.60
12–Jul	24,267	0.96	23,262	70.2	11,581	0.85	9,876	29.8	35,848	33,138	537,667	0.04	0.63
13–Jul	23,576	1.00	23,594	72.5	9,621	0.93	8,945	27.5	33,197	32,539	570,206	0.04	0.67
14–Jul	23,675	0.97	22,940	76.6	6,936	1.01	6,992	23.4	30,611	29,932	600,138	0.04	0.71
15–Jul	17,760	0.98	17,410	66.1	9,011	0.99	8,920	33.9	26,771	26,330	626,468	0.03	0.74
16–Jul	18,112	0.95	17,220	74.3	6,321	0.94	5,960	25.7	24,433	23,180	649,648	0.03	0.77
17–Jul	16,878	0.97	16,337	70.3	7,283	0.95	6,915	29.7	24,161	23,252	672,900	0.03	0.79
18–Jul	12,866	0.97	12,443	72.4	4,861	0.97	4,733	27.6	17,727	17,176	690,076	0.02	0.81
19–Jul	8,956	0.96	8,564	65.1	4,636	0.99	4,599	34.9	13,592	13,163	703,239	0.02	0.83
20–Jul	12,573	1.03	12,947	75.4	4,580	0.97	4,221	24.6	17,153	17,168	720,407	0.02	0.85
21–Jul	13,260	0.99	13,119	65.4	7,188	0.96	6,932	34.6	20,448	20,051	740,458	0.02	0.87
22–Jul	13,654	1.00	13,701	51.5	13,892	0.93	12,909	48.5	27,546	26,610	767,068	0.03	0.90
23–Jul	17,542	0.98	17,111	59.4	12,429	0.94	11,690	40.6	29,971	28,801	795,869	0.03	0.94
24–Jul	11,618	0.97	11,244	53.4	10,566	0.93	9,826	46.6	22,184	21,070	816,939	0.02	0.96
25–Jul	11,307	0.96	10,904	63.3	6,932	0.91	6,327	36.7	18,239	17,231	834,170	0.02	0.98
26–Jul	9,219	0.91	8,397	61.7	5,402	0.96	5,205	38.3	14,621	13,602	847,772	0.02	1.00
Total	640,977		608,879		249,365		238,893		890,342	847,772			
Mean		0.93		76.4		0.82		23.6					
Season adjust. factor[b]		0.95				0.96			0.95				

[a] Adjustment factor is the proportion of corrected daily sonar counts to the raw sonar counts.
[b] Season adjustment factor is the proportion of the corrected season sonar counts to the unadjusted sonar counts.

Table 2. Annual Anvik River sonar passage estimates and associated passage timing statistics of the summer chum salmon run 1979–1991.

Year	Sonar Passage Esitmate	First Quartile Day	Median Day	Third Quartile Day	Days Between Quartile Days: First & Median	Days Between Quartile Days: Median & Third	Days Between Quartile Days: First & Third
1979	277,712	02–Jul	08–Jul	12–Jul	6	4	10
1980	482,181	06–Jul	11–Jul	16–Jul	5	5	10
1981	1,479,582	27–Jun	02–Jul	07–Jul	5	5	10
1982	444,581	07–Jul	11–Jul	14–Jul	4	3	7
1983	362,912	30–Jun	07–Jul	12–Jul	7	5	12
1984	891,028	05–Jul	09–Jul	13–Jul	4	4	8
1985	1,080,243	10–Jul	13–Jul	16–Jul	3	3	6
1986	1,085,750	29–Jun	02–Jul	06–Jul	3	4	7
1987	455,876	05–Jul	12–Jul	16–Jul	7	4	11
1988	1,125,449	01–Jul	04–Jul	09–Jul	3	5	8
1989	636,906	01–Jul	07–Jul	15–Jul	6	8	14
1990	403,627	02–Jul	07–Jul	15–Jul	5	8	13
1991	847,772	02–Jul	10–Jul	16–Jul	8	6	14
Mean[a]		03–Jul	08–Jul	13–Jul	5.0	4.9	9.9
SE[a]		3.7	3.4	3.0	1.4	1.7	2.5

[a] Calculation of mean and SE includes estimates from years 1979–1985 and 1987–1990. In 1986 sonar passage counting was terminated early, probably resulting in the incorrect calculation of the quartile days. Therefore, 1986 run timing statistics were excluded from the calculation of the overall mean and SE.

Table 3. Sonar and corresponding oscilloscope counts of salmon at the Anvik River east and west bank sites, 1991.

	West Bank Sonar Site				East Bank Sonar Site			
Date	Hours	Sonar Count	Scope Count	Sonar/ Scope	Hours	Sonar Count	Scope Count	Sonar/ Scope
21–Jun	1.00	34	85	0.40	0.00	–	–	–
22–Jun	1.50	1	1	1.00	0.00	–	–	–
23–Jun	1.50	217	152	1.43	0.00	–	–	–
24–Jun	1.93	174	149	1.17	0.00	–	–	–
25–Jun	1.00	247	218	1.13	0.85	0	0	
26–Jun	1.25	537	468	1.15	0.95	34	14	2.43
27–Jun	1.05	572	494	1.16	1.23	129	3	43.00
28–Jun	0.52	424	392	1.08	0.92	37	58	0.64
29–Jun	0.50	392	355	1.10	1.10	83	87	0.95
30–Jun	0.63	356	350	1.02	1.12	75	71	1.06
01–Jul	0.37	252	238	1.06	1.22	56	51	1.10
02–Jul	0.95	277	242	1.14	1.42	27	25	1.08
03–Jul	0.87	207	196	1.06	1.17	25	34	0.74
04–Jul	0.00	–	–	–	0.17	16	13	1.23
05–Jul	0.67	107	115	0.93	1.33	146	118	1.24
06–Jul	0.90	153	156	0.98	1.00	14	12	1.17
07–Jul	0.77	175	176	0.99	1.12	16	16	1.00
08–Jul	0.73	257	248	1.04	1.43	160	157	1.02
09–Jul	0.35	220	213	1.03	0.30	253	246	1.03
10–Jul	0.52	271	260	1.04	0.50	207	193	1.07
11–Jul	0.38	217	208	1.04	0.70	327	350	0.93
12–Jul	0.55	219	210	1.04	0.77	245	201	1.22
13–Jul	0.67	196	196	1.00	0.87	185	173	1.07
14–Jul	0.40	200	196	1.02	0.75	163	162	1.01
15–Jul	0.78	280	273	1.03	0.77	178	180	0.99
16–Jul	0.80	199	189	1.05	0.53	134	128	1.05
17–Jul	0.37	172	161	1.07	0.68	192	182	1.05
18–Jul	0.65	212	205	1.03	0.65	170	164	1.04
19–Jul	0.75	209	200	1.05	0.83	205	202	1.01
20–Jul	0.85	251	252	1.00	0.87	192	188	1.02
21–Jul	0.72	242	245	0.99	0.82	231	222	1.04
22–Jul	0.60	256	256	1.00	0.70	199	177	1.12
23–Jul	0.33	172	128	1.34	0.98	339	278	1.22
24–Jul	0.45	162	156	1.04	0.75	134	125	1.07
25–Jul	0.45	124	120	1.03	0.68	82	74	1.11
26–Jul	0.72	219	202	1.08	1.03	141	133	1.06
Total	26.47	8,203	7,705	1.06	27.17	4,254	3,904	1.09

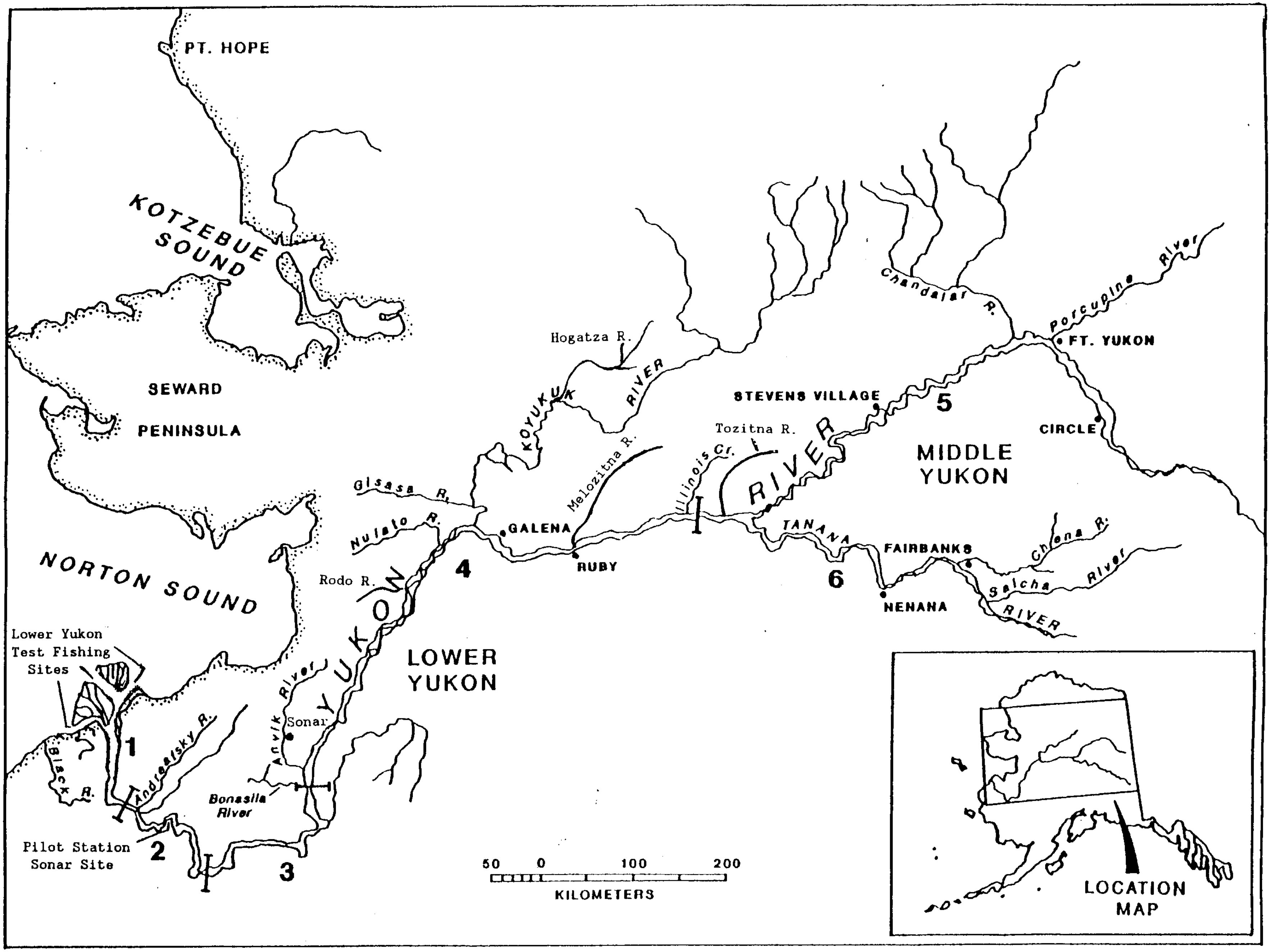

Figure 1. Alaskan portion of the Yukon River showing fishing district boundaries.

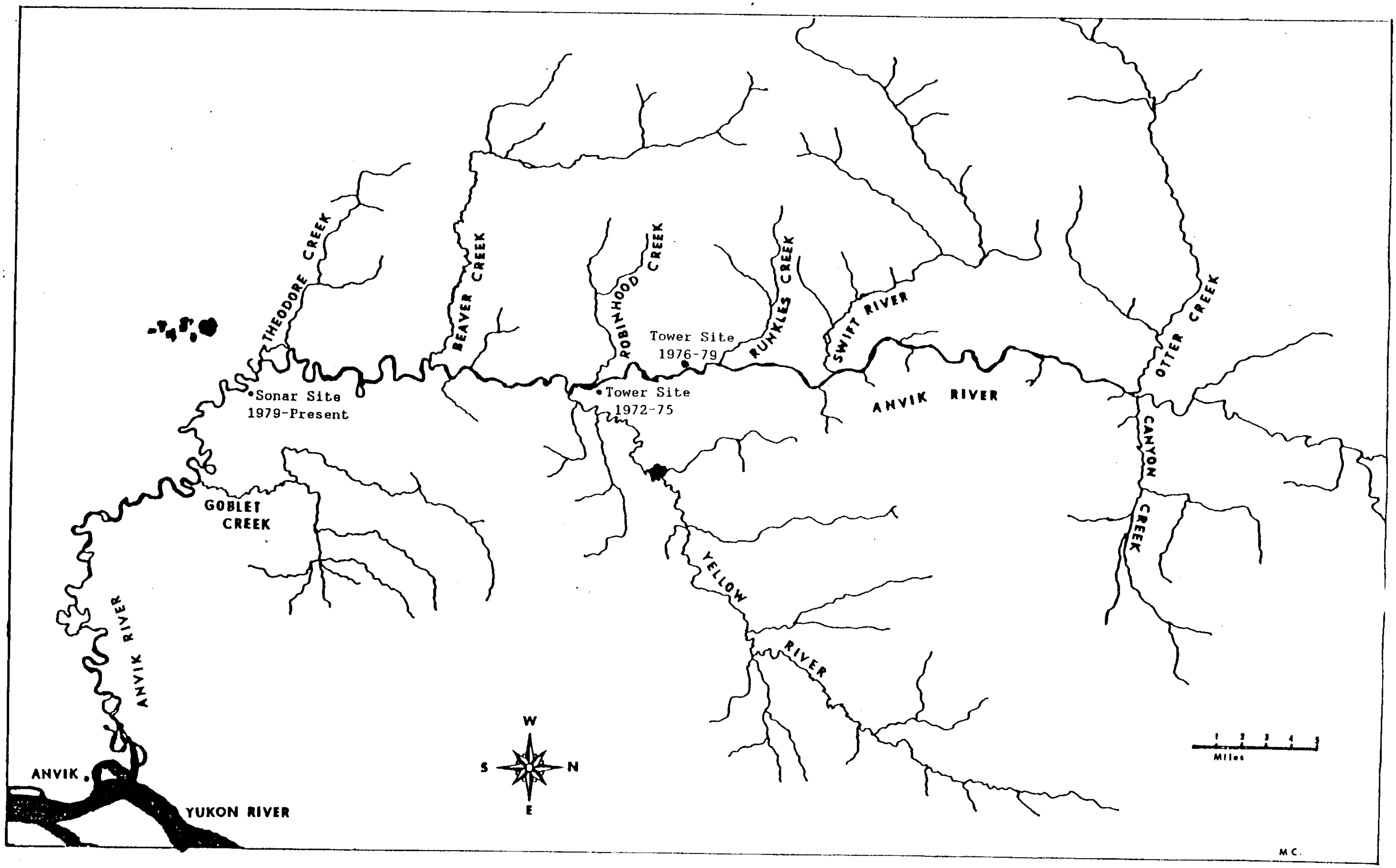

Figure 2. Map of the Anvik River drainage.

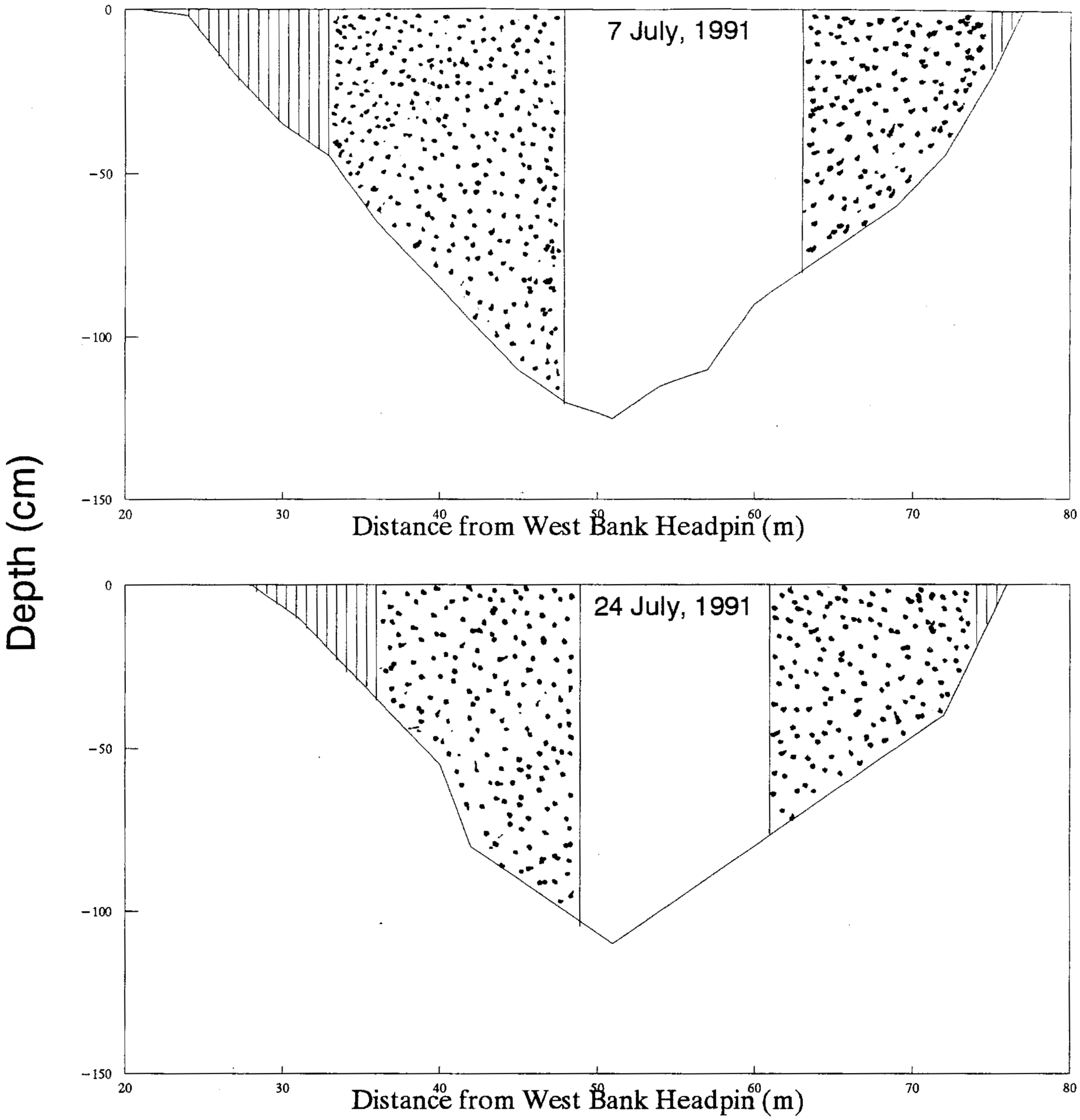

Figure 3. Anvik River depth profiles, 7 and 24 July, 1991. Stippled areas show approximate range of insonification. Weired areas are indicated by vertical lines.

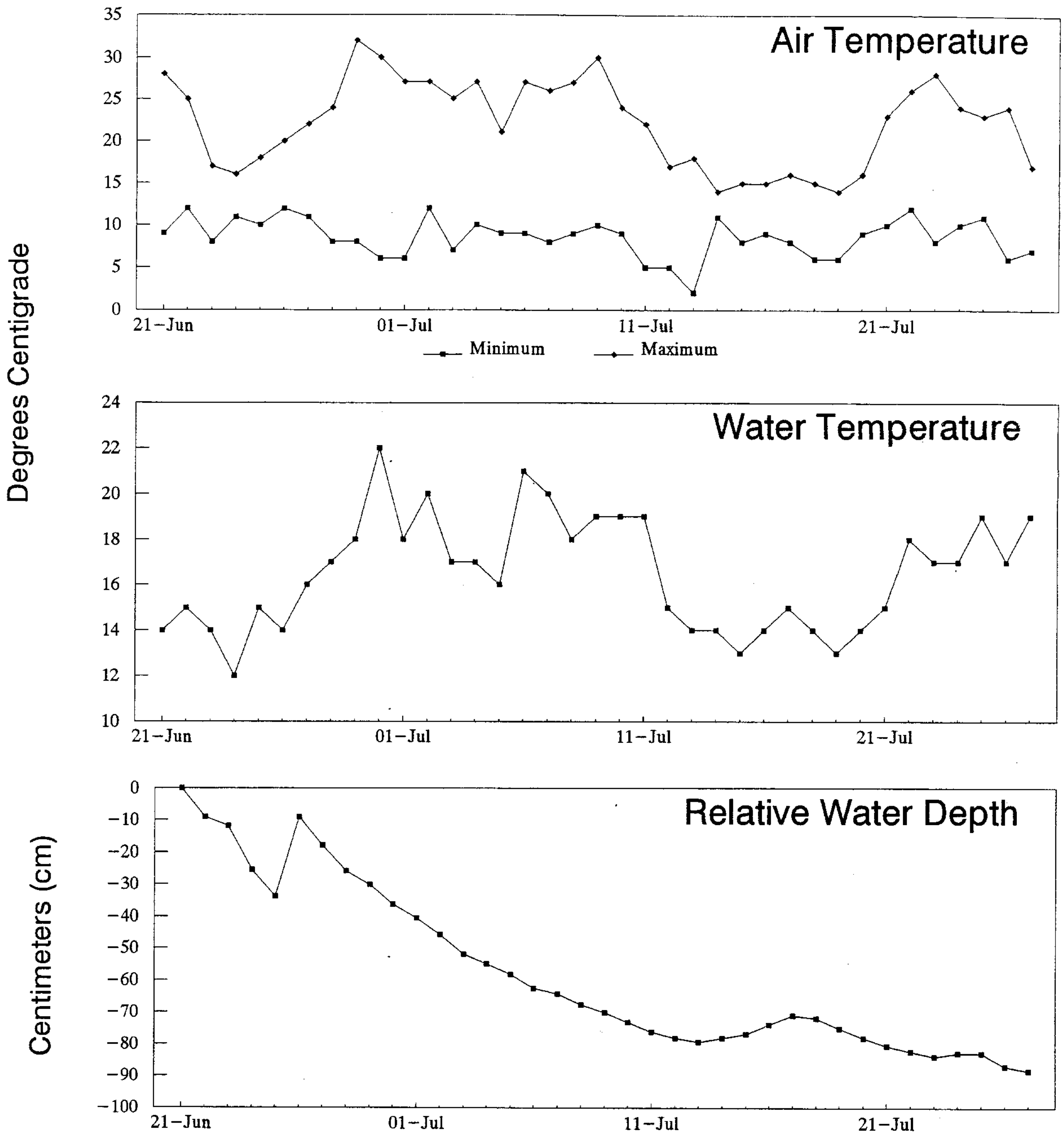

Figure 4. Daily minimum and maximum air temperatures, instantaneous water temperature, and relative water depth measured at approximately 1800 hours daily at the Anvik River sonar site, 1991.

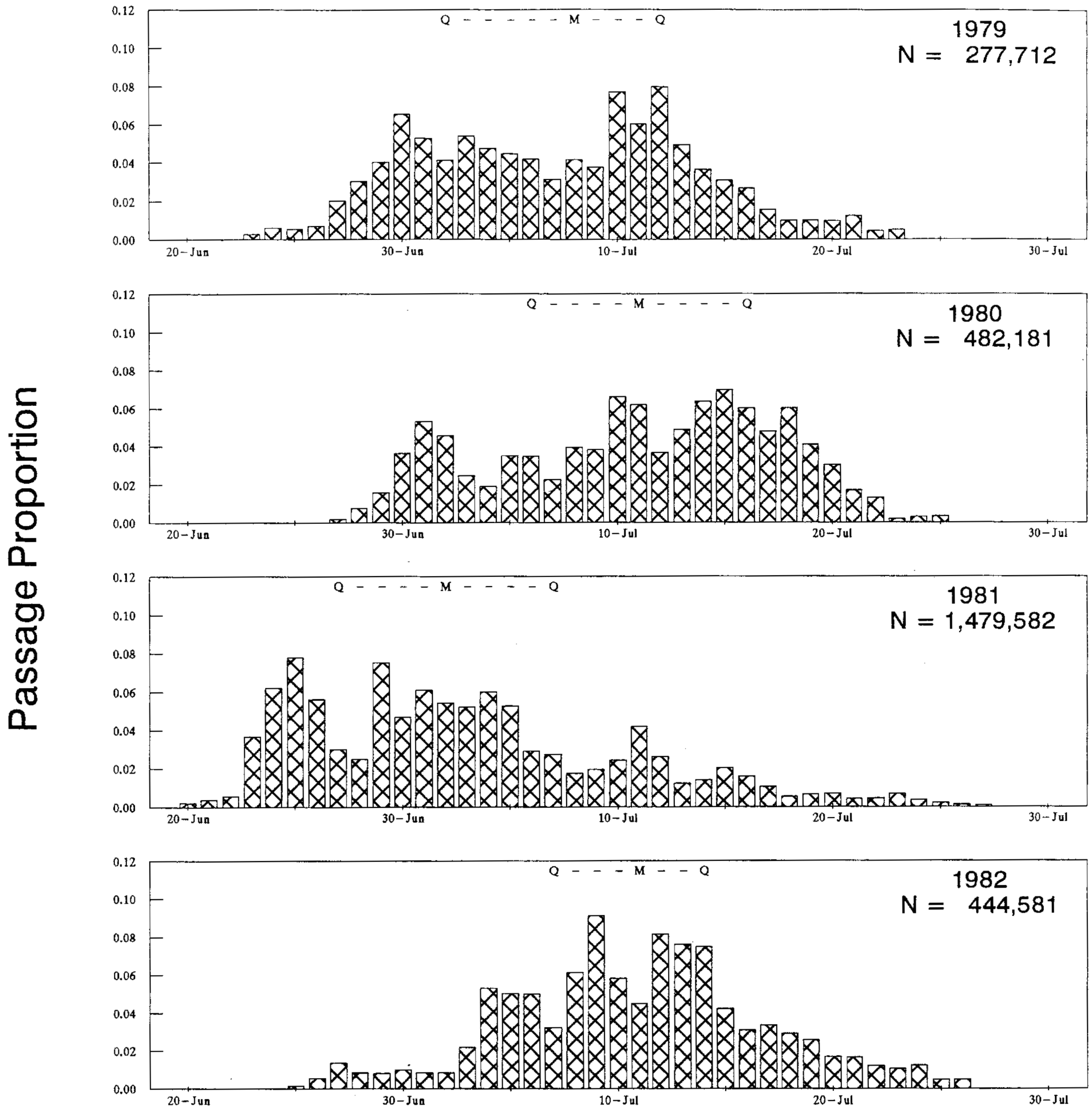

Figure 5. Daily proportion of corrected Anvik River sonar counts of summer chum salmon passage by day, 1979–1991 (N = total number of corrected counts). The first and third quartile passage days are indicated by the "Q"s, while the median day of passage is indicated by the "M".

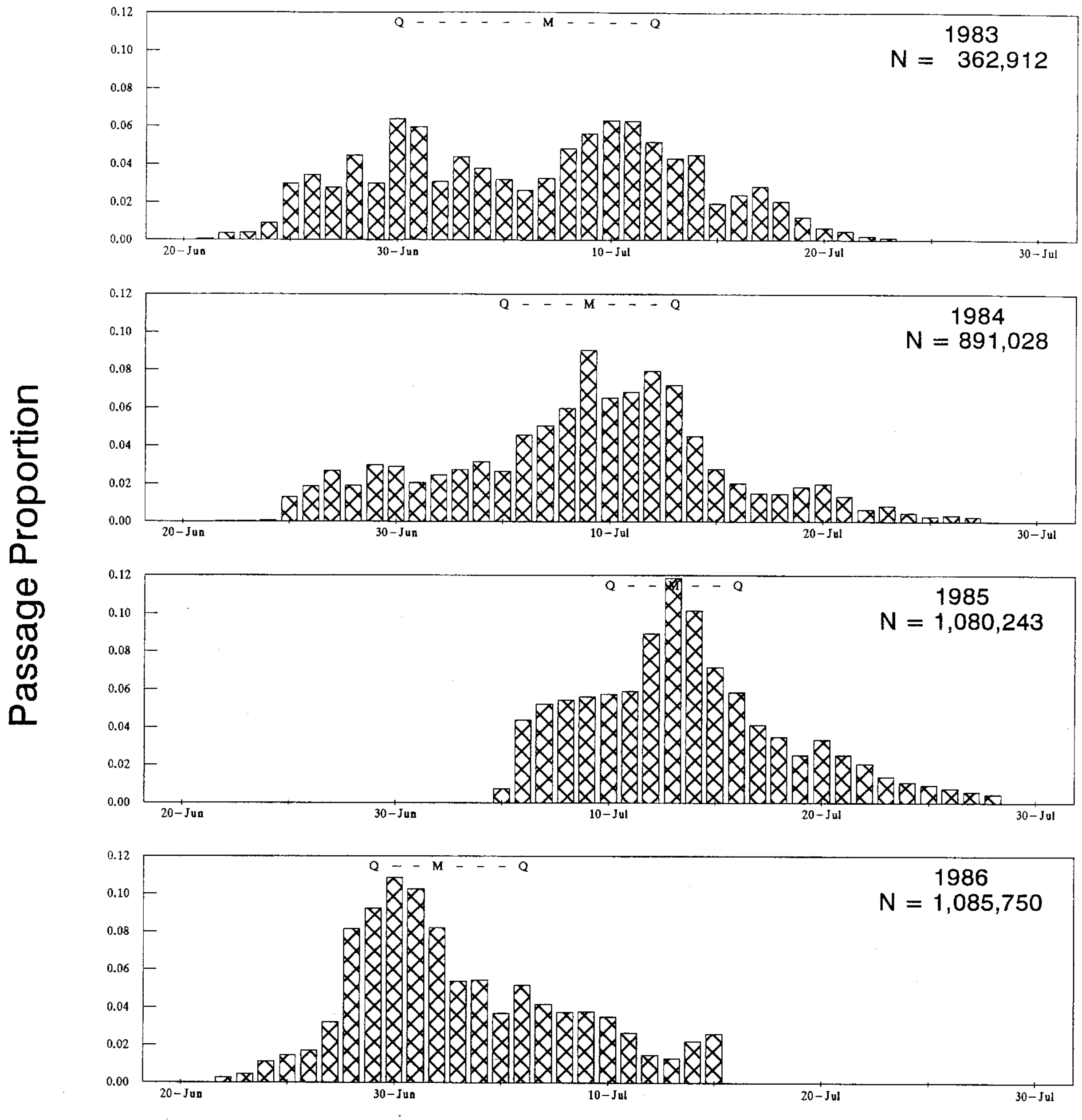

Figure 5. (page 2 of 4).

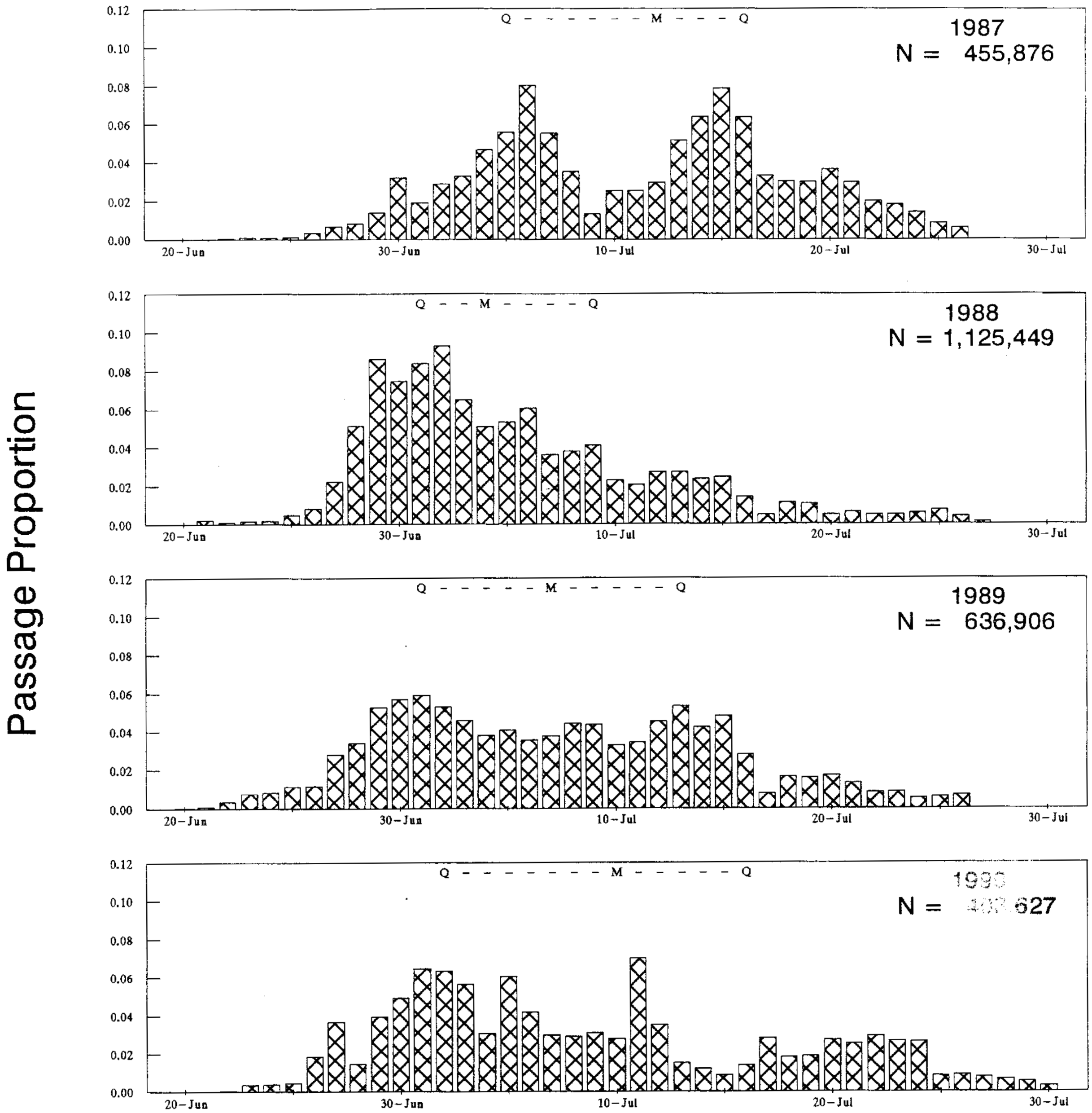

Figure 5. (page 3 of 4).

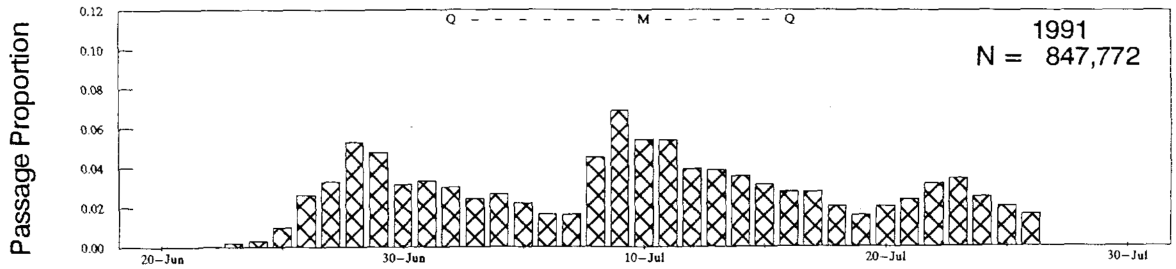

Figure 5. (page 4 of 4).

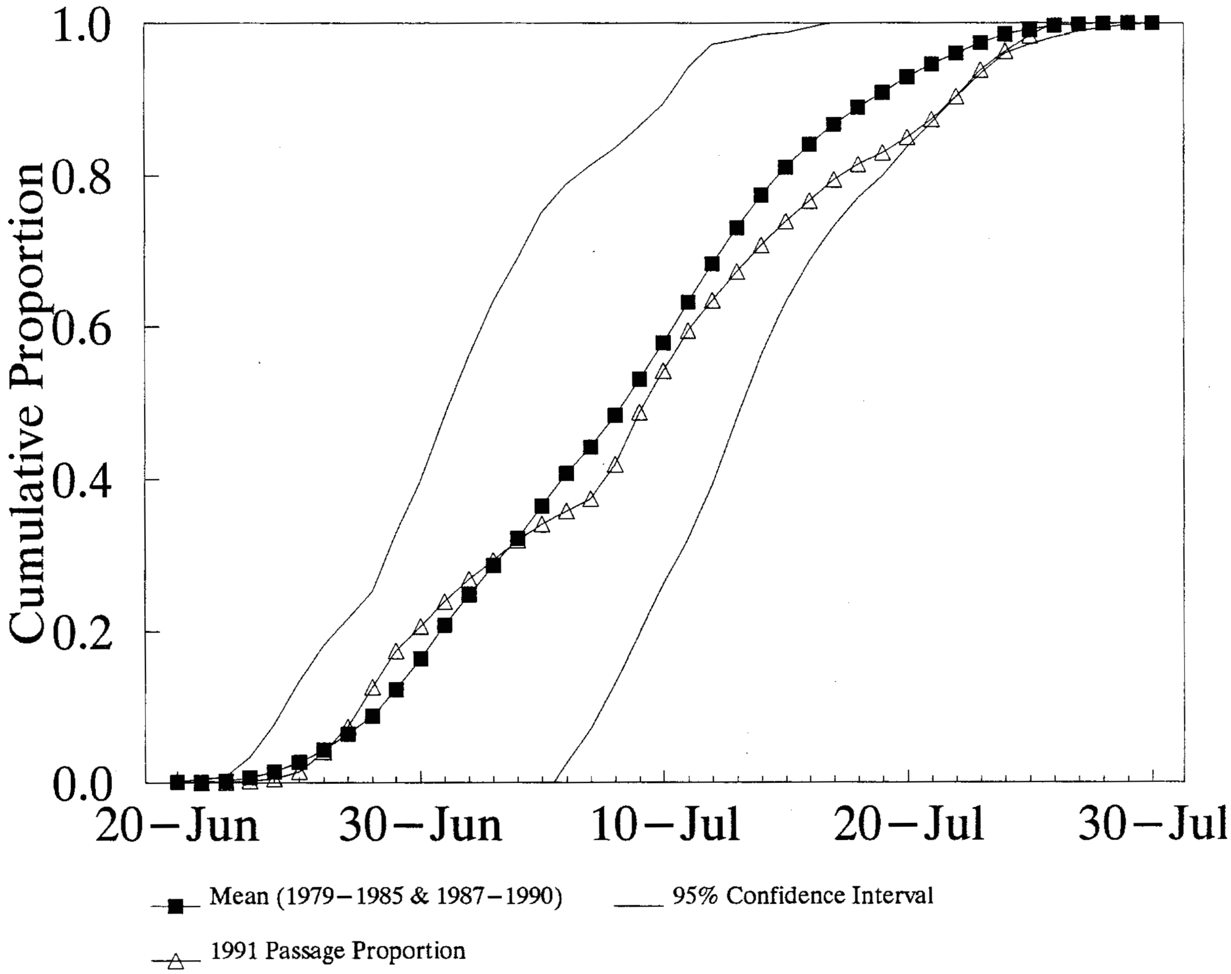

Figure 6. Mean (1979–1985 & 1987–1990) and the 1991 run timing curves for Anvik River summer chum salmon.

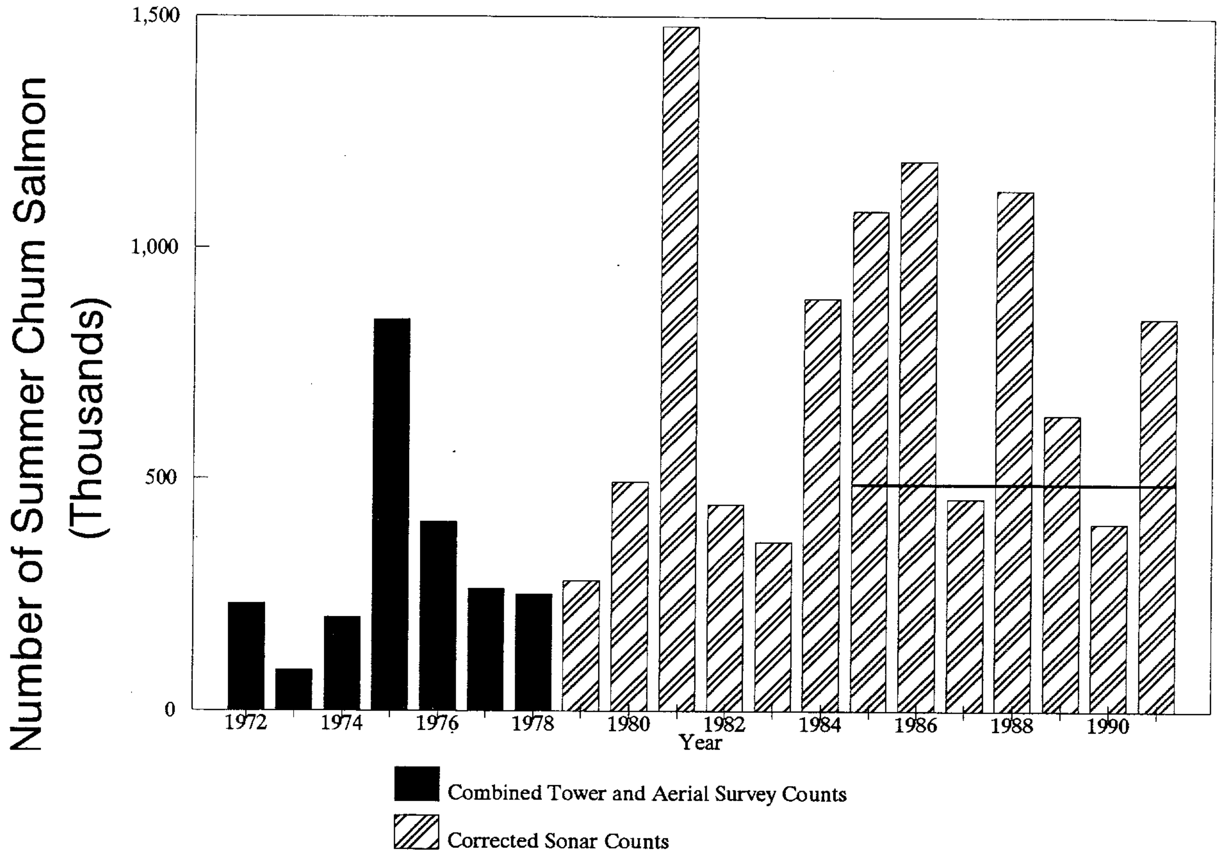

Figure 7. Anvik River summer chum salmon escapement estimated by combined tower and aerial survey count, 1972–1978, and by side–scanning sonar, 1979–1991. Sonar count escapement objective of 487,000 salmon is indicated by the horizontal line.

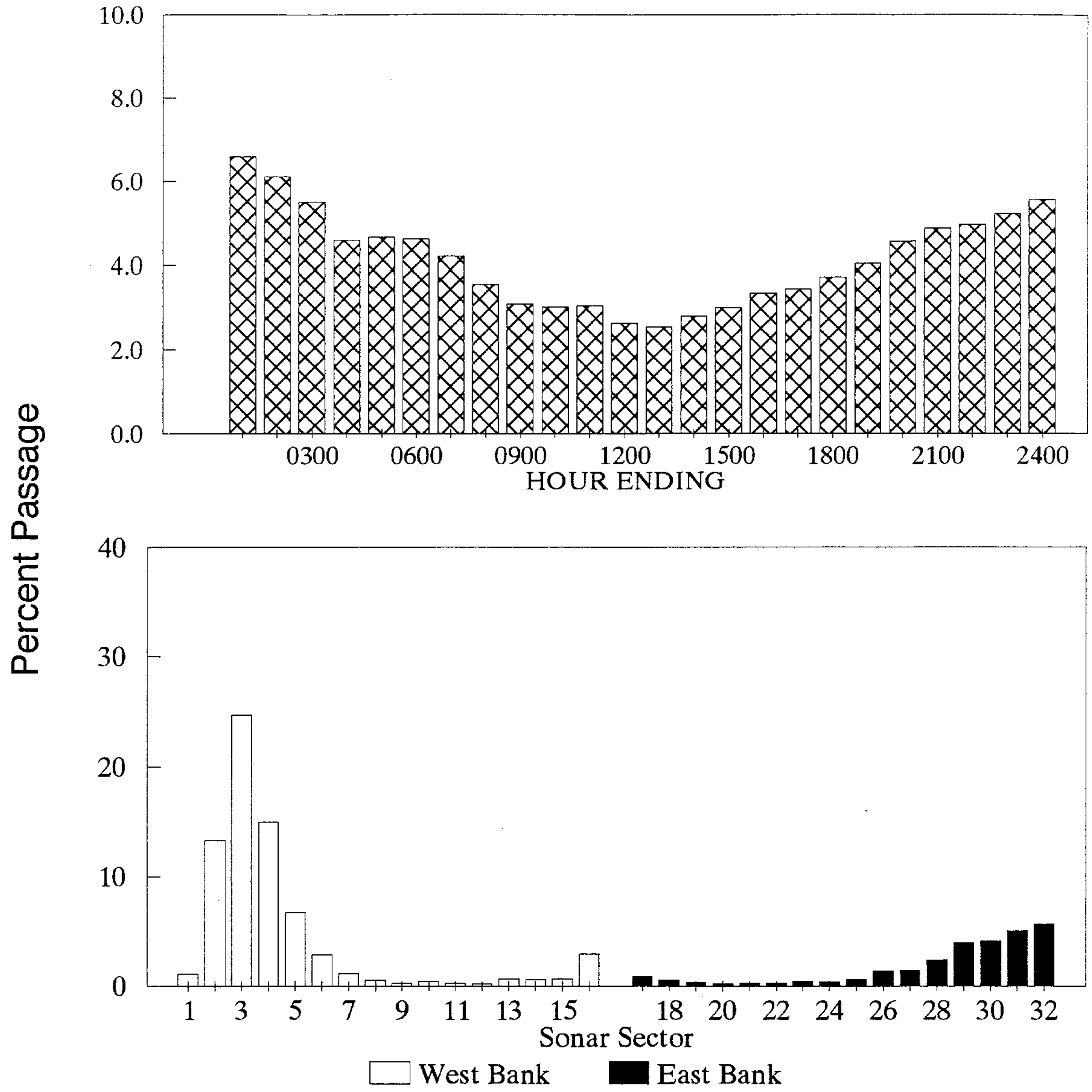

Figure 8. Estimated percent of the total summer chum salmon passage, 847,772 salmon, in relation to hour of the day (above) and sonar sector (below), Anvik River sonar site, 21 June – 26 July, 1991.

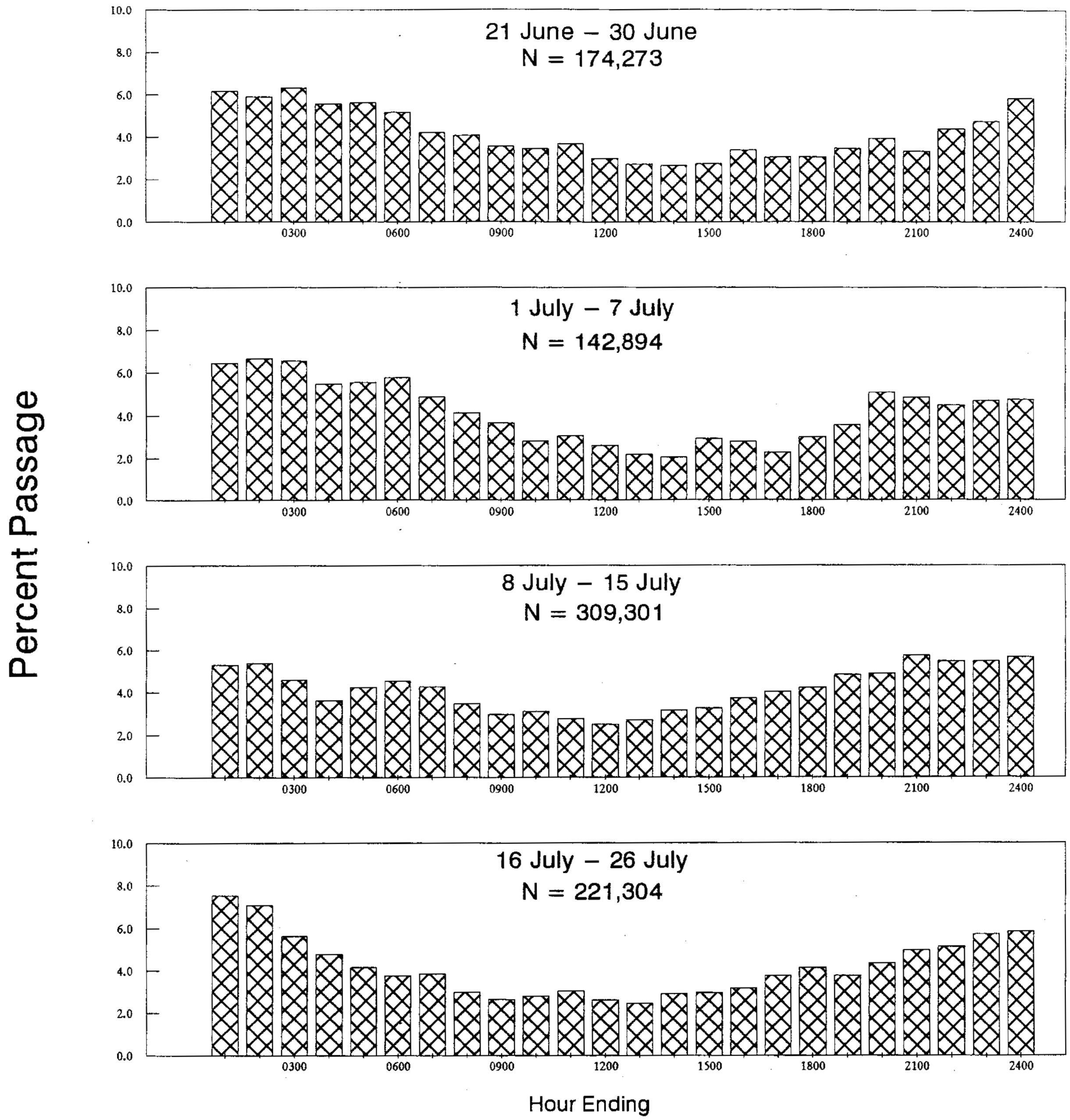

Figure 9. Estimated percent of summer chum salmon passage by sampling stratum and hour of the day, Anvik River, 1991.

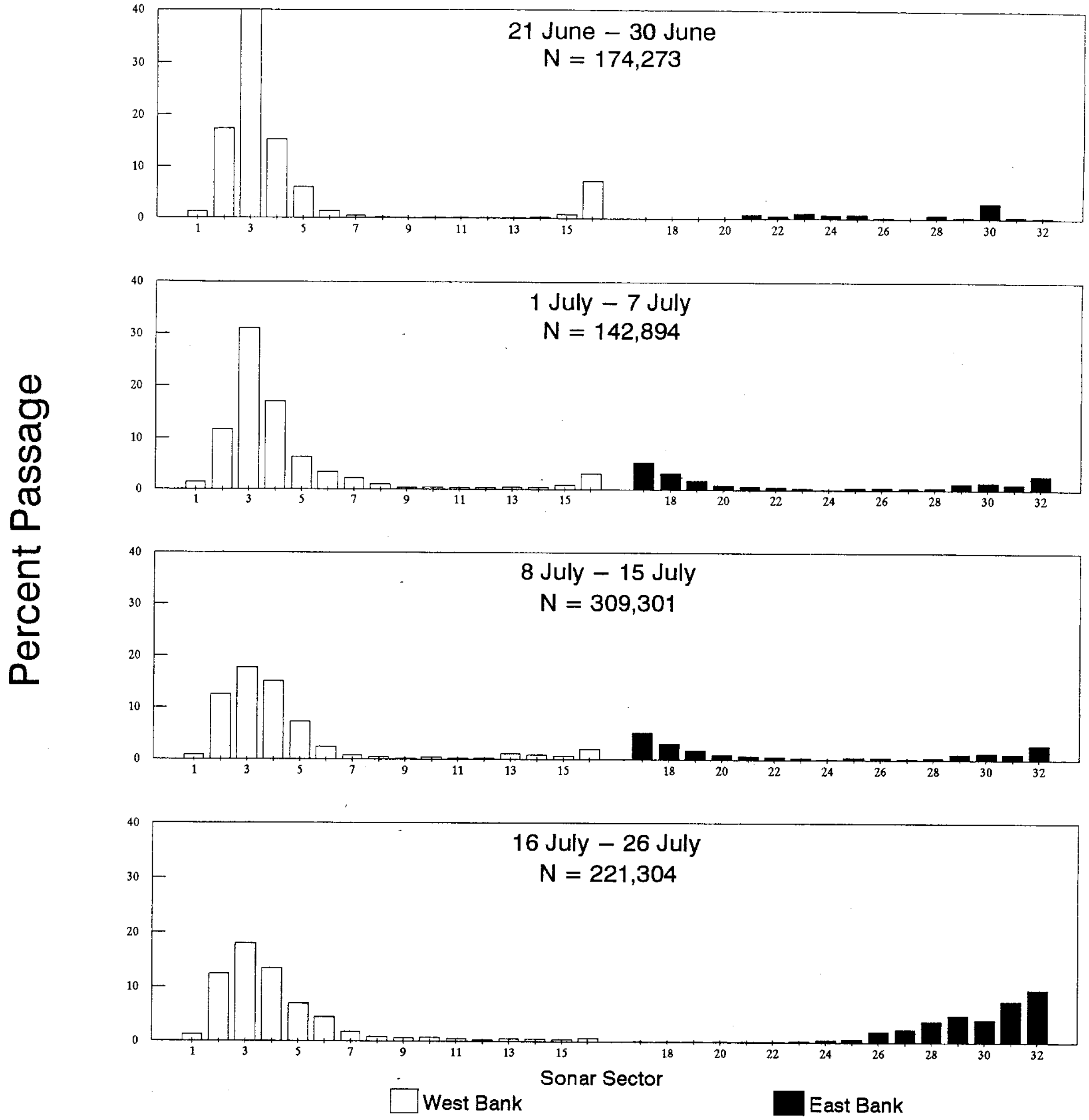

Figure 10. Estimated percent of summer chum salmon passage by sampling stratum and sonar sector, Anvik River, 1991.

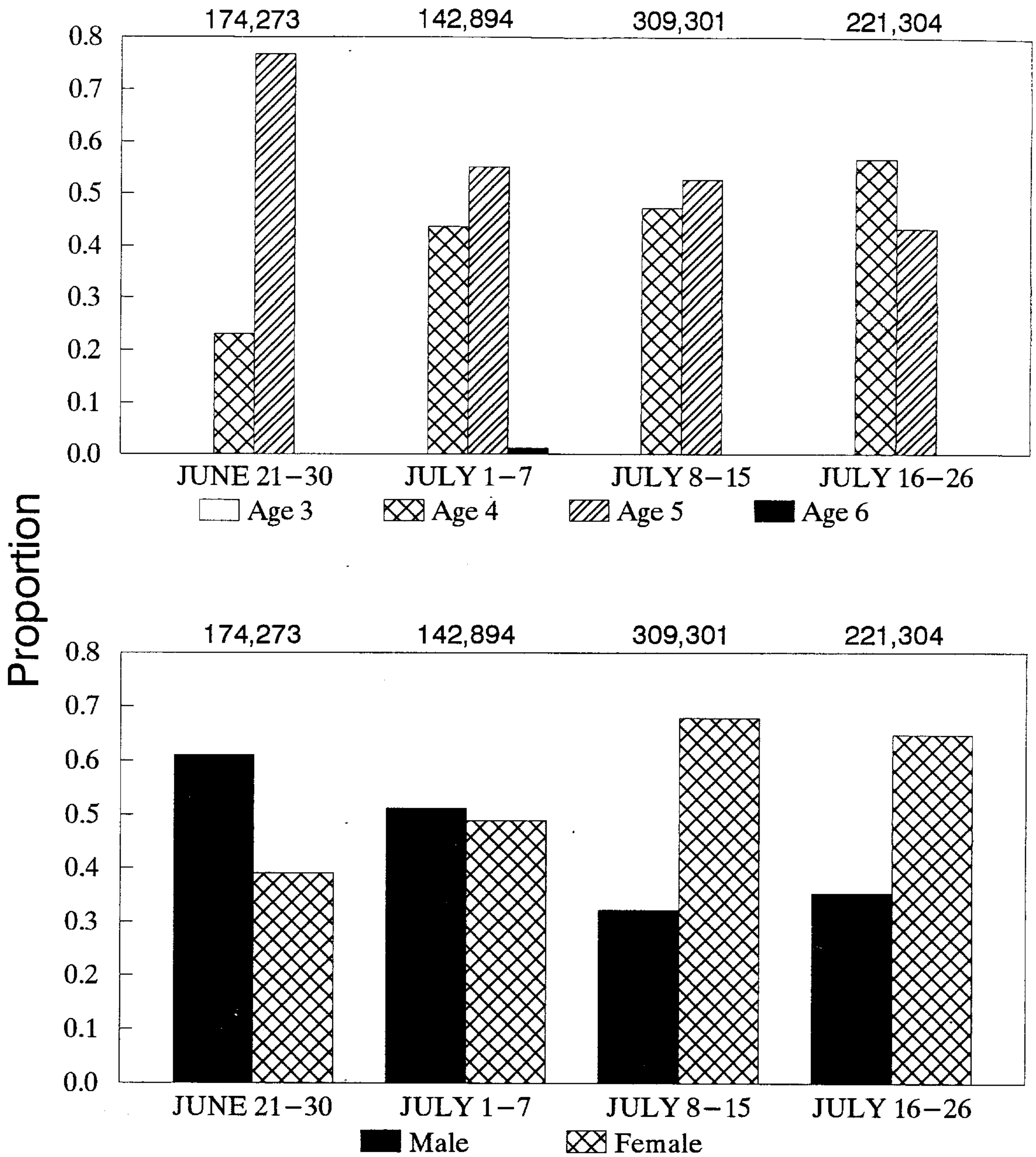

Figure 11. Age and sex compositon of sampled Anvik River summer chum salmon by sampling stratum, 1991. Numbers above bars indicate estimated passage during that stratum.

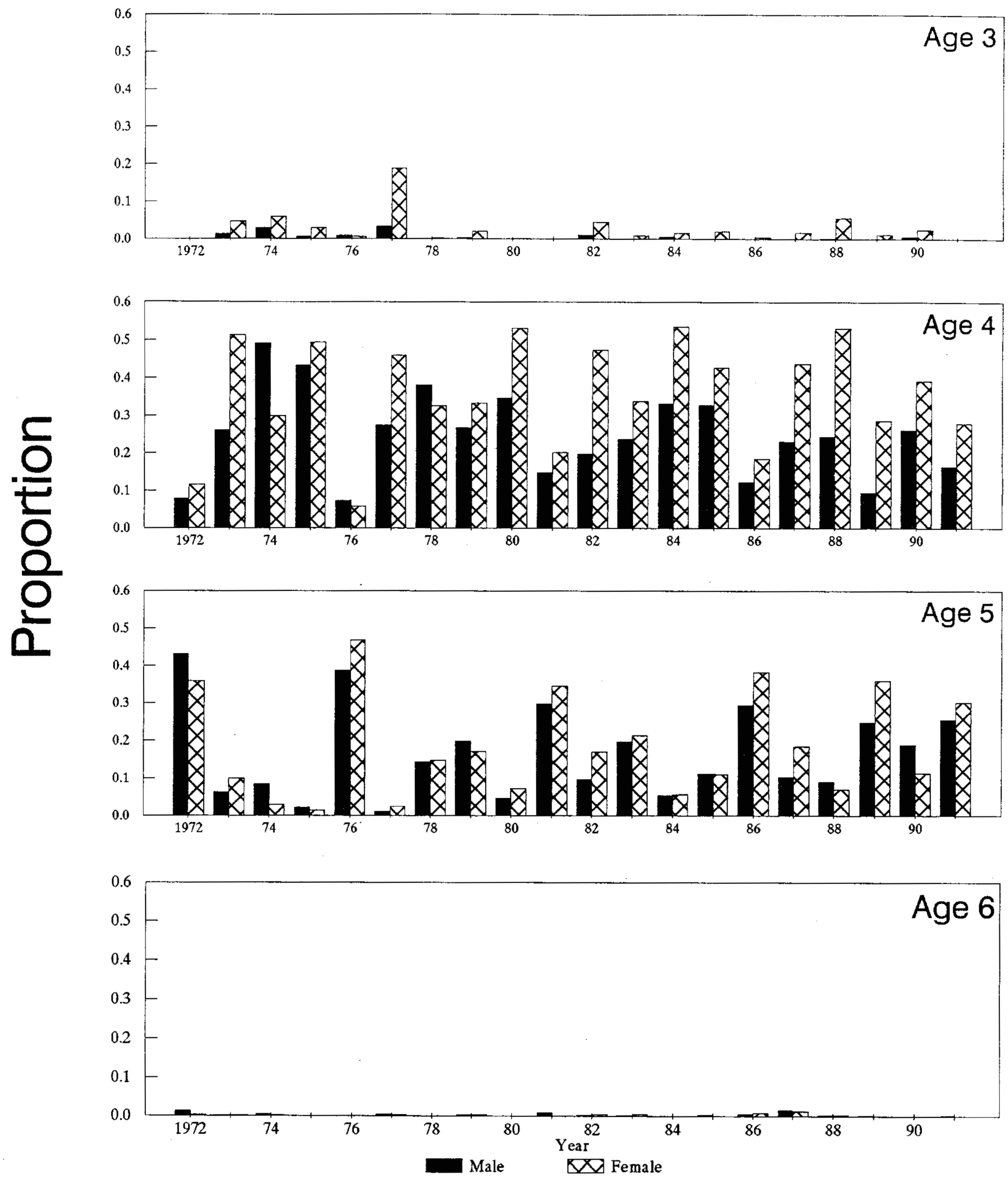

Figure 12. Age and sex compostion of sampled Anvik River summer chum salmon, 1972–1991.

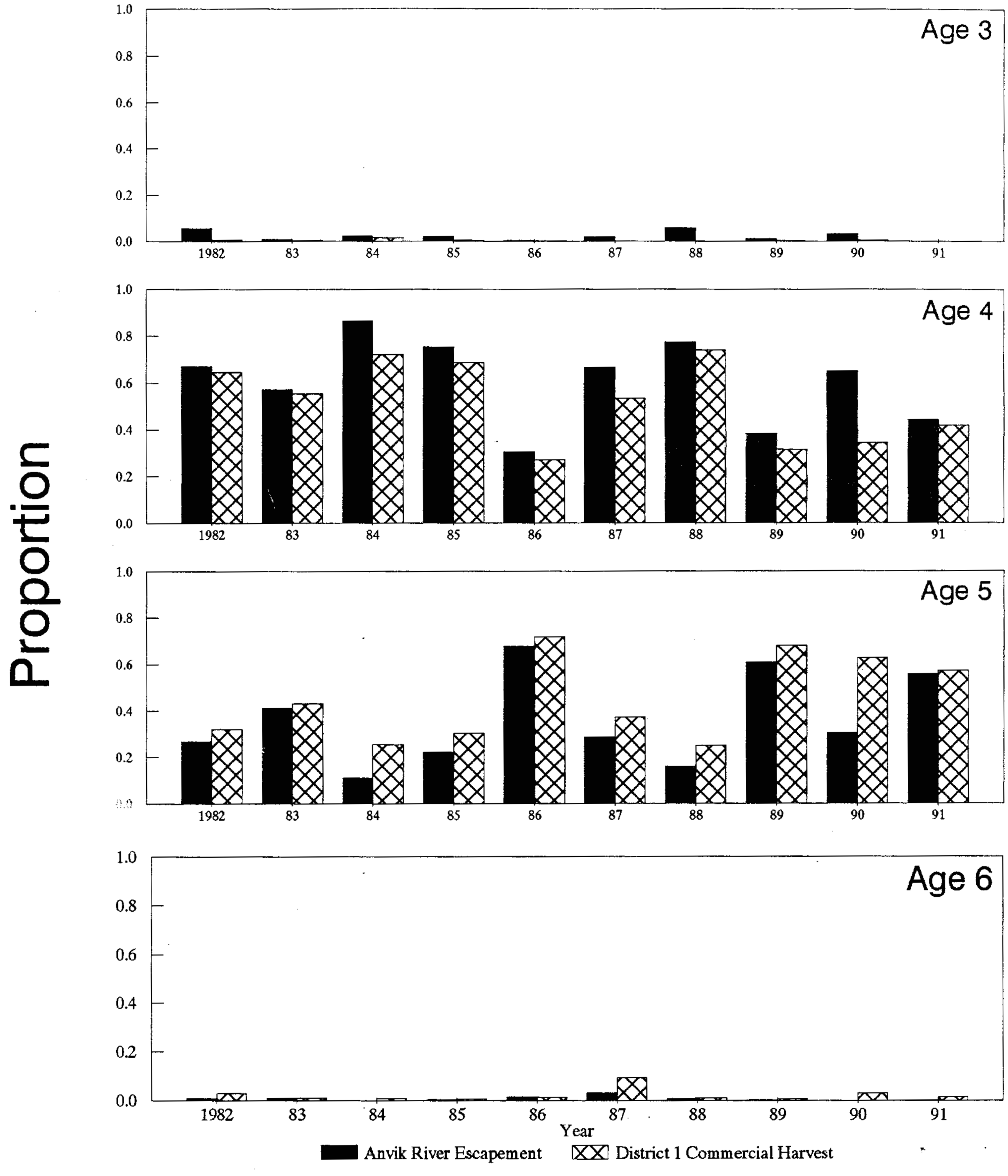

Figure 13. Proportion of summer chum salmon by age in the Anvik River escapement and District 1 commercial harvest, Yukon River, 1982–1991.

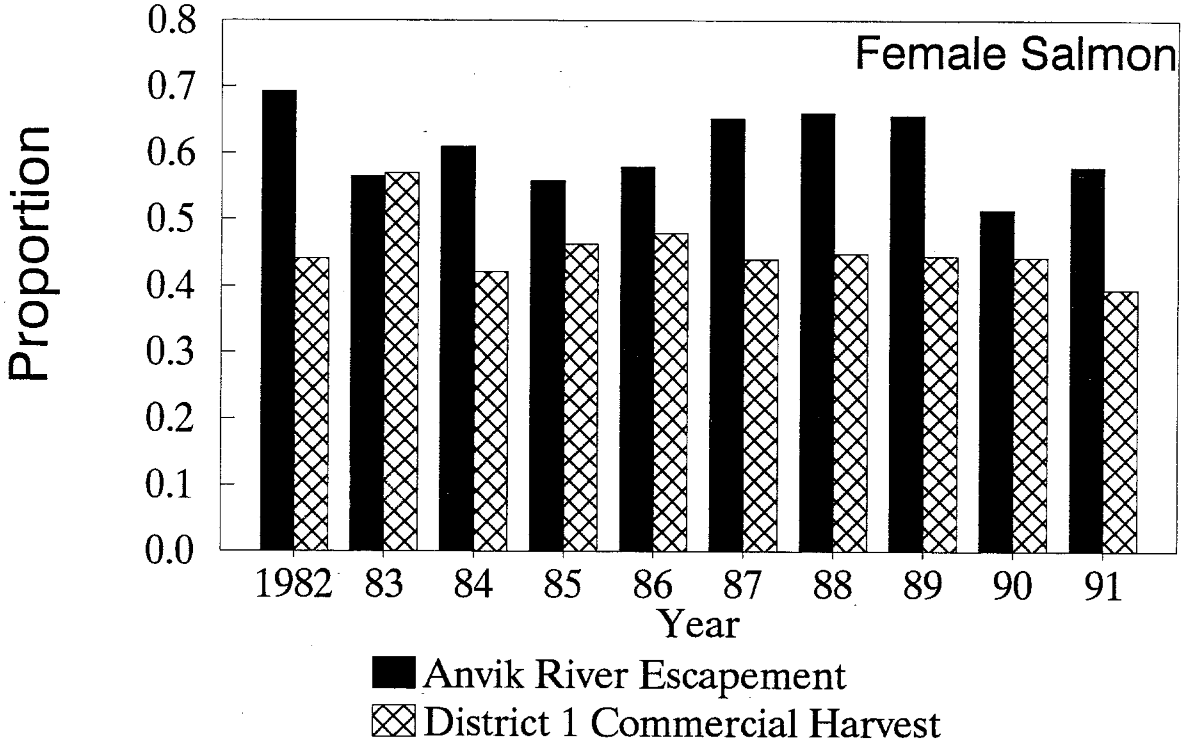

Figure 14. Proportion of female summer chum salmon in the Anvik River escapement and District 1 commercial harvest, Yukon River, 1982–1991.

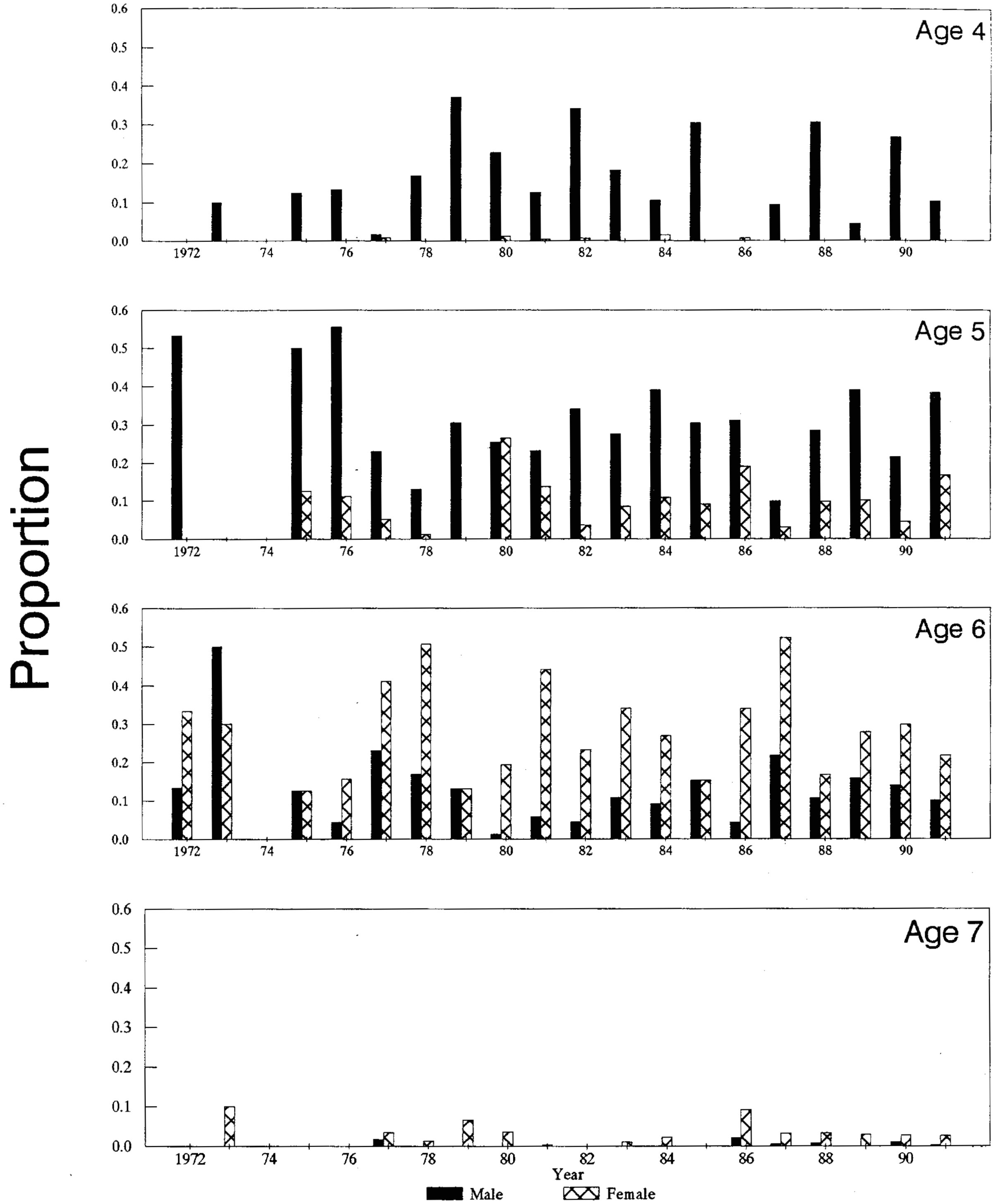

Figure 15. Age and sex compostion of sampled Anvik River chinook salmon, 1972–1991.

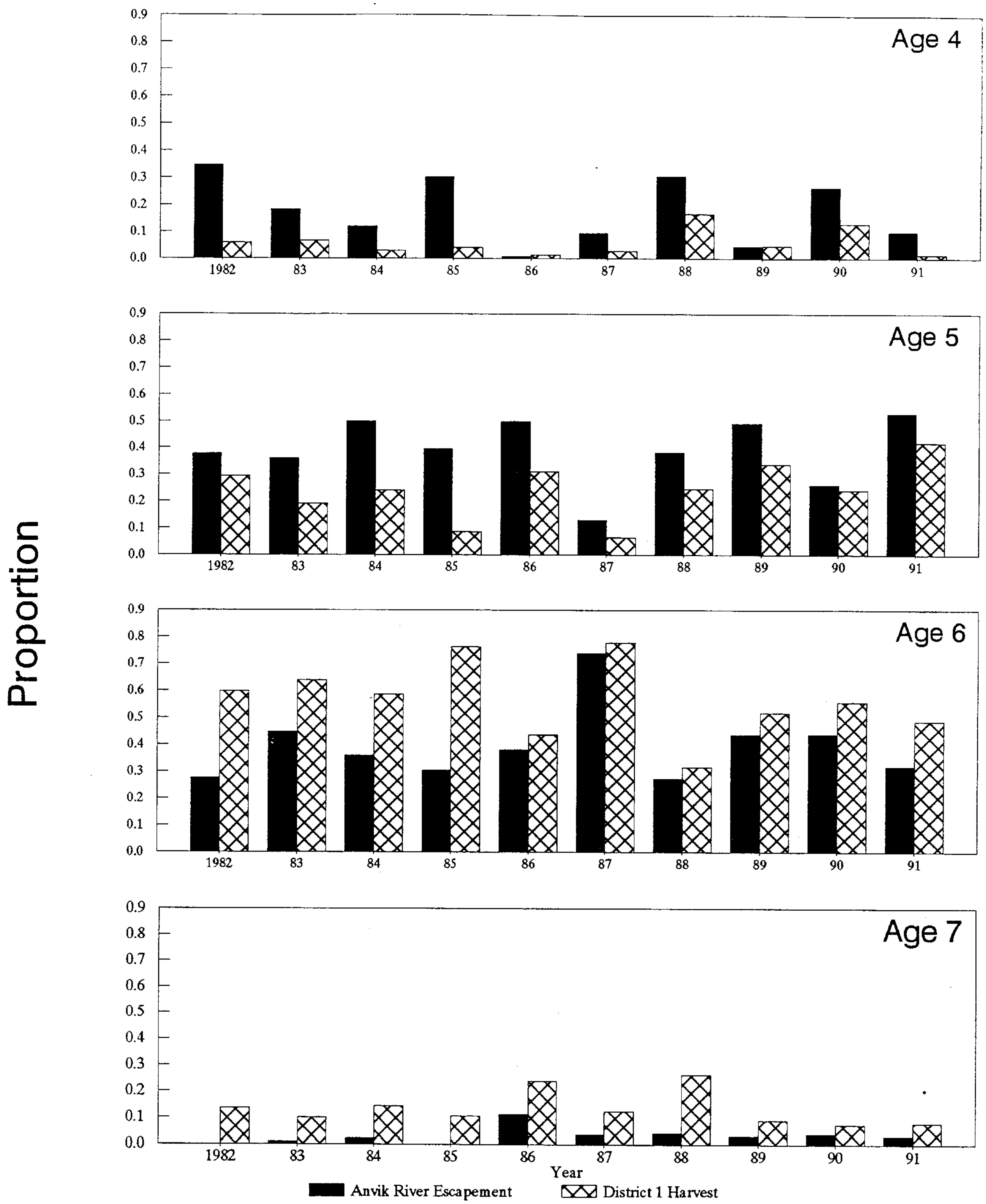

Figure 16. Proportion of chinook salmon by age in the Anvik River escapement and the District 1 harvest, Yukon River, 1982–1991.

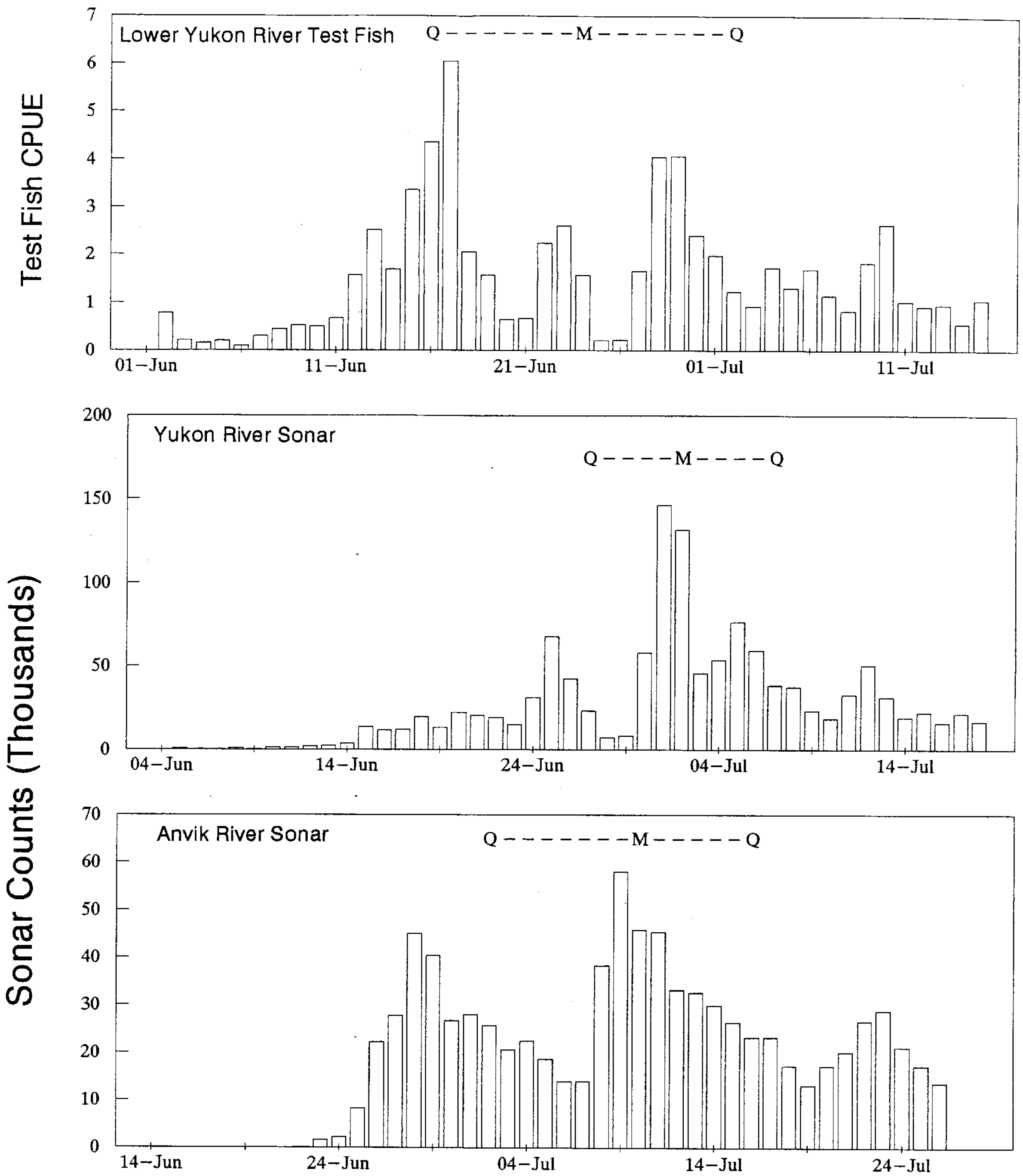

Figure 17. Run timing of Yukon River summer chum salmon in 1991 as indicated by test fish CPUE or sonar counts at three sites. First and third quartile passage days are indicated by the "Q", while the median quartile passage day is indicated by the "M". Note that the Yukon River sonar and Anvik River sonar graphs are time lagged by 3 and 13 days, respectively, from the lower Yukon River test fish graph.

APPENDIX

Appendix A1. West bank Anvik River corrected sonar counts by hour and date, 21 June – 26 July, 1991.

Hour Ending	21–Jun	22–Jun	23–Jun	24–Jun	25–Jun	26–Jun	27–Jun	28–Jun	29–Jun	30–Jun	01–Jul	02–Jul	03–Jul	04–Jul	05–Jul	06–Jul	07–Jul	08–Jul
0100	–	0	2	132	258	876	1,532	2,341	2,861	1,864	1,814	1,407	1,035	1,565	645	432	832	793
0200	–	0	2	101	427	1,236	1,273	2,149	2,743	1,696	1,919	1,428	1,076	1,502	819	627	1,025	743
0300	–	0	8	86	755	745	1,271	2,633	2,942	1,957	1,937	1,586	867	1,346	1,008	620	900	680
0400	–	0	14	41	479	831	1,652	2,034	2,071	1,794	1,630	1,232	789	933	910	564	641	670
0500	–	0	7	66	504	520	1,628	2,228	2,965	1,382	1,081	1,100	868	1,054	844	549	586	762
0600	–	0	6	56	496	549	1,970	1,369	2,828	1,008	1,343	1,214	910	886	979	615	596	750
0700	–	5	7	59	292	526	1,766	2,111	1,199	810	1,051	1,106	706	629	1,003	459	560	515
0800	–	18	7	30	264	500	1,695	2,375	984	597	823	714	464	460	693	608	324	511
0900	–	18	4	39	273	408	1,238	1,753	1,224	439	737	720	577	458	606	575	360	496
1000	–	26	6	9	243	829	1,079	1,631	862	520	362	660	449	505	609	402	327	575
1100	–	1	3	89	254	1,004	1,265	1,231	1,138	568	424	558	417	675	687	375	349	419
1200	–	3	2	74	181	913	755	1,187	1,265	339	414	355	328	612	614	308	283	222
1300	–	3	49	74	170	848	605	1,040	882	354	442	338	359	361	571	217	258	534
1400	–	4	79	108	167	835	435	975	1,335	132	454	332	329	281	351	400	346	1,401
1500	2	3	139	68	211	982	509	1,112	409	696	641	846	518	249	674	258	389	1,308
1600	0	0	117	69	230	934	1,326	1,073	744	738	420	599	513	372	490	203	385	1,194
1700	0	0	208	93	241	938	752	1,131	766	786	387	439	462	326	354	256	360	1,567
1800	0	27	194	137	198	1,273	790	1,335	327	681	513	603	750	347	381	355	389	1,146
1900	0	1	165	127	183	1,324	928	1,324	702	938	780	286	870	583	235	536	535	1,480
2000	1	0	164	105	312	1,138	1,117	1,785	971	1,003	1,416	581	839	654	385	515	432	1,690
2100	0	0	151	104	281	810	666	1,618	985	862	1,110	995	1,201	559	203	493	527	2,274
2200	0	1	76	230	495	1,255	648	1,408	1,445	1,115	944	636	926	491	486	780	507	2,499
2300	1	1	145	200	627	1,252	687	1,858	1,299	1,226	1,398	556	1,157	396	438	810	534	2,210
2400	18	1	97	182	722	1,519	1,707	2,283	1,698	1,113	1,079	844	1,261	316	332	741	905	1,455
Total	22	112	1,652	2,279	8,263	22,045	27,294	39,984	34,645	22,618	23,119	19,135	17,671	15,560	14,317	11,698	12,350	25,894

Appendix A1. (p 2 of 2).

Hour Ending	09–Jul	10–Jul	11–Jul	12–Jul	13–Jul	14–Jul	15–Jul	16–Jul	17–Jul	18–Jul	19–Jul	20–Jul	21–Jul	22–Jul	23–Jul	24–Jul	25–Jul	26–Jul
0100	1,337	1,744	1,879	1,379	1,524	1,840	720	1,341	1,501	1,043	457	710	1,103	818	1,022	988	734	857
0200	1,569	1,781	1,955	1,432	1,226	1,509	1,105	1,102	1,589	1,008	509	658	953	765	1,552	711	660	633
0300	1,456	1,410	1,669	954	883	1,163	780	956	1,196	855	324	616	724	537	691	618	408	351
0400	308	1,061	1,128	1,227	912	1,227	696	794	1,085	591	298	457	678	471	612	621	500	422
0500	1,329	1,149	1,163	1,102	1,072	1,752	854	685	869	503	246	352	567	493	613	467	395	329
0600	1,157	1,027	1,312	1,166	1,246	1,930	976	729	732	523	295	428	533	497	677	477	333	326
0700	1,426	1,325	963	1,132	1,250	1,767	927	943	556	528	368	426	485	420	714	440	413	429
0800	932	1,078	816	934	719	1,156	861	630	415	399	223	280	614	397	447	377	352	329
0900	927	1,061	886	668	555	991	451	461	392	227	212	267	346	281	528	346	255	252
1000	972	883	844	628	667	937	455	511	365	217	228	187	409	379	583	398	317	297
1100	774	743	642	609	522	1,102	693	617	462	367	220	320	525	289	508	492	263	325
1200	819	735	531	660	408	1,056	521	516	454	258	282	253	650	284	362	292	255	282
1300	762	736	767	576	453	861	393	499	455	312	249	151	408	306	317	301	242	239
1400	633	789	681	675	541	541	438	470	467	526	468	264	506	598	438	309	314	198
1500	736	732	679	720	650	495	458	494	472	477	323	528	485	782	608	332	302	237
1600	1,070	699	678	671	605	561	472	515	457	711	264	781	587	622	541	226	371	296
1700	929	445	868	902	743	485	491	509	377	668	324	642	500	760	616	534	559	265
1800	1,122	558	645	928	992	475	602	557	437	766	324	599	588	710	789	609	630	268
1900	1,658	790	903	1,410	1,095	472	685	637	423	594	432	653	418	466	653	568	542	275
2000	1,880	1,342	1,262	1,060	1,112	502	680	687	605	328	349	717	304	560	875	465	625	355
2100	2,072	1,717	1,399	965	1,268	485	906	617	685	319	406	720	349	605	1,259	479	677	320
2200	2,056	1,589	1,244	1,191	1,465	529	950	757	781	380	598	810	332	758	930	520	666	378
2300	1,513	1,871	1,089	1,190	1,671	528	1,172	895	781	369	574	860	367	830	783	674	579	349
2400	1,476	1,633	1,214	1,083	2,015	576	1,124	1,298	781	474	591	1,268	688	1,073	993	0	512	385
Total	28,913	26,898	25,217	23,262	23,594	22,940	17,410	17,220	16,337	12,443	8,564	12,947	13,119	13,701	17,111	11,244	10,904	8,397

Appendix A2. East bank Anvik River corrected sonar counts by hour and date, 21 June – 26 July, 1991.

Hour Ending	21–Jun	22–Jun	23–Jun	24–Jun	25–Jun	26–Jun	27–Jun	28–Jun	29–Jun	30–Jun	01–Jul	02–Jul	03–Jul	04–Jul	05–Jul	06–Jul	07–Jul	08–Jul
0100	–	0	0	0	0	2	18	150	329	368	319	451	9	252	213	149	92	51
0200	–	0	0	0	0	2	4	134	176	303	285	458	5	51	244	70	39	45
0300	–	0	0	0	0	4	18	134	128	312	292	466	6	165	99	71	34	18
0400	–	0	0	0	0	2	19	261	159	326	314	520	2	103	107	65	35	22
0500	–	0	0	0	0	5	16	139	139	185	354	952	8	245	151	107	31	81
0600	–	0	0	0	0	1	14	255	217	234	320	726	9	198	221	158	75	287
0700	–	0	0	0	0	1	11	314	169	78	201	594	5	183	299	128	22	135
0800	–	0	0	0	0	12	14	268	262	94	251	751	4	223	323	215	39	170
0900	–	0	0	0	0	20	48	199	394	119	167	386	5	199	244	132	48	272
1000	–	0	0	0	0	20	20	205	352	179	128	119	16	256	124	13	24	243
1100	–	0	0	0	0	2	21	543	138	156	116	119	143	282	138	13	29	127
1200	–	0	0	0	0	10	18	19	289	154	115	119	42	222	90	140	34	132
1300	–	0	0	0	0	4	37	341	194	160	93	27	14	202	90	7	98	532
1400	–	0	0	0	0	6	23	300	101	144	85	27	5	83	89	12	117	679
1500	–	0	0	0	0	7	31	238	352	32	25	30	7	113	129	21	229	625
1600	–	0	0	0	0	9	23	228	398	27	37	84	218	186	147	163	153	935
1700	–	0	0	0	0	16	4	261	79	28	28	49	26	264	142	9	128	994
1800	–	0	0	0	0	4	1	182	127	47	43	66	34	446	175	119	57	1,062
1900	–	0	0	0	0	10	4	177	145	38	22	131	214	484	240	140	23	1,022
2000	–	0	0	0	0	3	6	123	137	25	271	98	733	960	220	140	24	1,117
2100	–	0	0	0	0	8	24	67	198	44	221	74	592	447	264	140	75	1,004
2200	–	0	0	0	0	12	2	60	598	305	316	83	288	544	103	216	47	719
2300	–	0	0	0	0	4	6	174	396	369	462	61	255	349	215	6	43	816
2400	–	0	0	0	0	0	28	163	262	384	362	81	188	421	194	7	41	1,278
Total	0	0	0	0	0	164	410	4,935	5,739	4,111	4,827	6,472	2,828	6,878	4,261	2,241	1,537	12,366

Appendix A2. (p 2 of 2).

Hour Ending	09–Jul	10–Jul	11–Jul	12–Jul	13–Jul	14–Jul	15–Jul	16–Jul	17–Jul	18–Jul	19–Jul	20–Jul	21–Jul	22–Jul	23–Jul	24–Jul	25–Jul	26–Jul
0100	1,185	1,074	1,037	723	439	607	91	307	357	417	318	392	322	726	879	1,235	406	732
0200	1,044	952	968	686	342	973	359	355	603	431	241	366	251	757	265	1,016	508	721
0300	1,084	1,236	791	602	418	649	408	204	495	295	238	267	290	785	267	1,033	596	712
0400	950	912	674	411	188	469	420	147	352	166	180	256	303	795	208	784	294	568
0500	1,208	573	616	276	258	529	393	275	416	230	205	243	265	758	163	613	204	304
0600	1,115	807	876	452	249	367	294	191	282	168	241	268	184	676	102	334	170	150
0700	928	656	743	542	273	347	308	146	348	215	185	235	236	553	82	272	238	276
0800	1,071	685	567	514	246	245	246	167	295	194	124	156	160	503	47	235	144	127
0900	711	623	575	422	200	226	148	140	240	205	135	190	151	731	35	217	131	95
1000	947	888	666	345	214	157	189	143	269	172	123	172	152	565	284	176	146	121
1100	825	591	510	361	217	200	240	150	153	161	157	117	155	598	345	265	136	97
1200	705	610	540	245	247	121	181	150	191	122	110	106	180	409	272	190	122	81
1300	892	461	490	318	201	170	212	161	157	68	129	79	221	440	394	116	130	63
1400	1,325	506	591	365	329	160	152	210	137	110	160	102	113	216	588	90	80	79
1500	1,692	482	425	291	312	270	238	171	196	125	128	107	140	64	402	47	51	65
1600	1,740	651	771	345	299	194	693	166	180	116	149	76	180	83	513	73	92	35
1700	1,780	745	1,047	390	632	161	282	286	167	115	166	113	253	295	892	139	111	24
1800	1,766	1,028	1,289	279	740	163	281	325	165	180	176	127	411	543	528	182	173	46
1900	1,330	1,019	1,290	357	729	164	549	315	287	206	173	119	273	447	497	200	102	49
2000	1,105	782	1,246	399	490	164	252	372	278	189	223	139	453	358	857	330	453	109
2100	883	742	1,137	463	526	164	1,732	397	278	192	245	166	425	561	1,221	546	357	148
2200	1,260	824	984	411	447	164	577	333	315	172	271	179	480	691	878	632	282	191
2300	1,657	857	1,105	278	441	164	358	363	413	289	258	246	668	644	1,250	570	648	214
2400	1,952	1,137	1,140	401	508	164	317	486	341	195	264	0	666	711	721	531	753	198
Total	29,155	18,841	20,078	9,876	8,945	6,992	8,920	5,960	6,915	4,733	4,599	4,221	6,932	12,909	11,690	9,826	6,327	5,205

Appendix A3. West bank Anvik River corrected sonar counts by sector, 21 June – 26 July, 1991.

West Bank Sector	21–Jun	22–Jun	23–Jun	24–Jun	25–Jun	26–Jun	27–Jun	28–Jun	29–Jun	30–Jun	01–Jul	02–Jul	03–Jul	04–Jul	05–Jul	06–Jul	07–Jul	08–Jul
1	0	8	12	175	158	88	1,001	368	178	99	525	64	161	59	181	722	216	279
2	0	17	78	774	2,848	4,141	6,082	8,000	5,103	3,004	6,069	1,099	969	696	722	4,200	2,856	5,466
3	0	12	187	492	2,663	7,016	8,509	23,848	16,641	11,518	8,288	6,940	8,255	7,436	7,032	3,252	3,267	5,193
4	0	4	654	420	1,341	4,913	5,203	5,006	5,392	3,528	3,392	4,138	5,061	3,606	3,861	1,671	2,551	4,252
5	1	3	270	153	290	3,881	4,316	455	650	524	971	1,724	1,179	1,419	1,072	692	1,765	2,453
6	1	3	101	38	24	760	800	245	203	227	625	997	640	924	482	357	757	768
7	0	4	60	32	1	171	130	123	78	139	571	802	380	660	309	111	190	304
8	0	4	32	17	0	23	22	62	42	65	278	398	168	249	102	42	97	146
9	1	1	4	8	0	4	7	23	19	59	70	93	46	42	37	57	72	74
10	5	1	6	7	1	6	8	32	36	101	130	127	48	56	41	58	82	117
11	6	1	11	4	0	4	7	26	35	112	87	102	55	60	55	42	53	94
12	4	2	9	1	1	2	11	19	35	106	97	106	62	58	63	51	50	83
13	0	25	13	2	4	7	32	44	39	118	111	93	77	82	70	51	62	2,020
14	0	8	28	4	9	25	153	16	119	110	106	97	64	51	39	100	74	581
15	2	2	83	30	162	265	390	69	172	151	406	210	258	63	95	111	105	647
16	2	16	105	122	762	740	622	1,649	5,904	2,758	1,394	2,142	246	100	157	182	154	3,418
Total	22	111	1,653	2,279	8,264	22,046	27,293	39,985	34,646	22,619	23,120	19,132	17,669	15,561	14,318	11,699	12,351	25,895

Appendix A3. (p 2 of 2).

West Bank Sector	09–Jul	10–Jul	11–Jul	12–Jul	13–Jul	14–Jul	15–Jul	16–Jul	17–Jul	18–Jul	19–Jul	20–Jul	21–Jul	22–Jul	23–Jul	24–Jul	25–Jul	26–Jul
1	776	761	250	216	144	143	62	110	166	295	153	141	116	79	614	438	517	258
2	8,094	7,803	5,796	5,045	2,192	2,363	2,029	3,252	4,214	4,283	1,599	1,426	1,229	1,635	3,286	2,482	2,637	1,456
3	7,021	7,268	7,628	8,234	6,205	7,702	5,357	6,606	5,810	4,123	2,780	3,131	2,353	3,108	3,787	3,213	2,852	1,958
4	6,470	5,878	5,993	5,244	6,800	6,768	5,127	4,441	4,628	1,635	1,967	3,158	2,707	2,491	3,568	1,704	1,883	1,525
5	3,785	2,834	2,660	2,005	3,582	2,761	2,168	1,578	693	728	887	2,124	2,331	2,031	1,886	1,112	1,081	1,124
6	978	626	720	747	1,598	1,201	822	478	285	360	400	1,296	2,000	1,725	1,420	718	643	698
7	296	176	241	259	422	427	256	161	120	130	112	351	492	676	768	440	377	466
8	163	107	133	140	243	192	124	71	59	69	47	192	293	340	349	275	160	172
9	65	62	95	132	146	109	129	52	32	97	39	155	196	246	256	108	127	78
10	167	92	141	167	219	202	243	69	49	107	65	186	207	248	323	203	186	173
11	101	61	78	136	118	113	105	61	40	63	64	158	175	138	170	148	103	99
12	87	69	90	121	90	80	51	48	30	45	64	106	126	83	78	47	62	75
13	97	93	163	198	533	148	307	48	70	67	87	170	243	333	60	52	62	51
14	87	97	899	232	462	124	313	98	51	145	132	131	260	303	57	75	40	46
15	95	85	88	213	486	168	167	60	45	175	92	113	202	149	76	82	66	53
16	630	886	242	173	352	439	150	86	46	121	76	107	191	116	414	144	109	166
Total	28,912	26,898	25,217	23,262	23,592	22,940	17,410	17,219	16,338	12,443	8,564	12,945	13,121	13,701	17,112	11,241	10,905	8,398

Appendix A4. East bank Anvik River corrected sonar counts by sector, 21 June – 26 July, 1991.

East Bank Sector	21–Jun	22–Jun	23–Jun	24–Jun	25–Jun	26–Jun	27–Jun	28–Jun	29–Jun	30–Jun	01–Jul	02–Jul	03–Jul	04–Jul	05–Jul	06–Jul	07–Jul	08–Jul
17	–	0	0	0	0	0	0	0	0	0	453	1,557	889	2,302	1,565	394	295	260
18	–	0	0	0	0	0	0	0	0	0	253	524	368	1,555	1,063	396	291	433
19	–	0	0	0	0	0	0	0	0	0	98	137	266	959	615	299	129	375
20	–	0	0	0	0	0	2	0	0	0	69	110	158	451	317	45	118	331
21	–	0	0	0	0	49	60	438	588	320	29	99	108	356	222	28	39	199
22	–	0	0	0	0	30	12	353	498	200	28	99	96	313	158	25	18	125
23	–	0	0	0	0	43	22	702	788	288	35	108	64	145	85	27	3	87
24	–	0	0	0	0	10	20	476	531	146	13	62	13	27	19	12	2	23
25	–	0	0	0	0	10	6	568	576	164	94	225	34	106	77	12	20	135
26	–	0	0	0	0	0	2	170	174	57	265	284	10	31	23	14	3	392
27	–	0	0	0	0	0	0	11	8	4	75	298	0	3	3	20	2	606
28	–	0	0	0	0	0	0	648	263	352	43	393	1	0	5	27	55	1,211
29	–	0	0	0	0	0	58	100	104	122	87	993	2	19	29	427	60	1,717
30	–	0	0	0	0	0	0	1,254	1,966	1,984	112	1,108	192	186	42	122	170	1,689
31	–	0	0	0	0	0	7	164	166	373	0	421	376	290	29	230	233	2,669
32	–	0	0	0	0	22	221	51	78	101	3,173	54	251	135	10	164	97	2,113
Total	–	0	0	0	0	164	410	4,935	5,740	4,111	4,827	6,472	2,828	6,878	4,262	2,242	1,535	12,365

Appendix 4A. (p 2 of 2).

Sector	09–Jul	10–Jul	11–Jul	12–Jul	13–Jul	14–Jul	15–Jul	16–Jul	17–Jul	18–Jul	19–Jul	20–Jul	21–Jul	22–Jul	23–Jul	24–Jul	25–Jul	26–Jul
17	55	4	0	0	0	2	3	2	0	2	0	3	2	2	13	0	0	1
18	57	3	1	2	6	4	5	0	2	2	0	1	3	2	24	1	1	0
19	77	0	2	5	8	3	7	1	1	2	6	7	5	6	32	0	0	0
20	120	4	4	14	25	10	12	0	3	2	5	7	10	7	40	0	2	0
21	89	2	4	14	20	9	15	8	6	7	9	4	5	7	39	2	1	0
22	149	18	20	59	51	26	40	24	15	19	23	15	30	31	93	6	4	7
23	273	24	56	119	139	103	106	72	46	59	64	45	87	87	227	22	17	40
24	209	16	46	70	87	1,051	66	36	40	25	62	37	72	69	75	18	16	42
25	934	88	138	203	192	110	126	85	77	70	95	72	155	206	273	116	100	62
26	2,541	359	551	581	788	497	428	345	309	181	288	264	601	786	1,001	405	329	292
27	3,076	603	678	622	980	538	498	369	432	133	218	246	449	685	661	386	329	280
28	4,346	1,187	1,534	1,079	1,296	644	831	558	431	241	462	540	868	1,196	1,147	442	351	290
29	3,208	1,959	2,343	1,723	2,135	1,169	1,345	910	610	366	588	941	1,633	2,987	3,380	1,959	1,371	1,180
30	2,421	2,133	2,119	1,230	1,314	850	1,219	1,004	917	533	595	748	1,113	2,215	2,237	2,470	1,572	1,190
31	5,691	5,061	4,491	1,677	933	1,029	2,107	1,280	1,896	1,203	1,052	767	1,146	2,691	1,638	2,493	1,363	1,142
32	5,909	7,381	8,091	2,479	971	946	2,113	1,268	2,132	1,886	1,132	526	754	1,932	811	1,507	870	679
Total	29,155	18,842	20,078	9,877	8,945	6,991	8,921	5,962	6,917	4,731	4,599	4,223	6,933	12,909	11,691	9,827	6,326	5,205

Appendix A.5. Anvik River salmon beach seine catch by species, sex, and date, 1991.

	Chum Salmon			Chinook Salmon			Pink Salmon		
Date	Male	Female	Total	Male	Female	Total	Male	Female	Total
25–Jun									
26–Jun									
27–Jun	11	18	29	0	0	0	0	0	0
28–Jun									
29–Jun	10	7	17	0	0	0	0	0	0
30–Jun	33	8	41	0	0	0	0	0	0
01–Jul									
02–Jul	39	26	65	0	0	0	0	0	0
03–Jul									
04–Jul									
05–Jul	30	20	50	0	0	0	0	0	0
06–Jul									
07–Jul	23	49	72	0	0	0	0	0	0
08–Jul									
09–Jul									
10–Jul	8	19	27	0	0	0	0	0	0
11–Jul	29	70	99	0	0	0	0	0	0
12–Jul									
13–Jul									
14–Jul	12	16	28	0	0	0	0	0	0
15–Jul									
16–Jul									
17–Jul									
18–Jul	38	62	100	0	0	0	0	0	0
19–Jul									
20–Jul									
21–Jul									
22–Jul	3	8	11	0	0	0	0	0	0
23–Jul									
24–Jul	18	39	57	0	0	0	0	0	0
25–Jul									
26–Jul									
27–Jul									
28–Jul									
Total	254	342	596	0	0	0	0	0	0

Appendix A.6. Age and sex composition of Anvik River summer chum salmon escapement samples, 1972 – 1991.

	Number of Fish														
	Total Sample[a]			Age 0.2			Age 0.3			Age 0.4			Age 0.5		
Year	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
1972	167	153	320	0	0	0	25	37	62	138	115	253	4	1	5
1973	265	518	783	11	37	48	204	401	605	49	79	128	1	1	2
1974	245	157	402	12	24	36	197	120	317	34	12	46	2	1	3
1975	270	314	584	4	17	21	253	288	541	13	9	22	0	0	0
1976	281	320	601	5	4	9	43	35	78	233	281	514	0	0	0
1977	191	398	589	20	111	131	161	270	431	7	15	22	3	2	5
1978	289	263	552	0	1	1	210	180	390	79	82	161	0	0	0
1979	273	306	579	2	12	14	154	193	347	115	99	214	2	2	4
1980	167	258	425	0	1	1	147	226	373	20	31	51	0	0	0
1981	151	182	333	0	0	0	49	67	116	99	115	214	3	0	3
1982	117	265	382	4	17	21	75	181	256	37	65	102	1	2	3
1983	183	238	421	0	4	4	99	142	241	83	90	173	1	2	3
1984	138	215	353	2	6	8	117	189	306	19	20	39	0	0	0
1985	233	294	527	0	11	11	172	225	397	59	58	117	2	0	2
1986	205	281	486	0	2	2	59	89	148	143	186	329	3	4	7
1987	190	355	545	0	10	10	125	238	363	56	100	156	9	7	16
1988	180	351	531	1	30	31	129	282	411	48	37	85	2	2	4
1989	199	389	588	0	9	9	55	179	234	143	201	344	1	0	1
1990	172	227	399	3	12	15	98	169	267	67	45	112	4	1	5
1991	239	313	552	0	0	0	96	153	249	141	160	301	2	0	2

	Percent of Sample[c]														
	Total Sample			Age 0.2			Age 0.3			Age 0.4			Age 0.5		
Year	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
1972	52.2	47.8	100.0	0.0	0.0	0.0	7.8	11.6	19.4	43.1	35.9	79.1	1.3	0.3	1.6
1973	33.8	66.2	100.0	1.4	4.7	6.1	26.1	51.2	77.3	6.3	10.1	16.3	0.1	0.1	0.3
1974	60.9	39.1	100.0	3.0	6.0	9.0	49.0	29.9	78.9	8.5	3.0	11.4	0.5	0.2	0.7
1975	46.2	53.8	100.0	0.7	2.9	3.6	43.3	49.3	92.6	2.2	1.5	3.8	0.0	0.0	0.0
1976	46.8	53.2	100.0	0.8	0.7	1.5	7.2	5.8	13.0	38.8	46.8	85.5	0.0	0.0	0.0
1977	32.4	67.6	100.0	3.4	18.8	22.2	27.3	45.8	73.2	1.2	2.5	3.7	0.5	0.3	0.8
1978	52.4	47.6	100.0	0.0	0.2	0.2	38.0	32.6	70.7	14.3	14.9	29.2	0.0	0.0	0.0
1979	47.2	52.8	100.0	0.3	2.1	2.4	26.6	33.3	59.9	19.9	17.1	37.0	0.3	0.3	0.7
1980	39.3	60.7	100.0	0.0	0.2	0.2	34.6	53.2	87.8	4.7	7.3	12.0	0.0	0.0	0.0
1981	45.3	54.7	100.0	0.0	0.0	0.0	14.7	20.1	34.8	29.7	34.5	64.3	0.9	0.0	0.9
1982	30.6	69.4	100.0	1.0	4.5	5.5	19.6	47.4	67.0	9.7	17.0	26.7	0.3	0.5	0.8
1983	43.5	56.5	100.0	0.0	1.0	1.0	23.5	33.7	57.2	19.7	21.4	41.1	0.2	0.5	0.7
1984	39.1	60.9	100.0	0.6	1.7	2.3	33.1	53.5	86.7	5.4	5.7	11.0	0.0	0.0	0.0
1985	44.2	55.8	100.0	0.0	2.1	2.1	32.6	42.7	75.3	11.2	11.0	22.2	0.4	0.0	0.4
1986	42.2	57.8	100.0	0.0	0.4	0.4	12.1	18.3	30.5	29.4	38.3	67.7	0.6	0.8	1.4
1987	34.9	65.1	100.0	0.0	1.8	1.8	22.9	43.7	66.6	10.3	18.3	28.6	1.7	1.3	2.9
1988	33.9	66.1	100.0	0.2	5.6	5.8	24.3	53.1	77.4	9.0	7.0	16.0	0.4	0.4	0.8
1989[c]	34.4	65.6	100.0	0.0	1.2	1.2	9.4	28.5	37.9	24.8	35.9	60.7	0.1	0.0	0.1
1990[c]	48.7	51.3	100.0	0.6	2.5	3.2	26.0	39.1	65.1	18.8	11.3	30.1	1.2	0.4	1.6
1991[c]	42.1	57.9	100.0	0.0	0.0	0.0	16.4	27.8	44.2	25.6	30.1	55.6	0.2	0.0	0.2

[a] Samples collected by carcass survey 1972–1981, by beach seine 1983–1989, and by both methods combined in 1982.
[b] Sample percentages not weighted by time period or escapement counts unless otherwise noted.
[c] Sample percentages weighted by time period and escapement counts.

Appendix A.7. Age and sex composition of Anvik River chinook salmon escapement samples, 1972–1991.[a]

Number of Chinook Salmon

Year	Sample			Age 4			Age 5			Age 6			Age 7		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
1972	10	5	15	0	0	0	8	0	8	2	5	7	0	0	0
1973	6	4	10	1	0	1	0	0	0	5	3	8	0	1	1
1974	0	0	0	–	–	–	–	–	–	–	–	–	–	–	–
1975	6	2	8	1	0	1	4	1	5	1	1	2	0	0	0
1976	33	12	45	6	0	6	25	5	30	2	7	9	0	0	0
1977	58	59	117	2	1	3	27	6	33	27	48	75	2	4	6
1978	36	41	77	13	0	13	10	1	11	13	39	52	0	1	1
1979	37	9	46	17	0	17	14	0	14	6	6	12	0	3	3
1980	41	42	83	19	1	20	21	22	43	1	16	17	0	3	3
1981	109	154	263	33	1	34	61	36	97	15	116	131	0	1	1
1982	100	38	138	47	1	48	47	5	52	6	32	38	0	0	0
1983	173	133	306	56 [b]	0	56	84	26	110	33	104	137	0	3	3
1984	162	114	276	29	4	33	108	30	138	25	74	99	0	6	6
1985	25	8	33	10	0	10	10	3	13	5	5	10	0	0	0
1986	53	89	142	0	1	1	44	27	71	6	48	54	3	13	16
1987	92	130	222	21	0	21	22	7	29	48	116	164	1	7	8
1988	173	73	246	75	0	75	70	24	94	26	41	67	2	8	10
1989	226	155	381	17 [b]	0	17	149	38	187	60	106	166	0	11	11
1990	252	148	400	106 [b]	0	106	86	18	104	56	119	175	4	11	15
1991	223	155	378	39	0	39	145	63	208	38	82	120	1	10	11

Percent of Total Sample[c]

Year	Sample			Age 4			Age 5			Age 6			Age 7		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
1972	66.7	33.3	100.0	0.0	0.0	0.0	53.3	0.0	53.3	13.3	33.3	46.7	0.0	0.0	0.0
1973	60.0	40.0	100.0	10.0	0.0	10.0	0.0	0.0	0.0	50.0	30.0	80.0	0.0	10.0	10.0
1974	0.0	0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–
1975	75.0	25.0	100.0	12.5	0.0	12.5	50.0	12.5	62.5	12.5	12.5	25.0	0.0	0.0	0.0
1976	73.3	26.7	100.0	13.3	0.0	13.3	55.6	11.1	66.7	4.4	15.6	20.0	0.0	0.0	0.0
1977	49.6	50.4	100.0	1.7	0.9	2.6	23.1	5.1	28.2	23.1	41.0	64.1	1.7	3.4	5.1
1978	46.8	53.2	100.0	16.9	0.0	16.9	13.0	1.3	14.3	16.9	50.6	67.5	0.0	1.3	1.3
1979	80.4	19.6	100.0	37.0	0.0	37.0	30.4	0.0	30.4	13.0	13.0	26.1	0.0	6.5	6.5
1980	49.4	50.6	100.0	22.9	1.2	24.1	25.3	26.5	51.8	1.2	19.3	20.5	0.0	3.6	3.6
1981	41.4	58.6	100.0	12.5	0.4	12.9	23.2	13.7	36.9	5.7	44.1	49.8	0.0	0.4	0.4
1982	72.5	27.5	100.0	34.1	0.7	34.8	34.1	3.6	37.7	4.3	23.2	27.5	0.0	0.0	0.0
1983	56.5	43.5	100.0	18.3	0.0	18.3	27.5	8.5	35.9	10.8	34.0	44.8	0.0	1.0	1.0
1984	58.7	41.3	100.0	10.5	1.4	12.0	39.1	10.9	50.0	9.1	26.8	35.9	0.0	2.2	2.2
1985	75.8	24.2	100.0	30.3	0.0	30.3	30.3	9.1	39.4	15.2	15.2	30.3	0.0	0.0	0.0
1986	37.3	62.7	100.0	0.0	0.7	0.7	31.0	19.0	50.0	4.2	33.8	38.0	2.1	9.2	11.3
1987	41.4	58.6	100.0	9.5	0.0	9.5	9.9	3.2	13.1	21.6	52.3	73.9	0.5	3.2	3.6
1988	70.3	29.7	100.0	30.5	0.0	30.5	28.5	9.8	38.2	10.6	16.7	27.2	0.8	3.3	4.1
1989	59.3	40.7	100.0	4.5	0.0	4.5	39.1	10.0	49.1	15.7	27.8	43.6	0.0	2.9	2.9
1990	63.0	37.0	100.0	26.5	0.0	26.5	21.5	4.5	26.0	14.0	29.8	43.8	1.0	2.8	3.8
1991	59.0	41.0	100.0	9.8	0.0	9.8	36.3	16.7	52.9	10.1	21.7	31.7	0.3	2.6	2.9

[a] Samples collected mainly by carcass survey. In some years a very few fish were also collected by beach seine or hook and line.
[b] Includes one age–3 male.
[c] Sample percentages not weighted by time period or escapement counts.

Appendix A.8. Climatological and hydrological observations, Anvik River Sonar site, 1991.

					Temperature			Water Gauge				
					Air							
Date	Time	Precip. (Code)[a]	Wind (Direction and Velocity)	Cloud Cover (Code)[b]	Min. °C	Max. °C	Water °C	Actual (ft.)	Relative (ft.)	Relative (cm)	Water Color (code)[c]	Remarks
19–Jun												
20–Jun												
21–Jun	18:10	N	N 10	2	9	28	14	3.10	0.00	0.0	2	
22–Jun	18:45	A	N 0	1	12	25	15	2.80	−0.30	−9.1	2	
23–Jun	18:30	A	S 10	4	8	17	14	2.71	−0.39	−11.9	2	major thunder storm and rain.
24–Jun	17:24	N	S 10	4	11	16	12	2.26	−0.84	−25.6	2	
25–Jun	18:00	N	S 10	3	10	18	15	1.99	−1.11	−33.8	2	water level falling fast
26–Jun	17:50	N	S 6	3	12	20	14	2.80	−0.30	−9.1	2	moved gauge, 0.10=1.50
27–Jun	17:25	N	N 3	2	11	22	16	2.51	−0.59	−18.0	2	
28–Jun	18:48	N	N 15	2	8	24	17	2.25	−0.85	−25.9	2	
29–Jun	18:40	N	N 15	1	8	32	18	2.11	−0.99	−30.2	2	
30–Jun	18:15	N	N 16	1	6	30	22	1.91	−1.19	−36.3	2	hot and breezy
01–Jul	19:05	N	N 10	1	6	27	18	1.77	−1.33	−40.5	2	
02–Jul	18:50	N	N 20	2	12	27	20	1.60	−1.50	−45.7	2	moved gauge, 0.29=1.00
03–Jul	18:04	N	N 10	4	7	25	17	1.40	−1.70	−51.8	2	
04–Jul	19:15	N	N 10	1	10	27	17	1.30	−1.80	−54.9	2	nice day
05–Jul	19:20	N	N 5	3	9	21	16	1.19	−1.91	−58.2	2	
06–Jul	17:49	N	N 5	2	9	27	21	1.05	−2.05	−62.5	2	
07–Jul	18:05	N	Variable 0	2	8	26	20	0.99	−2.11	−64.3	2	
08–Jul	18:25	N	N 5	3	9	27	18	0.88	−2.22	−67.7	2	
09–Jul	18:00	N	NE 20	2	10	30	19	0.80	−2.30	−70.1	2	
10–Jul	17:35	N	NE 10–15	2	9	24	19	0.70	−2.40	−73.2	2	moved gauge, 0.10=0.70; smoke
11–Jul	18:30	N	NE 10	2	5	22	19	0.60	−2.50	−76.2	2	lots of smoke
12–Jul	17:49	N	Variable 0	2	5	17	15	0.54	−2.56	−78.0	2	
13–Jul	18:01	A	S 5	3	2	18	14	0.50	−2.60	−79.2	2	smoke and rain
14–Jul	18:05	A	S 5–10	4	11	14	14	0.54	−2.56	−78.0	2	cold
15–Jul	18:25	A	Variable 0	4	8	15	13	0.58	−2.52	−76.8	2	
16–Jul	18:05	A	Variable 0	3	9	15	14	0.68	−2.42	−73.8	2	crisp
17–Jul	18:30	A	Variable 0	4	8	16	15	0.77	−2.33	−71.0	2	light showers off and on
18–Jul	17:40	A	W 10	4	6	15	14	0.74	−2.36	−71.9	2	
19–Jul	17:50	A	S 5	4	6	14	13	0.64	−2.46	−75.0	2	
20–Jul	18:35	A	S 5–10	4	9	16	14	0.54	−2.56	−78.0	2	
21–Jul	18:55	N	S 10–15	1	10	23	15	0.46	−2.64	−80.5	2	
22–Jul	18:08	N	S 0–2	1	12	26	18	0.40	−2.70	−82.3	2	very dry and still– –bugs are bad
23–Jul	18:35	A	S 0–2	3	8	28	17	0.35	−2.75	−83.8	2	thunder showers
24–Jul	18:25	–	–	3	10	24	17	0.38	−2.72	−82.9	2	possible showers tonight
25–Jul	18:11	N	S 5–10	1	11	23	19	0.38	−2.72	−82.9	2	
26–Jul	18:15	–	Variable 0	2	6	24	17	0.25	−2.85	−86.9	2	
27–Jul	16:00	N	S 5	4	7	17	19	0.20	−2.90	−88.4	2	overcast, not going to get any summer today.
28–Jul	–	–	–	–	–	–	–	–	–	–	–	

[a] Precipitation code for the preceding 24–hour period: A = Intermittent rain; B = Continuous rain; C = Snow; D = Snow and rain mixed; and E = Hail.
[b] Instanteous 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: 1 = Clear; 2 = Light brown; 3 = Dark brown; and 4 = Murky or glacial.