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Anvik River Sonar Chum Salmon Escapement Study, 2008

Report for Project 08-202
USFWS Office of Subsistence Management
Fisheries Information Services Division

by

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March 2010

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye to fork	MEF
mideye to tail fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

The 2008 Anvik River sonar project operated from late June until the end of July to estimate the passage of summer chum salmon *Oncorhynchus keta*. Data from each bank was collected using a high frequency imaging sonar (DIDSON) sampling 30 minutes of each hour, 24 hours a day, 7 days a week. The estimated salmon passage was 1,109,766 (SE 2,943) of which pink salmon comprised 66% (734,837) and summer chum salmon passage was 374,929. The summer chum salmon passage was 7% above the minimum escapement objective for the Anvik River biological escapement goal of 350,000 to 700,000 chum salmon. Based on 1979–1985 and 1987–2007 mean quartile passage dates, timing of the 2008 chum salmon run was 2–3 days later for the first and third quartiles. A chum salmon diurnal migration pattern was observed with the highest passage (37%) occurring during the darkest part of the day (2300–0500 hours). Females comprised 54.9% of the catch in beach seines. Age-0.4 fish comprised 50.6% of the chum salmon run in 2008.

Key words: chum salmon, *Oncorhynchus keta*, pink salmon, *O. gorbuscha*, sonar, DIDSON, Anvik River

INTRODUCTION

The purpose of the Anvik River sonar project is to monitor escapement of summer chum salmon *Oncorhynchus keta* to the Anvik River drainage, believed to be the largest producer of summer chum salmon in the Yukon River drainage (Bergstrom et al. 1999). Additional major spawning populations of summer chum salmon occur in the following tributaries of the Yukon River: the Andreafsky River, located at river kilometer (rkm) 167; Rodo River (rkm 719); Nulato River (rkm 777); Melozitna River (rkm 938); and Tozitna River (rkm 1,096). Spawning tributaries in the Koyukuk River (rkm 817) drainage are the Gisasa River (rkm 907) and Hogatza River (rkm 1,255); and in tributaries to the Tanana River (rkm 1,118) drainage, which include the Chena River (rkm 1,480) and the Salcha River (rkm 1,553) (Figure 1). Chinook salmon *O. tshawytscha* and pink salmon *O. gorbuscha* spawn in the Anvik River concurrently with summer chum salmon. Fall chum, a later run of chum salmon, and coho salmon *O. kisutch* have been reported to spawn in the Anvik River drainage during the fall.

Timely and accurate reporting of information from the Anvik River sonar project helps Yukon River fishery managers ensure the Anvik River biological escapement goal (BEG) of 350,000 to 700,000 summer chum salmon is met. This assessment is necessary to determine if summer chum salmon abundance will meet upstream harvest and escapement needs.

Side-looking sonar, capable of detecting migrating salmon along the banks, has been in place in the Anvik River since 1980. The Electrodynamics Division of the Bendix Corporation[1] developed the side-looking sonar and conducted a pilot study using the side-looking sonar to estimate chum salmon escapement to the Anvik River in 1979. The results indicated sonar-based estimation of chum salmon escapements to the Anvik River was superior to the counting tower method used at that time (Mauney and Buklis 1980). Bendix sonar equipment was used for escapement estimates from 1979 to 2003. In 2003, a side-by-side comparison was done with Hydroacoustic Technology Incorporated (HTI) split-beam sonar equipment where it was found that the Bendix and HTI produced similar abundance estimates (Dunbar and Pfisterer 2007*)*. In 2004, the switch was made to HTI sonar equipment. In 2006 a side-by-side comparison was done between HTI and DIDSON sonar, high water for most of the season prevented normal operation of the split-beam, but it was found the DIDSON abundance estimate was 61% higher than the split-beam abundance estimate (McEwen 2007). In 2007 the switch was made to DIDSON sonar.

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[1] Product names used in this report are included for scientific completeness but do not constitute a product endorsement.

Background Information

Commercial and subsistence harvests of Anvik River chum salmon occur throughout the mainstem Yukon River, from the delta to the mouth of the Anvik River and within the first 19 km of the Anvik River. This section of the Yukon River includes Lower Yukon Area Districts 1, 2, and 3, and the lower portion of Subdistrict 4-A in the Upper Yukon Area (Figure 1). Most of the effort and harvest of this stock occurs in Districts 1 and 2, and in the lower portion of Subdistrict 4-A below the confluence of the Anvik and Yukon Rivers.

In the Lower Yukon Area, run timing of summer chum and Chinook salmon overlap, with runs beginning at river ice breakup in late May/early June and continuing through July. During this time commercial fisheries in the Lower Yukon Area have traditionally targeted Chinook salmon, while Subdistrict 4-A commercial fisheries have targeted summer chum salmon. In the Lower Yukon Area, large-mesh gillnets (stretch mesh greater than 15.2 cm) were employed to harvest Chinook salmon. Although these nets were efficient for Chinook salmon, the associated harvest of summer chum salmon through 1984 was minor in relation to the size of the chum salmon run. In order to allow directed harvests of summer chum salmon in the Lower Yukon, the Alaska Board of Fisheries (BOF), prior to the 1985 season, adopted regulations allowing fishing periods restricted to small-mesh gillnets (15.2 cm maximum stretch mesh) during the Chinook salmon season provided that (1) the summer chum salmon run was of sufficient size to support additional exploitation, and (2) incidental harvest of Chinook salmon during these small-mesh fishing periods did not adversely affect conservation of that species.

Increased market demand prompted allocation disputes between fishers in different districts. In February of 1990, the BOF established a guideline harvest range of 400,000 to 1,200,000 summer chum salmon for the entire Yukon River, allocated by district and sub-district based on the average harvests of the previous 15 years (ADF&G 1990). Summer chum salmon escapement to the Anvik River exceeded the lower range of the Anvik River BEG (Clark and Sandone 2001) of 400,000 salmon by an average of 233,000 salmon from 1979 to 1993. In 2004 the BOF established a BEG for the Anvik River of 350,000–700,000 (ADF&G 2004).

In 1994, the BOF adopted the Anvik River chum salmon fishery management plan, which permits a commercial harvest of summer chum salmon in the terminal Anvik River Management Area (ARMA, ADF&G 1994) to allow commercial exploitation of surplus chum salmon returning to the Anvik River. In 1996, the BOF established a harvest limit of 100,000 pounds of chum salmon roe for the ARMA (JTC 1996).

A more complete history and background information can be found in annual management reports for the Yukon Area published each year by the Alaska Department of Fish and Game (ADF&G).

OBJECTIVES

The objectives of the Anvik River sonar project are to:

1. Estimate chum salmon abundance in the Anvik River using DIDSON sonar from approximately June 20 through July 26.
2. Estimate age, sex, and length (ASL) composition of the total Anvik River chum salmon escapements from a minimum of 2 samples collected from each third of the

run, such that simultaneous 95% confidence intervals of age composition in each pulse are no wider than 0.20 (α=0.05 and d=0.10).

3. Monitor selected climatic and hydrological parameters daily at the project site for use as baseline data.

METHODS

STUDY AREA

The Anvik River originates at an elevation of 400 m and flows in a southerly direction approximately 200 km to its mouth at rkm 512 of the Yukon River (Figure 1). This narrow runoff stream has a substrate of mainly gravel and cobble. Bedrock is exposed in some of the upper reaches. The Yellow River (Figure 2) is a major tributary of the Anvik drainage and is located approximately 100 km upstream from the mouth of the Anvik River. Downstream from the confluence of the Yellow River, 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 greatly reduce water clarity of the Anvik River below their confluence. Numerous oxbows, old channel cutoffs, and sloughs are found throughout the lower Anvik River.

The Anvik river, at the sonar site, is characterized by broad meanders, with large gravel bars on the inside bends and cut banks with exposed soil, tree roots, and snags on the outside bends. As with past years, we were able to use the same location, due to the site's stability. The river substrate at the sonar site is fine, smooth gravel, sand, and silt. The right bank slopes gradually to the thalweg at roughly 25–35 m, while the left bank river bottom slopes steeply to the thalweg at about 10–15 m, depending on water level.

Anvik River salmon escapements were partially estimated from visual counts made at counting towers above the confluence of the Anvik and Yellow Rivers, from 1972 to 1979 (Figure 2). A site 9 km above the Yellow River, on the mainstem Anvik River, was used from 1972 to 1975 (Lebida[2]; 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 (Mauney 1979, 1980; Mauney and Geiger 1977). Since 1979, the Anvik River sonar project has been located approximately 76 km upstream of the confluence of the Anvik and Yukon Rivers, 5 km below Theodore Creek in Sections 34 and 35, Township 31 North, Range 61 West, Seward Meridian, at latitude/longitude 62° 44.208" N 160° 40.724" W. The land is public, managed by the Bureau of Land Management (BLM), and leased to ADF&G for public purposes until 2023. Aerial survey data indicate chum salmon spawn primarily upstream of this sonar site.

HYDROACOUSTIC DATA ACQUISITION

Equipment

Two DIDSON units were deployed at the Anvik sonar site, one for each bank. The sonar units operated at 1.1 MHz. Each DIDSON was mounted on an aluminum pod and manually aimed.

Each DIDSON was controlled by a laptop computer running either version 5.09 or 5.11 of the DIDSON software. A 152.4 m cable transferred power and data between a "topside box" and the

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[2] Lebida, R. C. *Unpublished*. Yukon River anadromous fish investigations, 1973. Alaska Department of Fish and Game, Juneau.

DIDSON unit in the water. For the right bank, a Honda model EU-2000 generator provided power for all equipment. An Ethernet cable routed data between the topside box and a 10/100 BT hub and then to a laptop computer. A 500 GB RAID enclosure was connected to the laptop for storing of all data from both banks (Figure 3). The enclosure was configured as RAID 1 allowing redundant copies of the data on two separate hard drives within the enclosure in the event one of the hard drives failed.

The left bank sonar electronic equipment was housed in a portable canvas wall tent and the equipment was powered by a single Honda model EU-1000 generator. A wireless Ethernet router (D-Link DWL-2100AP) transferred the data from the left bank DIDSON to the controlling laptop on the right bank where the data were saved to the RAID drive (Figure 3).

Equipment Settings

The DIDSON is a high frequency, multi-beam sonar with a unique acoustic lens system designed to focus the beam to create high resolution images. Sound pulses were generated by the sonar at center a frequency of 1.1 MHz. DIDSON simultaneously transmits on, and then receives from sets of 12 beams. Images or frames are built in sequences of these sets of pings. At frequencies of 1.1 MHz, 48 beams (4 sets of 12) 0.6° apart from each other on a horizontal plane are utilized to form the image. The right bank sampled at a range from 0.83 m to 20 m and the left bank sampled at a range from 0.83 to 10 m and the frame rate was set to 4 pings per second.

Transducer Deployment

The transducers were attached to an aluminum pod, deployed on each bank, and oriented perpendicular to the current. The wide axis of each beam was oriented horizontally and positioned close to the river bottom to maximize residence time of targets in the beam. Transducers were placed offshore 4 to 10 m from the right bank, and 1 to 2 m from the left bank. Daily visual inspections confirmed proper placement and orientation of the transducers and alerted operators as to when the transducers needed to be repositioned to accommodate changing water levels. The majority of the river (66–85%, depending on water level) was ensonified by using the right bank transducer to sample outwards 20 m and the left bank transducer to sample outward 10 m.

Partial weirs were erected perpendicular to the current and extended from the shore out one to 3 meters beyond the transducers. These devices moved chum salmon, Chinook salmon, and other large fish offshore and in front of the transducers to prevent them from passing undetected behind the transducers. The 4.4 cm gap between weir pickets was selected to divert large fish (primarily chum and Chinook salmon) while allowing passage of small, resident, non-target species grayling, *Thymallus thymallus*, pike, *Esox lucius*, sucker, *Catostomus* sp., whitefish, *Coregonus*.

Sampling Procedures

Sonar project activities commenced on June 18 and ended on July 26, 2008. Hydroacoustic sampling began at 0001 hours on June 18 on right and left bank and ran every day until 2359 hours on July 26. Passage estimates were available to fishery managers in Emmonak at 0810 hours daily.

Acoustic sampling was conducted on both banks at the top of each hour for 30 minutes, 24 hour a day, 7 days per week, except for short periods when the generator was serviced or transducer adjustments were made. This sampling was consistent with previous field seasons. Three fishery technicians operated and monitored equipment at the sonar site while rotating through shifts (one person per shift) occurring from 0600–1400, 1000–1800, and 1600–0100 hours. The technicians identified and tallied fish traces from the echogram recordings, the first shift counted fish from 0000–0800, the second shift counted fish from 0800–1600, and the third shift counted fish from 1600–0000. All fish were counted except for very small fish, which are assumed not to be salmon. Counting was done manually using the echogram and marking fish traces with the computer mouse. The video was used to verify fish target and fish size. The number of fish traces were then summed over the 30 minute periods and recorded onto forms. Completed data forms were entered into a spreadsheet and checked over by the crew leader. All sonar data was saved to the RAID drive in 30 minute intervals during the 8 hour shift for later review as an echogram and/or video.

The crew recorded all project activities in a project logbook. The logbook was used to document daily events of sonar activities and system diagnostics. During each shift, crew members were required to: 1) read the log from the previous shift; 2) sign the log book, including date and time of arrival and departure; 3) record equipment problems, factors contributing to problems, and resolution of problems; 4) record equipment setting adjustments and their purpose; 5) record observations concerning weather, wildlife, boat traffic, etc.; and 6) record visitors to the site, including their arrival and departure times.

ANALYTICAL METHODS

Abundance Estimation

Daily passage $\hat{y}_{dz}$ on day *d* and bank *z* was estimated by first calculating the hourly passage rate $\hat{y}_{dzp}$ for each period *p*:

$$\hat{y}_{dzp} = x_{dzp}\left(60 / m_{dzp}\right), \tag{1}$$

where the rate is calculated by expanding the count x_{dzp} by the inverse of the fraction of the hour sampled, where m_{dzp} is the minutes counted. Normally this is equivalent to doubling the 30 minute count (i.e. 60/30=2). The daily passage for each bank is estimated by summing the 24 hourly samples:

$$\hat{y}_{dz} = \sum_{p=1}^{24} \hat{y}_{dzp} \,. \tag{2}$$

Finally, the total daily passage $\hat{y}_d$ is estimated by adding the daily passage for the 2 banks:

$$\hat{y}_d = \sum_{z} \hat{y}_{dz} \tag{3}$$

Sonar sampling periods were spaced at regular (systematic) intervals. Treating the systematically sampled sonar counts as a simple random sample may overestimate the variance of the total since sonar counts can be highly auto correlated (Wolter 1985). To accommodate these data characteristics, a variance estimator based on the squared differences of successive observations was utilized. This estimator was adapted from the estimator used at the Yukon River sonar project (Pfisterer 2002). The variance for the passage estimate for bank *z* on day *d* was estimated as:

$$\hat{V}ar_{y_{dz}} = 24^2 \cdot \frac{1 - f_{dz}}{n_{dz}} \cdot \frac{\sum_{p=24}^{n_{dz}} \left(y_{dzp} - y_{dz,p-1}\right)^2}{2 n_{dz}\left(n_{dz} - 1\right)}, \qquad (4)$$

where n_{dz} is the number of periods sampled in the day (generally 24) and f_{dz} is the fraction of the day sampled (12/24=0.5). Finally, since the passage estimates are assumed independent between zones and among days, the total variance was estimated as the sum of the variances:

$$\hat{V}ar(\hat{y}) = \sum_d \sum_z \hat{V}ar(\hat{y}_{dz}). \qquad (5)$$

Missing Data

Depending on the amount of time that was missed, the crew used different methods to make up for incomplete or missing counts. If less than 25 minutes were missed the passage rate for the period within that interval was used to estimate passage for the non-sampled portion of the interval as in Equation (1).

If data from one or more complete samples was missing, counts were interpolated by averaging counts from samples before and after the missing sample(s) as follows:

$$\hat{y}_s = \left(1/n \sum_{i=1}^{n} x_i\right) \begin{Bmatrix} s = 1, n = 4 \\ s = 2, n = 6 \\ s = 3, n = 8 \end{Bmatrix} \qquad (6)$$

Where *s* is the number of missed samples, *n* is the number of samples used for interpolation (half before and half after the missing sample(s)), and x_i is the count for each sample *i*.

If more than 4 samples were missed, an XY scatterplot with a regression line was plotted using the known fish counts for the day from both left bank and right bank. The linear regression equation of the line was then used to calculate missing fish counts for each missing sample *s*:

$$\hat{y}_s = a + bx_s \qquad (7)$$

Where *a* and *b* are the regression coefficients, *x* equals the count for sample *s* on the opposite bank and $\hat{y}_s$ is the estimated passage for missing sample *s*.

Species Apportionment

During the 2008 season at the Anvik sonar project, daily passage estimates were reported inseason without any apportionment for species. Postseason adjustments were made for the unusually large pink salmon returns through a combination of applying the results of 1) visual tower counts made intermittently throughout the season on both banks and 2) test fish catches made on the right bank during the course of regular ASL sampling. Estimated proportions prior to July 1 were considered 100% chum salmon on all but one day (June 29) when a visual count was made on the right bank. Days without observations were interpolated.

Daily passage estimates y by species a were apportioned to either pink or chum salmon by applying the estimated proportion p to the unadjusted daily passage estimate for each bank z:

$$\hat{y}_{dza} = \hat{y}_{dz} \cdot \hat{p}_{dza} \qquad (8)$$

With only 2 species apportioned for, the variance of the proportion follows the binomial distribution:

$$Var(\hat{p}_{dza}) = \hat{p}_{dza} \cdot (1 - \hat{p}_{dza})/(n-1) \qquad (9)$$

and the variance of the species passage estimate was calculated as:

$$\hat{V}ar(\hat{y}_{dza}) = \hat{y}_{dz}^2 \cdot \hat{V}ar(\hat{p}_{dza}) + \hat{p}_{dza}^2 \cdot \hat{V}ar(\hat{y}_{dz}) - \hat{V}ar(\hat{y}_{dz}) \cdot \hat{V}ar(\hat{p}_{dza}) \qquad (10)$$

Total daily passage by species was estimated by summing both banks,

$$\hat{y}_{da} = \sum_{z} \hat{y}_{dza} \qquad (11)$$

and passage estimates were summed over both banks and all days to obtain a seasonal estimate for species y_a

$$\hat{y}_{a} = \sum_{d} \sum_{z} \hat{y}_{dza} \qquad (12)$$

Finally, passage estimates were assumed independent between banks and among days, so the variance of their sum was estimated by the sum of their variances:

$$\hat{V}ar\left(\hat{y}_a\right)=\sum_d \sum_z \hat{V}ar\left(\hat{y}_{dza}\right) \tag{13}$$

and, assuming normally distributed errors, 90% confidence intervals were calculated as,

$$\hat{y}_a \pm 1.645\sqrt{\hat{V}ar(\hat{y}_a)} \tag{14}$$

Tower counts were attempted 4 times per day (0900, 1300, 1600, 2000) for 15 minutes on each bank. On right bank a 15' tower was erected, and anchored in the river just upstream of the sonar. A crew member would stand on top with polarized sunglasses and count and identify the number of salmon going by the sonar. On left bank the crew member would tie the skiff to the end of the weir, with the motor off, and wait 5 minutes before counting. The crew member would stand on the bow of the boat with polarized sunglasses and count and identify the number of salmon going by the sonar. For each bank the technician would look out into the water as far as possible and still be able to identify salmon and count the number of salmon by species going upstream. Data would be entered into an MS Excel spreadsheet as to the number of each species for each bank, and how far out you could see. This year tower counts were made intermittently due to weather; (water turbidity, rain, sun glare, and darkness).

AGE, SEX, AND LENGTH SAMPLING

Temporal strata, used to characterize the age and sex composition of the chum salmon escapement, were defined as quartiles using dates on which 25%, 50%, 75%, and 100% of the total run had passed the sonar site. To determine current year ASL sampling dates we used the historical mean quartile ASL dates (Table 1). The 2008 quartile-sampling strata were determined postseason based on run timing data. They represent an attempt to sample the escapement for ASL information in relative proportion to the total run. In 2008, these strata were defined as: June 18 to July 3, July 4–9, July 10–14, and July 15-26

To meet region wide standards for the sample size needed to describe a salmon population, the initial seasonal ASL sample goal were 608 chum salmon, with a minimum of 162 chum salmon samples collected during each temporal stratum (Bromaghin 1993). Sample size goals are based on a 95% confidence with an accuracy (d) and precision (α) objectives of $d = 0.10$ and $\alpha = 0.05$, assuming 2 major age classes, and 2 minor age classes with a scale rejection rate of 15%. The beach seining goal for Chinook salmon was to sample all fish captured while pursuing the chum salmon sampling goal.

A beach seine (31 m long, 66 meshes deep, 6.35-cm mesh) was drifted, beginning approximately 10 m downstream of the sonar site, to capture chum salmon to collect ASL data. All resident freshwater fish captured were tallied by species and released. Pink salmon were counted by sex, based on external characteristics, and released. Chum salmon were placed in a holding pen and each was noted for sex, measured to the nearest 5 mm from mid eye to tail fork, and one scale was taken for age determination. Where possible, 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 sampled chum salmon to prevent resampling. If any Chinook salmon were caught, they were sampled using the same methods as for chum salmon, except three scale samples were taken from each fish.

CLIMATIC AND HYDROLOGIC SAMPLING

Climatic and hydrologic data were collected at approximately 1800 hours each day at the sonar site. Relative river depth was monitored using a staff gauge marked in 1 cm increments. Change in water depth was presented as negative or positive increments from the initial reading of 0.0 cm. Water temperature were measured using a HOBO water temp logger which electronically recorded the temperature 4 times per day starting at 0345 and again every 6 hours. The data was downloaded to a computer at the end of the season. Daily maximum and minimum air temperatures were recorded in degrees C. Subjective notes on wind speed and direction, cloud cover, and precipitation were recorded.

RESULTS

ESCAPEMENT ESTIMATES AND RUN TIMING

Full sonar operations on both banks began on June 18. Both transducers collected data through midnight on July 26. The 2008 summer salmon passage estimate was 1,109,766 (SE 2,943) fish. After postseason adjustments (Appendix A) an estimated 374,929 were summer chum salmon and 734,837 were pink salmon (Table 2). This includes estimates for missing sector/hourly counts and expansions for missing data. For the right bank a total of 10 hours (2.3%) was missed and on the left bank 17 hours (4%) was missed.

Summer chum salmon passage dates were 2-3 days late at the first and third quartile when compared to the historic run timing, based on 1979–1985 and 1987–2007 runs (Table 1). The summer chum passage quartiles were close to the historic median dates. The central half of the run passed between July 5 and July 16 (Table 1) and the duration of 11 days is near the historic mean of 10 days. The daily passage between the first and third quartile dates ranged from 8,909 (July 14) to 30,731 (July 6) with an estimated 205,910 summer chum salmon passing by the sonar site during this time (Table 2). The peak daily passage of 30,731 summer chum occurred on July 6 (Table 2). Pink salmon returned to spawn in 2008, and accounted for 66% (734,837) of the salmon passage estimate (Table 2). The 2008 chum salmon escapement estimate of 374,929 was 59% of the mean Anvik River escapement estimate of 635,725 fish, based on 1979–2007 data (Table 1). This year's escapement fell within the BEG of 350,000 to 700,000 summer chum salmon.

SPATIAL AND TEMPORAL DISTRIBUTION

There was a diurnal pattern to the passage in 2008 with 37% of the counts recorded between the hours of 2300 and 0500 (Figure 4). Spatially, 70% of the chum salmon were detected by the right bank sonar (Figure 5).

AGE AND SEX COMPOSITION

From June 28 to July 19, a total of 9 days of sampling was conducted for ASL. The age-0.3 and -0.4 chum salmon accounted for 93.6% of the entire run (Table 3; Figure 6). The age-0.4 chum salmon accounted for 50.6% of the entire run ranging from 37.4% to 69.7% throughout the run. The age-0.3 chum salmon accounted for 43.6% of the entire run. The age-0.5 and age-0.2 chum salmon comprised 4.2% and 1.6% respectively of the overall run. Females accounted for 54.9% of the entire run (Table 3).

HYDROLOGIC AND CLIMATOLOGICAL CONDITIONS

The summer of 2008 saw warm temperatures and wet conditions on the Anvik River. Due to rain in the headwaters the water level fluctuated at the sonar site throughout the season (Figure 7). The minimum air temperature was 1°C (July 22) and a maximum high of 35°C (July 5–6) with an average high and low of 19°C and 8°C (Figure 8). Water temperatures were measured 4 times per day (0345, 0945, 1545, 2145) the lowest average temperature by time was 8.5°C at 0345 the highest average temperature was 18.9°C at 1545 (Figure 9). The average water temperature over the operational period of the project was 11.6°C. The temperature averaged 11.1°C between the hours of 0345 and 0945 and 12.0°C from 1545 to 2145.

DISCUSSION

ESCAPEMENT ESTIMATION

The 2008 Anvik River summer chum salmon escapement estimate of 374,929 was 41% below the 1979–2007 average escapement of 635,764 and 19% below last year's DIDSON escapement estimate (460,121). This is the fifth year since 2002 that the summer chum salmon abundance has been within the BEG. Although the exact reason for the low salmon runs in past years is unknown, scientists speculate poor marine survival results from, or accentuated by, localized weather conditions in the Bering Sea (Kruse 1998).

Estimates by species were determined postseason using the species distribution from tower counts and the ASL beach seine to apportion out the counts (Appendix A). Pink salmon began outnumbering chum salmon by July 11. The majority of pink salmon returned during the last 2 weeks of July when approximately 597,203 pink salmon went by the sonar.

ASL Sampling

Age and sex composition of the Anvik River chum salmon passing the sonar site changes through the duration of the run. Usually, the trend is an increasing proportion of younger salmon and a higher proportion of female salmon as the run progresses (Fair 1997). The 2003 chum salmon year class returned to spawn this year as age-0.4, accounting for 50.6% (189,676) of the total run. Age -0.3 fish accounted for 43.6% (163,652) and age-0.5 accounted for 4.2% (15,778) of the total run.

The average age of the 2008 run was 4.5 years which is about even with the long-term average of 4.4 years (Figure 10) and there were 54.9% females, which is below the long term average of 55.9%.

SPATIAL AND TEMPORAL DISTRIBUTION

In 2008, chum salmon spatial migration followed historical trends with 70.4% passing on the right bank. Prior to 2006, passage has been associated with the right bank with the exception of 3 years: 1992, 1996, and 1997. In these years only 43%, 45%, and 39% of the adjusted passage occurred on the right bank, respectively (Sandone 1994; Fair 1997; Chapell 2001). The shift to the left bank in those years was attributed to low water conditions that affected chum salmon migration patterns at the sonar site. Although there is no river stage benchmark at the site to allow direct comparison with previous years, subjectively, the water level in 2008 appeared to be higher then last year.

Buklis (1982) first reported a distinct diurnal salmon migration pattern during the 1981 season with a higher proportion of the migration passing the sonar site during darker hours of the day. Similar diurnal patterns were reported from 1985 through 2005. Temporal distribution of sonar estimates in 2008 indicates a distinct diurnal pattern (Figure 4). The chum salmon could be migrating in greater numbers at night due to the fact that the water is slightly cooler (0.8°C) or to escape predation from various birds and mammals.

ACKNOWLEDGEMENTS

The USFWS Office of Subsistence Management provided $68,669 in funding support to ADF&G for this project (FIS 08-202) through the Fisheries Resource Monitoring Program under Cooperative Agreement No. 701818J693.

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TABLES AND FIGURES

Table 1.–Annual passage estimates and associated passage timing statistics for summer chum salmon runs, Anvik River sonar, 1979–2008.

						Days Between Quartiles			
Year	Sonar passage estimate	Day of first Salmon Count	First Quartile day	Median day	Third Quartile day	First count & first quartile	First & median	Median & third	First & third
1979	277,712	6/23	7/2	7/8	7/12	9	6	4	10
1980	482,181	6/28	7/6	7/11	7/16	8	5	5	10
1981	1,479,582	6/20	6/27	7/2	7/7	7	5	5	10
1982	444,581	6/25	7/7	7/11	7/14	12	4	3	7
1983	362,912	6/21	6/30	7/7	7/12	9	7	5	12
1984	891,028	6/22	7/5	7/9	7/13	13	4	4	8
1985	1,080,243	7/5	7/10	7/13	7/16	5	3	3	6
1986	1,085,750	6/21	6/29	7/2	7/6	8	3	4	7
1987	455,876	6/21	7/5	7/12	7/16	14	7	4	11
1988	1,125,449	6/21	6/30	7/3	7/9	9	3	6	9
1989	636,906	6/20	7/1	7/7	7/13	11	6	6	12
1990	403,627	6/22	7/2	7/7	7/15	10	5	8	13
1991	847,772	6/21	7/1	7/10	7/16	10	9	6	15
1992	775,626	6/29	7/5	7/8	7/12	6	3	4	7
1993	517,409	6/19	7/5	7/12	7/18	16	7	6	13
1994	1,124,689	6/19	7/1	7/7	7/11	12	6	4	10
1995	1,339,418	6/19	7/1	7/6	7/11	12	5	5	10
1996	933,240	6/18	6/25	7/1	7/6	7	6	5	11
1997	605,752	6/19	6/28	7/3	7/10	9	5	7	12
1998	487,301	6/22	7/5	7/10	7/14	13	5	4	9
1999	437,356	6/27	7/6	7/10	7/16	9	4	6	10
2000	196,349	6/21	7/8	7/11	7/13	17	3	2	5
2001	224,058	6/26	7/6	7/10	7/15	10	4	5	9
2002	459,058	6/22	7/3	7/7	7/12	11	4	5	9
2003	256,920	6/21	7/5	7/10	7/15	14	5	5	10
2004	365,353	6/22	6/29	7/5	7/9	7	6	4	10
2005	525,391	6/26	7/4	7/10	7/15	8	6	5	11
2006	605,485	6/28	7/3	7/6	7/12	5	3	6	9
2007	459,038	6/27	7/5	7/10	7/17	8	5	7	12
2008	374,929	6/18	7/5	7/8	7/16	17	3	8	11
Average	635,725	6/23	7/3	7/8	7/13	10	5	5	10
Median	502,355	6/22	7/3	7/8	7/13	10	5	5	10
SD	343,288		3.5	3.2	3.0	3	1	1	2

Note: The mean and standard deviation of the timing statistics includes estimates from years 1979–1985 and 1987–2007. In 1986, sonar counting operations were terminated early, probably resulting in the incorrect calculation of the quartile statistics. Therefore, the 1986 run timing statistics were excluded from the calculation of the overall mean and timing statistic and associated standard deviation (SD).

Table 2.–Summer chum and pink salmon daily and cumulative counts, Anvik River sonar, 2008. The large box indicates the central 50% of the chum salmon run (second and third quartiles).

	Right Bank		Left Bank		Daily Totals		Cumulative
Date	Chum	Pink	Chum	Pink	Chum	Pink	Total
6/18	266	0	282	0	548	0	548
6/19	168	0	242	0	410	0	958
6/20	146	0	264	0	410	0	1,368
6/21	160	0	308	0	468	0	1,836
6/22	340	0	620	0	960	0	2,796
6/23	534	0	525	0	1,059	0	3,855
6/24	838	0	254	0	1,092	0	4,946
6/25	752	0	398	0	1,150	0	6,096
6/26	2,318	0	734	0	3,052	0	9,148
6/27	4,298	0	1,956	0	6,254	0	15,402
6/28	7,886	0	1,699	0	9,585	0	24,987
6/29	9,515	881	1,336	0	10,851	881	36,719
6/30	5,034	0	520	0	5,554	0	42,273
7/1	9,250	538	2,618	81	11,869	619	54,761
7/2	6,384	780	688	44	7,072	824	62,657
7/3	8,288	776	1,327	124	9,616	900	73,173
7/4	9,061	839	2,480	371	11,541	1,209	85,923
7/5	10,202	1,572	8,951	1,735	19,153	3,307	108,383
7/6	13,450	1,409	17,281	6,621	30,731	8,030	147,143
7/7	17,685	4,845	12,488	8,086	30,173	12,931	190,247
7/8	20,761	3,572	6,172	6,476	26,934	10,047	227,228
7/9	21,727	3,195	4,335	4,165	26,062	7,360	260,649
7/10	9,593	4,999	1,697	1,485	11,290	6,484	278,423
7/11	8,547	11,697	977	5,023	9,524	16,720	304,667
7/12	12,353	13,691	1,227	7,911	13,581	21,601	339,849
7/13	5,082	12,978	4,173	7,511	9,254	20,490	369,593
7/14	6,179	20,699	2,730	13,652	8,909	34,351	412,853
7/15	6,784	19,818	2,282	18,094	9,066	37,912	459,831
7/16	8,618	22,060	2,616	23,546	11,234	45,606	516,671
7/17	8,529	31,685	2,789	25,097	11,318	56,782	584,771
7/18	7,609	26,977	4,049	36,439	11,658	63,416	659,845
7/19	9,190	31,599	4,145	37,301	13,335	68,901	742,081
7/20	9,307	32,999	2,714	24,428	12,022	57,426	811,529
7/21	5,575	20,973	2,791	25,121	8,366	46,094	865,989
7/22	5,036	20,144	3,297	29,677	8,333	49,821	924,143
7/23	5,157	21,985	3,690	33,214	8,847	55,199	988,189
7/24	3,432	15,634	3,730	33,572	7,162	49,206	1,044,556
7/25	2,345	11,447	2,338	21,042	4,683	32,489	1,081,728
7/26	1,638	9,337	169	16,893	1,807	26,230	1,109,766
Season Totals	264,037	347,130	110,892	387,707	374,929	734,837	1,109,766

Table 3.–Age and sex composition of chum salmon, Anvik River sonar, 2008. Number fish is based on the sonar estimate divided by percent of fish in age class and stratum.

			AGE									
			(0.2)		(0.3)		(0.4)		(0.5)		Total	
2008 Sample Date (Strata)	Sample Size	Sex	Number Fish	%	Number Fish	%	Number Fish	%	Number Fish	%	Number Fish	%
6/28-7/2	122	Male	0	0.0	10,320	14.8	30,960	44.3	574	0.8	41,854	59.8
(6/18-7/3)		Female	573	0.8	9,174	13.1	17,774	25.4	573	0.8	28,094	40.2
		Subtotal	573	0.8	19,494	27.9	48,734	69.7	1,147	1.6	69,948	100.0
7/5-8	131	Male	0	0.0	26,490	18.3	39,735	27.5	4,415	3.1	70,640	48.9
(7/4-9)		Female	2,208	1.5	33,113	22.9	36,424	25.2	2,208	1.5	73,952	51.1
		Subtotal	2,208	1.5	59,603	41.2	76,159	52.7	6,623	4.6	144,592	100.0
7/11-13	139	Male	378	0.7	13,612	25.9	9,831	18.7	756	1.4	24,577	46.8
(7/10-14)		Female	1,134	2.2	15,881	30.2	9,831	18.7	1,135	2.2	27,981	53.2
		Subtotal	1,512	2.9	29,493	56.1	19,662	37.4	1,891	3.6	52,558	100.0
7/16-19	141	Male	0	0.0	18,354	17.0	11,471	10.6	2,294	2.1	32,120	29.8
(7/15-26)		Female	1,530	1.4	36,708	34.1	33,649	31.2	3,824	3.6	75,710	70.2
		Subtotal	1,530	1.4	55,062	51.1	45,120	41.8	6,118	5.7	107,830	100.0
Season Total	533	Male	378	0.1	68,777	18.3	91,998	24.5	8,039	2.1	169,192	45.1
		Female	5,445	1.5	94,875	25.3	97,678	26.1	7,739	2.1	205,736	54.9
		Total	5,823	1.6	163,652	43.6	189,676	50.6	15,778	4.2	374,928	100.0

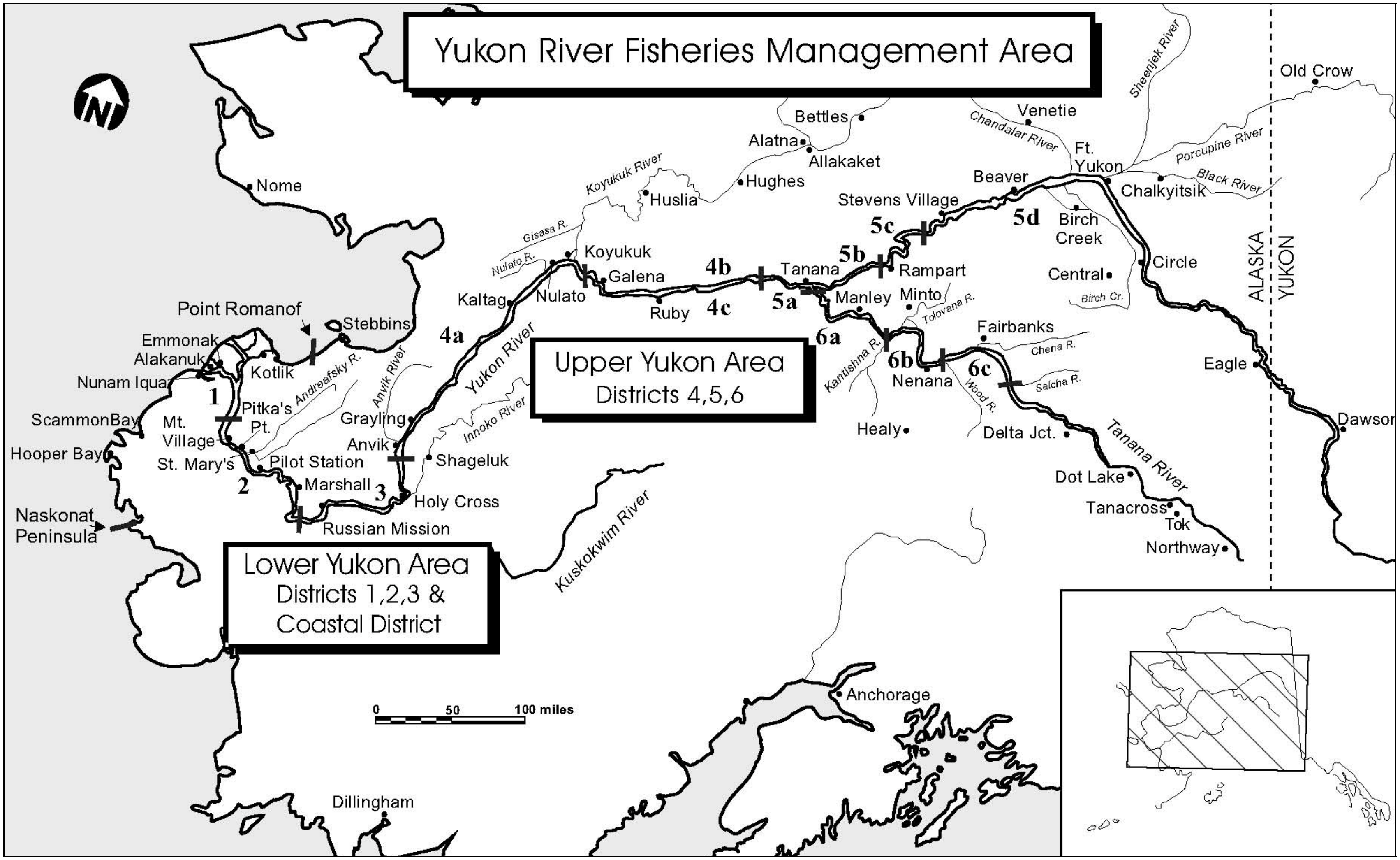


Figure 1.–Alaska portion of the Yukon River drainage showing communities and fishing districts.

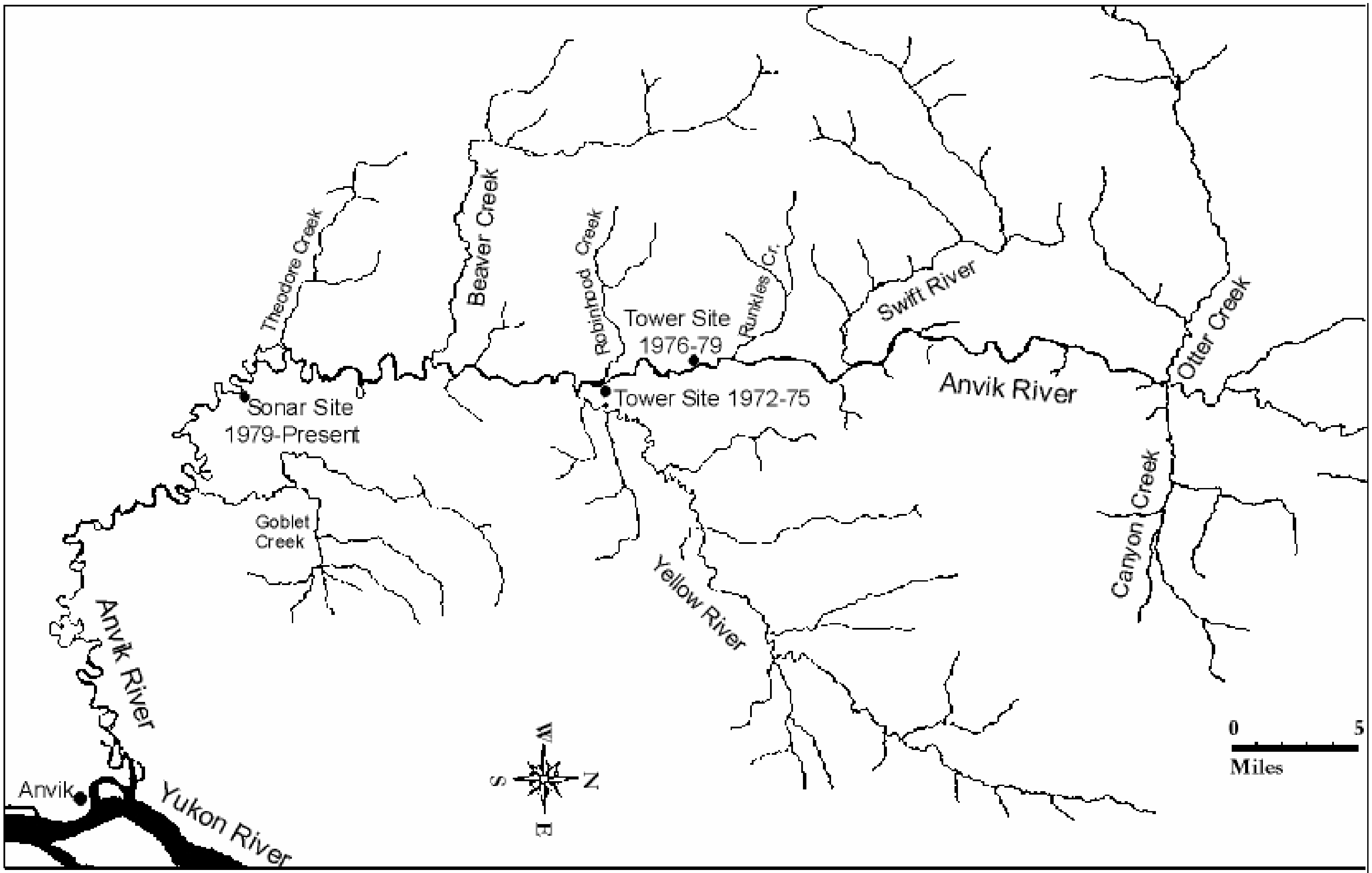


Figure 2.–Anvik River drainage with historical chum salmon escapement project locations.

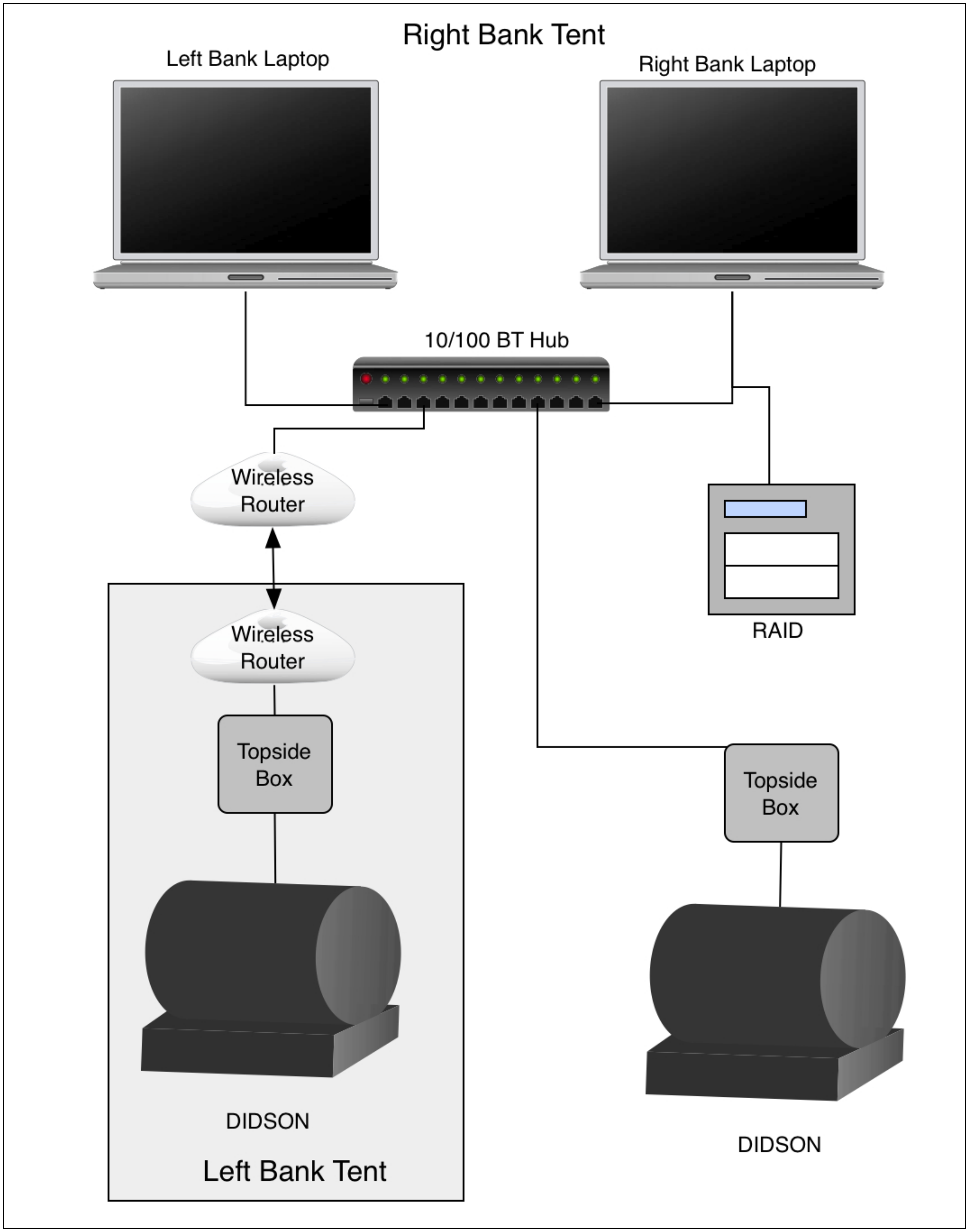


Figure 3.–DIDSON Sonar equipment schematic, Anvik River Sonar, 2008.

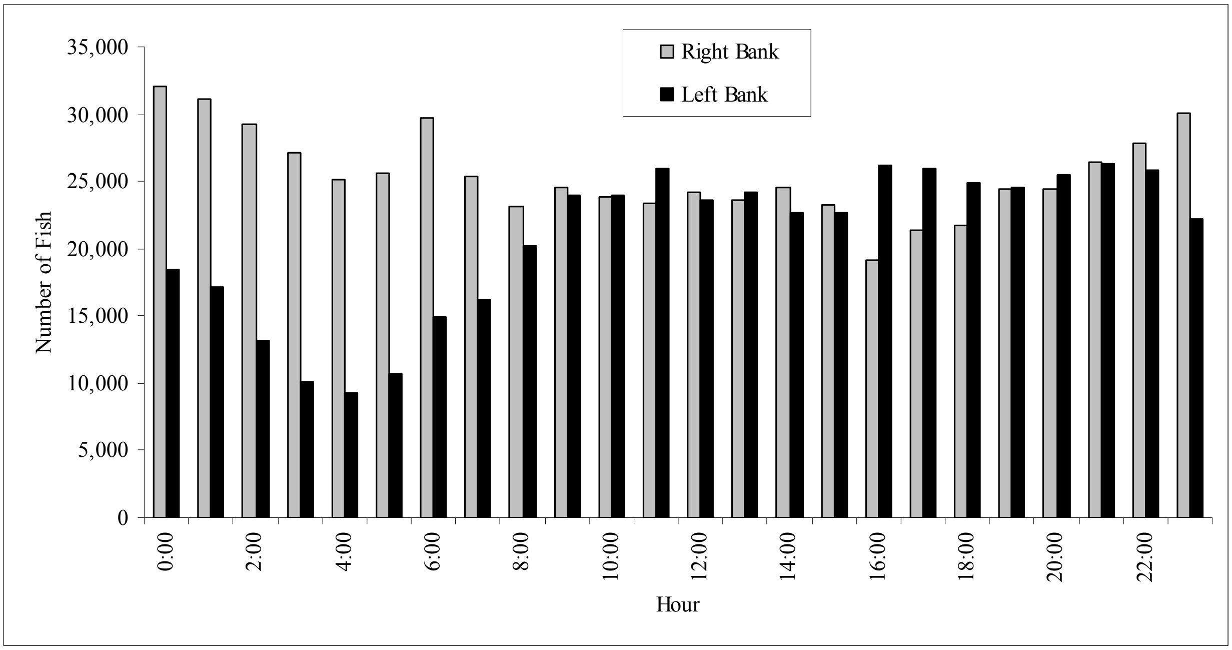


Figure 4.–Estimated passage of chum salmon by hour for each bank, Anvik River sonar 2008.

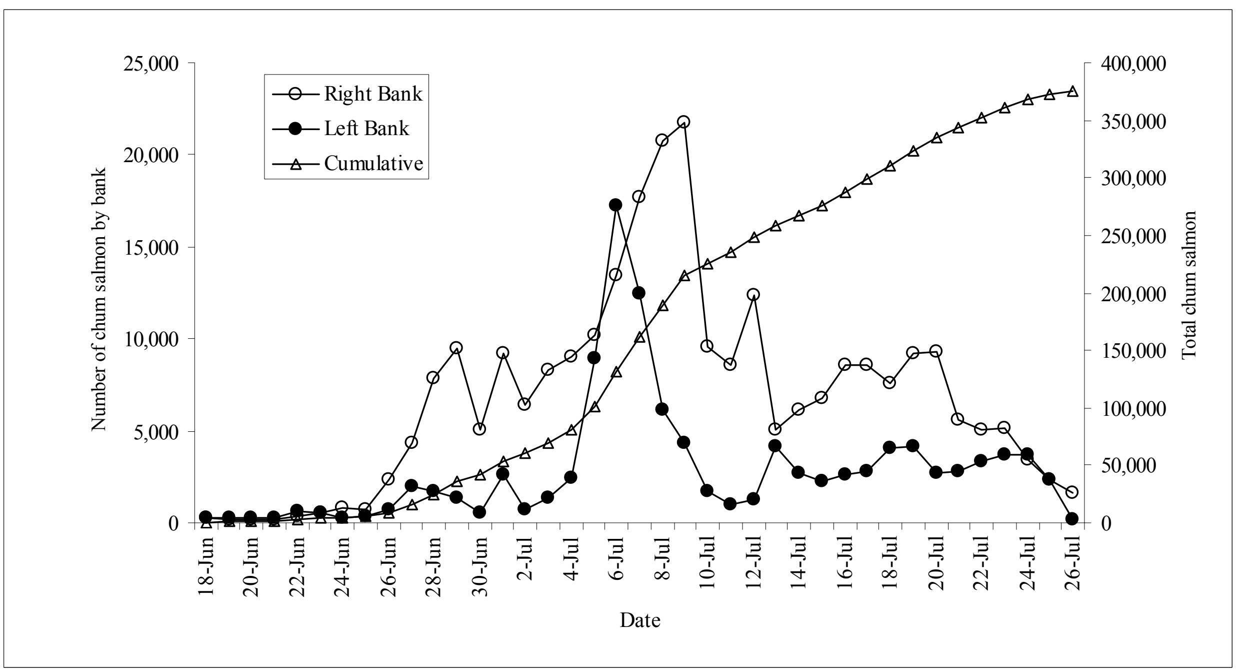


Figure 5.–Chum salmon daily and cumulative counts, Anvik River sonar 2008.

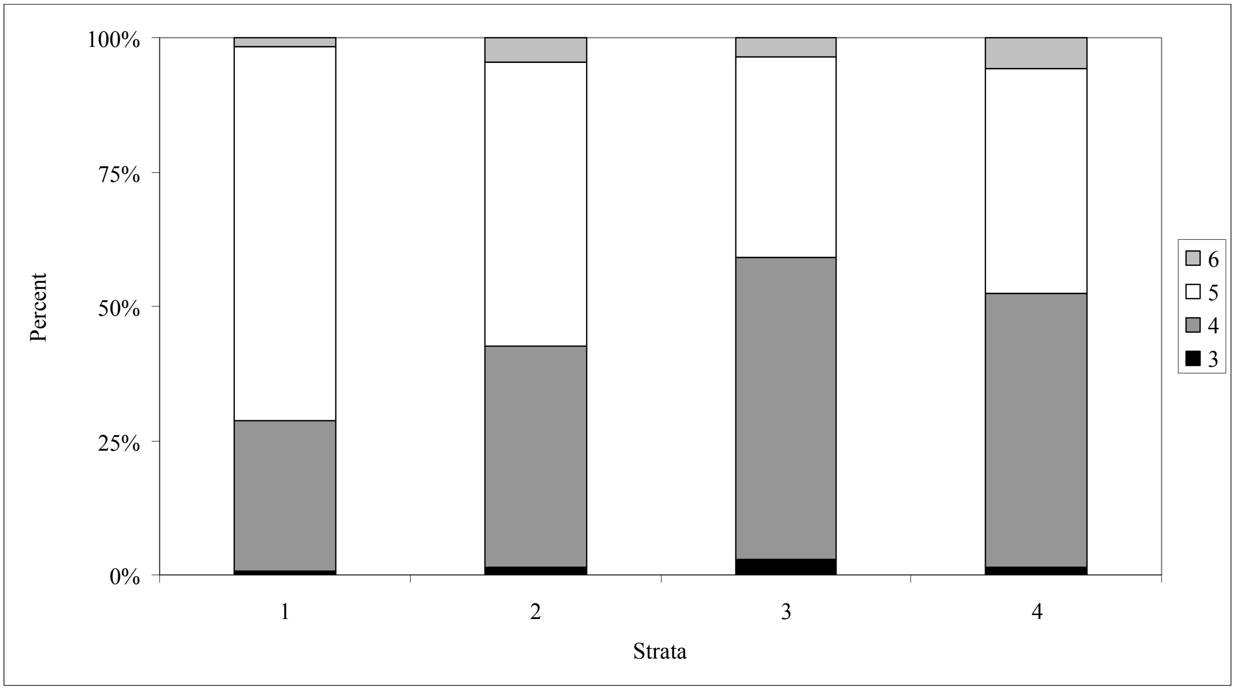


Figure 6.–Chum salmon age composition, Anvik River sonar, 2008.

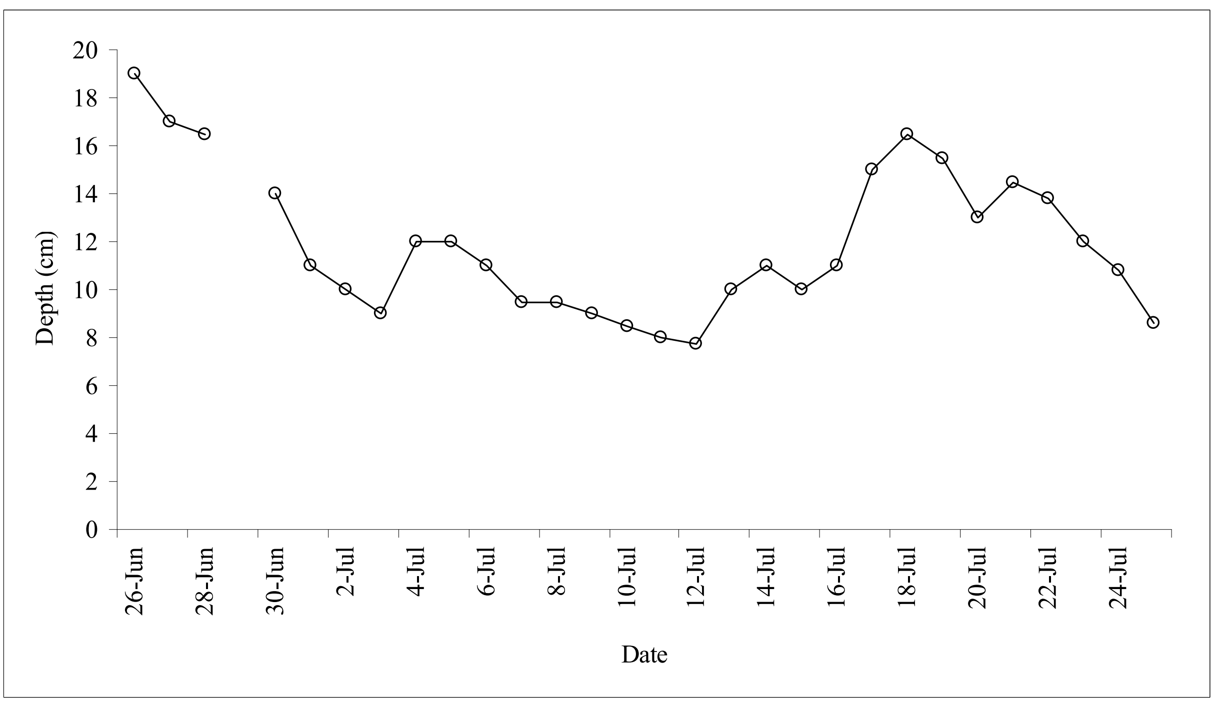


Figure 7.–Water depth at Anvik River sonar, 2008.

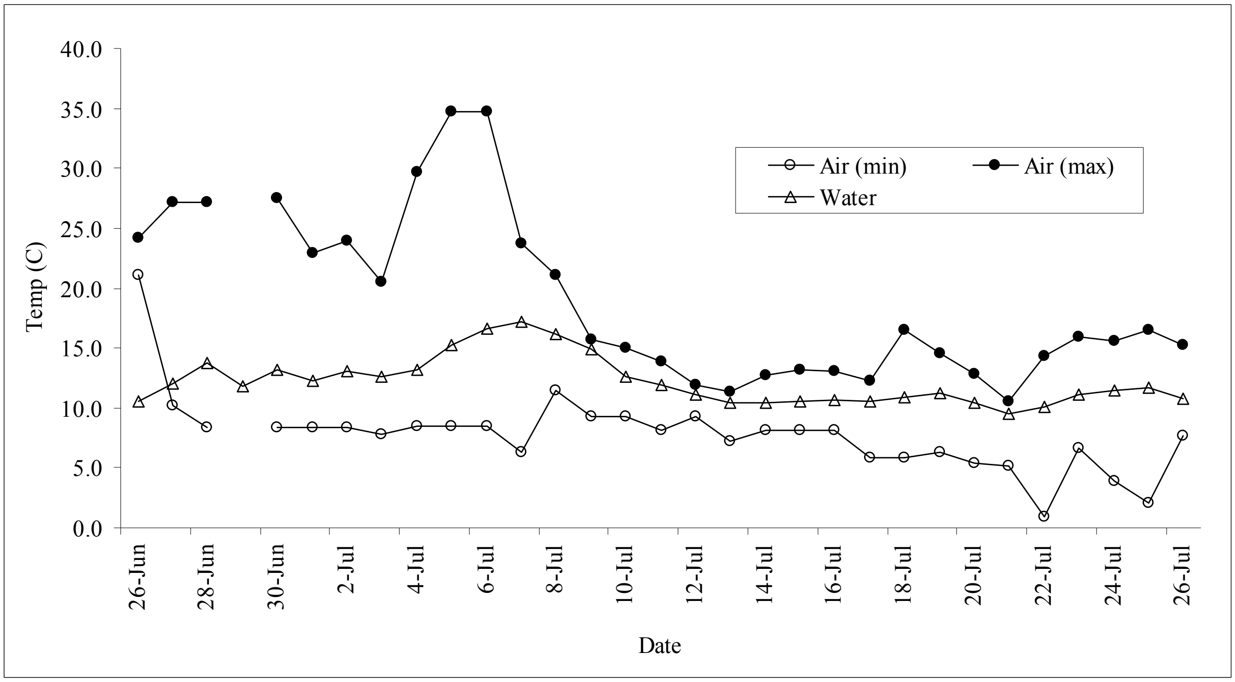


Figure 8.–Air and water temperature, Anvik River sonar, 2008.

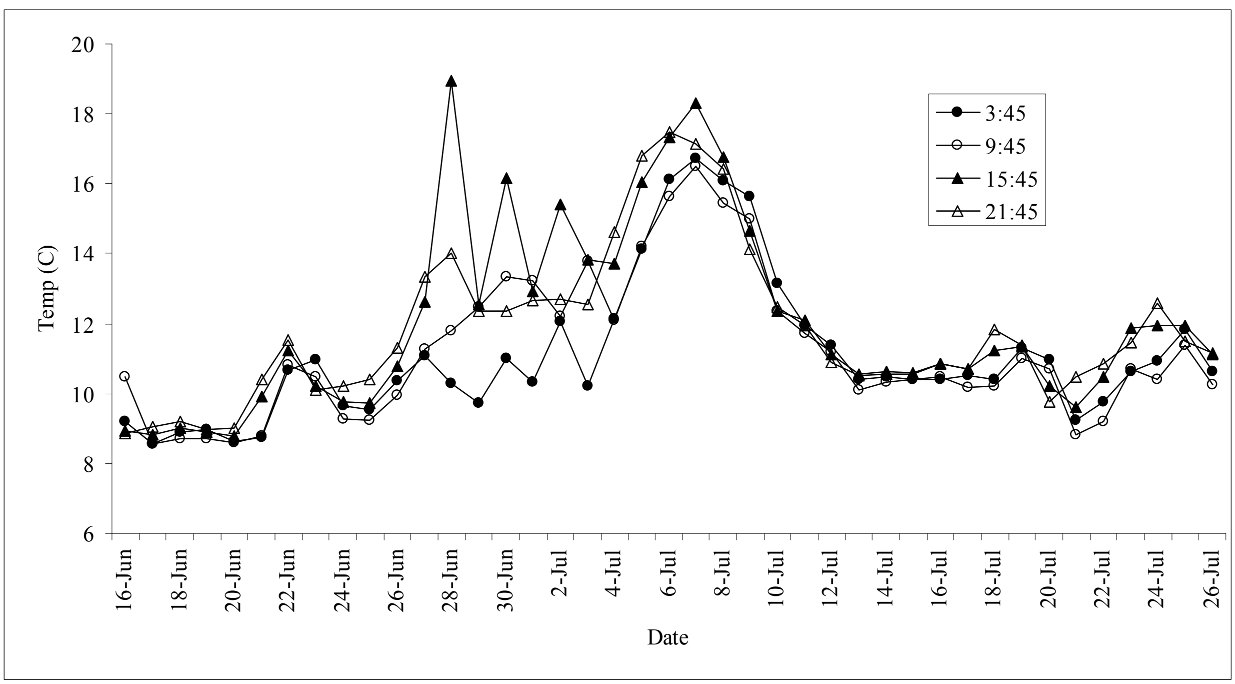
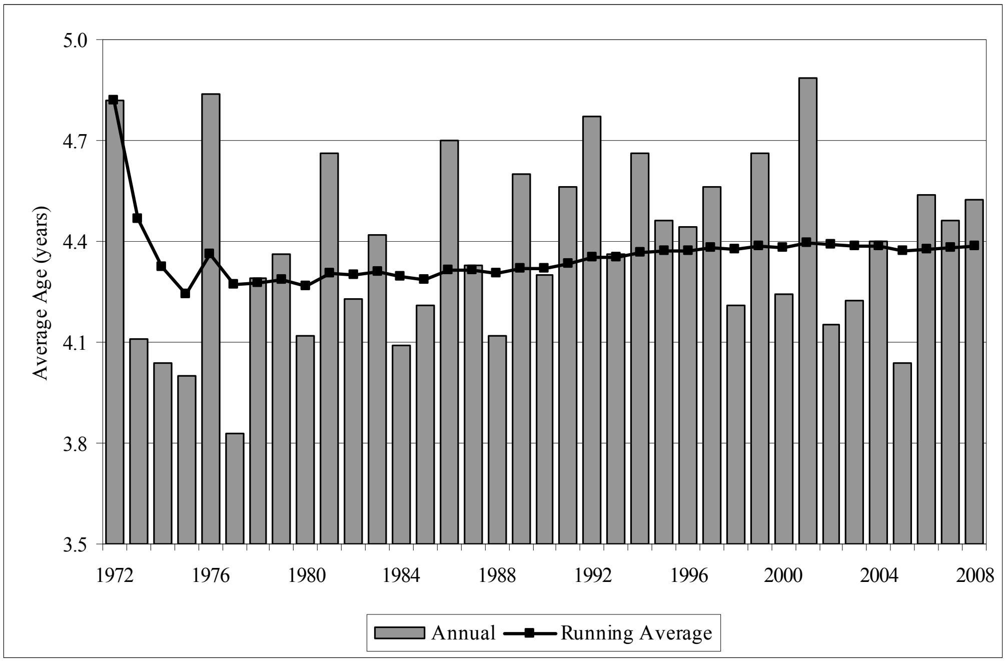


Figure 9.–Daily water temperature by time, Anvik River Sonar, 2008.



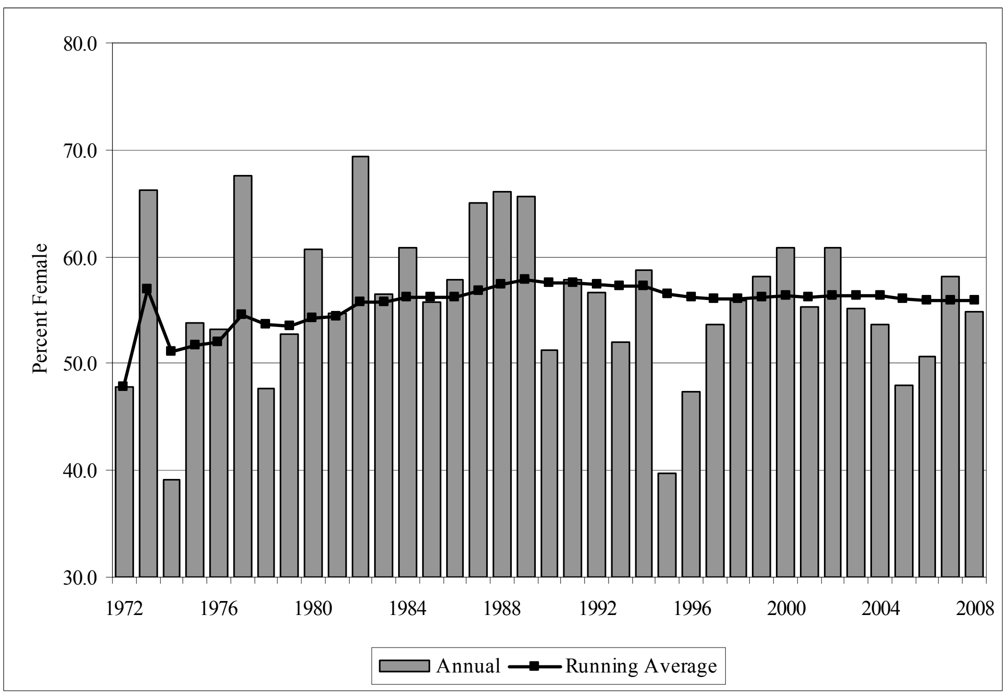


Figure 10.–Annual age at maturity (top) and percentage of females (bottom) of the Anvik River chum salmon escapement, 1972–2008.

APPENDIX A

STATE OF ALASKA

DEPARTMENT OF FISH AND GAME

DIVISION OF COMMERCIAL FISHERIES

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MEMORANDUM

TO: Distribution

FROM: Bruce McIntosh
AYK Regional Sonar Biologist

DATE: September 25, 2008

SUBJECT: Anvik River sonar 2008 – postseason adjustments

During the 2008 season at the Anvik sonar project, daily estimates were reported without any apportionment for species. This past season an unusually large pink salmon return resulted in very high sonar counts which did not accurately reflect the size of the summer chum salmon run. Tracking the Pilot Station chum estimate against the Anvik estimate made it clear that there was a problem (Figure 1). By mid-July the magnitude of the problem was apparent, and it was decided to report the estimates simply as fish until the data could be examined and an effort made at apportioning out chum and pink estimates.

The accompanying tables and figures represent the current postseason estimates for both summer chum and pink salmon. Chinook salmon and resident species represent a minor component of the total estimate and were not included. The apportionment method consisted largely of applying 1) the results of visual tower counts made intermittently throughout the season on both banks, and 2) testfish catches made on the right bank during the course of ASL sampling. Estimated proportions (Table 1) prior to July 1 were considered 100% chum on all but one day (June 29) when a visual count was made on the right bank. Days without observation were interpolated.

The cumulative estimate for the entire season, June 18 through July 26, was 1,109,766 (Table 2). After applying the estimated proportions of pink and chum salmon to the daily estimates, the final estimates broke down to 374,929 summer chum salmon 734,837 pink salmon, with the bulk of the pink salmon passing during the last quarter of the chum run (Figure 2). Pilot Station also had problems with apportionment for a short period at the end of June and early July. The Pilot Station results will be reported separately, but comparisons between the two projects after adjustments were made seem reasonable and in line with the historic relationship (Figures 3 and 4).

To avoid this problem in the future, we are in the process off revising our apportionment methods. Among other things, to increase fish visibility we expect to install a counting substrate typical of other tower operations, and we will be instituting a more rigorous tower sampling schedule. The possibility exists to use the measuring tools in the DIDSON software to attempt length based species ID, but at the moment we don't know how feasible (or efficient) this approach will be.

Table 1 – Chum proportions used to apportion species estimates, Anvik sonar 2008. Interpolated values are enclosed.

	Right Bank[a]	Left Bank[b]
6/18	1.00 [c]	1.00 [c]
6/19	1.00 [c]	1.00 [c]
6/20	1.00 [c]	1.00 [c]
6/21	1.00 [c]	1.00 [c]
6/22	1.00 [c]	1.00 [c]
6/23	1.00 [c]	1.00 [c]
6/24	1.00 [c]	1.00 [c]
6/25	1.00 [c]	1.00 [c]
6/26	1.00 [c]	1.00 [c]
6/27	1.00 [c]	1.00 [c]
6/28	1.00 [d]	1.00 [c]
6/29	0.92 [d]	1.00 [c]
6/30	1.00 [d]	1.00 [c]
7/1	0.95 [c]	0.97 [c]
7/2	0.89 [d,e]	0.94 [c]
7/3	0.91 [e]	0.91 [c]
7/4	0.92 [e]	0.87 [c]
7/5	0.87 [d,e]	0.84
7/6	0.91 [d,e]	0.72 [c]
7/7	0.78 [e]	0.61 [c]
7/8	0.85 [d,e]	0.49
7/9	0.87 [e]	0.51 [c]
7/10	0.66 [e]	0.53
7/11	0.42 [d,e]	0.16
7/12	0.47 [d,e]	0.13
7/13	0.28 [d,e]	0.36
7/14	0.23 [e]	0.17
7/15	0.26 [c]	0.11
7/16	0.28 [d,e]	0.10 [c]
7/17	0.21 [d,e]	0.10 [c]
7/18	0.22 [c]	0.10 [c]
7/19	0.23 [d]	0.10 [c]
7/20	0.22 [c]	0.10 [c]
7/21	0.21 [c]	0.10 [c]
7/22	0.20 [c]	0.10 [c]
7/23	0.19 [c]	0.10 [c]
7/24	0.18 [c]	0.10 [c]
7/25	0.17 [c]	0.10 [c]
7/26	0.15 [e]	0.01

a – Right bank proportions from tower and testfish catches
b – Left bank proportions from tower only
c – interpolated proportions
d – Right bank testfish
e – Right bank tower

Table 2 – Postseason daily and cumulative species estimates, Anvik sonar 2008.

	Daily			Cumulative		
Date	Chum	Pink	Total	Chum	Pink	Total
6/18	548	0	548	548	0	548
6/19	410	0	410	958	0	958
6/20	410	0	410	1,368	0	1,368
6/21	468	0	468	1,836	0	1,836
6/22	960	0	960	2,796	0	2,796
6/23	1,059	0	1,059	3,855	0	3,855
6/24	1,092	0	1,092	4,946	0	4,946
6/25	1,150	0	1,150	6,096	0	6,096
6/26	3,052	0	3,052	9,148	0	9,148
6/27	6,254	0	6,254	15,402	0	15,402
6/28	9,585	0	9,585	24,987	0	24,987
6/29	10,851	881	11,732	35,838	881	36,719
6/30	5,554	0	5,554	41,392	881	42,273
7/1	11,869	619	12,488	53,260	1,500	54,761
7/2	7,072	824	7,896	60,332	2,325	62,657
7/3	9,616	900	10,516	69,948	3,225	73,173
7/4	11,541	1,209	12,750	81,488	4,434	85,923
7/5	19,153	3,307	22,460	100,641	7,742	108,383
7/6	30,731	8,030	38,760	131,372	15,771	147,143
7/7	30,173	12,931	43,104	161,545	28,702	190,247
7/8	26,934	10,047	36,981	188,478	38,749	227,228
7/9	26,062	7,360	33,421	214,540	46,109	260,649
7/10	11,290	6,484	17,774	225,830	52,593	278,423
7/11	9,524	16,720	26,244	235,354	69,313	304,667
7/12	13,581	21,601	35,182	248,935	90,915	339,849
7/13	9,254	20,490	29,744	258,189	111,404	369,593
7/14	8,909	34,351	43,260	267,098	145,755	412,853
7/15	9,066	37,912	46,978	276,164	183,667	459,831
7/16	11,234	45,606	56,840	287,398	229,273	516,671
7/17	11,318	56,782	68,100	298,716	286,055	584,771
7/18	11,658	63,416	75,074	310,374	349,472	659,845
7/19	13,335	68,901	82,236	323,708	418,372	742,081
7/20	12,022	57,426	69,448	335,730	475,799	811,529
7/21	8,366	46,094	54,460	344,096	521,893	865,989
7/22	8,333	49,821	58,154	352,430	571,713	924,143
7/23	8,847	55,199	64,046	361,277	626,912	988,189
7/24	7,162	49,206	56,368	368,439	676,117	1,044,556
7/25	4,683	32,489	37,172	373,122	708,607	1,081,728
7/26	1,807	26,230	28,037	374,929	734,837	1,109,766

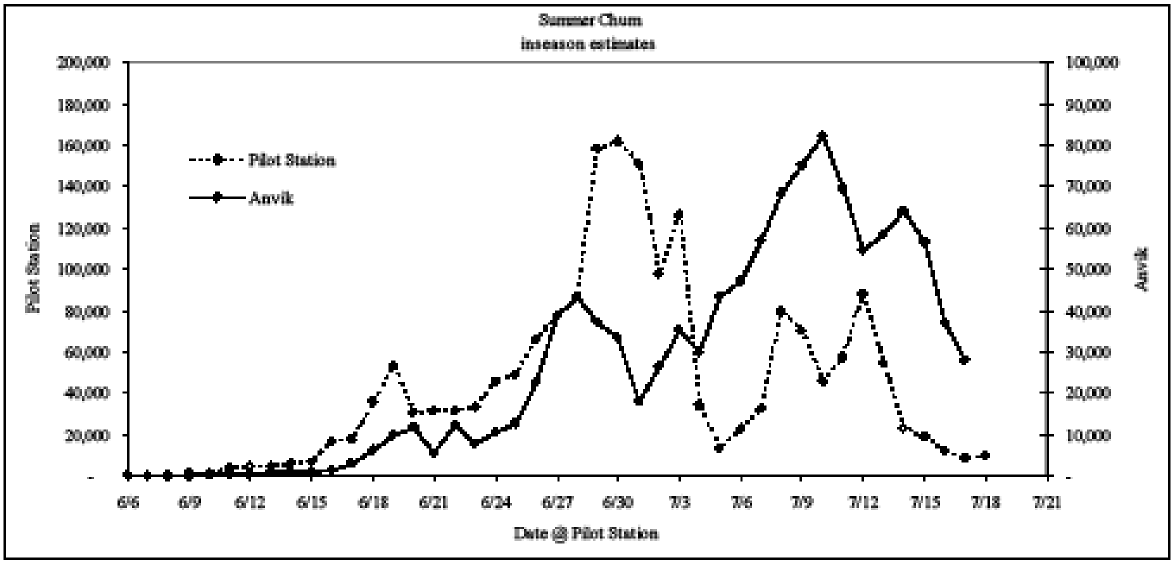


Figure 1 – Inseason daily estimates, prior to adjustments. Anvik sonar estimates are lagged 9 days.

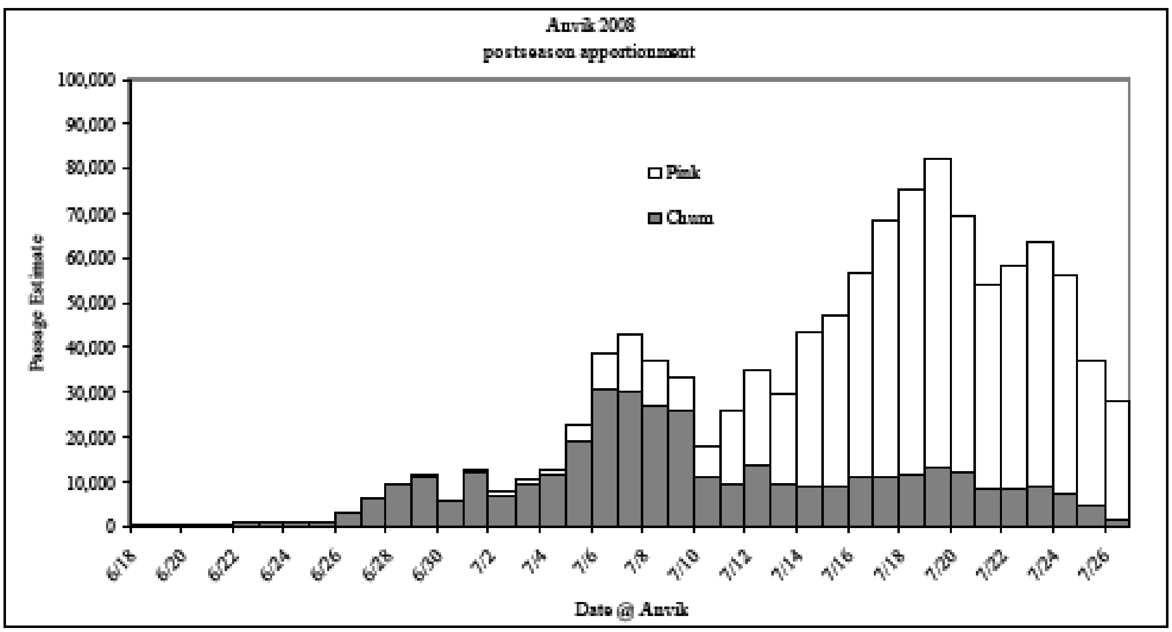
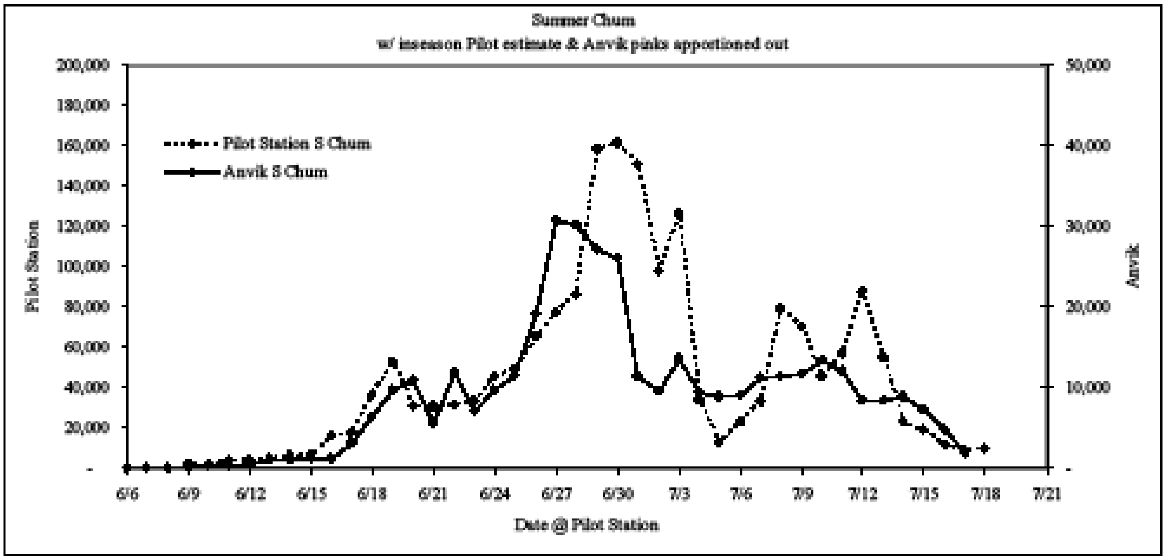


Figure 2 – Daily Anvik sonar estimates after postseason apportionment.



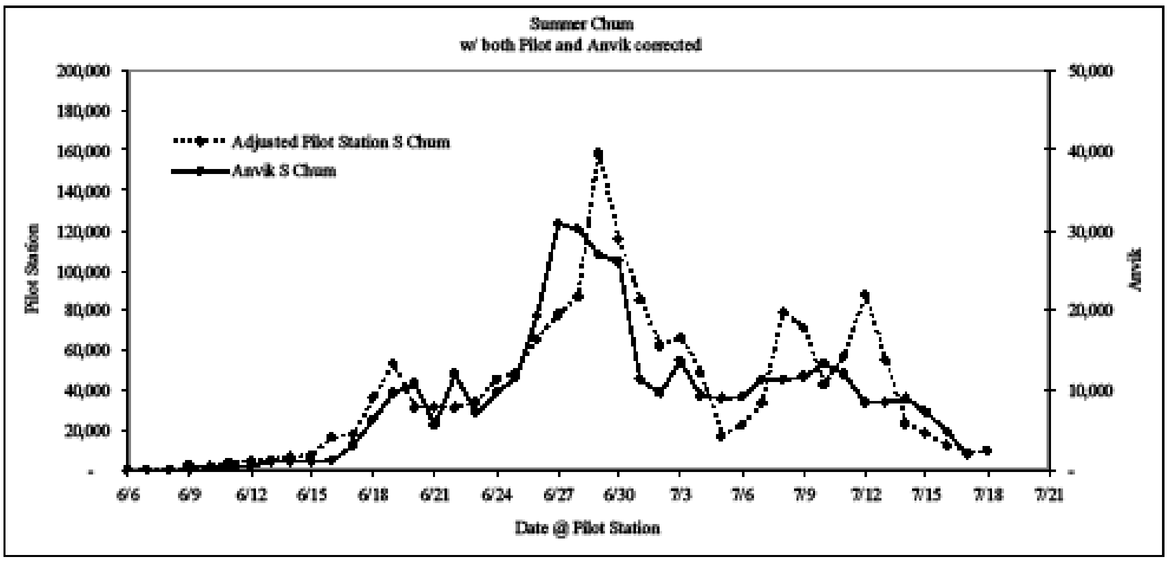
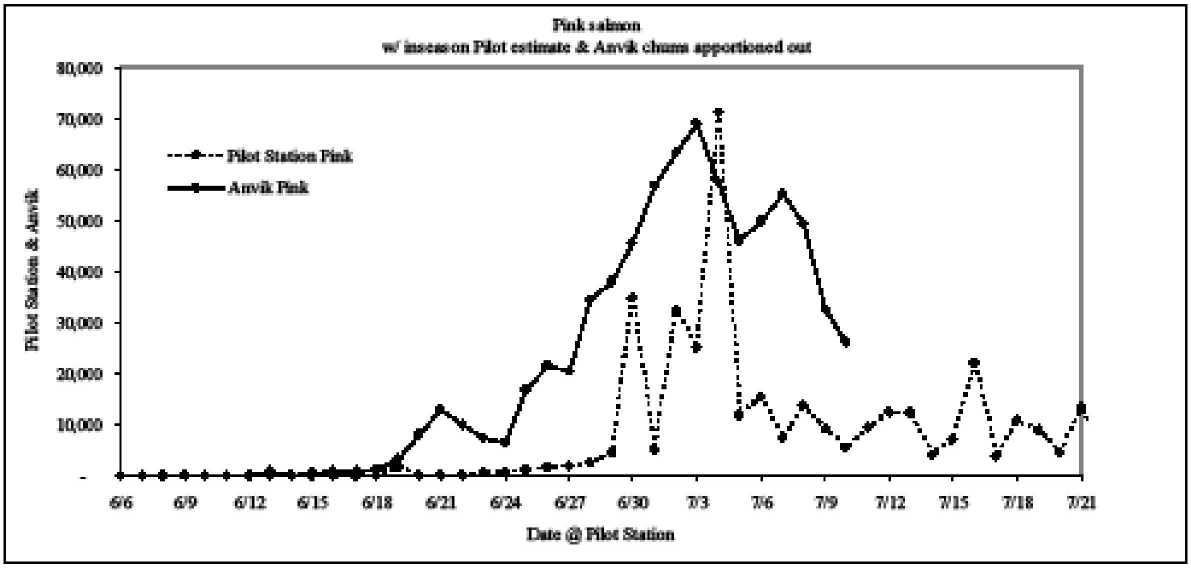


Figure 3 – Daily Anvik summer chum postseason estimates versus Pilot Station estimates, inseason and postseason. Anvik is lagged 9 days.



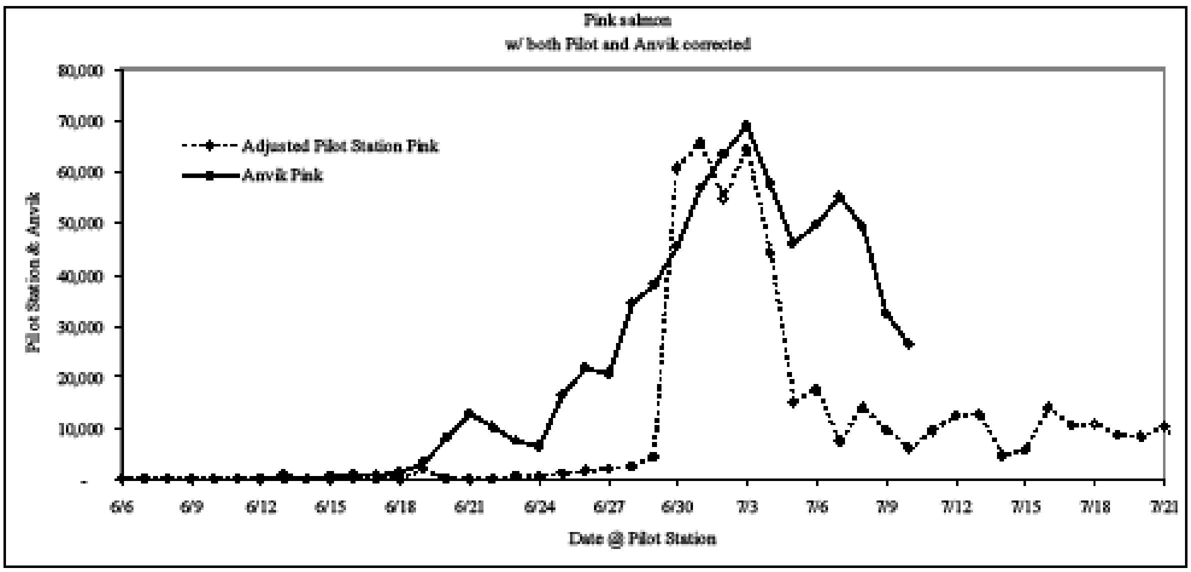


Figure 4 – Daily Anvik pink salmon postseason estimates versus Pilot Station estimates, inseason and postseason. Anvik is lagged 15 days.