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Anvik River Sonar Chum Salmon Escapement Study, 2005

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by

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August 2006

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 2005 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 sampled by a Hydroacoustic Technology Incorporated (HTI) split-beam sonar for 30 minutes of each hour, 24 hours a day, 7 days a week. The estimated summer chum salmon passage of 525,391 (SE 2,675) was 24% above the minimum escapement objective for the Anvik River Biological Escapement Goal of 400,000 to 800,000 chum salmon. Based on 1979–1985 and 1987–2004 mean quartile passage dates, timing of the 2005 chum salmon run was average. A chum salmon diurnal migration pattern was observed with the highest passage (43%) occurring during the darkest part of the day (2100–0500 hours). Females comprised 48% of the catch in beach seines. Age-0.3 fish comprised 96.4% of the chum salmon run in 2005 and, unlike past years, there were no age-0.2 chum salmon reported.

Key words: chum salmon, *Oncorhynchus keta*, pink salmon, *O. gorbuscha*, HTI sonar, 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 *O. tshawytscha* and pink *O. gorbuscha* salmon 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 allows Yukon River fishery managers to assess the strength of the Anvik River summer chum salmon run to meet the established Biological Escapement Goal (BEG) of 400,000 to 800,000. This information is important in the assessment of the strength of the summer chum salmon run on the Yukon River, upstream from the mouth of the Anvik River. 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) sonar

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

equipment. Dunbar and Pfisterer (*In Prep*) found that the comparison between Bendix and HTI produced similar abundance estimates. In 2004, the switch was made to HTI sonar equipment.

Project results for escapement studies using sonar technology on the Anvik River, from 1979 to 2004, have been reported by Mauney and Buklis (1980), Buklis (1981-1987), Sandone (1989-1990b, 1993-1996), Fair (1997), Chapell (2001), Moore and Lingnau (2002), Lingnau (2002), Dunbar (2003), and McEwen (2006).

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 through early 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 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 goals for the 2005 Anvik River summer chum salmon study were to estimate the timing and magnitude of adult chum salmon escapement and characterize age and sex composition. To accomplish these tasks, these specific objectives were identified:

1. Estimate timing and magnitude of chum salmon escapement using fixed-location, split-beam sonar in a side-looking configuration.
2. Estimate age and sex composition of the spawning population from sampled portions of the escapement using a beach seine as the capture technique.
3. Monitor selected climatological 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.

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 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). 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 (Figure 2) 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.

SONAR DEPLOYMENT AND OPERATION

Sonar systems operate by transmitting sound waves outward along the riverbed, from transducers located near the shore. Echoes from targets passing through the sonar beam are reflected back to the transducer and processed in the transceiver. Echoes, which satisfy criteria for amplitude and frequency, are considered valid and are counted as fish. Echo selection criteria are designed to estimate fish passage and minimize debris counts. Echoes are combined and the traces counted to estimate fish abundance. For the Anvik River sonar salmon counting project, all fish targets are considered salmon. Paired visual counts from a tower overlooking the sonar confirm that nearly all fish observed are salmon.

An HTI hydroacoustic system was operated at the Anvik River sonar site in 2005. The HTI system consists of an HTI model 241 digital echo sounder (Appendix A1) with a 2° by10° 200 kHz split-beam transducer on the right bank and a 2.8° by 10° 200 kHz split-beam transducer on the left bank. Attached to the transducers are HTI model 662H dual-axis rotators with an HTI model 660 remote controller to facilitate aiming. The system is capable of distinguishing upstream fish from downstream fish and debris, determining the fish velocity, discriminating between random reverberation and fish targets, and providing a less-biased estimate of target strength than dual or single beam systems (HTI 2000).

The HTI model 241 is a scientific echo sounder designed for fisheries research. Accurate time-varied gain (TVG) stable transmit and receive sensitivities are possible. Short pulse widths can be used to improve resolution between targets. A Digital Echo Processor (DEP) is integrated into the system and paired with a laptop computer to provide access to all the DEP settings. An oscilloscope can be linked to the sounder for diagnostic use, such as in-situ system calibration or transducer aiming. After all parameters are determined for data acquisition, the system operates 24 hours a day sampling each bank alternately for 30 minutes. Files are created by the DEP and edited to produce an estimate of fish passage.

Two HTI sonar systems, one on each riverbank, were operated in 2005. These sites were the same sonar sites used in 2004. The right bank transducer was deployed on a slight inside bend, where a gravel bar slopes gently toward the thalweg. The left bank transducer was deployed from a more steeply sloping cut-bank on the outside of the same bend.

The right bank HTI transducer and automatic rotators were mounted on an aluminum mount secured with sandbags. Aim adjustments were made using the remote control for the automatic rotators. The system operator used an artificial acoustic target (1.5-inch tungsten carbide sphere) during deployment to ensure transducer aim was low enough to prevent salmon from passing undetected beneath the acoustic beam. The target was held with monofilament line from a pole along the river bottom and in the acoustic beams at multiple locations to ensure that the full counting range of the transducer was covered. When properly aimed, the target appeared as a trace on the echogram or vertical deflection (spike) on an oscilloscope screen as it transected the acoustic beam at a given distance. The left bank transducer was deployed in similar fashion as the right bank, but with the transducer and rotator cables running under the water to the right bank, where the sounder for both transducers was located in a tent.

SONAR CALIBRATION AND PASSAGE ESTIMATION

At the end of each day, data collected by the DEP in 24 thirty-minute text files for each bank were transferred to another computer for tracking and editing. To facilitate tracking, echoes from stationary objects were removed using a custom program created in *Java* computer language (Dunbar *In Prep*). The tracked data were manually edited to remove any spurious tracks such as those from any remaining bottom using *Polaris,* an echogram editor developed by Mr. Peter Withler through a cooperative agreement with the Department of Fisheries and Oceans Canada (DFO), ADF&G and HTI. The edited data were saved to a *Microsoft Excel* spreadsheet where each 30-minute file representing a sample was multiplied by 2 to account for a full hour. Linear interpolation was used when complete 30-minute periods of data were missing. If data from a complete 30 minutes were missing, counts were interpolated by averaging counts from 2 hours before and 2 hours after the missing period. If two complete 30-minute sample periods were missing, counts were interpolated by averaging counts from 3 hours before and 3 hours after the missing periods. If three 30-minute sample periods were missing, counts were interpolated by averaging counts from 4 hours before and 4 hours after the missing periods. If four or more 30-minute sample periods were missing, counts were interpolated by averaging counts from 5 hours before and 5 hours after the missing the hour. When a portion of a 30-minute sample was missing, passage was estimated by expansion based on the known fraction of the 30 minutes sampled. Thirty minutes was divided by the known number of minutes counted (if 10 minutes or more) and then multiplied by the number of fish counted in that period.

Echoes from stationary objects were removed before tracking by dividing data into range bins (0.2 meters), calculating the moving average (averaging window of 1,000 echoes) of the voltage in each range bin, and then removing the echo if the voltage was within 1.7 standard deviations of the mean and at least 100 echoes were within that range bin. The echo was not removed if the percentage of missed echoes relative to observed echoes was greater than 80. The percentage of missed relative to observed echoes was calculated by summing differences between observed ping numbers minus one and then dividing by the total number of echoes in the range bin.

After the data were cleaned up with the bottom removal program, the echoes were grouped into fish tracks that could be enumerated to produce an estimate of fish passage. Three times a day a technician would manually track fish traces to determine distribution.

Final editing was accomplished with *Polaris*. After all editing was complete, the data were imported to an *Excel* spreadsheet where the final estimate of hourly and daily fish passage was produced. Since the HTI estimates were produced from 30-minute samples, a variance estimate was calculated. The daily passage for bank z on day d was calculated by summing the hourly passage rates for each hour as follows:

$$\hat{y}_{dz} = \sum_{p=1}^{24} \frac{y_{dzp}}{h_{dzp}} \tag{1}$$

where h_{dzp} is the fraction of the hour sampled on day d, bank z, period p and y_{dzp} is the count for period p on bank z of day d.

The variance for the passage estimate for bank z on day d is estimated as:

$$\hat{V}_{y_{dz}} = 24^2 \frac{1-f_{dz}}{n_{dz}} \frac{\sum_{p=2}^{n_{dz}} \left(\frac{y_{dzp}}{h_{dzp}} - \frac{y_{dz,p-1}}{h_{dz,p-1}} \right)^2}{2(n_{dz}-1)} \tag{2}$$

where n_{dz} is the number of samples in the day (24) and f_{dz} is the fraction of the day sampled (12/24=0.5). y_{dzp} is the hourly count for day d on bank z for sample p.

Since the passage estimates are assumed independent between zones and among days, the total variance is estimated as the sum of the variances.

$$\hat{V}ar(\hat{y}) = \sum_{d}\sum_{z} \hat{V}ar(\hat{y}_{dz}) \tag{3}$$

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. These quartile-sampling strata were determined postseason based on 2005 run timing data. They represent an attempt to sample the escapement for age, sex, and length (ASL) information in relative proportion to the total run. In 2005, these strata were defined as: Pre June 30, July 1–7, July 8–13, and July 14 until end of the season.

To meet region wide standards for the sample size needed to describe a salmon population, the initial seasonal ASL sample goal was 608 chum salmon, with a minimum of 162 chum salmon samples collected during each temporal stratum (Bromaghin 1993). Sample size goals are based on accuracy (d) and precision (α) objectives of $d = 0.10$ and $\alpha = 0.05$, assuming two major age classes, and two 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 mideye to tail fork, and 1 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 3 scale samples were taken from each fish.

CLIMATOLOGICAL AND HYDROLOGIC SAMPLING

Climatological 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 was measured in degrees Celsius (C) near shore at a depth of approximately 50 cm. 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

The right bank sonar was up and running on June 26 and the left bank sonar was operational on June 26. Both transducers collected data through July 26. The 2005 summer chum salmon passage estimate is 525,391 (SE 2,675) (Table 1). This includes estimates for missing sector/hourly counts and expansions for missing data, for right bank passage on June 26, 27 and July 17, 23, and left bank passage on June 27 and July 22, 23, 24, 26. No pink salmon were observed while conducting visual counts in 2005; therefore, all counts were attributed to summer chum salmon.

Summer chum salmon passage dates were slightly later than historic run timing, based on 1979–1985 and 1987–2004 runs (Table 2). The summer chum passage quartiles were close to the historic mean dates. The central half of the run passed between July 4 and July 15 (Table 2); 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 14,602 (July 12) to 32,695 (July 15) with an estimated 300,450 fish passed by the sonar site during this time (Table 1). The peak passage day of 37,487 summer chum occurred on July 16 (Table 1). The summer chum salmon run was composed primarily of age-0.3 and -0.4 fish at 99.4% (Table 3; Figure 5), with age-0.3 chum salmon dominating the samples collected this season (96.4%).

The 2005 pink salmon run was very weak. This was expected for pink salmon in odd years. The low numbers of returning pink salmon were not deducted from the sonar counts because visual observations indicated the pink salmon return was so weak that their numbers were negligible (Table 1). The 2005 chum salmon escapement estimate of 525,391 was 81% of the mean Anvik River escapement estimate of 648,416 fish, based on 1979–2004 data (Table 2). This year's escapement fell within the BEG of 400,000 to 800,000 summer chum salmon, and was the highest in the past 8 years.

SPATIAL AND TEMPORAL DISTRIBUTION

There was a distinct diurnal pattern to the passage in 2005 with 41% of the counts recorded between the hours of 2100 and 0500 (Figure 3). Spatially, 82.5% of the chum salmon were detected by the right bank sonar (Figure 4).

AGE AND SEX COMPOSITION

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). From June 28 to July 14, a total of 9 days of sampling was conducted for ASL. The 2005 run did not follow the usual trend. Age-0.3 chum salmon dominated the entire run and there were more males then females overall. The age-0.3 chum salmon accounted for 96.4% of the entire run, ranging between 87.8% and 98.7% during the run. Age-0.4 chum salmon arrived during the first half of the run, comprising 9.5% in the first strata and 3.3% in the second strata, but then dropped off during the second half of the run and only accounted for 3% of the entire passage. There were no age-0.2 chum salmon in the age and sex composition. There were slightly more males than females throughout the run, except during the third strata when there was a greater number of females; overall 48% of the run was females (Table 3).

HYDROLOGIC AND CLIMATOLOGICAL CONDITIONS

The summer of 2005 saw warm temperatures and dry conditions on the Anvik River. The water level decreased steadily throughout the summer (Figure 6). It rained intermittently during the season which created a slight rise in the water level near the end of the season. The minimum air temperature was 2°C (June 30) and a maximum high of 30°C (July 3) with an average high and low of 21°C and 9°C (Figure 7). The water temperature averaged 15°C with a maximum high of 19°C (July 3 and 22) and a minimum of 12°C (July 11).

DISCUSSION

ESCAPEMENT ESTIMATION

The 2005 Anvik River summer chum salmon escapement estimate of 525,391 was 19% below the 1979–2004 average escapement of 648,416 and 44% above last years escapement. This is the first year since 2002 that the summer chum salmon abundance has been within the BEG. Although the exact reason for the low salmon runs in recent years is unknown, scientist speculate poor marine survival results from, or accentuated by, localized weather conditions in the Bering Sea (Kruse 1998).

This year's strong run of age-0.3 chum salmon, at 506,717 fish, is a continuation from last year of the relatively strong 2001 year class when 11,691 chum salmon returned as age-0.2 fish. Interestingly, there were no age-0.2 fish in the chum salmon sampled in 2005. This lack of age-0.2 fish is not unique and from 1979 to 2004 there have been 5 years when there has been no age-0.2 chum salmon represented in the samples: 1981, 1991, 1994, 1998 and 1999 (Figure 8). The following year when these chum salmon came back as age 0.3, they made up an average of 51.6% of the entire run with the following breakdown: 1982-67%, 1992-26.5%, 1995-53.3%, 1999-37.4%, and 2000-73.8%. Overall at this project, it does not appear that the percentage of age-0.2 fish is a good predictor of the expected age-0.3 return.

The predominant age classes of age-0.3 and age-0.4 salmon accounted for 99.4% of the chum salmon sampled in 2005. In comparison to historical mean values from 1972–2004, the age-0.3 proportion of the 2005 run was 39.2% higher and the age-0.4 proportion was 36.1% lower, which represented an average age of 4.0, which is below the long-term average of age of 4.4 (Figure 9). The exceptionally high percentage of age-0.3 chum salmon is the highest since the inception of the project in 1979 (Figure 8) and should result in a strong return of age-0.4 fish in 2006.

SPATIAL AND TEMPORAL DISTRIBUTION

In 2005, chum salmon spatial migration followed historical trends with 82.5% passing on the right bank. Prior to 2005, 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 1994a; 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, the water level in 2005 appeared to be similar to the last 4 years, subjectively.

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 (Figure 3). Similar diurnal patterns were reported from 1985 through 2004. Temporal distribution of sonar estimates in 2005 indicates a distinct diurnal pattern (Figure 3). The chum salmon could be migrating in greater numbers at night due to the fact that the water is cooler and to escape predation from various birds and mammals.

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TABLES AND FIGURES

Table 1.–Summer chum and pink salmon daily and cumulative counts by bank and total, Anvik River sonar, 2005.

	Daily						Cumulative					
	Right Bank		Left Bank		Total		Right Bank		Left Bank		Total	
Date	**Chum**	**Pink**	**Chum**	**Pink**	**Chum**	**Pink**	**Chum**	**Pink**	**Chum**	**Pink**	**Chum**	**Pink**
6/26	3,743	0	510	0	4,253	0	3,743	0	510	0	4,253	0
6/27	5,740	0	228	0	5,968	0	9,483	0	738	0	10,221	0
6/28	7,078	0	706	0	7,784	0	16,561	0	1,444	0	18,005	0
6/29	10,388	0	726	0	11,114	0	26,949	0	2,170	0	29,118	0
6/30	9,470	0	559	0	10,029	0	36,419	0	2,728	0	39,147	0
7/01	10,396	0	680	0	11,076	0	46,815	0	3,409	0	50,223	0
7/02	18,921	0	1,932	0	20,853	0	65,736	0	5,341	0	71,077	0
7/03	22,747	0	3,633	0	26,380	0	88,484	0	8,973	0	97,457	0
7/04	21,932	0	4,256	0	26,188	0	110,415	0	13,229	0	123,645	0
7/05	23,138	0	3,708	0	26,846	0	133,553	0	16,937	0	150,491	0
7/06	20,396	0	2,520	0	22,916	0	153,949	0	19,457	0	173,406	0
7/07	20,120	0	2,016	0	22,136	0	174,069	0	21,473	0	195,543	0
7/08	16,922	0	1,060	0	17,982	0	190,992	0	22,533	0	213,525	0
7/09	24,159	0	2,635	0	26,794	0	215,151	0	25,168	0	240,319	0
7/10	19,872	0	3,111	0	22,983	0	235,022	0	28,280	0	263,302	0
7/11	23,405	0	3,174	0	26,579	0	258,427	0	31,454	0	289,881	0
7/12	12,848	0	1,754	0	14,602	0	271,274	0	33,208	0	304,482	0
7/13	23,872	0	4,979	0	28,851	0	295,146	0	38,187	0	333,333	0
7/14	26,529	0	5,350	0	31,879	0	321,676	0	43,537	0	365,212	0
7/15	26,427	0	6,268	0	32,695	0	348,103	0	49,804	0	397,907	0
7/16	24,669	0	12,818	0	37,487	0	372,772	0	62,622	0	435,394	0
7/17	18,742	0	5,019	0	23,761	0	391,514	0	67,641	0	459,155	0
7/18	8,518	0	3,193	0	11,711	0	400,032	0	70,834	0	470,866	0
7/19	6,441	0	2,190	0	8,631	0	406,473	0	73,024	0	479,497	0
7/20	6,052	0	2,058	0	8,110	0	412,525	0	75,082	0	487,607	0
7/21	5,288	0	3,286	0	8,574	0	417,813	0	78,368	0	496,181	0
7/22	5,534	0	4,372	0	9,906	0	423,347	0	82,740	0	506,087	0
7/23	4,940	0	3,596	0	8,536	0	428,287	0	86,336	0	514,623	0
7/24	2,224	0	2,464	0	4,687	0	430,511	0	88,799	0	519,310	0
7/25	1,856	0	1,724	0	3,581	0	432,367	0	90,524	0	522,891	0
7/26	1,309	0	1,191	0	2,500	0	433,676	0	91,715	0	525,391	0

Note: The large box indicates the central 50% of the run (second and third quartiles). The small box indicates the median passage date (mean quartile).

Table 2.–Annual passage estimates and associated passage timing statistics for summer chum salmon runs, Anvik River sonar, 1979–2005.

Year	Sonar Passage Estimate	Day of First Salmon Counts	First Quartile Day	Median Day	Third Quartile Day	First Count & First Quartile	Days Between Quartiles First & Median	Median & Third	First & Third
1979	277,712	6/23	7/02	7/08	7/12	9	6	4	10
1980	482,181	6/28	7/06	7/11	7/16	8	5	5	10
1981	1,479,582	6/20	6/27	7/02	7/07	7	5	5	10
1982	444,581	6/25	7/07	7/11	7/14	12	4	3	7
1983	362,912	6/21	6/30	7/07	7/12	9	7	5	12
1984	891,028	6/22	7/05	7/09	7/13	13	4	4	8
1985	1,080,243	7/05	7/10	7/13	7/16	5	3	3	6
1986	1,085,750	6/21	6/29	7/02	7/06	8	3	4	7
1987	455,876	6/21	7/05	7/12	7/16	14	7	4	11
1988	1,125,449	6/21	6/30	7/03	7/09	9	3	6	9
1989	636,906	6/20	7/01	7/07	7/13	11	6	6	12
1990	403,627	6/22	7/02	7/07	7/15	10	5	8	13
1991	847,772	6/21	7/01	7/10	7/16	10	9	6	15
1992	775,626	6/29	7/05	7/08	7/12	6	3	4	7
1993	517,409	6/19	7/05	7/12	7/18	16	7	6	13
1994	1,124,689	6/19	7/01	7/07	7/11	12	6	4	10
1995	1,339,418	6/19	7/01	7/06	7/11	12	5	5	10
1996	933,240	6/18	6/25	7/01	7/06	7	6	5	11
1997	605,752	6/19	6/28	7/03	7/10	9	5	7	12
1998	487,301	6/22	7/05	7/10	7/14	13	5	4	9
1999	437,356	6/27	7/06	7/10	7/16	9	4	6	10
2000	196,349	6/21	7/08	7/11	7/13	17	3	2	5
2001	224,058	6/26	7/06	7/10	7/15	10	4	5	9
2002	459,058	6/22	7/03	7/07	7/12	11	4	5	9
2003	256,920	6/21	7/05	7/10	7/15	14	5	5	10
2004	365,353	6/22	6/29	7/05	7/09	7	6	4	10
2005	525,391	6/26	7/04	7/10	7/15	8	6	5	11
Average	**648,416**	**6/22**	**7/02**	**7/08**	**7/12**	**10.4**	**5.1**	**4.8**	**9.9**
Median	**487,301**	**6/21**	**7/03**	**7/08**	**7/13**	**10.0**	**5.0**	**5.0**	**10.0**
SD	**361,336**		**3.64**	**3.28**	**3.04**	**3.0**	**1.5**	**1.3**	**2.3**

Note: The mean and standard deviation of the timing statistics includes estimates from years 1979–1985 and 1987–2003. 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 3.–Age and sex composition of chum salmon, Anvik River sonar, 2005.

			Age											
			(0.2)		(0.3)		(0.4)		(0.5)		(0.6)		Total	
2005 Sample Date (Strata)	Sample Size		Esc. Estimate	No. Sample	Esc. Estimate	No. Sample	Esc. Estimate	No. Sample	Esc. Estimate	No. Sample	Esc. Estimate	No. Sample	Esc. Estimate	%
6/28-30	147	Males	0	0	35,297	73	3,868	8	1,451	3	0	0	40,615	57
6/26-7/2		Females	0	0	27,077	56	2,901	6	484	1	0	0	30,462	43
		Subtotal	0	0	62,374	129	6,769	14	1,934	4	0	0	71,077	100
7/4, 6	150	Males	0	0	66,382	80	4,149	5	0	0	0	0	70,531	57
7/3-7/7		Females	0	0	53,935	65	0	0	0	0	0	0	53,935	43
		Subtotal	0	0	120,317	145	4,149	5	0	0	0	0	124,466	100
7/9-11	152	Males	0	0	46,586	65	717	1	717	1	0	0	48,019	44
7/8-7/12		Females	0	0	60,920	85	0	0	0	0	0	0	60,920	56
		Subtotal	0	0	107,506	150	717	1	717	1	0	0	108,939	100
7/14	151	Males	0	0	111,186	76	2,926	2	0	0	0	0	114,112	52
7/13-7/26		Females	0	0	105,335	72	1,463	1	0	0	0	0	106,798	48
		Subtotal	0	0	216,521	148	4,389	3	0	0	0	0	220,910	100
Season Total	600	Males	0	0	259,451	294	11,660	16	2,167	4	0	0	273,278	52
		Females	0	0	247,267	278	4,364	7	484	1	0	0	252,114	48
		Total	0	0	506,717	572	16,024	23	2,651	5	0	0	525,392	100

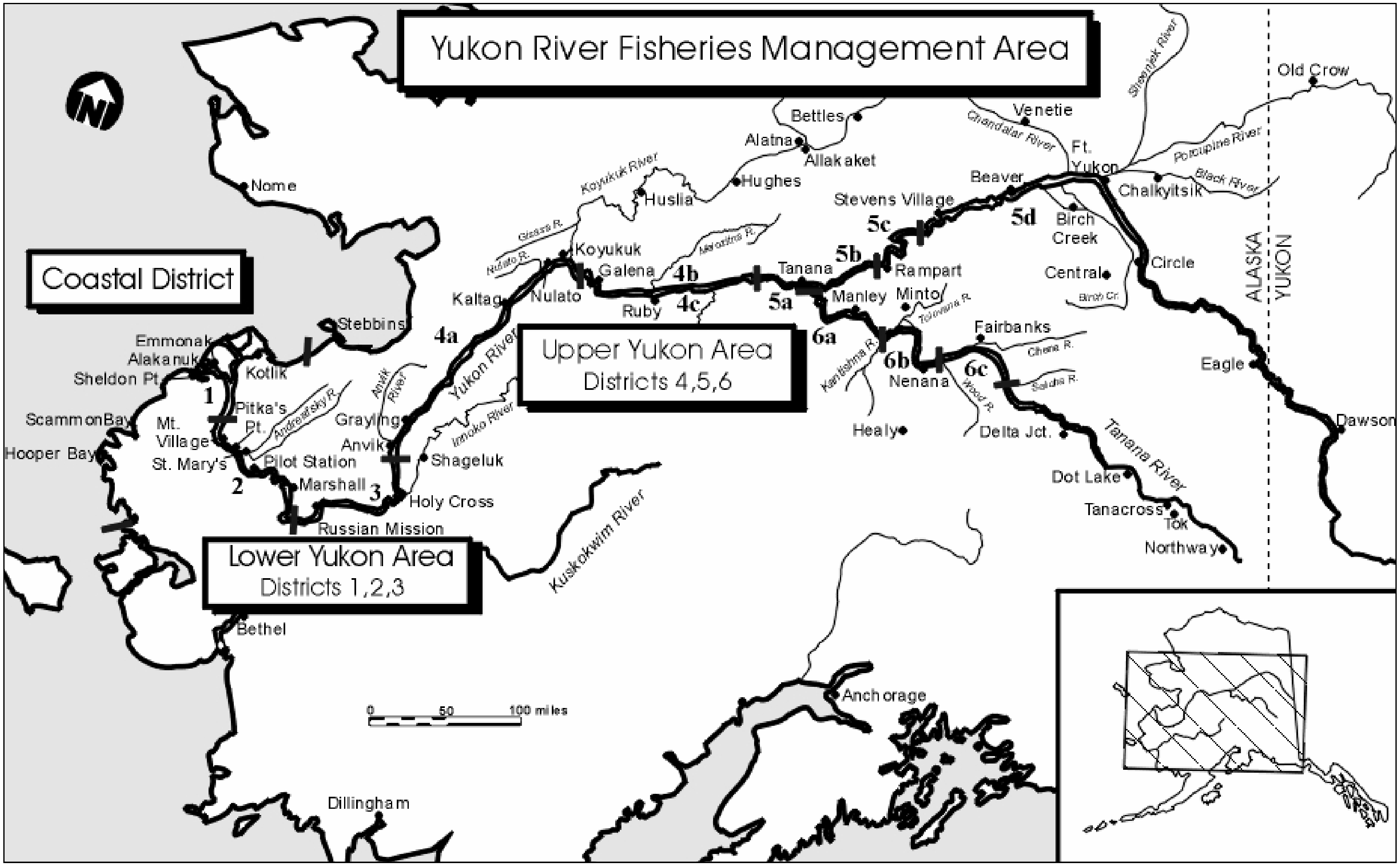


Figure 1.–Alaska portion of the Yukon River drainage showing communities and fishing districts.

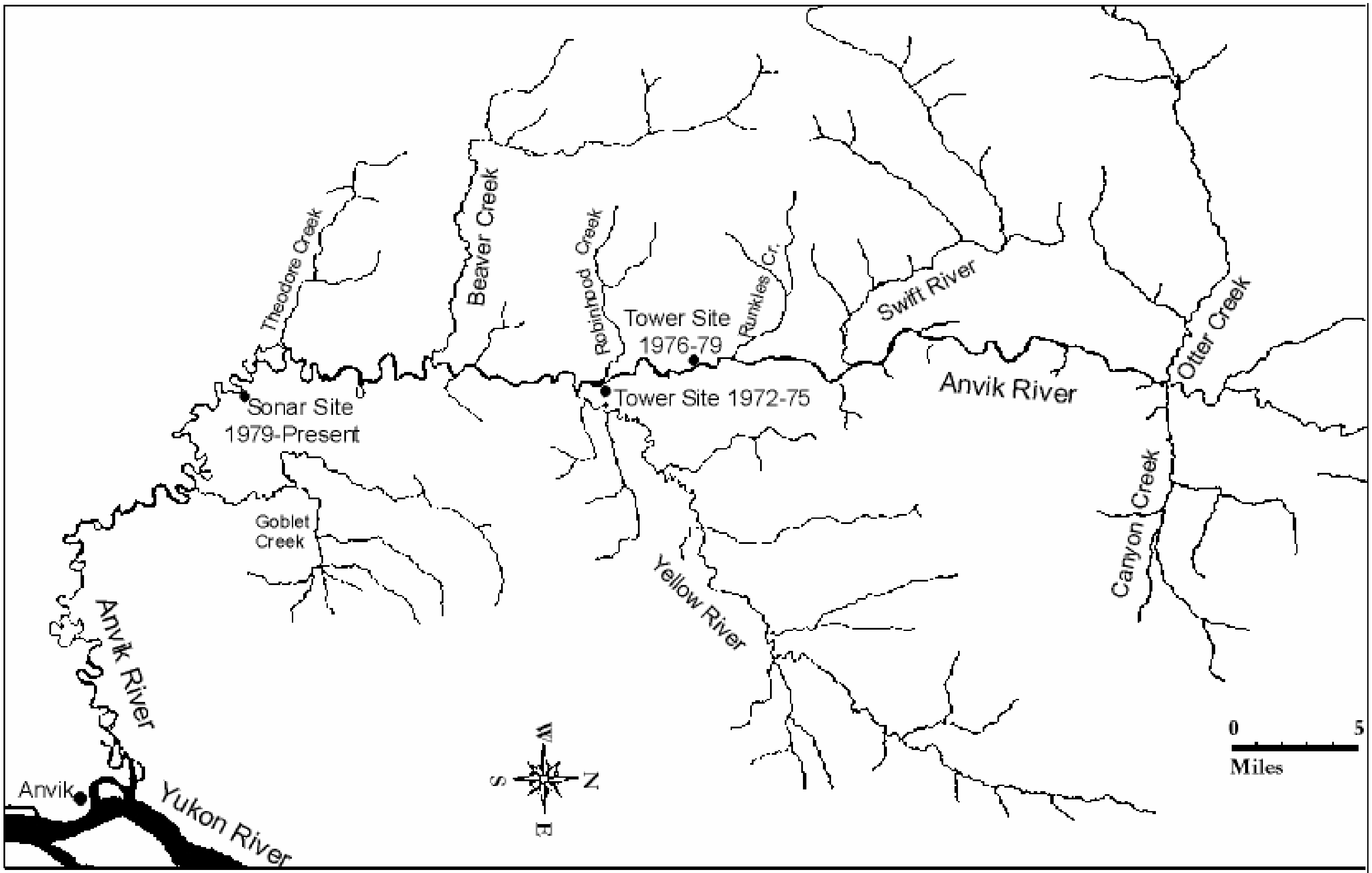


Figure 2.–Anvik River drainage with historical chum salmon escapement project locations.

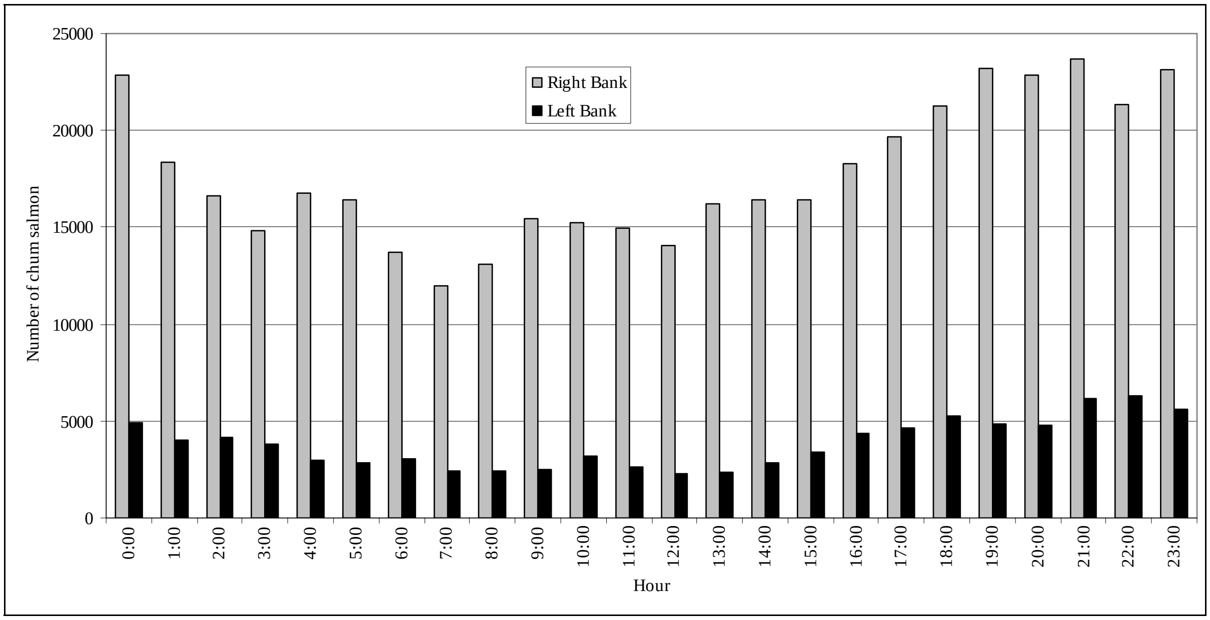


Figure 3.–Estimated passage of chum salmon by hour for each bank, Anvik River sonar, 2005.

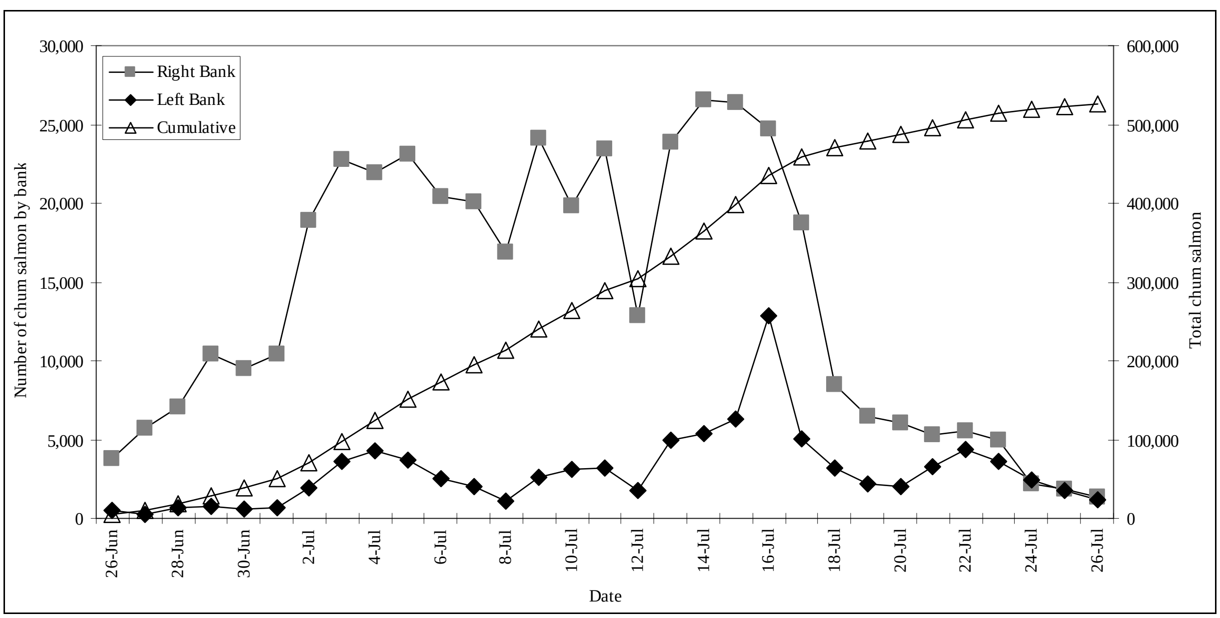


Figure 4.–Chum salmon daily and cumulative counts, Anvik River sonar, 2005.

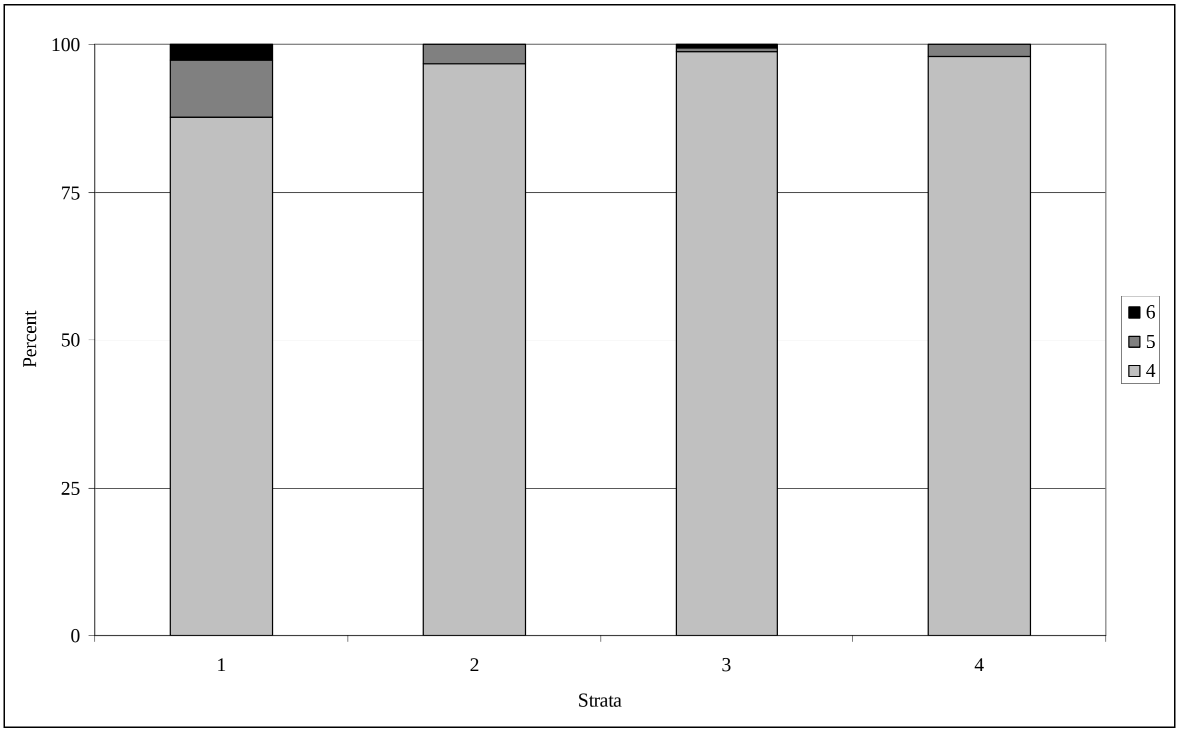


Figure 5.–Chum salmon age composition, Anvik River sonar, 2005.

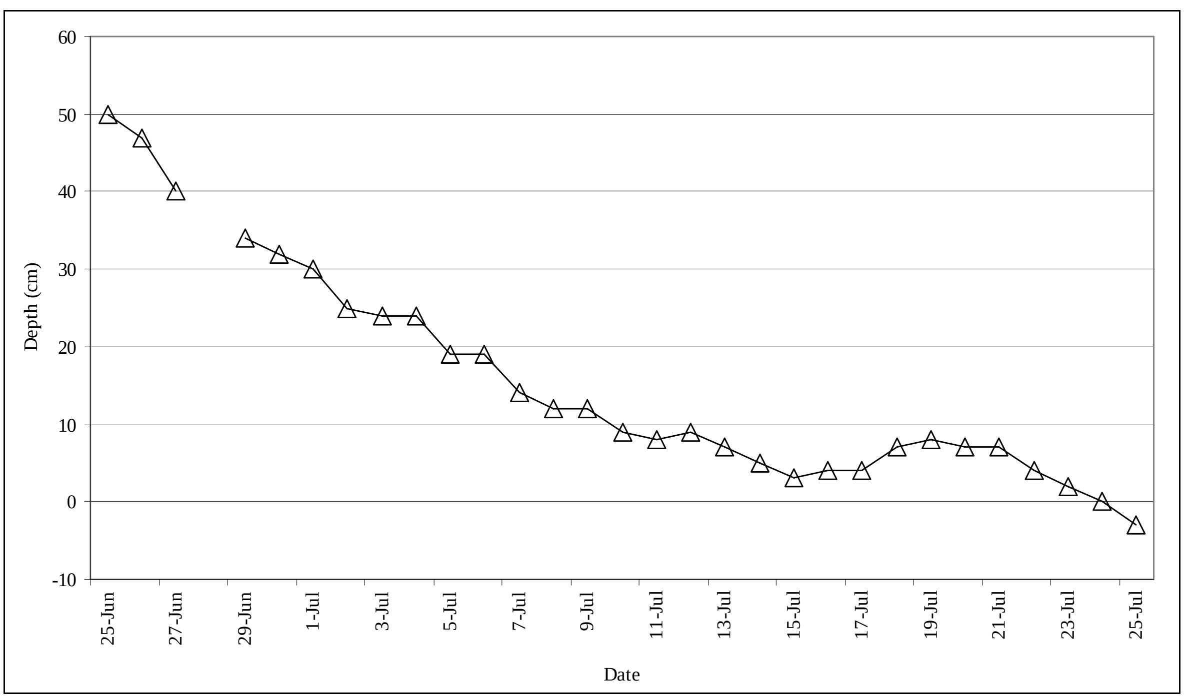


Figure 6.–Water depth at Anvik River sonar, 2005.

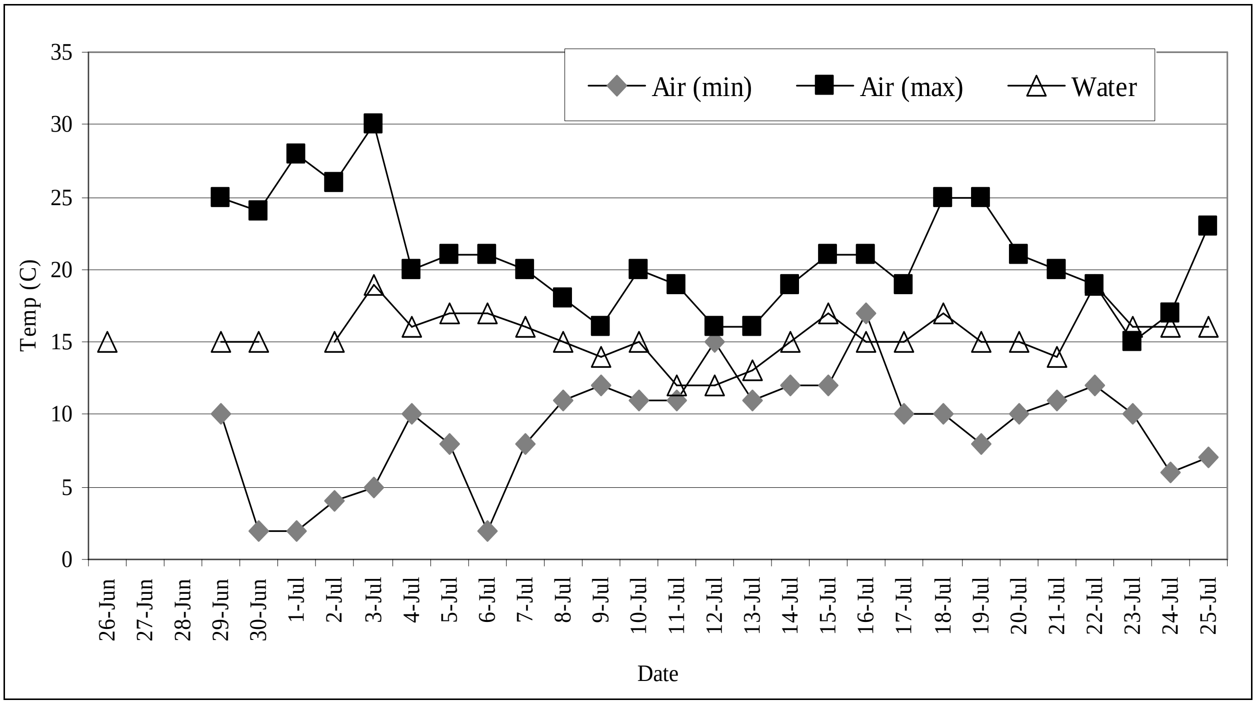


Figure 7.–Hydrological and climatological observations, Anvik River sonar, 2005.

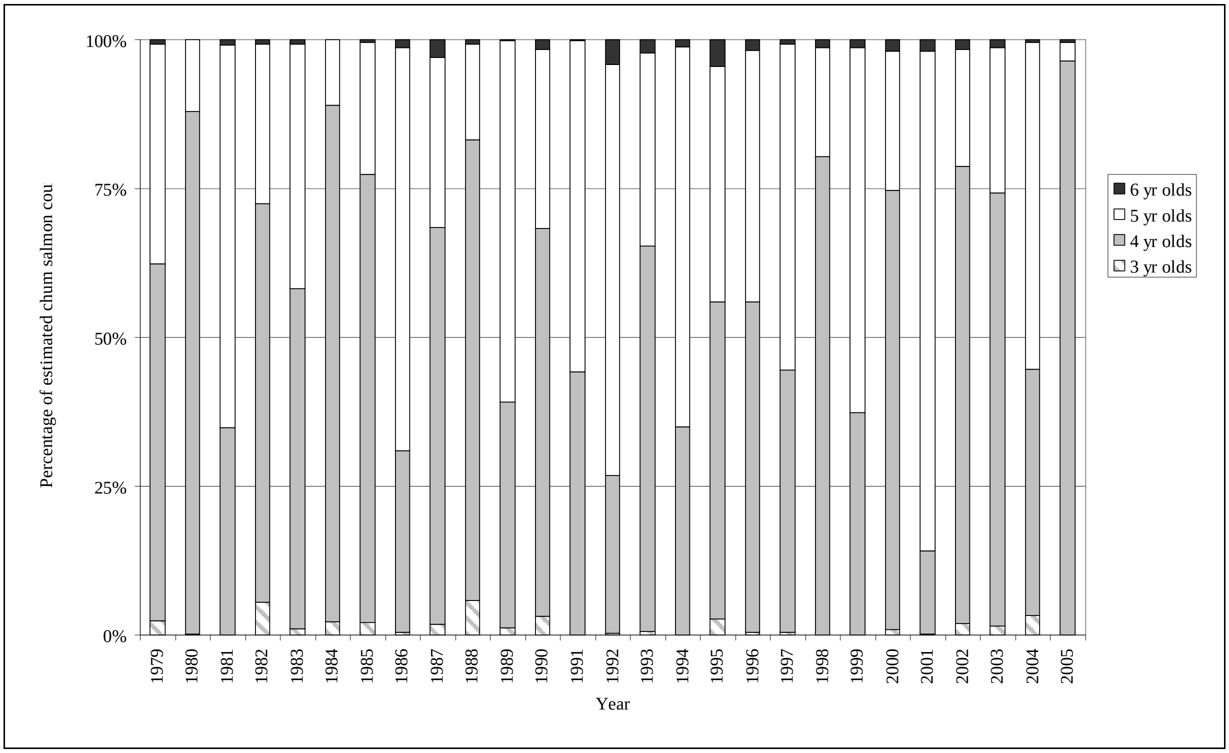
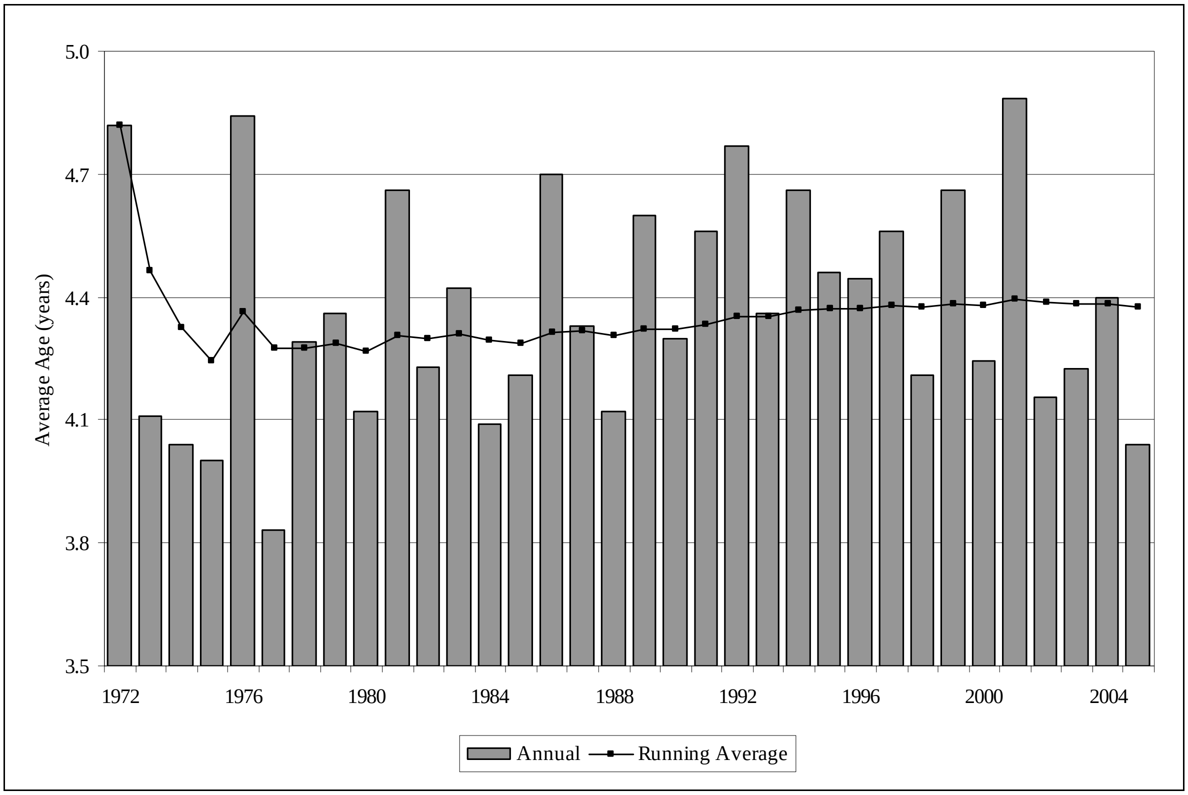


Figure 8.–Percentage of chum salmon by age since 1979, Anvik River sonar.



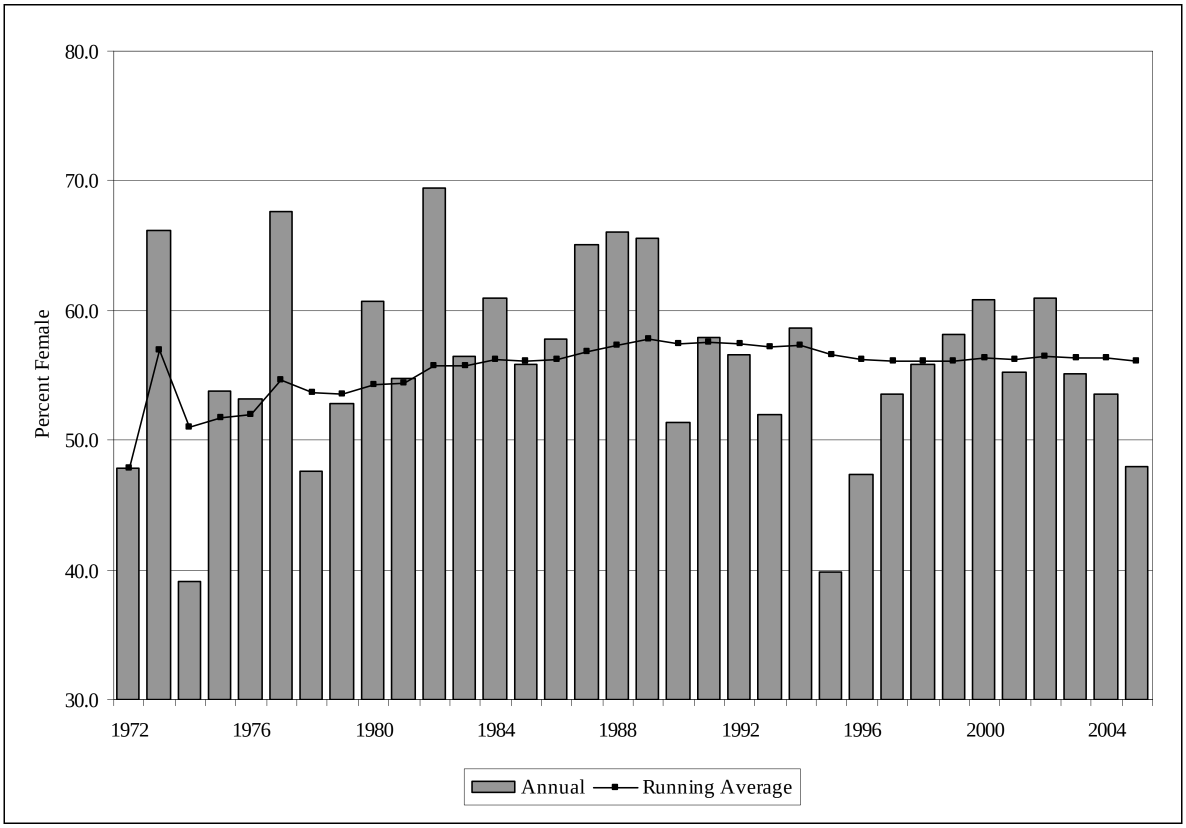


Figure 9.–Annual age at maturity (top) and percentage of females (bottom) of the Anvik River chum salmon escapement, 1972–2005.

APPENDIX A.

Appendix A1.–Technical specifications for the HTI Model 241 Portable Split-Beam Digital Echo Sounder.

Size:	10 inches wide x 4.3 high x 17 long, without PC or transducer (254 mm wide x 109 high x 432 long).
Weight:	20 lb. (9 kg) without PC or transducer.
Power Supply:	Nominal 12 VDC standard (120 VAC and 240 VAC optional).
Operating Temperature:	5-50°C (41-122°F).
Power Consumption:	30 watts (120 - 200 kHz), without laptop PC.
Frequency:	200 kHz standard (120 kHz and 420 kHz optional).
Transmit Power:	100 watts standard for 120-200 kHz. 50 watts standard for 420 kHz.
Dynamic Range:	140 dB
Transmitter:	Output power is adjustable in four steps over a 20 dBw range (+2, +8, +14, and 20 dBw).
Pulse Length:	Selectable from 0.1 ms to 1.0 ms in 0.1 ms steps.
Bandwidth:	Receiver bandwidth is automatically adjusted to optimize performance for the selected pulse length.
Receiver Gain:	Overall receiver gain is adjustable in five steps over a 40 dB range (-16, -8, 0, +8, +16 dB).
TVG Functions:	Simultaneous 20 and 40 log(R)+2αr TVG. Spreading loss and alpha are programmable to nearest 0.1 dB. Total TVG range is 80 dB. TVG start is selectable in 1m increments. The minimum TVG start is 1.0 m to maximum of 200 m
Receiver Blanking:	Start and stop range blanking is selectable in 1m steps.
Undetected Output:	12 kHz, for each formed beam
Detected Output:	10 volts peak
System Synchronization:	Internal or external trigger
Ping Rate:	0.5-40.0 pings/sec
Phase Calculation:	Quadrature demodulation
Angular Resolution:	+/- <0.1° (6° beam width, 200 kHz)
Tape recording:	With Split-Beam Data Tape Interface and optional Digital Audio Tape (DAT) recorder, directly records the digitized split-beam data, permitting complete reconstruction of the raw data output.
Calibrator:	source. Pulse and CW calibration functions provided in step settings.
Positioning:	GPS positioning information (NMEA 0183 format) via serial port of computer

Source: Model 241 operator’s manual.