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Estimation of Abundance and Distribution of Chum Salmon in the Unalakleet River Drainage, 2004

by

Jeffrey L. Estensen,

Gary L. Todd,

and

Carlos S. Monsivais

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

Symbols and Abbreviations

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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

FISHERY DATA SERIES NO. 05-52

ESTIMATION OF ABUNDANCE AND DISTRIBUTION OF CHUM SALMON IN THE UNALAKLEET RIVER DRAINAGE, 2004

By
Jeffrey L. Estensen, Gary L. Todd,
Division of Commercial Fisheries, Nome
and
Carlos S. Monsivais
Division of Commercial Fisheries, Anchorage

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1599

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Jeffrey L. Estensen, Gary L. Todd,
Alaska Department of Fish and Game, Division of Commercial Fisheries,
P.O. Box 1148, Nome, AK 99762 USA
and
Carlos S. Monsivais
Alaska Department of Fish and Game, Division of Commercial Fisheries,
333 Raspberry Road, Anchorage, AK 99518 USA

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ABSTRACT

This project employed radiotelemetry and mark–recapture methodologies to determine what proportion of chum salmon *Oncorhynchus keta* entering the Unalakleet River drainage migrate into the North River and to estimate total drainage abundance. In addition, stock composition, run timing, migration characteristics, and spawning distribution of chum salmon in the Unalakleet River drainage were examined. A potential weir site on the Unalakleet River was also evaluated. Radio tags were placed externally on chum salmon caught in the lower reach of the Unalakleet River. Stationary receiver tracking stations (SRS) were placed at selected sites to monitor upriver movement of tagged fish. Spawning destinations of tagged fish were determined by information obtained from SRS and aerial radiotracking flights. Chum salmon were sampled for age, sex, and length (ASL) determination.

A total of 144 radiotagged fish were used to determine proportion, abundance, and distribution. Of the 144 radiotagged fish, 19 passed the North River counting tower for a proportion of 0.13. Using Chapman's modification of Petersen's model, drainage wide abundance of chum salmon was estimated to be 70,262 fish ± 27,889. Of 144 radiotagged fish, 122 migrated into the Unalakleet River above the confluence with North River. Of these, 65 had spawning locations above the proposed weir site for a proportion of 0.54. Results indicated that the migration timing of chum salmon throughout the drainage was highly variable and no clear patterns were evident.

The majority of chum salmon sampled for ASL determination were male (52%). The predominant age class was age 0.4 (60.5%), followed by age 0.3 (34.3%).

Key words: Norton Sound, Unalakleet River, chum salmon, *Oncorhynchus keta*, radiotelemetry, mark–recapture.

INTRODUCTION

The Unalakleet River drainage is located in Western Alaska on the eastern shore of Norton Sound (Figure 1). Unalakleet River originates in the Nulato Hills and flows southwesterly for approximately 160 km until emptying into Norton Sound at the village of Unalakleet. Unalakleet River and its tributaries drain an area of approximately 2,700 km^2. The upper 130 km of Unalakleet River have been designated a National Wild and Scenic River.

Chum salmon *Oncorhynchus keta* stocks originating in the Unalakleet River drainage are exploited by subsistence, commercial, and sport fish users. Subsistence fishers operate gillnets and seines in the main river, and to a lesser extent, in coastal marine waters near the mouth. Subsistence chum salmon harvests since 1964 have ranged from 588 fish to 16,481 fish, averaging 5,724 fish (Table 1). The average subsistence harvest from 1998–2002 is 8,612 fish. Commercial salmon fishing in the Norton Sound Area, by regulation, is conducted with set gillnet gear only. Commercial harvests in Subdistricts 5 and 6 are managed for chum salmon originating in the Unalakleet River drainage (Figure 1). The commercial fishing season in both subdistricts typically opens between June 8 and July 1, depending largely on Chinook salmon *O. tshawytscha* abundance and run timing, and closes by regulation after September 7. Both subdistricts are managed jointly as they have a common boundary line. In recent years, restrictions to both commercial and subsistence fishing have been implemented because of continued weak returns. The opening of the commercial season has been delayed until mid to late July because of concerns with Chinook and chum salmon stocks. In those years, coho salmon *O. kisutch* was the targeted species, and chum salmon harvests were incidental. Since 1961, combined commercial harvests for both subdistricts have ranged from 600 fish to 176,530 fish (Table 1), averaging 44,030. The recent 5-year (1999–2003) commercial harvest average is 4,165 fish. The Unalakleet River is the most popular sport fishing river in the Norton Sound Area. The average annual angler days from 1997–2001 was 4,283 days (DeCicco 2004), while chum salmon sport fish harvests (1990–2002) have ranged from 116 to 714 fish (Table 1; DeCicco 2004), averaging 368 fish. Lodges and guide services operate on the Unalakleet River, mainly targeting Chinook and coho salmon.

Obtaining accurate chum salmon escapement information for the Unalakleet River drainage has been problematic. Previous attempts to establish ground based escapement projects such as enumeration weirs, counting towers, and sonar (Lean 1985) were hindered by high water levels and increased turbidity associated with seasonal precipitation events. Currently, chum salmon abundance and run timing are assessed by a test fishery located in the lower Unalakleet River (Kohler 2002). This project provides limited information as it serves as an index to monitor trends in chum salmon run magnitude and timing and does not provide an estimate of chum salmon escapement. In addition, a counting tower has been operated on North River, a lower Unalakleet River tributary (Figure 2), since 1996 (Kohler and Knuepfer 2002). Since then, chum salmon escapements past the tower have ranged from 1,526 to 9,859 fish (Table 1), averaging 6,745 fish. However, area managers assume that most chum salmon spawn in Unalakleet River and tributaries upriver of its confluence with North River, and it is unknown what proportion of returning chum salmon spawn in North River compared to the rest of the Unalakleet River drainage. As a result, chum salmon escapement at the North River counting tower is not a good indicator of total drainage wide escapement. Also, aerial surveys are flown over sections of the Unalakleet River drainage. Similar to the test fishery, they serve as an index rather than an estimate of total escapement.

This study employed radiotelemetry and mark–recapture methodologies to estimate what proportion of chum salmon entering the Unalakleet River drainage migrate past the North River counting tower. In addition, information from this project will be used to estimate total abundance, run timing, migration characteristics, and spawning distribution of chum salmon in the Unalakleet River drainage. These methodologies are commonly used in stock assessment (Todd et al. 2001; Wuttig and Evenson 2002), estimating fish abundance (Evenson and Wuttig 2000; Hasbrouck et al. 2000; Todd 2004; Wuttig 1998, 1999) and determining distribution and movement (Boyce and Eiler 2000; Meka et al. 2000).

This was the first year of a 3 year study. A minimum of 3 years of proportional information is needed to observe variation between years. If proportions are consistent (low variation) over several years, an average proportion can be used as an expansion factor for the North River counting tower escapement data to estimate drainage wide escapement.

Objectives for this project were:

1. Estimate the proportion of the chum salmon fitted with radio tags in the lower Unalakleet River that migrate upriver and past the North River counting tower.
2. Estimate drainage-wide escapement of chum salmon in the Unalakleet River, such that, with 95% confidence, the estimate is within ±25% of the true value.
3. Estimate run timing and migration rates of Unalakleet River chum salmon and compare with North River chum salmon timing and migration rates.
4. Estimate the age, sex, and length (ASL) composition of chum salmon entering the Unalakleet River drainage such that all estimated proportions are within 5 percentage points of the actual proportions 95% of the time, and compare to tagged fish that migrate into the North River.
5. Determine tributary distribution and major spawning locations, as represented by chum salmon fitted with radio tags and tracked to their final spawning location within the Unalakleet River drainage, and using those tagged fish to estimate peak spawning timing.
6. Evaluate the location of a proposed enumeration weir.

METHODS

Radiotelemetry Equipment

Advanced Telemetry Systems (*ATS*), *Inc*., *Isanti*, *MN*[1] manufactured the radiotelemetry equipment used during this study. Model R4500C receiver-dataloggers equipped with GPS were used at all stationary receiver-tracking sites (SRS) and during aerial tracking surveys. Model F2110 pulse-coded externally mounted radio transmitter tags were used. Radio tags were equipped with a mortality switch that activated when a fish remained motionless for approximately 4 hours. The radio tags weighed approximately 15 g and have an expected operational life in excess of 45 days. A total of 16 frequencies in the 148 to 149 MHz range with 10 pulse codes each allowed detection of 160 unique tags.

Stationary Receiver Sites

SRS were established at 4 locations along the Unalakleet River drainage (Figure 2). At each SRS water depth was measured perpendicular across the river along transects located at, above, and below each site, and down the middle of the river and along each bank. To assess receiver coverage, each site was tested with 2 or 3 radio tags suspended approx 20–30 cm above the river bottom to simulate tagged fish swimming along the river bottom.

SRS 1 (GPS coordinates N 63° 52.2125, W 160° 43.4677) was located 1 km upriver from the mouth of the Unalakleet River, and 2 km below the capture and tagging area. The width of the river channel was approximately 100 m and maximum water depth was approximately 4 m. SRS 2 (GPS coordinates N 63° 52.5418, W 160° 39.7462) was placed at the confluence of the Unalakleet and North Rivers, approximately 5 km upriver from the mouth and 2 km upriver from the tagging location. The river channel width was approximately 15 m wide and maximum water depth was 2 m. SRS 3 (GPS coordinates N 63° 53, W 160° 39) was placed at North River counting tower approximately 3 km upriver from the confluence with Unalakleet River. The width of the river channel was approximately 30 m and the maximum water depth was 2 m. SRS 4 (GPS coordinates N 64° 53.3939, W 160° 29.1515) was placed on the Unalakleet River approximately 22 km upriver from the mouth. The width of the river channel was approximately 60 m, and the maximum depth was approximately 1.5 m.

At each SRS, a 12-V marine battery and solar panel wired through a solar charge controller provided power for the equipment. A total of two 4-element Yagi antennae were used at all sites except the Unalakleet-North River confluence site, which had 3 antennae. The antennae were positioned to monitor downriver and upriver movement of tagged fish. The third antenna at the confluence monitored the movement of tagged fish up the North River. At all sites except SRS 3, the antennae (at 6 m) and the solar panel (at 3 m) were mounted to a 6 m high aluminum mast, then bolted to a waterproof equipment box containing the receiver and battery. All cables were run inside the antenna mast to the equipment box to avoid possible damage from animals. At SRS 3, antennae were mounted to the counting tower scaffolding. At all sites, a switchbox allowed scanning on all antennae simultaneously until a tag was received, then would switch to scan each antenna (direction could be determined by the antenna with the strongest signal). Before site deployment, all frequencies were entered manually into the receiver and scanning

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

parameters set according to site-specific criteria. The primary parameters were scan time (amount of time the receiver remains on each frequency), time out (period of time that the receiver will quit scanning before the scan time is up if there are no incoming signals), and store rate (interval of time between storing same frequency/code if present). Scanning parameters were set to scan a frequency for 6 s with a 4 s timeout. At all SRS except at SRS 2, store rates were set at 2 min. The store rate at SRS 2 was set at 5 min.

CAPTURE, TAGGING, AND AGE, SEX, AND LENGTH COLLECTION

The Unalakleet River capture/tagging site was approximately 2 km below the confluence with North River (GPS coordinates N 63° 51.6135 W 160° 42.3860; Figure 2). Capture and tagging occurred from June 16 through July 30. This location was down river from where the majority of the sport fish harvest occurs and up river from where the majority of the subsistence harvest occurs. A gravel bar was located along the south bank and water depth gradually increased moving away from the gravel bar with the main channel running along the north bank. The width of the river at the capture site varied depending on tidal status, ranging from approximately 60 m at low tide to over 100 m at high tide. Attempts were made to seine during the incoming tide when possible. At low tide seine deployments covered the majority of the river width (thus avoiding potential stock bias because of bank orientation). At high tide, approximately 60 m of the river extending from the south bank was not covered to ensure the north side was covered (water depth for the first 60 m extending out from the south bank during high tide was less than 0.5 m and it was assumed no chum salmon were passing in this area during seining events). Chum salmon were primarily captured using a 30.5 m long by 2.1 m deep, 8.9 cm stretched mesh beach seine. Chum salmon were also captured by drift fishing with a 24.4 m long by 45 meshes deep, 15 cm stretched mesh gillnet. Gillnet use was discontinued 1 week into capturing fish because of high abundance of pink salmon *O. gorbuscha*. Seining events occurred twice daily, once in the morning and once in the evening.

Captured chum salmon were placed in a sampling cradle modified from Larson (1995). The modifications included a sliding meter stick attached to the outside of the cradle for length measurements, and side notches were deeper to facilitate scale collection and tag mounting. Complete removal of the fish from the water was avoided.

Only healthy, vibrant chum salmon showing minimal impacts of capture were radiotagged. Tagging needles were placed over the radio tag cables, and then dipped in a 10% povidone iodine solution. Radio tags were mounted on the left side of the fish. The anterior needle was inserted between the pterygiophore bones near the posterior edge of the dorsal fin; the second needle was inserted through the musculature posterior of the dorsal fin (Barton 1992). The needles were removed and disk tags and sleeves were placed over the cables extending from the right side of the fish. Tags were held firmly against the fish and sleeves were crimped onto the cable, and excess cable removed. The anterior disk tags were sequentially numbered so if fish were caught and released, they could be identified. ADF&G posted several letters in the village of Unalakleet and at local sport fishing lodges informing the public of the project and providing instructions to record information if a tagged fish was caught and released.

A total of 160 radio tags were deployed. This number was determined using methods from Bromaghin (1993) so that the 95% confidence interval of the proportion estimate (objective 1) was within 10% of the true range. Tags were deployed according to a schedule developed from historical run timing information collected at the North River counting tower and the Unalakleet

River test fishery. From the historical information, a normal run timing curve was derived. A schedule was produced so that the number of tags deployed daily increased as the chum salmon run approached the midpoint of the run timing curve (the goal being the greatest number of tags deployed centered around the midpoint of the run). After the midpoint, the number of tags deployed daily decreased. Tags were deployed in order by pulse code and frequency. The lowest pulse code was deployed first, in order by increasing frequency. The same order was used for subsequent increasing frequencies. This order was chosen to avoid having large numbers of pulse codes on one frequency deployed simultaneously, potentially causing data recording problems at SRS and during aerial tracking. While tagging, a receiver was present in the boat with stripped coaxial cable suspended overboard to serve as an underwater antenna (McCleave et al. 1977; Solomon 1982). As fish were tagged, the receiver automatically recorded the pulse code and frequency of the tag, and date and time the fish was tagged. This verified the radio tag was functioning properly.

In addition, age, sex, and length (ASL) information was collected from all chum salmon that were tagged. ASL information was also collected from an additional 360 chum salmon captured but not tagged. The adipose fin was clipped on all radiotagged and sampled chum salmon, to serve as a secondary mark. ASL samples from non-tagged chum salmon were collected in 3 strata (pulses) of 120 fish each, distributed equally over the tag deployment schedule. Each sampled fish was measured for length from the mideye to tail fork (METF) to the nearest 0.5 cm. Sex was determined by examination of external characteristics such as development of the kype and the presence or absence of an ovipositor. One scale was collected from the left side of the fish, approximately 2 rows above the lateral line in an area crossed by a diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (INPFC 1963). Scales were arranged on gum cards in the field and sent to the Nome office for processing. Impressions from the gum cards were made on cellulose acetate cards with a heated hydraulic press (Clutter and Whitesel 1956). Salmon ages were determined by examining scale impressions (Mosher 1968), and ages were recorded in European notation (Koo 1962). Tissue samples for genetic stock identification/baseline were collected from 150 of the 160 chum salmon tagged. To obtain tissue samples, the left axillary process was removed and placed in 1 mL of 100% ethanol. When genetic sampling was completed, all samples were shipped to the ADF&G genetics lab in Anchorage along with the individual fish data (paired genetic and fish data).

AERIAL SURVEYS

Aerial tracking flights were flown in a Cessna 180 aircraft. Tracking flights were flown at altitudes ranging from approximately 230 m (750 ft) to 450 m (1500 ft) above ground level. Flights were flown at 230 m when numerous tagged fish were present in the area, and flown at 450 m when tagged fish were widely dispersed. Two antennae were used during survey flights; each was mounted side looking with a 30 degree tilt down from horizontal on the aircraft wing lift strut (Gilmer et al. 1981; Kenward 1987). An aircraft switch box inside the fuselage (connected to both antennae) allowed the observer to switch between left, right, or both antennae to better locate the direction of tagged fish (Winter et al. 1978).

A total of 6 aerial tracking flights were flown over the Unalakleet River drainage between July 16 and August 2. Tracking flights were flown along the main stem of Unalakleet River and major tributaries. When a tagged fish was pulse coded by the receiver, frequency and pulse code, mortality if activated, and river location were recorded on the aerial survey log by the observer. In addition, GPS coordinates, date and time, frequency, pulse, and mortality data were stored internally in the receiver by keying the store button. On subsequent scan cycle, if tag signal strength was greater than previous cycle, new data was stored. If the receiver was not able to identify the tag, the antenna switchbox was used to determine which antenna had the strongest reception. If the aircraft had already passed the fish, the plane circled back until the tag was identified.

ABUNDANCE ESTIMATE

Chapman's modification of Petersen's model (Seber 1982) was used to estimate the total Unalakleet River chum salmon population.

Chapman's modification:

$$\hat{N} = \frac{(m+1)(c+1)}{(r+1)} - 1 \qquad (1)$$

where:

$\hat{N}$ = estimated chum salmon population in the Unalakleet River drainage,

c = captured chum salmon at the North River tower,

m = marked and released chum salmon, and

r = marked and recaptured chum salmon at the North River tower.

Variance of total abundance will be estimated using the following formula:

$$v(\hat{N}) = \frac{(m+1)(c+1)(m-r)(c-r)}{(r+1)^2(r+2)} \qquad (2)$$

where:

$v(\hat{N})$ = variance of the estimate.

The North River counting tower expanded chum salmon count (see Kohler and Knuepfer 2002) was expanded by the proportion of marked (radiotagged) chum salmon that migrated past and spawned above the North River to estimate abundance.

RESULTS

CAPTURE AND TAGGING

A total of 160 radio tags were deployed between June 16 and July 30. Tag deployment began approximately 10 days early when compared to the 2004 run timing information from the Unalakleet River test fishery and the North River counting tower (Figure 3). In addition, tag deployment ended at the 62nd percentile of the run for the Unalakleet River test fishery, and at the 83rd percentile of the run at the North River counting tower.

Of the 160 radio tags deployed, 145 (90.6%) were assigned spawning destinations. The remaining 15 radiotagged fish were censored as a result of: 3 tags were recaptured in either the sport, subsistence, or test fishery; 1 tag left the system immediately after tagging; 6 tags remained in the river no longer than 5 days after tagging and never went above the North River confluence, presumably never reaching their spawning destination; 2 tags had conflicting or nonsensical SRS and aerial tracking information; and 3 tags had no SRS records after tagging.

PROPORTION/ABUNDANCE ESTIMATE

Of the 145 tags assigned a spawning location, 19 were recorded (recapture) at the North River counting tower (Table 2), giving a proportion of 0.13. Using Chapman's modification, the 2004 abundance estimate of chum salmon in the Unalakleet River drainage was 70,262 fish, with a lower bound of 42,373 and an upper bound of 98,150, based on a 95% confidence interval.

AGE, SEX, AND LENGTH

A total of 446 chum salmon (including the 160 radiotagged fish) were sampled for ASL determination. Sampled fish were predominately male (51.8%), and 60.5% of the fish sampled were age 0.4 (Table 3). Age-0.3 chum salmon comprised 34.3% of the fish sampled, and age-0.2 fish comprised 4.9% of the sample. Age-0.4 fish ranged in length from 49.5 cm to 67.0 cm with an average length of 57.9 cm (Table 4). Age-0.3 fish ranged in length from 48.5 to 62.5 cm with an average length of 55.4 cm. Age-0.2 fish ranged in length from 47.0 cm to 59.5 cm in length with an average of 53.3 cm. ASL information collected from sampled chum salmon was compared to radiotagged ASL information to determine if a capture bias existed, and no notable differences were found.

DISTRIBUTION

Of the 145 radiotagged fish that were assigned a spawning location, 19 (13%) were located above the North River counting tower, 5 (3%) were located between the North River confluence and the North River counting tower, 16 (11%) were located between the lower site and the North River confluence (fish potentially spawning in the South River), 40 (28%) were located between the North River confluence and the proposed weir site, and 65 (45%) were located above the proposed weir site on the Unalakleet River (Table 2; Figure 2). Using tagged fish located in the Unalakleet River only (not including North River), 52% of the tagged fish migrated past the proposed weir site. Of the 65 tags located above the proposed weir site, 23 were located at or above the confluence with the Chiroskey River, and 3 were located at or above the confluence with the Old Woman River. No tags were located upriver of the confluence with 10-Mile River, and no tags were located in the North Fork Unalakleet River or in other major tributaries.

AERIAL TRACKING

Aerial tracking flights commenced on July 16, approximately 1 month after the first radio tag was deployed. Of the 144 fish assigned a spawning location, 108 (74%) were located at least once during aerial tracking. A total of 16 (11%) tags assigned above the proposed weir site SRS and 12 (8%) tags assigned destinations between the confluence SRS and the proposed weir SRS were not located during aerial tracking. Additionally, 6 (4%) tags assigned at or around the confluence SRS, and 1 tag assigned between the confluence SRS and the counting tower SRS were not located during aerial tracking. Two censored tags were also not located during aerial tracking.

MIGRATION TIMING

Radiotagged fish assigned a spawning location in the Unalakleet River above the confluence with the North River took an average of 31.5 hr ($n = 101$, $\sigma = 47.3$) to reach the confluence after tagging and an average of 105.3 hr ($n = 97$, $\sigma = 54.2$) to reach the proposed weir site after tagging (Table 5). In addition, these fish spent on average 27.6 hr ($n = 103$, $\sigma = 26.8$) holding at the confluence. Tagged fish assigned a spawning location in the North River took on average 40.6 hr ($n = 25$, $\sigma = 68.7$) to reach the confluence after tagging and an average of 126.0 hr ($n = 25$, $\sigma = 78.9$) to reach the counting tower after tagging (Table 5). These fish spent on average 54.0 hr ($n = 25$, $\sigma = 40.4$) holding at the confluence. Tagged fish assigned a spawning location at or near the confluence of the North River took on average 50.1 hr ($n = 16$, $\sigma = 41.4$) to reach the confluence after tagging (Table 5).

Diel migration timing of tagged chum salmon were similar at the confluence, proposed weir site, and North River counting tower. At the confluence and counting tower SRS, the highest percentage (27.4% and 36.4%, respectively) of tagged chum salmon passed between 20:00 and 24:00. At the proposed weir site SRS, the highest percentage (28%) passed from 00:00 to 04:00, although 26% passed during 20:00 to 24:00. At the confluence, tower, and proposed weir site SRS, the lowest percentages of tagged fish passed between 08:00 and 16:00.

DISCUSSION

The primary objective of this project was to determine what proportion of chum salmon entering the Unalakleet River drainage migrate into the North River. Area managers have assumed that a higher proportion of chum salmon migrate into Unalakleet River. The proportion of 0.13 observed in the North River during 2004 supports this assumption. Caution is needed when applying this proportion as an expansion factor in estimating total drainage wide abundance in subsequent and past years. A minimum of 3 years of similar data is needed to observe potential annual variations. If the proportion is consistent (low variation) for several years, an average proportion can then be used as an expansion factor. The 2004 drainage wide abundance estimate of 70,262 chum salmon ± 27,889 fish had a coefficient of variation of 0.20, meeting the target objective for the project.

Distribution information collected in 2004 indicates the majority of chum salmon migrating into the Unalakleet River drainage (72%) go above the confluence of North River. Within this group, 62% migrate above the proposed weir site location. No tagged fish were located in the upper tributaries (Chiroskey River, Old Woman River, and 10-Mile River). This is surprising, particularly for Old Woman River, which has been documented as a chum salmon producing river. Chum salmon aerial survey counts of Old Woman River (17 surveys since 1970) have ranged from 5 fish (1999) to 4,470 (1970; the average of all surveys is 939 fish) indicating chum salmon migration into the tributary is highly variable. It is possible that a low number of chum salmon migrated into Old Woman River in 2004, hence the absence of any radio tags recorded during aerial tracking flights. In addition, early run chum salmon may migrate higher into the drainage. As the first aerial tracking flight was not conducted until July 16, it is possible some tagged fish bound for Old Woman River and other upper tributaries migrated, spawned, and went back downriver prior to the first aerial tracking flight. In any case, greater effort will be made to conduct flights earlier in 2005 to monitor Old Woman River and other upper tributaries to examine this question further.

A total of 16 tags were assigned destinations at or near the confluence of North River. These may be chum salmon spawning in South River, or near the confluence. Anecdotal information from residents of the area indicate that some chum salmon spawn in that area. If chum salmon are spawning in the lower reaches of South River near the confluence, they would be recorded by the

Unalakleet-North River confluence SRS. In addition, it would be difficult to determine if tagged fish were in South River or Unalakleet River during aerial tracking flights if they were located near the confluence. Attempts will be made in 2005 to answer this question.

Tag deployment did not track with run timing for the Unalakleet River test fishery or North River counting tower in 2004, indicating that tag deployment was not distributed proportionally over the course of the entire run. The 2004 run was protracted compared to normal run timing; tagging would have finished in the mid to high 80's percentile during normal timing. In addition, Division of Sport Fish biologists conducting a coho salmon radiotelemetry study in Unalakleet River reported capturing chum salmon several weeks after tagging ceased (P. Joy, Sport Fish Biologist, ADF&G, Fairbanks; personal communication). As a result, tags were not deployed in the later portion of the chum salmon run. The tag deployment schedule used in 2004 was based on available historical chum salmon run timing information gathered from the Unalakleet River test fishery and North River counting tower. This information may not be sufficient for developing a preseason deployment schedule. Alternatives to a preseason schedule, such as deploying tags in proportion to run strength by standardizing fishing time will be considered in 2005. Also, an additional 15 tags will be deployed in 2005, and capture/tagging will be extended through the first week of August.

The large percentage of deployed radio tags not located during aerial tracking flights is likely the result of the nearly 1 month delay in initiating flights. Air charter service was arranged prior to the season, but mechanical difficulties prevented flights from commencing on schedule. The first aerial tracking flight occurred on July 16. The majority of the radio tags not located by aerial tracking were deployed prior to July 5. In 2005, back up charter services will be identified prior to the season to ensure tracking flights occur on time.

Another objective of this project was to determine what proportion of chum salmon in the Unalakleet River spawn above the proposed weir site. There are concerns that because of the distance upriver (22 km) a substantial number of Chinook, chum, and coho salmon may spawn below the proposed weir location. Determining proportions above and below the site would allow biologists to assess the location of this site in enumerating total escapements. A previous investigation examined the distribution of Chinook salmon throughout the Unalakleet River drainage using radiotelemetry techniques (Wuttig 1998, 1999). From that study, tag locations determined from aerial tracking flights indicate the majority of Chinook salmon migrating into Unalakleet River spawn above the proposed weir site. However, in 2004, the proportion of tagged chum salmon migrating into Unalakleet River that passed the proposed weir site was 0.54, indicating just over half of the chum salmon migration in 2004 would have been enumerated if a weir were located at this site. This project provided an opportunity to investigate chum salmon migration timing throughout the drainage. Results show that migration timing is highly variable among fish and no clear patterns were evident.

This was the pilot year for this study. No technical difficulties were encountered with the telemetry equipment, nor were any difficulties encountered with capture and tagging methodologies. SRS placements throughout the drainage provided information required to monitor radiotagged chum salmon migration throughout the drainage to answer objectives 1; proportion past North River tower, and 6; proportion past weir site. ASL information collected in 2004 (and future years) will help research and management staff develop a brood table that in turn can be used in establishing escapement goals. In addition, migration timing information can help assist managers in developing better management practices and goals for the Unalakleet

River drainage chum salmon stock. If the proportion of chum salmon migration into the North River exhibits a low variability over several years, an average proportion could be used as an expansion factor to estimate the Unalakleet River drainage escapements in future years and for past years. This in turn could also facilitate the development of a drainage wide escapement goal, allowing for management consistent with the State's Policy for the Management of Sustainable Salmon Fisheries (5 AAC 39.222).

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TABLES AND FIGURES

Table 1.–Historical North River escapement and subsistence, sport, and commercial harvests of chum salmon originating in the Unalakleet River drainage, 1961–2004.

		Harvest				
		Subsistence	Sport[a]	Commercial [b]		
Year	North River Escapement	Unalakleet River	Unalakleet River	Subdistrict 6	Subdistrict 5	Subdistricts 5/6 combined
1961	n/a	n/a	n/a	23,586	24,746	48,332
1962	n/a	n/a	n/a	30,283	8,718	39,001
1963	n/a	n/a	n/a	27,003	19,153	46,156
1964	n/a	6,726	n/a	19,611	35,272	54,883
1965	n/a	8,791	n/a	26,498	8,356	34,854
1966	n/a	3,387	n/a	16,840	8,292	25,132
1967	n/a	n/a	n/a	8,502	1,655	10,157
1968	n/a	2,982	n/a	14,865	2,504	17,369
1969	n/a	4,196	n/a	22,032	8,645	30,677
1970	n/a	7,214	n/a	40,029	15,753	55,782
1971	n/a	7,073	n/a	37,543	13,399	50,942
1972	n/a	4,132	n/a	20,440	12,022	32,462
1973	n/a	3,426	n/a	25,716	14,500	40,216
1974	n/a	588	n/a	36,170	26,391	62,561
1975	n/a	2,038	n/a	48,740	49,536	98,276
1976	n/a	2,832	n/a	24,268	15,798	40,066
1977	n/a	6,085	n/a	32,936	36,591	69,527
1978	n/a	3,442	n/a	37,079	35,388	72,467
1979	n/a	1,597	n/a	30,445	22,030	52,475
1980	n/a	5,230	n/a	64,198	27,453	91,651
1981	n/a	4,235	n/a	39,186	21,097	60,283
1982	n/a	4,694	n/a	44,520	26,240	70,760
1983	n/a	4,401	n/a	109,220	67,310	176,530
1984	n/a	3,348	n/a	43,317	32,309	75,626
1985	n/a	1,968	n/a	25,111	13,403	38,514
1986	n/a	0	n/a	30,239	16,126	46,365
1987	n/a	n/a	n/a	17,525	14,088	31,613
1988	n/a	n/a	n/a	25,363	21,521	46,884
1989	n/a	1,388	n/a	20,825	19,641	40,466
1990	n/a	n/a	298	23,659	21,748	45,407
1991	n/a	n/a	497	39,609	31,619	71,228
1992	n/a	n/a	379	52,547	27,867	80,414
1993	n/a	n/a	116	28,156	20,864	49,020
1994	n/a	12,732	220	12,288	5,411	17,699
1995	n/a	13,460	207	24,843	14,775	39,618
1996	9,789	16,481	463	7,369	3,237	10,606
1997	6,904	7,649	228	17,139	5,747	22,886
1998	1,526	7,962	447	6,210	7,080	13,290
1999	5,600	10,040	211	5,700	2,181	7,881
2000	4,971	7,294	403	2,700	2,751	5,451
2001	6,515	9,163	714	1,512	1,819	3,331
2002	5,918	8,599	607	339	261	600
2003	9,859	n/a	n/a	3,075	485	3,560
2004	9,624	n/a	n/a	4,924	1,372	6,296

Note: n/a = information not available.
[a] Source: DeCicco 2004.
[b] Harvested chum salmon in both subdistricts originate from both the Unalakleet and Shaktoolik River drainages, and to some extent, other drainages in the Norton Sound Area.

Table 2.–Assigned spawning locations of radiotagged chum salmon from aerial survey and stationary receiver data, Unalakleet River drainage, 2004.

Spawning Location	Number of Tags Assisgned
Unalakleet River	
At or near confluence	16
Between confluence and proposed weir site[a]	40
Above the proposed weir site[b]	65
at or above Chiroskey River	23 [c]
at or above North Fork River	3 [c]
at or above Old Woman River	3 [c]
at or above 10-Mile River	0 [c]
Total Unalakleet River and tributaries	120
North River	
Between the confluence and counting tower	5
Above the tower	19
Total North River	24

[a] 12 tags assigned to the Unalakleet River between the confluence and proposed weir site were not picked up with aerial tracking.

[b] 16 tags assigned to the Unalakleet River above the proposed weir site were not picked up with aerial tracking.

[c] Spawning locations determined via aerial tracking.

Table 3.–Age and sex composition of sampled chum salmon from Unalakleet River, 2004.

		Age Class				
		0.2	**0.3**	**0.4**	**0.5**	**Total**
Dates Sampled	6/16-7/1					
Number Sampled	122					
Male	Number of Samples	0	16	44	0	60
	Percentage of Sample	0.0	13.1	36.1	0.0	49.2
Female	Number of Samples	2	16	44	0	62
	Percentage of Sample	1.6	13.1	36.1	0.0	50.8
Total	Number of Samples	2	32	88	0	122
	Percentage of Sample	1.6	26.2	72.1	0.0	100.0
Dates Sampled	7/2-7/14					
Number Sampled	175					
Male	Number of Samples	4	33	63	0	100
	Percentage of Sample	2.3	18.9	36.0	0.0	57.1
Female	Number of Samples	6	25	44	0	75
	Percentage of Sample	3.4	14.3	25.1	0.0	42.9
Total	Number of Samples	10	58	107	0	175
	Percentage of Sample	5.7	33.1	61.1	0.0	100.0
Dates Sampled	7/15-7/30					
Number Sampled	149					
Male	Number of Samples	3	24	43	1	71
	Percentage of Sample	2.0	16.1	28.9	0.7	47.7
Female	Number of Samples	7	39	32	0	78
	Percentage of Sample	4.7	26.2	21.5	0.0	52.3
Total	Number of Samples	10	63	75	1	149
	Percentage of Sample	6.7	42.3	50.3	0.7	100.0
		SEASON TOTALS				
Dates Sampled	6/16-7/30					
Number Sampled	446					
Male	Number of Samples	7	73	150	1	231
	Percentage of Sample	1.6	16.4	33.6	0.2	51.8
Female	Number of Samples	15	80	120	0	215
	Percentage of Sample	3.4	17.9	26.9	0.0	48.2
Total	Number of Samples	22	153	270	1	446
	Percentage of Sample	4.9	34.3	60.5	0.2	100.0

Table 4.–Mean length composition (mideye to tail fork) of Unalakleet River chum salmon samples by age class and sex, 2004.

		Age Class			
		0.2	**0.3**	**0.4**	**0.5**
Dates Sampled	6/16-7/1				
Number Sampled	122				
Male	Number of Samples	0	16	44	0
	Range	0	53.0-60.5	51.5-67.0	0
	Average Length (cm)	0	56.6	58.4	0
	Standard Deviation	0	2.2	3.5	0
Female	Number of Samples	2	16	44	0
	Range	54.5-57	50.5-59.0	50.5-63	0
	Average Length (cm)	55.7	54.2	55.2	0
	Standard Deviation	1.8	2.4	2.7	0
Total	Number of Samples	2	32	88	0
	Range	54.5-57.0	50.5-60.5	50.5-67.0	0
	Average Length (cm)	55.7	55.4	56.8	0
	Standard Deviation	1.8	2.5	3.5	0
Dates Sampled	7/2-7/14				
Number Sampled	175				
Male	Number of Samples	4	33	63	0
	Range	50.5-55.5	49.0-61.0	52.0-64.5	0
	Average Length (cm)	54.0	56.1	58.5	0
	Standard Deviation	2.3	2.8	2.7	0
Female	Number of Samples	6	25	44	0
	Range	48.5-54.0	48.5-57.0	49.5-59.0	0
	Average Length (cm)	51.1	52.8	55.3	0
	Standard Deviation	2.2	2.6	2.2	0
Total	Number of Samples	10	55	107	0
	Range	48.5-55.5	48.5-61	49.5-64.5	0
	Average Length (cm)	52.5	54.7	57.2	0
	Standard Deviation	2.6	3.1	2.9	0
Dates Sampled	7/15-7/30				
Number Sampled	148				
Male	Number of Samples	3	24	43	1
	Range	52.0-59.5	51.0-62.0	53.0-66.5	62.0
	Average Length (cm)	55.3	57.4	61.3	n/a
	Standard Deviation	3.8	2.6	2.9	n/a
Female	Number of Samples	7	38	32	0
	Range	47.0-57.0	50.0-62.5	53.0-64.0	0
	Average Length (cm)	53.2	55.3	58.5	0
	Standard Deviation	3	2.8	2.9	0
Total	Number of Samples	10	62	75	1
	Range	47.0-59.5	50.0-62.5	53.0-66.5	62.0
	Average Length (cm)	53.8	56.1	60.1	n/a
	Standard Deviation	3.2	2.9	3.2	n/a
SEASON TOTALS					
Dates Sampled	6/16-7/30				
Number Sampled	445				
Male	Number of Samples	7	73	150	1
	Range	50.5-59.5	49.0-62.0	51.5-67.5	62.0
	Average Length (cm)	54.6	56.6	59.3	n/a
	Standard Deviation	2.8	2.6	3.3	n/a
Female	Number of Samples	15	79	120	0
	Range	47.0-57.0	48.5-51.5	49.5-64.0	0.0
	Average Length (cm)	52.7	54.3	56.1	0
	Standard Deviation	2.9	2.8	2.9	0
Total	Number of Samples	22	152	270	1
	Range	47.0-59.5	48.5-62.5	49.5-67.0	62.0
	Average Length (cm)	53.3	55.4	57.9	n/a
	Standard Deviation	3	3	3.5	n/a

Table 5.–Tagged chum salmon migration rates from the tagging site to upriver stationary receiver sites, Unalakleet River drainage, 2004.

Spawning Location of Tagged Fish	Number of Fish	Mininum (hours)	Maximum (hours)	Average (hours)	SD
Unalakleet River above confluence with North River					
Travel time to confluence after tagging	101	1.8	344.1	31.5	47.3
Holding time at confluence	103	0.0	121.5	27.6	26.8
Travel time to proposed weir site after tagging	97	19.0	275.0	105.3	54.2
Travel time to proposed weir site after confluence	95	0.0	235.0	59.9	44.5
North River					
Travel time to confluence after tagging	25	2.3	308.2	40.6	68.7
Holding time at confluence	25	1.4	163.6	54.0	40.4
Travel time to tower after tagging	25	20.0	345.6	126.0	78.9
Travel time to tower after confluence	22	6.3	271.5	53.8	64.0
Unalakleet/North River confluence					
Travel time to confluence/tagging	16	5.25	129.9	50.1	41.4

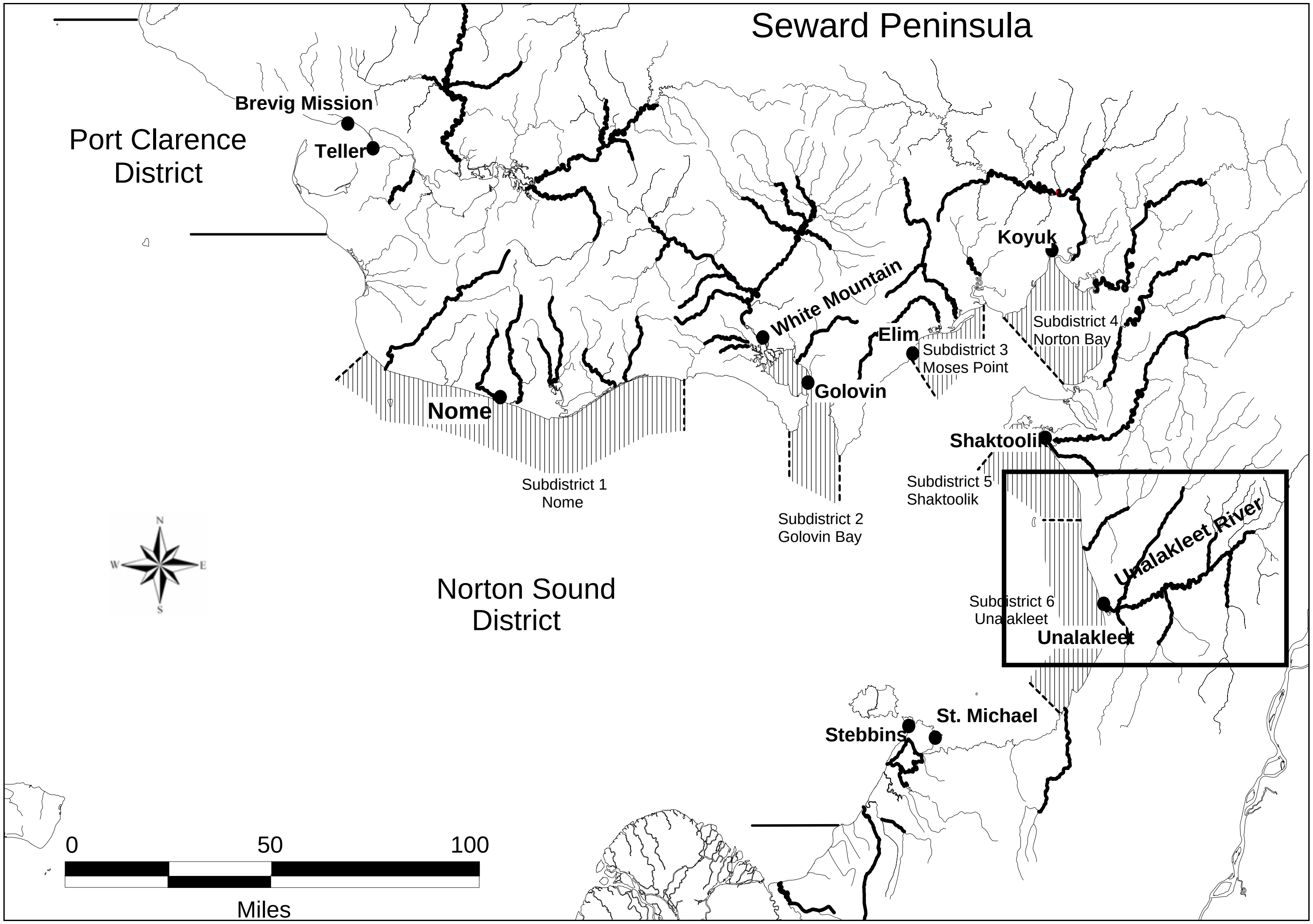
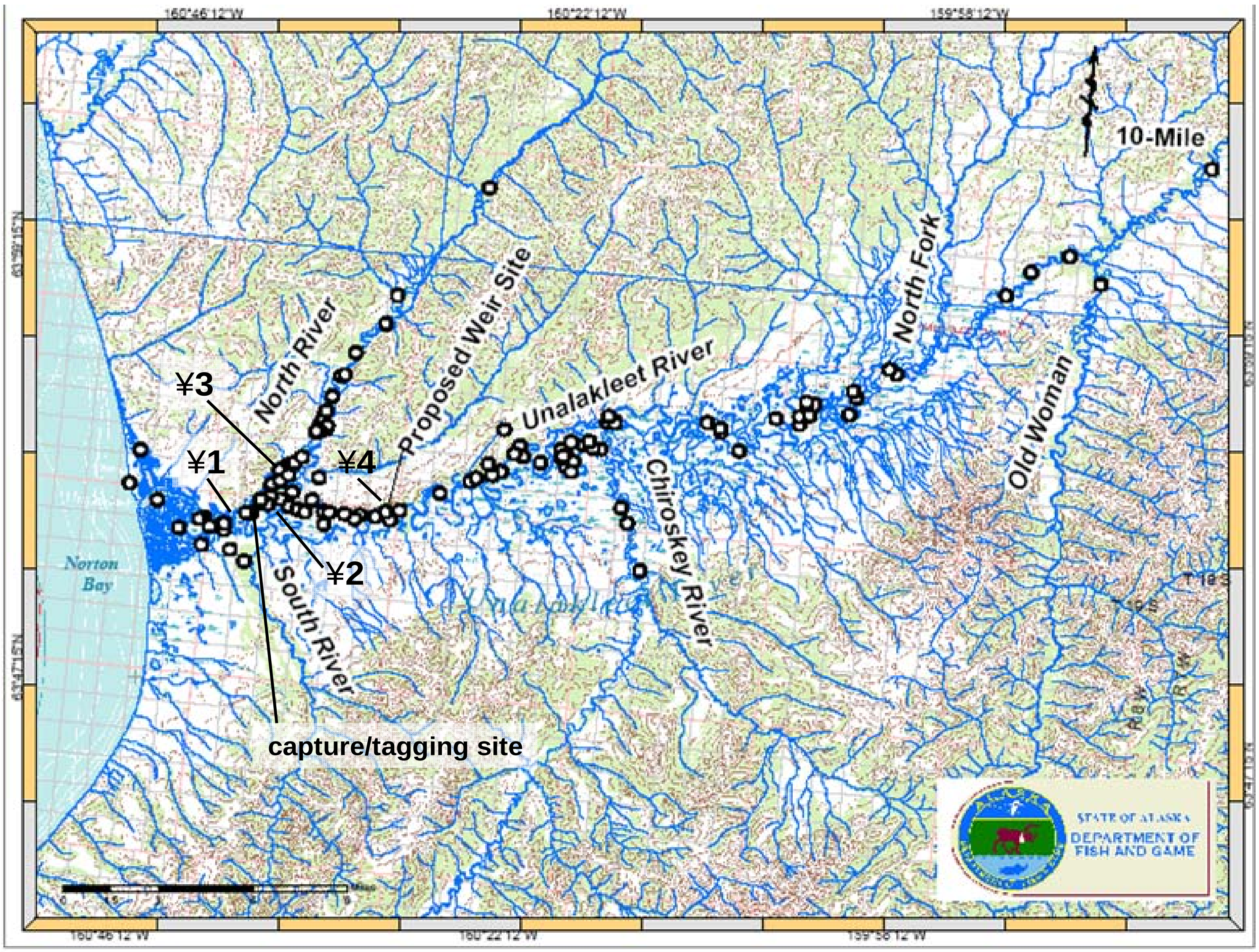


Figure 1.–Location of the Unalakleet River drainage in the Norton Sound Area.



Note: ¥ 1= Lower site SRS; ¥ 2= North and Unalakleet Rivers confluence SRS; ¥ 3= North River counting tower SRS; ¥ 4= proposed weir site SRS.

Figure 2.–Unalakleet River drainage showing spawning locations of radiotagged chum salmon (circles) determined from aerial tracking flights, the capture/tagging site, stationary receiver sites (SRS), proposed weir site, and major tributaries.

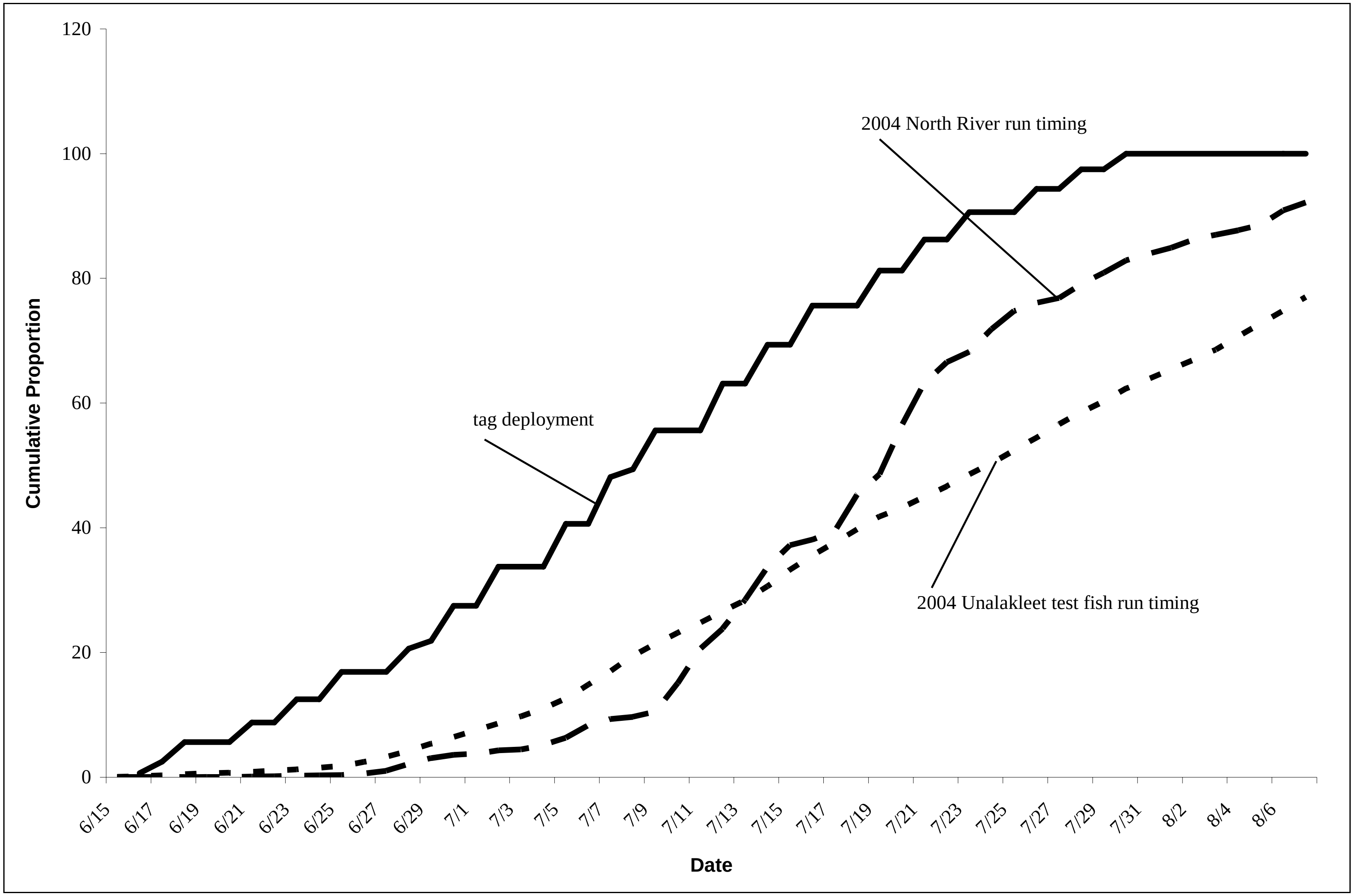


Figure 3.–Comparison of tag deployment with North River counting tower and Unalakleet River test fishery chum salmon run timing, 2004.