Fishery Data Series No. 17-48

Distribution and Movement Patterns of Fall Chum Salmon in the Upper Tanana River in 2007-2008

by

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December 2017

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)

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. 17-48

DISTRIBUTION AND MOVEMENT PATTERNS OF FALL CHUM SALMON IN THE UPPER TANANA RIVER IN 2007-2008

by
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ABSTRACT

A 2-year radiotelemetry study was conducted in order to better understand fall chum salmon *Oncorhynchus keta* distribution and spawning habitat utilization in mainstem of the upper Tanana River. Fieldwork in 2007 consisted of feasibility investigations involving tagging, tracking, and habitat monitoring methods. In 2008, a total of 412 chum salmon were radiotagged in the lower Tanana River and 294 were successfully tracked to final spawning areas upriver. The majority of radiotagged chum salmon (67.4%) were tracked to spawning areas located in the upper Tanana River mainstem from Fairbanks to upstream of Delta Junction, excluding tributaries. Variations in timing by spawning location were observed. Average dates of passage at the tagging site were August 26 for radiotagged chum salmon destined for runoff tributaries; September 9 for the Delta River and Tanana River mainstem above Big Delta; and September 17 for the Tanana mainstem downstream from Big Delta. Migration rates of chum salmon radiotagged in 2008 averaged 19.0 km/day between the tagging site and the first upstream mainstem remote tracking station, 31.2 km/day between the first and second mainstem tracking stations, before dropping and 15.2 km/day as chum salmon approached spawning areas in the upper Tanana River. The distribution of tagged chum salmon, combined with habitat monitoring data, suggests that the upwelling areas located in the upper Tanana River mainstem serve as spawning habitat for approximately 85% of Tanana River fall chum salmon. The data collected by this study demonstrated that mainstem spawning areas of the Tanana River are crucial to overall Tanana River fall chum salmon production.

Key words: chum salmon, *Oncorhynchus keta*, radiotelemetry, upwelling, Tanana River, Yukon River

INTRODUCTION

Chum salmon *Oncorhynchus keta* are the most abundant salmon species in the Yukon River drainage and support important commercial, personal use and subsistence fisheries. Genetically distinct summer and fall runs of chum salmon migrate up the Yukon River (Crane et al. 2001). Characteristics that distinguish fall chum from summer chum salmon include larger average size, higher fat content, lower abundance, and spawning habitat requirements. Although summer chum salmon typically spawn in runoff streams, fall chum salmon spawn in areas of upwelling (Leman 1988; Putivkin 1989; Leman 1993). The higher temperature regimes of upwelling habitats during the winter months allow fall chum salmon fry spawned in October and November to emerge at a comparable time to summer chum salmon fry spawned in runoff streams during August. Availability of upwelling habitats for fall chum salmon spawning, however, is limited to only a few river systems in the Yukon River drainage. These areas include the Fishing Branch, Kluane, mainstem Yukon between Fort Selkirk and Carmacks, Chandalar, Sheenjek, and Tanana rivers (Figure 1).

The Tanana River is one of the largest tributaries of the Yukon River, flowing 700 km northwest through the interior of Alaska and draining an area of 155,250 km^2. The headwaters of Tanana River flow primarily from glacial systems originating on the north side of the Alaska Range which terminate with the Tanana River on its south bank, whereas systems flowing into the Tanana River on its north bank are primarily tannic runoff streams. During winter, the glacial run off subsides and flow is dominated by upwelling aquifer waters, particularly on the south bank of the Tanana River. Fall chum and coho (*O. kisutch*) salmon generally migrate to tributaries entering the south side of the Tanana River, whereas Chinook (*O. tshawytscha*) and summer chum salmon generally migrate to tributaries entering the north side. Production from the Tanana River alone supplies approximately 30% of the total Yukon fall chum salmon run annually (Bue et al. 2009). It is difficult to monitor and identify fall chum salmon spawners and spawning areas of the Tanana River because the river is glacial fed, heavily silted, and extremely braided. Known tributaries that support fall chum salmon spawning in the Tanana River drainage include Toklat River in the Kantishna River drainage and the Delta River (Figure 1). The uniqueness of upwelling areas can be observed in the Delta River where an average of 14,000 fall chum salmon concentrate within the lower 2 miles of the system (JTC 2016). The Toklat River springs supports an average of 31,000 fall chum salmon (JTC 2016).

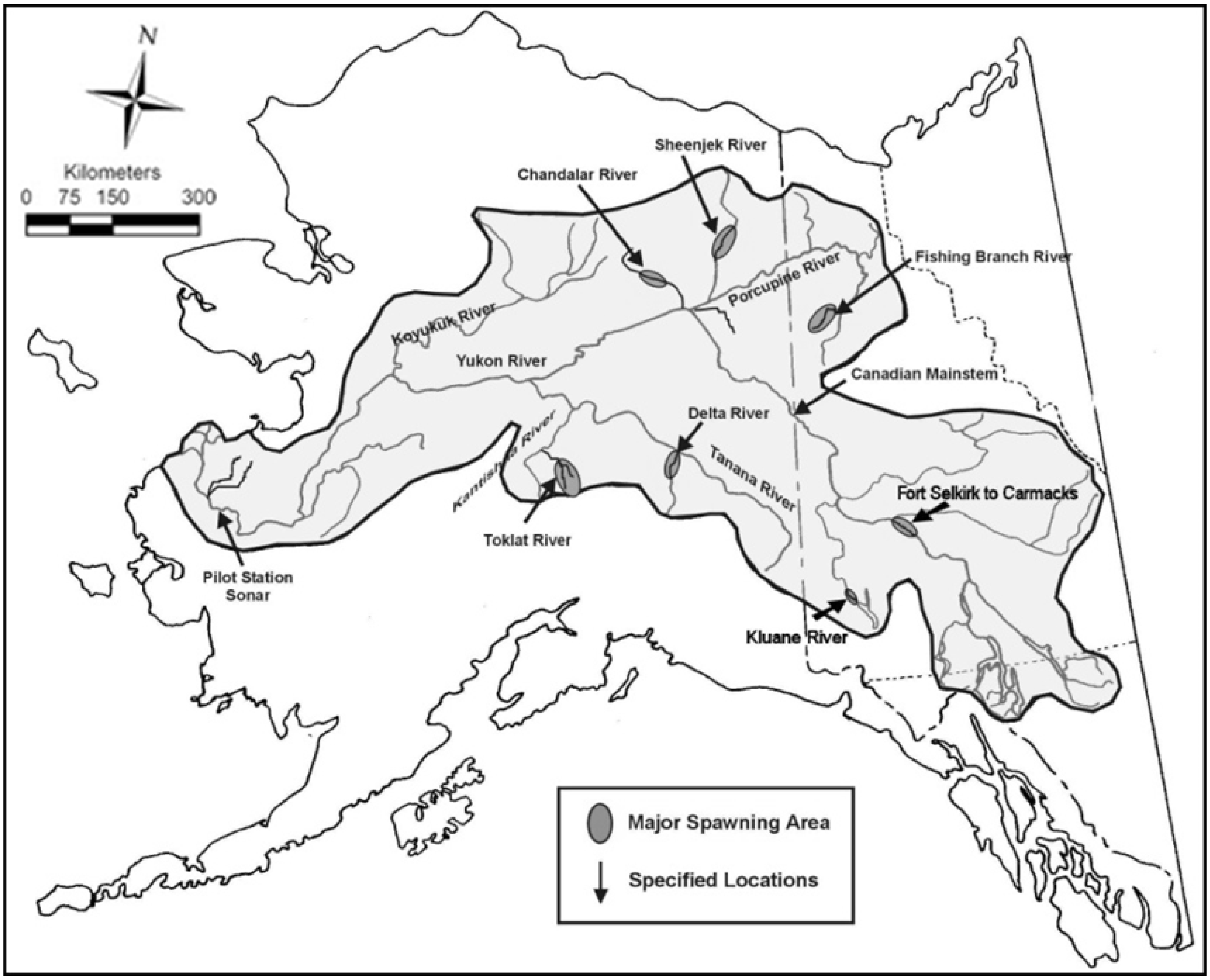

Figure 1.–Major spawning areas of fall chum salmon in the Yukon River drainage.

The timing of spawning at the very onset of winter and the glacial nature of the system make salmon escapement surveys in this region difficult. Mark–recapture studies have shown an average of 144,000 fall chum salmon migrating to the upper Tanana River (Cleary and Hamazaki 2008). The final spawning destinations for the majority of these fish are largely suspected to be in the mainstem Tanana River; however, only the Delta and Toklat rivers are regularly monitored after cessation of glacial runoff, when the underlying clear upwelling waters become the dominant flow. The Delta and Toklat river spring areas have been treated as index areas for enumeration, but due to the limited availability of primary spawning habitat, these stocks may not fluctuate with the overall run size. Current monitoring in the Tanana River drainage leaves an estimated 60–70% of Tanana fall chum salmon unaccounted for in escapement surveys. The limited understanding of fall chum spawning areas was the motivation for a radiotelemetry project conducted on the upper Tanana River in 1989 that tracked 82% of tagged fall chum salmon to unmonitored mainstem habitats (Barton 1992).

Fisheries and habitat management has often treated glacial mainstem habitats merely as migration corridors for salmon with no role in spawning. Escapement monitoring sites are usually established near the mouths of spawning tributaries. Interests and efforts concerning salmon habitats are typically focused on protections or restoration of headwater tributaries, whereas issues concerning development of mainstem reaches are considered in terms of securing safe passage of salmon (e.g., installment of fish ladders as mitigation for mainstem dam construction). However, numerous studies on sockeye salmon utilization of mainstem areas for spawning in Southeast Alaska challenged this long held view. Research on the Taku River established that mainstem habitats can serve as important spawning habitats and contribute significantly to the production of a river system (Wood et al. 1987; Eiler et al. 1988; Eiler et al 1992). Existing information about Tanana River fall chum salmon suggests a similar form of salmon production.

Chum salmon are currently classified only as “present” in the Tanana River, according to the Alaska Department of Fish and Game’s (ADF&G) catalog of waters important for spawning, rearing, and migration of anadromous fishes (Johnson and Blanche 2010). Such a classification gives little protection to mainstem habitat of the upper Tanana River, because there are currently insufficient data available to further classify these areas as “spawning” or “rearing” habitats which would precipitate longer periods of protection. Meanwhile, the potential for negative environmental impacts on the Tanana watershed has steadily increased due to population growth and increased urbanization throughout the Tanana River valley. Communities along the upper mainstem Tanana include Nenana, Fairbanks North Star Borough (FNSB), Big Delta, Delta Junction and Fort Greely. Populations of those communities have increased along with urbanization, particularly within FNSB. Developmental pressures in those areas are more significant than anywhere else within the Alaska portion of the Yukon River drainage. These activities include, but are not limited to, development of agriculture, timber, mineral, hydroelectric, and petroleum resources along the mainstem Tanana River. Exploration and development often includes an access component by either seasonal or all-season roads or rail, some of which require bridges, gravel and rock material sites, and engineered beds to minimize impacts on sub-surface and surface water flows. Continued growth and future development of resources in the area have the potential to profoundly impact fall chum salmon populations that utilize spawning habitats in the mainstem Tanana River.

To better evaluate the potential consequences of development on upper Tanana fall chum salmon stocks, a 2-year radiotelemetry project was conducted to better understand fall chum salmon distribution and habitat use in upper Tanana River mainstem areas. The project was operated cooperatively with ADF&G, Tanana Chiefs Conference (TCC), University of Alaska Fairbanks (UAF), U.S. Fish and Wildlife Service (USFWS), and the U.S. Geological Survey (USGS). The purpose of the overall study was as follows 1) verify fall chum salmon spawning in mainstem habitats, 2) identify and characterize mainstem spawning habitats, 3) determine the relative contribution of mainstem spawners to overall upper Tanana fall chum salmon populations, and 4) construct models that predict mainstem spawning locations.

Radiotelemetry has proven an effective technique for studying salmon populations in large glacial systems (e.g., Eiler 1990; Eiler et al 2004; Savereide 2005). Previous telemetry projects in the Tanana River drainage provided applicable feasibility information for this study (Holder and Fair 2002) and highlighted the need for a more comprehensive understanding of fall chum salmon stocks in the upper Tanana mainstem areas (Barton 1992). Work in 2007 focused primarily on feasibility investigations of fall chum salmon tagging and tracking methods on the Tanana River, and included a limited deployment of radio tags. The knowledge and experience gained from the 2007 field season were then applied to full scale radio tag deployment, tracking, and habitat monitoring in 2008. After locations in the mainstem were identified through radiotelemetry as spawning areas, these spawning habitats were characterized in a portion of the study directed by USGS (Burril et al. 2010). In another portion of the study, a model was constructed to predict mainstem spawning habitat (South 2010 and Wirth et al. 2012). The overall project was funded by the Arctic-Yukon-Kuskowkim Sustainable Salmon Initiative (AYKSSI) from 2007 to 2009 (Project Number 724).

OBJECTIVES

The objectives of the radiotelemetry portion of the study were as follows:

1) Confirm fall chum salmon use Tanana River mainstem habitat for spawning.
2) Determine relative contributions of mainstem spawners to overall fall chum salmon populations in the upper Tanana River.
3) Estimate stock specific run timing, migration rate, and movement patterns.
4) Characterize migration via archival radio tags that record depth and temperature information during travel.

METHODS

STUDY AREA AND GENERAL STUDY DESIGN

The study area encompassed a 440 km portion of the Tanana River drainage ranging from the mouth of the Kantishna River upstream to the mouth of the Gerstle River (Table 1 and Figure 2). The mainstem spawning areas of primary interest were located between Fairbanks and Big Delta approximately 285 km above the confluence of the Kantishna River, a known major fall chum spawning tributary. In order to primarily target those fall chum salmon destined for spawning areas in the upper Tanana River, the tagging site was located approximately 9 km above the confluence of the Kantishna River. Tagged fish were tracked by 9 stationary tracking stations installed along the river and aerial tracking surveys conducted throughout the migration season.

TAG DEPLOYMENT

Tagging Site

The radio tag deployment site was located on the north (right) bank of the Tanana River (Yukon River 1,269 rkm) in a narrow stretch of river suitable for capture of fall chum salmon using a fish wheel (Figure 2). The fish wheel used for tag deployment was operated under contract by a local fisherman who was able to monitor the wheel’s efficiency and make any necessary changes or repairs in a timely manner. Radiotagging at the fish wheel was conducted by a sampling crew of 3 people based out of a field camp 9 km downriver from the tagging site. The tagging fish wheel was equipped with a HOBO Water Temp Pro v2 Onset[1] temperature data logger fixed within the livebox approximately 2 feet under the water surface to record temperatures every 6 hours or 4

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

times per day each year of the study. Water temperatures were recorded at 0004, 0604, 1204, and 1804 hours in 2007 and 0547, 1147, 1747, and 2347 hours in 2008.

Table 1.–Remote tracking stations used to monitor fish movements including distance from tagging location, mainstem (MS) Gateway, and the distances between stations.

Remote tracking station	Description	River distance (rkm) from tagging location
Manley	Mainstem below tagging site	-65
Kantishna	Tributary below tagging site	-25
Tolovana	Tributary (gateway for Swanneck Slough)	16
MS gateway	Mainstem gateway	26
Nenana	Mainstem	114
Chena	Tributary	200
Salcha	Tributary	266
Upper Tanana	Mainstem	311
Gerstle	Mainstem	428

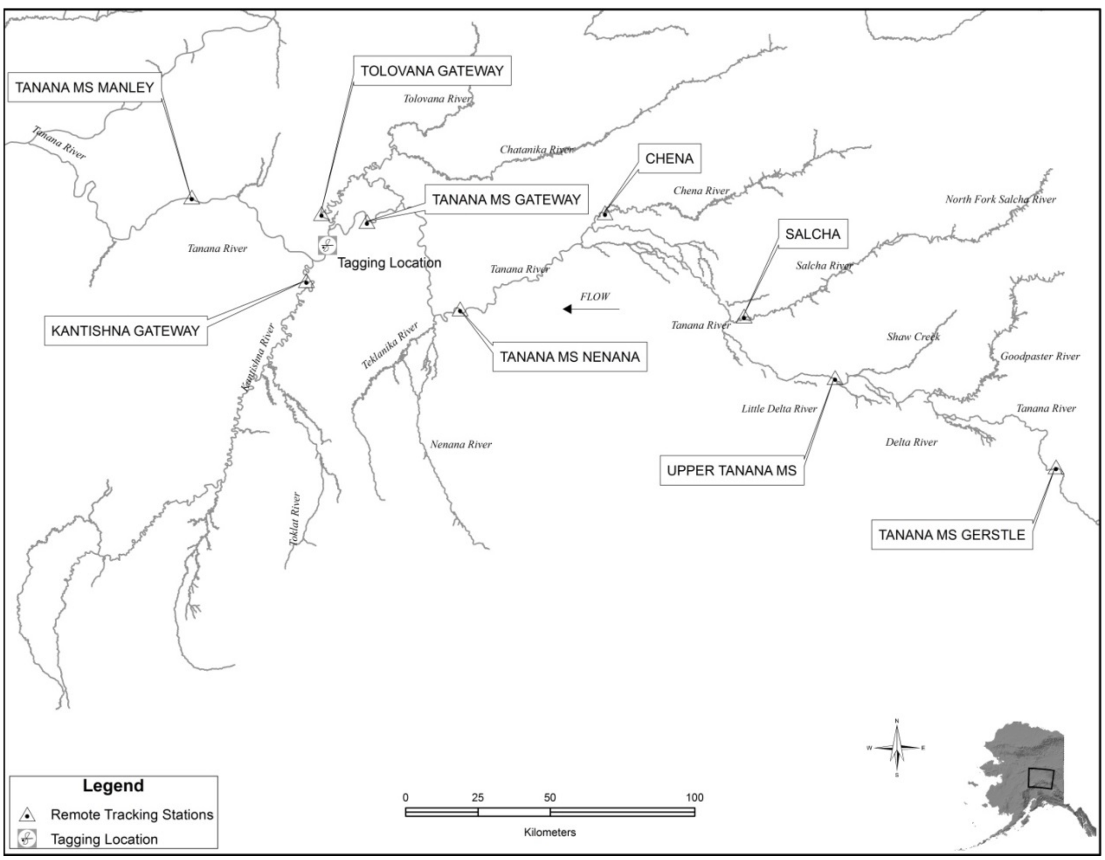

Figure 2.–Map of the Tanana River study area with locations of remote tracking stations (triangle symbols including tributary gateways and Tanana mainstem [MS]) and the tagging site (fish wheel symbol) indicated.

TAG TESTING IN A CONTROLLED ENVIRONMENT

Feasibility research was conducted in 2007 with a selection of radio tag specifications prior to full deployment. Of primary concern was possible high occurrence of regurgitation and stomach ruptures in radiotagged chum salmon this far up in the drainage (Holder and Fair 2002). Additionally, this tagging project targeted female chum salmon, which are typically smaller than male chum salmon. Because the focus of the project was spawning habitat, radio tags were applied to females because they were expected to stay and protect the redd more than males.

Three different types of internal pulse coded radio transmitters were tested: a larger diameter tag with a tapered posterior "cone", mid-sized tag with no taper, and a smaller length and diameter tag with a tapered posterior (Table 2; Figure 3). The tags consist of a micro-processor encased in electrical resin for water proofing. Typically the posterior end of a radio tag is shaped like a double AA battery, round but blunt. Extending and tapering the battery cover and components into a cone shape assisted in opening the esophagus as the tag was inserted, thereby theoretically reducing ruptures.

Transmitters were operated in the 150 MHz frequency range and were spaced a minimum of 20 kHz apart. Each frequency could carry up to 100 distinct pulse codes. Each transmitter emitted a unique frequency and pulse code combination. Battery life of transmitters was a minimum of 245 days. Transmitters also featured a built-in motion sensor and activity monitor to detect immobilization, which indicated the possibility of mortality. When no motion was detected for 24 hours, a code indicating lack of movement was transmitted. Those features made it possible to track movement and mortality of individual fish.

The radio tag was slowly guided through the fish's mouth into the stomach cavity using a plastic tube 0.7 cm in diameter which was hollow to accommodate the antenna during insertion. Each fish was also tagged externally with an orange, uniquely numbered, 14-inch spaghetti tag (Floy Tag and Manufacturing, Inc., Seattle, WA), inserted behind the dorsal fin (Wydoski and Emery 1983). An axillary process was removed as a secondary mark and retained for genetic material. Recorded information for each tagged fish included capture time, length, sex, coloration, tagger ID, qualitative comments on fish condition, and release time. Length was recorded from mid eye to fork of tail (METF), to the nearest 5 mm. Color categories were used to distinguish degree of maturation and possible assessment of whether the fish was a summer or fall run chum salmon because of overlap in run timing during the August portion of sampling. The degree of coloration was classified as either dark (blackened belly and striped sides), light (white/grey belly with pale stripes), or bright (white belly and iridescent silver sides). The entire data collection process was practiced on all the tagged fish.

Sample size was 40 female chum salmon for each tag type. After tagging, the fish were to be held in aerated totes with circulating water for 2 hours. The fish were then sacrificed and stomach necropsies were conducted to examine tag seating. This work would also be used to provide time to train the sampling crew in fish handling, data collection, and tag insertion. ADF&G and U.S. Fish and Wildlife Service personnel would collaborated on techniques of proper fish handling and tagging at the beginning of tag testing.

Table 2.–Specifications of the different radio transmitter models tested in 2007.

Transmitter model	Length (cm)	Diameter (cm)	Weight (g)	Battery life (days)	Shape
F1835B-small	4.8	1.7	16	185	Bottle with cone posterior
F1840B-medium	5.6	1.7	22	245	Bottle
F1845B-large	5.6	1.9	26	311	Bottle with cone posterior
F1840B Archival[a]	6.6	1.7	27	-	Bottle

Note: Dash indicates data was not provided by manufacturer Advanced Telemetry Systems (ATS).

[a] Transmitter model was not tested in 2007 but was used to tag a sub-sample of 35 chum salmon in 2008.

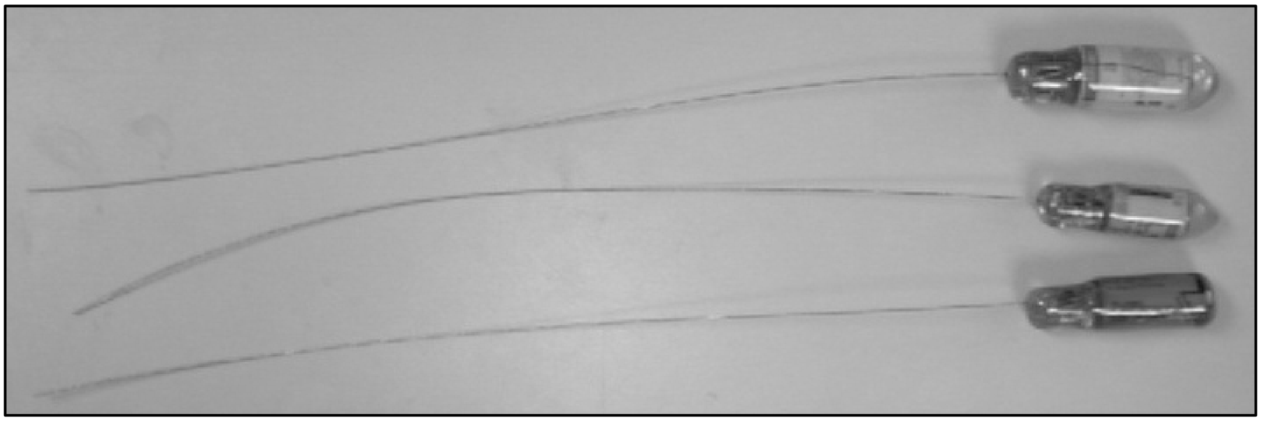

Figure 3.–Transmitter models tested in 2007: F1845B (top: large), F1835B (middle: small), and F1840B (bottom: medium).

2007 TAG DEPLOYMENT

At the conclusion of tag testing in totes, all 3 types of tags were deployed in live samples (10 fish per tag type totaling 30 live samples) released immediately over the outside edge of the boat after being sampled. Total handling and tagging time was approximately 2–4 minutes per fish. The released fish were captured on September 17 and September 19, 2007, during the peak of fall chum salmon passage. Samples were spread evenly between 2 days, with 15 female chum salmon tagged each day.

2008 TAG DEPLOYMENT

In the full deployment year of 2008, the following tag type was selected: length 5.6 cm, diameter 1.7 cm, weight approximately 22 g, and transmitting antenna length 30 cm long (Table 2; Figure 3). Additionally, archival transmitters were deployed and these tags afforded collection of supplementary migration data including date, time, temperature and pressure (depth). The pulse rate alters as the temperature changes and is sensed by an internal tag temperature sensor. The archival tags were rated down to -40° Celsius. Specifications for the pressure sensor were not provided by ATS. The archival data was recordable but was not transmittable therefore the tags had to be recovered to download. Because of the larger size of tag (Table 2), to accommodate the hardware to collect the additional data, larger female chum salmon were selected for archival tag deployment with the target of at least 570 mm in length (METF).

The tagging goal was a total of 407 (372 regular and 35 archival) radio transmitters deployed throughout the fall chum salmon run from mid-August through September, 2008. The project was designed for a 7 week tagging schedule, which was designed to cover 95% of the run, with deployment of a smaller sub-sample of archival tags skewed toward the end of the schedule in an effort to target mainstem Tanana River spawners. The preliminary tagging schedule was derived based on historical run timing from catch per unit effort information from the tagging site (Cleary and Hamazaki 2008). Inseason run timing information was available from test fishing projects located near Emmonak, Pilot Station, and Kaltag to adjust the schedule so that the radio transmitters would be deployed proportional to the run.

Chum salmon given archival tags were distinguished by a green external spaghetti tag as opposed to the orange spaghetti tag used with the regular radio tags. Sampling methods and procedures remained unchanged from those used in the 2007 radio tag deployment.

TRACKING PROCEDURES

Stationary Remote Tracking Stations

A total of 9 remote tracking stations (RTS) were installed on important migration corridors and the lower portions of major spawning tributaries throughout the Tanana River drainage (Table 1 and Figure 2). Along Tanana River mainstem, stations were located at Manley Hot Springs, MS Gateway (the first mainstem station above the tagging site), Nenana, mouth of Delta Creek (Upper Tanana), and upstream of the mouth of the Gerstle River. Major spawning tributaries with stations included the lower portions of the Kantishna, Tolovana, Chena, and Salcha rivers. The Tolovana station was also used a gateway to monitor fish migrating through Swanneck Slough. Each station consisted of a receiver (ATS R4500C model), satellite uplink (Campbell Scientific, Logan, Utah), an erected aluminum tower frame which elevated upriver and downriver antennas, and a self-contained power system composed of a battery bank connected to solar panels. Each station recorded signal strength, activity pattern (active or inactive), date, time, and the orientation of the fish in relation to the station (i.e., upriver or downriver from the station; Appendix B1). Data obtained by the receiver was transmitted every hour by satellite uplink to a geostationary operational environmental satellite (GOES) and relayed to a receiving station near Washington D.C. (Eiler 1995). The transmitted information was accessed over the Internet every 1–3 days and uploaded into a database for analysis.

The Tolovana Gateway could not be placed far enough up the tributary to bypass the connecting (Swanneck) Slough therefore some fish were able to vary their routes in a combination of ways that had to be evaluated (Appendix A1). After tagging, a fish may have continued migrating upriver and was detected first at either 1) the Tanana mainstem gateway tower or 2) the Tolovana gateway tower. If fish migrated from either of these 2 possible first contacts directly to the second tower on the mainstem Tanana River at Nenana they were included in the average travel rates (Appendix A1). Once at this location, average travel rate from Nenana to any subsequent upstream tower including tributaries was calculated. Fish were not included in travel rates if they contacted both gateways before contacting the mainstem Tanana tower at Nenana because the most direct route would be unknown. Travel rates of fish moving downstream were not included if they were already registered farther up river.

Radiotagged chum salmon that passed the upstream gateway stations were assumed to have recommenced normal movements. The stationary downstream RTS monitored tagged chum salmon that backed out or left the study area and therefore were removed from the analysis, and was used to estimate possible mortality caused by handling and tagging. When the upriver signal strength became greater than the downriver signal strength, it was assumed that the fish passed the station. A limited number of boat surveys were also conducted between the tagging site and gateway station to monitor behavior of tagged chum salmon after handling.

Aerial Tracking

Aerial surveys were conducted to determine movement patterns and final spawning locations, using fixed wing aircraft (Cessna 185 and Cessna 206) and helicopters (Robinson R44) equipped with 4-element yagi type receiving antennas mounted on both sides of the aircraft. Aerial surveys concentrated on tracking fish movements around Tanana River mainstem spawning and holding areas. In an effort to more precisely locate radiotagged chum salmon, 2 personnel performed each survey and divided the tag frequencies between 2 separate receivers. Surveys were performed approximately twice per week from August to December. The Tanana River mainstem was surveyed from Manley Hot Springs to the Gerstle River mouth. As tagged chum salmon migrated to possible spawning areas in the upper Tanana mainstem, aerial surveys focused on those areas and monitored the movement patterns of tagged chum salmon. Those tributaries with remote tracking stations were also surveyed, as were any other tributaries located near the last recorded location of a radio tag.

TAG RECOVERY

To recover radio transmitters from fishermen in the study area (particularly archival tags), letters detailing the project were sent to permit holders, flyers were posted in fishing communities, and announcements were periodically aired on local radio stations. Whenever possible, any radio tags returned by fishermen were redeployed at the downriver tagging site. Radio tags were also opportunistically recovered during concurrent salmon escapement and habitat monitoring surveys on the upper Tanana River. Weekly foot surveys were conducted in the Delta River from October to December primarily not only to estimate spawner population, but also to recover tagged fish. The foot surveys provided both ground-truthing for the aerial surveys and opportunities to recover radio tags from the Delta River. Field recovery of archival tags utilized an R44 helicopter equipped with aerial survey equipment to track locations, land remotely, and manually recover accessible tags.

DATA ANALYSIS

All radio tag tracking data were entered into ArcGIS for determination of spawning location and calculation of migration distance and speeds. Migration distance was calculated for all fish with aerial records each was assigned a distance (rkm from tagging site) using ArcGIS Network Analyst with Origin-Destination (OD) cost matrix tool (Nielsen 2010 and Will Putman, Tanana Chiefs Conference; personal communication). To determine habitat usage within the mainstem Tanana River above the confluence with the Chena River, fish observations were subdivided into 10 rkm sections.

Catch Per Unit Effort

Catch per unit effort (CPUE) for each day was calculated as:

$$CPUE = \left(\frac{c}{t}\right) \cdot 24, \qquad (1)$$

where c is the number of chum salmon captured and t is fishing time in hours converted to 24 hours per day.

Catch per unit effort was provided to fishery managers daily for comparison to historical data at this site to provide relative abundance and run timing. CPUE was also used to evaluate the proportion of tags applied to the run during this project.

Determination of Spawning Locations

At their spawning site, chum salmon select a nest site, construct a nest and redd, mate, spawn, and die in a period of 10 to 15 days (Salo 1991). Based on this general characteristic, spawning location was determined within a 1 kilometer area where a fish remained more than 14 days before mortality signal indicated the fish was dead. Within the 1 kilometer area, the location of highest signal strength was identified as the spawning location. In many of those locations, actively spawning fish were observed (Burril et al. 2010). When active spawning fish were not observed, presence of redds, carcasses, or predation was used as verification of spawning location.

Stock Timing

Stock timing was determined based on the tagging date of each chum salmon compared to the date of arrival at each fish's final spawning location and summarized relative to specific areas of the Tanana River.

Migration Rate

The migration rate ($\hat{M}$) of a fish travelling between 2 remote tracking stations was calculated as the river distance in kilometers (*RD*) between the stations over the time difference (*T*) between signals registered at the 2 stations:

$$\hat{M} = \frac{RD}{T}. \tag{2}$$

Movements between the tagging site and gateway station were not used for migration rate calculations due to possible tagging and handling effects.

Proportion of Spawners by Area

The proportion of chum salmon using specific spawning areas within the Tanana River study area ($\hat{p}_i$) was estimated by dividing the number of radiotagged chum salmon spawning in a specific tributary or mainstem location (x_i) by total number of radiotagged salmon spawning in Tanana River study area:

$$\hat{p}_i = \frac{x_i}{\sum x_i}. \tag{3}$$

The 95% confidence interval of this proportion was:

$$CI = 1.96\sqrt{\frac{\hat{p}(1-\hat{p})}{\sum x_i}}. \quad (4)$$

RESULTS

CONTROL TAG TESTING 2007

Tag testing occurred from September 7 to September 11, 2007. Fish were dipped from the fish wheel and held in an onboard aerated tote of water and driven upstream to the onshore testing site. Fish where then transferred to the tagging tote onshore (travel took approximately 10 minutes from wheel to tagging tote). After tagging, the fish were held in aerated totes with circulating water for 2 hours. Four individual totes were used for holding fish. Each group of tag sizes were tested together with the medium tags all tested first, large tags tested second and smallest tags tested last. Fish were placed in various totes without documentation specific to the tote inhabited. Of the fish tagged on September 7, 22% died in the totes; on September 8, 60% died in the totes; and September 9–11, on average, 11% died in the totes. Most of the deaths in the first 2 days of tagging were traced to a single holding tote which was believed to be contaminated by an unknown chemical. Discontinuing the use of the contaminated tote reduced the premature deaths substantially. Besides the issue with the tote, fish tagged on day 1 were also a small sample size and handling could have been affected to a greater extent during training.

All fish were sacrificed and necropsies were performed to examine tag seating. The results of tag type testing on 120 female chum salmon revealed different rates of regurgitation and stomach rupturing among the 3 tag types tested. The medium sized transmitter (model F1840B) exhibited the highest correct placement among live fish examined from the holding totes (Table 3).

Table 3.–Results from tag type testing conducted in 2007.

		Observed correct tag placements [a]				Observed regurgitations				Observed stomach ruptures			
Model	*N*	Alive[b]	%	Dead[c]	%	Alive[b]	%	Dead[c]	%	Alive[b]	%	Dead[c]	%
F1835B	40	25	62.5	6	15.0	6	15.0	0	0.0	1	2.5	2	5.0
F1840B	40	31	77.5	2	5.0	3	7.5	1	2.5	3	7.5	0	0.0
F1845B	40	25	62.5	10	25.0	1	2.5	2	5.0	1	2.5	1	2.5
All models	120	81	67.5	18	15.0	10	8.3	3	1.7	5	4.2	3	2.5

[a] Correct tag placement classified as 1) retaining the radio tag after 2 hours in the holding tote and 2) no sign of stomach rupture during necropsy.

[b] Tagged chum salmon were alive when removed from the holding totes.

[c] Tagged chum salmon had died during the 2 hours in the holding totes.

TAG TESTING IN RIVERINE ENVIRONMENT 2007

Tag Deployment

At the conclusion of tag testing in totes, all 3 types of tags were deployed in live samples (10 fish per tag type totaling 30 live samples) released on September 17 and September 19, 2007, during the peak of fall chum salmon passage. Samples were spread evenly between 2 days, with 15 female chum salmon tagged each day. The fish radiotagged and released were slightly larger than those selected during the control portion of the study (Figure 4).

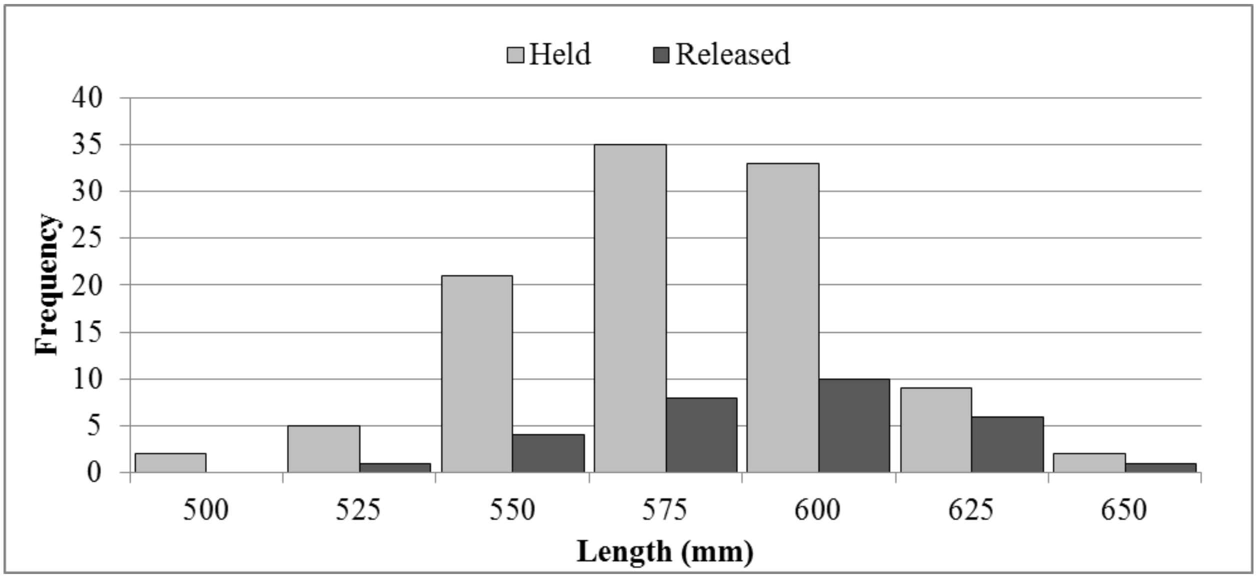

Figure 4.–Length frequency of radiotagged chum salmon in 2007.

Aerial Tracking

Twenty-two aerial surveys were conducted, approximately twice per week, from September 21 to December 6, 2007. The primary focus of aerial surveys was to evaluate the upriver progress of tagged chum salmon and monitor the performance of the different tag types. Another aspect to evaluate was the coverage needed to determine distribution of fish between the mainstem and tributaries in preparation for the full year of tagging. Surveyed areas included the Tanana River mainstem from the furthest downriver station at Manley Hot Springs to the furthest upriver station at the Gerstle River mouth. Although the surveys were concentrated on the mainstem some flights were used to confirm locations of fish in selected tributaries including the Tolovana River to the Chatanika River, Nenana River to Teklanika River, and other runoff streams such as Chena and Salcha rivers. Radio tags that continually registered near the tagging site were considered to have been regurgitated.

Of the 6 radiotagged fish not located in spawning areas, 1 fish (52470) passed Tolovana RTS on September 21, 2007, and moved downriver past the Tolovana RTS 4 days later. This fish was not located during 2 aerial surveys of the area on September 28 and October 2, 2007, or by other remote tracking stations. One fish (57109) in 2008 displayed similar movement patterns and is thought to have possibly gone up Baker Creek. Three radio tags (2 small and 1 large) were regurgitated at the tagging fish wheel, one of which was identified as harvested in the local fishery by its spaghetti tag, and 2 radio tags (both large) were recovered from fishermen in Nenana (Table 4). The remaining 24 fish migrated upriver and spawning locations were determined.

Table 4.–Fate of radiotagged chum salmon, Tanana River drainage, 2007.

Fates	No. Tags
Regurgitated (spaghetti tag recovered in fishery)	3
Reported harvest	2
Traveled to unknown locations	1
Spawning location identified by radio tag	24
Total	30

Tag Type Evaluation

The average migration rate of radiotagged chum salmon between the tagging site and the mainstem gateway station were 13.0 km/day and increased to 19.6 km/day for all tag types between the gateway and the next tower located 117 km further upstream (Nenana MS; Table 5 and Appendices B3–B5). A small number of fish were detected at the Tolovana River gateway, 1 fish with a small tag traveled 10.8 km/day, 1 fish with a large tag traveled at 8.5 km/day and 2 fish with medium sized tags also traversed this route traveling at an average of 14.0 km/day. The fish that migrated as far up as the upper Tanana mainstem tower expressed a decrease in migration rate to an average of 4.8 km/day. This reduction in migration rates was anticipated once the fish were in the spawning areas (Eiler et. al. 2004).

Comparisons of overall migration rate by tag size resulted in fish with the large and medium tag sizes traveling similarly at approximately 17 km/day, and the small tag sizes traveled slightly faster at 20.4 km/day (Table 5). Based on 50 observations the proportions of tags tracked by individual towers included 30% large tags, 32% small tags, and 38% medium tags.

Battery life of the different radio tags was examined by observing the approximate dates when signals weakened. Battery life based on the manufactures specifications were approximately 185, 245, and 311 days for the small, medium, and large tags (Table 2). Actual use in the field from the day the fish was tagged and released to the last day of aerial surveying on the spawning ground averaged 71, 76, and 86 days smallest to largest respectively (n = 24). This tracking does not include the usage of the tags during the controlled tag testing phase.

Table 5.–Migration rate (km/day) of radiotagged chum salmon between upriver mainstem remote tracking stations, by tag type, Tanana River, 2007.

Station to station		Speed	95% Confidence Interval	
Tag size	N	(km/day)	Lower	Upper
Tagging site to Tolovana Gateway				
Small	1	10.8	–	–
Medium	2	14.0	–	–
Large	1	8.5	–	–
Station to station		Speed	95% Confidence Interval	
Tag size	N	(km/day)	Lower	Upper
Subtotal	4	11.8	–	–
Tagging site to Gateway MS				
Small	7	15.5	10.1	20.8
Medium	8	12.4	6.8	18.0
Large	8	11.3	5.7	16.9
Subtotal	23	13.0	10.2	15.7
Gateway MS to Nenana MS				
Small	7	25.3	19.1	31.6
Medium	8	22.4	17.1	27.6
Large	6	24.5	19.1	30.0
Subtotal	21	24.0	21.2	26.7
Nenana MS to Upper Tanana MS				
Small	1	5.4	–	–
Medium	1	4.3	–	–
Large	0	–	–	–
Subtotal	2	4.8	–	–

Distribution of Tagged Chum Salmon

The average migration rate per tag type in 2007 was examined (Table 5); however, no appreciable differences were observed among the 3 tag types. The majority of the tagged fish migrated to spawning areas in the mainstem Tanana River adjacent to the community of North Pole upstream to the confluence of the Delta Creek (Figure 5).

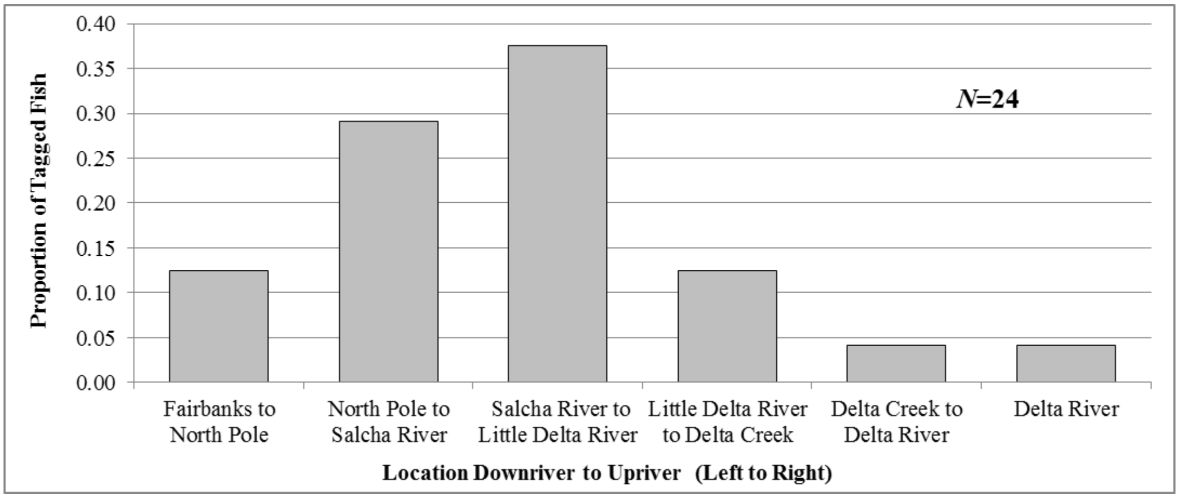

Figure 5.–Distribution of radiotagged chum salmon with final spawning locations determined, Tanana River, 2007.

FULL TAGGING SEASON IN 2008

Tag Deployment

In 2008, the number of medium sized transmitters (model F1840B) deployed was slightly ahead of the actual run timing as observed inseason by the daily CPUE (Figure 6). The Tanana River component of the fall chum salmon run being the latest stock to enter the Yukon River basically increased throughout most of the season to a pronounced peak on September 20 and decreased abruptly after September 27 (Figure 6). On the last day of operations all of the remaining tags were deployed. Run timing in 2008 was later than the 1995–2007 average, with the last pulse occurring larger in magnitude and shorter in duration as evidenced by the cumulative catch at the tagging site (Figure 7). Although females were targeted, some male chum salmon were radiotagged on the last day of tag deployment due to falling catch rates and freezing temperatures. Nine radio tags recovered from fishermen were redeployed, boosting the number of fish tagged relative to the target. Archival tags (model F1840B archival) were deployed in 35 female chum salmon between September 15 and September 26 (Table 6), during the last major pulse of the fall chum salmon migrating past the tagging site.

Table 6.–Target and actual radio tag deployment in 2008, including total weekly catch at the fish wheel from August 16 to September 28, 2008.

		Targeted deployment		Actual deployment		
Capture week	Dates	Regular tags	Archival tags	Regular tags	Archival tags	Total captured
33	10–16 Aug	5		0		5
34	17–23 Aug	41		46		181
35	24–30 Aug	37		32		274
36	31 Aug–6 Sep	39		50		368
37	7–13 Sep	65		75		367
38	14–20 Sep	91	10	89	10	938
39	21–27 Sep	94	25	65	25	632
40	28 Sep–4 Oct			20[a]		20
Totals		372	35	377	35	2,785

[a] Sampling included 10 male chum salmon and 2 unknown sex on September 28, 2008.

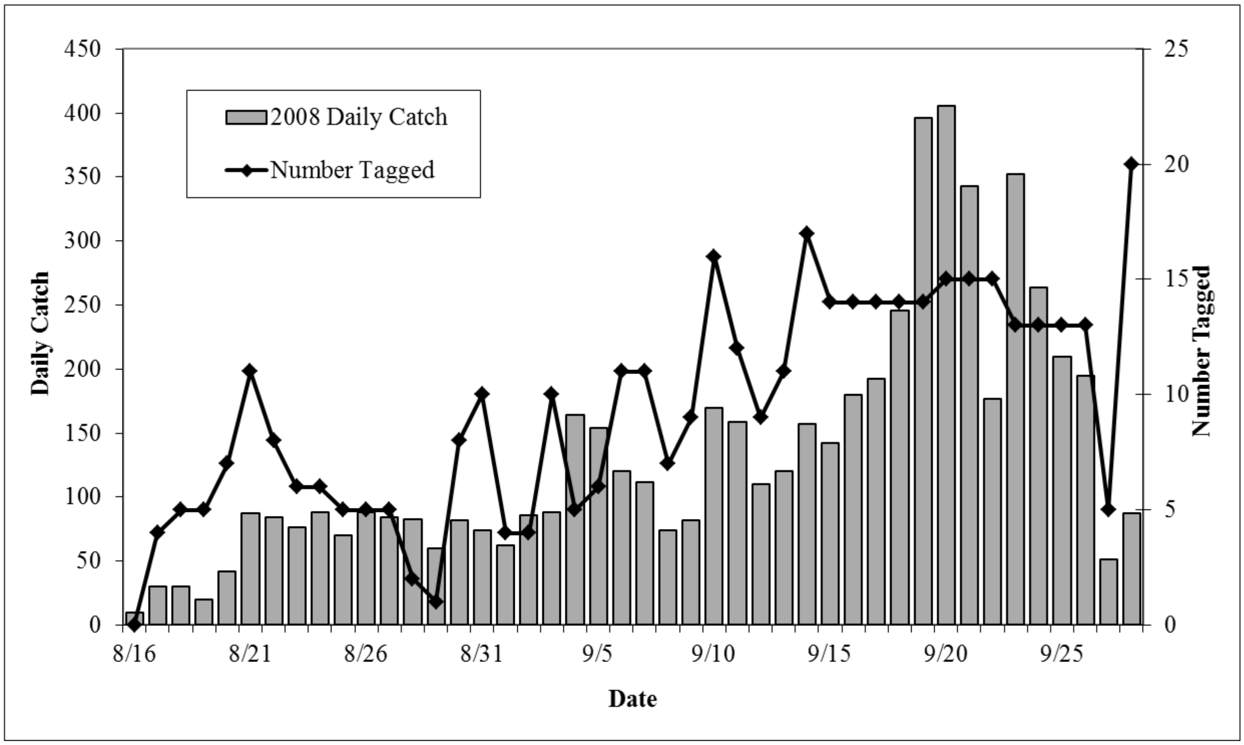

Figure 6.–Comparison of the daily catch and the number of chum salmon radiotagged each day, Tanana River, 2008.

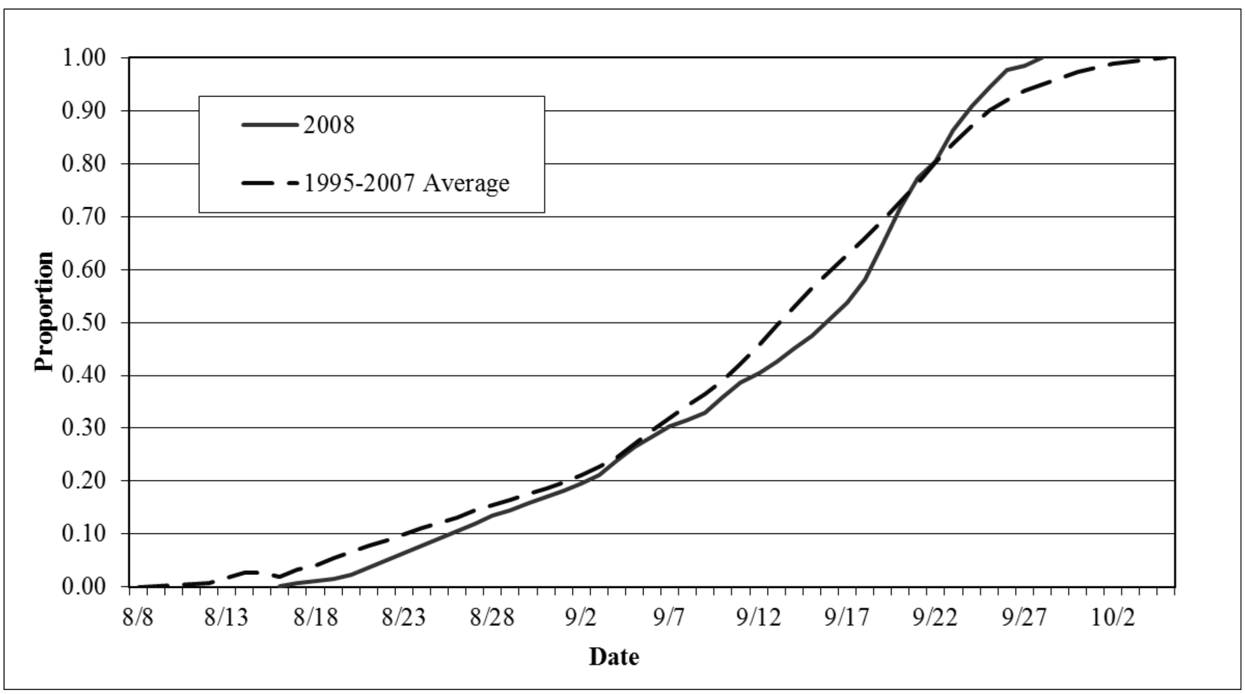

Figure 7.–Cumulative proportion of catch in 2008 compared to the historical average 1995–2007 providing run timing at the tag deployment fish wheel site, Tanana River.

Mean length of chum salmon tagged with regular radio transmitters (n = 377) was 568 mm ranging from 490 to 675 mm (*SD* = 33.1) and those with archival transmitters (n = 35) was 602 mm ranging from 570 to 635 mm (*SD* = 14.8; Figure 8).

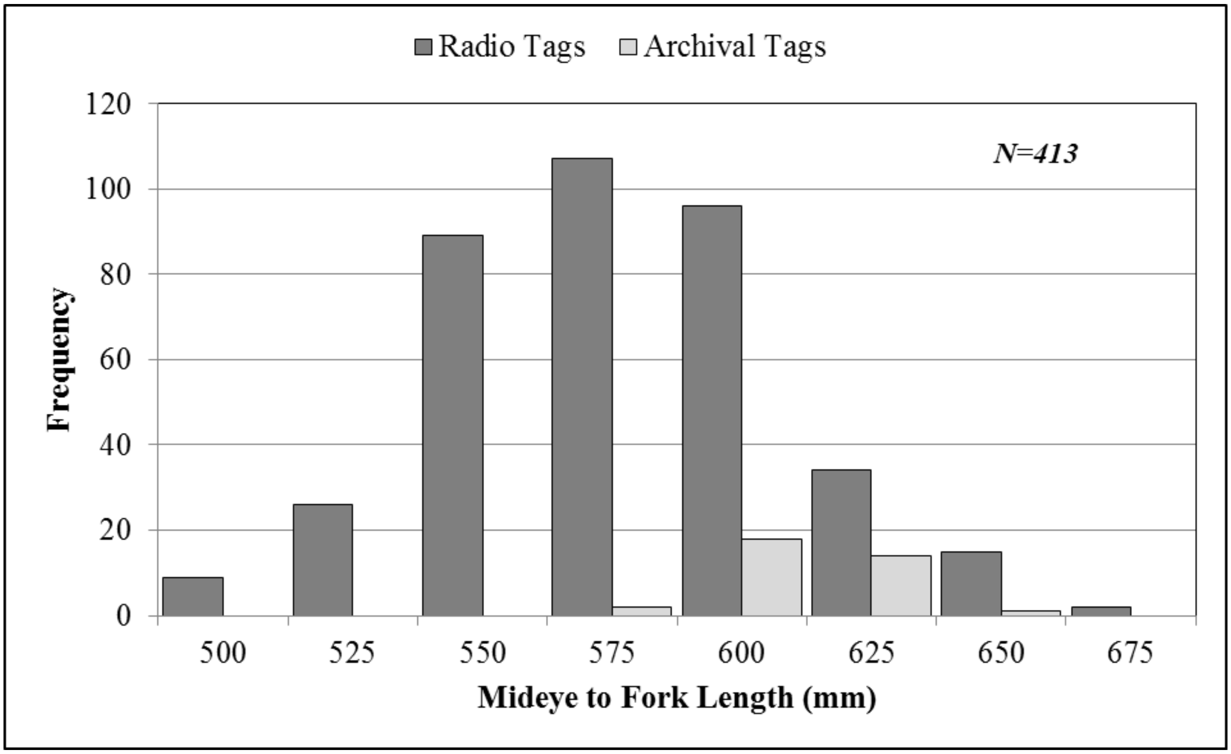

Figure 8.–Length frequency of radiotagged compared to archival tagged chum salmon in 2008.

Coloration of chum salmon at the deployment wheel was similar throughout season, except the first week which contained fewer bright fish and correlates to the week that more summer chum salmon stocks would be expected to be present. Similarly, coloration appeared relevant to comparisons with final location as well as the week tagged. Chum salmon (n = 296) bound for the Kantishna, Delta, and Goodpaster rivers and the mainstem Tanana River averaged 62% bright at the time of tagging, whereas the Chatanika, Nenana, Chena, and Salcha rivers averaged only 15% bright (Figure 9).

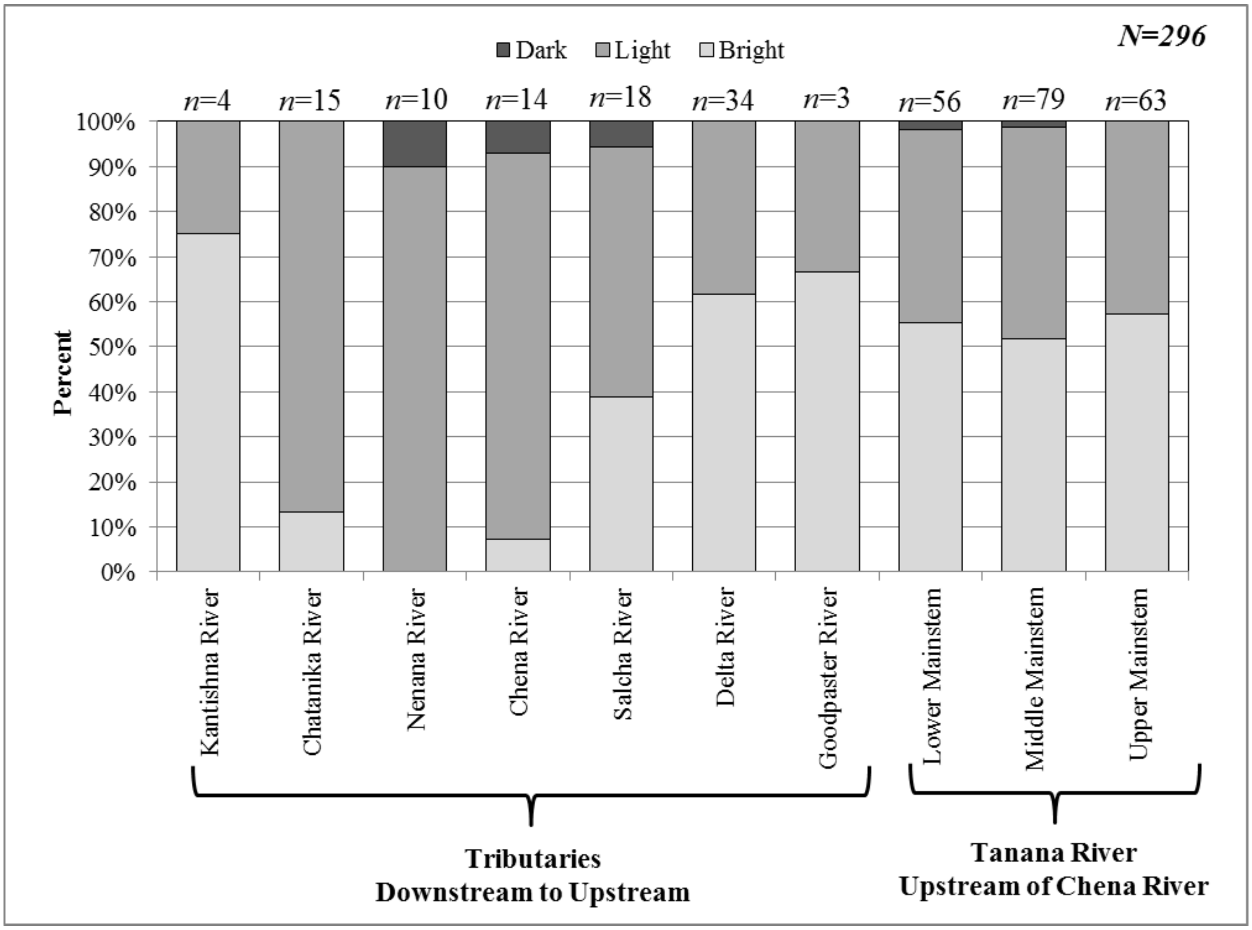

Figure 9.–Coloration of radiotagged chum salmon at the tagging site compared to the final locations in 2008.

Tag Tracking

A total of 24 aerial surveys were conducted from August 22 to December 12, 2008, to evaluate the upriver progress of tagged chum salmon and track the fish to the spawning grounds within the mainstem Tanana River. Of the 412 tagged fish, 13 were omitted due to tag malfunctions or regurgitation, and 19 moved downstream (Table 7). Of the remaining 380 fish that were detected as moving upstream, 49 were harvested (17 reported, 32 unreported), 1 moved above the survey area, and 3 were not detected again. Of the 327 fish that remained in spawning areas and were detected again, specific spawning locations were identified for 297 fish. These included 198 fish in the mainstem and 99 fish in tributaries (Appendices A2–A9). The other 30 fish did not meet the criteria for identifying spawning location and were classified as mainstem spawners with unknown spawning location. Forty-six fish were included in migration rates analysis based on tower passage although final spawning locations were not determined.

Table 7.–Fate of radiotagged chum salmon, Tanana River drainage, 2008.

Fates	No. Tags
Tag malfunction	6
Regurgitated	7
Downriver immediately [a]	3
Downriver after moving upstream initially [a]	16
Reported harvest	17
Unreported harvest (based on proximity to communities or gear)	32
Moved above survey area	1
Traveled to unknown locations	3
Fairbanks-Delta spawning location unknown	30
Spawning location identified by external tag	3
Spawning location identified by radio tag	294
Total	412

[a] Fish that backed out of the study area could indicate possible mortality caused by handling and tagging.

Tag Recovery

A total of 55 standard and 16 archival radio tags were physically recovered. Eighteen standard tags were returned from fishermen at Nenana and of these, 9 were redeployed. During escapement and habitat surveys, 25 standard tags were retrieved from the Delta River, 9 were retrieved from Bluff Cabin Slough, and 3 were retrieved from mainstem areas. Helicopter retrieval of archival transmitters began in October when aerial surveys began to detect inactivity code transmissions from a significant portion of the deployed archival tags. These efforts were successful in recovering 13 archival tags, all located in the mainstem Tanana River between Fairbanks and Big Delta (Appendix A10). Two more archival tags were recovered from fishermen near Nenana in September, and 1 additional archival tag was retrieved on a Delta River foot survey in mid-November.

Distribution of Tagged Chum Salmon

Tanana River tributaries accounted for 99 (33%) of the 297 radiotagged chum salmon that were confirmed to have spawned. Tagged chum salmon were tracked to the Kantishna, Tolovana/Chatanika, Nenana/Teklanika, Chena, Salcha, Delta, Delta Clearwater, and Goodpaster rivers (Figure 10). Recorded fish passage counts by individual mainstem tower was 9 for Manley, 371 for Mainstem Gateway, 327 for Nenana, 134 for Upper Tanana, and 1 for the upper-most mainstem tower near the Gerstle River. Recorded fish passage counts that remained in the systems by individual tributary tower were 4 for Kantishna, 15 for Tolovana/Chatanika, 14 for Chena, and 18 for Salcha. The fish that migrated to Chatanika, Chena, Goodpastor, Nenana, and Salcha rivers were considered summer chum salmon because of early migration timing (Figure 11) and observations that fall chum salmon typically do not spawn in those rivers.

Of those 234 fish considered fall chum salmon, 89% (95% CI ±5%) (n = 198) migrated to mainstem Tanana River spawning areas located between Fairbanks and Bluff Cabin Slough (Figure 10). Those consisted of Fairbanks to North Pole (n = 12), North Pole to the Salcha River mouth (n = 44), Salcha River mouth to Little Delta River mouth (n = 63), Little Delta River mouth to Delta Creek mouth (n = 16), Delta Creek mouth to Delta River mouth (n = 32), Delta River mouth to Gerstle River mouth (n = 31).

Larger clusters of radiotagged chum salmon were observed at a few select mainstem spawning areas. These included an area 5 rkm above upper Salchaket Slough (*n* = 7), 7 rkm below the Salcha River mouth (*n* = 15), 5 rkm above the Salcha River mouth (*n* = 10), Silver Fox (*n* = 13), south side sloughs between Silver Fox and the Little Delta River mouth (*n* = 15), and just above the Little Delta River mouth (*n* = 8) (Appendices A5–A6). There were also 10 tagged chum salmon concentrated in Bluff Cabin Slough and 8 located in an area approximately 2 rkm upstream of Bluff Cabin Slough (Appendix A9).

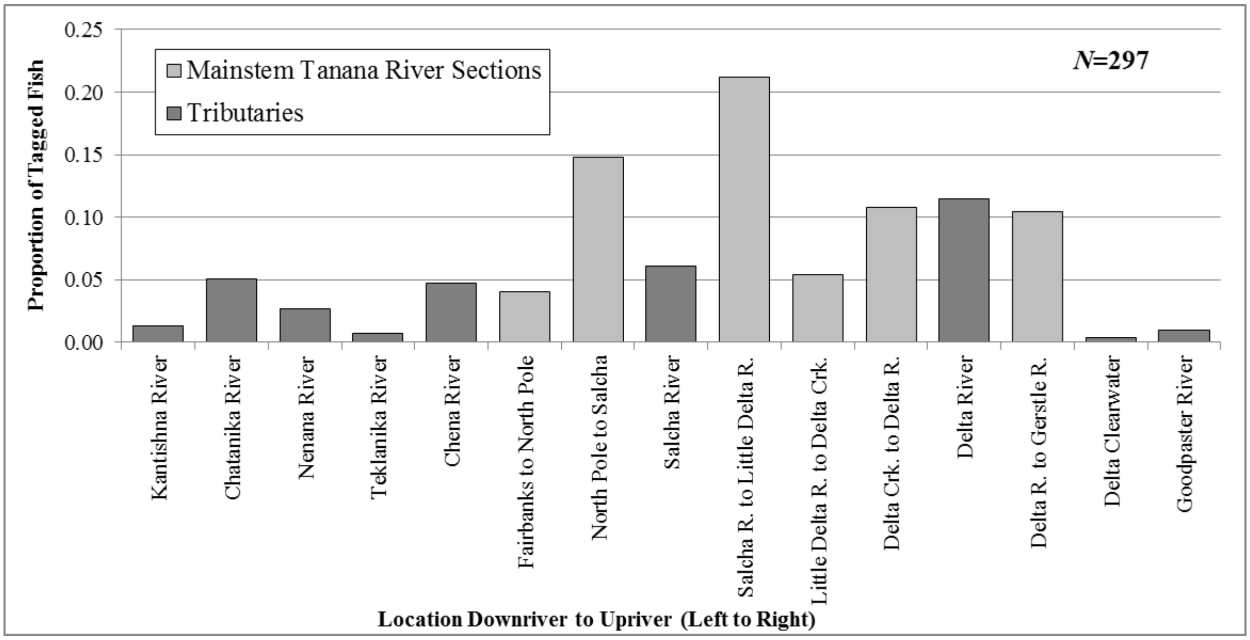

Figure 10.–Distribution of radiotagged chum salmon with final spawning locations determined, Tanana River, 2008.

STOCK TIMING

Except for Delta and Kantishna River, spawners of tributary rivers tended to migrate earlier than the mainstem spawners. The mean date of passage at the tagging site for fish destined for the Tolovana/Chatanika, Nenana, Chena, Salcha and Goodpaster rivers was August 24, 2008 and represented 20% of the stocks (Figure 11). Mainstem Tanana and Delta River stocks became dominant by early September and were the only stocks observed by the middle of September. The mainstem spawners in the uppermost section and include the Delta River stocks displayed slightly earlier run timing (mean passage date was September 9, 2008, and represented 22% of the stocks) than those of lower section (mean passage date was September 17, 2008, and represented 56% of the stocks).

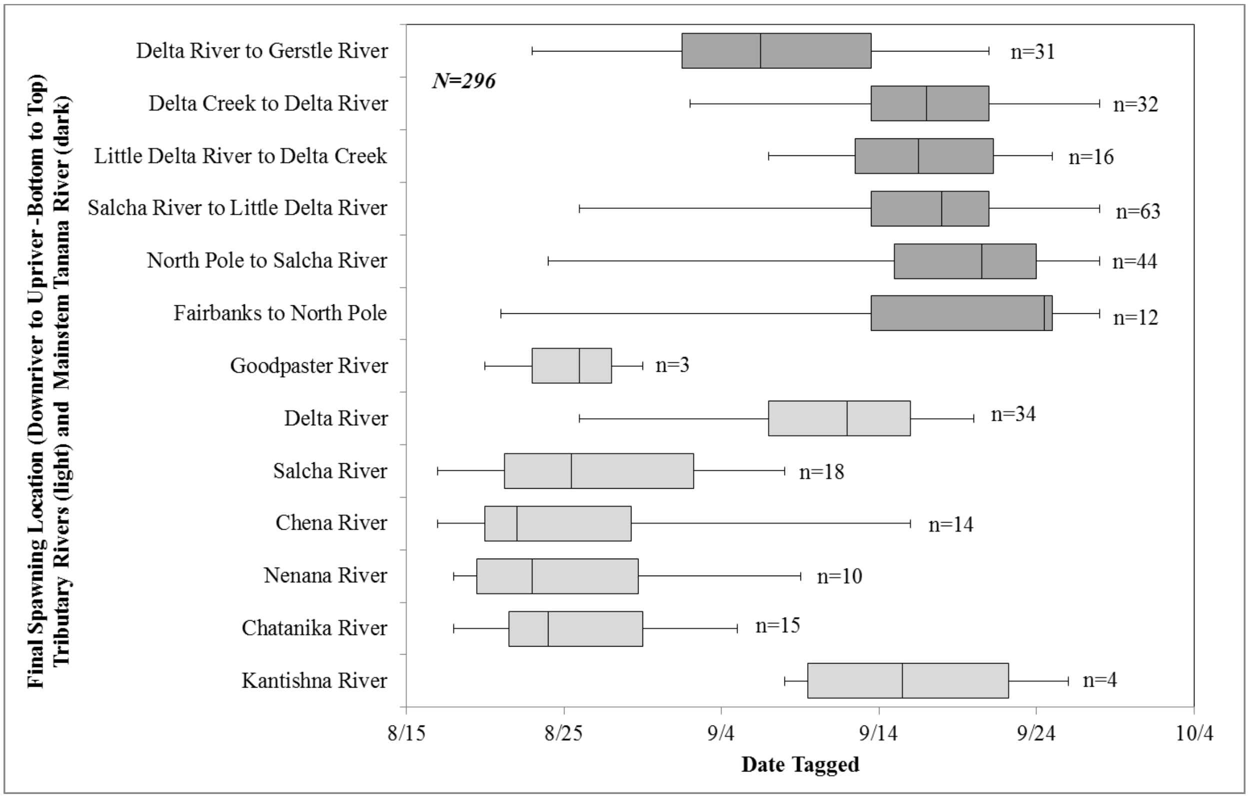

Figure 11.–Stock timing based on radiotagging date of chum salmon compared to final spawning destination, Tanana River, 2008. Error bars represent minimums and maximums, shaded areas represent 25% to 75%, and vertical line within bars represent the mean.

MIGRATION RATE

The average migration rate of radiotagged chum salmon between the tagging site and gateway station was 19.0 km/day; however, this typically represents recovery from handling (Table 8; Appendix B3). After passing the Gateway mainstem station, migration rate increased substantially. Between Gateway and Nenana mainstem stations the average migration rate was 31.2 km/day (Appendix B4). When they reached the upper mainstem spawning grounds (between the Nenana and Upper Tanana mainstem), migration rate decreased to an average of 15.2 km/day (Appendix B5). Similar patterns were also observed for spawners migration to the Chena and Salcha rivers. Spawners with archival tags also migrated at similar rate as those with standard tags.

Table 8.–Migration rate (km/day) of radiotagged chum salmon between upriver remote tracking stations (mainstem designated as MS), Tanana River, 2008.

Station to station	*N*	Rate (km/day)	95% Confidence Interval Lower	95% Confidence Interval Upper
Tagging site to Tolovana	28	24.8	19.8	29.7
Tolovana to Nenana MS	5	18.0	9.8	26.2
Tagging site to Gateway MS	369	19.1	18.4	19.9
Gateway MS to Nenana MS	320	31.2	30.5	31.9
Nenana MS to Chena River	14	28.2	25.3	31.1
Nenana MS to Salcha River	20	20.7	18.4	23.0
Nenana MS to Upper Tanana MS	134	15.2	14.3	16.1

MIGRATORY AND SPAWNING BEHAVIOR OF CHUM SALMON

In the mainstem Tanana River observations from multiple aerial surveys were used to map out the habitat usage in 10 rkm sections. Out of the 198 mainstem spawners, 94% of fish spawned in the mainstem Tanana River above the confluence of the Chena River (Figure 12 at 200 rkm). Extremely low numbers of spawners, relative to the other surrounding areas, were observed in river section 300 rkm, between Little Delta River and Delta Creek (Figure 12 and Appendix A7). Fish were categorized as migrating when there was only 1 observation per section, typically in sequence as the fish moved to their chosen spawning area where they typically remained. However, not all fish went straight to their final spawning grounds in the mainstem. Thirty-four percent of fish (*n* = 68) visited other known spawning locations in their search for their final destination (Figure 12). Of those 68 fish, 40% (*n* = 27) were observed multiple times in more than 1 nonconsecutive sections of the spawning area between Fairbanks and the Gerstle River. The majority of the multiple observations were observed between the confluence of the Salcha River and upper Tanana Mainstem tower (Figure 12 between 260–290 rkm). In contrast, all tributary spawners moved into their natal tributary without staying in mainstem locations.

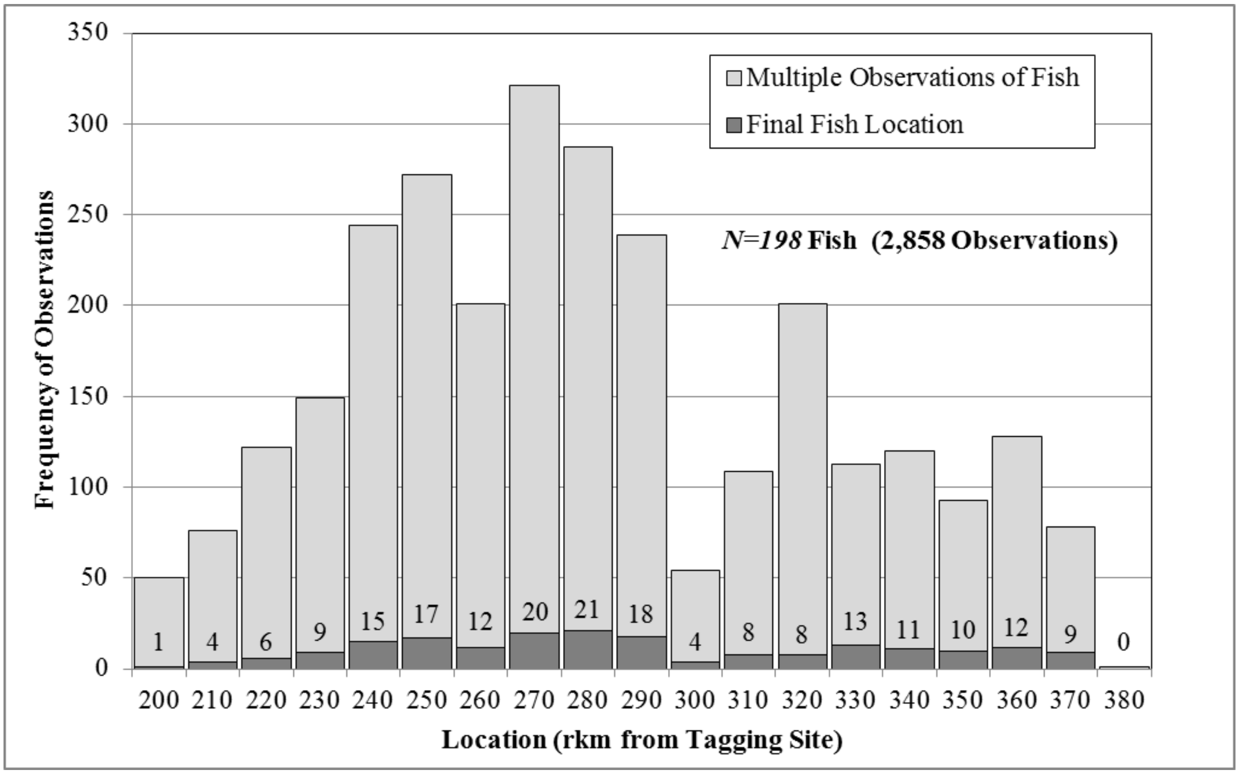

Figure 12.–Frequency of locations fish were observed in the mainstem Tanana River relative to river kilometer from tagging site, including final spawning location, 2008.

ARCHIVAL TAGS

Most archival tagged chum salmon were found in shallow water areas by early October (Appendix B6). Temperatures in these shallower waters ranged from -0.5 to 3.5 °C during the month of October. By late October, most tagged chum salmon spawning in the mainstem were transmitting inactivity codes signifying mortality. Thirteen tags were recovered during 3 flights on October 23, 25, and 30, 2008; all were found separated from the host. The temperatures registered by the archival tagged salmon during migration up the Tanana River were similar to the temperatures logged at 2 test fish wheels on the mainstem Tanana River (Appendix B7).

Depth profiles showed that the fish ranged from 12.1 m to the surface and the median depth of travel was 0.60 m. During the first 7 days of travel (since tagged), although the fish were observed at greater depths on occasion, these fish (n = 13) spent up to 85% of their time in water less than 1 m in depth (median 65%). The archival tagged fish traveled in less than 2 m of water 9% to 37% of the time with a median of 23% and proportions continued to drop to less than 2% at 5 m (Figure 13). The archival tags presented a profile of the Tanana River throughout the migration route with some of the deepest transects occurring between the tagging site and 114 km upstream and as the fish moved up river to the spawning areas their trajectories became increasingly shallow. Nine of 13 archival tagged fish transitioned to greater depths while traveling in the vicinity of the tower located on a bluff 3 bends upstream of the community of Nenana (Tanana MS Nenana; Figure 2). During the 24 hours the fish traveled through this area the median depth was 3.8 m and the median of the maximum depths was 8.5 m (Appendix C7).

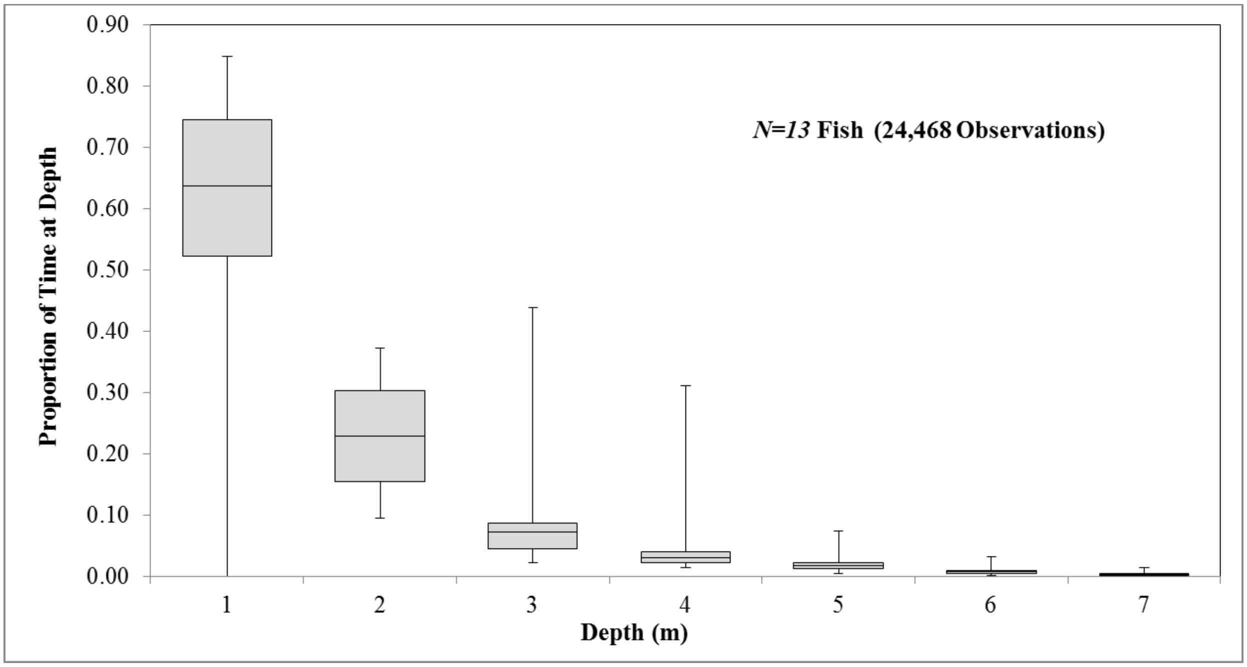

Figure 13.–Proportion of time traveling at depth (m) based on the first 7 days of travel from the tagging site to approximately 192 km upstream for 13 archival tagged chum salmon, Tanana River, 2008. Error bars represent minimums and maximums, shaded areas represent 25% to 75%, and horizontal lines within bars represent the mean.

Case Study (Fish Number 21957)

The archival tagged chum salmon (fish 21957) not only migrated through the majority of the study area but also provided unique temperature and depth profiles from 2 unique spawning areas in the upper reach (Figure 14; Appendix B6, page 3). October was spent in the Tanana mainstem near Rika's Roadhouse (a known spawning area) in waters ranging from 0.0°C to 5.8°C. In late October, fish 21957 then migrated a short distance down the Tanana River and ascended the Delta River, another known spawning area; it remained in these waters ranging from 2.5°C to 4.9°C until mid-November and then expired. This fish may have spawned in both locations Rika's or the Delta River where it was found spawned out. Some archival tagged chum salmon recorded depth readings above zero (Figure 14), which partially has to do with the tags ability to record pressures in very shallow waters. In areas like the Delta River, the salmon's dorsal side becomes exposed out of the water while traversing and/or spawning in shallow water.

Movement of fish searching for spawning areas is no more evident than examples like fish number 21957 that moved upriver and then down river and then again upriver (Figure 15). Six salmon in the vicinity of the upper Tanana tower traveled past that tower a minimum of 3 times (up-down-up) and 29 fish were recorded moving upstream of this tower then subsequently traveled downstream, past the tower again (Appendices A10, A12–A13).

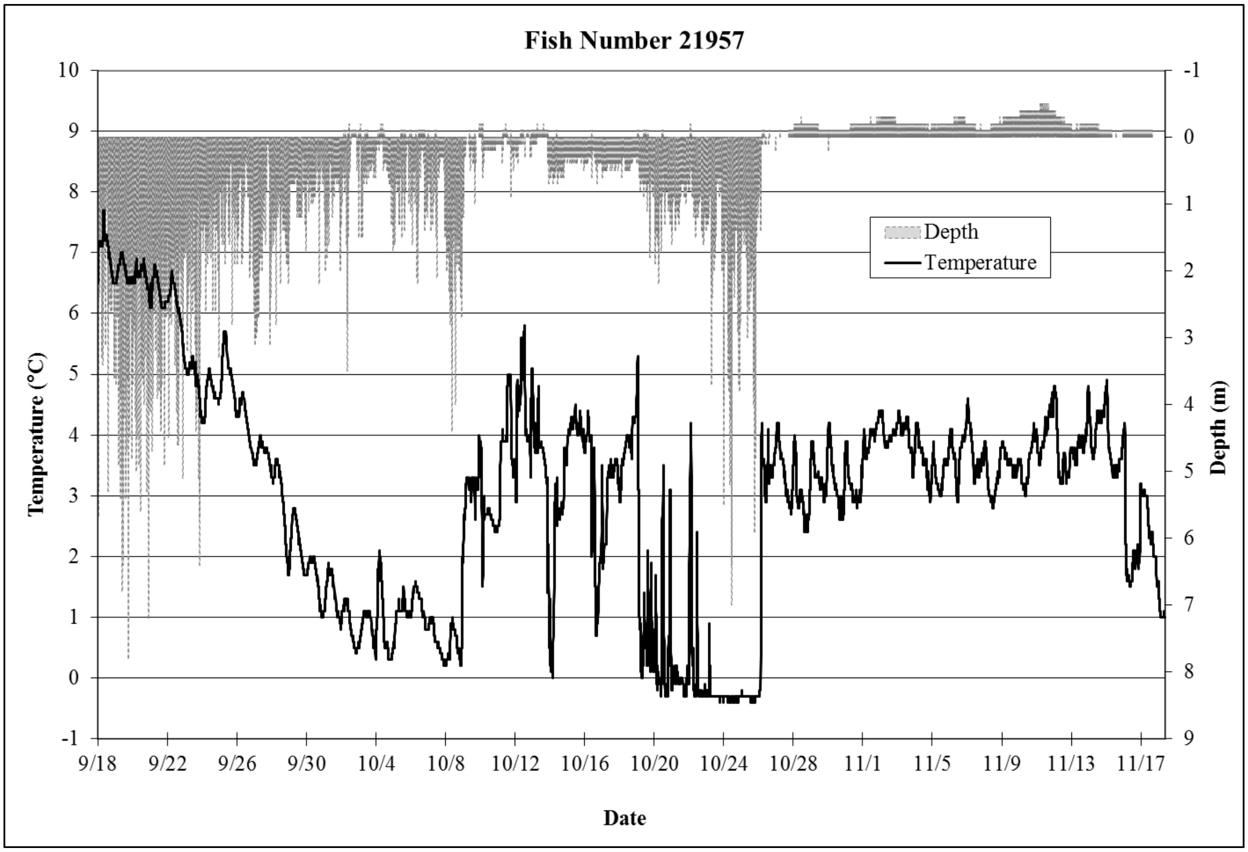

Figure 14.–Temperature and depth profile of an archival radiotagged chum salmon that spawned in the Delta River, 2008.

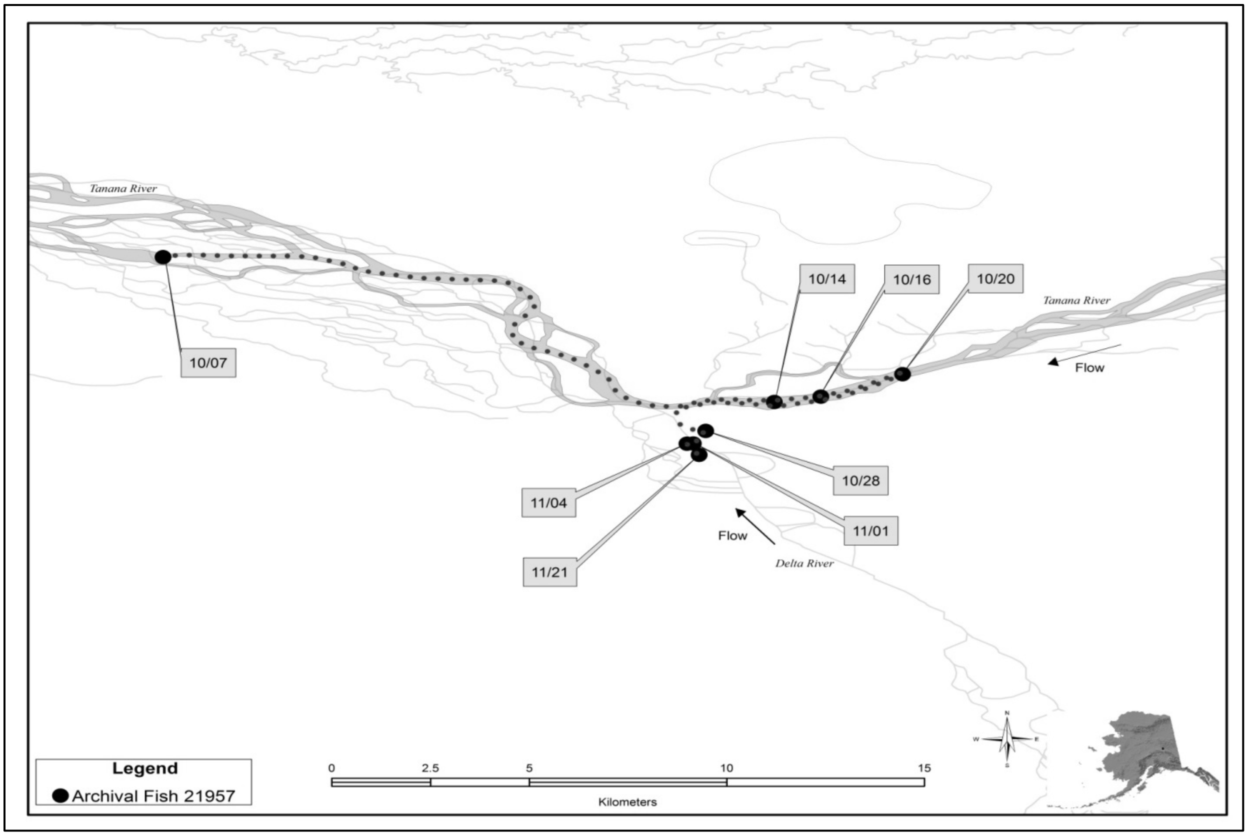

Figure 15.–Movement pattern of fish number 21957 as it approached the final spawning area, Tanana River drainage, 2008.

DISCUSSION

This report includes the tag testing phase in 2007 as well as the full scale study conducted in 2008 because many of the procedures are the same. Selection of tag type to use in the 2008 full deployment portion of the study was based on the combination of tag size relative to seating in the fish and battery life. The small tags had a slightly higher chance of regurgitation and the shortest time period in which to conduct the study. The large tags had a slightly higher chance of rupturing the stomach during the tagging procedure, although they would have sufficient battery life for the duration of the project. The medium sized tag was chosen for use in the 2008 study based on its optimal size for the species, life stage, and distance traveled thus far relative to distance yet to travel to possible spawning locations. Though small and medium tags exhibited nearly the same battery life during the field test, they were not deployed during the full-time frame as would occur in the 2008. The added battery life of the medium tag also was considered due to concerns for the cold temperatures that would be encountered.

During the course of selecting fish from an operating fish wheel, 12 tagged fish were recaptured in 2008; however, all recoveries occurred on the same day they were originally tagged. Fish were released on the outside (river side) of the fish wheel and boat platform but typically go downriver on release and once reoriented they swim back up along the riverbank side and become susceptible to recapture. Nothing in the related fish capture data indicates any specific cause for increased probability of recapture. One of the recaptured fish turned around and migrated downriver past the Manley tower out of the study area, and the remainder continued their migration up river past the gateways at Tolovana or Tanana mainstem. Several of the fish went into tributary spawning areas, in the Chatanika and Chena rivers, and a couple fish were located in the mainstem spawning areas upstream of Fairbanks.

Chum salmon radiotagging and tracking methods were effective in locating final spawning locations of chum salmon in a challenging study area. A sufficient number of aerial surveys were conducted in 2008 in order to document upriver migration and movement patterns of tagged chum salmon, which was essential in determining final spawning areas. Remote tracking stations were successful in detecting 96.8% of radiotagged chum salmon in 2008, and upriver tower passage records showed that over 95% of tagged chum salmon resumed upriver migration from the tagging site. Tagging and handling had an effect on migration rates initially, but tagged chum salmon appeared to recover quickly, based on the increased migration rate observed between the mainstem gateway and Nenana mainstem stations (Table 8). As tagged chum salmon neared spawning areas upriver, migration rates decreased. Fish that were observed 3 or more times within a 10 rkm section were considered slowing down in pursuit of a place to spawn. Thirty-four percent of the fish were observed in more than one 10 rkm section, which could be a result of the binning because 79% of the locations were consecutive; however, the remaining 21% of multiple locations observed were not consecutive (Figure 12). An observed decrease in migration rates as tagged salmon approach their natal streams has been commonly observed in radiotelemetry projects, including a study examining radiotagged Chinook salmon in the Tanana River drainage (Eiler et al. 2004). The overall slower migration rates observed in 2007 are probably attributed to the higher water levels that occurred in September 2007 compared to those in 2008 (Appendix B2).

Travel rates and depths of travel can be affected by high water events as well as water temperature. The water column of the Tanana has been observed to be fairly well mixed with small perturbations occurring in a diel pattern associated with high levels of glacial melt in the summer. These observations have been maintained by ADF&G by measuring water temperatures at field projects, in this case using 2 fish wheels operating in the Tanana River over many years. The temperature logger on the tagging fish wheel, located approximately 5 rkm below the confluence with the Tolovana River on the same bank in 2008, may have been influenced from the heat sink draining the Minto Flats area through the end of August. High and low temperatures ranged up to 6 degrees, whereas another fish wheel site farther upstream was typically within a degree. The second fish wheel was located 78 rkm upstream of the tagging site on the right bank of the Tanana River and was operated with digital fish counting equipment and was also outfitted with a similar water temperature data logger. The confluence of the Nenana River is located on the left bank another 28 rkm upstream therefore the water should be fairly mixed. Also the Nenana River is partially glacial which matches the majority of the systems that contribute to the temperature profile of the Tanana River. Through the month of September both the site’s daily highs and lows were within a degree of each other as fall weather cooled down the entire drainage.

One concern using the archival tag is whether the tag is recording the ambient temperature of the water or registering heat generated by muscles of the fish in the act of the swimming. Results from this study showed that external water temperatures were similar to those taken from within the archival tagged chum salmon but could be related to the narrow temperature range within the mainstem Tanana River at that time of year (Appendix B7). Additional calibration tests of the archival tags would need to be conducted to confirm (John Eiler, National Oceanic and

Atmospheric Administration, U.S. Department of Commerce; personal communication). Temperatures at the video fish wheel indicated the coolest temperatures on average for July, August and September occurred during 0900–1500 hours and the warmest temperatures occurred during 2100–0300 hours recordings. During the operations of this site in 2003 mean hourly proportions of fall chum salmon passage were tallied from the video monitoring project (Borba 2007) and it was noted that the lowest passage rates occurred overnight, whereas the passage rates were highest during the daytime hours. Temperature may play a bigger role in diel patterns of migration than daylight in the Tanana River because the turbidity from silt and long hours of daylight at this latitude during migration. Spawning ground temperature regimes are covered in (Burril et al. 2010 and South 2010).

This study documented fall chum salmon spawning in a large segment of the upper Tanana River mainstem in 2007 (Appendix A2) and 2008 (Appendices A3–A10). Active chum salmon spawning was documented in the Tanana mainstem from Fairbanks to the Delta Clearwater Creek mouth while searching out locations for habitat monitoring sites used in the companion studies (South 2010 and Burril et al. 2010). The spawning sites located by this project provided more intensive ground verification of chum salmon spawning in the mainstem Tanana River than has been previously collected. The areas identified for habitat monitoring had relatively small concentrations of spawning fall chum salmon but are believed to be representative of the numerous mainstem spawning areas that exist in the upper Tanana River. Additional mainstem areas containing congregations of chum salmon were observed during aerial surveys that were probably used for spawning, but not all of these were thoroughly investigated due to time, cost, and weather constraints.

The distribution of tagged chum salmon to the Delta River was only 10.6% compared to 67.9% for the Tanana mainstem (Figures 10 and 11), which is near the average proportion (11.1%) observed in the Delta River based on the upper Tanana River mark–recapture estimates from 1995–2007 (Cleary and Hamazaki 2008). The Delta River escapement is currently monitored as an index area. The Delta River population estimate in 2008 was 23,055 fall chum salmon based on the area-under-the-curve constructed from the weekly foot surveys conducted from October to December (JTC 2016). The distribution of radiotagged chum salmon in 2008 shows that upper Tanana River fall chum salmon stocks are composed primarily of mainstem spawners, with the most significant spawning populations between Fairbanks to just upstream of the Delta River confluence (Figure 10). Results from this project support the assumption of Barton (1992) regarding the important role mainstem habitats play in fall chum salmon production in the Tanana River. The percentage of radiotagged chum salmon identified as mainstem spawners in 2008 was 85%, which was similar to 82% estimated in the 1989 radiotelemetry study (Barton 1992). Similarly, large proportions of chum salmon spawning in mainstem habitats have been documented in other river systems using radiotelemetry. In a study on the Taku River in Southeast Alaska, 94.1% of radiotagged chum salmon spawners were located in braided portions of the mainstem (Andel 2010).

Tracking data suggests that individual fall chum salmon may explore multiple areas of the upper Tanana mainstem before selecting a spawning site, as evidenced by some radiotagged chum salmon that displayed upriver and downriver movements along the mainstem between different observed spawning congregations (Figures 12 and 14). It is unknown if females spawn in more than 1 location even though fish 21957 spent a considerable amount of time in 2 known spawning locations (Figure 14). These movement patterns could be indicative of milling behavior dictated by river conditions and time spent ripening. Water levels and turbidity change drastically from September through October probably affecting the suitability and availability of spawning sites in the mainstem Tanana and Delta rivers as the glacial influence subsides.

Chum salmon are primarily bank oriented (Crane and Dunbar 2011); however, they do traverse from deep cut banks to point bars as the river sinuates or they may cross the thalweg at some depth to change banks altogether. Travel depth is probably influenced by river morphology because flows may be increased when the river is constricted to 1 channel or because hardened surfaces, such as a bluff affecting the vertical shape of the channel. For purposes of interpreting the archival depth information consider the profile of the Tanana River. In the study area upstream of the tagging site, the Tanana River consists of moderate braiding with large islands and sandbars at every bend. Through this area the land elevation is less than 122 m. The Tanana River near the community of Nenana is constricted to 1 channel at several locations along the bluffs on the right bank, which range up to 488 m in elevation, and the deepest forays by the fish were generally observed within this lower reach. Upstream of the community of Fairbanks, the Tanana River becomes highly braided with more numerous sandbars within a broader floodplain corresponding to the shallower depths the fish traversed based on the archival tags. Significant bluffs (518 to 610 m elevation) that the river runs up against also occur on the right bank between Little Delta River and Delta Creek. The next significant feature is the bluffs on the right bank (305 m elevation) at the confluence of the Delta River which fish were observed traveling deep (7 m) in this vicinity (Figures 14–15 and Appendix A9). As noted in Figure 12, there was an absence of fish tracked to rkm 300 for spawning similar to that observed in an earlier study (Barton 1992). This area also has prominent bluffs on the north bank, but at this location the channel is highly braided and the river is not constricted to single channels like the bluffs in the vicinity of Nenana.

The data obtained by this project detailing fall chum salmon distribution and spawning habitat utilization in the mainstem upper Tanana River has important management and conservation applications. Limiting commercial harvests to below the confluence of the Chena River located near Fairbanks is appropriate, and although it could be best practices not to allow harvests within a spawning area, a personal use fishery continues upriver within the mainstem Tanana River. Locating and characterizing mainstem spawning areas is an important step towards improving our understanding of fall chum salmon habitat requirements in the Tanana River.

The results of this study can also be applied to the responsible development of resources in the area by providing more adequate protection to those mainstem reaches of the Tanana River where spawning has been documented. Conservation of Tanana fall chum salmon stocks greatly depends on the preservation of the upper Tanana River mainstem spawning habitats characterized by this study.

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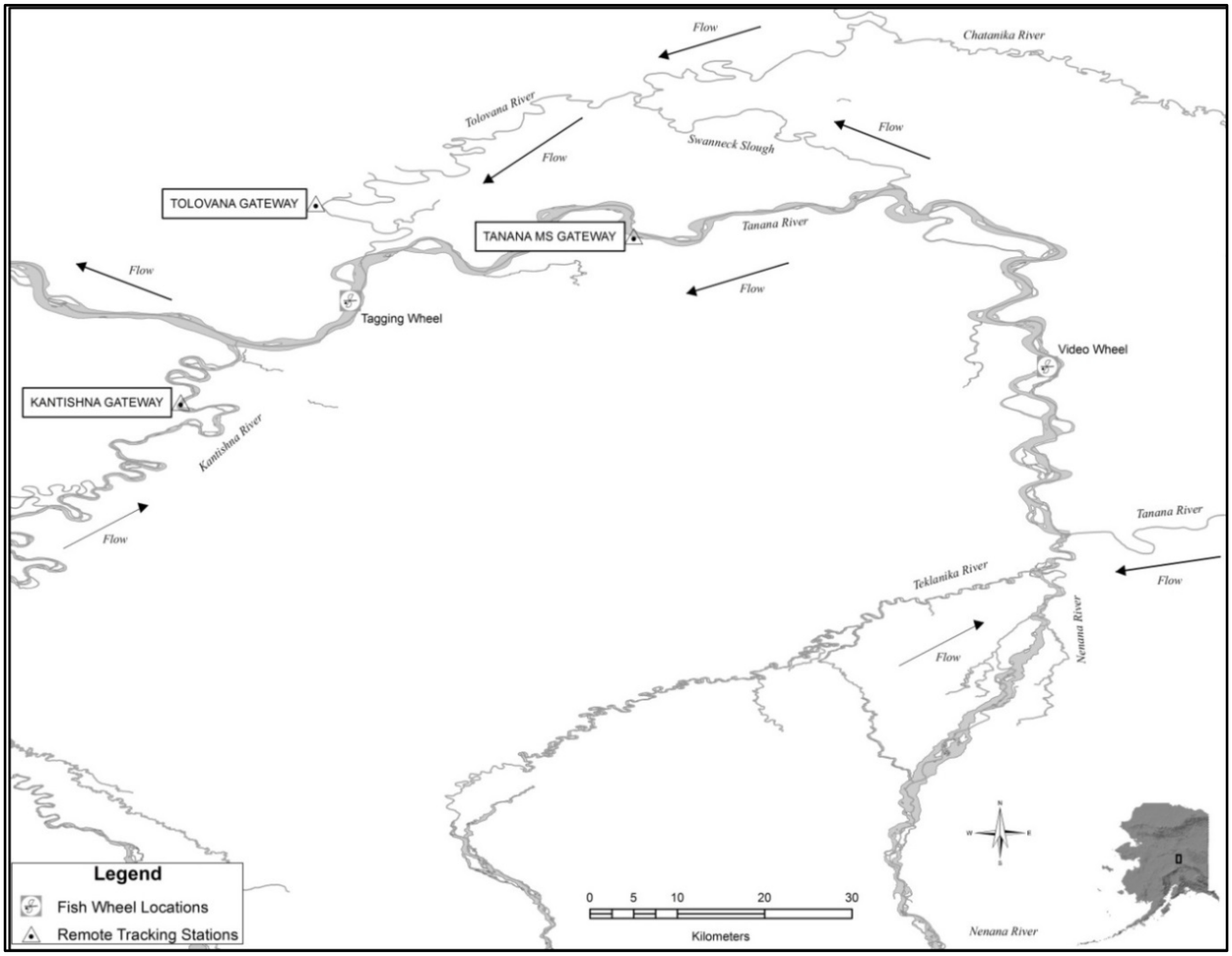
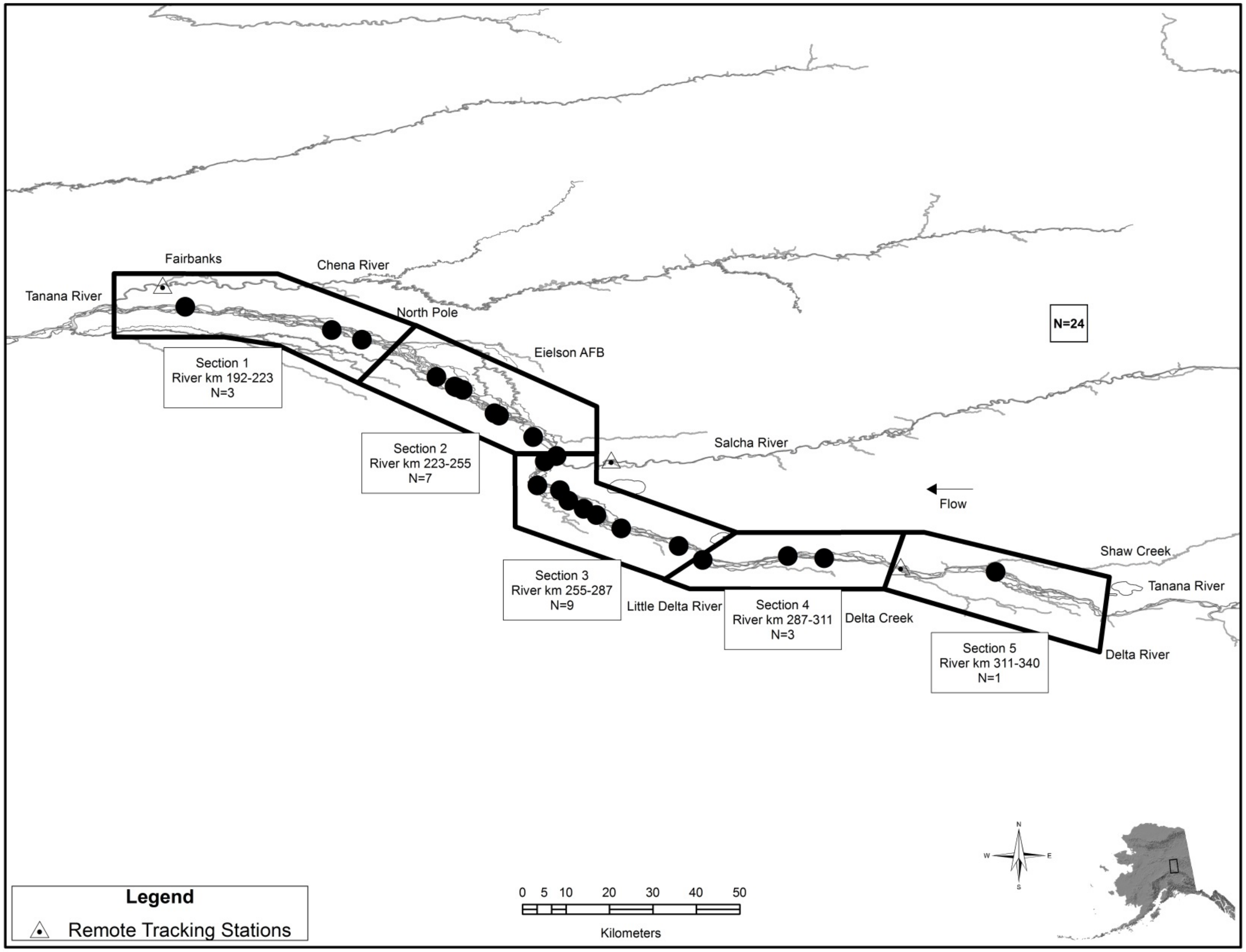
APPENDIX A: DISTRIBUTION AND MOVEMENTS OF TAGGED SALMON

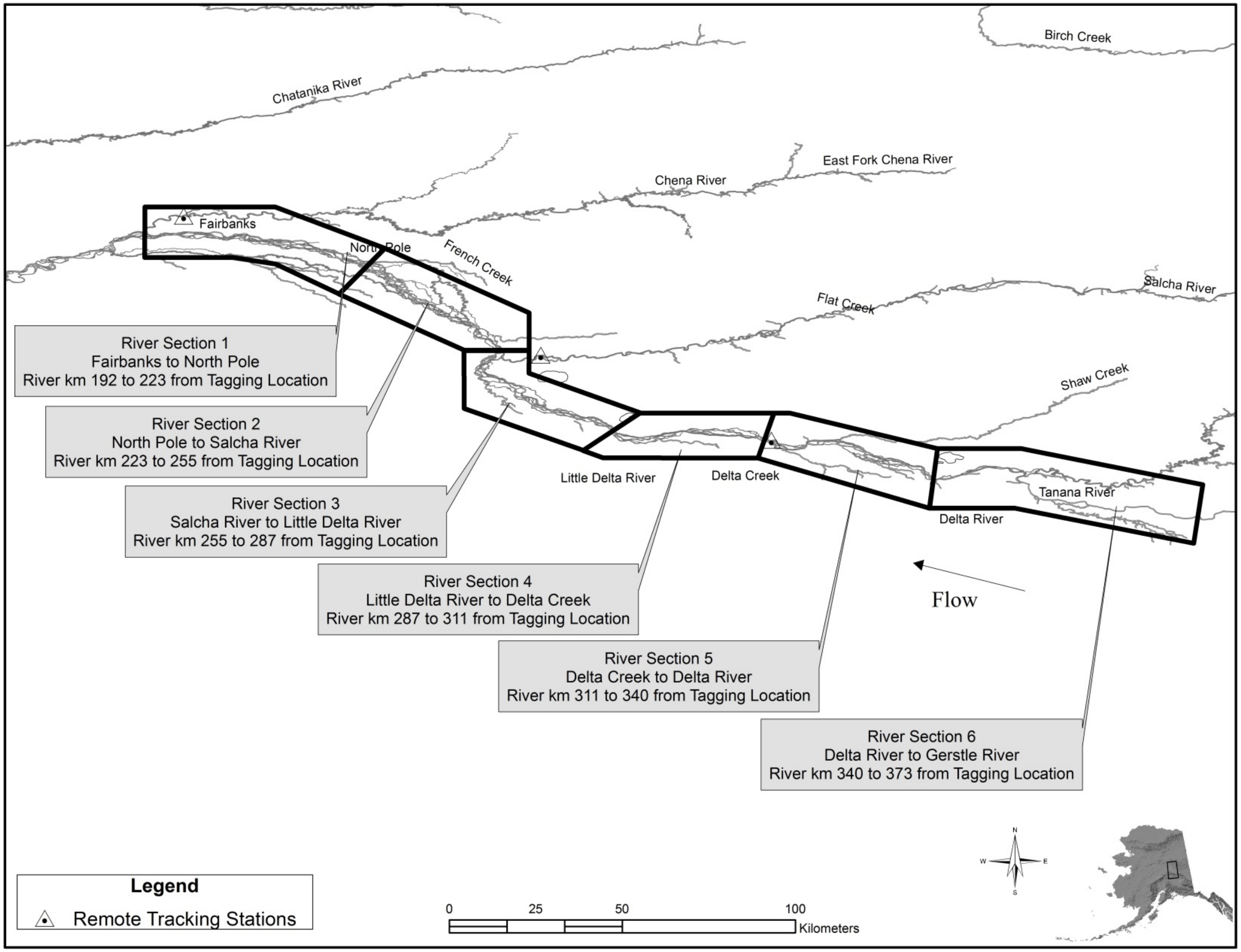
Appendix A1.–Map of a section of the Tanana River showing the telemetry tagging locations relative to 3 gateway towers including the alternate route via the Tolovana River to the mainstem Tanana River, 2007–2008.



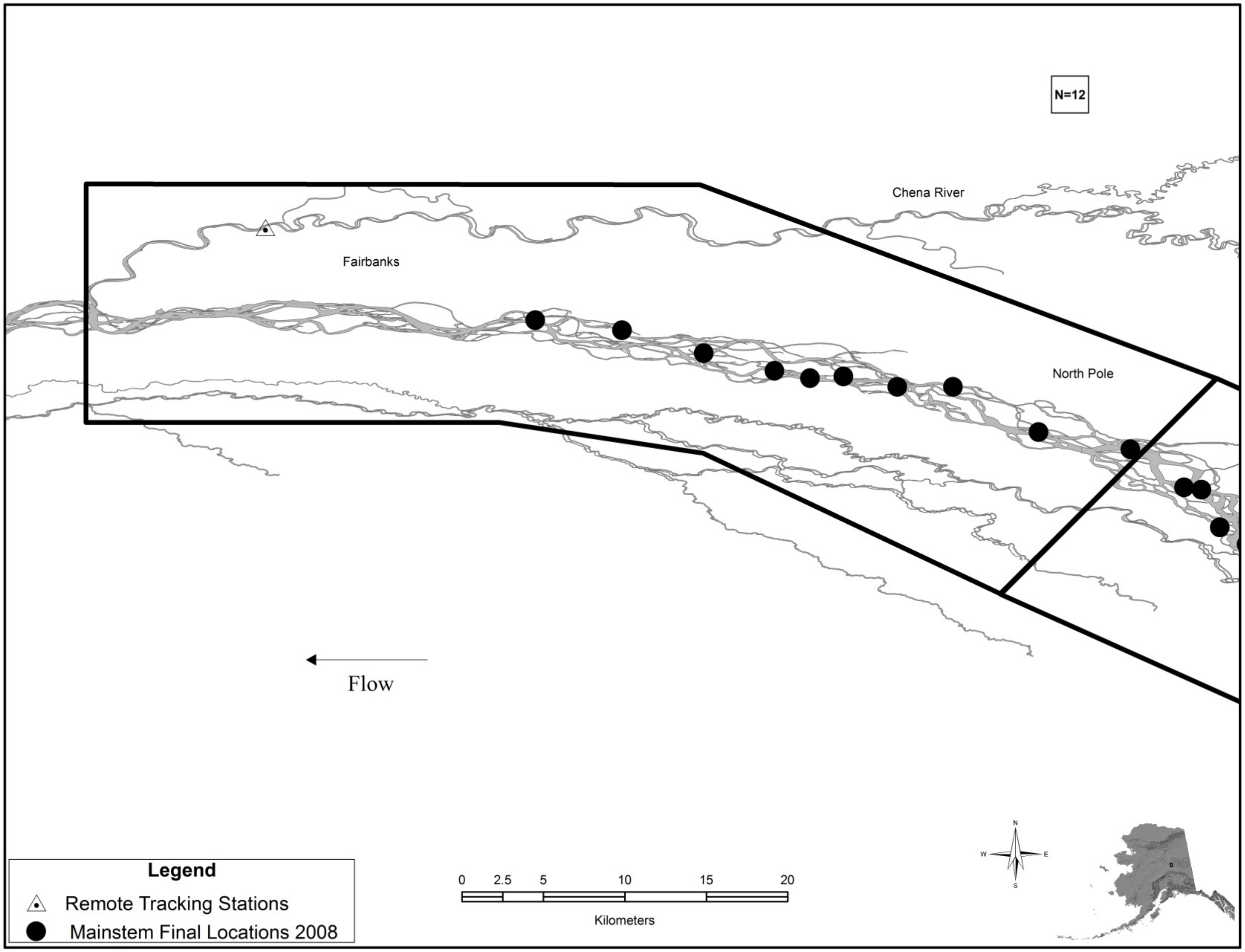
Appendix A2.–Distribution and final spawning locations of radiotagged chum salmon in the Tanana River between the adjacent community of Fairbanks to the Delta River, 2007.



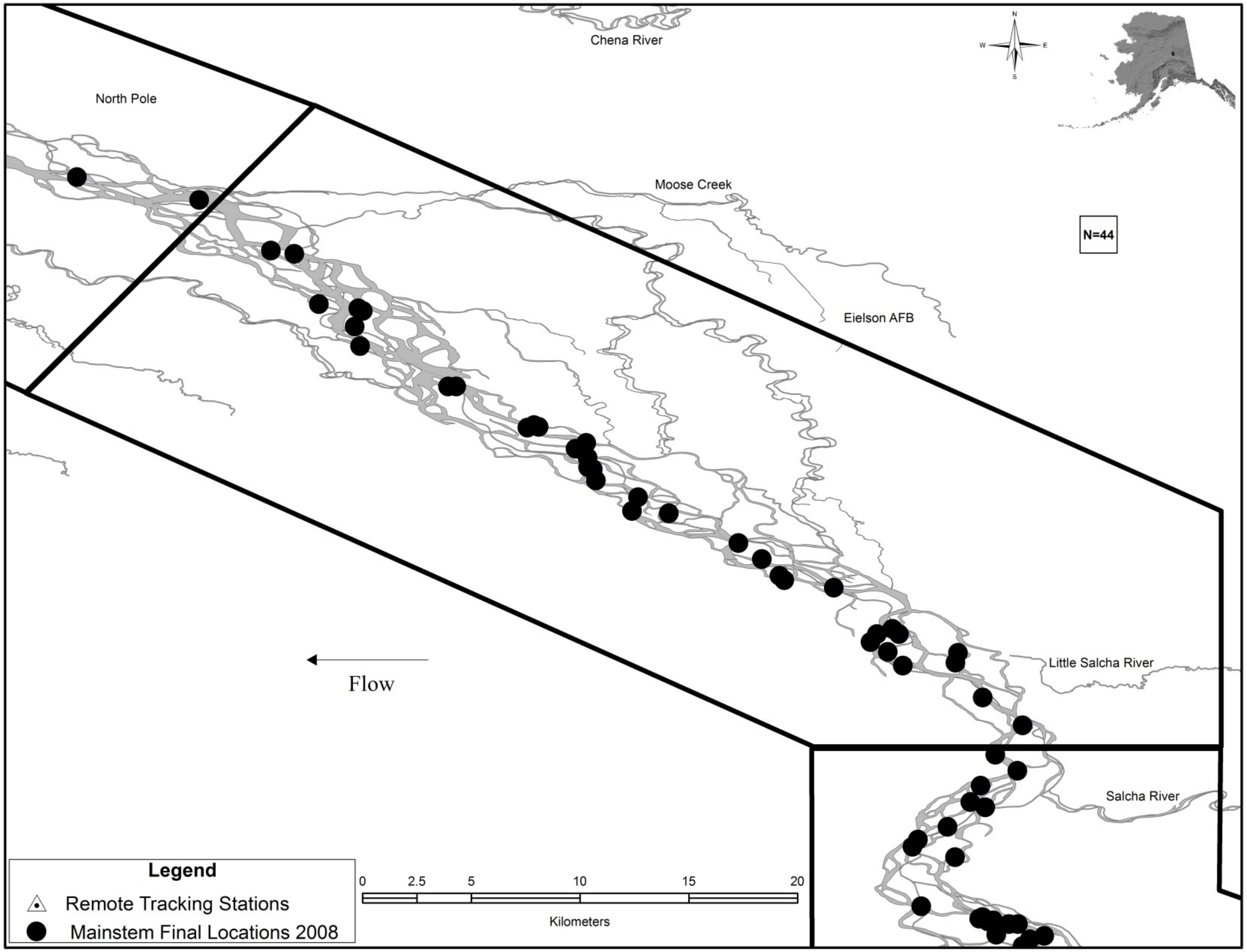
Appendix A3.–Mainstem river sections in the study area relative to river kilometer from tagging site upstream within Tanana River, 2008.



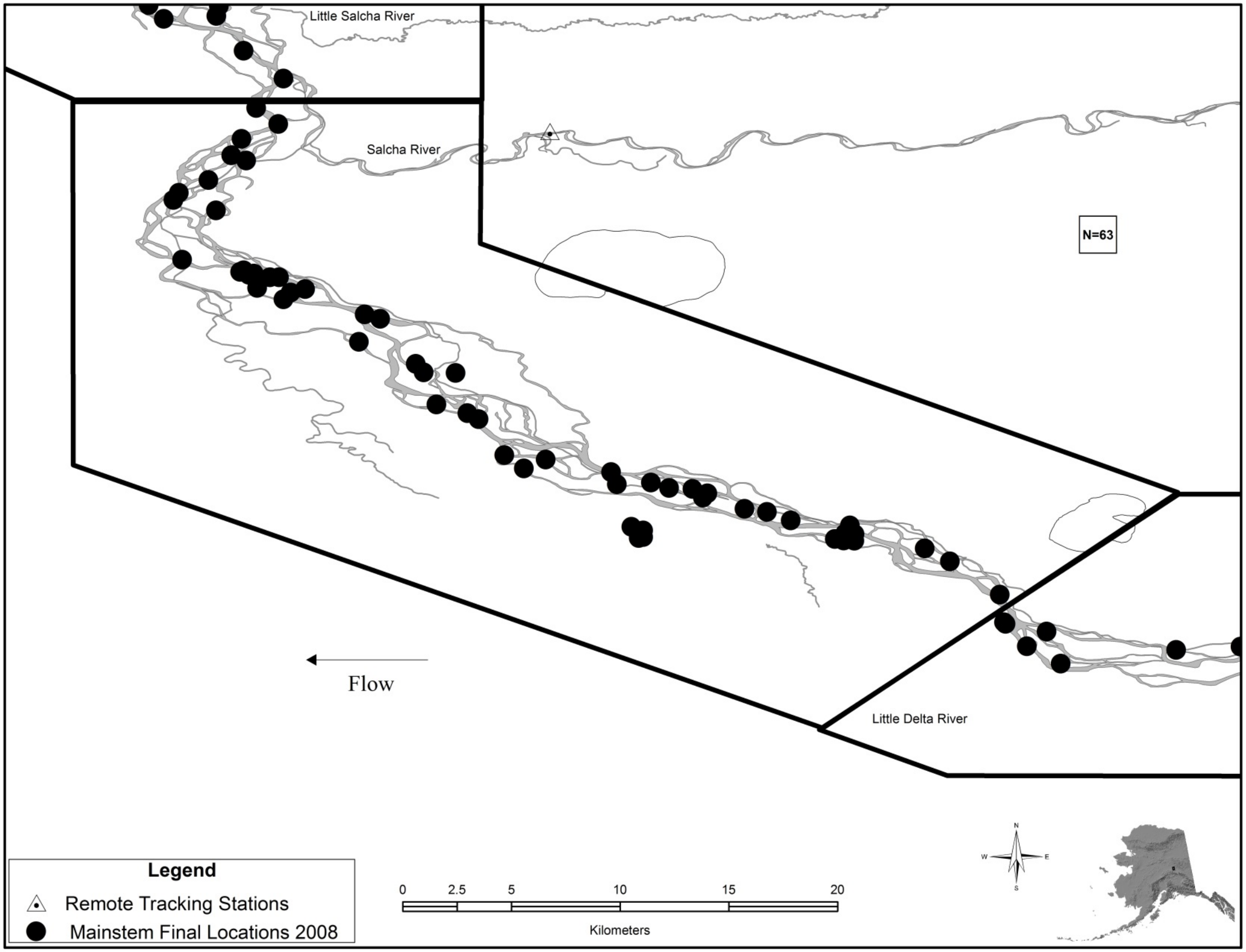
Appendix A4.–Distribution and final spawning locations of radiotagged chum salmon on the mainstem adjacent to the community of Fairbanks upstream to the community of North Pole, Tanana River, 2008.



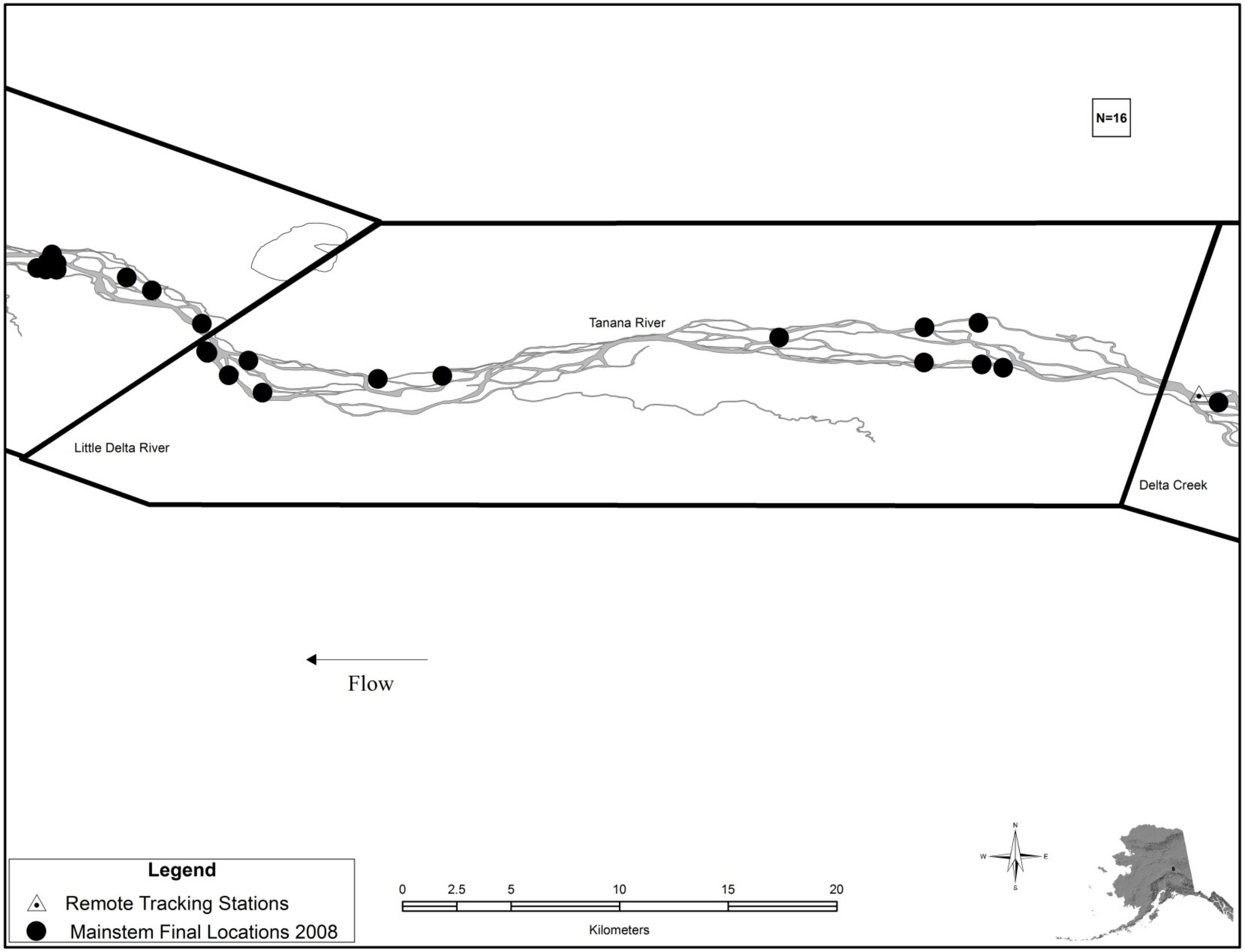
Appendix A5.–Distribution and final spawning locations of radiotagged chum salmon on the mainstem adjacent to the community of North Pole upstream to the confluence of the Salcha River, Tanana River, 2008.



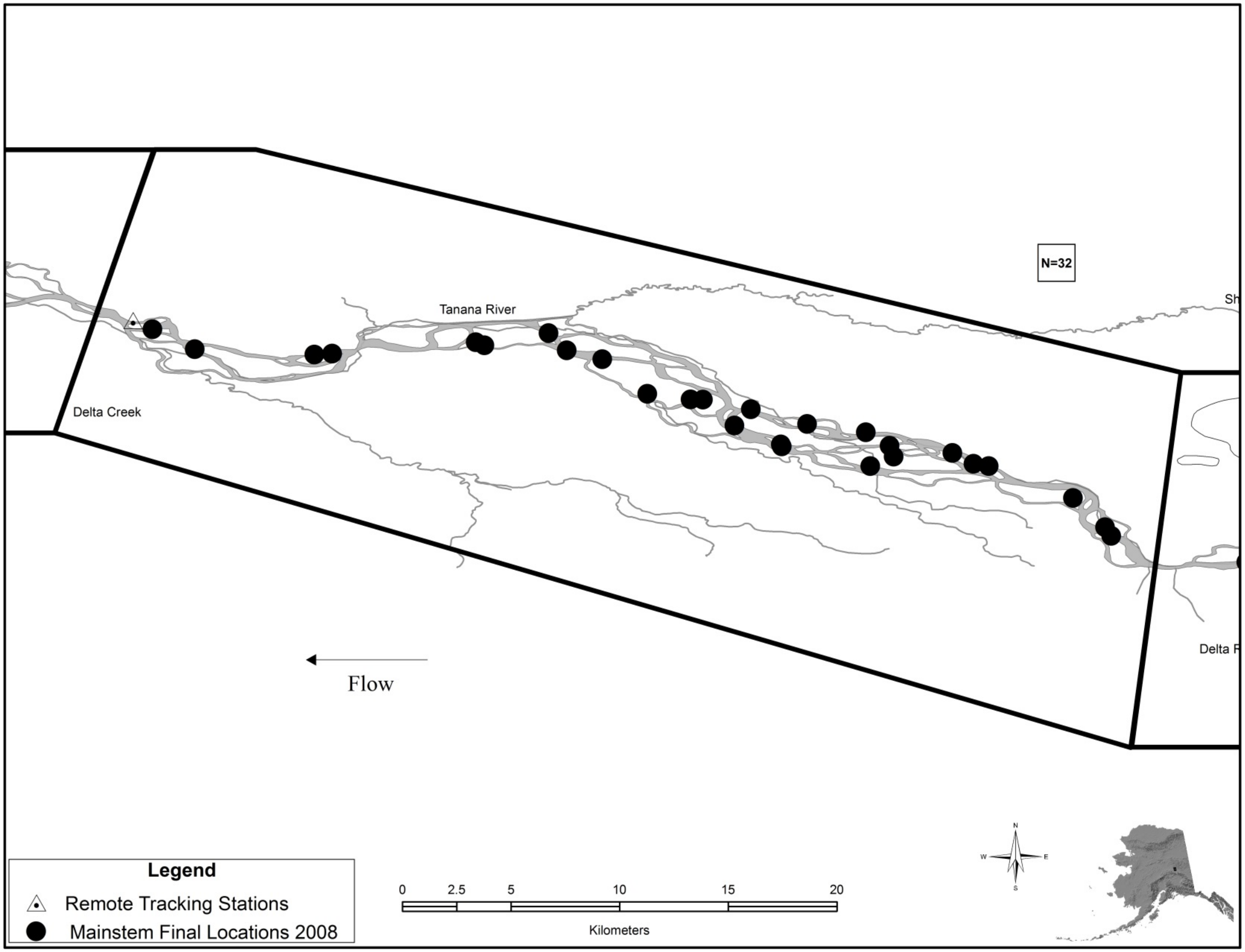
Appendix A6.–Distribution and final spawning locations of radiotagged chum salmon on the mainstem from the confluence of the Salcha River upstream to the confluence of the Little Delta River, Tanana River, 2008.



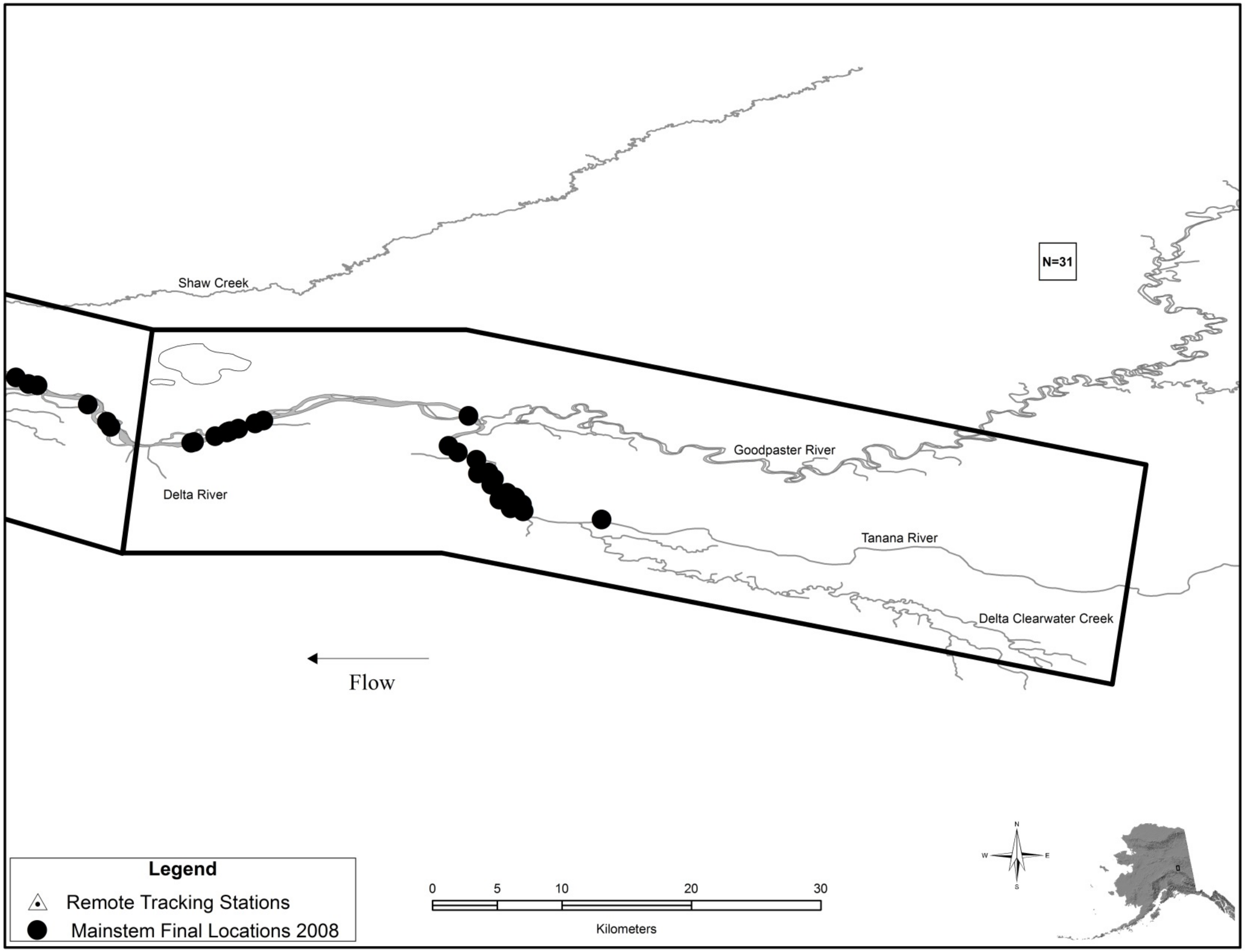
Appendix A7.–Distribution and final spawning locations of radiotagged chum salmon on the mainstem from the confluence of Little Delta River upstream to the confluence Delta Creek, Tanana River, 2008.



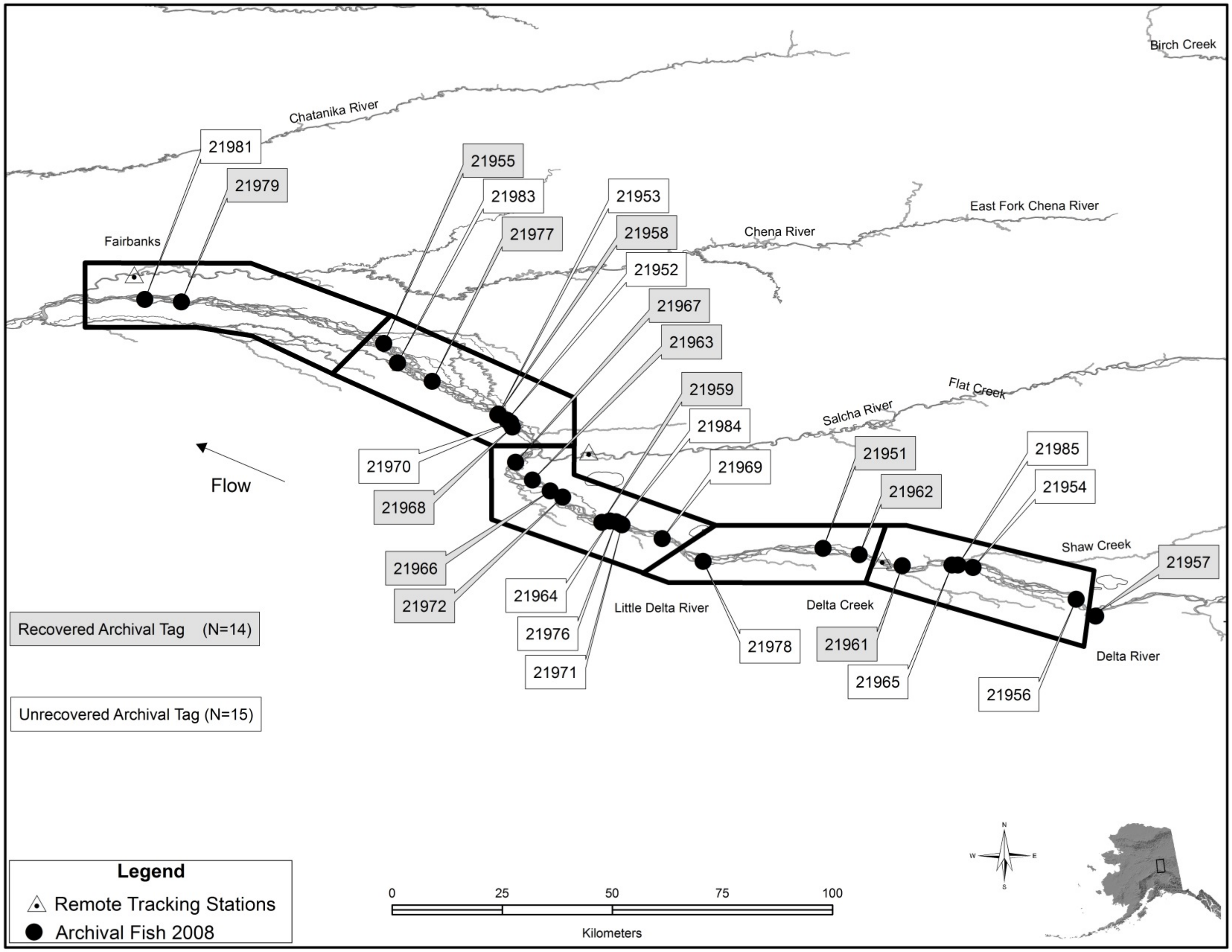
Appendix A8.–Distribution and final spawning locations of radiotagged chum salmon on the mainstem from the confluence of Delta Creek upstream to the confluence Delta River, Tanana River, 2008.



Appendix A9.–Distribution and final spawning locations of radiotagged chum salmon on the mainstem upstream from the confluence of Delta River, Tanana River, 2008.



Appendix A10.–Locations of archival radio tag recoveries for fall chum salmon, Tanana River, 2008.



Appendix A11.–Movement patterns of conventional radiotagged fall chum salmon based on dates of passage at remote tracking stations, Tanana River, 2007.

Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower
52451	9/17				9/21						
52451						9/26					
52452	9/17				9/19						
52452						9/22					
52454	9/17				9/19						
52454						9/22					
52456	9/17				9/19						
52456						9/22					
52457	9/17			9/18							[b]
52457						9/27					
52458	9/17				9/18						
52458						9/21					
52460	9/17				9/22						
52460						9/29					
52461	9/17				9/18						
52461						9/21					
52462	9/17				9/20						
52462						9/23					
52463	9/17				9/20						
52464	9/17				9/19						
52464						9/24					
52465	9/17				9/19						
52465						9/22					
52466	9/19				9/21						
52466						9/25					
52467	9/19				9/23						
52467						9/28					
52468	9/19				9/21						
52468						9/25					
52469	9/19				9/21						
52469						9/25					

-continued-

Appendix A11.–Page 2 of 2.

Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
52470	9/19			9/21								
52470				9/25								[a]
52471	9/19				9/20							
52471						9/23						
52471									10/29			
52472	9/19				9/22							
52472						9/26						
52473	9/19				9/21							
52473						9/24						
52474	9/19			9/19								[b]
52474						9/25						
52474									11/10			
52475	9/19				9/20							
52475						9/23						
52476	9/19			9/19								[b]
52476						9/29						
52477	9/19				9/30							
52478	9/19				9/21							
52478						9/25						
52479	9/19				9/25							
52479						9/30						
52480	9/19				9/21							
52480						9/26						

[a] Represents downstream movement.

[b] Represents fish that traveled through Swanneck Slough (located upstream of the tagging site) often bypassing the mainstem gateway tower.

Appendix A12.–Movement patterns of conventional radiotagged fall chum salmon based on dates of passage at remote tracking stations, Tanana River, 2008.

Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57001	8/17				8/19							
57001						8/22						
57002	8/17				8/19							
57002						8/21						
57002							8/24					
57003	8/17				8/19							
57003						8/22						
57004	8/17				8/19							
57004						8/21						
57004								8/28				
57006	8/18				8/19							
57007	8/18				8/19							
57007					8/24							[a]
57008	8/18				8/19							
57008						8/23						
57008							8/26					
57009	8/18			8/19								
57010	8/19				8/20							
57011	8/19			8/20								
57012	8/19				8/21							
57012						8/24						
57012								9/2				
57013	8/19				8/21							
57014	8/19				8/27							
57014					8/27							[a]

-continued-

Appendix A12.–Page 2 of 36.

Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57015	8/20				8/22							
57015						8/26						
57015							8/29					
57016	8/20				8/22							
57016						8/25						
57017	8/20			8/22								
57017				8/23								[a]
57017					8/24							
57017						8/27						
57017							8/30					
57018	8/20				8/22							
57018						8/26						
57018							8/29					
57019	8/20			8/21								
57020	8/20				8/22							
57020						8/24						
57020									9/4			
57021	8/20				8/22							
57021						8/25						
57021								9/2				
57022	8/22				8/22							
57022						8/25						
57022								9/2				
57022								9/13				[a]
57023	8/21			8/21								

-continued-

Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57024	8/21				8/22							
57024						8/25						
57024							8/28					
57025	8/21				8/22							
57027	8/21				8/22							
57027						8/25						
57028	8/21			8/22								
57028				9/16								[a]
57028		9/17										[a]
57029	8/21				8/23							
57029						8/27						
57030	8/21				8/23							
57030						8/27						
57031	8/21				8/22							
57031						8/25						
57031								9/3				
57032	8/21				8/25							
57032						8/27						
57032						8/31						[a]
57033	8/22				8/23							
57033						8/25						
57033								9/6				
57034	8/22			8/22								
57035	8/22				8/23							
57035						8/25						
57035							8/28					

-continued-

Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower
57036	8/22				8/23						
57036						8/25					
57036								9/2			
57037	8/22				8/23						
57037						8/26					
57037							8/29				
57038	8/22				8/28						
57038						8/31					
57039	8/22				8/26						
57039						8/29					
57039								9/6			
57040	8/22			8/23							
57041	8/23				8/24						
57041						8/26					
57042	8/23				8/24						
57042						8/26					
57043	8/23				8/26						
57043						8/30					
57044	8/23				8/24						
57044						8/26					
57044									9/8		
57045	8/23			8/24							
57046	8/23			8/23							
57047	8/24				8/25						
57047						8/28					
57047								9/4			

-continued-

Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57048	8/24				8/25							
57048						8/28						
57049	8/24			8/26								
57050	8/24				8/25							
57050						8/28						
57050							9/2					
57050							9/2					[a]
57051	8/24				8/25							
57051						8/28						
57051							9/1					
57052	8/24			8/24								
57053	8/25			8/26								
57054	8/25				8/27							
57054						8/31						
57055	8/25				8/26							
57056	8/25				8/30							
57056						9/4						
57056						9/15						[a]
57056					9/16							[a]
57056		9/17										[a]
57057	8/25				8/27							
57057						8/30						
57057									9/13			
57058	8/26				8/27							
57058						8/30						
57058								9/6				
57058								9/8				[a]

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57059	8/26				8/28							
57059						9/1						
57059									9/20			
57059									9/25			a
57060	8/26				8/27							
57061	8/26				8/27							
57061						8/30						
57061									9/8			
57062	8/26				8/27							
57062						8/29						
57062									9/8			
57063	8/27				8/28							
57063						8/31						
57063								9/6				
57064	8/27				8/31							
57066	8/27				8/28							
57066						8/31						
57067	8/27				9/2							
57067						9/5						
57067						9/5						a
57067						9/5						
57067						9/17						a
57068	8/28			8/31								
57069	8/28				8/30							
57069						9/2						
57069									9/18			
57070	8/29			8/31								

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57071	8/30				9/2							
57071						9/5						
57071									9/18			
57071									9/30			a
57071						10/4						a
57071					10/5							a
57071				10/6								
57071				10/9								a
57071		10/10										a
57072	8/30				9/1							
57072						9/4						
57072									9/16			
57073	8/30				9/1							
57073						9/5						
57073									9/23			
57075	8/30				9/1							
57075						9/5						
57075									9/16			
57076	8/30				9/3							
57076						9/6						
57076								9/13				
57077	8/30				9/1							
57077						9/4						
57077									9/18			
57077									9/29			a
57077						10/2						a

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57077					10/3							[a]
57077		10/5										[a]
57078	8/30				9/3							
57078						9/5						
57079	8/31			8/31								
57080	8/31				9/1							
57080						9/4						
57080									9/13			
57081	8/31				9/3							
57081						9/6						
57081									9/21			
57082	8/31				9/3							
57082						9/5						
57082								9/10				
57082								9/17				[a]
57083	8/31				9/1							
57083						9/4						
57085	8/31				9/1							
57086	8/31				9/2							
57086						9/5						
57087	8/31				9/1							
57087						9/4						
57087							9/6					
57088	8/31				9/2							
57088						9/5						
57088								9/12				

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57089	9/1				9/2							
57089						9/5						
57090	9/1				9/2							
57090						9/5						
57090									9/19			
57091	9/1				9/2							
57091						9/6						
57091									9/16			
57092	9/1				9/4							
57092						9/7						
57092									9/18			
57093	9/2			9/3								
57094	9/2			9/4								[b]
57094						9/9						
57094									9/25			
57095	9/2				9/4							
57095						9/6						
57095									9/19			
57095									10/1			[a]
57095									10/6			
57095									10/15			[a]
57096	9/2				9/3							
57096						9/5						
57096									9/13			
57097	9/3				9/5							
57098	9/3				9/5							

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower
57099	9/3				9/4						
57099						9/7					
57100	9/3				9/4						
57100						9/7					
57100							9/10				
57101	9/3				9/5						
57101						9/7					
57101							9/10				
57102	9/3				9/7						
57103	9/3			9/4							
57104	9/3				9/6						
57104						9/9					
57104									9/21		
57105	9/3				9/4						
57105						9/6					
57105								9/12			
57106	9/3				9/6						
57106						9/9					
57106									9/24		
57107	9/4				9/5						
57107						9/7					
57107									9/18		
57109	9/4			9/4							
57109				9/8							[a]
57110	9/4			9/5							
57111	9/4				9/6						
57111						9/9					

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57111								9/23				
57111								9/28				a
57111						9/29						a
57111				10/1								a, b
57111		10/2										a
57112	9/5			9/6								
57112				9/8								a
57113	9/5				9/7							
57113						9/9						
57114	9/5				9/6							
57115	9/5				9/7							
57115						9/9						
57115									9/19			
57115											9/28	
57116	9/5				9/6							
57116						9/8						
57116									9/19			
57116									9/19			a
57117	9/5				9/8							
57117						9/10						
57117									9/25			
57118	9/6				9/7							
57118						9/9						
57118									9/18			
57119	9/6				9/7							
57119						9/9						
57119									9/20			

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57120	9/6				9/7							
57120						9/10						
57120									9/20			
57120									9/24			[a]
57120									9/24			
57120									9/30			[a]
57120									10/2			
57121	9/6				9/7							
57121						9/9						
57121								9/15				
57122	9/6				9/8							
57122						9/10						
57122									9/25			
57123	9/6				9/7							
57123						9/9						
57123									9/20			
57123									9/26			[a]
57124	9/6				9/8							
57124						9/10						
57124									9/23			
57124									9/23			[a]
57125	9/6				9/12							
57125						9/15						
57126	9/6				9/9							
57126						9/11						
57126									9/25			

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57126									10/17			[a]
57126						11/14						[a]
57127	9/6				9/8							
57127						9/10						
57127									9/18			
57128	9/6				9/8							
57128						9/10						
57128									9/30			
57128									10/22			[a]
57129	9/7				9/8							
57129						9/10						
57129									9/20			
57129									9/20			[a]
57130	9/7				9/8							
57130						9/11						
57131	9/7				9/8							
57131						9/11						
57131									9/22			
57132	9/7				9/8							
57132						9/11						
57132								9/16				
57132								9/30				[a]
57133	9/7				9/8							
57133						9/11						
57133									9/21			

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57134	9/7				9/8							
57134						9/10						
57134									9/21			
57135	9/7				9/8							
57135						9/11						
57135						11/4						[a]
57136	9/7				9/8							
57136						9/11						
57136								9/20				
57137	9/7				9/9							
57137						9/12						
57137									9/24			
57138	9/7				9/8							
57138						9/10						
57138									9/26			
57139	9/7				9/8							
57139						9/10						
57139									9/22			
57140	9/8				9/9							
57140						9/12						
57140									9/28			
57140									10/10			[a]
57140						10/15						[a]
57140					10/18							[a]
57140		10/21										[a]

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57141	9/8				9/9							
57141						9/11						
57141								9/17				
57142	9/8				9/11							
57143	9/8				9/9							
57143					9/11							[a]
57143			9/11									
57144	9/8				9/9							
57144						9/13						
57144									10/6			
57144									10/6			[a]
57144									10/15			
57144									10/17			[a]
57144						11/5						[a]
57144					11/8							[a]
57145	9/8				9/9							
57145						9/12						
57145									9/24			
57145									10/19			[a]
57146	9/8				9/9							
57146						9/12						
57146									9/24			
57147	9/9				9/10							
57147						9/13						
57147									9/23			
57148	9/9				9/10							
57148						9/13						

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57149	9/9				9/14							
57149					9/17							a
57149		9/20										a
57150	9/9				9/10							
57151	9/9			9/12								
57151				9/17								a
57151					9/20							
57151						9/24						
57152	9/9				9/11							
57152						9/21						
57153	9/9	9/10										a
57154	9/9				9/11							
57154						9/14						
57154									9/30			
57155	9/9				9/11							
57155						9/14						
57155									9/26			
57156	9/10				9/11							
57156						9/15						
57156									10/7			
57156									10/11			a
57156						10/20						a
57156				10/24								a, b
57156			10/28									
57157	9/10				9/12							
57157						9/16						
57157									9/27			

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower
57158	9/10				9/12						
57158						9/16					
57158									9/30		
57159	9/10				9/12						
57159						9/15					
57159									9/27		
57160	9/10				9/12						
57160						9/15					
57161	9/10				9/11						
57162	9/10				9/13						
57162						9/18					
57162									10/12		
57163	9/10				9/12						
57163						9/15					
57164	9/10				9/12						
57164						9/15					
57165	9/10				9/13						
57165						9/17					
57166	9/10				9/12						
57167	9/10				9/11						
57167						9/14					
57167									9/23		
57168	9/10				9/11						
57168						9/14					
57168									9/25		
57169	9/10				9/16						
57169						9/19					

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57169									9/30			
57169									10/17			[a]
57169						10/22						[a]
57169				10/25								[a, b]
57170	9/10				9/13							
57170						9/16						
57170									9/26			
57171	9/10				9/14							
57171						9/18						
57171									9/27			
57172	9/11				9/12							
57172						9/15						
57172									9/26			
57172									10/18			[a]
57173	9/11				9/12							
57173						9/15						
57173									9/26			
57173									10/19			[a]
57174	9/11				9/12							
57174						9/15						
57174									9/25			
57175	9/11				9/13							
57175						9/18						
57176	9/11				9/12							
57176						9/15						
57177	9/11				9/12							
57177						9/14						

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57177									9/27			
57177										11/5		
57178	9/11				9/12							
57178						9/16						
57178									9/26			
57179	9/11				9/14							
57179					9/18							[a]
57179		9/19										[a]
57180	9/11				9/12							
57180						9/15						
57181	9/11				9/14							
57181						9/17						
57181									10/1			
57182	9/11				9/13							
57182						9/16						
57183	9/11				9/13							
57183						9/16						
57184	9/12				9/14							
57184						9/17						
57184									9/28			
57185	9/12				9/13							
57185						9/16						
57185									9/26			
57186	9/12				9/13							
57186						9/16						
57186									9/29			
57186									10/9			[a]

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower
57187	9/12				9/13						
57188	9/12				9/15						
57188						9/18					
57188									9/29		
57188									10/15 [a]		
57188									11/1		
57189	9/12				9/13						
57189						9/16					
57189									9/30		
57190	9/12				9/14						
57191	9/12				9/14						
57191						9/17					
57191									10/2		
57192	9/12				9/15						
57192						9/17					
57192									10/4		
57193	9/13				9/14						
57193						9/18					
57193									9/28		
57194	9/13				9/15						
57194						9/18					
57195	9/13				9/15						
57195						9/18					
57195									10/1		
57196	9/13				9/17						
57196						9/21					

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57197	9/13				9/14							
57197						9/17						
57197									9/26			
57199	9/13				9/14							
57199						9/16						
57200	9/13				9/17							
57200						9/19						
57201	9/13				9/14							
57201						9/17						
57201									9/26			
57202	9/13				9/14							
57203	9/13				9/16							
57203						9/19						
57203									10/8			
57203									10/16			[a]
57204	9/14				9/15							
57204						9/17						
57204									9/27			
57204									10/2			[a]
57204									10/9			
57204									10/9			[a]
57204									10/10			
57204									10/22			[a]
57205	9/14				9/15							
57205						9/18						
57205									9/27			
57205									9/29			[a]

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57206	9/14				9/16							
57206						9/19						
57206									10/2			
57206									10/3			[a]
57207	9/14				9/15							
57207						9/18						
57208	9/14				9/16							
57208						9/18						
57208									9/27			
57209	9/14				9/15							
57209						9/17						
57211	9/14				9/17							
57211						9/20						
57213	9/14				9/16							
57213						9/20						
57214	9/14				9/15							
57214						9/19						
57214									10/1			
57214									10/22			[a]
57215	9/14				9/16							
57215						9/19						
57215									9/28			
57216	9/14				9/16							
57216						9/19						
57216									10/7			
57217	9/14				9/16							
57217						9/19						

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57218	9/14				9/16							
57218						9/19						
57218									10/7			
57218									10/16			[a]
57219	9/14				9/16							
57219						9/19						
57219									10/1			
57220	9/14				9/16							
57220						9/19						
57220									9/27			
57221	9/15				9/16							
57221						9/19						
57222	9/15				9/17							
57222						9/19						
57222									9/28			
57222									10/13			[a]
57223	9/15				9/18							
57223						9/20						
57223									10/6			
57224	9/15				9/18							
57225	9/15				9/16							
57225						9/18						
57225									9/26			
57226	9/15				9/16							
57226						9/19						

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57227	9/15				9/16							
57227						9/19						
57227									9/29			
57228	9/15				9/17							
57228						9/20						
57228						9/29						[a]
57228					10/1							[a]
57229	9/15				9/17							
57230	9/15				9/16							
57230						9/19						
57230									10/1			
57231	9/15				9/16							
57231						9/20						
57231									10/2			
57232	9/15				9/17							
57232						9/21						
57233	9/16				9/17							
57233						9/20						
57233									9/29			
57234	9/16				9/18							
57235	9/16				9/17							
57235						9/18						
57235									9/26			
57236	9/16		9/17									
57236			9/30									[a]
57236					10/2							
57237					9/20							

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower
57238	9/16				9/18						
57238						9/21					
57239	9/16				9/18						
57239						9/21					
57239							9/23				
57240	9/16				9/17						
57240						9/19					
57240									9/29		
57241	9/16				9/17						
57241						9/19					
57241									9/28		
57242	9/16				9/18						
57242						9/20					
57243	9/16				9/18						
57244					9/17						
57244						9/19					
57245	9/17				9/18						
57245						9/21					
57246	9/17				9/18						
57246						9/20					
57247	9/17				9/19						
57247						9/22					
57247									10/10		
57248	9/17				9/21						
57248						9/24					

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower
57249	9/17				9/18						
57249						9/20					
57249									9/30		
57250	9/17				9/18						
57251	9/17				9/19						
57251						9/21					
57252	9/17				9/19						
57252						9/22					
57253	9/17				9/18						
57253						9/21					
57254	9/17				9/19						
57254						9/24					
57256	9/17				9/18						
57256						9/21					
57257	9/17				9/18						
57257						9/21					
57258	9/18				9/20						
57258						9/22					
57259	9/18				9/21						
57259						9/23					
57259									11/9		
57260	9/18				9/19						
57260						9/21					
57260									9/29		
57262	9/18				9/19						
57262						9/21					
57262									10/1		

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57263	9/18				9/19							
57263						9/22						
57264	9/18				9/20							
57264						9/23						
57265	9/18				9/20							
57265						9/22						
57265									10/8			
57266	9/18				9/21							
57266						9/23						
57266						10/31						[a]
57266					11/1							[a]
57267	9/18				9/19							
57267						9/22						
57267									10/2			
57268	9/18				9/19							
57268						9/22						
57268									10/8			
57268										10/31		
57269	9/18			9/19								[b]
57269						9/22						
57270	9/18				9/19							
57270						9/22						
57271	9/19				9/21							
57271						9/24						
57271									10/11			
57271									10/18			[a]

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Appendix A12.–Page 28 of 36.

Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower
57272	9/19				9/20						
57272						9/23					
57272									10/7		
57273	9/19				9/20						
57273						9/22					
57273									9/30		
57274	9/19				9/20						
57274						9/22					
57275	9/19				9/21						
57275						9/24					
57275									10/11		
57276	9/19				9/21						
57276						9/23					
57276									11/7		
57277	9/19				9/20						
57277						9/22					
57278	9/19				9/20						
57278						9/22					
57278									10/5		
57279	9/19				9/20						
57279						9/23					
57279									10/9		
57279									11/6		[a]
57280	9/19				9/20						
57280						9/23					
57281	9/19				9/21						
57281						9/24					

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Appendix A12.–Page 29 of 36.

Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower
57282	9/19				9/20						
57282						9/23					
57283	9/20				9/22						
57283						9/25					
57284	9/20				9/21						
57284						9/23					
57285	9/20				9/21						
57285						9/24					
57286	9/20				9/21						
57286						9/23					
57287	9/20				9/21						
57287						9/24					
57287									10/8		
57288	9/20				9/21						
57288						9/24					
57289					9/21						
57289						9/24					
57289									10/7		
57290					9/22						
57290						9/24					
57291	9/20				9/22						
57291						9/24					
57291									10/29		
57292	9/20				9/21						
57292						9/24					
57293	9/20				9/21						

-continued-

Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower
57294	9/20				9/21						
57294						9/23					
57296	9/21				9/23						
57296						9/26					
57296									11/8		
57297	9/21				9/23						
57297						9/26					
57298	9/21				9/22						
57298						9/24					
57299	9/21		9/22								
57301	9/21				9/23						
57301						9/26					
57302	9/21				9/22						
57302						9/25					
57302									10/27		
57303	9/21				9/29						
57304	9/21				9/23						
57304						9/25					
57304									10/10		
57304										11/2	
57305	9/21				9/23						
57305						9/26					
57306	9/21				9/22						
57306						9/24					
57307	9/22				9/23						
57307						9/26					

-continued-

Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57308	9/22				9/23							
57308						9/26						
57309	9/22				9/23							
57309						9/25						
57310	9/22				9/24							
57310						9/27						
57311	9/22				9/23							
57311						9/25						
57312	9/22				9/23							
57312						9/27						
57312									11/13			
57313	9/22				9/23							
57313						9/25						
57314	9/22				9/23							
57314						9/26						
57314						9/26						[a]
57314						9/26						
57315	9/22				9/25							
57316	9/22				9/23							
57316						9/26						
57317	9/22				9/23							
57317						9/26						
57317									10/12			
57317									10/27			[a]
57317									11/3			
57317										11/11		

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Appendix A12.–Page 32 of 36.

Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57318	9/22				9/23							
57318						9/26						
57319	9/23				9/25							
57320	9/23				9/25							
57320						9/28						
57320						9/28						[a]
57320						9/28						
57321	9/23				9/24							
57321						9/27						
57321									10/21			
57322	9/23				9/24							
57322						9/26						
57323	9/23				9/24							
57323						9/27						
57324	9/23			9/23								[b]
57324						9/27						
57325	9/23				9/25							
57326	9/23				9/24							
57327	9/23				9/24							
57327						9/27						
57328	9/24				9/25							
57328						9/29						
57329	9/24				9/26							
57329						9/29						
57330	9/24				9/25							
57330						9/28						

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Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower
57331	9/24				9/25						
57331						9/28					
57332	9/24				9/26						
57332						9/29					
57333	9/24				9/25						
57333						9/28					
57334	9/24				9/25						
57335	9/24				9/26						
57335						9/29					
57336	9/24				9/25						
57336						9/29					
57337	9/25				9/29						
57337						10/3					
57338	9/25				9/26						
57338						9/29					
57339	9/25				9/26						
57339						9/29					
57340	9/25				9/26						
57341	9/25				9/26						
57341						9/29					
57342	9/25				9/26						
57342						9/29					
57343	9/25				9/27						
57343						9/30					
57344	9/25				9/26						
57344						9/29					

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Appendix A12.–Page 34 of 36.

Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57345	9/25				9/26							
57345						9/30						
57346	9/26				9/27							
57346						9/30						
57347	9/26		9/27									
57348	9/26			9/27								
57349	9/26				9/27							
57350	9/26				9/27							
57350						9/30						
57351	9/26				9/27							
57351						9/30						
57352	9/26				9/27							
57352						9/30						
57353	9/26				9/28							
57353						10/1						
57353						10/1						[a]
57353						10/1						
57354	9/26				9/27							
57354						9/30						
57354									11/16			
57354									11/18			[a]
57355	9/27				9/29							
57355						10/3						
57356	9/27				9/29							
57357	9/27				9/28							
57358	9/27				9/29							
57358						10/3						

-continued-

Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower	
57359	9/27				9/30							
57359						10/5						
57360	9/28				9/30							
57360						10/7						
57360									11/15			
57360									12/9			[a]
57361	9/28				9/30							
57362	9/28			9/29								[b]
57362						10/6						
57363	9/28				9/29							
57363						10/2						
57363									11/12			
57364	9/28				9/30							
57365	9/28				10/3							
57365						10/6						
57366	9/28				9/30							
57366						10/5						
57366									11/18			
57367	9/28				9/29							
57367						10/2						
57367									11/11			
57368	9/28				10/5							
57369	9/28				9/29							
57369						10/2						
57370	9/28				9/30							
57370						10/5						
57370									11/12			

-continued-

Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower
57371	9/28				9/29						
57371						10/3					
57372	9/28				9/29						
57372						10/2					
57372									11/15		
57373	9/28				9/30						
57373						10/5					
57374	9/28				9/29						
57375	9/28				10/1						
57375						10/4					
57376	9/28				9/30						
57377	9/28				9/30						
57377						10/5					
57378	9/28				9/30						
57378						10/5					
57379	9/28				9/29						
57379						10/4					

Note: Shaded sections represent each individual fish number. Duplicate dates for an individual fish are different time frames.

[a] Represents downstream movement.

[b] Represents fish that traveled through Swanneck Slough (located upstream of the tagging site) often bypassing the mainstem gateway tower.

Appendix A13.–Movement patterns of archival radiotagged fall chum salmon based on dates of passage at remote tracking stations, Tanana River, 2008.

Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower
21951	9/15				9/16						
21951						9/19					
21952	9/15				9/17						
21952						9/20					
21953	9/16				9/18						
21953						9/21					
21954	9/16				9/17						
21954						9/20					
21954									10/7		
21954									10/26		[a]
21955	9/17				9/19						
21955						9/22					
21956	9/17				9/18						
21956						9/20					
21956									10/6		
21957	9/18				9/19						
21957						9/21					
21957									10/6		
21958	9/18				9/20						
21958						9/24					
21959	9/19				9/20						
21959						9/22					
21961	9/20				9/21						
21961						9/23					
21961									10/11		

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Appendix A13.–Page 2 of 3.

Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower
21962	9/20				9/21						
21962						9/24					
21963	9/20				9/22						
21963						9/25					
21964	9/21				9/22						
21964						9/25					
21965	9/21				9/22						
21965						9/25					
21965									10/12		
21966	9/21				9/22						
21966						9/25					
21967	9/22				9/23						
21967						9/26					
21968	9/22				9/23						
21968						9/26					
21969	9/22				9/23						
21969						9/26					
21970	9/23				9/24						
21970						9/26					
21971	9/23				9/24						
21971						9/27					
21972	9/23				9/25						
21972						9/28					
21973	9/23				9/24						
21974	9/24				9/28						
21974						10/5					

-continued-

Appendix A13.–Page 3 of 3.

Fish Number	Tag Date	Manley Tower	Kantishna Tower	Tolovana Tower	Mainstem Gateway Tower	Nenana Tower	Chena Tower	Salcha Tower	Upper Tanana Tower	Delta Tower	Gerstle Tower
21975	9/24				9/25						
21975						9/29					
21976	9/24				9/25						
21976						9/28					
21977	9/24				9/25						
21977						9/28					
21978	9/25			9/26							[b]
21978						10/4					
21979	9/25				9/26						
21979						9/29					
21980	9/25				9/26						
21980						9/29					
21981	9/25				9/27						
21981						10/1					
21983	9/26				9/27						
21983						9/29					
21984	9/26				9/28						
21984						10/5					
21985	9/26				9/28						
21985						10/1					
21985									11/12		

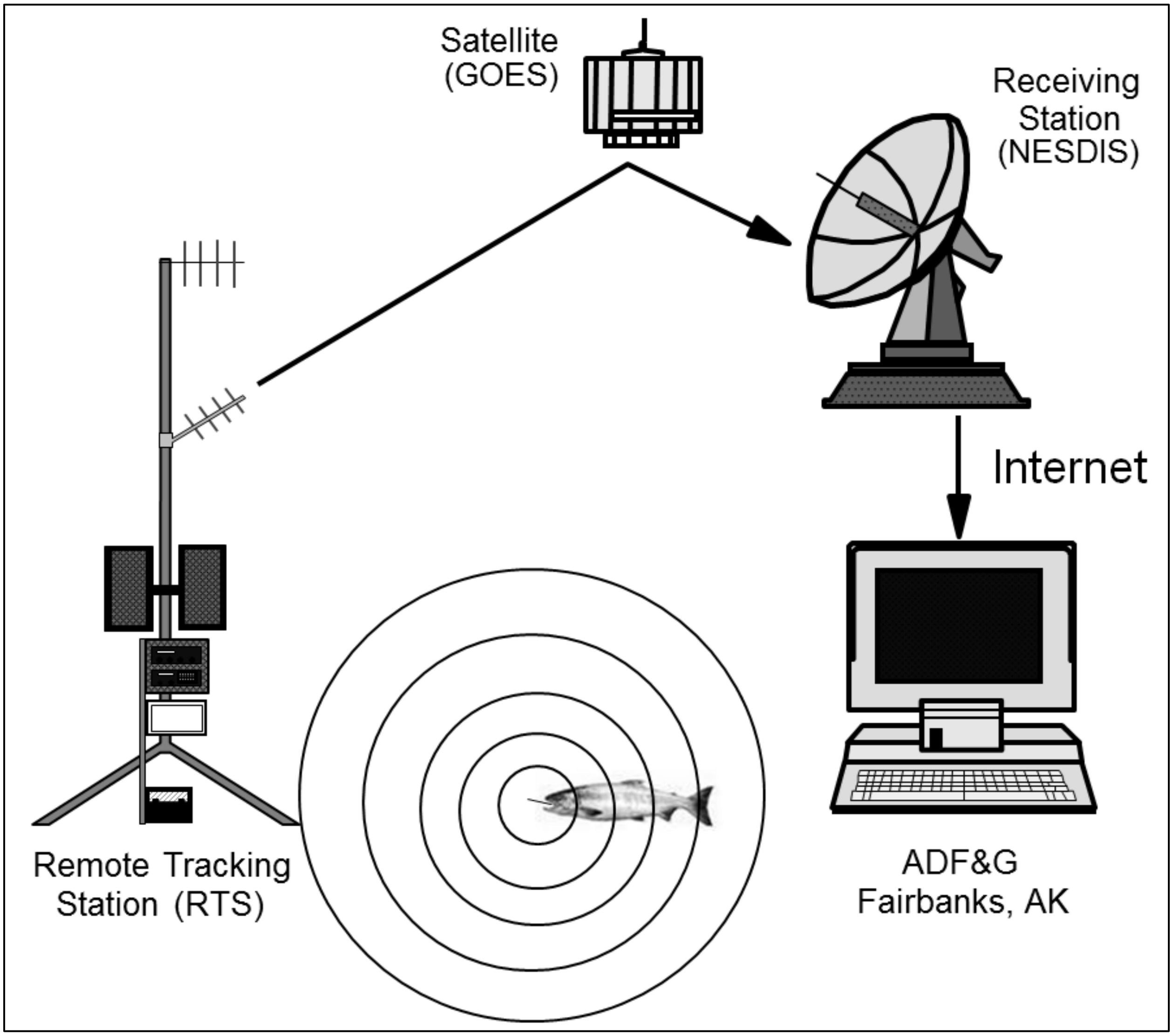
Note: Shaded sections represent each individual fish number.

[a] Represents downstream movement.

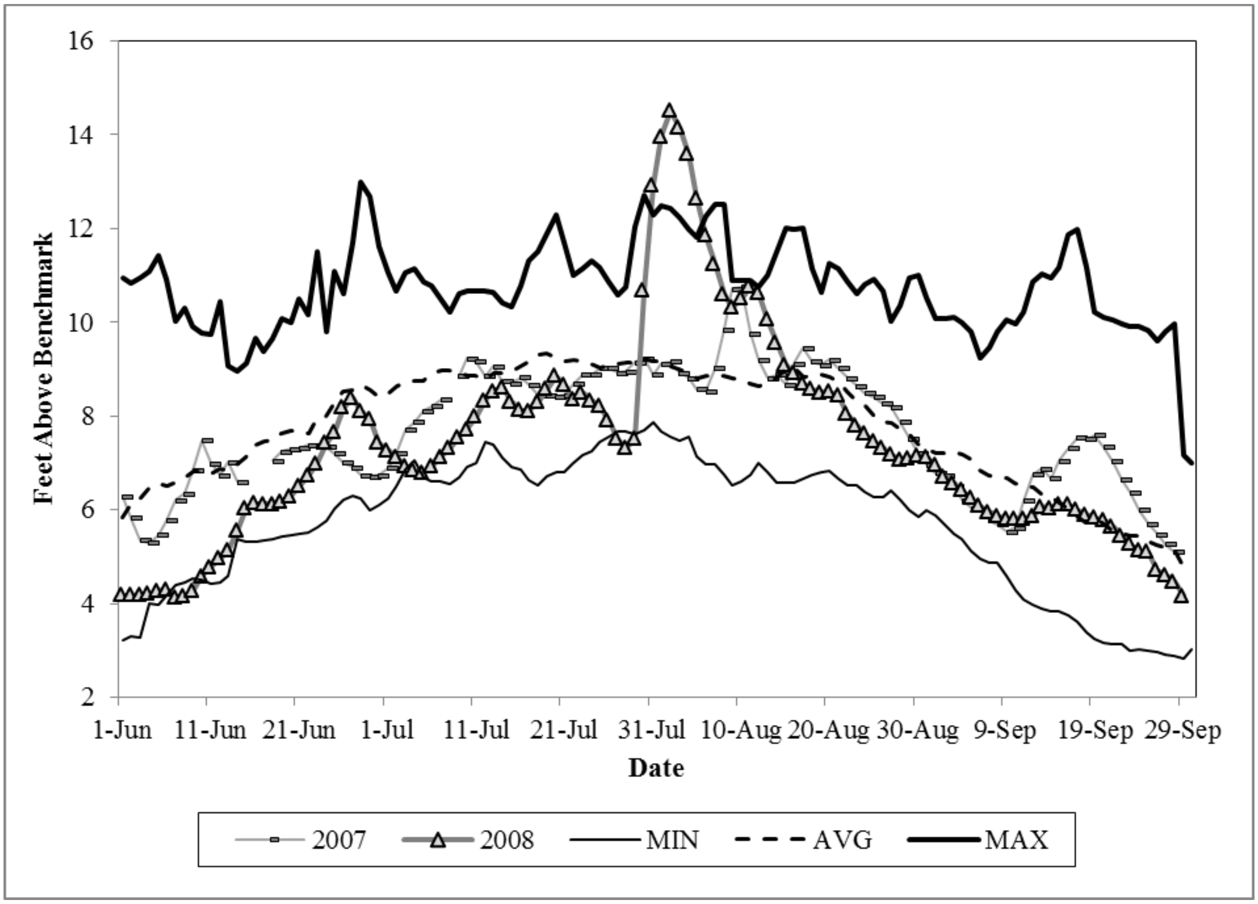
[b] Represents fish that traveled through Swanneck Slough (located upstream of the tagging site) often bypassing the mainstem gateway tower.

APPENDIX B: MIGRATORY CONDITIONS

Appendix B1.–Remote tracking station and satellite uplink diagram used to collect and access movement information of chum salmon in the Tanana River study area.



Appendix B2.–Minimum, average, and maximum water levels from 1987 to 2006 of the Tanana River near Nenana, compared to water levels in 2007 and 2008.



Appendix B3.–Migration rate of radiotagged chum salmon between the tagging site and gateway remote tracking station, by capture week, Tanana River, 2008.

			95% Confidence Interval	
Capture week	*N*	Rate (km/day)	Lower	Upper
34	35	20.0	16.8	23.1
35	25	17.7	14.3	21.1
36	41	19.3	16.5	22.0
37	73	18.7	16.9	20.6
38	99	18.8	17.5	20.1
39	79	19.8	18.5	21.2
40	19	17.4	13.8	21.0
All	371	19.0	18.3	19.8

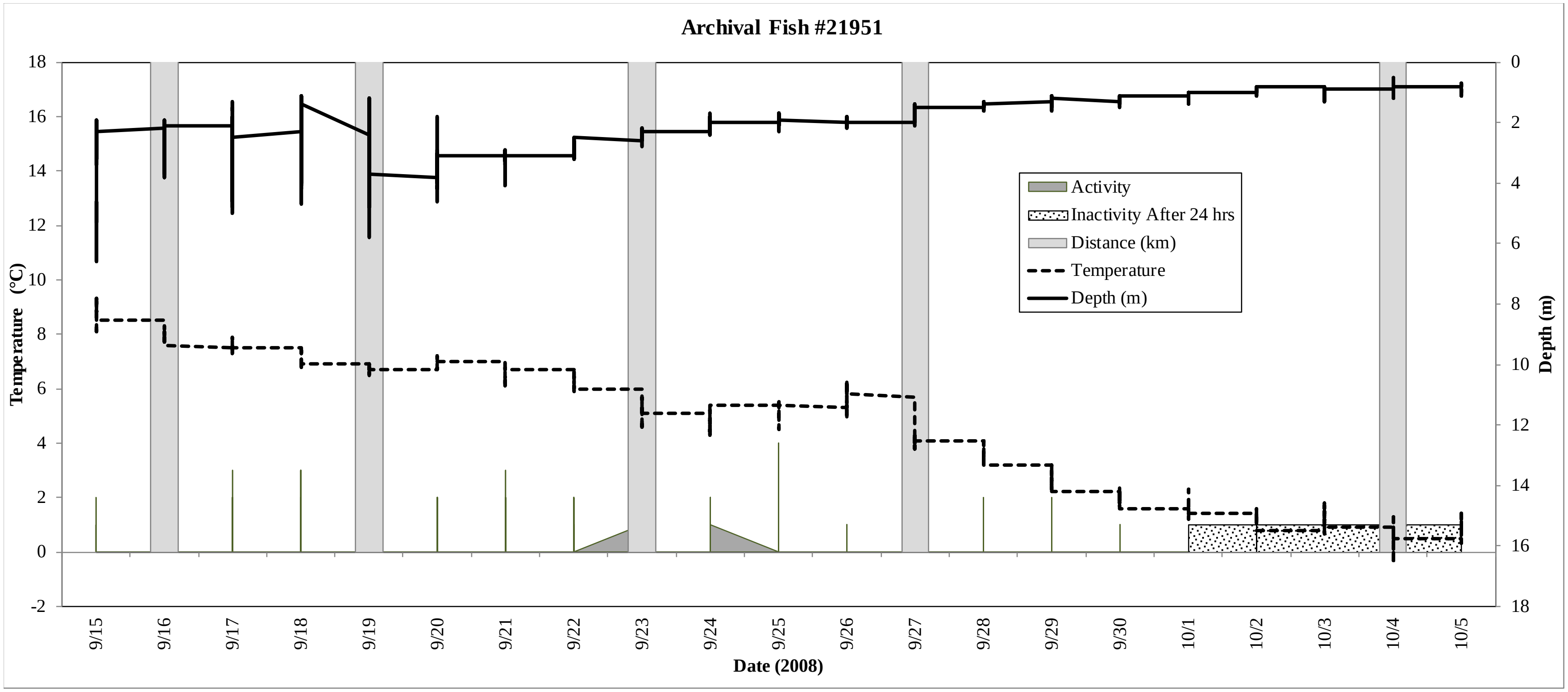
Appendix B4.–Migration rate of radiotagged chum salmon between Gateway and Nenana remote tracking stations, by capture week, Tanana River, 2008.

			95% Confidence Interval	
Capture week	*N*	Rate (km/day)	Lower	Upper
34	29	30.4	28.4	32.5
35	22	28.8	26.3	31.2
36	36	35.2	33.4	37.0
37	63	30.5	29.1	32.0
38	90	33.9	32.7	35.2
39	68	29.1	27.8	30.5
40	14	22.2	19.0	25.5
All	322	31.2	30.5	31.9

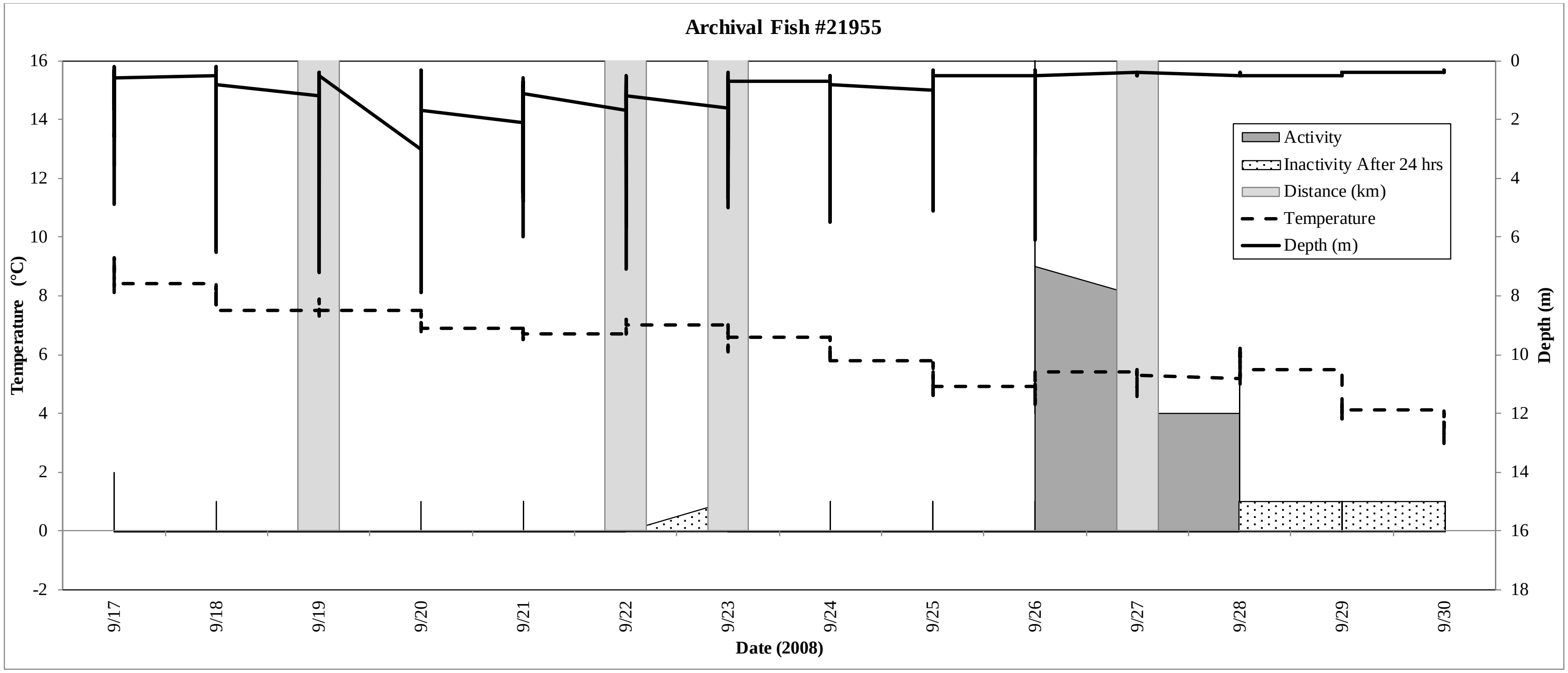
Appendix B5.–Migration rate of radiotagged chum salmon between Nenana and Upper Tanana remote tracking stations, by capture week, Tanana River, 2008.

			95% Confidence Interval	
Capture week	*N*	Rate (km/day)	Lower	Upper
34	2	16.7	5.0	28.4
35	10	15.3	12.5	18.1
36	23	16.9	15.3	18.6
37	42	16.5	15.3	17.6
38	42	16.1	14.4	17.8
39	9	7.6	4.8	10.5
40	6	4.8	4.5	5.1
All	134	15.2	14.3	16.1

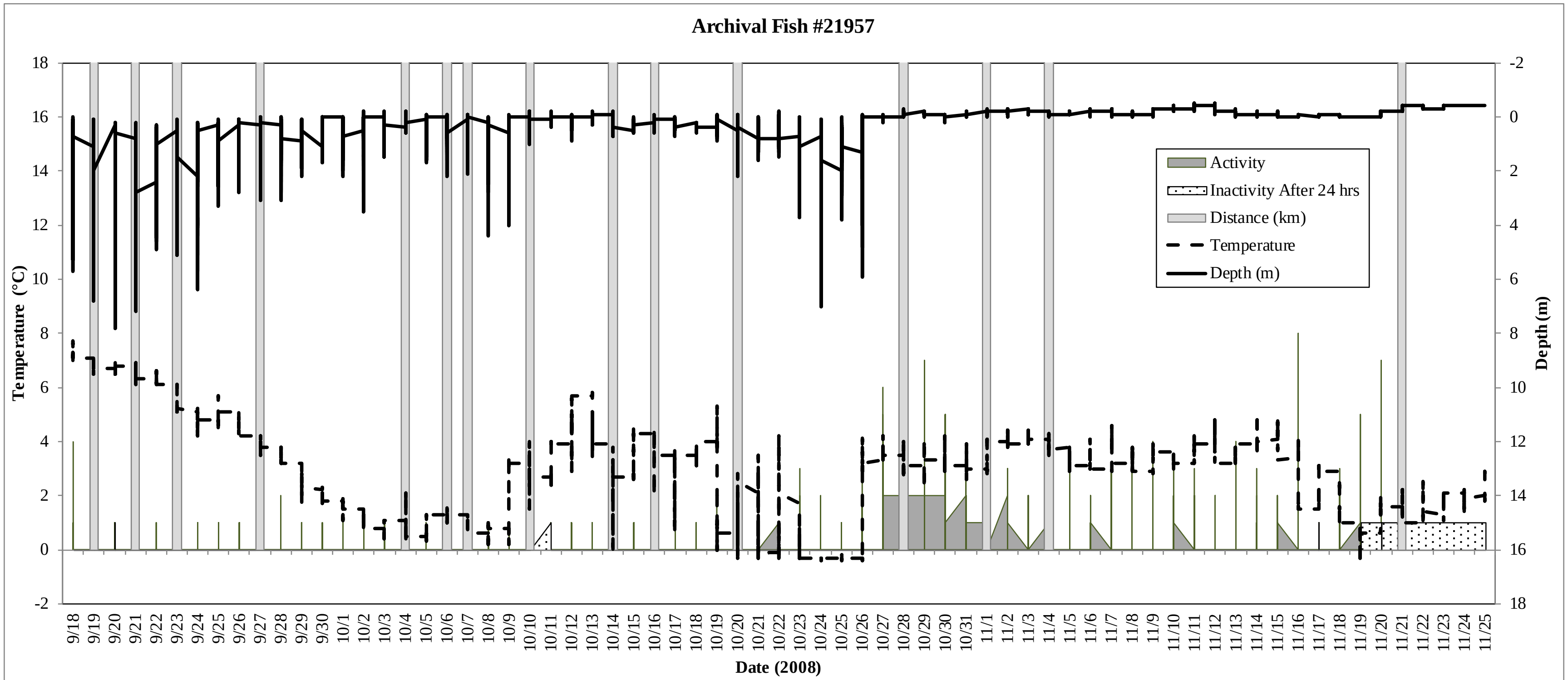
Appendix B6.–Temperature and depth profiles with activity sensor data and corresponding river mile locations (based on the tagging/release site as zero kilometer), from archival radiotagged chum salmon that traversed the mainstem Tanana River, 2008.



Release to Gateway	Gateway to Nenana Tower	Nenana Tower to Fairbanks	Fairbanks to below Salcha River	Salcha River to below Upper Mainstem Tower
0-26 km	26-114 km	114-223 km	223-267 km	267-302 km

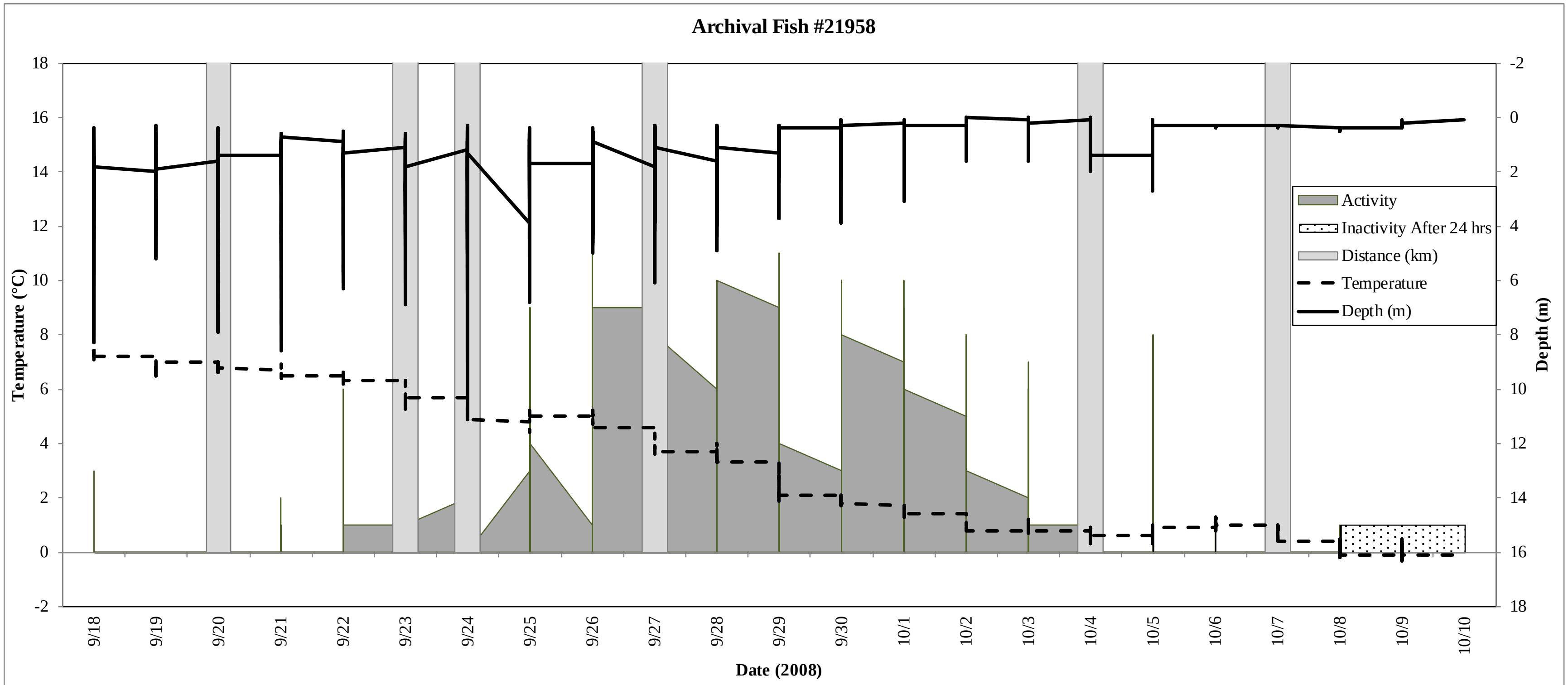


Release to Gateway	Gateway to Nenana Tower		Between Fairbanks and Salcha River
0-26 km	26-114 km	114-154 km	154-225 km



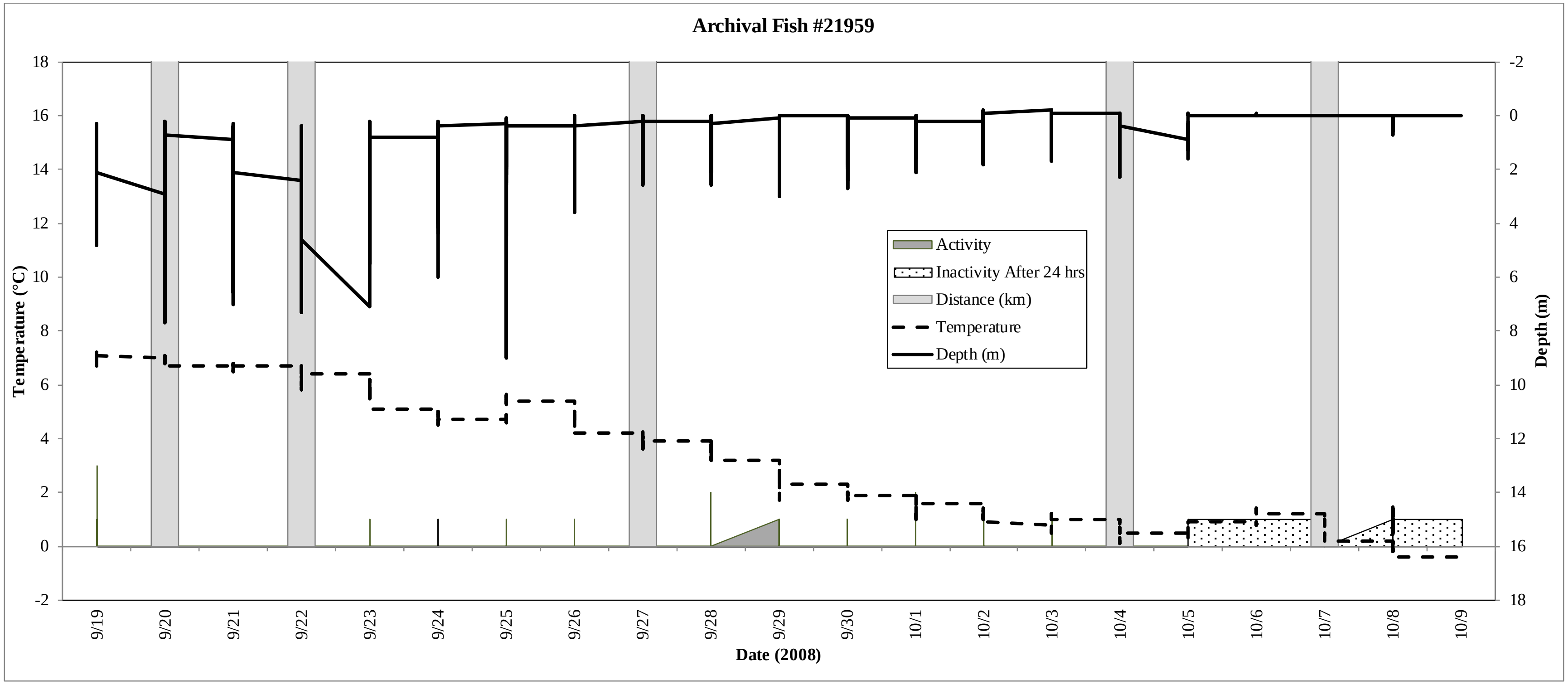
Release to Gateway	Gateway to Upper Mainstem Tower	312-332 km	Rika's Roadhouse All four locations	Mainstem Tanana Bluff Area	Ascended Delta River known fall chum salmon spawning area. Recovered as a spawned out carcass.
0-26 km	26-114-167-245-300-312 km	332-342 km	341-343 km	Confluence Delta River	341-342 km all four locations

Appendix B6.–Page 4 of 15.



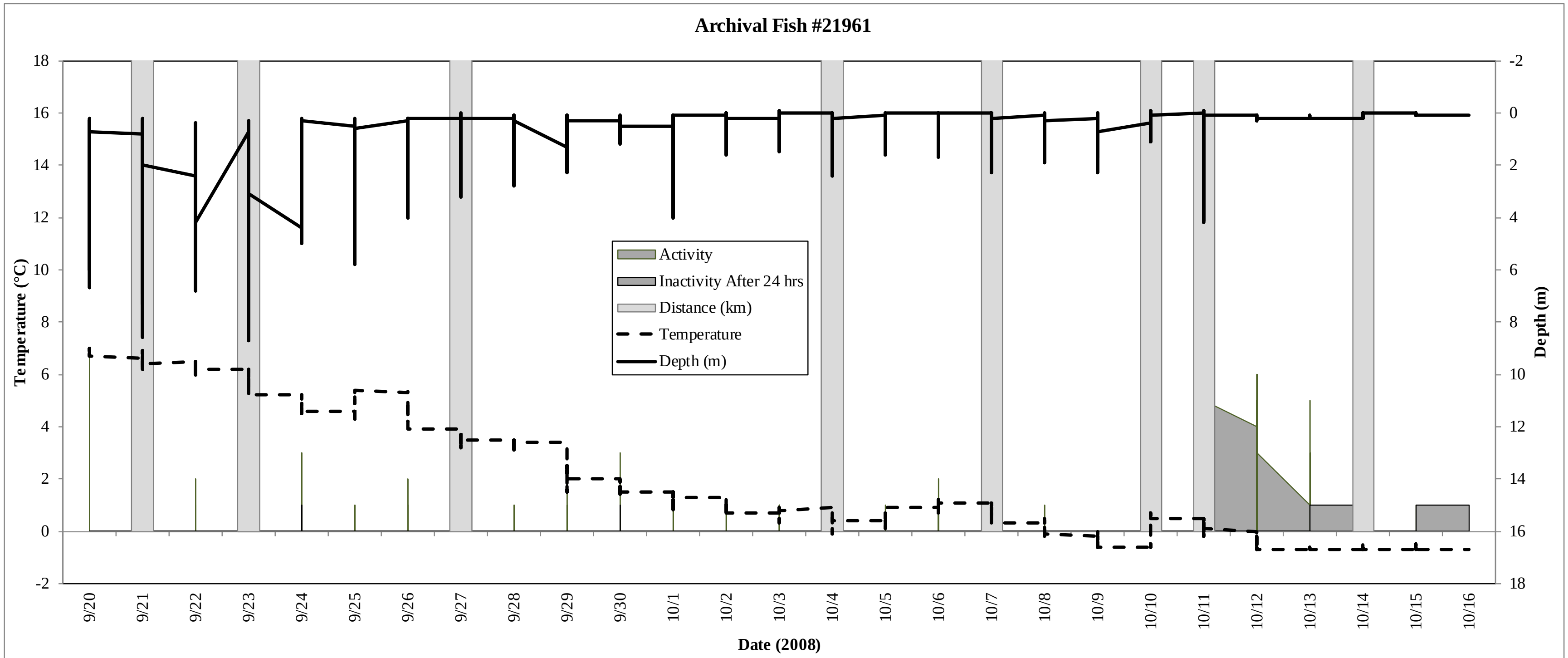
Release to Gateway	Gateway to Nenana Tower	Nenana to Fairbanks	Fairbanks to Delta Junction	Delta Junction
0-26 km	26-96-114 km	114-187 km	187-243 km	243-246 km

Appendix B6.–Page 5 of 15.

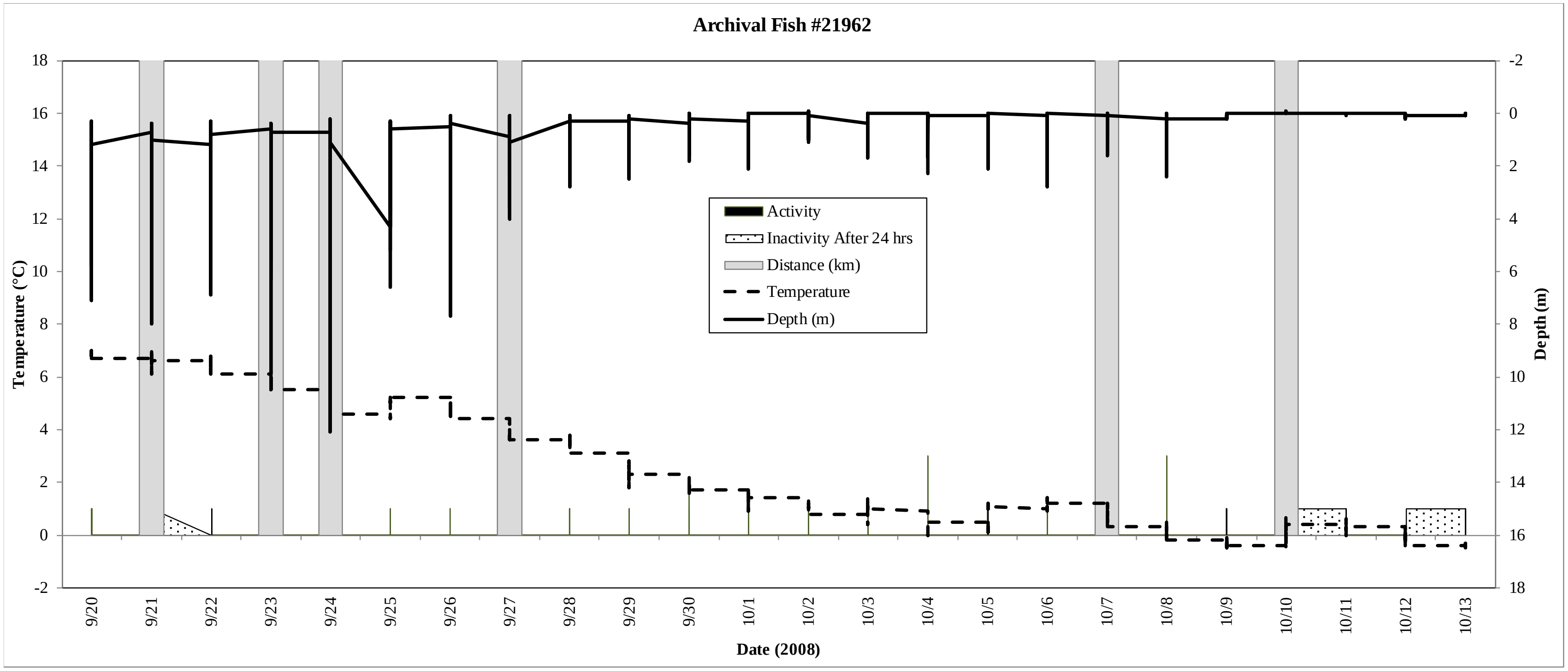


Release to Gateway	to Nenana Tower	Nenana Tower to North Pole	North Pole to downstream of Upper Mainstem Tower	
0-26 km	26-114 km	114-235 km	235-271 km	271-277 km

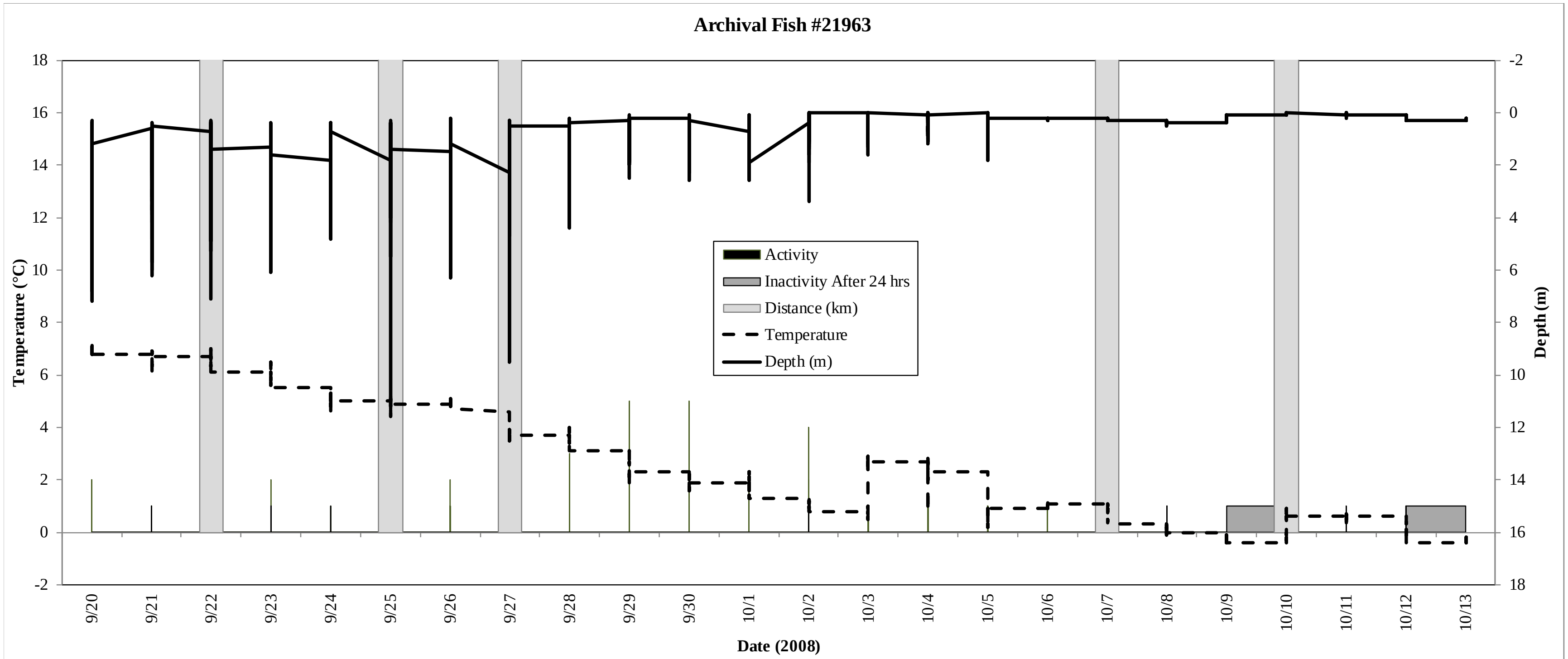
Appendix B6.–Page 6 of 15.



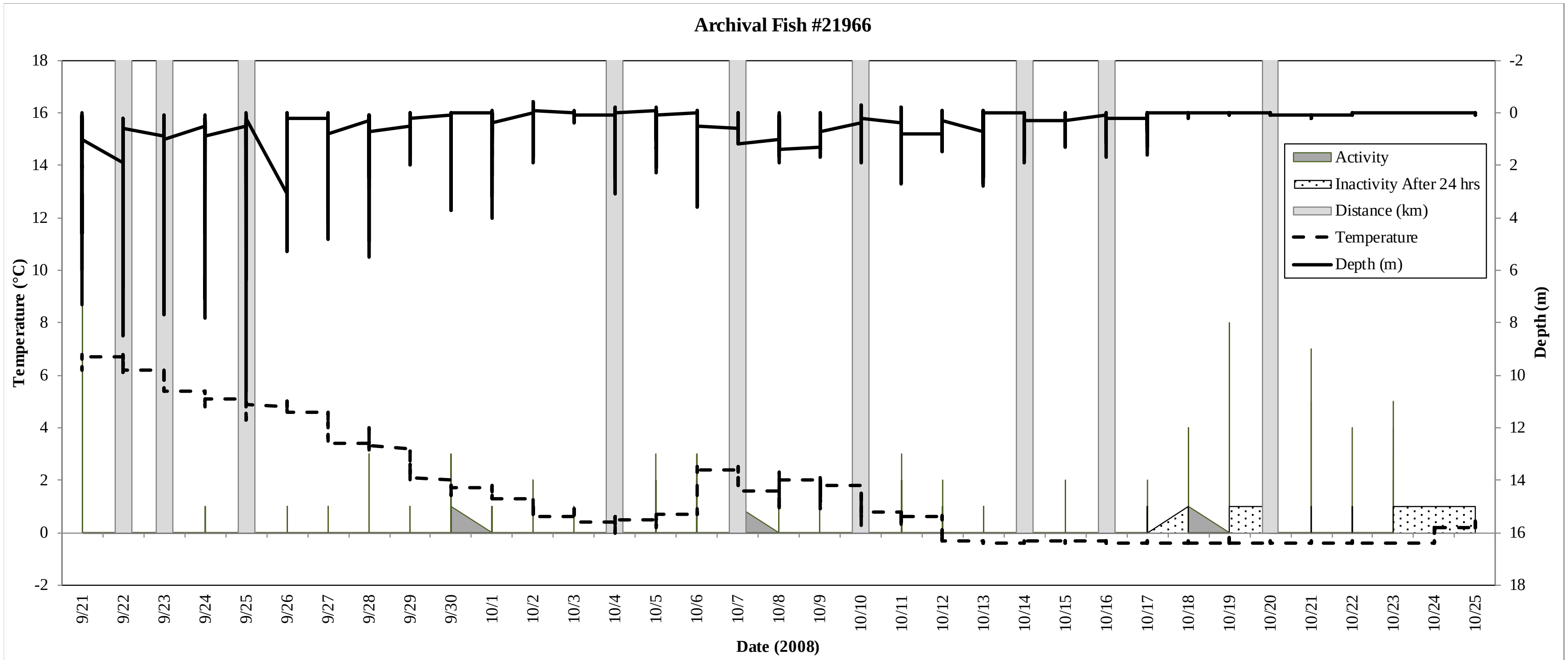
Release to Gateway	Nenana Tower	Nenana Tower to North Pole	North Pole to Upper Mainstem Tower			
0-26 km	26-114 km	114-225 km	225-271	271-294 km	294-303-311 km	311-314 km



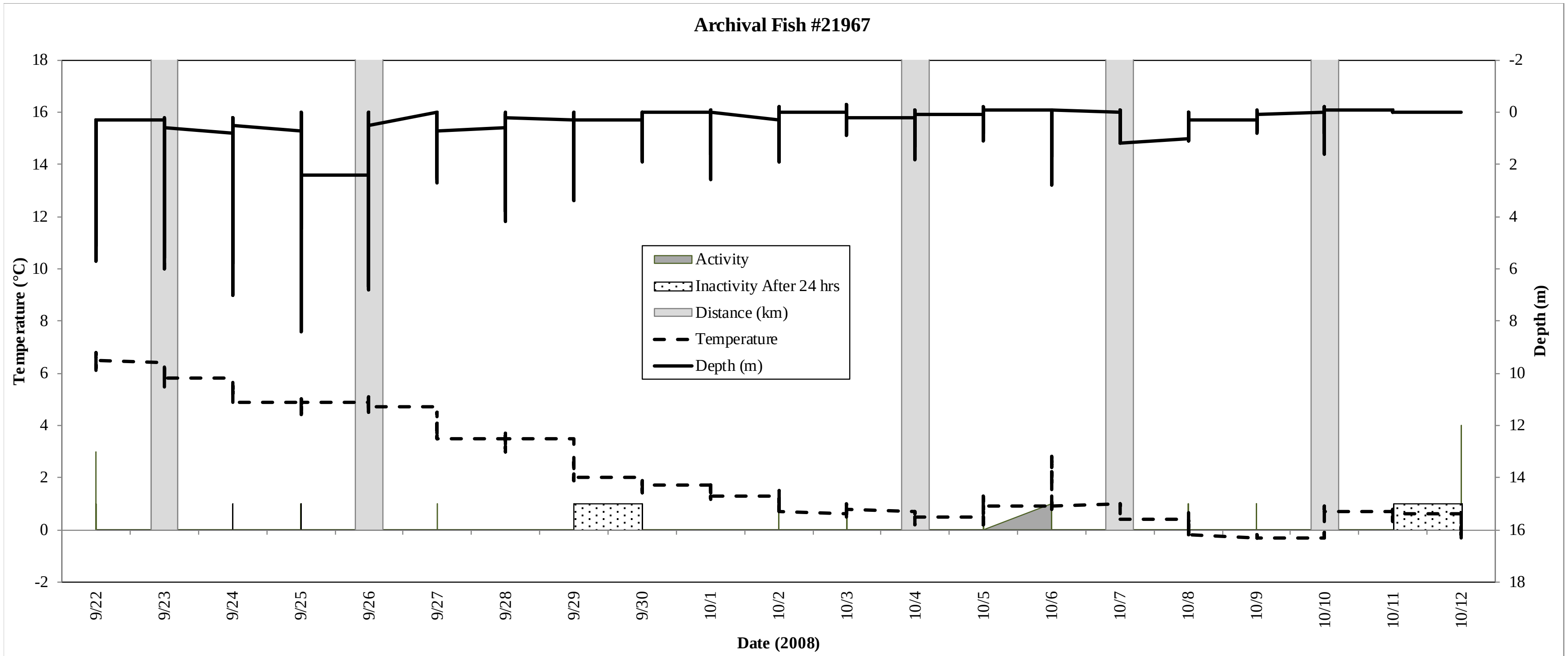
Release to Gateway	to Nenana Tower	Nenana to Fairbanks	Fairbanks to downstream of Upper Mainstem Tower
0-26 km	26-96-114 km	114-214 km	214-299-309 km



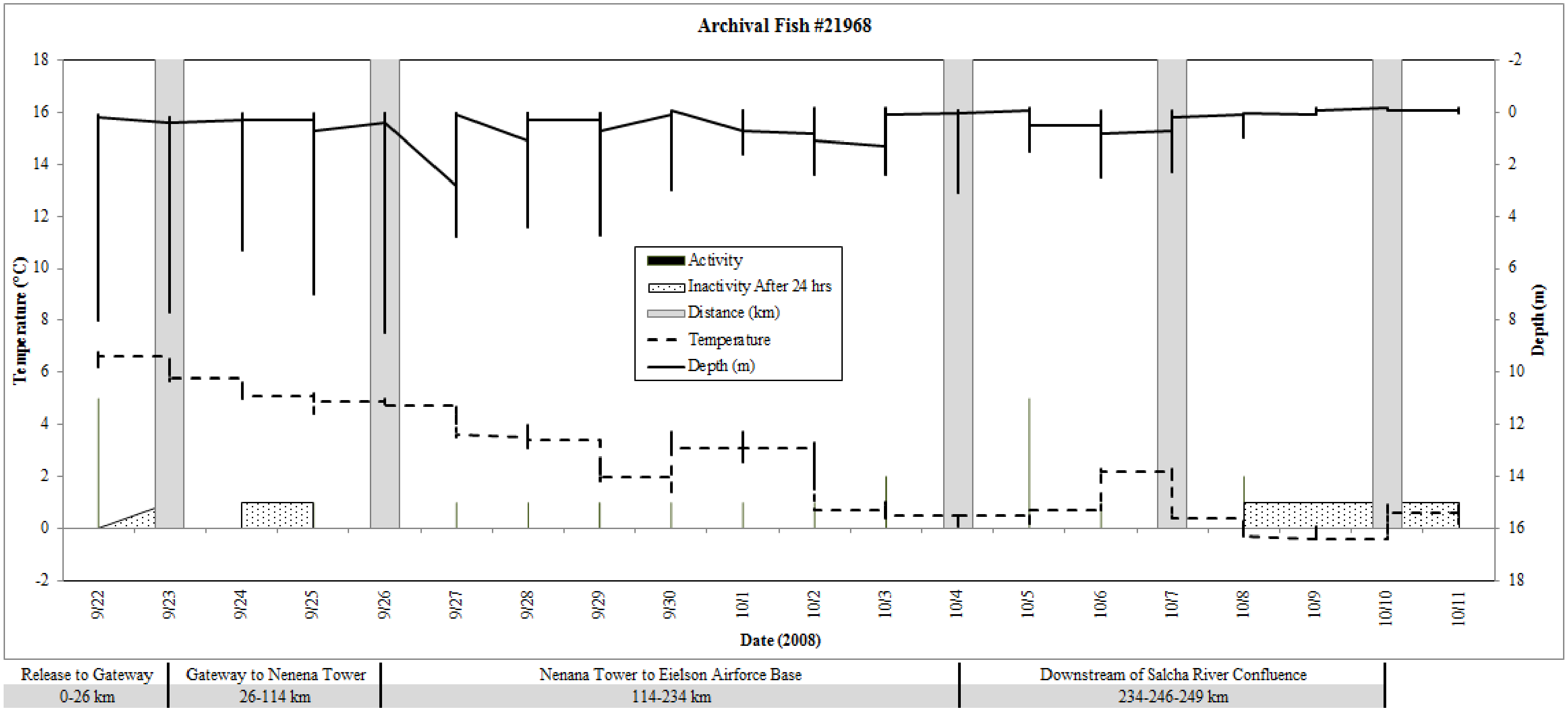
Release to Gateway	to Nenena Tower	to Fairbanks	Fairbanks to downstream of Upper Mainstem Tower
0-26 km	26-114 km	114-194 km	194-263-264 km



To Gateway	to Nenana Tower	Fairbanks to North Pole	North Pole to Salcha River	Upstream of Salcha River
0-26 km	26-53-114 km	114-236 km	236-245-247 km	267 km (all three last locations)

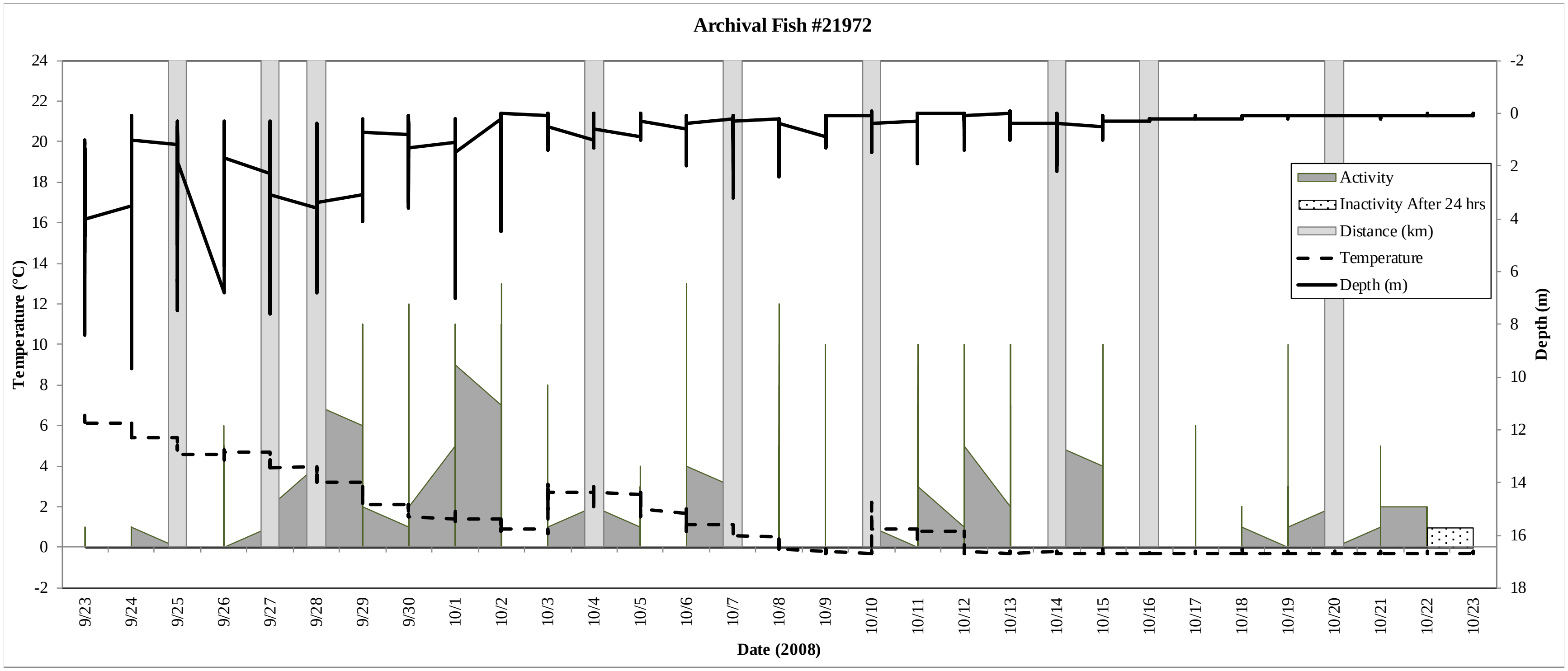


Release to Gateway	Gateway to Nenena Tower	Nenana Tower to downstream of Salcha River		
0-26 km	26-114 km	114-240 km	240-250 km	250-260 km



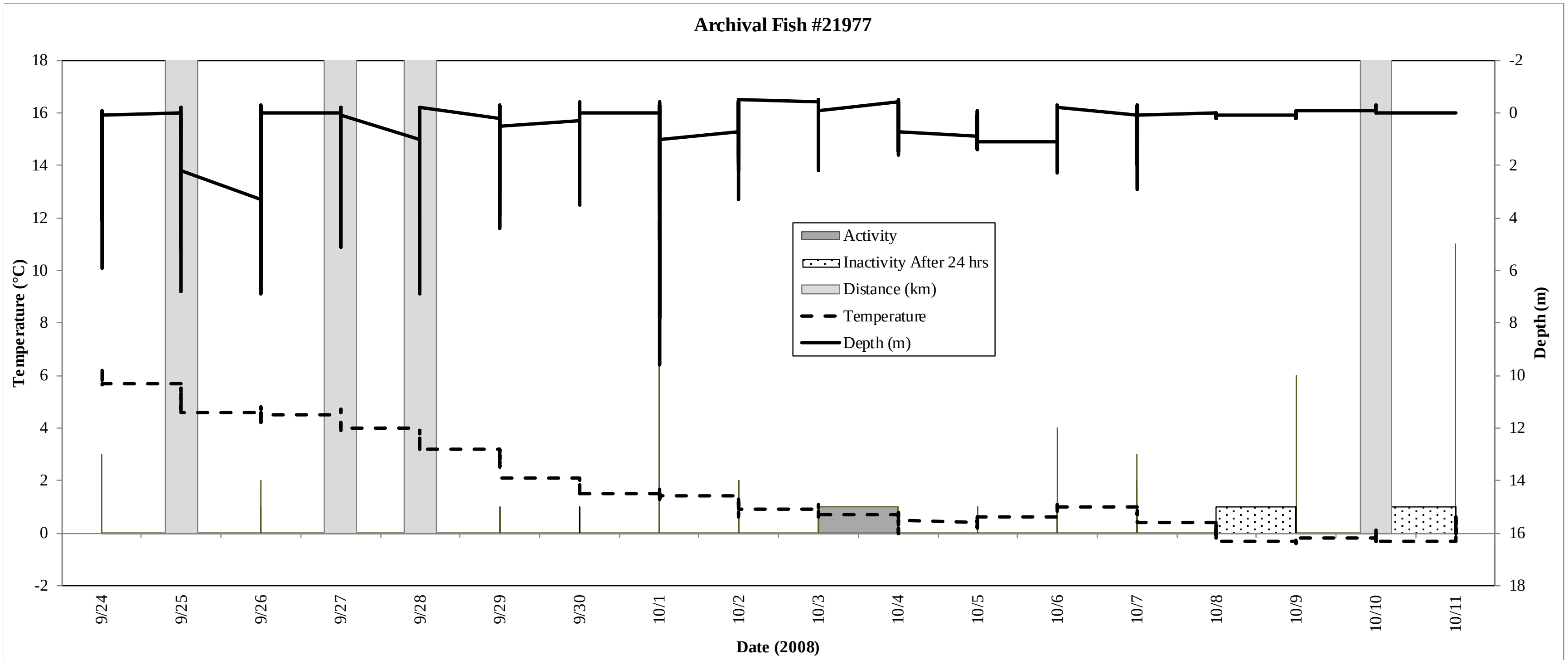
Archival Fish #21968
Temperature (°C)
Depth (m)
Date (2008)
Activity
Inactivity After 24 hrs
Distance (km)
Temperature
Depth (m)
9/22
9/23
9/24
9/25
9/26
9/27
9/28
9/29
9/30
10/1
10/2
10/3
10/4
10/5
10/6
10/7
10/8
10/9
10/10
10/11
Release to Gateway
0-26 km
Gateway to Nenena Tower
26-114 km
Nenana Tower to Eielson Airforce Base
114-234 km
Downstream of Salcha River Confluence
234-246-249 km

Appendix B6.–Page 12 of 15.

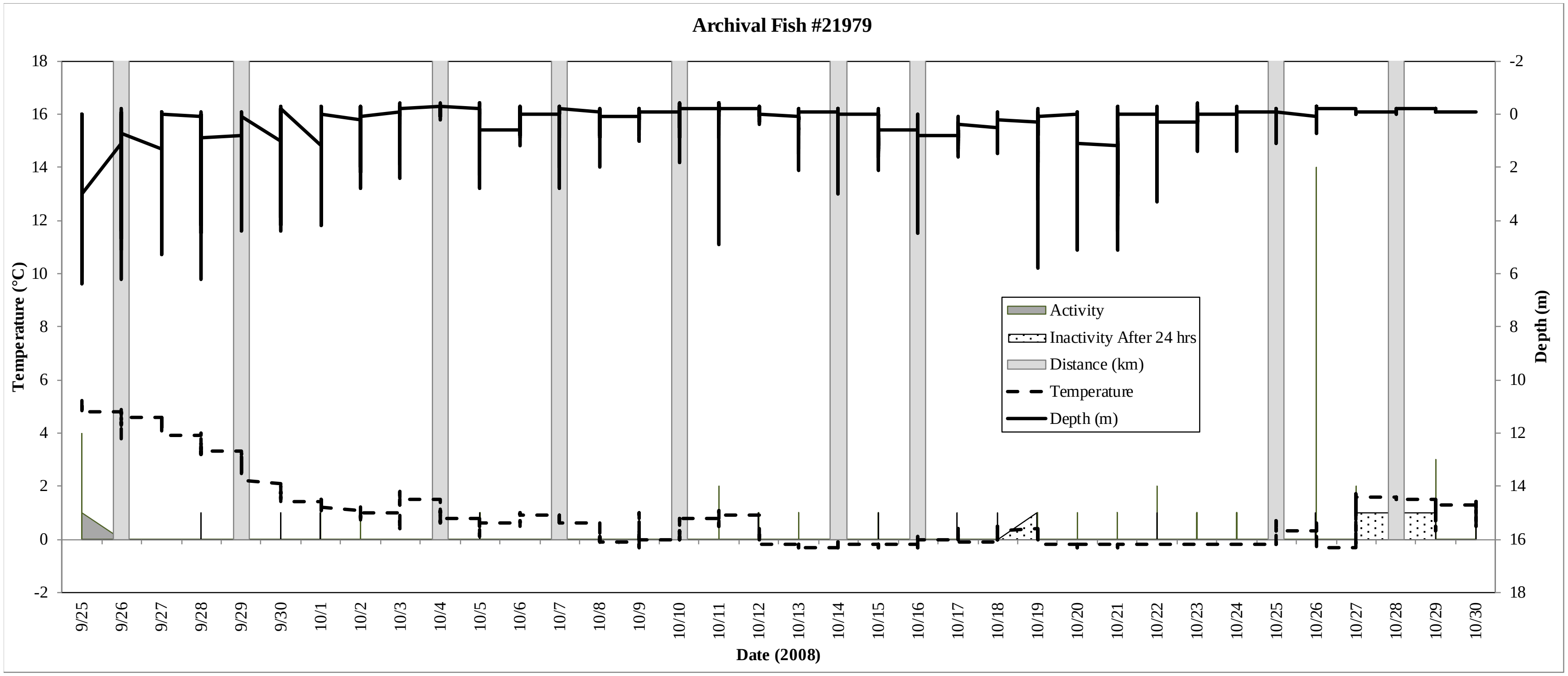


Release to Gateway	to Nenena Tower	Nenana to North Pole	North Pole to Salcha River	Salcha River to downstream of Little Delta River confluence
0-26 km	26-93-114 km	114-217 km	217-231-252 km	252-250-269-271 km

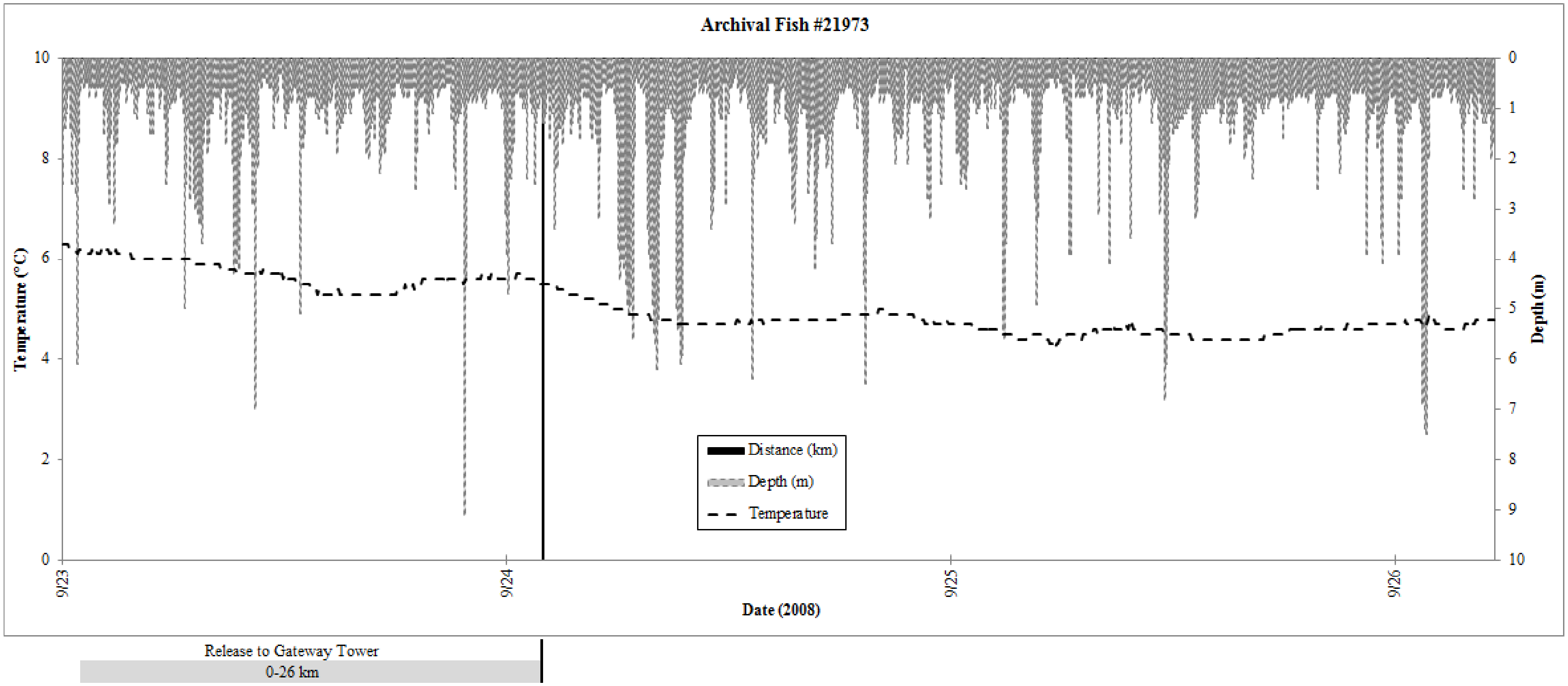
Appendix B6.–Page 13 of 15.



Release to Gateway	Gateway to Nenena Tower	Nenana Tower to downstream of Salcha River
0-26 km	26-86-114 km	114-236 km

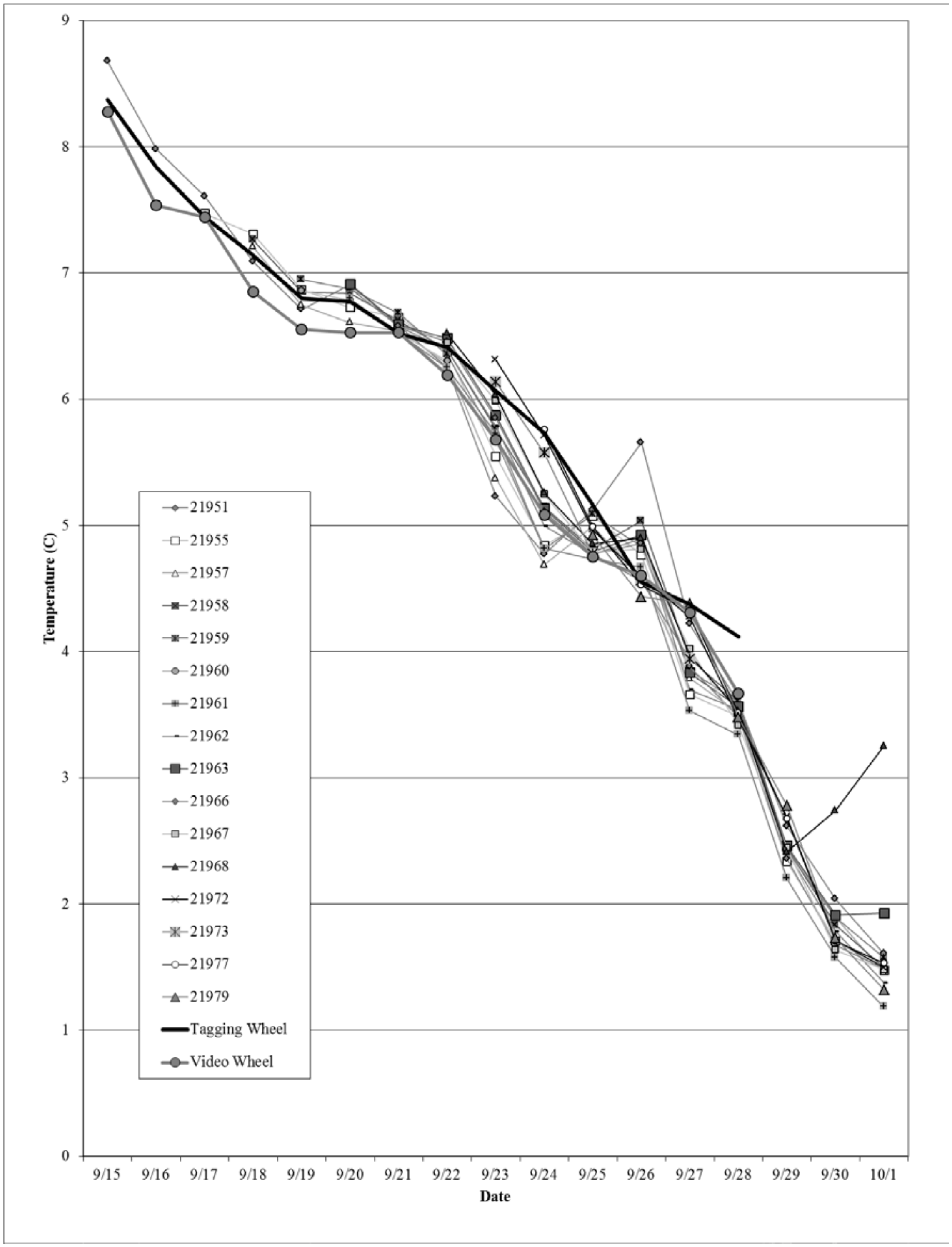


To Gateway	to Nenana Tower	Nenana to Fairbanks	Vicinity of Fairbanks and North Pole
0-26 km	26-114 km	114-194 km	194-200-200-195-194-198-199 km



Note: Fish 21973 was harvested in the fishery and shown at a finer scale than those prior.

Appendix B7.–Water temperature profiles for archival radiotagged chum salmon (by fish number) that traveled the Tanana River (includes reference HOBO temperatures at 2 fish wheel sites en route), September 2008.



Note: Only includes travel through the mainstem from tagging date through October 1, after which based on site selections temperatures become more variable.

Appendix B8.–Data files used to analyze fall chum salmon movements in the Tanana River, 2007–2008.

Data Files	Description
FallChumTelemTanana08_ReportTabsFigs.xlsx[a]	Excel spreadsheets with data analyzed for daily catch information, tagging rates, stock timing, migration rates, depth of travel and temperature profiles.
FallChumTelemTanana08_ReportAppends.xlsx[a]	Excel spreadsheets with data analyzed from tag testing in 2007, migration rates, water levels affecting migration, and individual fish depth of travel and temperature profiles.
Primary data resides in a sequel server database[b]	Contains raw fish capture data, all tower and aerial tracking downloads, archival temperature and depth profiles and temperature data from the modeling component of the project.

[a] Data files have been archived at the Alaska Department of Fish and Game, Research and Technical Services, Anchorage, Alaska 99518.

[b] Primary data resides with the Alaska Department of Fish and Game, Division of Commercial Fisheries, Data Resource Management, Anchorage, Alaska 99518; contact the author for data requests, Division of Commercial Fisheries, 1300 College Road, Fairbanks, Alaska 99701.