Fishery Data Series No. 04-04

Seasonal Habitat Use and Experimental Video Enumeration of Rainbow Trout within the Gulkana River Drainage

by

Douglas F. Fleming

March 2004

Alaska Department of Fish and Game **Division of Sport Fish**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used in Division of Sport Fish Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications without definition.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

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

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
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	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
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
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

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	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
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.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
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
standard length	SL
total length	TL
variance	Var

FISHERY DATA SERIES NO. 04-04

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ABSTRACT

Between May 2000 and August 2001, two studies were conducted that were designed to aid in the development of an efficient means for future stock assessments of rainbow trout *Oncorhynchus mykiss* in the Gulkana River drainage: 1) assessing the feasibility of using underwater videography to enumerate rainbow trout migrating to spawning areas; and, 2) a radiotelemetry study to gather life-history information. Underwater videography was examined to determine if this method, deployed in conjunction with a small constriction weir, would yield video images of sufficient quality needed to identify and enumerate resident rainbow trout and steelhead during their prespawning migration. Images of sufficient quality were attained, however, supplemental lighting was required for 24-h imagining. The second study was a telemetry study of adult rainbow trout in which aerial tracking was used to locate overwintering and spawning areas. Twenty-three rainbow trout were captured and surgically implanted with radio transmitters during July and August 2000 in different sections of the Gulkana River drainage. By May of 2001, eleven rainbow trout survived to spawning and five (42%; SE = 15%) fish utilized the two previously documented spawning areas in the Middle Fork Gulkana River drainage, near the outlet of Dickey Lake and in Hungry Hollow Creek. Among the other seven fish, one likely spawned in the Middle Fork Gulkana River just upstream of Swede Creek, four likely spawned in the upper mainstem of the Gulkana River, and two fish ascended a previously undocumented spawning stream, 12-Mile Creek. A total of 10 aerial trackings were conducted which terminated approximately after a period of 12 months, during August 2001. At that time, 80% of the fish were within 2 mi from their initial capture location.

Key Words: Gulkana River, Middle Fork Gulkana River, West Fork Gulkana River, Hungry Hollow Creek, 12-Mile Creek, rainbow trout, *Oncorhynchus mykiss,* radiotelemetry, underwater video, weir, spawning areas, spawning stocks, overwintering, site fidelity, hook-and-line gear, stock assessment.

INTRODUCTION

Rainbow trout and steelhead *Oncorhynchus mykiss* populations inhabit the upper Copper River drainages and are unique in that they are considered the northernmost wild populations in North America (Figure 1). These populations have been found to exist exclusively, such as in the Hanagita River where only steelhead are found, and sympatrically where both steelhead and rainbow trout utilize the same spawning beds, such as in the Middle Fork Gulkana River. Similar to other salmonid species living on the edges of their distribution, these stocks are thought to be relatively sparse and unproductive (Flebbe 1994). Because of their population and life history characteristics (relatively small stock sizes, migration patterns, and seasonal presence), and the vastness and inaccessibility of the Copper River drainage only limited information on this species exists. Most of the information exists on larger stocks that are accessible and have been detected by anglers, such as the Gulkana and Hanagita rivers.

Management of wild rainbow trout and steelhead in the Copper River drainage is guided by a wild rainbow and steelhead trout management policy. In 1987, the Alaska Board of Fish (BOF) approved an amendment to the Cook Inlet Rainbow/Steelhead Trout Management Policy (CIRTMP), which extended the policy's geographic coverage to include Upper Copper Upper Susitna Management Area (UCUSMA). This policy was initially developed to provide a framework of several rainbow and steelhead trout fishery management policies (ADF&G 1987):

Policy I: native rainbow trout populations will be managed to maintain historical size and age composition and stock levels; and,

Policy II: a diversity of sport fishing opportunities for wild and hatchery rainbow/steelhead trout will be provided through establishment of special management areas by regulation.

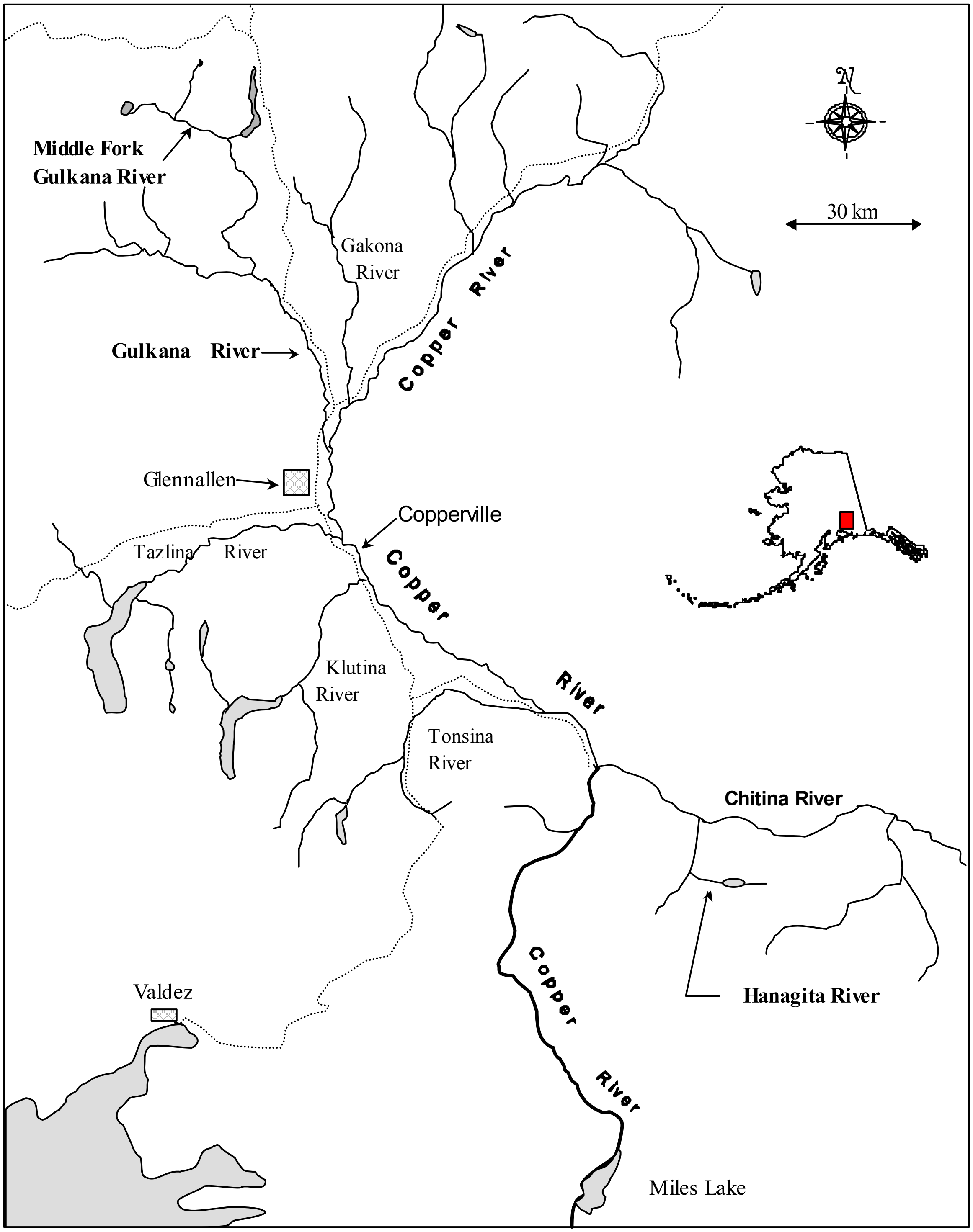

Figure 1.-Copper River drainage.

These policies have resulted in more conservative regulations for well-documented and unknown stocks of rainbow and steelhead within the UCUSMA. At the time of the policy's approval, the BOF gave recommendations for research which included:

1. developing adequate methodologies to estimate rainbow trout abundance and fishing mortality;
2. developing an index of the relative abundance for rainbow/steelhead trout in selected waters;
3. examining spatial and seasonal distribution of rainbow trout in selected waters;
4. characterizing size and age composition of rainbow/steelhead trout in selected waters;
5. developing information on the harvest of rainbow trout/steelhead trout; and,
6. developing angler-preference information pertaining to the management of rainbow trout fisheries.

THE GULKANA RIVER FISHERY

The Gulkana River is located north of Glennallen (Figure 2) and was designated a National Wild River on December 2, 1980 when Congress amended the Wild and Scenic Rivers Act (P.L. 90-542) as part of the Alaska National Interest Lands Conservation Act (P.L. 96-487). The Gulkana River supports the largest recreational fishery in the UCUSMA, and accounts for as much as 50% of the estimated annual angling effort (Mills 1978-1994; Howe et al. 1995-2001c; Table 1). This drainage continues to support the largest known fisheries for rainbow and steelhead trout, chinook salmon *O. tshawytscha*, and Arctic grayling *Thymallus arcticus* within the management area (Szarzi 1996).

Following approval of the 1987 management policies, rainbow trout and steelhead bag limits were reduced. Bag limits were changed from 10 fish per day and 10 in possession (only 2 of which could exceed 20 inches) to 2 fish per day and 2 in possession (only 1 fish over 20 inches). By 1990, managers believed the rainbow trout and steelhead population had declined and that the current harvest levels were unsustainable (Szarzi 1996). Beginning in 1991, the Gulkana River rainbow trout and steelhead fishery has been managed by a catch-and-release regulation, with progressively more gear restrictions in upstream areas where rainbow and steelhead are more frequently encountered. In 1991, the fishing gear was restricted to the use of unbaited, artificial lures only in an area restricted to all waters of the Gulkana River upstream of a departmental marker located 7.5 miles upstream of the West Fork (Figure 2). Below this location, anglers could use bait all year. In 1999, a new bait/season regulation was approved to make rainbow trout/steelhead regulations in the Gulkana River more consistent with recommendations within the rainbow trout management policy. That regulation allows bait in the same areas, but only between June 1 and July 19 when anglers target chinook salmon. Additional regulations have closed portions of Gulkana River to all angling during spawning periods of rainbow trout and steelhead. Specifically, this seasonal spawning area closure runs from April 15 thru June 15 each year and includes the 3-mi section immediately downstream of Dickey Lake, and all of Hungry Hollow and 12-Mile creeks.

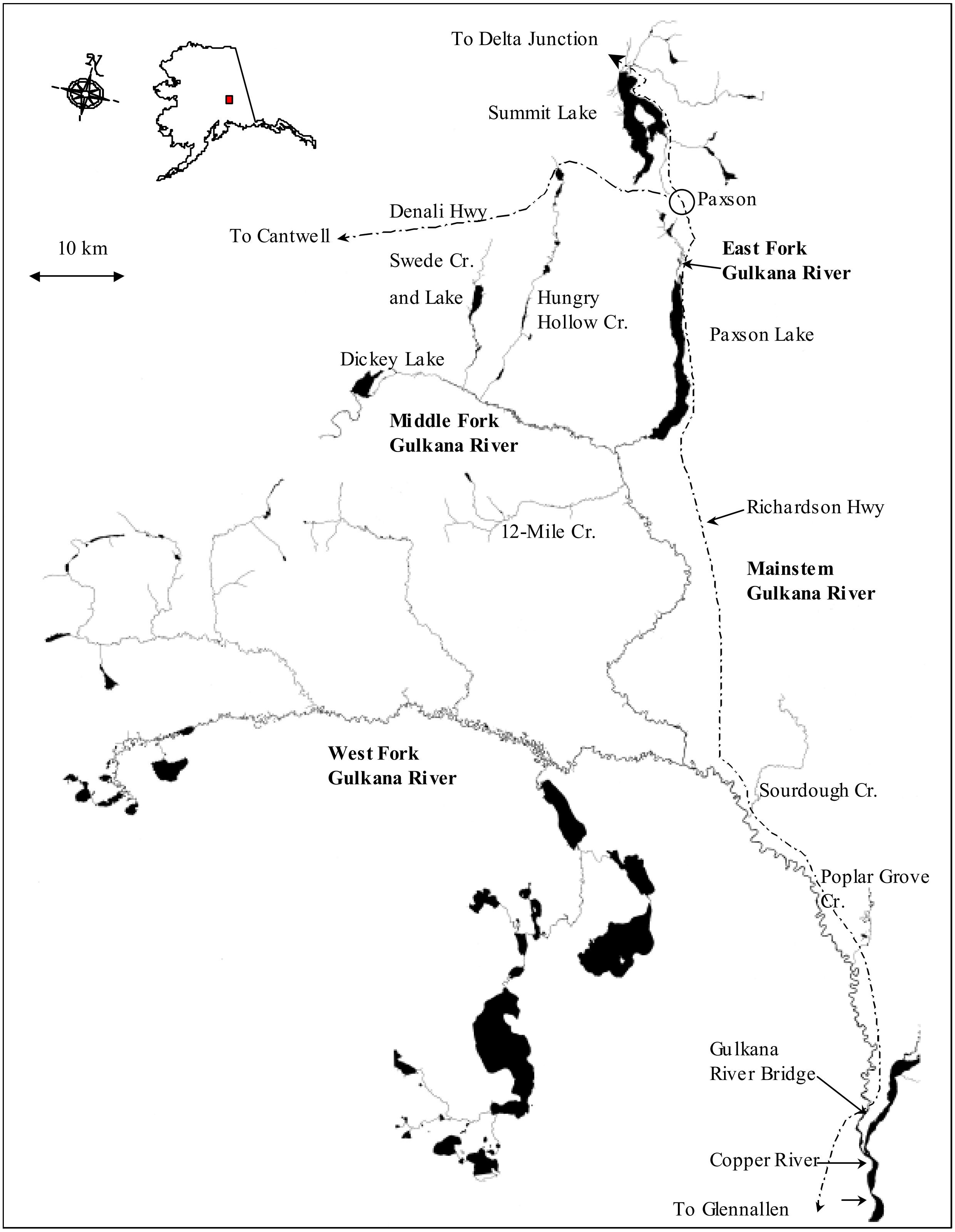

Figure 2.-Gulkana River drainage.

Table 1.-Yearly effort[a], harvest[b], and catch of wild rainbow trout and steelhead by sport anglers fishing the Gulkana River for the period from 1977-2001.

		Rainbow trout		Steelhead trout	
Year	Effort	Harvest	Catch	Harvest	Catch
1977	4,165	752		0	
1978	6,570	1,256		0	
1979	17,323	1,455		0	
1980	13,752	1,249		0	
1981	14,430	1,469		0	
1982	14,979	1,257		52	
1983	16,911	1,341		21	
1984	12,870	1,266		0	
1985	14,080	2,098		137	
1986	14,219	1,104		18	
1987	17,354	1,517		104	
1988	11,299	1,218		18	
1989	15,285	656		47	
1990	18,782	425	2,395	34	68
1991	20,944	150	1,133	0	26
1992	25,650	16	1,654	8	39
1993	27,034	40	2,724	0	102
1994	25,357	0	3,380	0	0
1995	32,656	0	3,958	0	41
1996	25,552	0	6,694	0	121
1997	23,593	0	8,124	0	126
1998	27,146	0	5,428	0	109
1999	29,840	0	7,610	0	256
2000	20,674	0	6,829	0	169
2001	18,685	0	4,148	0	219

[a] Estimates of angling effort included the Gulkana River only, and do not include effort within lakes.

[b] Estimates of harvest and catch include fish harvested at Paxson Lake; some rainbow trout fishing and harvests occur in the outlet area.

THE ISSUE: POPULATION MONITORING

The need to assess these populations for management has been supported both by the UCUS rainbow/steelhead management policy and area managers requesting stock status information. Because of popularity of the Gulkana River fisheries, area managers have proposed that research efforts focus on stock assessment of the resident rainbow trout population. According to estimates generated in the statewide harvest and participation surveys, estimated sport angling effort of up to 32,000 angler-days occurred in recent years from a population of unknown size. Given this level of use, tools or methods that could assess the overall population, or a part of it, were needed.

The high catches of rainbow trout from the Gulkana River, which occur almost exclusively along the mainstem of the Gulkana River from Paxson Lake to it's mouth, is partially attributed to its relative easy access. Anglers can access the mainstem of the Gulkana River from several locations: 1) from Paxson Lake people can float the entire mainstem (approximately 80 river miles); 2) from a campground and motorized boat launch at Sourdough Creek (motorized boats cannot travel the mainstem beyond a marker located 7.5 miles upstream of the West Fork); 3) by foot and boat at the Richardson Highway Bridge; and, 4) at several private access points between Sourdough Campground and the Richardson Highway Bridge. Additionally, anglers can access the more remote areas of the drainage via floatplanes or all-terrain vehicles, including most of the Middle Fork Gulkana drainage (~25 mi) and parts of the extensive West Fork Gulkana River drainage, which includes approximately 190 miles of rivers and stream.

Previous studies on Gulkana River rainbow trout populations often focused on spring spawning aggregations of adult rainbow trout and steelhead. In 1998, ADF&G staff initiated baseline biological studies on rainbow trout and steelhead in the Copper River basin (Fleming 1999). Surveys and biological sampling were conducted using hook-and-line gear and visual counts along portions of the Middle Fork and mainstem Gulkana River in 1998 and 1999. Some sampling occurred during the spring spawning season (late-May to early-June) in 1998 and 1999 in the known Middle Fork Gulkana River spawning areas (Burger et al. 1983; Stark 1999; Brink 1995), and along the mainstem Gulkana River above Sourdough. Sampling also occurred during summer (late July) along the mainstem Gulkana River during 1998 and 1999. In these surveys, baseline information on the sizes and ages of resident rainbow sampled indicated that catch-and-release regulations appeared to allow resident rainbow trout to survive and grow to sizes desired by sport anglers (Fleming 1999). Although efforts to tag and sample fish in 1998 and 1999 were limited, movements by Floy™-tagged rainbow trout were documented between the Middle Fork Gulkana River spawning areas (Dickey Lake and Hungry Hollow Creek) and mainstem summer feeding areas and between mainstem summer feeding areas and Middle Fork spawning areas. Spawning site fidelity of rainbow trout in the Middle Fork spawning areas was also documented.

In order to conduct future stock assessments of resident rainbow trout it was recognized that more comprehensive life-history information and a cost-effective assessment tool were needed. Radiotelemetry was identified as a means to collect life history information and underwater videography was identified as a potential cost-effective means to enumerate significant spawning aggregations, which could be used as an index of total abundance.

Radiotelemetry has been an effective means to collect life history information that has been used to design fisheries research (Roach 1998; Ridder 1998a, 1998b) or fisheries regulations (Fish 1998). In 1983, a telemetry project on steelhead migrating up the Copper River identified the currently known spawning areas in the Gulkana River (Burger et al. 1983). Within the Gulkana River, two spawning areas were located: 1) the first three miles of the Middle Fork Gulkana River immediately below Dickey Lake; and, 2) Hungry Hollow Creek. These areas were also used by resident rainbow trout. After locating spawning areas, ADF&G and U.S. Bureau of Land Management (BLM) staff conducted helicopter and stream surveys that resulted in counts of approximately 200 fish within the identified spawning sections of the Middle Fork drainage (Williams and Potterville 1985), although, resident rainbow trout could not be discerned from steelhead trout. Later, Stark (1999) reported visual counts of between 20 and 30 steelhead spawning with rainbow trout during field investigations conducted between 1993 and 1995 in these same areas. Although the 1982-1983 study included only a small number of steelhead with functioning implanted radio transmitters (n = 17), these two spawning locations in the Gulkana River drainage were thought to represent the two largest aggregations in the Gulkana River drainage, and hence, have been the focus of the limited studies conducted. If a greater number of steelhead had been radio-tagged, it is likely that additional spawning concentrations of steelhead, and coincidentally rainbow trout, would have been identified in the Gulkana River. Within the Gulkana River exclusively, radiotelemetry studies have not been conducted on rainbow trout.

Past observations of pre- and post-spawning rainbow and steelhead trout migrating to and from spawning areas near Dickey Lake have suggested that relatively inexpensive methods could be developed for enumerating and monitoring these spawning populations. Similar to earlier efforts, approaches that relied on visual counts, such as shore-based and aerial counts. In 1999, ADF&G attempted to detect and count spawning rainbow and steelhead trout in headwater areas using aerial helicopter counts apportioned by ground sampling, in an effort to develop index counts as an assessment tool (Fleming 2000). However, aerial counts in known spawning areas below Dickey Lake and in Hungry Hollow Creek were hampered by several factors. Wind conditions (strength and direction), poor lighting, and the "skittish" behavior of pre-spawning trout resulted in aerial counts that were less than shore-based counts. Moreover, poor visibility resulting from turbid, high flows and overhanging vegetation precluded efforts to visually locate other spawning areas suspected in tributaries to the West Fork Gulkana River and to survey spawning areas in Hungry Hollow Creek.

Counting towers were also considered as a way to count rainbow trout and steelhead entering or leaving spawning areas. This method was not selected because it would be costly and prone to bias because of variables affecting detection of fish and classification of fish by life-history type (resident rainbow trout v. steelhead). Variables may include; poor lighting conditions, migrations in deep waster, low probability of detecting small fish, poor contrast (fish relative to background), and potential poor water clarity due to high water. Moreover, enumeration of fish by life history types would be prone to classification error owing to the overlapping size distributions between large rainbow trout and small to average-sized steelhead trout.

If visual observations of fish could be made directly in the water column, it was thought that the distinguishing features of rainbow trout and steelhead could be identified and accurate counts could be attained. At present two enumeration methods rely on underwater observation. Snorkeling counts are used to provide indices of peak adult steelhead abundance in a number of index streams in Southeast Alaska (Johnson and Jones 1999). Similar to bank or aerial surveys, this method results in peak index counts of adult steelhead spawners observed during multiple surveys conducted throughout the spawning period. Unfortunately, information on overall abundance cannot be attained with snorkel counts if stock-specific immigration and emigration patterns overlap. This index method requires an annual commitment to draw inferences about stock status and the snorkeling method may not be adaptable for all size streams and types of habitats.

An alternative enumeration method uses underwater videography. Video enumeration has been used to enumerate escapements of salmon and steelhead in the Columbia River drainages (Hatch et al. 1994; Faurot et al. 2000). In Alaska, video enumeration is used to enumerate sockeye salmon *O. nerka* at the Chignik weir and methods have been explored to enumerate and apportion runs of pink and chum salmon in Prince William Sound (T. Otis, Alaska Department of Fish and Game, Homer, personal communication). Depending on the choice of study objectives, underwater video enumeration may provide a cost-effective method to enumerate and classify small spawning populations of rainbow trout and steelhead. Benefits of underwater videography are that only a small crew is needed and that rainbow trout and steelhead can be accurately enumerated with minimal disruption to their migration and spawning. A disadvantage would be that length or age information could not be collected.

GOAL STATEMENT

The goals of this project were to: 1) describe the seasonal distributions of rainbow trout over a 12-month period in the Gulkana River using radiotelemetry; and 2) assess the feasibility of using underwater videography as a stock-monitoring tool in the Gulkana River for both rainbow trout and steelhead. Specifically, radiotelemetry was used to 1) collect migratory timing information; 2) locate overwintering and spawning locations; and, 3) describe the proportion of the rainbow trout spawning population that utilizes the Dickey Lake spawning area. The Dickey Lake spawning area was selected for the underwater videography site. Ultimately, the goal of this project and future work is to provide a reliable means to assess or monitor the rainbow trout population in the Gulkana River drainage.

OBJECTIVES

The research objectives for 2000 were to:

1. estimate the proportion of radio-tagged adult rainbow trout that entered known spawning areas within the Middle Fork of the Gulkana River in late-May and early-June; and,
2. determine areas where spawning and overwintering occurred within the Gulkana River drainage.

In addition to these objectives, other research tasks were to:

1. build and deploy a constriction weir immediately downstream of the known spawning area on the Middle Fork Gulkana River below Dickey Lake;
2. evaluate the feasibility of underwater videography for enumeration and classification of migrating rainbow and steelhead as they pass upstream or down of the weir; and,
3. conduct periodic aerial radio trackings that correspond to biologically meaningful seasons (late fall, overwintering, early spring, spawning, and summer feeding).

STUDY AREA

The Gulkana River is a non-glacial, runoff stream that flows southwards out of the Alaska Range for approximately 112 miles before reaching the Copper River near Glennallen (Figure 2). The

East Fork Gulkana River begins above timberline at Gunn Creek, a tributary to Summit Lake and continues until it enters Paxson Lake. An early account claimed the East Fork Gulkana River flowed from the Gulkana Glacier and from Gunn Creek into Summit Lake (Allin 1957). Below Summit Lake, the river flowed into Gulkana Lake (currently known as Paxson Lake) carrying glacial silt. Below the lake outlet, the Gulkana River retained a milky glacial color. Eventually glacial outwash from the Gulkana Glacier was diverted into the Delta River drainage, which acted to clear the lakes and flowing waters of suspended glacial silt. The mainstem of the Gulkana River begins at the outlet of Paxson Lake and has two major tributary drainages, the West Fork (192 mi in length including major tributaries) and the Middle Fork (35 mi in length including major tributaries). Floatplane, or combinations of canoeing and overland portaging are necessary for access to either the West Fork or Middle Fork drainages. The United States BLM manages much of the land bordering the river, and much of the river drainage was designated as a National Wild River through the 1980 Alaska National Interest Lands Conservation Act (ANILCA). The AHTNA Native Corporation owns most of the land downstream of Sourdough, which borders the lower 37 mi of the watershed. Stream habitat within the Gulkana River drainage range from slow meandering reaches to high gradient sections of Class III+ rapids in small, incised canyons. Much of the habitat has been described by Albin (1977) and more recently by Brink (1995) and was later classified by Stark (1999).

The West Fork Gulkana River (hereafter referred to as the West Fork) includes two branches, the south branch and the north branch, which both enter approximately 51 mi up the West Fork (Figure 3). The south branch flows for approximately 52 mi through a series of interconnecting lakes before reaching the confluence with the north branch of the West Fork. This southern branch has a very low gradient (average 6 feet per mile; range 0 to 24) with slow flows of tannic stained water draining a large area of wet-muskeg tundra south of the Alphabet Hills. To date, there is no documented anadromous fish use in the south branch (T. Taube, Alaska Department of Fish and Game, Glennallen, personal communication). The north branch of the West Fork is formed from a collective of runoff and lake-fed tributaries within the Alphabet Hills, which drain to the south and east. The north branch originates at Monsoon Lake and within its drainage there is approximately 90 mi of streams including the tributaries of Moose and Keg creeks, outlet streams from Bear Lake, and an unnamed lake. The north branch drainage is characterized by clear water and high stream gradients (average 24-feet per mile: range 4 to 106 ft) and provides chinook and sockeye salmon spawning and rearing habitat. Known anadromous waters make up 68% of its total length (61 of the 90 mi total). Below the confluence of the south and north branches, the West Fork has two significant tributary drainages that are documented as anadromous, the Fish Lakes drainage and Victor Creek (unofficially named; K. Roberson, ADF&G-retired, Glennallen, personal communication). Victor Creek drains the eastern portion of the Alphabet Hills and runs approximately 25 mi before joining the West Fork. This creek is a documented sockeye salmon spawning stream in its lower 18 mi. The extensive Fish Lakes drainage has been the site of a sockeye salmon enhancement project conducted by the Prince William Sound Aquaculture Association.

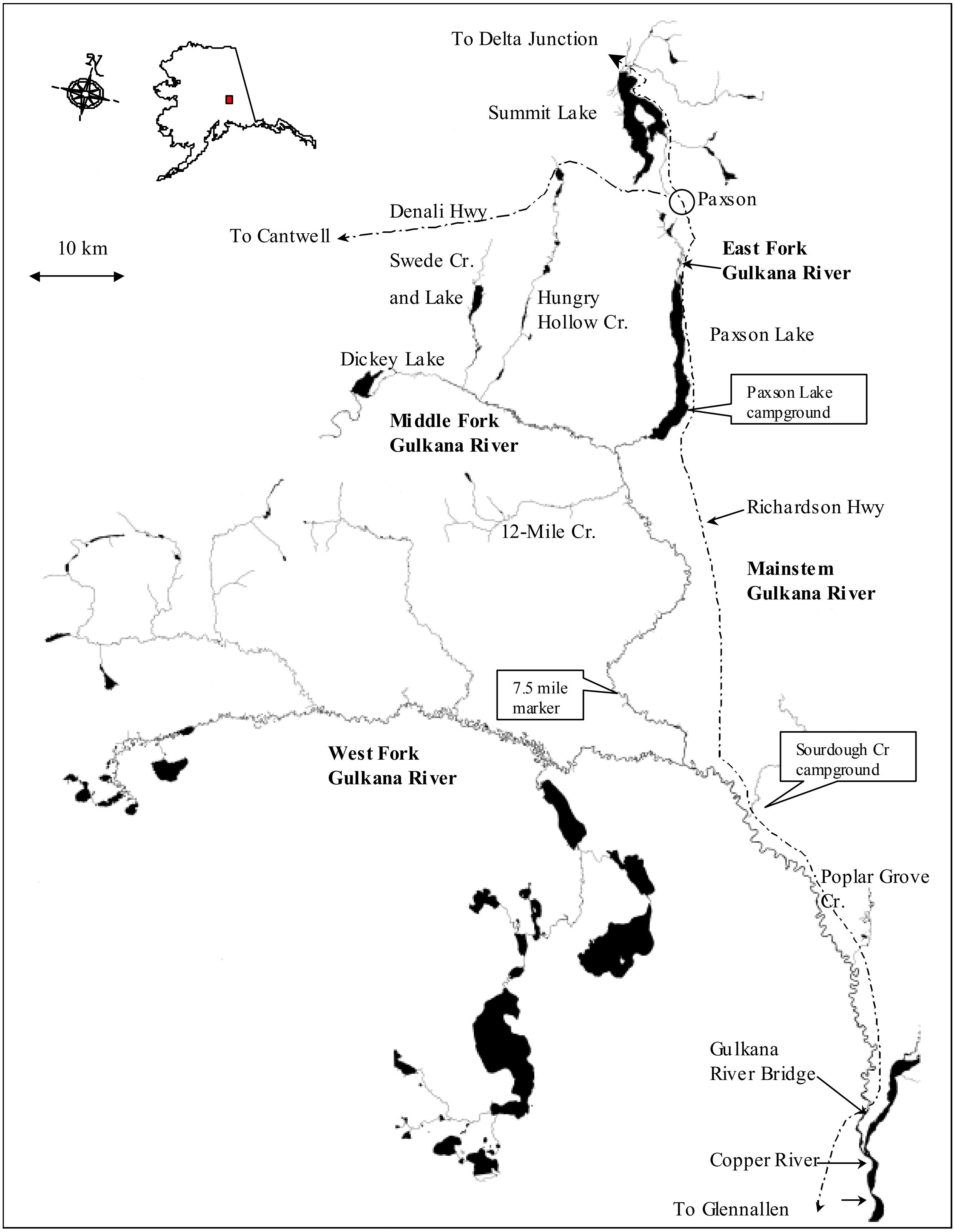

Figure 3.-Gulkana River drainage including features of the West Fork Gulkana River and previously known spawning areas.

It is believed that the Middle Fork Gulkana River (hereafter referred to as the Middle Fork) includes the primary rainbow and steelhead spawning areas of the Gulkana River drainage as well as providing habitat juvenile rearing for rainbow trout and steelhead (Stark 1999; Figure 3).

METHODS

SAMPLING DESIGN (OVERVIEW)

Beginning in 2000, the Alaska Department of Fish and Game and the U.S. BLM agreed to jointly fund field studies on rainbow trout in the Gulkana River through a Challenge Cost Share (CCS) project. In summer 2000, a radiotelemetry study was initiated to better characterize the life history of resident rainbow trout throughout the Gulkana River drainage. The emphasis of the radiotelemetry study was to locate previously undetected spawning areas and to validate the selection of the Dickey Lake spawning area as a site where a significant proportion of the mature rainbow trout population in the Gulkana River could be assessed with video enumeration, if feasible. During July and August, 2000 (summer feeding period), mature-sized rainbow trout (≥ 400 mm FL) were captured and implanted with radio tags along the mainstem of the Gulkana River and their movements were monitored until August 2001. During early June of 2000, the feasibility study for the underwater videography was conducted at the Dickey Lake spawning area. A suitable location was identified, a constriction weir was partially constructed, and experimental underwater video footage of migrating steelhead and rainbow trout was taken.

Video Enumeration

Underwater video enumeration was attempted to determine if a combination of underwater videography and a constriction weir could allow accurate and cost effective enumeration of rainbow trout and steelhead moving into or out of spawning areas. Video success was set as having the ability to capture and record high quality video images of resident trout and anadromous steelhead as they pass upstream or downstream 24-h per day. Because physical differences between rainbow trout and steelhead are subtle, sufficient image quality was needed to assure accurate classification. Visual features used in video images for classification (Fleming 2000) included:

1. the coloration pattern: steelhead have a broad reddish band extending downward toward the ventral surfaces, whereas resident rainbow trout have a more centralized and narrow red stripe or band;
2. the spotting density: the density on steelhead is notably lower than on resident rainbow trout;
3. the girth-to-length ratio: the ratio for steelhead is smaller when compared to rainbow trout that appear more robust and stout; and,
4. the presence of a scar from sea lice above the anal fin: not all steelhead have a pronounced scar, but it is unique to steelhead.

The current technology in underwater video gear and time-lapse video recorders were evaluated in reference to these traits, and whether accurate classification of rainbow and steelhead abundance was achievable.

On 30 May, a multi-agency crew of three persons was transported to the site by helicopter to erect the weir and conduct the experimental videography. Work was completed on 6 June. The initial task was to construct a partial weir that would concentrate passing fish through a constricted opening and that would permit unrestricted fish passage and be optimally-sized for video enumeration. The location for the video enumeration trial was approximately 3 mi downstream of Dickey Lake. This site was selected because: 1) familiarity of the site from previous studies; 2) it was thought to support one of the primary spawning aggregations for rainbow trout and steelhead in the Gulkana drainage; and, 3) its hydrological characteristics were suitable. The Middle Fork begins at the outlet of Dickey Lake and for approximately the first 3 miles (spawning area) the rivers gradient is moderate, it is relatively shallow and runs over a mixture of gravel and small cobble substrates, and its flows are buffered by Dickey Lake resulting a more stable discharge with minimal turbidity. Below this spawning area the gradient accelerates and the Middle Fork flows through a small canyon. Physical measurements were taken at the weir site including measurements of stream width, velocity, depth, stream level, and discharge. Discharge and water velocities were measured with a Pygmy flow meter and tag line, and stream level was measured using a staff gauge.

The weir design was patterned after video enumeration work conducted by Faurot et al. (2000) in small upper Snake River drainages. The design allows for two-way passage and enumeration without physically handling fish, and therefore has been applied in endangered species studies. The original X-shaped design included a centrally located chute for bi-directional fish passage, with weir fences angled 30-45° from adjacent shoreline (Figure 4). The weir was constructed using two 70-ft cables anchored along the streambed by duckbilled anchors (size #68) driven ~ 3 ft into the streambed at 4 ft intervals, and terminally anchored into the stream banks. These two cables crossed near their midpoints. A second set of cables were located approximately six feet above, with each cable end anchored by several duckbill anchors driven into the ground 6-10 ft from the stream bank. These were tensioned by "come-a-longs" connected to the stream bank anchors. Galvanized hardware cloth mesh (3/4-in square mesh) and Vexar (similar mesh size) was suspended between cables, attached with chain lap links. Steel rebar rods (3/4 in diameter by 6 ft length) were driven into the streambed along the cables at approximately 5-ft intervals to provide additional support to the suspended fencing.

The width and shape of the constricted opening was designed to allow passage of fish, ice fragments, and other debris, and to allow sufficient video imaging. On one side of the constriction weir or "video chute" a light gray "flash" panel was affixed in vertically oriented position and a camera supported by a mounting bracket was positioned on the opposite side. Submerged visual targets were passed through the constriction and vary distances from the underwater camera to determine how the underwater conditions would affect image quality. This information was used to scale the weir constriction dimensions to accommodate capturing high quality video images of fish passing through the weir's "video chute".

Images of fish passing through the chute were recorded by a Sony™ M-370 high-resolution (0.5 in format CCD) monochrome closed-circuit television video camera submerged in a Furman Diversified™ waterproof housing. The closed-circuit television (CCTV) camera had low light sensitivity (0.1 lux) and was sensitive to visible and infrared spectrum lighting, allowing nighttime recording under infrared illumination generated by a Cyberview™ CV-100 Series - Infrared Illuminator (980 nm wavelength). Images were transferred via RG-59 coaxial cable to a

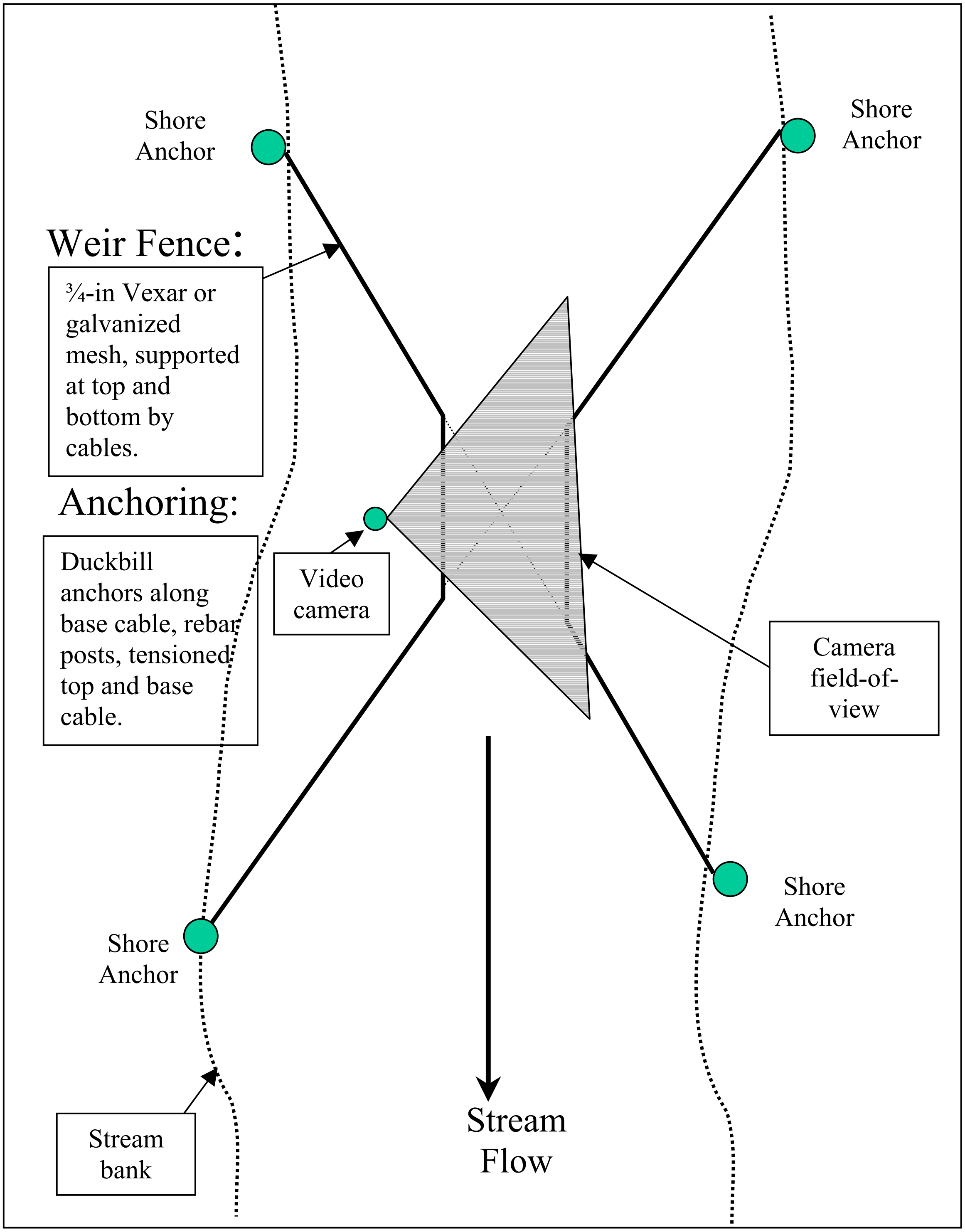

Figure 4.-Schematic of original constriction weir design showing positioning of weir fence, anchoring, video camera, and enumeration chute.

Sony™ SVT-DL224 time-lapse VHS recorder where they were recorded at 10 frames-per-second, allowing a 12-h recording on a standard 120 min VHS tape. Underwater camera, infrared illuminators, and time-lapse video recorder were powered by 12 VDC power supplied by a deep-cycle marine battery and a Honda™ EU 2000 generator.

Following completion of trial recordings, video footage was reviewed and times of fish passage events were noted for later reexamination. Video editing was conducted later using a 9-in black-and-white Panasonic security monitor and the video recorder. Images were subjectively examined relative to visual cues used to classify rainbow trout and steelhead to determine whether image quality was sufficient.

Radiotelemetry Project

The second part of this investigation included a 12-month radiotelemetry study of resident rainbow trout in the Gulkana River. Information from radio-tagged rainbow trout was collected using a series of aerial tracking surveys to describe seasonal distributions of rainbow trout and to verify the belief that rainbow trout spawning below Dickey Lake represented a significant proportion of all spawning fish in the Gulkana River, which would validate the choice of this site for video enumeration.

Telemetry Sampling Design

Information gained through tag recoveries since 1998, and earlier works by Stark (1999) and Brink (1995) helped provide a basis for the sampling design. This study was designed to: 1) attain an unbiased estimate of the proportion of adult rainbow trout that use known spawning areas within the Middle Fork; 2) locate new spawning areas, 3) locate overwintering areas; and, 3) examine fidelity to summer feeding areas.

To help ensure that the radio tags were deployed in a representative manner, rainbow trout were radio-tagged during the summer feeding period and the study area was divided into four sections (Figure 5). By deploying the radio tags during the summer spawning period it was assumed that:

1. the geographic distribution of rainbow trout is widespread during the summer feeding period, which occurs between late June and early September;
2. geographic mixing of rainbow trout from all spawning areas occurs during the summer feeding period;
3. adult rainbow trout in summer feeding locations move significant distances from their respective spawning areas;
4. the low population density and feeding habits of mature rainbow trout (Stark 1999; Brink 1995) results in clumped distributions during the summer feeding period;
5. the spawning destination for a trout selected for transmitter implantation is not dependent on feeding area; and,
6. tagged rainbow trout behave similar to untagged rainbow trout.

The assumption of geographic mixing of rainbow trout from different spawning areas was based on previous tag recoveries where fish tagged in the Dickey Lake and Hungry Hollow spawning grounds were caught by anglers or ADF&G personnel in the upper and middle portions of the Gulkana River. The clumping of rainbow trout occurs because of a preference for feeding areas

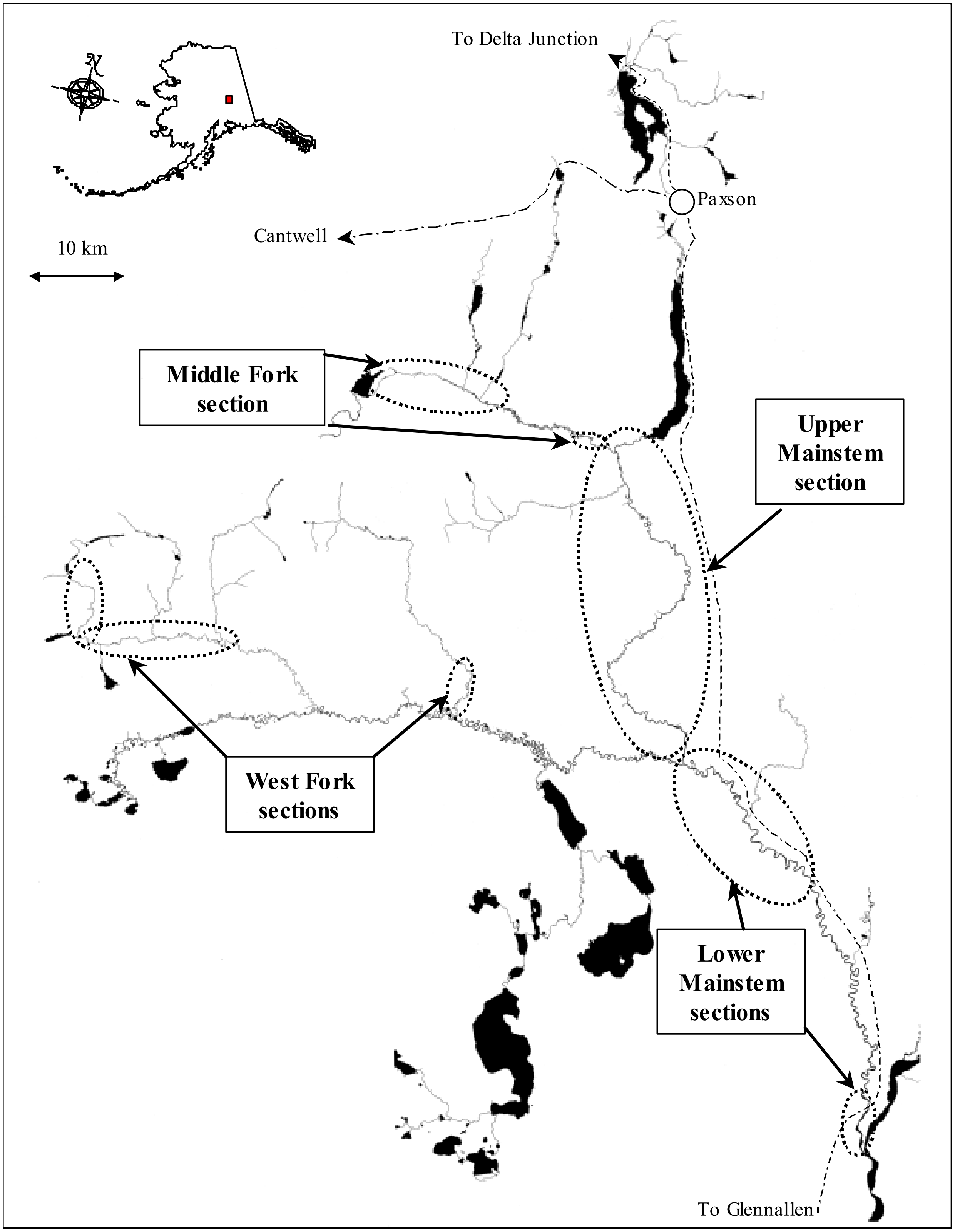

Figure 5.-Map of Gulkana River demarcating the areas sampled or surveyed within each of the four sampling sections.

behind spawning salmon (when occurring), whitewater areas (e.g., behind large boulders), and pool entrances.

To help ensure the distribution of radio tags throughout the Gulkana River drainage, the study area was divided into four geographically distinct sections: the Middle Fork, the upper and lower mainstem Gulkana River bounded by the West Fork, and the West Fork. The available radio tags were then divided equally among the sections. A total of 50 radio transmitters were purchased for this study. This sample size (n = 50), if deployed in a representative manner, would have ensured the desired statistical power (> 95%) to detect significant spawning areas that contained ≥ 10% of active spawners in any of the four designated sections.

This project required transmitters with a one-year operational life and that were small and light weight. Those selected were Lotek™ MBFT-5 designed to limit frequency drift to ± 1 kHz. Transmitter signals were in the 148-149 MHz bandwidth range with frequencies separated by 10kHz at a pulse rate of 64 beats per minute. The radio tags were programmed to transmit 8 hr per day (between 1030 and 1830 hours), 7 days per week, with a guaranteed operational life of 372 days.

Radio transmitters were only surgically implanted into fish that were large enough to be sexually mature and to adequately accommodate the implanted transmitters. Fish used in the study exceeded 400 grams which was required accommodate the selected radio transmitters (2% rule; Winter 1983). It was preferred to implant transmitters into fish that ≥ 450 mm FL to increase the probability of selecting mature fish based on 1998 and 1999 sampling in spawning areas (Fleming 1999, 2000). Transmitter weight (8.9 g) was expected ≤ 1.5% of the live weight of the fish based on limited length-weight information for Gulkana River rainbow trout.

FISH CAPTURE

A two-person field crew captured fish for transmitter implantation in each of the four designated sections of the Gulkana River. Capture methods included hook-and-line gear and baited hoop traps. When using hook-and-line gear, egg patterns were used near salmon spawning aggregations, while flies and lures patterned after salmon smolt were used in other areas. Hoop traps were 10 ft long with seven steel hoops that tapered from a 2-ft diameter at the entrance to 1.5 ft at the cod end. Each trap had two throats (positioned at the 2nd and 4th hoop), which narrowed to a diameter of 4 in. The hoop netting was constructed of a 1-in knotted nylon mesh, bound with #15 cotton twine, and treated with an asphaltic compound. Each trap was erected or "stretched" using two approximately 10-ft long pieces of ¾-in (I.D.) polyvinyl chloride (PVC) pipe with snap clips at each end of the pipe, which clipped to the distal hoops of the trap (Figure 6). Cured salmon roe was placed into perforated plastic containers that were inserted into the cod end of the trap. Traps were generally placed in areas with large woody debris, cutbank areas, and pools with slower current velocities to protect captured fish. Each trap was fished for a 24-hr period, which was defined as a trap set.

Lower Mainstem Gulkana River

From July 17 – 21, a crew of two traveled by a 16-ft riverboat from access points located at the Gulkana River Bridge and the BLM Sourdough Campground (MP 126 and MP 147 Richardson Highway, respectively). High flows and large boulders made angling and seining ineffective for capturing trout and baited hoop traps were used instead. Set locations were distributed from the West Fork confluence downstream 14 miles to a location five miles below Sourdough Creek for


Figure 6.-Hoop trap used in the lower Gulkana River study section.

a total of 18 sets. From August 29-30, five additional sets were fished in the lowermost Gulkana River between the Richardson Highway Bridge and the Copper River.

West Fork Gulkana River

On July 25, a two-person crew traveled by floatplane to the Monsoon Lake area. Hook-and-line gear was used to capture fish. The crew sampled and traveled downstream along the north branch of the West Fork using two 14-ft inflatable boats until reaching Keg Creek, 21 mi downstream. The crew then flew 33 miles downstream to Victor Creek using a BLM helicopter to conduct a foot surveys and sampling along Victor Creek. Sampling ceased on July 29 owing to a low probability of finding more rainbow trout and because of time and budget considerations to finish the remaining work in the Middle Fork and mainstem study sections. From Victor Creek the crew traveled by BLM helicopter to the Middle Fork Gulkana River.

Middle Fork Gulkana River

A two-person crew was dropped off by a BLM helicopter below Dickey Lake and sampling was conducted along this section from July 29 to Aug 1 by floating the river downstream using inflatable rafts. Sampling efforts were only focused in areas of suitable feeding habitat for adult rainbow trout, which included the reach between Dickey Lake and Hungry Hollow Creek, and the lowermost mile of the river above its confluence with the mainstem. Hook-and-line gear was used to capture fish and sampling efforts were focused at locations where chinook salmon were aggregated or spawning. Sampling was not conducted in much of the lower 16 miles of the Middle Fork because in this 16-mi section, the river is meandering, has low water velocities, its streambed and banks are primarily composed of silt, and no aggregates of chinook salmon were observed except for the lowermost mile of the Middle Fork where there is suitable spawning habitat. The last mile of the Middle Fork was sampled on August 1 during the start of the upper Gulkana River sampling trip and was accessed by hiking upstream from the mainstem Gulkana River.

Upper Mainstem Gulkana River

From July 31 to August 4, a two-person crew floated the 42-mi long section of the Gulkana River from Paxson Lake to the West Fork using two 14-ft inflatable rafts. This section was accessed using the boat launches at Paxson Lake and Sourdough campgrounds. This section consisted of four distinct reaches: 1) the outlet of Paxson Lake to the Middle Fork (3 mi in length); 2) the Middle Fork confluence to the head of the portage trail that leads around the Canyon Rapids (20 mi); 3) the Canyon Rapids (approximately 1 mi); and, 4) end of the portage trail to the West Fork (18 mi). Hook-and-line gear was used to capture fish.

Transmitter Implantation Procedures and Data Collection

Criteria were used to determine if a captured rainbow trout was to be radio-tagged: 1) it was preferred that fish exceeded ≥ 450 mm FL, although fish 400 – 450 mm were deemed acceptable when it was difficult to capture larger; and, 2) fish must have been uninjured and judged to be in good condition.

Prior to surgeries rainbow trout were held temporarily in a water-filled 50-litre cooler while surgical supplies were organized and anesthesia solutions were mixed. All surgical tools and radio transmitters, which were stored in a cold sterilant solution (Novasan™), were rinsed in buffered saline solution prior to use. Fish were anesthetized in a 50-litre cooler using a 25-mg/l clove oil solution (Anderson et al. 1997). After losing equilibrium, fish were weighed to the nearest gram using a digital balance and transferred ventral side up to a wetted v-shaped tagging cradle lined with open-celled foam rubber. Throughout the surgery, one crewmember irrigated the fish's gills with the clove-oil solution and periodically with fresh water to maintain respiration.

After cutting a 15-mm incision anterior to the pelvic girdle, a variation of the shielded-needle method described by Ross and Kleiner (1982) was used to implant transmitters. A horse catheter (Abbocath-T Radiopaque FEP I.V. 14G x 140 mm) with its cutting edge shielded by a nylon tube was threaded through the incision and coelomic cavity to a location anterior to the anal vent. The nylon tube was then retracted, and the catheter advanced, which pierced the body wall and formed an exit incision for the transmitter's whip antenna. The catheter was held in place and the terminal end of the antenna was fed through the hollow catheter and out through the exit location. Before inserting the radio transmitter, the catheter was pulled out through the exit incision. The transmitter was then slipped into the coelomic cavity as the remainder of the antenna was lightly pulled through the exit incision. The incision area was topically treated with Furacin, a topical antibiotic, prior to suturing. Three to four sutures were used to close the incision using non-absorbing monofilament sutures (3/0) mounted with an FS-1cutting needle and forceps. Incision wounds were then cleansed using sterile gauze pads and 90% isopropyl alcohol and the suture knots were sealed with Vetbond™ cyanoacrylate adhesive. After allowing the adhesive to air dry for approximately 30-s, the fish were placed in a cooler with fresh water for recovery. Each implanted fish was tagged with a green 44,000 tag series internal anchor tag (Floy), measured for length, and scales were collected for age determination. Sex could not be reliably determined during surgeries because the incision was too small to inspect the gonads. Fish were held in fresh water until regaining full equilibrium, and then released. Release locations were recorded using hand-held Global Positioning System (GPS) units. Captured fish that were not radio-tagged were similarly measured for length, tagged with an anchor tag, and had scales removed.

Following field activities, scale samples were sorted under a dissection microscope and several scales were cleaned and mounted between microscope slides. Ages were determined by counts of scale annuli magnified to 40X with the aid of a microfiche reader. Scale analysis and age determination of rainbow trout incorporated aging criteria developed by Beamish and McFarlane (1987) and Minard and Dye (1998). Estimated age was determined by counting regions of the scales where circuli were broken or compacted.

Radio Transmitter Surveys

A combination of aerial and ground-based surveys were used to locate radio-tagged rainbow trout. Ten aerial surveys were conducted periodically from August 29, 2000 to August 4, 2001 at times corresponding to biologically meaningful activities (overwintering, pre-spawning, spawning, summer feeding). Tracking flights always included the mainstem Gulkana River and the Middle Fork. A Piper Supercub equipped with an H-type antenna mounted on each wing strut, an antenna switch box, and a model 4000 Advanced Telemetry Systems (ATS) receiver was used to locate radio-tagged fish to within approximately 250 m. Ground based surveys were conducted from a jet boat or inflatable canoe using a Telonics TR-2 receiver with an attached TS-1 scanner and an H-type antenna. During all surveys, locations were recorded with a GPS and the data were later transferred onto base maps created from U.S. Bureau of Land Management GIS coverages providing hydrological features digitized at a 1:63,360 scale.

Mortality was inferred when a radio-tagged fish failed to move after the initial survey or when seasonal movement was expected (e.g., a fish moved downstream for overwintering and never moved again). Overwintering determinations for surviving rainbow trout were made during a late-February flight to take advantage of increased day-length and lighting conditions. Spawning area determinations required multiple tracking flights after breakup in late-May.

Confirmation of New Spawning Areas
After completing several tracking flights during the spawning period, ground-based surveys were used to confirm spawning activities at previously undocumented spawning locations. Inflatable boats and helicopter were used to access sites for these surveys. Spawning was confirmed at a site when:

1. actively spawning rainbow trout were observed;
2. captured trout were sexually mature and in a ripe or spent condition; and,
3. spawning redds were observed and judged to have been recently constructed, which was based on the cleaned appearance of rocks and gravels in the redd relative to surrounding materials.

Fidelity To Summer Feeding Locations
Fidelity to summer feeding areas was inferred by the proximity between the release location during 2000 and the approximate location 12 months later for those fish that survived. Distances were measured by digitizing along river and stream channels displayed on 1:63,360 scale digitized topographic maps using on-screen digitizing within Delorme™ Alaska 3-D TopoQuads software.

ESTIMATION OF PROPORTIONS

The relative importance of the documented spawning areas (Dickey Lake and Hungry Hollow) to the overall adult rainbow trout population in the Gulkana River was inferred from the proportion of surviving radio-tagged rainbow trout found within the known spawning areas during the late-May to early-June spawning period.

The proportion and variance estimators were:

$$\hat{p} = \frac{x}{n}, \text{ and} \tag{1}$$

$$\hat{V}[\hat{p}] = \frac{\hat{p}(1-\hat{p})}{n-1} \tag{2}$$

where: $\hat{p}$ = the proportion of adult rainbow trout that spawned in previously known spawning areas (Dickey Lake and Hungry Hollow) in 2001;

x = the number of rainbow trout located in previously known spawning areas; and,

n = the total number of radio-tagged rainbow trout alive during tracking events conducted in the late-May to early-June spawning period.

RESULTS

VIDEO ENUMERATION TRIALS

During 2000, the river at the weir site was approximately 35 ft wide and 1 to 1.5 ft deep, and previous discharge measurements taken along this reach were up to 80 cubic feet per second (Stark 1999). During 2001, water levels at the site were higher than (see Shelby et al. 1990) expected with current velocities ranging to 7 feet-per-second (fps) and depths to 2 ft. Stream discharge was estimated on May 31 to be 215 cfs, which far exceeded earlier observations. Over a 5-day period the staff gauge recorded a peak water level on June 2.

The design of the constriction weir was inadequate for the unexpectedly high water levels and velocities. After attaching one of the mesh panels (pieces of galvanized hardware cloth) to the elevated and stream bottom cables, fine stream debris, primarily consisting of riparian willow root segments, built-up rapidly. Within two hours the top of the weir fence was driven under the water surface by water pressure and became impossible to clean. No additional fence pieces were added to the cables. However, the partial weir fence remained intact and was used to divert migrating fish across the main channel to slower waters along a shallow cutbank.

As a result, tests of the video equipment were relocated to an area with slower flows where migrating fish were observed (Figure 7). Several rebar stakes supported the underwater camera housing and supported the infrared lighting housing in a backwater to avoid damage or equipment loss. The painted plywood flash panel was attached to steel rebar stakes driven into the streambed, and oriented parallel to the flow at a distance of 4.5 ft from the underwater housing faceplate. After running 12 VDC power and RG-59 coaxial video cables to the video recorder and battery, video trials started in the evening on June 2, and were completed June 4 when power supplies had been exhausted.

Field trials using underwater video depth-of-field measurements indicated that high quality images could be recorded under natural lighting to a target distance of 5 ft, and visual image extinction occurred at 7.5 ft.

Approximately 60-h of video footage was recorded. One tape contained 12-h of footage that could be reviewed in approximately 1.5-h by adjusting the playback speed. A total of three rainbow trout and two steelhead were identified as they passed upstream between the camera and the flash panel (Figure 8). Camera sensitivity was sufficient to capture images between 0400 and 2300 hrs. However, during the darkest hours, infrared lighting failed to adequately illuminate targets at distances more than 12 inches from the camera.

RADIOTELEMETRY

At completion of the sampling trips, 23 fish bearing one-year radio transmitters were released out of 60 fish captured (Tables 2 and 3; Figure 9). The crew sampled 91 of the 148 river miles that made up the four study sections over a period of 18 days. Ideal water conditions allowed the crew to easily spot aggregations of chinook salmon. Out of a total of 58 fish hooked by angling, 14 escaped capture before landing which included as many as eight large fish that likely could have been implanted with transmitters.

Figure 7.-Partial weir (upper) and video camera setup (lower).

Figure 8.-Video image of a steelhead migrating to the Dickey Lake spawning area with flash panel shown in the background.

Table 2.-Number of rainbow trout captured, sampled, and radio-tagged among the four designated sampling sections of the Gulkana River drainage during 1999.

Sampling Section	Sampling Period	Total # of Fish Sampled	# of Fish > 450 mm FL	# of Fish Radio-tagged	Gear Type Used	# of Fish Hooked but Not Landed
Lower mainstem						
West Fork to 5 mi US of Sourdough	7/17 to 7/21	8	6	6	Hoop trap	N/A
Richardson Hwy to Copper R.	8/29 to 8/30	8	1	1	Hoop trap	N/A
Subtotals		16	7	7		N/A
Upper mainstem	7/31 to 8/5					
Paxson Lake to Middle Fork		3	2	2	H&L	4
Middle Fork to portage trail		8	4	3	H&L	0
Rapids at portage trail		7	4	4	H&L	2
Portage trail to West Fork		11	3	3	H&L	4
Subtotals		29	13	12		12
Middle Fork Gulkana	7/29 to 8/1					
Dickey Lake to Hungry Hollow		3	1	1	H&L	2
Lower mile of Middle Fork		11	4	3	H&L	2
Subtotals		14	5	4		4
West Fork Gulkana	7/25 to 7/29					
		1	1		H&L	0
Total		60	26	23		14

Table 3.-Date, release location, frequency, length, weight, age, tag, and fate of 23 rainbow trout implanted with radio transmitters in four areas of the Gulkana River, July 18 through August 30, 2000.

Date	Location Released	Frequency	Length (mm FL)	Weight (g)	Age (years)	Floy Tag No.	Final Fate[a]
7/18/00	Lower mainstem	148.121	515	1,220	nd	44435	Mortality
7/20/00	Lower mainstem	148.102	530	1,190	4+	44436	Mortality
7/20/00	Lower mainstem	148.142	435	907	4+	44437	Tag fail
7/21/00	Lower mainstem	148.161	440	949	4+	44438	Mortality
7/21/00	Lower mainstem	148.182	435	850	6+	44441	Mortality
7/21/00	Lower mainstem	148.202	448	900	5+	44442	Tag fail
8/30/00	Lower mainstem	148.612	530	1,690	nd	44329	Mortality
7/30/00	Middle Fork	148.461	nd	nd	nd	nd	Mortality
8/01/00	Middle Fork	148.431	423	925	nd	44449	Alive
8/01/00	Middle Fork	148.502	495	1,500	7+	44316	Alive
8/01/00	Middle Fork	148.531	414	900	3+	44448	Alive
7/31/00	Upper mainstem	148.171	505	1,450	5+	44447	Alive
7/31/00	Upper mainstem	148.442	545	1,950	5+	44446	Alive
8/02/00	Upper mainstem	148.392	449	1,070	4+	44318	Alive
8/02/00	Upper mainstem	148.421	550	2,000	5+	44317	Mortality
8/02/00	Upper mainstem	148.572	540	2,225	7+	44319	Tag fail
8/03/00	Upper mainstem	148.492	565	2,450	6+	44320	Alive
8/03/00	Upper mainstem	148.542	445	1,040	nd	44326	Alive
8/03/00	Upper mainstem	148.552	450	1,050	5+	44321	Alive
8/04/00	Upper mainstem	148.412	500	1,580	5+	44322	Alive
8/05/00	Upper mainstem	148.452	451	1,240	6+	44327	Alive
8/05/00	Upper mainstem	148.561	495	1,470	4+	44328	Mortality

[a] Fate was determined through the course of 10 tracking flights.

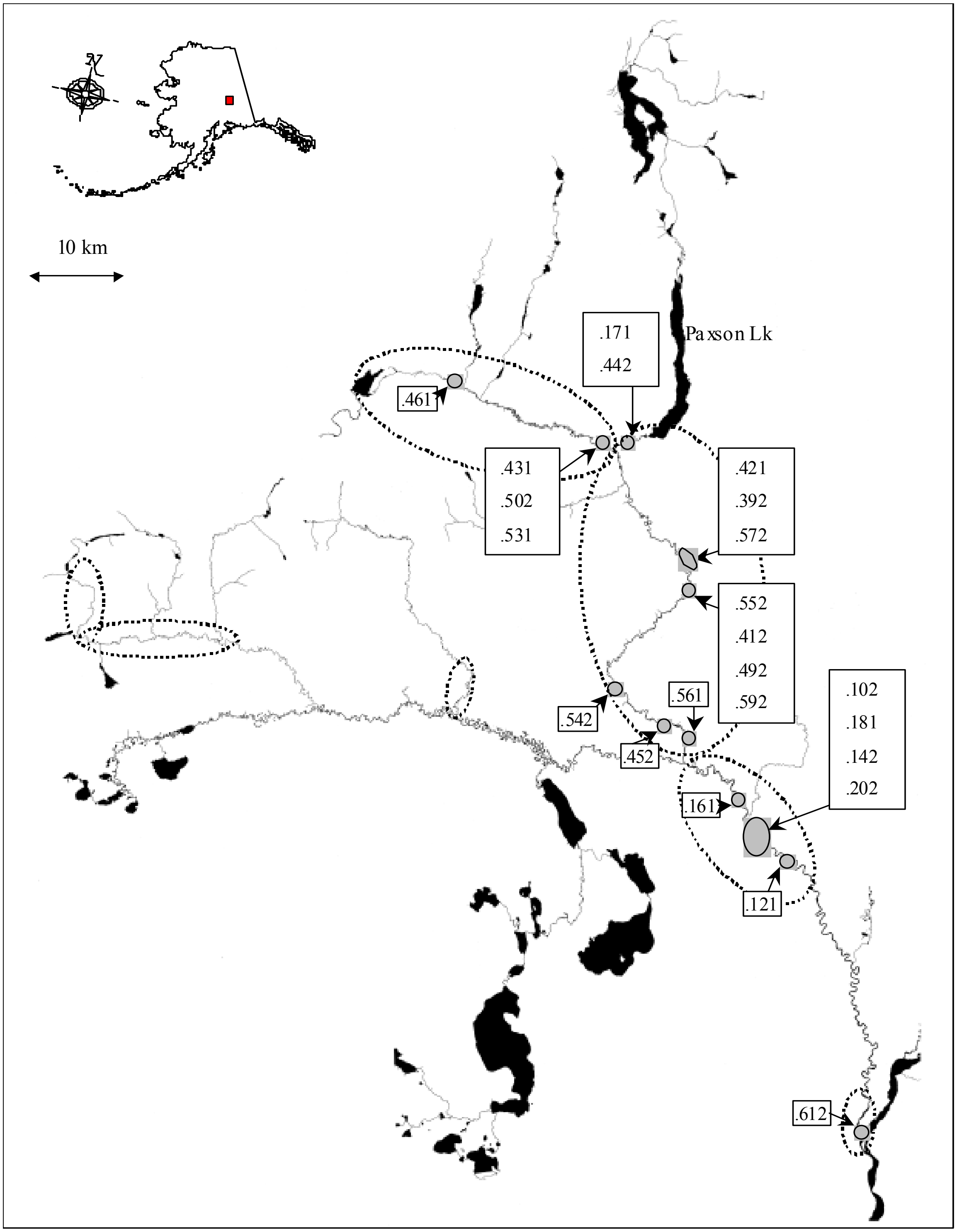

Figure 9.-Release locations of radio-tagged rainbow trout relative to the areas sampled within the Gulkana River drainage, 2000. Numbers in boxes are the last three digits of radio-tag frequencies.

Among implanted fish, the median length was 495 mm, median weight was 1,220 g, and the median transmitter/live weight ratio was 0.7%. Estimated ages ranged from 3 to 7 years, with additional "plus growth" noted for the current year. Sex classification was incomplete for fish bearing transmitters.

Lower Mainstem

Between July 17 and 21, 18 trap sets yielded a catch of eight trout. Of these, six were large enough to be radio-tagged. Between August 29 and 30, 5 trap sets between the Richardson Highway Bridge and the Copper River yielded a catch of eight trout – one large enough for radio-tagging (Table 2).

West Fork Gulkana

Between Monsoon Lake (located 86 mi from the mainstem Gulkana River) and Keg Creek, 21 river miles were surveyed and sampled. The stream channel morphology varied greatly in this section, ranging from 5 to 50 feet wide, and substrates varied considerably over short distances (Appendix B). Migrating chinook and sockeye salmon were observed throughout the section and several smaller aggregates of actively spawning chinook salmon were observed. Other species observed or captured included Arctic grayling and round whitefish. One rainbow trout (290 mm FL) was captured in a chinook spawning aggregation near Moose Creek (Table 2).

In the lower portions of Victor Creek, large numbers of spawning sockeye salmon were observed, but no rainbow trout were observed or captured. No transmitters were implanted into rainbow trout in this section.

Middle Fork Gulkana

Only two small rainbow trout (150 to 200 mm FL) were caught in the upper three miles of the Middle Fork, which comprises to the Dickey Lake spawning area. Adult-sized rainbow trout were found between 7 and 11 mi below Dickey Lake in close proximity to aggregates of spawning chinook salmon. Three large rainbow trout were hooked in the area between Swede and Hungry Hollow creeks, and one of the fish was landed and implanted with a transmitter. In the lowermost 1-mile reach of the Middle Fork, 13 rainbow trout were hooked, three of which were implanted with transmitters. Fish landed and released without transmitters ranged between 200 and 460 mm FL. In total, 14 fish were sampled and 4 fish were radio-tagged in the 27-mi Middle Fork Gulkana study section.

Upper Mainstem

A total of 29 fish were sampled and 13 were implanted with radio tags, which ranged in length from 450 to 545 mm FL. Lengths of fish that were not radio-tagged ranged between 150 and 400 mm FL.

Aerial Tracking

Generally, fish were detected in the mainstem Gulkana and Middle Fork corridors, and their positions were located to within a 1- or 2-mi radius. Over the 12-month period, three transmitters were suspected to have failed (e.g., did not transmit during the programmed time). Expanded tracking surveys, including areas along the upper Copper River, were conducted on several occasions to track a suspected mortality (freq 148.612). On June 4, 2001 a survey of the entire West Fork was conducted to locate previously unlocated tags, and tags that were not located during spawning surveys (May 29 and June 4). Tracking detection rates ranged between 85 and 95% based on the number of deployed transmitters, but the average probability of detection all tracking flights was recalculated to be 98.7% when transmitter failures were removed (Table 4).

Tag Mortalities and Failures

Over the course of the 12-month period, eight fish were classified as mortalities. Of these, six fish were thought to have died soon after tagging because no meaningful movement was observed (Appendix A). One other fish (148.121) initially traveled upstream ~15 mi, then failed to move again during the remainder of the study period. The last suspected mortality (148.421) traveled upstream from its release location to overwinter, but moved downstream between May 6 and June 4 to a final location that remained there through the next three tracking events.

Most of the mortalities and transmitter failures occurred in fish that were captured in the lower mainstem section. All fish tagged in this section either died or had transmitters that failed.

Overwintering

A total of 13 fish survived the overwintering period. The majority of fish overwintered in the upper mainstem Gulkana River. An aggregation of five fish was located in a slow flowing section between 6 and 11 miles downstream of the Middle Fork confluence. Three other fish also remained in close proximity to one another in the lower Middle Fork near its confluence with the mainstem Gulkana River, and the five remaining fish were dispersed into other areas (Figure 10).

Spawning

During the tracking flight on May 29 all but three fish remained in locations observed earlier in presumed overwintering locations. These three fish moved between 3 and 5 miles from their overwintering locations. Additional tracking flights were conducted on June 4, and 8, 2001. Movements to spawning areas appeared to have been completed by June 4.

Twelve radio-tagged fish survived to the spawning period and traveled up to 55 mi upstream to spawning areas from overwintering sites. Of these 12 fish: 1) Six fish ascended and spawned in the Middle Fork; 2) four fish were found in the upper mainstem Gulkana River where they presumably spawned; and, 3) two fish spawned in 12-Mile Creek (Figure 11). Of the fish that ascended the Middle Fork, five were found in previously documented spawning areas (one in Hungry Hollow and four at Dickey Lake area), and one in a new, yet unconfirmed, spawning area near the mouth of Swede Creek. (148.452).

Based on the 12 fish bearing transmitters that survived winter and presumably spawned, the estimated the proportion of radio-tagged adult rainbow trout that entered known spawning areas within the Middle Fork Gulkana River was 42% (SE = 15%).

Ground surveys of previously undocumented spawning areas were conducted on June 12 and 13, 2001. Using tracking data from June 8 a crew was transported by helicopter into the 12-Mile Creek drainage to validated spawning on June 12, 2001 (Figure 12). There one of the two implanted fish still present and was located and observed, and captured three other rainbow trout and one steelhead were captured in a spawning aggregation approximately 10 mi upstream from the mainstem Gulkana River. On the next day, the crew traveled by inflatable canoe to locate four implanted fish suspected to have spawned in the upper mainstem Gulkana River. Two of the four fish were located and an attempt was made to triangulate their position in the river

Table 4.-Tracking survey schedules and tracking results for aerial surveys of radio-tagged rainbow trout in the Gulkana River drainage, 2000 to 2001.

			Number of Tags		
Tracking	Date	Purpose for Tracking	Searched[a]	Found	Failed Tags[b]
1	8/29/2000	Follow-up after release	22	21	0
2	9/28/2000	Seasonal redistribution	23	21	0
3	12/12/2000	Early overwintering	23	22	1
4	2/28/2001	Overwintering	23	22	1
5	5/6/2001	Pre-spawning	23	20	3
6	5/29/2001	Early-spawning period	21	18	3
7	6/4/2001	Mid-spawning period	22	19	3
8	6/8/2001	Late-spawning period	22	19	3
9	6/30/2001	Post-spawning	22	19	3
10	8/4/2001	Summer feeding fidelity	23	20	3

[a] The number of tags searched was not always the same. The last fish implanted (148.612) was released after the first tracking flight. This fish was also deemed a mortality in the Copper River, an area that was not tracked every flight due to time and budget constraints.

[b] Failed tags were inferred to include transmitters that could not be relocated during subsequent aerial trackings after a final tracking in locations far enough upstream, where drifting out of the Gulkana River and overall tracking area was unlikely.

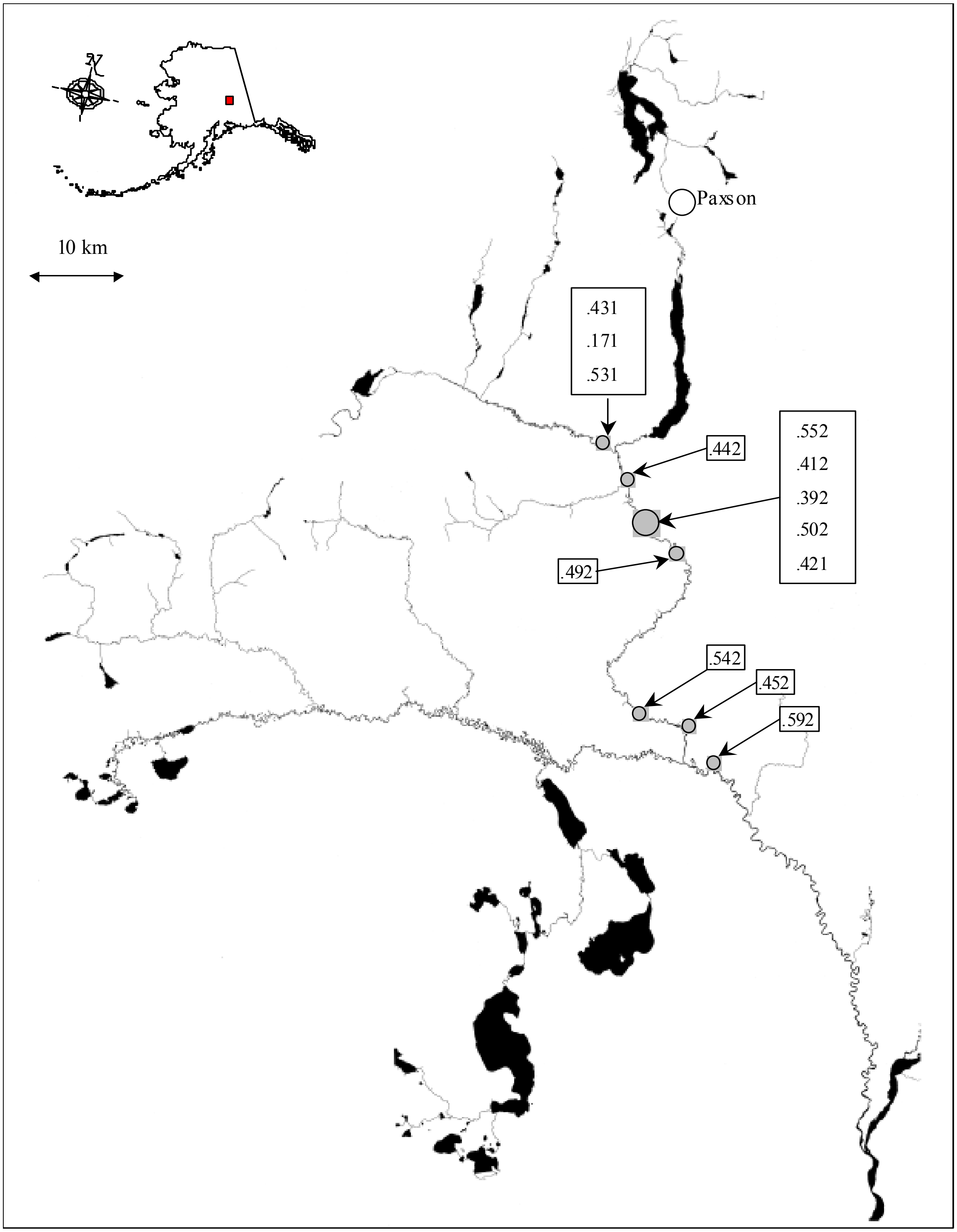

Figure 10.-Overwintering locations of radio-tagged rainbow trout within the Gulkana River drainage on February 28, 2001. Numbers in boxes are the last three digits of radio-tag frequencies.

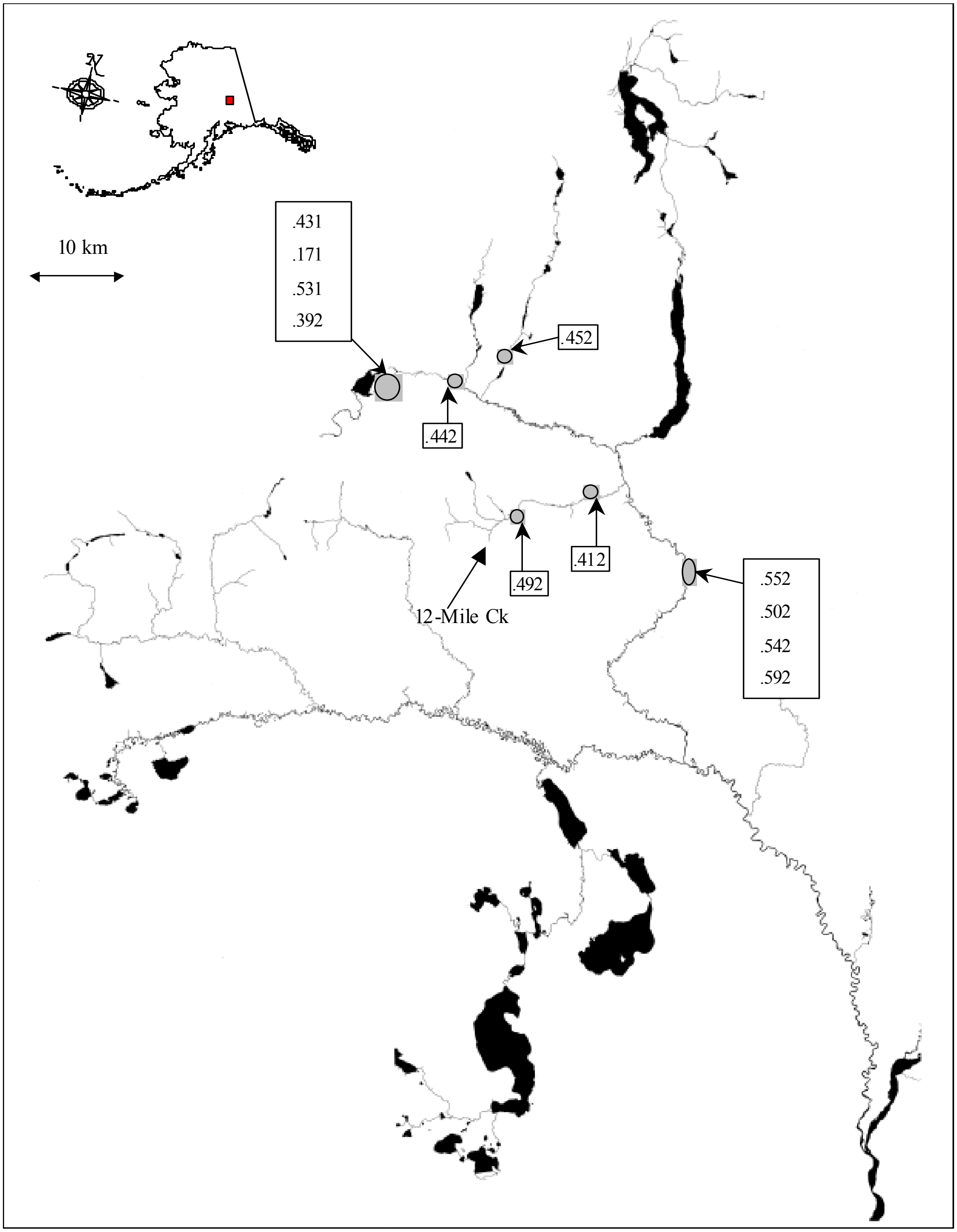

Figure 11.-Spawning locations of radio-tagged rainbow trout within the Gulkana River drainage on June 4, 2001. Numbers in boxes are the last three digits of radio-tag frequencies.

Figure 12.-Rainbow trout and steelhead spawning area in 12-mile Creek, 2001.

channel using H- and paddle-type antennas. Neither fish was observed because they were holding in deep water areas, however, at least one recently constructed spawning redd was located along the shoreline at the site of one fish. These four fish were presumed to have spawned within 2 mi of this location. The spawning redd was located out of the main channel in an area of gravel and small cobble substrate in 12-16 inches of water.

No ground survey was conducted where a radio-tagged fish was located near the mouth of Swede Creek in the Middle Fork. However, this fish presumably spawned nearby because: 1) the fish had a pronounced upstream migration during between May 29 and June 4 and then eventually retreated back downstream; and, 2) this river section contains good spawning habitat for sockeye and chinook salmon.

Post-Spawning and Summer Period

Late-June and early-August tracking flights indicated two fish remained in their spawning locations, unlike 10 other post-spawning fish that returned to summer feeding areas in the Middle Fork and upper mainstem Gulkana River. Although the tracking data suggested post-spawning mortality may have occurred, project and budget limitations precluded efforts to evaluate the status of these fish. One fish failed to leave Hungry Hollow Creek (148.452) and the other fish remained near its spawning location in 12-Mile Creek (148.492) that was upstream of numerous beaver dam blockages. The final tracking flight was conducted to observe summer feeding site fidelity among the 10 surviving rainbow trout. Thirty percent (3 of 10 fish) were within 0.25 mi (measured along river) from their initial release site, 50% (5 of 10) were within 2 miles, and 80% were within 3 miles. The remaining two fish had relocated to summer feeding areas that were 5.9 and 22.5 miles, respectively, from initial capture and release sites.

DISCUSSION

This study was designed to provide information to be used in the development of future stock-assessment methods on rainbow trout in the Gulkana River drainage. The Challenge Cost Share (CCS) project between the department and BLM allowed both agencies to participate and ultimately share resulting information for a smaller investment than could be otherwise accomplished.

The trial efforts with underwater video enumeration had mixed results. Underwater videography yielded images of sufficient quality to discern a fish as being either a prespawning rainbow trout or steelhead, but only under natural daylight conditions. Supplemental lighting remained the one concern for 24-h video recordings, particularly for enumeration projects conducted in remote settings, such as the upper Middle Fork. The effective range of reflected infrared illumination was found to be very short (~ 12 in), limiting the potential of low power infrared lighting with underwater videography. Other researchers have utilized or examined high power infrared, and visible lighting such as fluorescent type fixtures (Faurot et al. 2000; Hiebert et al. 2000). In one of the studies it was found that fish behavior did not markedly differ when passing fish were illuminated with high powered infrared or visible wavelengths in fish passes at hydro dams (Hiebert et al. 2000). However, power generation needed for sufficient illumination at this remote setting and the unknown effects of the visible light on fish passage behavior could be problematic. Additional efforts will be made in the future to evaluate lower power lighting sources such as underwater dive lights, which could be successfully adapted for the stationary closed circuit television approach desired for this application. Future studies should examine the effects of various types and levels of supplemental lighting on fish passing stationary sites, particularly if unimpaired fish passage is desired. If it is found that supplemental lighting continues to be problematic with small constriction weirs, then researchers could consider video counting only during hours with sufficient light levels and otherwise closing the weir to achieve count objectives.

The design of the trial, low-cost constriction weir proved inadequate in standing up to the heavy flows and debris loads observed below Dickey Lake in 2000. Although it appeared to divert upstream migrating fish toward the submerged video camera, it is unlikely that the lightweight construction could withstand the impact of ice flows following spring breakup. Near the completion of the May 2000 field investigation, a more suitable site for a picket-weir structure was identified. It was located roughly 300 ft upstream from the constriction weir site, where a 70-ft "picket-and-tripod" weir could be operated independently, or in conjunction with underwater video enumeration.

In Alaska, radiotelemetry is commonly used with some fishes to better understand their life history, determine critical habitats, and in some instances to estimate their abundances. For the current study the goal was to better understand the life history of adult resident rainbow trout, and how it might relate to future stock assessment and management of Gulkana River rainbow trout. Although the planned number of radio transmitters could not be deployed, and roughly half of the fish suffered mortality (six post-surgery; five natural) before the end of study, valuable information was nevertheless attained from the remaining radio-tagged fish.

Radio-tracking a relatively small number of implanted fish led to the documentation of the 12-Mile Creek drainage as an additional spawning area for Gulkana River rainbow and steelhead trout stocks. It also led to the identification of two other likely spawning areas, one located in the mainstem Gulkana River just upstream of the Portage Canyon Trail, and the other in the Middle Fork Gulkana River just upstream of Swede Creek. However, confidence in using the estimated proportions to represent the proportion of Gulkana River rainbow trout that spawn in any one location is low because: 1) only 12 fish survived to the spawning period; 2) spawning was not confirmed at two of the previously unknown located areas; and, 3) none of the fish radio-tagged in the lower Gulkana survived to spawning.

Although the estimated proportion was likely not representative of the population, the relatively large fraction of radio-tagged fish that spawned in the Middle Fork Gulkana River strongly suggests that future assessment activities upon spawning stocks in the Middle Fork areas could provide a reliable index for the status of the overall Gulkana River rainbow trout population. However, in order to manage the resident trout population based on Middle Fork spawner stock assessments, the assumption that all Middle Fork stocks are geographically mixed with other spawning stocks during the angling season would need to be tested. Radio-tagging fish exiting the Middle Fork spawning area spawning grounds and monitoring their movements throughout the angling season could help test this assumption.

Much information remains unknown about the life history of resident rainbow trout in the lower mainstem Gulkana River. Post-surgery mortality and transmitter failures precluded garnering any information from this portion of the population. It is possible the first fish fitted with transmitters were impacted or subjected to a greater level of stress by marginally-longer surgery times, by the warmer water conditions in this section, or by being captured in hoop traps as opposed to hook-and-line gear. Baited hoop traps were an effective capture method in the

Gulkana River's large channel downstream of the West Fork, although the number of river access points and channel conditions limit the areas accessible by small jet boats. In the future, if managers and researchers decide to undertake additional telemetry work in the lower mainstem Gulkana River, baited hoop trapping gear should be strongly considered for use, but boating access/logistics will need to be considered in detail.

This study did not give evidence that fish in the lower river could belong to a separate, or still unknown spawning stock. Other radiotelemetry and genetics studies, however, have indicated geographically separated stocks of rainbow trout along the course of large rivers such as the Kenai River (Palmer 1998; Spearman et al. 1999). Geographically differing levels of exploitation upon Gulkana River rainbow stocks, brought on by incidental mortalities and levels of angling effort, would be of greater concern, if there were geographically segregated stocks. It logically follows that greater understanding of lower river rainbow trout stocks and life history if present would be important to researchers and managers for assessment or monitoring and managing. Such an assessment program might physically assess a seemingly small portion of the population, but may be sufficient to effectively manage a relatively sparse population spread over 100 or more river miles.

The extensive area sampled in this study provided a means to look at previously un-surveyed areas such as the headwater areas of the West Fork Gulkana where sub-populations of rainbow trout might exist. One small rainbow trout was captured in an area that was 70 miles from the mainstem Gulkana River, and was sampled in proximity to numerous spawning chinook salmon, where summer feeding rainbow trout are often found. Based on these observations, it is likely that a smaller population of rainbow trout may exist in the West Fork as a separate stock from the rest of the Gulkana River population. During the helicopter surveys, many miles of suitable rainbow trout habitat were observed as indicated by the numerous salmon spawning aggregations, but couldn't be sampled because of time and budget constraints. These tributaries included most of the Keg Creek drainage, and accessible portions of Moose and Victor creeks. Future surveys might also examine the drainages entering the West Fork from Crosswind and Ewan lakes where rainbow trout may feed on the abundant hatchery-reared sockeye salmon smolt.

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APPENDIX A

Appendix A.-Locations of radio-tagged rainbow trout in the Gulkana River drainage for the period July 17, 2000 through August 4, 2001.

		Latitude		Longitude	
Frequency	Survey Date	Degrees	Minute	Degrees	Minute
148.102	Release	62	31.11	145	32.13
	29 Aug	62	17.55	145	22.67
	28 Sep	62	17.55	145	22.84
	12 Dec	62	17.48	145	22.93
	28 Feb	62	17.52	145	22.93
	6 May	62	17.50	145	22.79
	29 May	62	17.50	145	22.77
	4 Jun	62	17.50	145	22.76
	8 Jun	62	17.50	145	22.76
	30 Jun	62	17.50	145	22.76
	4 Aug	62	17.46	145	22.71
148.121	Release	62	28.62	145	
	29 Aug	62	35.55	145	27.74
	28 Sep	62	35.55	145	37.05
	12 Dec	62	35.57	145	37.03
	28 Feb	62	35.56	145	37.07
	6 May	62	35.59	145	36.94
	29 May	62	35.59	145	36.91
	4 Jun	62	35.59	145	36.96
	8 Jun	62	35.58	145	36.88
	30 Jun	62	35.58	145	36.96
	4 Aug	62	35.57	145	36.91
148.142	Release	62	31.11	145	32.13
	29 Aug	62	19.24	145	22.31
	28 Sep	62	19.28	145	22.24
	12 Dec	nf[a]		nf	
	28 Feb	nf		nf	
	6 May	nf		nf	
	29 May	nf		nf	
	4 Jun	nf		nf	
	8 Jun	nf		nf	
	30 Jun	nf		nf	
	4 Aug	nf		nf	

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		Latitude		Longitude	
Frequency	Survey Date	Degrees	Minute	Degrees	Minute
148.161	Release	62	32.45	145	31.90
	29 Aug	62	23.88	145	23.62
	28 Sep	62	23.75	145	23.54
	12 Dec	62	23.80	145	23.57
	28 Feb	62	23.84	145	23.49
	6 May	62	23.80	145	23.44
	29 May	62	23.81	145	23.41
	4 Jun	62	23.87	145	23.36
	8 Jun	62	23.87	145	23.36
	30 Jun	62	23.85	145	23.39
	4 Aug	62	23.82	145	23.41
148.171	Release	62	51.08	145	38.32
	29 Aug	62	51.06	145	38.21
	28 Sep	62	50.95	145	40.75
	12 Dec	62	51.07	145	41.27
	28 Dec	62	51.09	145	41.30
	6 May	62	51.15	145	41.18
	29 May	62	56.16	146	4.55
	4 Jun	62	55.98	146	5.02
	8 Jun	62	55.99	146	4.95
	30 Jun	62	51.11	145	38.12
	4 Aug	62	51.11	145	38.09
148.181	Release	62	31.11	145	32.13
	29 Aug	62	29.44	145	30.24
	28 Sept	62	29.46	145	30.29
	12 Dec	62	29.42	145	30.59
	28 Feb	62	29.50	145	30.21
	6 May	62	29.49	145	30.20
	29 May	62	29.50	145	30.15
	4 Jun	62	29.54	145	30.00
	8 Jun	62	29.52	145	30.02
	30 Jun	62	29.47	145	30.23
	4 Aug	62	29.48	145	30.22

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		Latitude		Longitude	
Frequency	Survey Date	Degrees	Minute	Degrees	Minute
148.202	Release	62	31.11	145	32.13
	29 Aug	nf		nf	
	28 Sep				
	12 Dec	62	29.48	145	30.28
	28 Feb	62	29.50	145	30.21
	6 May	nf		nf	
	29 May	nf		nf	
	4 Jun	nf		nf	
	8 Jun	nf		nf	
	30 Jun	nf		nf	
	4 Aug	nf		nf	
148.392	Release	62	44.60	145	34.10
	29 Aug	62	44.56	145	34.09
	28 Sep	62	46.87	145	37.95
	12 Dec	62	46.61	145	37.99
	28 Feb	62	46.66	145	37.68
	6 May	62	46.74	145	37.60
	29 May	62	54.86	145	55.21
	4 Jun	62	56.35	146	3.04
	8 Jun	62	56.12	146	4.63
	30 Jun	62	44.60	145	34.01
	4 Aug	62	44.58	145	33.86
148.412	Release	62	43.14	145	34.97
	29 Aug	62	45.62	145	35.50
	28 Sep	62	46.79	145	37.81
	12 Dec	62	46.58	145	38.00
	28 Feb	62	46.48	145	37.86
	6 May	62	47.51	145	38.33
	29 May				
	4 Jun	62	48.61	145	42.33
	8 Jun	62	48.56	145	42.70
	30 Jun	62	43.10	145	35.06
	4 Aug	62	42.99	145	34.94

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		Latitude		Longitude	
Frequency	Survey Date	Degrees	Minute	Degrees	Minute
148.421	Release	62	44.92	145	34.30
	29 Aug	62	43.95	145	35.10
	28 Sep	62	46.14	145	37.27
	12 Dec	62	46.86	145	37.65
	28 Feb	62	46.72	145	37.76
	6 May	62	46.17	145	37.27
	29 May	62	41.25	145	40.12
	4 Jun	62	33.24	145	32.87
	8 Jun	62	33.26	145	32.88
	30 Jun	62	33.23	145	32.90
	4 Aug	62	33.26	145	32.90
148.431	Release	62	50.93	145	40.71
	29 Aug	62	51.24	145	42.31
	28 Sep	62	51.68	145	42.62
	12 Dec	62	51.21	145	41.36
	28 Feb	62	51.09	145	41.30
	6 May	62	51.11	145	41.17
	29 May	62	55.19	145	55.95
	4 Jun	62	56.27	146	3.76
	8 Jun	62	56.29	146	3.47
	30 Jun	62	51.81	145	44.31
	4 Aug	62	51.40	145	37.16
148.442	Release	62	51.27	145	37.46
	29 Aug	62	51.22	145	37.78
	28 Sep	62	49.58	145	39.94
	12 Dec	62	49.53	145	40.03
	28 Feb	62	49.19	145	39.71
	6 May	62	49.52	145	39.82
	29 May	62	55.18	145	55.88
	4 Jun	62	55.16	145	56.02
	8 Jun	62	55.19	145	56.07
	30 Jun	62	55.20	145	55.88
	4 Aug	62	55.19	145	56.06

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		Latitude		Longitude	
Frequency	Survey Date	Degrees	Minute	Degrees	Minute
148.452	Release	62	36.68	145	38.76
	29-Aug	62	36.68	145	38.83
	28-Sep	62	36.61	145	38.81
	12-Dec	62	36.61	145	37.37
	28-Feb	62	36.28	145	37.40
	6-May	62	36.33	145	38.52
	29-May	62	36.56	145	42.59
	4-Jun	62	40.48	145	50.91
	8-Jun	62	56.30	145	50.89
	30-Jun	62	56.25	145	50.85
	4-Aug	62	56.28	145	50.96
148.461	Release	62	54.99	145	55.53
	29-Aug	62	47.87	145	39.10
	28-Sep	62	47.87	145	39.11
	12-Dec	62	47.86	145	39.12
	28-Feb	62	47.87	145	39.17
	6-May	62	47.90	145	39.06
	29-May	62	47.87	145	38.93
	4-Jun	62	47.90	145	39.06
	8-Jun	62	47.89	145	38.99
	30-Jun	62	47.91	145	39.08
	4-Aug	62	47.89	145	39.03
148.492	Release	62	43.14	145	34.97
	29-Aug	62	43.01	145	35.15
	28-Sep	62	44.17	145	34.18
	12-Dec	62	43.82	145	34.28
	28-Feb	62	45.20	145	35.26
	6-May	62	47.51	145	38.30
	29-May				
	4-Jun	62	48.29	145	51.94
	8-Jun	62	48.42	145	51.74
	30-Jun	62	48.74	145	51.38
	4-Aug	62	48.75	145	51.39

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		Latitude		Longitude	
Frequency	Survey Date	Degrees	Minute	Degrees	Minute
148.502	Release	62	50.93	145	40.71
	29-Aug	62	51.32	145	36.74
	28-Sep	62	51.24	145	37.89
	12-Dec	62	46.58	145	38.00
	28-Feb	62	46.72	145	37.76
	6-May	62	44.85	145	34.21
	29-May	62	43.94	145	34.23
	4-Jun	62	44.39	145	34.22
	8-Jun	62	46.01	145	36.23
	30-Jun	62	50.77	145	39.99
	4-Aug	62	51.36	145	37.20
148.531	Release	62	50.93	145	40.71
	29-Aug	62	51.22	145	37.78
	28-Sep	62	51.22	145	37.56
	12-Dec	62	51.07	145	41.27
	28-Feb	62	50.99	145	40.82
	6-May	62	51.11	145	41.12
	29-May	62	56.39	146	2.53
	4-Jun	62	56.29	146	3.66
	8-Jun	62	56.34	146	3.17
	30-Jun	62	50.77	145	40.08
	4-Aug	62	51.31	145	37.21
148.542	Release	62	38.77	145	43.75
	29-Aug	62	38.88	145	44.01
	28-Sep	62	37.13	145	40.91
	12-Dec	62	37.36	145	40.77
	28-Feb	62	37.35	145	40.70
	6-May	62	37.37	145	41.44
	29-May	62	41.70	145	38.44
	4-Jun	62	43.65	145	34.33
	8-Jun	62	43.69	145	33.97
	30-Jun	62	39.03	145	43.89
	4-Aug	62	38.35	145	43.17

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		Latitude		Longitude	
Frequency	Survey Date	Degrees	Minute	Degrees	Minute
148.552	Release	62	43.14	145	34.97
	29-Aug	62	45.96	145	36.29
	28-Sep	62	47.32	145	38.06
	12-Dec	62	43.82	145	34.28
	28-Feb	62	46.40	145	37.72
	6-May	62	46.49	145	37.70
	29-May	62	45.30	145	35.04
	4-Jun	62	44.54	145	33.80
	8-Jun	62	44.57	145	33.87
	30-Jun	62	42.78	145	35.78
	4-Aug	62	44.42	145	33.72
148.561	Release	62	35.70	145	37.12
	29-Aug	62	34.21	145	36.88
	28-Sep	62	34.22	145	36.95
	12-Dec	62	34.22	145	36.94
	28-Feb	62	34.22	145	36.95
	6-May	62	34.28	145	36.89
	29-May	62	34.27	145	36.96
	4-Jun	62	34.24	145	36.84
	8-Jun	62	34.26	145	36.92
	30-Jun	62	34.28	145	37.00
	4-Aug	62	34.26	145	36.92
148.572	Release	62	44.42	145	33.88
	29-Aug	62	42.90	145	35.40
	28-Sep	62	46.56	145	37.94
	12-Dec	62	46.58	145	38.00
	28-Feb	62	46.14	145	37.37
	6-May	nf		nf	
	29-May	nf		nf	
	4-Jun	nf		nf	
	8-Jun	nf		nf	
	30-Jun	nf		nf	
	4-Aug	nf		nf	

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		Latitude		Longitude	
Frequency	Survey Date	Degrees	Minute	Degrees	Minute
148.592	Release	62	43.14	145	34.97
	29-Aug	62	42.84	145	35.28
	28-Sep	62	34.11	145	35.07
	12-Dec	62	34.08	145	34.33
	28-Feb	62	34.09	145	34.37
	6-May	62	34.04	145	34.21
	29-May	62	42.93	145	35.26
	4-Jun	62	43.65	145	34.02
	8-Jun	62	43.69	145	33.93
	30-Jun	62	42.96	145	35.18
	4-Aug	62	41.03	145	41.54
148.612	Release	62	14.93	145	24.43
	29-Aug	nf		nf	
	28-Sep	nf		nf	
	12-Dec	nf		nf	
	28-Feb	61	1.34	145	19.91
	6-May	61	58.64	145	18.51
	29-May	61	58.56	145	18.60
	4-Jun	nf		nf	
	8-Jun	nf		nf	
	30-Jun	nf		nf	
	4-Aug	61	58.56	145	18.70

[a] nf means the fish could not be found or located during an aerial tracking survey.

APPENDIX B

Appendix B.-Survey notes for the previously unsampled North Branch of the West Fork of the Gulkana River.

A crew of two flew by chartered float plane on July 25, 2000 to the Monsoon Lake area to start surveys 86 mi upstream of the mainstem confluence along the north branch of the West Fork Gulkana River. Angling was conducted during the four days while traveling the 21 mi stretch of river that ended at Keg Creek. The stream channel morphology changed considerably throughout this survey section, ranging from 5 to 50 feet wide, and substrates varied considerably over short distances. The upper portion of the north branch was narrow (5-15 ft wide) and overhung with heavy alder growth for much of the first four miles.

Upper north branch of West Fork Gulkana.

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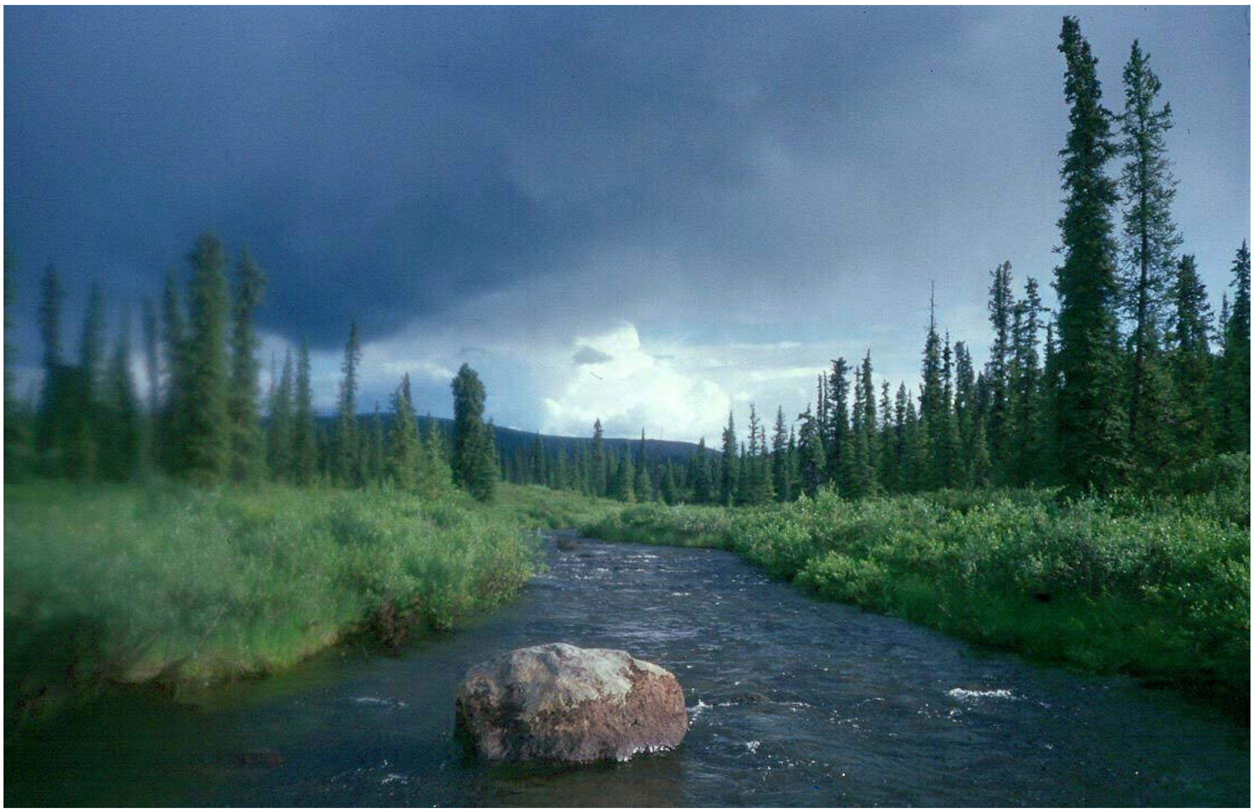
Periodically, deeper pools were observed that had fine sand and silt substrates which supported heavy growths of *Pomatoegonia* sp. In the next two miles, the channel became wider and shallower, with bedrock, cobbles, and boulders.



West Fork Gulkana River above Bear Creek, 2000.

The first significant aggregates of spawning chinook salmon were present in the 3 miles downstream of the outlet of a lake commonly known as Bear Lake. In this section the channel included alternating riffles and runs with washed gravel and small cobble substrates. The river channel became highly incised, meandering, with sand and silt substrates over the next six miles to Moose Creek, with one bedrock area forming a short rapid. Immediately upstream of Moose Creek the river straightened into riffle-run sequences that were heavily utilized by spawning chinook. Here the river was ~ 40 ft wide and bordered by grassy cutbanks and minor gravel bars. Chinook and sockeye salmon were observed throughout, with small aggregates of actively spawning chinook, and migrating salmon passing upstream in other segments. Other species observed or captured included Arctic grayling and round whitefish. In the first three days 143 chinook were counted (120 live, 23 carcasses or bear remains) under ideal water conditions in areas upstream of Moose Creek. After actively angling in all areas of chinook spawning and

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other areas, one rainbow trout (290 mm FL) was captured in a chinook spawning aggregate, but not implanted due to its small size. River-spawning sockeye were noted in several areas: at the start of the survey near Monsoon Lake, and with a concentration of approximately 20 fish in the first mile downstream of Moose Creek. Between Moose and Keg creeks only 28 additional chinook salmon were clearly counted owing to poor count conditions resulting from heavy rains. Sampling was discontinued in the north branch of the West Fork after reaching Keg Creek, where a BLM Fire Service helicopter transported us to a unnamed creek, locally named Victor Creek. The crew then unsuccessfully sampled the lower 2-3 miles of Victor Creek where large numbers of sockeye salmon were spawning but no trout were observed or captured. West Fork sampling activities ceased on July 29, owing to a low probability of finding more rainbow trout given time considerations to finish the remaining work in the Middle Fork and mainstem study sections.