Fishery Data Series No. 11-69

Spawning Movements of Cutthroat Trout on a Copper River Delta Tributary

by

Brian H. Marston

Matt G. Miller

and

Steven J. Fleischman

December 2011

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

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

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. 11-69

MOVEMENTS OF SPAWNING CUTTHROAT TROUT ON A COPPER RIVER DELTA TRIBUTARY

by

Brian H. Marston
Division of Sport Fish, Cordova

Matt G. Miller
Division of Sport Fish, Anchorage

and

Steven J. Fleischman
Division of Sport Fish, Research and Technical Services, Anchorage

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

December 2011

This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-11, 12, 13 & 14, Job No. R-3-4 (b).

ADF&G Fishery Data Series was established in 1987 for the publication of Division of Sport Fish technically oriented results for a single project or group of closely related projects, and in 2004 became a joint divisional series with the Division of Commercial Fisheries. Fishery Data Series reports are intended for fishery and other technical professionals and are available through the Alaska State Library and on the Internet: http://www.adfg.alaska.gov/sf/publications/. This publication has undergone editorial and peer review.

Brian H. Marston,
Alaska Department of Fish and Game, Division of Sport Fish,
PO Box 669 Cordova, AK, 99574, USA

Matt G. Miller,
Alaska Department of Fish and Game, Division of Sport Fish
333 Raspberry Road, Anchorage, AK 99518, USA

and

Steven J. Fleischman
Alaska Department of Fish and Game, Division of Sport Fish,
333 Raspberry Road, Anchorage, AK 99518, USA

This document should be cited as:
Marston, B H., M. G. Miller, and S. J. Fleischman. 2011. Movements of spawning cutthroat trout on a Copper River Delta tributary. Alaska Department of Fish and Game, Fishery Data Series No. 11-69, Anchorage.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

Coastal cutthroat trout (*Oncorhynchus clarkii clarkii*) movements were tracked using radio transmitters implanted into mature fish as they ascended a tributary stream near the mouth of the Copper River during the spring spawning season. The study area lies within the Copper River Special Management Area for Trout on the Copper River Delta in Southcentral Alaska. Initial foot surveys to observe spawning locations and studies to test transmitter implantation procedures occurred May through October in 2004. In 2005, one tributary stream was chosen to examine spawning movements in relation to proposed road development. Cutthroat trout were implanted with transmitters and tracked from April through June in 2005. Thirty-five transmitters were surgically implanted in fish from 328 mm to 511 mm total length (TL; mean = 384 mm, SE = 6.9). Fish were tracked initially by plane and subsequently by boat or on foot. The maximum upriver extent of travel by fish was mapped with Global Positioning System (GPS) software, the presence of potential redd construction was recorded, potential spawning reaches were identified, and postspawning movements were tracked when possible. Additionally, habitats with woody debris in the principle stream channel were measured and mapped. This information was compared to a proposed road corridor along the area, and potential spawning habitats upstream of the road corridor were identified. There were 23 cutthroat trout successfully tracked, of which, 5 were recorded as mortalities before or during spawning migration. There were 7 spawning areas found by tracking tagged fish. Three fish used locations upstream of the proposed road corridor. Most fish moved out of the study area and were lost after the spawning ascent of the stream, but a few postspawning movements were recorded later (into July) that were of considerable distances (range = 123 m to 36 km), showing that migrations occur among drainages.

Key words: Copper River Special Management Area, Green River, cutthroat trout *Oncorhynchus clarkii clarkii*, radiotelemetry, spawning, movement.

INTRODUCTION

Prince William Sound represents the northern range of cutthroat trout (*Oncorhynchus clarkii*) distribution, which extends southward throughout the western United States and Canada to California. In Alaska, anadromous coastal cutthroat trout (*O. clarkii clarkii*), 1 of 12 subspecies of cutthroat trout, are found from the southern end of Southeast Alaska northward to Prince William Sound in Southcentral Alaska. The coastal cutthroat trout is the only subspecies of cutthroat trout known to exist in Alaska.

Coastal cutthroat trout and rainbow trout (*O. mykiss*) are important sport fishes in Alaska. The state management policy (5 AAC 75.222) for wild trout in Alaska emphasizes maximizing sustained yield fisheries, maintaining current size-at-age characteristics, and protecting essential habitats. In Southcentral Alaska, the trout management policy led to development in 1999 of the Copper River Special Management Area for Trout (CRSMT; Figure 1). The Alaska Department of Fish and Game (ADF&G), Division of Sport Fish, began studies of CRSMT trout in 2000 (Miller 2002; Marston et al. 2005). Trout fisheries in CRSMT are currently managed as catch-and-release fisheries.

Coastal cutthroat trout life history traits vary within drainages and among populations. Anadromous and resident forms can exist within populations, and individuals may express both traits (Johnson et al. 1999). Coastal cutthroat trout often coexist and occasionally interbreed with rainbow trout, a closely-related species. Hybrid trout and multiple life history traits have been observed within CRSMT (Marston et al. 2005; Dayna Kuntz, U.S. Forest Service (USFS) fisheries biologist, Cordova, Alaska, unpublished data).

Potential road development within CRSMT for resource development (Figure 1) may increase human access to the area and potentially change sport fisheries for trout (Miller 2002; Marston et al. 2005). Migration corridors and habitats used by cutthroat trout and other fishes may also be altered by developments through this area. This study used radiotelemetry to assess spawning movements of cutthroat trout in the Green River drainage, an area of potential road development, to help identify essential spawning habitats. Woody debris, a critical habitat component, was also cataloged along the mainstem of the Green River. The Green River is part of the Glacial Martin River drainage in the eastern portion of the Copper River Delta.

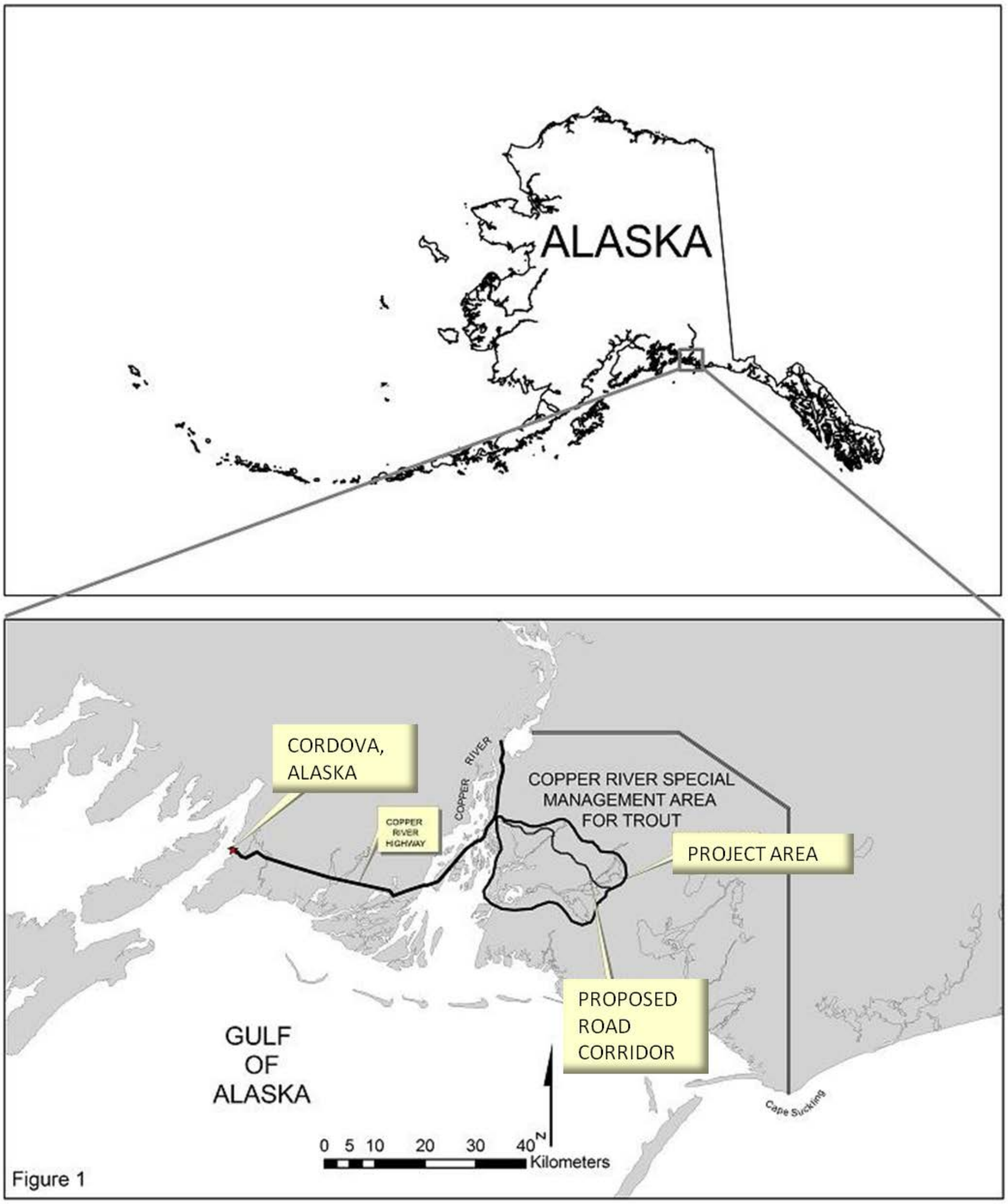


Figure 1.–Study area location in Southcentral Alaska.

METHODS

The main objective of this study was to track fish movements and observe fish locations for the presence of spawning habitat or potential redds in relation to a proposed road corridor. The Green River is a clear water tributary of the Glacial Martin River on the eastern Copper River Delta (Figure 2). The Glacial Martin River empties into the Copper River 29 km from the Gulf of Alaska. Along with the Clear Martin River to the south, this area is the principal recreational fishery within CRSMT. The Green River was selected for the spawning habitat study in 2005 due to its known cutthroat trout population (Miller 2002; Marston et al. 2005) and its proximity to the proposed road corridor.

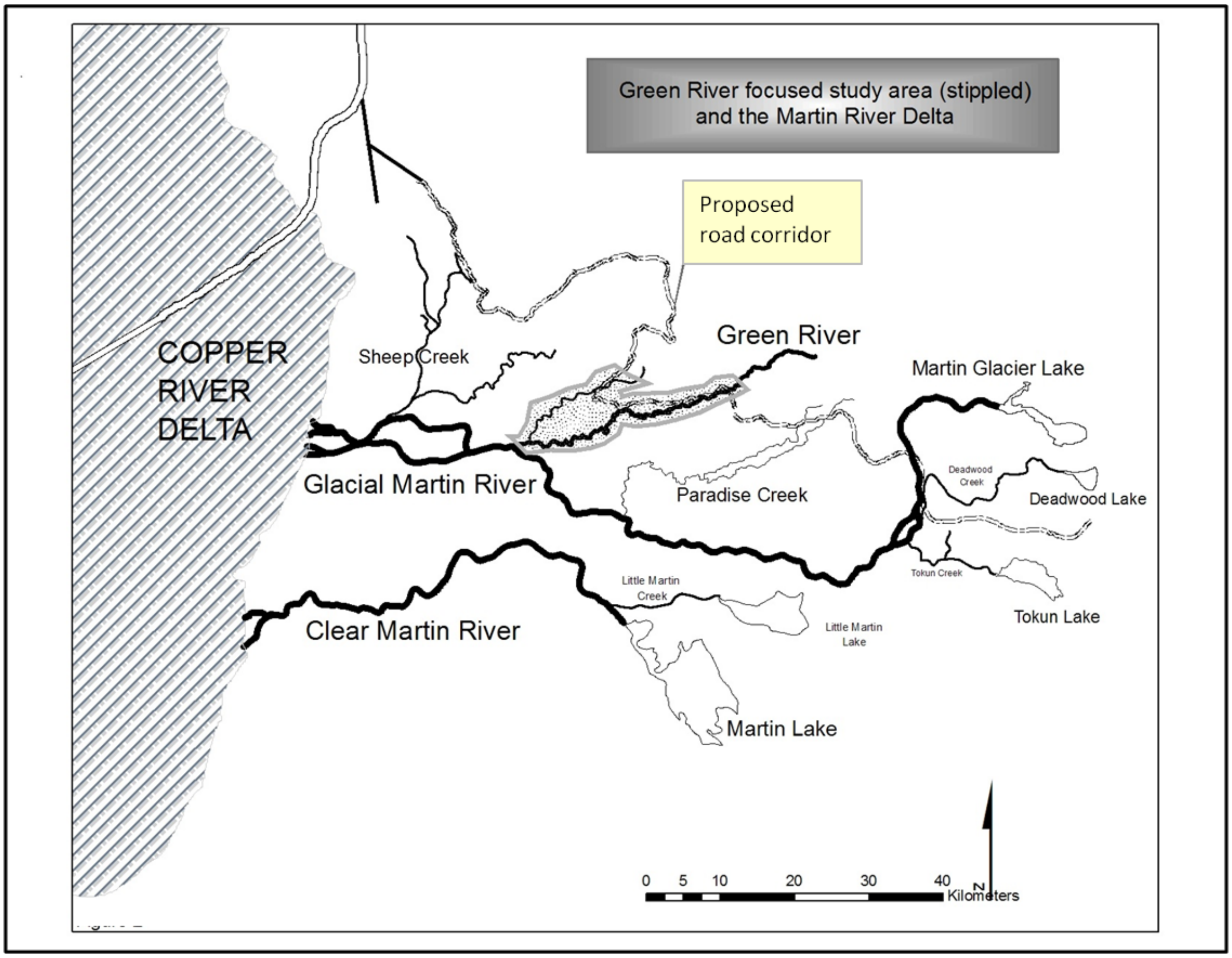


Figure 2.–Green River drainage study area within Copper River Special Management Area for Trout.

A preliminary sample of fish was taken from Sheep Creek (Figure 3, Appendix A1) in summer 2004 to help plan surgical techniques. Fish were captured to determine the anesthesia time required for surgery and to estimate the relationship of fish length to fish weight. This relationship facilitated selection of a minimum target length for tagging fish (see below), which was necessary to keep the ratio of transmitter weight to fish body weight below 2% and minimize harm to the fish[1] (Adams et al. 1998;Zale et al. 2005). Additionally, preliminary foot surveys were done to look for spawning cutthroat trout, determine efficient radio foot-tracking survey routes, and to test reception range of the transmitters. In order to determine reception range in areas with differing stream bank heights, a transmitter was placed inside a dead herring, which was submerged in 1 foot of water, and a receiver was moved away from the bank until the signal was lost. Telemetry "stations" were also located at tributary forks that were good locations to receive signals during foot-tracking surveys to determine if fish may have entered a tributary stream. In fall 2004, 4 cutthroat trout were implanted with transmitters to further refine surgical techniques prior to full studies in 2005. Previous ADF&G studies on cutthroat trout also helped guide early planning (Miller 2002; Marston et al. 2005).

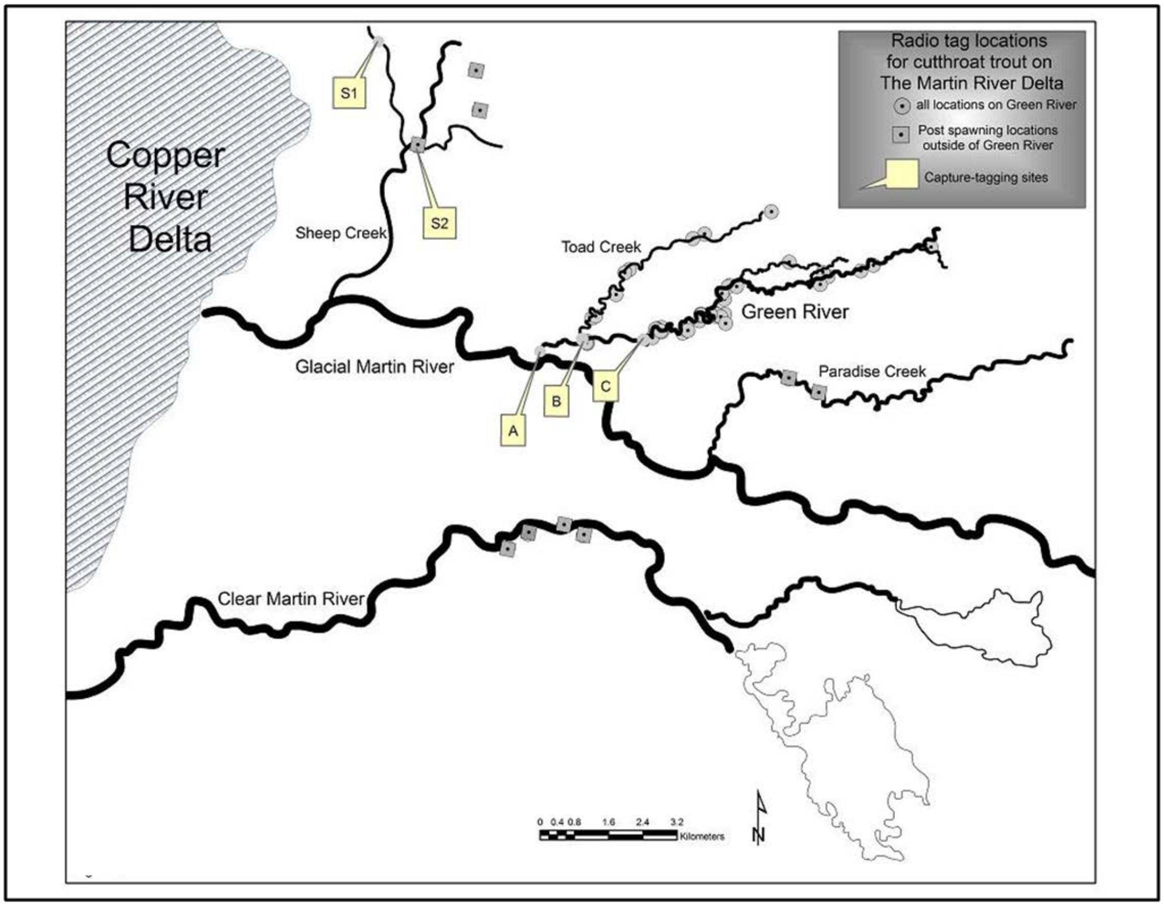


Figure 3.–Fish capture locations A, B, and C (from 2005) from cutthroat trout habitat studies within Copper River Management Area for Trout (S1 was from 2004 and S2 from 2005 to replace a dead transmitter).

In 2005, sampling trips began prior to ice breakup on the mainstem Copper River. Ice breakup on the Green River typically precedes the Copper River, allowing earlier access to fish. A capture and surgical platform placed on a 16-ft airboat allowed for safe transport across ice and efficient

[1] Because 8 g transmitters were used, attempts were made to tag fish greater than 400 g.

surgical procedures at each capture site. Tagging trips began on 19 April, though fish were not seen or captured until 27 April.

Fish were sampled from 3 sites in the lower reaches of the Green River (A, B, C [Figure 3]). Sampling was stratified to tag subsamples of fish at each site, though progression of the spawning run dictated captures to some extent. Effort at each site was relative to sampling success. Pools with woody debris were targeted because trout tend to concentrate in these areas. Fish were captured with hook and line and placed in a live well until 4 to 6 fish greater than 340 mm total length (TL) had been collected, or no more fish were caught. Baited hoop traps were set in all sampling areas but were ineffective at capturing fish.

Captured fish large enough to tag "based on length" were anesthetized with clove oil. Preliminary captures in 2004 showed that fish greater than 340 mm TL would be greater than 400 grams (Appendix B1). Additionally, previous studies (Marston et al. 2005) showed that fish greater than 340 mm TL were 5 years old or greater, which is the mean length-at-age of maturity for cutthroat trout. Mature fish were needed to ensure they were spawning fish. As a general rule, fish greater than 340 mm were used in 2005 to ensure adequate size and age. Fish length was visually estimated and not measured until each fish was anesthetized for surgery to minimize stress to the fish. A subsample of fish were also weighed in 2005 to ensure the 2% rule was followed, and to further describe length-weight relationships by combining 2004 and 2005 data (Appendix B2). The anesthesia used was a mixture of 1 ml of un-emulsified clove oil and 17 liters of river water in a covered live well, similar to the methods used by Prince and Powel (2000). The water was agitated to mix the final solution of 59 mg clove oil per liter of water. Each fish was kept in the solution until 5 minutes after they lost equilibrium to achieve a level 4 effect as described by Prince and Powel (2000).

Procedures for implanting radio tags followed those described by Winter (1983) using 8 g ATS and Habit Research transmitters.[2] Anesthetized fish were cradled in a sling while half-strength clove oil solution (29 mg/L) was administered with a 1-liter squeeze bottle to flood the gills. A surgical scalpel was used to incise an opening just anterior to the pelvic girdle. A canula was then inserted posterior of the pelvic fins, reversed, and the blunt end pushed toward the incision. The blunt end of the scalpel was used to make contact with the canula end and guide it out through the incision. The transmitter antenna was then inserted through the canula and the transmitter was drawn into the body cavity by gently pulling the antennae and removing the canula. Three evenly spaced surgical staples (3M company, 35L) were used to close the incision. The antenna was cut off at the fish's tail and trailed behind the pelvic fins. All surgeries were done in fewer than 120 seconds. The total time it took to do the surgical implantations, including anesthesia, ranged between 8 and 15 minutes. To ensure the fish were in spawning condition, fish were observed for gonad development during implantation, but in most cases only female gonads could be seen through the small incision during the brief surgical time. Fish were then immediately placed in a third live well, which was vented with flowing stream water, and allowed to recover for at least 45 minutes or until fully mobile and reacting to stimuli. The live well was then opened and all fish were allowed to swim freely from the site of capture.

---

[2] Product names used in this publication are included for completeness but do not constitute product endorsement.

A minimum sample size of 30 cutthroat trout implanted with transmitters was needed to obtain the primary study objective. This goal was met on 11 May 2005 (Table 1), but tags were also implanted opportunistically (until 13 May) when gravid fish that were untagged (only 1 more) were encountered heading upstream to spawn (based on spawning coloration and girth). The 4 cutthroat trout, implanted with transmitters in fall 2004 in pilot studies on Sheep Creek (S1, Figure 3), were not considered part of the above sample. These preliminary tags were searched for in 2005, but locations found for these fish were excluded from analysis of the Green River cutthroat trout spawning distribution.

A Habit Research Osprey receiver and Yagi antennas were used for all tracking. Preliminary tracking surveys occurred on the lower river while the crew continued to implant a total of 31 transmitters. A radiotracking flight was conducted on 10 May to determine if fish moved upstream from the capture site, and to obtain a general idea of where fish were going. Beginning on 13 May, after 31 radio tags were implanted, tracking was conducted systematically 3 times per week on foot. Each tracking day consisted of walking a section of the study drainage with the receiver and antenna to record fish locations. Sections were done in sequence so that the entire study drainage of the Green River was surveyed equally once per week. Tagged fish were located by tracking transmitters to a pool and, if possible, visually observing the transmitter antenna. Failing this, the location where the strongest radio signal was found by triangulation was recorded. Use of woody debris by the fish was recorded when it occurred. Systematic tracking continued until 31 May, at which time all radiotagged fish had stopped moving up river and were beginning to descend.

Because all of the tagged fish were large enough to be mature and many contained visible eggs, fish location sites upstream of where the fish was tagged were considered spawning movements. Sites were visually assessed for spawning habitat by observing the area from end to end of the pool or riffle where the fish was located. Notations were made regarding the presence of other fish, the presence of redds or disturbed gravel without redds, and the presence of preferred (pea sized) gravel or pool structure (tail outs or shallow glides) for spawning coastal cutthroat trout (Hunter 1973; Jones 1978, Jones 1984; Trotter 1989). Redds, as defined by Schmetterling (2001) for westslope cutthroat trout (*O. clarkii lewisi*), were small depressions and gravel mounds dug into the preferred substrate. This definition is consistent with observations of coastal cutthroat trout (Steve McCurdy, ADF&G Fisheries Biologist, Craig, AK, personal communication). Fish located directly over an apparent redd or suitable spawning gravel were recorded as being on potential spawning sites. Fish not over spawning gravel were classified as being on holding sites. Other areas seen while tracking that contained suitable gravel with no fish were also recorded as potential spawning habitat. No attempt was made to directly confirm spawning activity, so all observed redds were termed “apparent redds.” Each trout location was plotted into Arcview geographic information system (GIS) software and for each located fish, the furthest upstream point of migration within the watershed was determined.

Postspawning movements were also tracked, though less intensively, until 14 July. Tracking of postspawning fish focused mainly on streams near the Green River, but also occurred opportunistically elsewhere within the Martin River drainage. Postspawning movements were defined as movements downstream after cessation of upstream moves. In conjunction with trips for habitat analysis, the crew continued to track fish located within and just outside of Green River. One aerial survey to track tagged fish was also conducted on 21 June over Green River, Sheep Creek, and Paradise Creek. Tracking by boat to the Clear Martin River was conducted on

2 occasions (27 June and 14 July) and to Sheep Creek on 4 occasions (10, 17, 20, and 22 June). Foot surveys were then done to closely locate postspawning fish if any were detected by boat or by plane. The total riverine distance between moves was measured from GIS software and reported as ranges.

Table 1.–Fish capture data from Copper River Special Management Area for Trout at Green River, 2004–2005.

Date	Capture location	Fish #	Body length (mm)	Body weight (g)	Sex	Tag/body weight (%)	Relocated fish
21 Sep 2004	S1[a]	32	358	492	m	1.63	yes
21 Sep 2004	S1[a]	33	458	492	m	1.63	
21 Sep 2004	S1[a]	34	353	452	m	1.77	
13 Oct 2004	S1[a]	35	422	752	m	1.06	
27 Apr 2005	a	1	382		f		yes
27 Apr 2005	a	2	400		f		yes
27 Apr 2005	a	3	355		m		
29 Apr 2005	a	4	362		f		
29 Apr 2005	a	5	511		f		
29 Apr 2005	a	6	408		m		yes
29 Apr 2005	a	7	382		m		
29 Apr 2005	a	8	373		m		yes
1 May 2005	c	12	347	340	f	2.35	yes
1 May 2005	c	13	378	560	f	1.43	yes
1 May 2005	c	14	365	460	m	1.74	yes
1 May 2005	b	18	485	1220	m	0.66	yes
4 May 2005	a	9	410	740	m	1.08	
4 May 2005	c	10	425	660	m	1.21	yes
4 May 2005	c	11	425	740	m	1.08	yes
4 May 2005	a	15	395	380	m	2.11	
4 May 2005	a	16	380	440	m	1.82	
4 May 2005	a	17	350	400	m	2.00	yes
6 May 2005	c	19	350	460	m	1.74	yes
6 May 2005	c	20	360	420	m	1.90	yes
6 May 2005	c	21	374	540	f	1.48	yes
6 May 2005	c	22	363	420	m	1.90	
6 May 2005	c	23	362	500	m	1.60	
9 May 2005	c	24	328	360	m	2.22	yes
9 May 2005	c	25	337	420	m	1.90	
9 May 2005	c	26	392	680	f	1.18	yes
9 May 2005	c	27	398	580	f	1.38	yes
9 May 2005	c	28	374	600	m	1.33	
11 May 2005	c	29	457	940	f	0.85	
11 May 2005	c	30	370	520	f	1.54	
11 May 2005	c	31	394	680	f	1.18	yes

-continued-

Table 1.–Part 2 of 2.

Date	Capture location	Fish #	Body length (mm)	Body weight (g)	Sex	Tag/body weight (%)	Relocated fish
26 May 2005	C	36	330		m		yes
26 May 2005	C	37	382		m		yes
13 Jun 2005	C	38	354		m		yes
17 Jun 2005	B	39			m		yes
17 Jun 2005	S2[b]	40			m		

[a] Fish captured at location S1 were captured in 2004.

[b] A fish captured at location S2 was a recapture of fish #11.

Cataloging woody debris, a secondary objective of the study, occurred while tracking postspawning activity. In June 2005, after most tagged fish had left the area, the Green River mainstem was surveyed and woody debris was cataloged from the uppermost tributary fork to the last debris jam upstream of the capture sites (Figure 6). For each item of woody debris greater than 25 cm diameter at breast height, the following information was recorded: type, diameter, length, and angle of the debris to the stream flow. Debris types were logs, root wads, root-wad-log combinations, newly fallen trees (with green foliage), or beaver dam remnants. Locations were plotted into Arcview software. Tributaries and the mainstem above the surveyed section were not surveyed.

RESULTS

There were 48 cutthroat trout captured during preliminary sampling in 2004 (Appendix A1). Mean induction time for anesthetizing fish was 4.4 minutes (SD = 0.3, n = 28). Anesthesia sampling was limited to 28 fish due to unusually high water temperatures. The length-weight relationship for preliminary samples indicated that fish greater than 340 mm were heavy enough to tag (Appendix B1). Four transmitters were implanted in October 2004 on Sheep Creek after temperatures cooled (S1, Figure 3). These transmitters were duty cycled to turn off for winter (October to April) and resume transmitting in 2005. Preliminary foot and boat surveys determined survey routes and telemetry stations (Appendix C1), and a maximum over-ground signal reception of 1 km. In addition, evidence of spawning was found in smaller tributaries of upper Sheep Creek, and Green River (Appendix C1).

There were 31 transmitters implanted in fish in the Green River during the main spawning run between 27 April and 11 May 2005, and 4 more were implanted between 26 May and 17 June (Table 1, Figure 3). All fish successfully survived the tagging and were tracked moving within the capture pools after surgery. Only one fish (number 27) did not leave the capture site pool. One fish (number 10) was also recaptured in late spring with a dead transmitter. That transmitter was successfully removed and replaced with a functional one (S2, Figure 3). Transmitter weight as a percent of body weight did not exceed 2.4% of any tagged fish and only 3 exceeded 2% (Table 1). Twelve of the 35 fish tagged in 2005 were ripe females noted with large mature eggs (Table 1). Length-weight relationships of all captured fish weighed from both years combined is depicted in Appendix B2.

Tracking surveys successfully located 23 individual fish 96 times (Table 1, Figures 3 and 4), of which 22 fish and 92 locations were from fish tagged in 2005. Two fish[3] were excluded, leaving 21 located fish and 91 locations for analysis. Of these, 4 tags (19%, SE = 9%) were tracked to the banks of upriver tributaries from fish that were apparently consumed by predators while ascending to spawn. Mink or otter tracks and dens were seen in conjunction with these 4 tags. In 1 case, fish eggs were found with the tag at the entrance of a mink den, but no carcasses were seen with any of the 4 depredated tags. Locations of these 4 fish were included as sites of highest migration, and the areas were assessed for potential spawning habitat, but they were not used to determine specific spawning redds. Thirteen of 35 fish were never relocated after tagging in 2005. Relocated fish were not significantly different in total length (TL; $t = 2.06$, df = 24, $P = 0.6$) or weight ($t = 2.05$, df = 24, $P = 0.8$) from fish that were not relocated. Recapture rate of small fish (less than the median TL of 376 mm) did not differ from that of large fish (greater than 376 mm TL) ($\chi^2 = 0.12$, df = 1, $P = 0.72$).

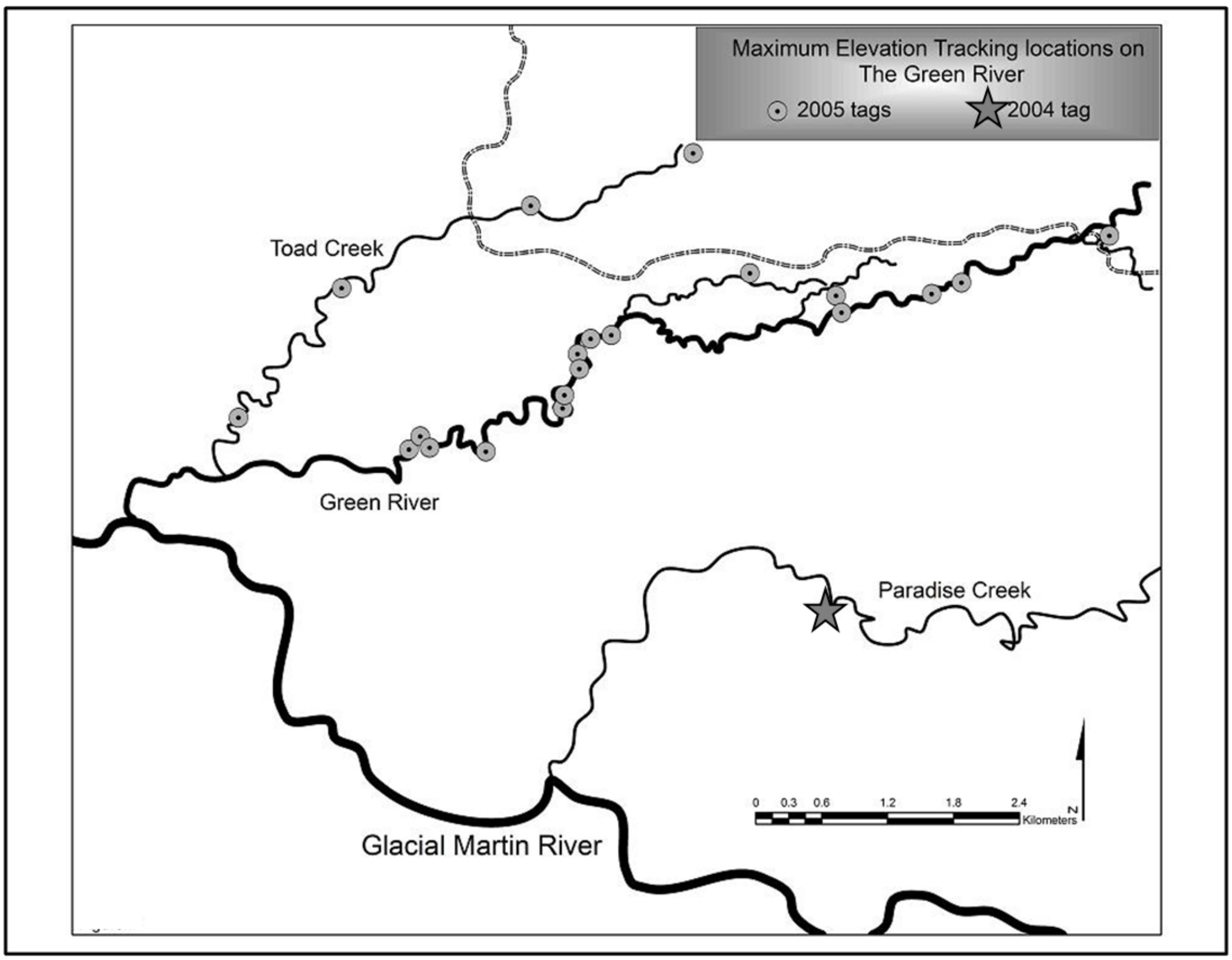


Figure 4.–Furthest upstream locations of radiotagged cutthroat trout in the Green River.

3 One fish was tagged in 2004 in Sheep Creek; the other died shortly after tagging in the capture pool.

Although some of the small tributaries contained flat shale substrates unlikely to be good cutthroat trout spawning habitat, long sections of some streams contained what appeared to be ideal spawning habitats, and isolated pockets of the preferred gravel substrate were also observed at active beaver dam areas (Figure 5) and all log jams (Figure 6). Three fish (14%, SE = 8%) were located upstream of the proposed road corridor at their highest migration point and 2 others (10%, SE = 7%) were downstream within 1 km (Figure 4). There were 7 radiotagged fish (33% SE = 11%) directly associated with spawning gravel habitats or potential redds (Table 2; Figure 5) at 1 or more upstream locations.

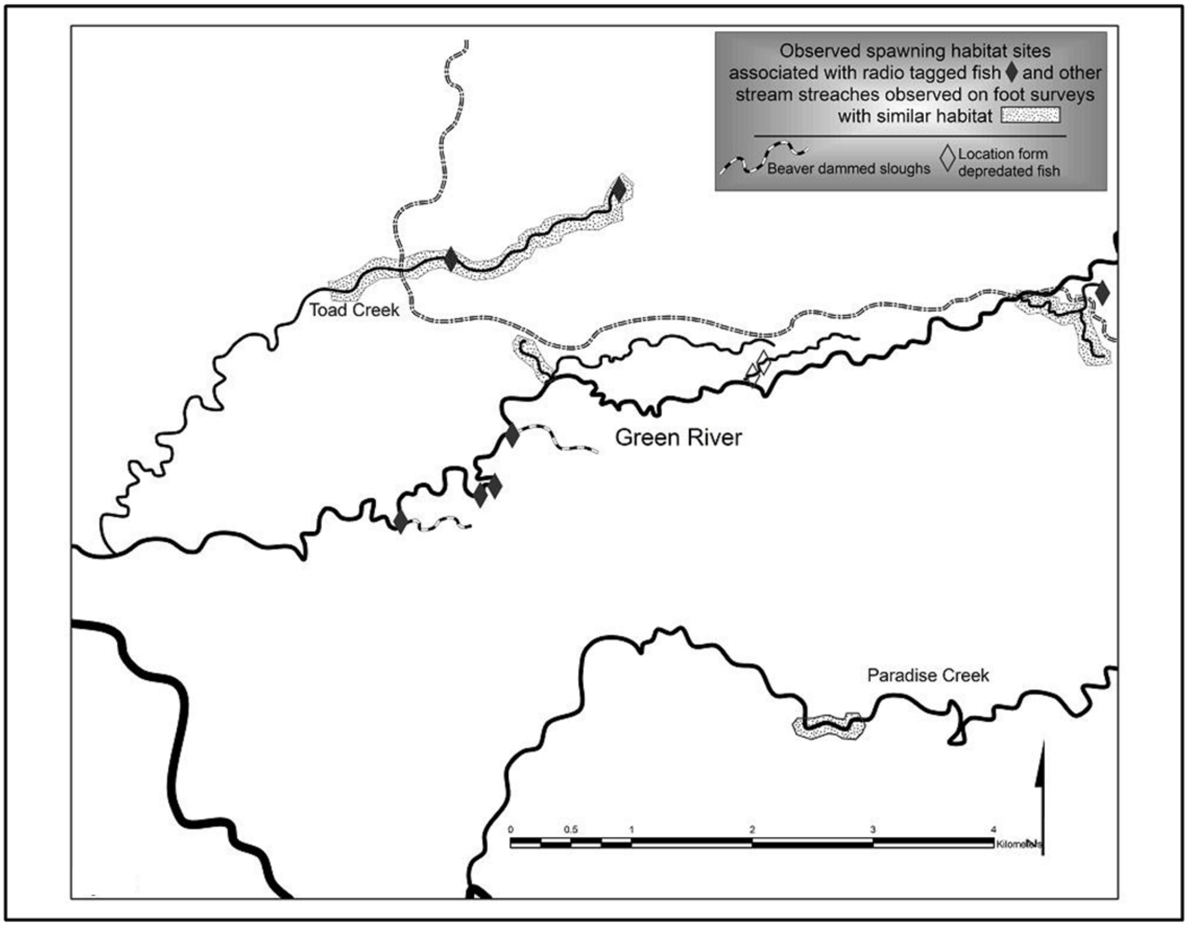


Figure 5.–Spawning habitats on Green River determined from radiotagged cutthroat trout.

There were 2 kinds of postspawning movements. Some fish left the Green River area entirely and others stayed in the mainstem Green River, but all fish moved out of the smaller tributaries. Two fish left the Glacial Martin system entirely and were found in the Clear Martin River (Figure 3). One of these fish also was found in Sheep Creek west of Green River prior to moving to the Clear Martin River. One other fish movement was tracked into beaver dam ponds on Sheep Creek, and another into Paradise Creek (tag from 2004) east of the Green River. Total riverine movement distance (n = 10) ranged from 123 meters to 36 km. The mean date that the first postspawning movements were detected was 21 May. Rate of movement (distance/days between locations) ranged from 20 to 1,534 meters per day.

There were 94 woody debris items cataloged in 44 locations along 6.18 km of the Green River main channel (Table 3; Figure 6). Debris jams with multiple items (n = 19 locations) included from 2 to 16 different items. Most woody debris items were logs without roots attached. Logs with root wads attached were secondarily abundant, and unattached root wads were third in abundance. A smaller percentage of woody debris was newly fallen trees, or remnant beaver dams (less than 10%). Twenty-five percent of the fish locations from 14 different fish (67% ;14 of the total 21 located fish) were directly associated with woody debris.

Table 2.–Cutthroat trout location data from Green River spawning surveys, 2005.

Date	Method of first location	Fish #	Spawner site	Above road
6 May 2005	foot while capturing	10	Yes	
6 May 2005	foot while capturing	19		
10 May 2005	plane	2	Yes	yes
10 May 2005	plane	6		
10 May 2005	plane	12		
10 May 2005	plane	21		
10 May 2005	plane	27		
10 May 2005	plane	8	Yes	yes
11 May 2005	foot while capturing	1		
13 May 2005	foottracking	17		
16 May 2005	foottracking	13	Yes	
16 May 2005	foottracking	24	Yes	
16 May 2005	foottracking	26		
16 May 2005	foottracking	31		
20 May 2005	foottracking	18	Yes	yes
24 May 2005	foottracking	14	Yes	
31 May 2005	foottracking	36		
15 Jun 2005	foottracking	38		
17 Jun 2005	foottracking	11		
22 Jun 2005	foottracking	37		
24 Jun 2005	foottracking	32		
24 Jun 2005	foottracking	39		
27 Jun 2005	foottracking	20		

Table 3.–Woody debris data from the Green River, 2005.

Type of wood	*n*	% of total	Mean length (m)	SD	Mean width (cm)	SD	Mean % wetted [a]	SD	Mean aspect [b]	SD
Beaver dams	6	6	1.8	1.1	ND	ND	100	0	60	52
Beaver lodge	1	1	ND	ND	ND	ND	ND	ND	ND	ND
Fallen tree	5	5	12.0	2.9	42.5	15.1	57	49	68	45
Log	36	38	8.4	5.0	47.6	14.6	63	39	57	36
Root wad	15	16	2.3	1.4	47.6	10.2	97	10	18	33
Root wad log	31	33	12.1	6.5	65.3	28.7	70	39	44	37

[a] % of item in water.

[b] Aspect to river flow.

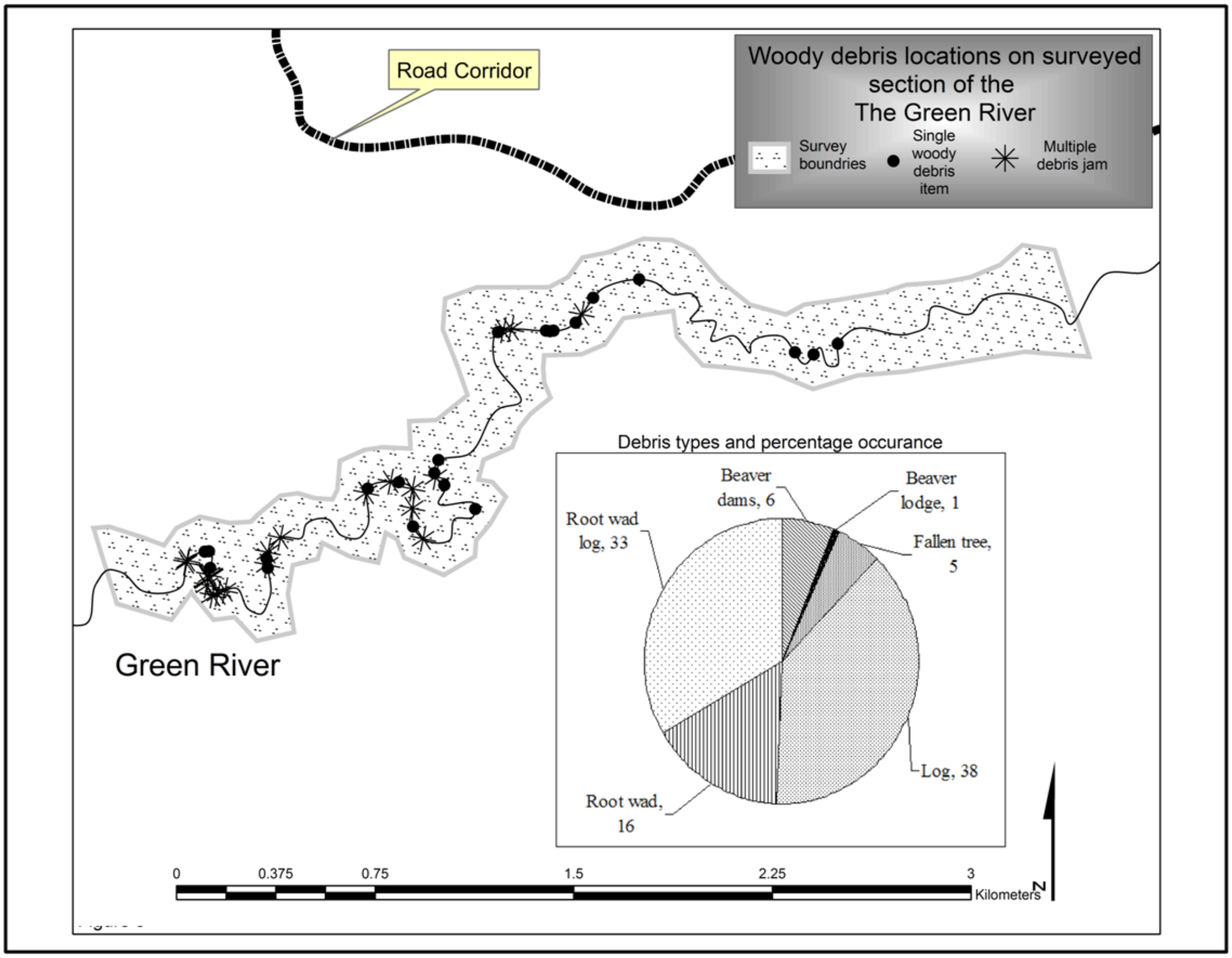


Figure 6.–Woody debris locations on the Green River.

DISCUSSION

There was only 1 confirmed fish mortality as a result of tag implanting procedures, and predation may have played a role because the tag was found underneath a bald eagle perch (fish #17). Several fish moved upstream the next day after tagging, and all but one moved out of the tagging pools. Two fish, recaptured late in the study to observe the stapled incisions, were both healed, with 2 of the 3 staples intact. Additionally, the antenna exit point had healed in both fish. Surgical staples appear to heal well as found by Swanberg et al. (1999) and they considerably shorten surgery time, which likely limits mortality of tagged fish. Extra care must be used for female fish as eggs can be extruded from the incision during implantation. The tag's antenna was visible on several fish tracked into shallow pools and is a potentially effective way to visually detect tagged fish in clear shallow waters.

Although 22 individual fish were tracked, 13 fish (37%) were never relocated after tagging in 2005. There are several possible fates that may have befallen these fish. First, some fish in 2005 were tagged on April 27, yet systematic tracking did not begin until May 11, when the goal of 30 tagged fish was met. This allowed enough time (up to 13 days) for some tagged fish to ascend, spawn, and retreat downstream. Three tracked fish were already moving downstream by May 13.

Second, the Green River is only 1 of several tributaries in the Glacial Martin River drainage. Some of the fish tagged in the lower river may have been moving through this area prior to ascending a spawning tributary outside the tracking area. Third, although all tagged fish survived and swam away after tagging, it is possible that some died soon after, and may have drifted downstream out of the area. However, it was likely that any fish carcasses would settle in the tagging pools, and not likely drift out on their own. These tagging pools were searched for tagged fish using radiotelemetry the days following surgery and no dead fish were found. Lastly, although mature gonads were observed in many fish, it was not possible to confirm if all of the fish we captured were spawning. Some non-gravid fish may have temporarily swam upstream for other reasons, only to swim back downstream after being tagged.

The proposed road corridor primarily traverses upland habitats rather than lower, marshy terrain. Some tagged fish (14%) were tracked above the proposed road corridor and another 10% immediately downstream, suggesting that some cutthroat trout spawning habitat could potentially be impacted by road construction. However, many small upland tributaries within the study area, but not associated with tagged fish locations, are crossed by the road corridor. Radiotagged cutthroat trout in this system appeared to prefer streams with white, granitic, round, pea-gravel substrate. Many tributaries upstream of the proposed road corridor that lacked observed fish locations were shale-like dark, flat gravel substrates (personal observation), whereas areas upstream of the corridor where fish were observed was underlain by the preferred spawning substrate. Knowledge of surface geology (specifically, distribution of the 2 substrates) would potentially be extremely useful for predicting cutthroat trout spawning habitat.

Many small tributaries in the area may have been utilized by tagged fish during hours we were not tracking. We tracked fish only in daytime hours. Other research has shown that cutthroat trout enter smaller streams at night to spawn then retreat (Trotter 1989). Our specific objective was to determine if fish could be detected upstream of the road corridor. The study was not designed to detect all important tributary streams, and our data cannot exclude tributaries from habitat importance.

The detection of postspawning movements was largely opportunistic in this study. Consequently, only a small sample size was obtained and only a small area could be surveyed relative to that available to the fish. Results can only be interpreted as minimum movement distances within some fraction of the total postspawning habitat since much larger movements beyond our focused study area could have occurred and gone undetected. The mean date observed for the first detection of these movements (21 May) denotes that, at least in the sample from Green River, spawning movements were largely over by late May. At minimum, some of the Green River spawning cutthroat trout appear to move throughout the Martin River Delta in the summer after spawning. Although some fish stayed in the mainstem Green River, and one of the preliminary Sheep Creek tags implanted in 2004 was found upstream in the Paradise Creek drainage, no postspawning movements were detected upstream into the upper Glacial Martin System. However, the wintering habitats of these fish are not known. Suitable wintering lakes and the presence of cutthroat trout in these lakes in summer, were found in the upper portions Martin River Delta during past studies (Marston et al. 2005). Longer term tracking studies would be needed if postspawning and wintering habitats for cutthroat trout in the CRSMT are to be completely identified.

Locations of woody debris were clumped in the middle reaches of the Green River. Woody debris has been identified as an important component of juvenile cutthroat trout habitat use (Boss and Richardson 2002). The productivity of the upper spawning tributaries located in this study may be linked to this habitat variable in the lowland sections if newly hatched fish require this habitat to survive. Several fish locations were located in woody debris logjams and 3 potential spawning sites were also found adjacent to beaver dams or at the intersections of beaver dammed sloughs. Twenty three of the fish locations (25%) from Green River were at woody debris locations from 14 individual fish (67%). Spawning fish in the Green River may require wood within the channel as cover when migrating to and from upriver spawning sites, or as in the case of beaver dam plunge pool glides, as spawning locations. Isolated pockets of appropriate sized spawning gravel habitat were also seen underneath all of the larger logjams (personal observation) which may be utilized by spawning fish.

This study provided valuable information by confirming that the habitat and substrate preferred by spawning cutthroat trout exists above the proposed road corridor in the study stream, and that trout, at least to some degree, utilize that habitat. Habitat assessments done prior to implementing construction projects increase options for habitat conservation, increase the effectiveness of mitigation, and can help with the permitting process. Additionally, this study provided basic logistical knowledge for further, more elaborate studies of spawning cutthroat trout in this area. The actual spawning event of coastal cutthroat trout may occur at night in order to limit exposure to predation, and our surveys occurred in daytime hours. Although spawning activity was not directly observed in this study, what appeared to be redds in several sites, and gravid fish moving upstream of the potential development sites were both observed during the spawning season. The small sample size and focus on 1 small tributary limits our ability to infer the importance of the Green River to the entire cutthroat trout population of the CRSMT. If information about the overall reproductive importance of any particular area to spawning cutthroat trout populations is required, more studies would be needed to locate all potential spawning tributaries and determine the relative importance of each tributary to the population(s) of cutthroat trout on the CRSMT.

The presence of spawning cutthroat trout in the Green River, and subsequent postspawning movements, suggest that individual Green River tributaries contain habitat used by trout ranging throughout a large area. Fish sampling trips occurred for 2 weeks prior to seeing or capturing fish in the river. All fish captured were not likely resident in Green River and migrated in from outside the Green River to spawn. It is possible that these fish are riverine migrants that came in from the mainstem Copper River, lakes of the delta, or both, but this kind of obligate freshwater migratory life history has not been observed within Alaska. The proximity of the ocean to the Green River, and the abundance of anadromous cutthroat trout throughout the southern coast of Alaska make anadromy seem more likely. The detection of anadromous migrations and habitat used by cutthroat trout upstream of potential road developments, as well as basinwide postspawning migrations indicate trout populations of the entire area are linked. As such, stream crossings that do not impede fish movements may be needed if road developments are to be as benign as possible for cutthroat trout population(s), and cutthroat trout fisheries of the entire Martin River Delta. Because several other sport fish and commercial fish species (Johnson and Blanche 2010; Ashe et al. 2005) are found throughout this area, this concern may also be applicable to these species and fisheries as well.

ACKNOWLEDGEMENTS

Matt Miller initiated the cutthroat work in 2000 and Jan Bullock worked at various points in the project and provided veterinary guidance. Jason Lynch worked during the 2004 preliminary season and Chris Brockman provided most of the tagging and tracking field expertise for this work in 2005.

REFERENCES CITED

Adams, N. S., D. W. Rondorf, S. D. Evans, and J. E. Kelly. 1998. Effects of surgically and gastrically implanted radio transmitters on growth and feeding behavior of juvenile Chinook salmon. Transactions of the American Fisheries Society 127:128-136.

Ashe, D., D. Gray, B. Lewis, R. Merizon, and S. Moffitt. 2005. Prince William Sound Management Area 2003 annual finfish management report. Alaska Department of Fish and Game, Fishery Management Report No. 05-54, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fmr05-54.pdf

Boss, S. M., and J. S. Richardson. 2002. Effects of food and cover on the growth, survival, and movement of cutthroat trout (*Oncorhynchus clarki*) in coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 59(6):1044-1053.

Hunter, J. 1973. A discussion of gamefish in the State of Washington as related to water requirements. Washington Department of Fish and Wildlife, Olympia, WA.

Johnson, J., and P. Blanche. 2010. Catalog of waters important for spawning, rearing, or migration of anadromous fishes – Southcentral Region, Effective June 1, 2010. Alaska Department of Fish and Game, Special Publication No. 10-06, Anchorage. http://www.sf.adfg.state.ak.us/FedAidpdfs/SP10-06.pdf

Johnson, O. W., M. H. Ruckelshaus, W. S. Grant, F. W. Waknitz, A. M. Garrett, G. J. Bryant, K. Neely, and J. J. Hard. 1999. Status review of coastal cutthroat trout from Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-37.

Jones, D. E. 1978. Development of techniques for enhancement and management of steelhead trout in Southeast Alaska. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1977-1978(19)AFS 42-6-A, Juneau. http://www.sf.adfg.state.ak.us/FedAidPDFs/fredF-9-10(19)AFS-42-6-A.pdf

Jones, D. E. 1984. A study of cutthroat - steelhead in Alaska. Alaska Dept. of Fish and Game, Federal Aid in Fish Restoration, Annual Report of Progress, 1983–1984. Volume 25 (AFS-42-11-A), Juneau

Marston, B. H., M. G. Miller, and S. J. Fleischman. 2005. Copper River Delta trout assessment. Alaska Department of Fish and Game, Fishery Data Series No. 05-62, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds05-62.pdf

Miller, M. G. 2002. Copper River Delta trout assessment, 2000. Alaska Department of Fish and Game, Fishery Data Series No. 02-22, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds02-22.pdf

Prince, A., and C. Powel. 2000. Clove oil as an anesthetic for invasive field procedures on adult rainbow trout. North American Journal of Fisheries Management 20:1029-1032.

Schmetterling, D. A. 2001. Seasonal movements of fluvial westslope cutthroat trout in the Blackfoot River Drainage, Montana. North American Journal of Fisheries Management 21(3):507–520.

Swanberg, T. R., D. A.Schmetterling, and D. H. McEvoy. 1999. Comparison of surgical staples and silk sutures for closing incisions in rainbow trout. North American Journal of Fisheries Management 19:215-218.

Trotter, P. C. 1989. Coastal cutthroat trout: a life history compendium. Transactions of the American Fisheries Society 118:463–473.

Winter, J. D. 1983. Underwater telemetry. Pages 371-395 [*In*] L. A. Nielsen and D. L. Johnson, editors. Fisheries techniques. American Fisheries Society, Bethesda, Maryland.

Zale, A. V., W. C. Fraser, and C. Booke. 2005. Effects of surgically implanted transmitter weights on growth and swimming stamina of small adult westslope cutthroat trout. Transactions of the American Fisheries Society 134:653-660.

APPENDIX A: CUTTHROAT TROUT CAPTURE DATA FROM PRELIMINARY YEAR, 2004

Appendix A1.–Cutthroat trout capture data from preliminary year, 2004.Cutthroat trout capture data from preliminary year, 2004.

Date		Total length (mm)	Weight (g)	Time [a] in clove oil	Partial effect sedation time [a]	Flaccid time [a]	Induction length (minutes)	Tag # [b,c]
27 May	Green River log jam							nt
4 Jun	Sheep Creek confluence	385	620					334
4 Jun	Sheep Creek beaver dam	296						736
4 Jun	Sheep Creek tributary	277						735
8 Jun	Green River log jam	228						734
8 Jun	Green River log jam	240						733
8 Jun	Green River log jam	280						732
8 Jun	Green River log jam	292						731
8 Jun	Green River confluence	296						730
22 Jun	Green River log jam							732
29 Jun	Sheep Creek confluence	342		1140.30		1148.35	8.05	nt
29 Jun	Sheep Creek confluence	326		1150.30		1155.41	5.11	729
29 Jun	Sheep Creek confluence	384		1156.00		1206.00	10	728
29 Jun	Sheep Creek confluence	358		1209.00		1214.00	5	727
29 Jun	Helicopter Slough	404		1505.00		1512.00	7	926
29 Jun	Helicopter Slough	308		1512.30		1514.30	2	726
6 Jul	Sheep Creek confluence	235	100	1202.48	1205.25	1212.24	9.76	927
6 Jul	Sheep Creek confluence	299	300					928
6 Jul	Sheep Creek confluence	345	440	1216.24	1217.39	1220.15	3.91	929
6 Jul	Sheep Creek confluence	368	520	1221.26	1227.00	1234.25	12.99	930
6 Jul	Sheep Creek confluence	260	160	1325.30	1330.43	1333.00	7.7	931
6 Jul	Sheep Creek confluence	283	220	1332.15	1333.50	1336.50	4.35	932
16 Jul	Sheep Creek confluence	396	600	1215.45	1217.30	1219.45	4	332
16 Jul	Sheep Creek confluence	304	280	1220.35		1222.35	2	nt
16 Jul	Sheep Creek confluence	308	280	1356.00		1358.00	2	933
16 Jul	Sheep Creek confluence	315	320	1358.00		1359.30	1.3	934
16 Jul	Sheep Creek confluence	328	340	1546.20	1548.20	1548.50	2.3	935
17 Aug	Green River log jam	335	380	1153.41	1157.00	1203.45	10.5	936
17 Aug	Green River log jam	267	210	1206.27	1209.04	1209.48	3.21	937
17 Aug	Green River log jam	276	220	1210.55	1213.30	1215.18	4.63	938
17 Aug	Green River log jam	277	220	1217.00		1220.34	3.34	939
17 Aug	Green River log jam	273	200	1221.24		1223.45	2.21	940

-continued-

Appendix A1.–Page 2 of 2.

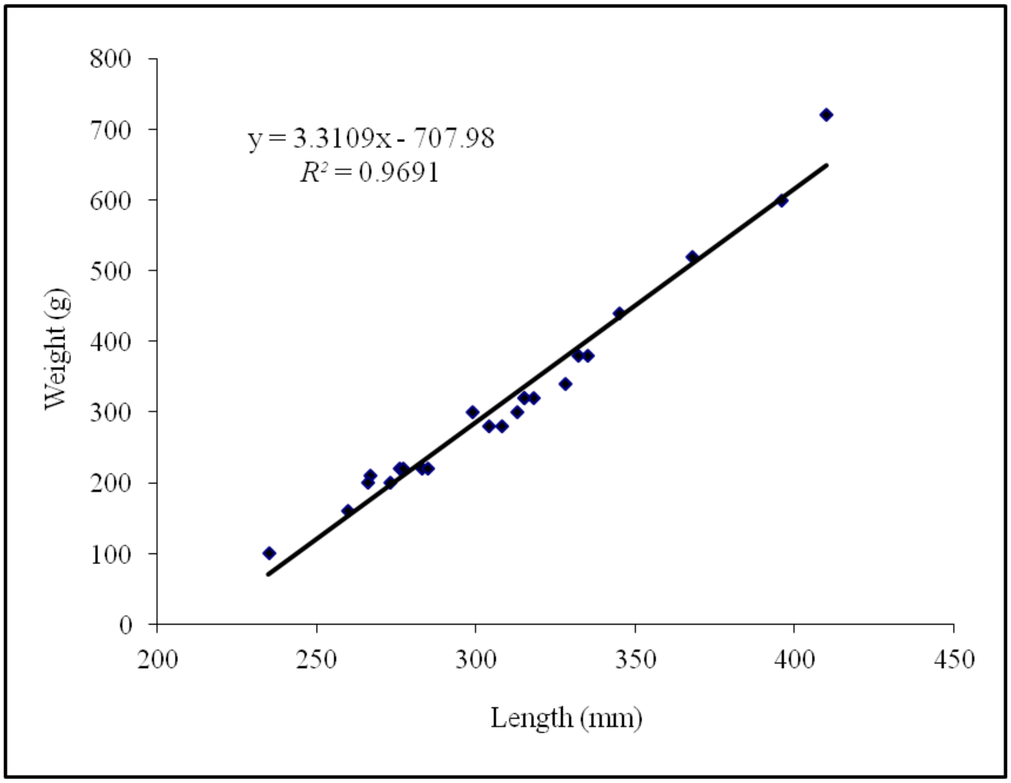
Date	Capture location	Total length (mm)	Weight (g)	Time [a] in clove oil	Partial effect sedation time [a]	Flaccid time [a]	Induction length (minutes)	Tag # [b,c]
17 Aug	Sheep Creek confluence	318						nt
17 Aug	Sheep Creek confluence	293						nt
17 Aug	Sheep Creek confluence	272						nt
17 Aug	Sheep Creek confluence	341						344
17 Aug	Sheep Creek confluence	363						941
26 Aug	Sheep Creek confluence	318	320	1156.15	1158.17	1159.30	3.15	942
26 Aug	Helicopter Slough	266	200	1344.44	1312.51	1345.00	0.56	nt
26 Aug	Helicopter Slough	332	380	1314.00		1315.50	1.5	943
26 Aug	Beaver dam	410	720	1316.40	1319.00	1319.30	2.9	944
26 Aug	Beaver dam	285	220	1403.30	1404.40	1405.10	1.8	945
26 Aug	Beaver dam	315	320	1406.20	1407.37	1408.45	2.25	946
26 Aug	Beaver dam	313	300	1433.16	1433.55	1434.18	1.02	947
21 Sep	Helicopter Slough	358	492					152.097
21 Sep	Helicopter Slough	458	492					153.596
21 Sep	Helicopter Slough	353	452					153.797
13 Oct	Helicopter Slough	422	752					152.898

[a] Times are recorded as time of day (military) with minutes expressed as decimal.

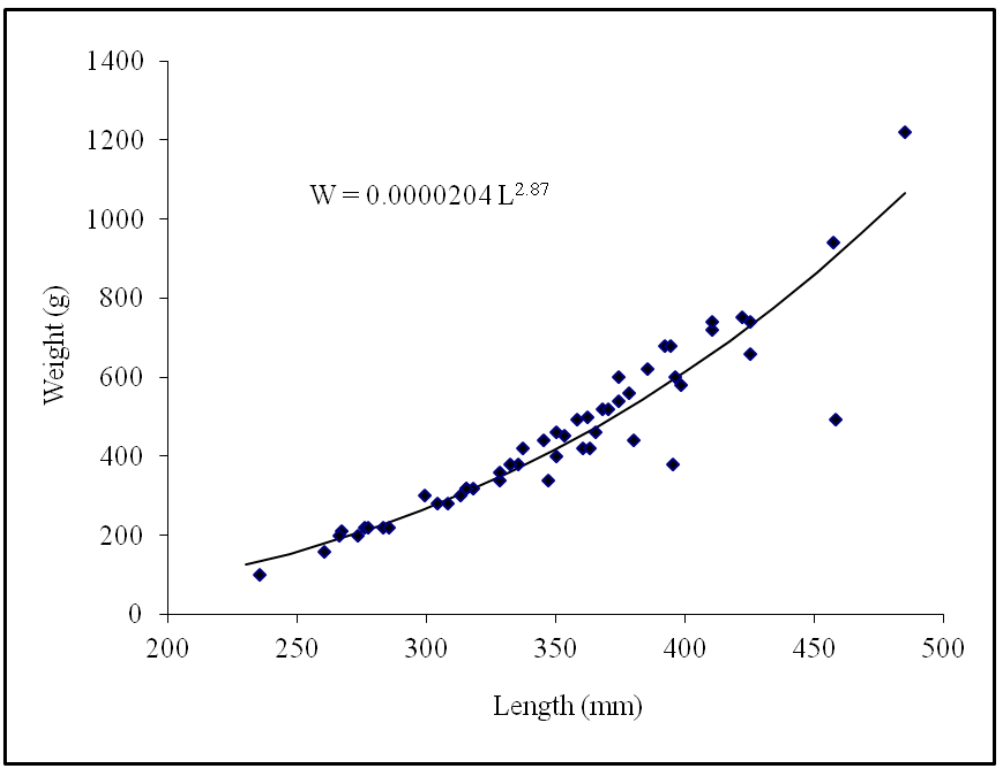
[b] Floy tags are 3-digit tag numbers; 6-digit numbers are radio tags and the frequency.

[c] "nt" means the fish was not tagged.

APPENDIX B: LENGTH-WEIGHT RELATIONSHIPS OF CAPTURED CUTTHROAT TROUT

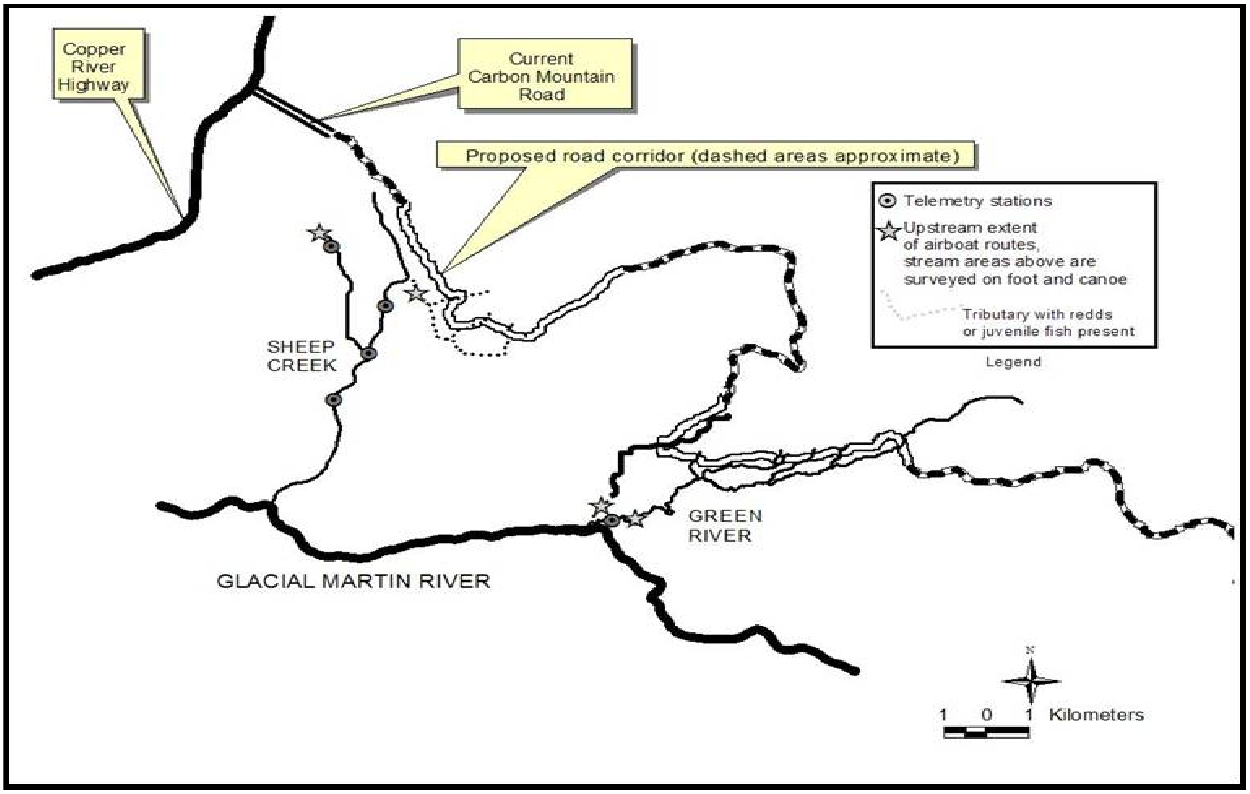


Appendix B1.–Length-weight relationship of cutthroat trout captured in 2004.



Appendix B2.–Length-weight relationship of all captured cutthroat trout, 2004–2005.

APPENDIX C: SURVEY STREAMS AND PRELIMINARY CUTTHROAT TROUT SPAWNING OBSERVATIONS, 2004



Appendix C1.–Survey streams and preliminary cutthroat trout spawning observations, 2004.