Fishery Data Series No. 02-10

Influences of Breaching Beaver Dams on the Distribution of Arctic Grayling in Piledriver Slough, 2001

by
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July 2002

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 REPORT NO. 02-10

INFLUENCES OF BREACHING BEAVER DAMS ON THE DISTRIBUTION OF ARCTIC GRAYLING IN PILEDRIVER SLOUGH, 2001

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ABSTRACT

Due to sharp declines in Arctic grayling *Thymallus arcticus* abundances coincident with the encroachment of several beaver dams in Piledriver Slough, an experimental study was initiated in 1998 to determine the response of Arctic grayling distributions and relative abundance to dam removals. In 1998, the locations and dimensions of eight beaver dams and impoundments were documented in the study area from Stringer Road to Bailey Bridge. From 1998 to 2001 beaver dams were incrementally breached, beavers were removed by area trappers, Arctic grayling distributions within the study area were assessed, and water temperatures were monitored. Two thousand and one was the last year of this study and the project objectives were to determine the spatial distribution of juvenile and adult Arctic grayling in the reclaimed reaches of Piledriver Slough. Additional project tasks were to monitor water temperatures at seven locations, measure the length of slough reclaimed after breaching dams in 2000, and examine all breached dams for signs of renewed beaver activity. The distribution of Arctic grayling was assessed using visual observations and hook-and-line gear. Electronic thermographs recorded water temperatures. During the fall of 2001, the last remaining beaver dam within the study area was breached and, in total, 9 km of Piledriver Slough has been reclaimed since 1998. Arctic grayling dispersing upstream of dams site breached in 2000 and the relative abundance of Arctic grayling upstream of breached dams increased to levels equal to observed levels in downstream areas prior to removal. Beaver dams appeared to have a negligible effect on water temperatures. Beaver control measures appeared to be effective with no recolonization of beavers occurring at any dams breached in prior years. The results of this study demonstrated that the beaver dams in Piledriver Slough affected distributions of Arctic grayling by restricting passage to upstream areas. If the beaver population can be effectively managed and the breached dams remain open, it is likely that the additional habitat available for spawning, rearing, and feeding will result in increased production and abundance of Arctic grayling in Piledriver Slough.

Key words: Arctic grayling, *Thymallus arcticus*, beaver, *Castor canadendis*, Piledriver Slough, beaver dams, habitat, abundance, distribution

INTRODUCTION

Before 1940, Chena Slough was one of several side channels of the Tanana River that carried large volumes of glacial water. As early as 1909, floods from the Chena River at Fairbanks were attributed to overflow from the Tanana River flowing through connecting side sloughs, particularly Chena Slough. In 1943, Chena Slough was bisected by the construction of a flood control project, Moose Creek Dike, designed to divert waters back into the Tanana River, which created both Badger Slough (downstream half of Chena Slough) and Piledriver Slough (upstream portion that was still connected to the Tanana River). As part of the Chena River Flood Control Project in 1976, dikes that cutoff flows from the Tanana River were placed at the entrance of Piledriver Slough. These dikes converted Piledriver Slough from a glacial side channel of the Tanana River into a controlled and low flow (1-2 m^3/s) groundwater system fed by upwellings from the Tanana River aquifer.

The conversion of Piledriver Slough to a groundwater-fed system markedly enhanced the productivity of Arctic grayling *Thymallus arcticus* and thereby enhanced the sloughs recreational appeal for sport fishing. It is likely that Arctic grayling straying in from nearby streams and rivers colonized Piledriver Slough. Currently, Arctic grayling move into the slough to spawn in the spring, and inhabit the slough during summer for feeding. The extent to which Piledriver Slough is used for overwintering is not known. However, Merritt (1993) found that Arctic grayling radiotagged in Piledriver Slough in August migrated to the Tanana River and adjacent streams to overwinter. A substantial Arctic grayling fishery, and more recently from stockings, a popular rainbow trout *Oncorhynchus mykiss* fishery developed in Piledriver Slough since its conversion to a clearwater stream. Between 1988 and 2000, an average of 33,500 rainbow trout were stocked annually. Estimated annual catch of Arctic grayling between 1990 and 2000 averaged 23,400 fish.

In response to this effort, the Arctic grayling population was monitored. Abundance estimates steadily declined from 17,323 in 1991 to 8,860, when the last population estimate was conducted in 1997 (Fleming 1991 and 1998). This decline was not abated with the implementation of catch and release regulations in 1994.

Beginning in 1990, the Arctic grayling stock was sampled and assessed, starting upstream of Stringer Loop Road crossing and moving downstream 32 km toward the confluence with the Tanana River (Figure 1). Since 1991, the length of the stock assessment area was necessarily shortened as beavers started to colonize the upper reaches of the slough. By 1996, the length of the stock assessment area had been reduced to 13.8 km because of beaver damming (Figure 1). Pronounced declines in abundance of Arctic grayling that have been apparent since 1992 occurred in conjunction with the construction of new beaver dams. By 1998, only 48% of the original habitat utilized by Arctic grayling in the summer and spring of 1990 and 1991 remained available (Figure 1). The evidence suggested that beavers reduced the carrying capacity for Arctic grayling in Piledriver Slough. It was thought that there would be further encroachment by new beaver dams, which would reduce carrying capacity even further.

Instream habitat can be greatly altered by beavers, resulting in either beneficial or detrimental effects on fish populations. Beavers in boreal forests can modify stream hydrology, increase retention of sediment and organic matter by reducing stream velocity, increase standing stocks of carbon, alter stream acidity and temperature, and inhibit fish passage (D' Efron et al. 1995). McRae and Edwards (1994) observed higher temperatures at the outlets of beaver ponds than at the inlets, and warmer downstream temperatures influenced the distribution of brook trout. However, the warming of downstream reaches caused by beaver impoundments is also affected by the degree of shading, air temperature, groundwater flow, and stream volume. Leidholt-Bruner et al. (1992) found that beaver dams increased summer pool habitat for rearing coho salmon fry. In addition, beaver impoundments can result in an increase in benthic insect density and diversity.

In 1998, a multi-year study was initiated to determine the response of Arctic grayling to an incremental removal of beaver dams over several years. A measure of project success was determined to be Arctic grayling recolonization of habitat that was excluded by beaver dam complexes. It was believed that increased availability of the slough for feeding, rearing, and spawning should ultimately translate into additional Arctic grayling production. During the final year of the study, Arctic grayling have reacted as expected to dam removal. The primary project objective of determining the spatial distribution of juvenile and adult Arctic grayling in relation to beaver dam complexes prior to and after breaching within the study area has remained unchanged throughout all four years of the study. Other project tasks have included mapping beaver dams and impoundments, monitoring of water temperatures in Piledriver Slough in relation to beaver dams, breaching beaver dams, monitoring of beaver activity, and documenting the amount of reclaimed riffle habitat.

OBJECTIVES

In 2001, the project objective was to:

1. determine the spatial distribution of juvenile and adult Arctic grayling in the reclaimed reaches of Piledriver Slough downstream of the Stringer Loop Road crossing by inspection, angling, and seine hauls.

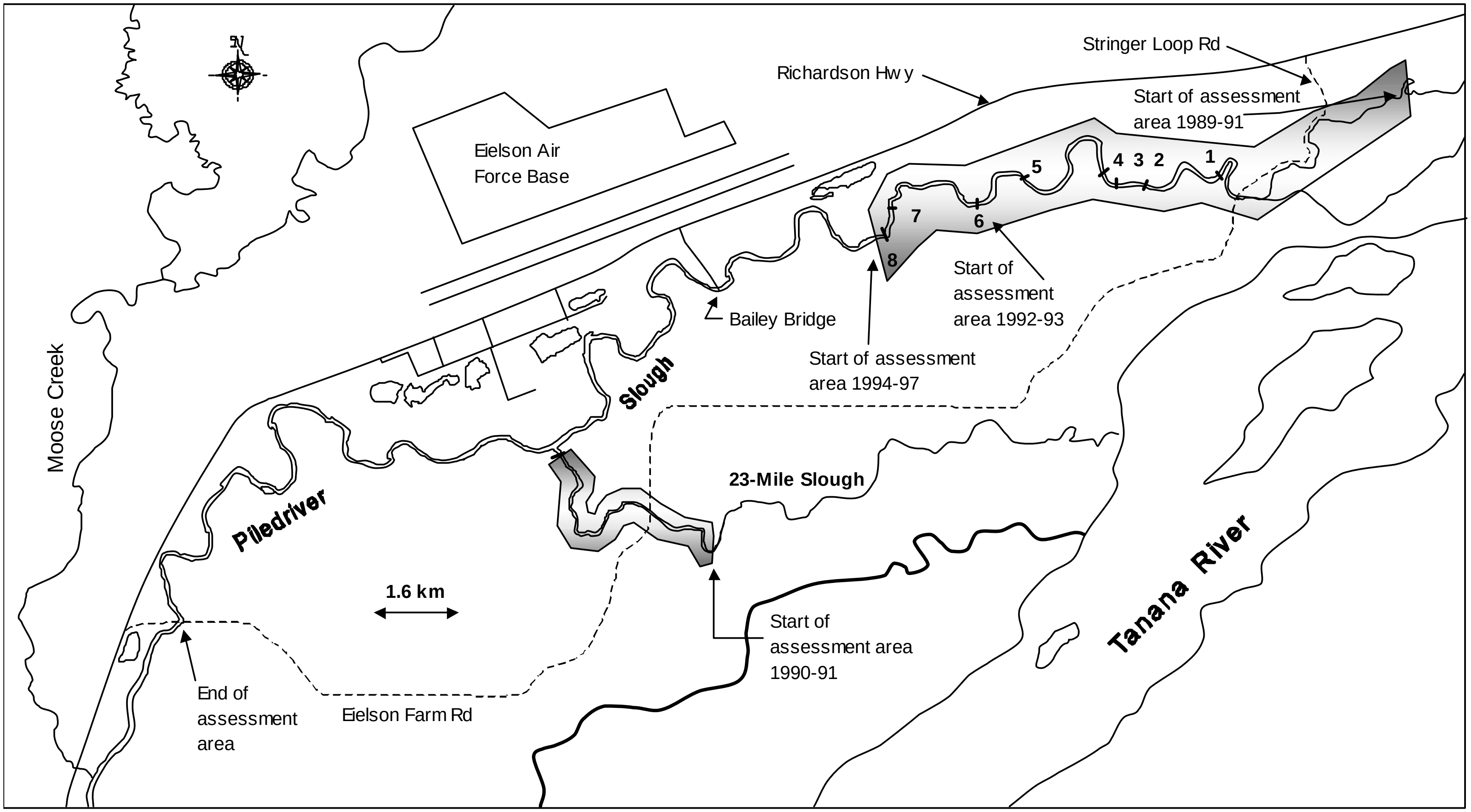

Figure 1.-Assessment areas and locations of beaver dams in Piledriver Slough. Numbers indicate beaver dam locations. Shaded areas indicate sections of stream that supported Arctic grayling prior to dam construction. The mouth of 23-Mile Slough was dammed in 1992 and was not assessed after 1991.

In addition, project tasks were to:

1. monitor water temperatures at seven locations in the reclaimed stretch of Piledriver Slough;
2. measure the length of slough reclaimed after dam breaching in 2000; and,
3. examine breached dams for signs of renewed beaver activity.

METHODS

STUDY SITE

Piledriver Slough is 34 km long, has an average channel slope of 0.00077 m/km, drains approximately 75 km^2, and consists of a long series of pools intermittently broken by shallow riffles and glides (Wuttig 1997). Adjacent to the slough are limited agricultural lands and urban development. Much of the land adjacent to Piledriver Slough lies within the Eielson Air Force Reservation.

SYNOPSIS (1998 – 2000)

In July 1998, a reach of Piledriver Slough from Stinger Road to Bailey Bridge was surveyed to determine the locations and dimensions of all beaver dams and impoundments, to determine the distribution of Arctic grayling in relation to the dams and impoundments encountered, and to deploy data loggers to monitor slough temperatures adjacent to beaver dams. The locations of beaver dams within the study area were recorded with a GPS and then were transcribed onto a 1:25,000-scale topographic map. Dam dimensions were measured and all dams and ponded areas were numbered sequentially starting at the upper most dam and moving downstream such that pond number one was impounded by dam number one (Wuttig 2000; Figure 2; Appendix A1). The distribution of Arctic grayling in relation to beaver dam complexes was determined and data loggers were deployed to monitor water temperatures (Wuttig 2000 and *Unpublished* 2001).

During the fall of 1998 and 1999, working cooperatively with personnel from Eielson Air Force Base and the Alaska Department of Fish and Game (ADF&G), Division of Wildlife, preseason trapping permits (nuisance permits) were issued to recreational trappers to aid in the removal of beavers within the study area. On 2 through 4 November 1998, 5–10 m sections from dams #6 and #8 were removed (Figure 2). Dam #7 was inactive and was already breached. On 6 October 1999, dam #5 was breached and on 5 October 2000, sections were removed from dams #2, #3, and #4. At the start of the project (1998), dam #1 was inactive and was already breached, and remained so until the summer of 2001 when beavers started to rebuild it. By the fall of 2001, dam #1 was rebuilt to its former height.

In July of 1999 and 2000, the redistribution of the Arctic grayling within the study area was assessed, the length of slough (riffles) reclaimed was measured, and the slough was monitored for signs of renewed beaver activity after dam breaching (Wuttig 2000 and *Unpublished* 2001). Methods used in prior years (1998 – 2000) were similar to those used in 2001.

2001

In 2001, seven temperature data loggers were deployed to monitor water temperatures adjacent to beaver dams and downstream areas of Piledriver Slough. Optic StowAway temperature data

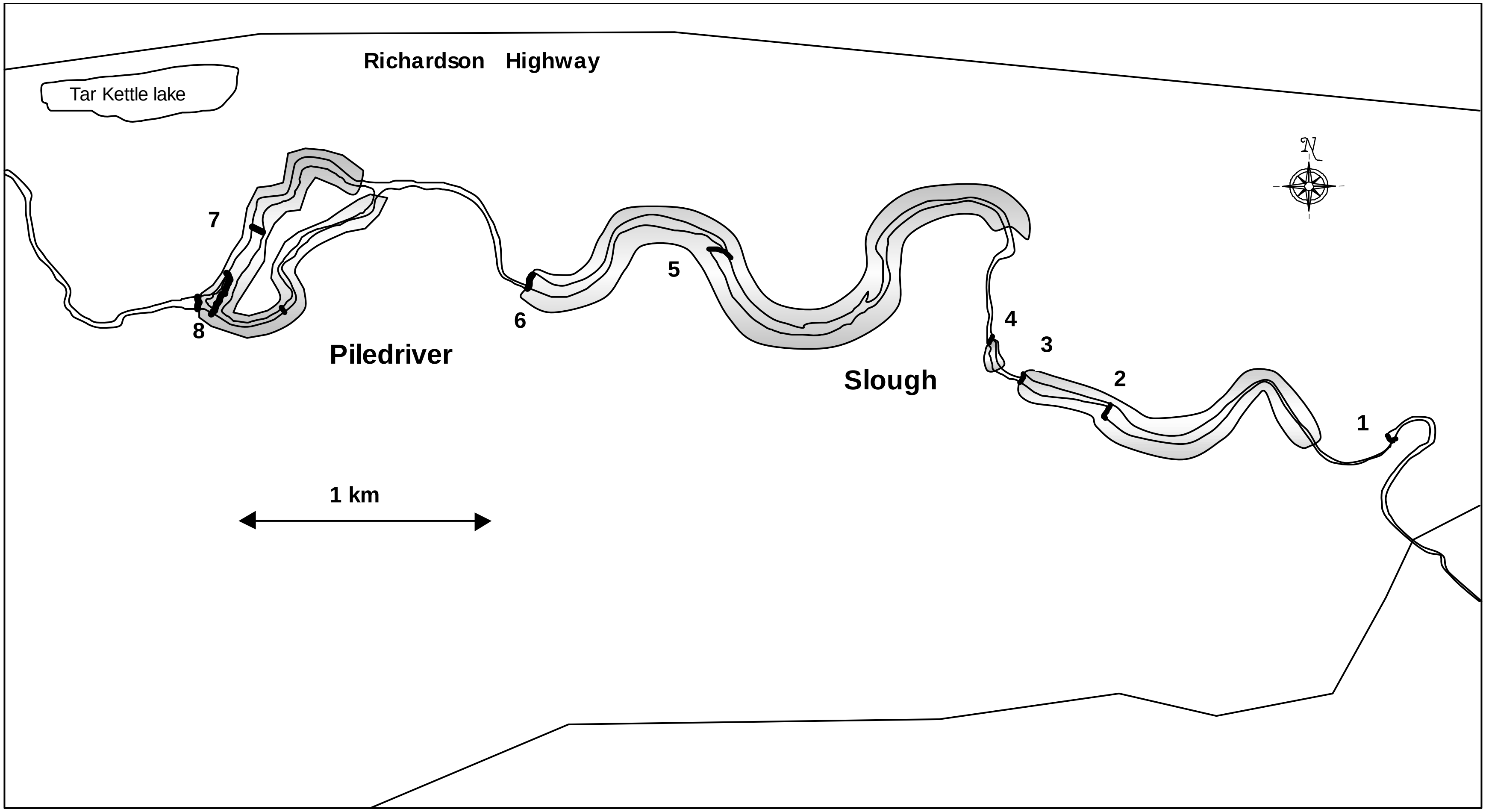

Figure 2.-Locations of beaver dams in the study area along Piledriver Slough prior to breaching, 1998. Shaded areas represent ponded areas, and beaver dams are numbered.

loggers manufactured by Onset Corporation[1] were used with temperatures recorded at 0.5-hr intervals. Loggers were deployed on 3 June and were placed immediately below dam #3, above what was pond #5, below dam #5, in a riffle above dam #7, at dam #8, at Bailey Bridge, and at the Eielson Farm Road crossing. Data loggers were retrieved on 25 September.

On 13–15 July, the spatial distribution of juvenile and adult Arctic grayling in relation to dams breached in previous years was examined using visual inspections and hook-and-line sampling. The study area was accessed by floating and walking a canoe from Stinger Road to Bailey Bridge. Visual observations were made from the canoe and on foot. Areas of the most suitable habitat (riffles and heads of pools) were closely inspected. Water visibility was very high and polarized sunglasses were worn to decrease glare. Approximately two hours (1 hr x two persons) were spent angling between each set of dams and four hours were spent below the lower most dam. Terminal gear consisted of a combination of artificial flies, spinners, and small jigs. A relative measure of abundance of adult fish (≥ 100 mm) between two dams was inferred from catch data. In previous years (1998 to 2000), seine hauls in combination with visual counts were used to determine the presence of age-0 fish and to index the relative abundance of age-0 Arctic grayling. In 2001, only visual observations or counts were used because catches with the seine were highly variable. The relative abundance of age-0 grayling was attained from visual observations and the counts were gross approximations.

All captured Arctic grayling were measured to the nearest 1-mm FL and examined for tags. All fish < 100 mm FL were assumed to be age-0 fish. Each fish ≥ 100 mm FL received an upper caudal fin clip, and two scales were taken and mounted directly on gum cards for aging. Scales were taken from the preferred area approximately six scale rows above the lateral line just posterior to the insertion of the dorsal fin (W. Ridder *Unpublished*). Scales were briefly cleaned by removing slime and dirt and then mounted directly to gum cards. The gum cards were used to make triacetate impressions of the scales (30 seconds at 137, 895 kPa, at a temperature of 97°C). Ages were determined by counts of annuli from impressions of scales magnified to 40X with the aid of a microfiche reader. Criteria for determining the presence of an annulus where when: 1) complete circuli cut over incomplete circuli; 2) clear areas or irregularities in circuli were observed along the anterior and posterior fields; and, 3) regions of closely spaced circuli were followed by a region of widely spaced circuli (Kruse 1959).

On 5 October, a crew of four persons removed an approximately 5-m section of material from dam #1. Dam material was removed primarily with a chainsaw winch tethered to a grappling hook and secondarily with hand tools (axes, shovels, polaskies, and crowbars). As in previous years, the dam was breached at the onset of winter conditions when ice was formed in the pond to preclude any remaining (untrapped) beavers from repairing dams. Furthermore, it was thought that draining of the ponds after ice formation might aid in eradicating any remaining beavers by excluding winter food caches and over-wintering habitat, and by freezing dens by exposing den openings.

RESULTS

Periodic examinations in the summer and fall of 2001 revealed no signs of beaver activity at the lodges, food caches, and sights where the dams had been breached in previous years (dams #2 -

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[1] Use of this company name does not constitute endorsement, but is for scientific completeness.

#8). Food caches appeared untouched, no fresh tracks or cuttings were observed, and the breaches remained opened. Breaching of dams #2, #3, and #4 opened the remaining section of the slough within the study area to fish passage, and exposed four new riffle sections (Figure 3). Large areas of gravel bars and shoreline that had been submerged were exposed as well as openings into the bank dens. Scour holes formed below breached openings and gravel substrates had been scoured 10-50 m below the breaches. Renewed beaver activity was observed at dam #1 on 3 June. Fresh cuttings had been added to the dam face but did not hinder fish passage because the breach was still open. By 13 July, the breach in dam #1 had been partially repaired and water levels above the dam had risen approximately 0.2 m; fish passage was likely hindered at this point. By 3 October, the breach had been completely repaired and the water level differential above and below the dam was approximately 0.5 m.

In July 2001, Arctic grayling were found throughout the study area (Table 1). In the area above dam #3, where no Arctic grayling were found (observed or captured) in 2000, numerous adult and age-0 fish were observed up to dam #1 (Tables 2 and 3). Several small schools of age-0 Arctic grayling but no adult grayling were observed above dam #1. Arctic grayling were also distributed throughout the entire length of the slough between dams #4 and #8. Particularly high densities of age-0 fish were observed in June and July along stream margins that were previously flooded by dams #2 through #5. One hundred and six Arctic grayling (≥ 100 mm FL) were captured, and lengths ranged from 217 mm FL to 342 mm FL. Of these, 71 fish were aged and 5 years was the median age (Table 3).

From 10 June to 10 August 2001, the average daily water temperature at dam #3 was slightly greater (1.3 C^o) than at dam #8. The average daily maximum temperature was 11.0 C^o at dam #3 compared to 14.6 C^o at Eielson Farm Road (Figure 4). Weather conditions during this period were generally cooler than normal.

On 10 October, approximately five meters of material was removed from dam #1. Several age-0 grayling were observed immediately above and below the dam prior to breaching. During the winter, October through February, area trappers did not report capturing any beaver within the study area.

DISCUSSION

It is evident that beaver dams on Piledriver Slough have influenced the distribution of Arctic grayling by restricting fish passage based upon the observed differences in the distribution of fish within the study area prior to dam construction, after dam construction, and then after dam breaching. Prior to the construction of any dams Arctic grayling were known to utilize the

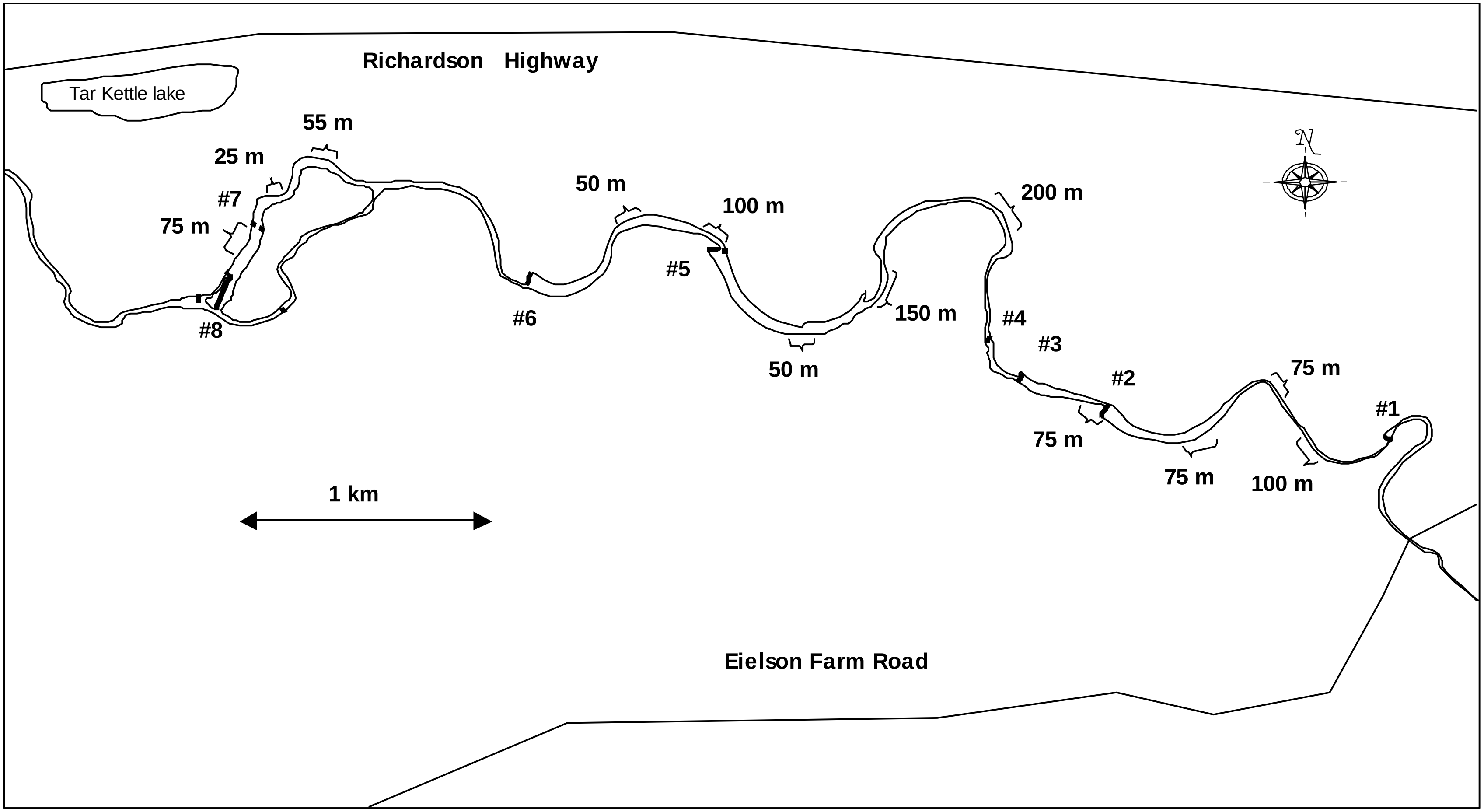

Figure 3.-Locations of breached beaver dams in the study area along Piledriver Slough, 2001. Newly exposed riffle sections are indicated with brackets and labeled by their length (m).

Table 1.-Number of Arctic grayling > 100 mm FL captured in slough reaches between dams within Piledriver Slough, 1998 - 2001.

Slough Reach	1998	1999	2000	2001
Dam #1 - #2	0	0	0	20
Dam #2 - #3	0	0	0	7
Dam #3 - #4	1	1	7	13
Dam #4 - #5	1	1	23	31
Dam #5 - #6	0	10	4	14
Dam #6 - #7	42	20	9	12
Dam #7 - #8	0	0	1	0
Below dam #8	38	34	29	9

Table 2.-Number of age-0 Arctic grayling observed and or captured within Piledriver Slough, 1998 - 2001.

Slough Reach	1998	1999	2000	2001
Dam #1 - #2	0	0	0	500
Dam #2 - #3	0	0	0	2000+
Dam #3 - #4	0	300+	2,000+	500
Dam #4 - #5	60	100+	1,500+	2000+
Dam #5 - #6	0	1,000+	500+	1000+
Dam #6 - #7	500+	250+	425+	1000+
Dam #7 - #8	0	25+	125+	100
Below dam #8	2,000+	500+	2,000+	1000+

Table 3.-Proportions and mean lengths (mm) by age class of captured Arctic grayling in Piledriver Slough, 2001.

Age	Sample Size	Proportion	Mean	Min	Max
2	1	0.01	217	217	217
3	6	0.08	244	222	282
4	22	0.31	264	229	304
5	25	0.35	283	233	315
6	14	0.20	306	285	342
7	3	0.04	317	314	320
Total	71		278	217	342

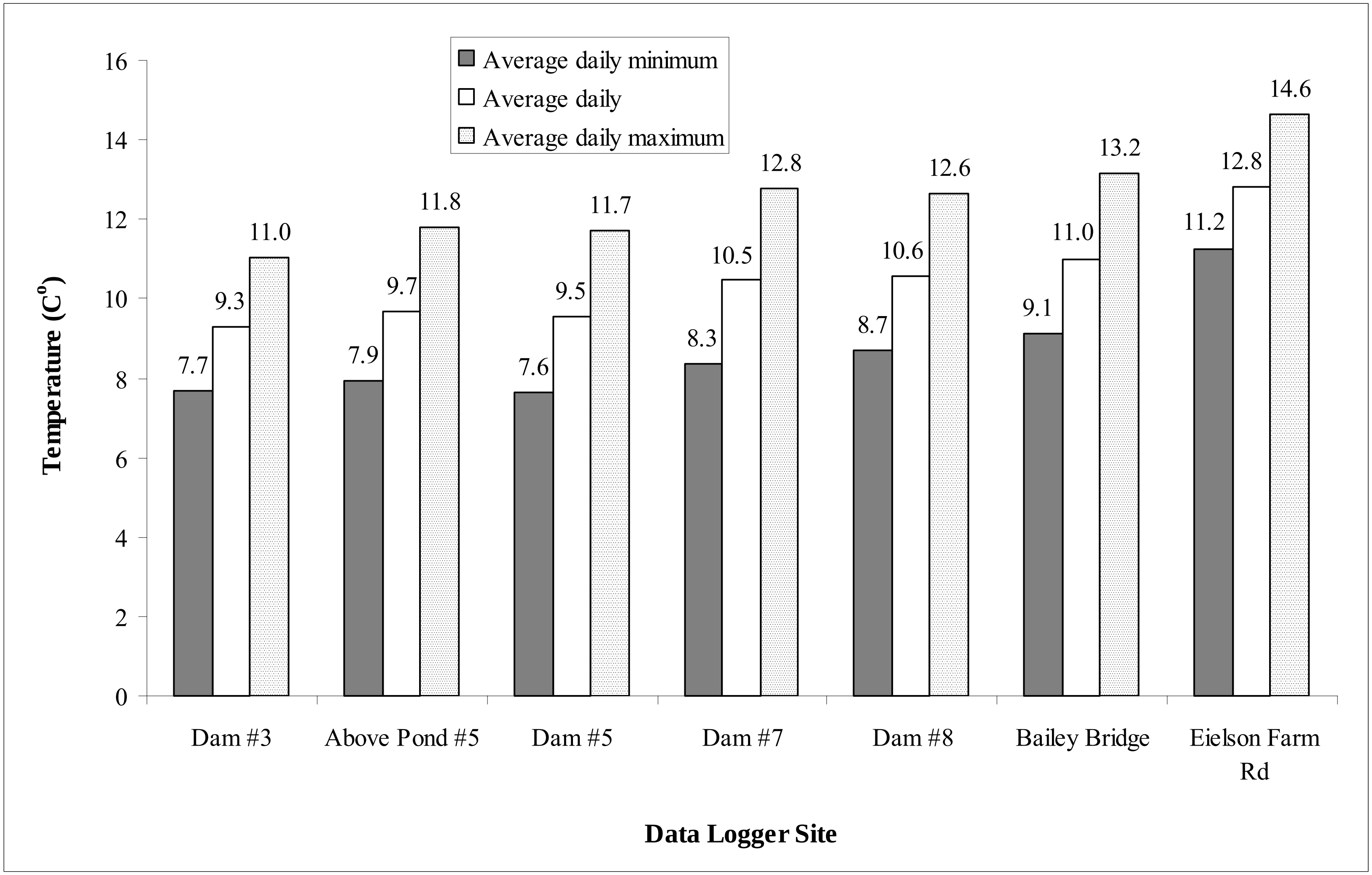

Figure 4.-Average, average daily maximum, and average daily minimum water temperatures in Piledriver Slough, 10 June to 10 August, 2001.

section of Piledriver Slough between Stringer Road and Bailey Bridge. In 1990, there was an estimated 516 Arctic grayling ≥150 mm FL in a 3-km reach of Piledriver Slough upstream of Stringer Road and 570 fish between Stringer Road and Bailey Bridge (Fleming 1991). By 1994, dams #3 and #6 had been constructed and Arctic grayling were captured above dam #6, however the number captured was insufficient to attain an estimate of abundance upstream of dam #6 (Fleming 1994).

By 1998, eight beaver dams had been constructed within the study area and we found incrementally fewer Arctic grayling moving upstream from the lowermost dam. Below dam #8 what was thought to be normal densities of adult and age-0 Arctic grayling were found, between dams #6 and #8 a lesser number of fish were found, between dams #3 and #6 only two adult Arctic grayling were captured and one school of age-0 fish was observed, and above dam #3 we did not capture or observe any Arctic grayling. In 1999, after pulling dams #6 and #8, the distribution pattern observed in 1998 appeared to have expanded upstream to the lowermost unbreached dam, dam #5. In 1999, there was what was thought a normal dispersal or distribution of fish below dam #5, there was an increased number of fish between dams #3 and #5, and no fish were captured nor seen above dam #3. Again in the summer of 2000, the distribution of Arctic grayling had expanded upstream after pulling dam #5 the previous fall, and by 2001, Arctic grayling were dispersed throughout the study area between Stringer Road and dam #8. The most convincing observation that beaver dams restricted fish passage was the change in the relative abundance and distribution of Arctic grayling in a 400-m section between dams #4 and #5. In 1999, no age-0 or adult fish were observed in this section, but 95 adult Arctic grayling were counted and hundreds of age-0 fish were seen in 2000. While walking through the littoral vegetation of this same section, hundreds of age-0 Arctic grayling scattered out from underfoot.

There is little evidence that documents positive responses in salmonid production from the control of beavers (Dubois and Schramm 1993). The benefits to salmonids derived from beavers are generally associated with the additions of pool or lentic habitat in high gradient streams where little or none existed before, stream flow stabilization, and increased water temperatures in areas where water temperatures are characteristically too cold to support adequate salmonid production (Leidholt-Bruner et al. 1992 and Hammerson 1994). However, these benefits are contingent upon access to the impoundments, which can occur only during periods of high flow. Piledriver Slough is not typical of most Interior Alaska streams that exhibit periods of high flow each spring from melting snow and during fall rains. Rather, the discharge in Piledriver Slough remains very stable because it is a groundwater fed system, and the catchment has very little gradient and is too small to generate enough discharge to raise water levels high enough to create temporary fish passage over the tops or around the beaver dams.

Because fish passage was restricted, the beaver dams in Piledriver Slough excluded Arctic grayling from using potential spawning, rearing, and feeding habitat. Of all the Arctic grayling captured or observed within the study section, no fish were captured or seen in the large ponded areas above dams. Instead, adult Arctic grayling tended to occupy riffles and glides or resided in pools immediately below riffles. Flooding of riffle areas above the dams removed these areas of preferred habitat used for feeding and spawning. Adult Arctic grayling were shown to preferentially spawn over pea-sized gravel associated with riffle areas (Armstrong 1986), but age-0 fish prefer to feed within the channel over exposed substrates (Lucko 1992).

Several other fish species inhabit Piledriver Slough including three whitefish *Coregonus* spp., burbot *Lota lota*, slimy sculpin *Cottus cognatus*, longnose suckers *Catostomus catostomus*, adult and juvenile chum salmon *Oncorhynchus keta*, juvenile coho salmon *O. kisutch*, and others. Although there was no directed effort to assess these species, observations made prior to and after dam breaching suggests that the beaver dams did affect their distributions as well. Prior to any dam breaching, the only fish species found upstream of a beaver dam in any year of the study were slimy sculpin and rainbow trout *Oncorhynchus mykiss* rainbow trout, which were stocked annually at Stringer Road. We are confident in this assessment because the clear water clarity allows fish to be easily seen. After dam breaching we did observe adult chum salmon carcasses near dam #5 in the fall of 2000, and in 2001 we observed schools of juvenile suckers along the stream margins downstream of dam #3. The degree to which all fish species in Piledriver Slough aside from Arctic grayling were affected could not be evaluated.

Influence of beaver dams on water temperatures in Piledriver Slough was not detected. In all years of this study, only slight increases in average daily water temperatures were observed above and below a beaver dam impoundment prior to and after dam breaching. In 2001, Piledriver Slough warmed only 3.5 C^o between Dam #3 and Eielson Farm Road, compared to approximately 3.0 C^o in 1996 when dams were active. The negligible influence of the beaver dams on water temperatures is attributed to the sloughs characteristics: 1) the continual inputs of ground water along the length of the slough which buffers any warming; and, 2) even without the impoundments, Piledriver Slough consists a series of long pools only intermittently broken by riffles and has slow flow. Inputs of cool groundwater and vegetative shading can make it difficult to generalize the effects of beaver impoundments on water temperatures (McRae and Edwards 1994).

Beaver dams did appear to affect rates of heating and cooling by reducing the diel temperature fluctuations immediately below an impoundment. Unimpounded sections experienced greater rates of heating and cooling (higher temperatures during midday and cooler at night) than did the outlet of an impoundment. Since thermal tolerance levels for Arctic grayling range from 20 – 24 C^o (LaPerriere and Carlson 1973) the effects of water temperature changes caused by beaver dams is probably not a concern for Arctic grayling in Piledriver Slough. During 1996 and from 1998 – 2001 water temperatures in Piledriver Slough exceeding 20 C^o were measured at only one station for 4 days. In general, rarely and only in the lower section of Piledriver Slough do water temperatures exceed 16 C^o.

During deployment of the temperature loggers a pronounced lack of Arctic grayling was observed between Stringer Road and Bailey Bridge in 2000 and again in 2001. Typically, one can observe numerous fish in this stretch of the slough in mid May and mid July (Fleming 1997, Wuttig 1997; Wuttig 2000). However, on 2 June 2000 and 3 June 2001, no Arctic grayling were seen in this stretch of water. This observation was consistent with similar reports of no fish from anglers who regularly fish this section of Piledriver Slough in late spring. In both years, some anglers reported not seeing or catching any Arctic grayling from the later part of May until early June. Reports of fishing were good before and after this period. Life histories of Arctic grayling are dynamic and reasons to why there were no Arctic grayling observed in Piledriver Slough during this period are not known. This information should be considered for planning any future field activities, and it is recommended that the study area be reexamined in early June 2002 to determine if Arctic grayling are again absent between Stringer Road and Bailey Bridge.

Whether or not the removal of beaver dams will translate into additional production of Arctic grayling has yet to be determined. Arctic grayling observed utilizating the reclaimed habitat (riffles and runs), which was previously excluded by the beaver dams, however, suggests a strong potential for increased production. With the breaching of all beaver dams (#1 - #8), approximately 9 km of habitat was "reclaimed" and represents a substantial portion of the habitat available to Arctic grayling prior to 1991. Beaver dams above Stringer Road have been reported by local residents but have not been investigated. Upstream of Stringer Road flows are minimal and would likely offer only limited habitat for Arctic grayling.

To determine if the abundance of Arctic grayling has increased in Piledriver Slough, a stock assessment project in the spring of 2005 is recommended. This would allow sufficient time for at least one cohort of Arctic grayling to have fully utilized the additional 9 km of habitat and to have fully recruited into the sampling gear. Between 2002 and 2005 continued monitoring of beaver activity, active beaver management by aggressive trapping, and maintaining dam breaches would be required and is recommended.

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APPENDIX A

Appendix A1.-Piledriver Slough beaver dam and pond dimensions, July 1998.

Dam #	Width (m)	Max height (m)	Water level differential[b] (m)	Length of pond (km)
1[a]	15.2	0.46	0.00	-
2	68.6	1.13	0.21	0.92
3	55.5	1.58	1.22	0.33
4	29.0	0.52	0.15	0.13
5	105.2	1.37	0.52	1.37
6	69.5	1.52	1.19	0.78
7[a]	44.5	0.94	0.00	-
8	168.2	1.65	1.16	0.48

[a] Beaver dam has been breached.

[b] Difference in height of water levels above and below dam.