Fisheries Investigations on the Kandik, Charley, Nation, and Tatonduk Rivers, Yukon-Charley Rivers National Preserve, 1987 and 1988

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ABSTRACT

During the summer and fall of 1987 and 1988, baseline fisheries investigations were conducted on the Kandik, Charley, Nation, and Tatonduk rivers within the Yukon-Charley Rivers National Preserve to describe 1) distribution, relative abundance, population characteristics, and habitat use for anadromous and resident fish species; 2) spawning areas and run timing of chinook *Oncorhynchus tshawytscha*, coho *O. kisutch*, and chum salmon *O. keta*; and, 3) aquatic macroinvertebrate density, biomass, diversity, and composition. At selected sites, fish and macroinvertebrates were collected and physical and chemical parameters were measured. Fish sampling methods included gill netting, minnow trapping, beach seining, electrofishing, and angling.

Fifteen fish species were found in the four study drainages. Chinook salmon were captured in all four streams. Spawning habitat appeared abundant, though few adults were captured. Spawning chum salmon were captured in the Tatonduk River on August 19, 1988. Resident fish species appeared scarce throughout the four rivers. The most common residents found in upstream sites were Arctic grayling *Thymallus arcticus*, slimy sculpin *Cottus cognatus*, round whitefish *Prosopium cylindraceum*, burbot *Lota lota*, and longnose suckers *Catostomus catostomus*. Resident Dolly Varden char *Salvelinus malma* occurred in small numbers on the Nation River. Areas at or near the confluence with the Yukon River had the greatest fish species diversity. Experimental gill nets were most effective in capturing post-yearling Arctic grayling and beach seining captured the most young-of-the-year species.

Growth (length-at-age) of Arctic grayling appears faster than for most interior Alaskan stocks. The Nation and Tatonduk rivers had the highest water quality values and aquatic macroinvertebrate density and biomass measurements.

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INTRODUCTION

The National Park Service (Park Service) is mandated by Section 201 of the Alaska National Interest Lands Conservation Act (ANILCA) to "maintain the environmental integrity of the entire Charley River basin, including streams, lakes, and other natural features in its undeveloped natural condition for public benefit and scientific study; [and] to protect habitat for, and populations of, fish and wildlife." An accurate and comprehensive database is needed by Park Service managers to effectively assess the impacts to fish, wildlife, and their habitats from potential resource development; e.g., asbestos, coal, and tungsten mining and oil and gas exploration on state and Native corporation lands adjacent to preserve boundaries. To fulfill this requirement, the Park Service signed an Interagency Agreement with the U.S. Fish and Wildlife Service (Service) to conduct baseline aquatic studies on the principal streams of the Yukon-Charley Rivers National Preserve.

Preliminary fishery investigations have been conducted on portions of the Kandik, Charley, Nation, and Tatonduk rivers in the Yukon-Charley Rivers National Preserve (Alt 1965, 1969, 1971, 1979; O'Brien and Huggins 1975; Tepley 1981; Barton 1984; Welp *in preparation*). Seventeen fish species have been reported to use the preserve (Table 1). Arctic grayling and round whitefish have been found throughout all four study drainages (Alt 1971; O'Brien and Huggins 1975; Tepley 1981; and Welp *in preparation*). Small numbers of spawning adult chinook salmon (< 10 fish) have been documented in the Charley, Kandik, and Nation rivers (Welp *in preparation*; Barton, Alaska Department of Fish and Game, Fairbanks, personal communication). No chum salmon were captured by previous fisheries investigators, although interviews with local residents indicate that chum salmon do enter rivers inside the preserve (Barton 1984). The size of these runs is not known, but appear to be very small. Alt (1965, 1969, 1971, 1979) reported inconnu (sheefish) using the mouths of upper Yukon River tributaries for rearing and feeding. Adult northern pike have been captured on the Kandik River (Tepley 1981).

This study was undertaken on the Kandik, Charley, Nation, and Tatonduk rivers to address the following objectives: (1) describe distribution, relative abundance, population characteristics, and habitat use for anadromous and resident fish species; (2) identify spawning areas and run timing of chinook, coho, and chum salmon; and (3) determine aquatic macroinvertebrate density, biomass, diversity, and species composition.

STUDY AREA

As a result of ANILCA, 2.5 million acres were set aside as the Yukon-Charley Rivers National Preserve. The Kandik, Nation, and Tatonduk rivers begin in the Ogilvie Mountains of Northwest Territories, Canada and flow southwest into the Yukon River (Figure 1). The Charley River is a federally designated national wild river entirely within the preserve, originating in the Yukon-Tanana Uplands and flowing northeast into the Yukon River.

The Kandik River is 132 km long and drains approximately 3,108 km^2 (Stern 1978). The upper portion, above Johnson Gorge, consists mainly of cobble type substrate with occasional cliffs along the river. The river is a single channel with intermittent pools throughout. Johnson Gorge is unique, with boulders and large cobble substrate comprising the majority of substrate types. Cliffs on both sides of the river form the gorge, which runs approximately 13 km. Below Johnson Gorge, gravel comprises the

Table 1. List of fish species reported from the Yukon-Charley Rivers National Preserve.

Common name	Scientific name
LAMPREYS	PETROMYZONTIDAE
Arctic lamprey	*Lampetra japonica*
TROUTS AND SALMONS	SALMONINAE
Coho salmon	*Oncorhynchus kisutch*
Chinook salmon	*Oncorhynchus tshawytscha*
Chum salmon	*Oncorhynchus keta*
Dolly Varden	*Salvelinus malma*
GRAYLING	THYMALLINAE
Arctic grayling	*Thymallus arcticus*
WHITEFISHES	COREGONINAE
Broad whitefish	*Coregonus nasus*
Humpback whitefish	*Coregonus pidschian*
Least cisco	*Coregonus sardinella*
Round whitefish	*Prosopium cylindraceum*
Inconnu (sheefish)	*Stenodus leucichthys*
PIKES	ESOCIDAE
Northern pike	*Esox lucius*
MINNOWS	CYPRINIDAE
Lake chub	*Couesius plumbeus*
SUCKERS	CATOSTOMIDAE
Longnose sucker	*Catostomus catostomus*
TROUT-PERCHES	PERCOPSIDAE
Trout-perch	*Percopsis omiscomaycus*
CODFISHES	GADIDAE
Burbot	*Lota lota*
SCULPINS	COTTIDAE
Slimy sculpin	*Cottus cognatus*

Sources: McPhail and Lindsey 1970; Scott and Crossman 1973; Morrow 1980

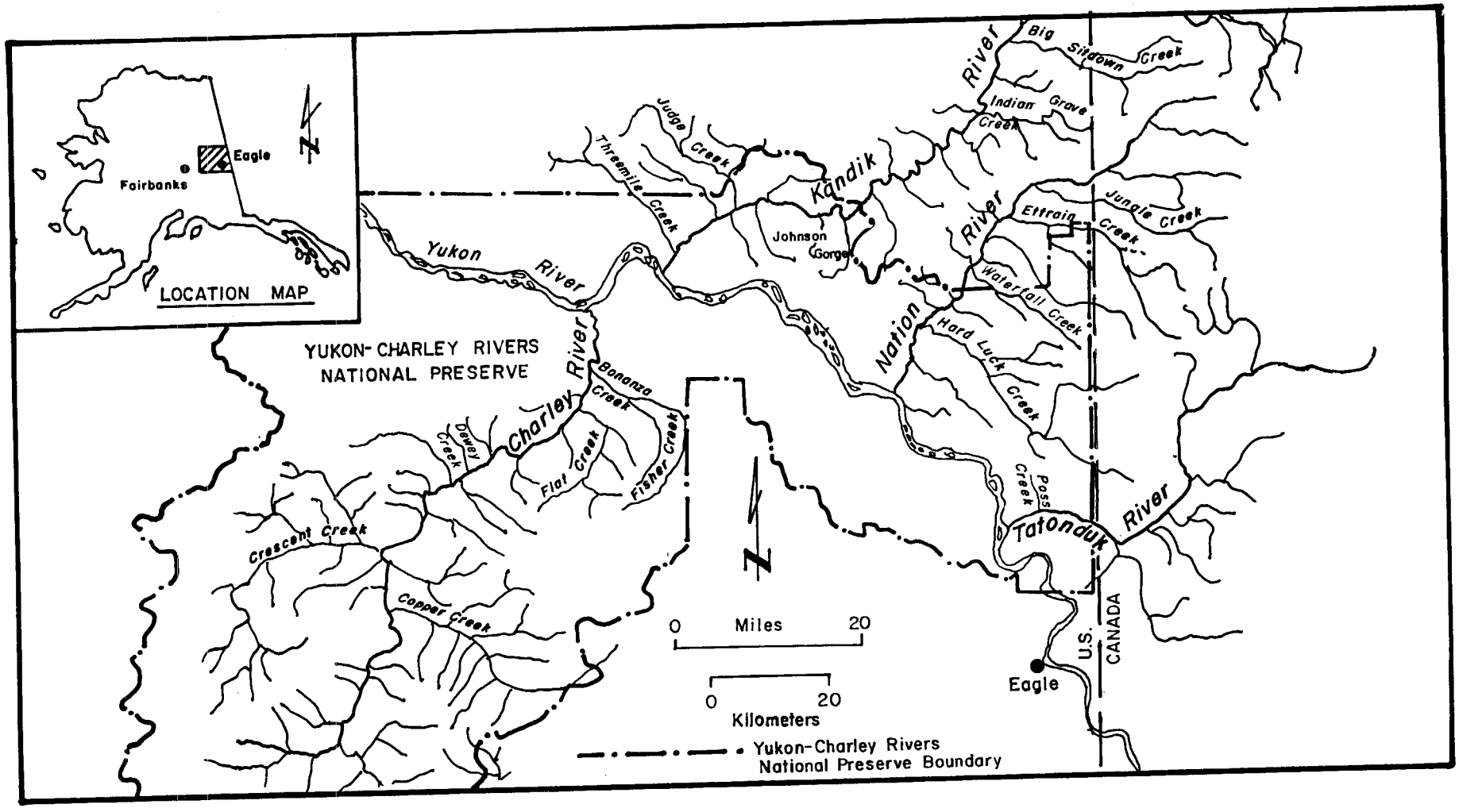

Figure 1. Major tributaries of the Yukon River within the Yukon-Charley Rivers National Preserve.

majority of the substrate with pools common within the river channel and overhanging trees (sweepers) lying along its meanders. The river is divided in numerous side channels near the mouth. The Kandik River is clear and fed mainly by groundwater and runoff.

The Charley River is 171 km long and encompasses a watershed of roughly 4,403 km^2 (U.S. Department of the Interior 1985). The Charley River can be divided into three major reaches. The upper section, from the headwaters to Crescent Creek, is shallow with occasional braiding of the river channel. Large boulder fields exist in this reach. The middle reach, from Crescent Creek to Dewey Creek, becomes a single fairly uniform channel. Boulder fields become interspersed with deep pool areas. The lower reach, below Dewey Creek, meanders, with the main channel becoming deeper and wider. Pools are common throughout and the substrate decreases in size to mostly gravel and sand. The water in the river runs clear throughout its course to Bonanza Creek, where the mainstem water becomes heavily tannic stained from peat type soils.

The Nation River flows 80 km and drains approximately 2,331 km^2 (Stern 1978). The river consists of a meandering single channel for the majority of its length. Logjams are common throughout and have altered the river's course, leaving large expanses of exposed gravel. Beaver dams and lodges are common along the mainstem and tributary streams. Pool areas are scarce with the majority occurring below Hard Luck Creek. The mainstem substrate is mainly gravel and small cobble with areas of bedrock appearing between Waterfall and Hard Luck creeks. The river runs clear until Waterfall Creek, where leaching from numerous bog areas causes tannic staining.

The Tatonduk River is 97 km long and drains roughly 3,497 km^2 (Orth 1967). Above Pass Creek, the mainstem consists mainly of a single channel with numerous rapids flowing between steep cliffs. Many deep pools occur within this area. Below Pass Creek, the mainstem splits into numerous side channels with logjams commonplace. The predominant substrate types are gravel and small cobble. The water runs clear except during periods of localized precipitation, when the water quickly becomes turbid. Two perennial water supplies occur in the lower river.

METHODS

Fish Sampling

Mainstem and tributary areas of the Kandik, Charley, Nation, and Tatonduk rivers were sampled during 1987 and 1988 (Table 2). Two sampling periods were planned for each river, mid-summer and fall. Mid-summer surveys were designed to coincide with projected chinook salmon spawning runs. All rivers were surveyed during the mid-summer period. Flooding of the Tatonduk River in early August, 1988 resulted in sampling dates delayed, survey areas shortened, and tributaries not sampled. The fall sampling period corresponded with projected chum salmon spawning runs. The Kandik and Nation river sites were sampled during the fall period.

Access into the survey areas was by fixed-wing aircraft. On-site surveys were conducted on foot or in inflatable rafts. On September 20 and 24, 1988, aerial surveys of the Nation and Tatonduk rivers, respectively, were conducted with a fixed-wing aircraft (Super-cub), flying 100 km/h at 91 m above ground level, to estimate relative spawning densities of chum salmon.

Table 2.—Number of mainstem (MS) and tributary (TR) sampling sites for fish, chemical and physical parameters, and macroinvertebrates, Yukon-Charley Rivers National Preserve, 1987 and 1988.

River (sampling period)	Number of sites						
	Fish		Chemical		Physical		Macroinvertebrates
	MS	TR	MS	TR	MS	TR	MS
Kandik River							
(07/29 to 08/08/87)	6	3	6	7	6	7	6
(09/10 to 09/16/87)	5		8	7			5
Charley River							
(08/09 to 08/20/87)	5	1	5	5	5	5	5
Nation River							
(07/19 to 08/05/88)	5	2	6	3	6	3	5
(09/09 to 09/22/88)	1		1		1		
Tatonduk River							
(08/17 to 08/23/88)	3		2		3		5

During both years, fish were collected with the following gear types: 12.2 x 2.4 m monofilament experimental gill nets consisting of four-3.0 m panels of 1.3, 2.5, 3.8, and 5.0 cm bar mesh; baited minnow traps (40.6 x 20.3 cm with 0.6 cm bar mesh); 9.0 x 1.2 m beach seine with 0.16 cm ace mesh; and hook and line. Minnow traps were baited with salmon roe and crackers. In 1987, a Type 15-A Smith-Root backpack electrofisher was also used. In 1988, three gear types were added: 30.5 x 3.7 m multifilament gill nets with 10.4 cm bar mesh; 30.5 x 3.0 m multifilament gill nets with 7.4 cm bar mesh; and a dip net with 0.16 cm ace mesh. The backpack electrofisher was not used during the 1988 field season due to space limitations.

Gill nets were checked at 12 hour intervals and minnow traps were checked and rebaited every 24 hours. Except for adult salmon, fish fork length was measured to the nearest millimeter. Adult salmon were measured from mid-eye to the fork in the caudal fin. Weights of fish were determined using 0.1, 0.25, 0.5, 2.5, 5.0, 10.0, and 20.0 kg spring scales. A systematic sample of young-of-the-year salmon was taken for species identification using techniques described in Trautman (1973).

Fish Distribution and Abundance

Fish distribution is presented as a synthesis of all available data, including our results as well as previous fisheries investigations (see Appendix 1 for specific sample site reference list). Combining all known information gives a better representation of the spatial distribution of fish species throughout each drainage. Species were classified as young-of-the-year or post-yearling since state of maturity and sex were not consistently reported by all investigators.

Relative abundance of each species (1987 and 1988 field seasons only) was determined using catch-per-unit-effort (CPUE) data from specific gear types, including: experimental and multifilament gill nets; minnow traps; beach seine; and electrofisher. Dipnet, angling, and visual observation data were not included in abundance calculations.

Length-at-age Relationships

Scale samples (a minimum of six scales per fish) from Arctic grayling, round whitefish, chinook salmon, and longnose sucker were collected from the left side of the fish, between the lateral line and the posterior insertion of the dorsal fin. Four vertebrae from each chum salmon carcass were removed for age determination. Scale samples were pressed on 0.05 cm triacetate slides (1,055 kg/cm^2 for 30 seconds at 65°C) and read with a microfiche reader in the laboratory. All scale and vertebrae samples were independently read twice by the author. A third reading was made of the samples in which ages disagreed and a final age was assigned based on majority agreement. Samples that were unreadable were discarded. Salmon ages were reported using the European method described by Foerster (1968). Other fish species ages were reported using age-group definitions defined in Ricker (1975).

Weight-length Relationships

The geometric mean functional regression technique (Ricker 1975) was used to estimate weight-length relationships for Arctic grayling using the growth model:

$$W = aL^b$$

where a and b are constants derived from regressing the logarithms (base 10) of fish weight (W) and fork length (L).

Chemical Parameters

Mainstem and tributary sites were sampled for pH, total hardness (mg/L $CaCO_3$), and total alkalinity (mg/L $CaCO_3$) using a Hach Water Ecology Test Kit, Model AL-36E in 1987. The Hach Combination Test Kit, Model AL-36DT with digital titrator, and Portable Hach One pH Meter, Model 43800-00, were used during the 1988 field season to improve accuracy. Conductivity (uS/cm) was measured using a Hach Mini-Conductivity Meter. Water temperature (°C) was determined using a mercury-filled thermometer. Average values for all chemical parameters were calculated from three replicate samples per site.

Physical Parameters

Stream gradient was determined from United States Geological Survey (Survey) 1:63,360 scale topographic maps (Orth 1983). Stream order was assigned using Strahler's method (1957). Percentages of pool, riffle, and run, and predominant substrate types were determined by on-site observation of a 100 m stream section at each site. Pools were defined as slow moving water without surface turbulence; riffles as areas of turbulent water; and runs as smoothly moving water without surface turbulence. Substrate was classified according to Platts et al. (1983).

Water depth was measured to the nearest 3 cm with a standard wading rod. Velocity was measured with a Marsh-McBirney, Model 201, current meter at 0.6 of the water column depth, for depths less than 75 cm, and at 0.2 and 0.8 of the water column depth, for depths greater than 75 cm. Discharge was calculated for each station using the Survey's midsection method (Orth 1983). River stage, at the time of discharge measurement, was determined for Nation River sites. River stage was defined as the elevation difference between water surface and bankfull level.

Aquatic Macroinvertebrates

Aquatic macroinvertebrates were collected at mainstem sample sites. Three samples per site were collected from riffle areas with a 0.1 m^2 Hess Benthos Sampler (500 micron mesh size) and preserved in a 10% formalin solution. Each sample was sorted and macroinvertebrates were identified to genus, where possible. Data from the two sampling periods on the Kandik River were combined for final analysis.

Macroinvertebrate density is presented as numbers/0.1 m^2. Invertebrate biomass (ash-free dry weight) was determined for each sample. The invertebrates were placed in pre-ignited and weighed aluminum pans which were then dried at 50°C until constant weight was achieved (usually 24 hours) and weighed. Samples were then ignited in a muffle furnace at 500°C for one hour and again weighed. Ash-free dry weight was determined as the difference between dry weight and the weight of the ash. The Sequential Comparison Index (Cairns et al. 1968; Cairns and Dickson 1971) was used to calculate a diversity index for each sample. Five repetitions of the index were calculated for each sample and averaged.

Invertebrates were assigned functional group designations according to Cummins and Merritt (1984). Functional groups (collector-gatherers, collector-filterers, predators, scrapers, and shredders) are classifications based on feeding ecology and can give an insight into the invertebrate community structure at different sample sites.

RESULTS

Fish Distribution

Kandik River

Of the 14 fish species documented in the Kandik River, Arctic grayling had the widest distribution, being found at 12 of 15 sites, with both young-of-the-year and post-yearling fish present (Table 3; Figure 2). The greatest diversity occurred at the mouth (site 12) with all 14 species present, including many young-of-the-year fish. Young-of-the-year chinook salmon, Arctic grayling, and burbot were captured below Johnson Gorge indicating that these species use the lower Kandik River and possibly some of its tributaries for spawning and rearing.

During the two 1987 Kandik River sampling periods, Arctic grayling, longnose sucker, chinook salmon, burbot, slimy sculpin, and least cisco were captured (Table 3; Figure 2). Young-of-the-year chinook salmon were found at sites 8 and 10. No chum or coho salmon were observed. Arctic grayling and slimy sculpin were found at two of the three tributaries sampled (sites F and G).

Previous studies in the Kandik River (Alt 1969, 1971, 1979; Tepley 1981; Barton 1984; Barton, Alaska Department of Fish and Game, Fairbanks, personal communication) have documented 14 of the 17 fish species reported by McPhail and Lindsey (1970), Scott and Crossman (1973), and Morrow (1980) to use the preserve area (Table 3; Figure 2); coho salmon, Dolly Varden, and broad whitefish were not found. During an aerial survey conducted August 19, 1985, Barton identified one chinook salmon carcass at river kilometer 32 (site 7; Barton, Alaska Department of Fish and Game, Fairbanks, personal communication). No coho or adult chum salmon were documented, though reports from local residents suggest that the Kandik River supports a small population of chum salmon (Barton 1984). Adult northern pike were captured from river kilometer 43 (site 5) to the mouth (Alt 1971; Tepley 1981).

Table 3.—Distribution of young-of-the-year (Y,y) and post-yearling (A,a) fish species in the Kandik River. Uppercase letters denote information gathered from this study in 1987, whereas lowercase letters represent data from other sources[a].

Species	Mainstem sites												Tributary sites		
	1	2	3	4	5	6	7	8	9	10	11	12	C	F	G
Chinook salmon							a	Y		Y		y			
Chum salmon												y			
Arctic grayling	a	A		A	Aa	A	yAa	A	YA		a	y		A	Y
Round whitefish	a											y			
Humpback whitefish											a	y			
Least cisco								A			a	ya			
Inconnu												ya			
Longnose sucker				A	Aa	A	Aa	A			a	ya			
Slimy sculpin			A		YA		Aa		A			a		A	A
Northern pike					a		a				a	ya			
Burbot							y	Y				y			
Lake chub												a			
Arctic lamprey												a			
Trout-perch												y			

[a]Alt 1965, 1971, 1979; Tepley 1981; Barton 1984; Barton, ADF&G, Fairbanks, personal communication (Appendix 1).

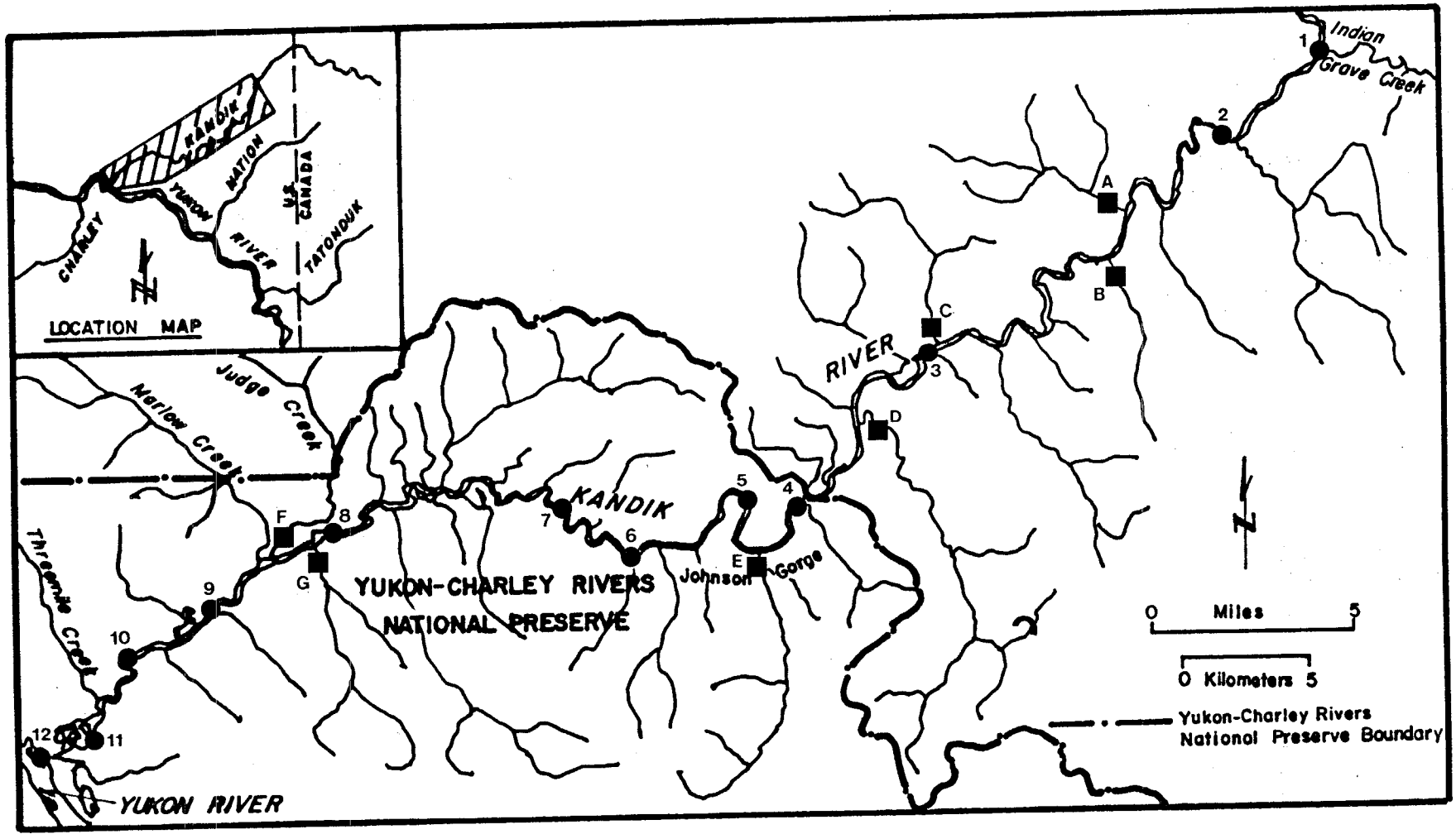

Figure 2. Mainstem (●) and tributary (■) sampling site locations on the Kandik River, Yukon-Charley Rivers National Preserve. Site locations are from this study along with previous fisheries investigations.

Charley River

Adult chinook salmon had the widest distribution of the 12 species found in the Charley River (Table 4; Figure 3). Site 10 (river kilometer 3) showed the greatest diversity with nine species present. Arctic grayling were found in the upper and middle reaches, while longnose suckers occurred in the middle and lower river. Spawning and rearing habitats for chinook salmon and grayling were abundant throughout the study area.

During the August 9-20, 1987 sampling period, Arctic grayling, longnose sucker, chinook salmon, and slimy sculpin were captured on the Charley River (Table 4; Figure 3). One adult chinook salmon was observed at site 1 on August 10. No chum or coho salmon were found. Tributary site C contained slimy sculpin.

Past studies (Alt 1965, 1969, 1971; O'Brien and Huggins 1975; Welp *in preparation*; Barton 1984; Barton, Alaska Department of Fish and Game, Fairbanks, personal communication) have documented 12 fish species in the Charley River (Table 4; Figure 3). Welp (*in preparation*) captured 323 young-of-the-year burbot at site 10. Adult chinook salmon were observed moving up the Charley River on August 8-19, 1985 and 1986 (Welp *in preparation*; Barton, Alaska Department of Fish and Game, Fairbanks, personal communication). Six chinook salmon carcasses were found by Welp (*in preparation*) at site 10 and one young-of-the-year site 7. On September 20, 1974, four chum salmon carcasses were observed at the mouth (Barton 1984).

Nation River

Of the 11 fish species documented on the Nation River, Arctic grayling had the widest distribution, being found at all 13 sample sites (Table 5; Figure 4). Adult slimy sculpin and young-of-the-year chinook salmon were captured at 12 sites. The mouth (site 11) showed the greatest diversity with nine species present. Chinook salmon, grayling, round whitefish, slimy sculpin, and burbot spawn and rear throughout the drainage.

During the two 1988 Nation River sampling periods, 11 fish species were captured (Table 5; Figure 4). The first recorded captures of resident adult Dolly Varden char were found at sites 2. One male chinook salmon was captured at site 7 on July 31 and one male and one spent female chinook salmon carcass were located at sites 7 and 8, respectively, on September 15. Two ripe chum salmon were captured at the mouth on August 3. No chum salmon were caught during the September 9-22 sampling period at site 8 and none were observed during the September 20 aerial survey (Figure 4). Tributary sites B and C contained slimy sculpin and young-of-the-year chinook salmon and Arctic grayling. One immature round whitefish was captured at site B.

Previous studies (Alt 1965, 1969, 1979; Welp *in preparation*; Barton 1984; Barton, Alaska Department of Fish and Game, Fairbanks, personal communication) have documented eight species in the Nation River (Table 5; Figure 4). Welp (*in preparation*) captured 166 young-of-the-year Arctic grayling and 44 young-of-the-year round whitefish at the mouth (site 11). Five chinook salmon carcasses were observed downstream of site 4, during an aerial survey conducted on August 19, 1985 (Barton, Alaska Department of Fish and Game, Fairbanks, personal communication). No coho or chum salmon were observed, although reports from local residents suggest that the Nation River supports a small population of chum salmon (Barton 1984).

Table 4.—Distribution of young-of-the-year (Y,y) and post-yearling (A,a) fish species in the Charley River. Uppercase letters denote information gathered from this study in 1987, whereas lowercase letters represent data from other sources[a].

Species	Mainstem sites											Tributary site
	1	2	3	4	5	6	7	8	9	10	11	C
Chinook salmon	A				a		ya		a	a	a	
Chum salmon											a	
Arctic grayling	A	y		YA		A		y				
Round whitefish								y		y		
Humpback whitefish										ya		
Broad whitefish										y		
Inconnu											ya	
Longnose sucker			A	A				A		a		
Slimy sculpin				A						a		A
Northern pike										a		
Burbot										y	ya	
Lake chub										a		

[a]Alt 1965, 1969, 1971; O'Brien and Huggins 1975; Welp *in preparation*; Barton 1984; Barton, ADF&G, Fairbanks, personal communication (Appendix 1).

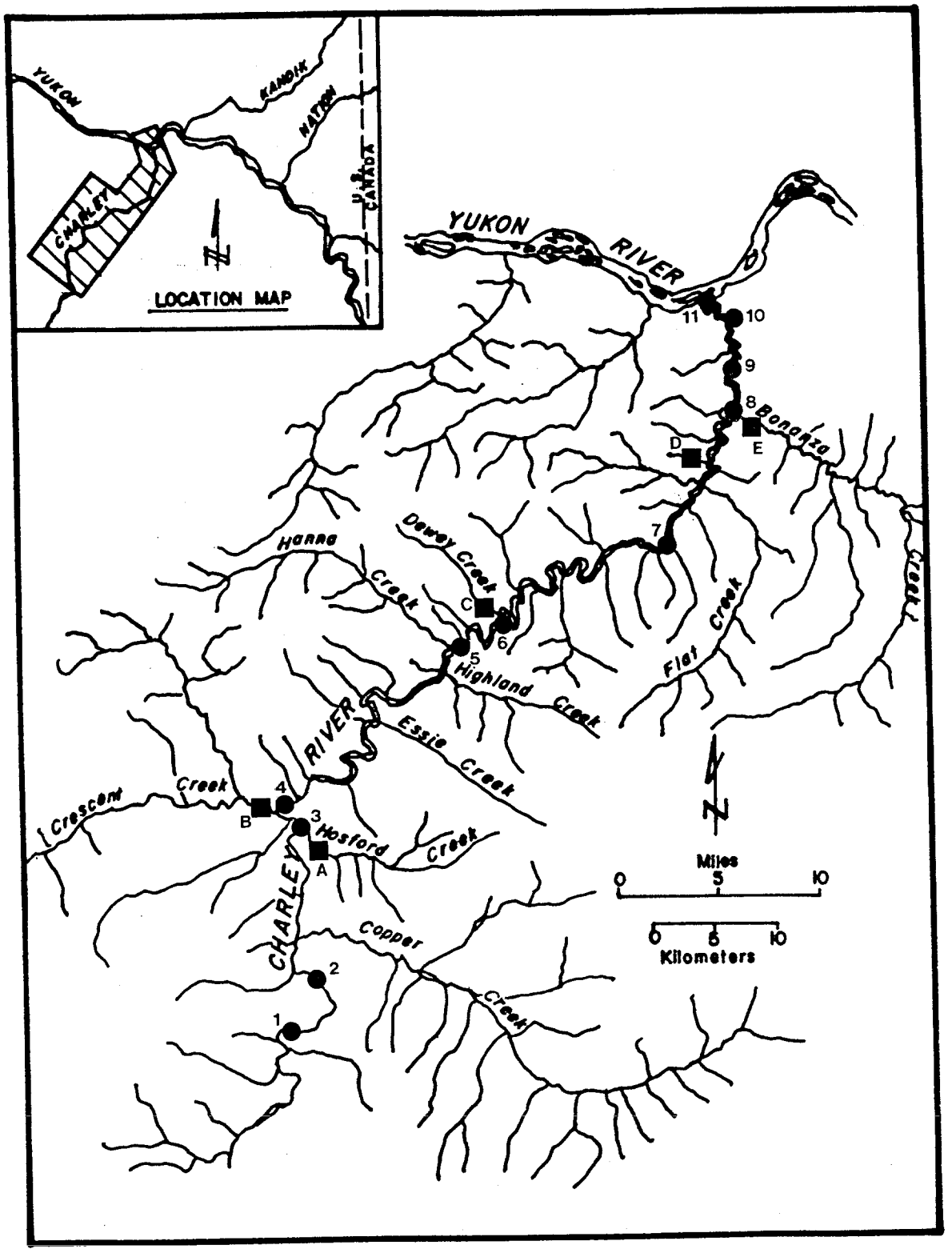

Figure 3. Mainstem (●) and tributary (■) sampling site locations on the Charley River, Yukon-Charley Rivers National Preserve. Site locations are from this study along with previous fisheries investigations.

Table 5.—Distribution of young-of-the-year (Y,y) and post-yearling (A,a) fish species in the Nation River. Uppercase letters denote information gathered from this study in 1988, whereas lowercase letters represent data from other sources[a].

Species	Mainstem sites											Tributary sites	
	1	2	3	4	5	6	7	8	9	10	11	B	C
Chinook salmon		Y	Y	ya	Yy	y	YA	YAa	y	y	y A	Y	Y
Chum salmon													
Arctic grayling	YA	YA	YA	y	yA	y	YyA	YyA	y	y	YyA	YA	YA
Round whitefish		A		y	yA		YyA	YA	y	y	Yy	Y	
Inconnu											yAa		
Longnose sucker	A	A					A	A			Aa		
Slimy sculpin	A	YA	A		YA	ya	YA	YA	a	a	YAa	YA	YA
Northern pike											A		
Burbot				y				YA					
Lake chub										a	A		
Dolly Varden char		A											

[a]Alt 1965, 1969, 1979; Welp *in preparation*; Barton 1984; Barton, ADF&G, Fairbanks, personal communication (Appendix 1).

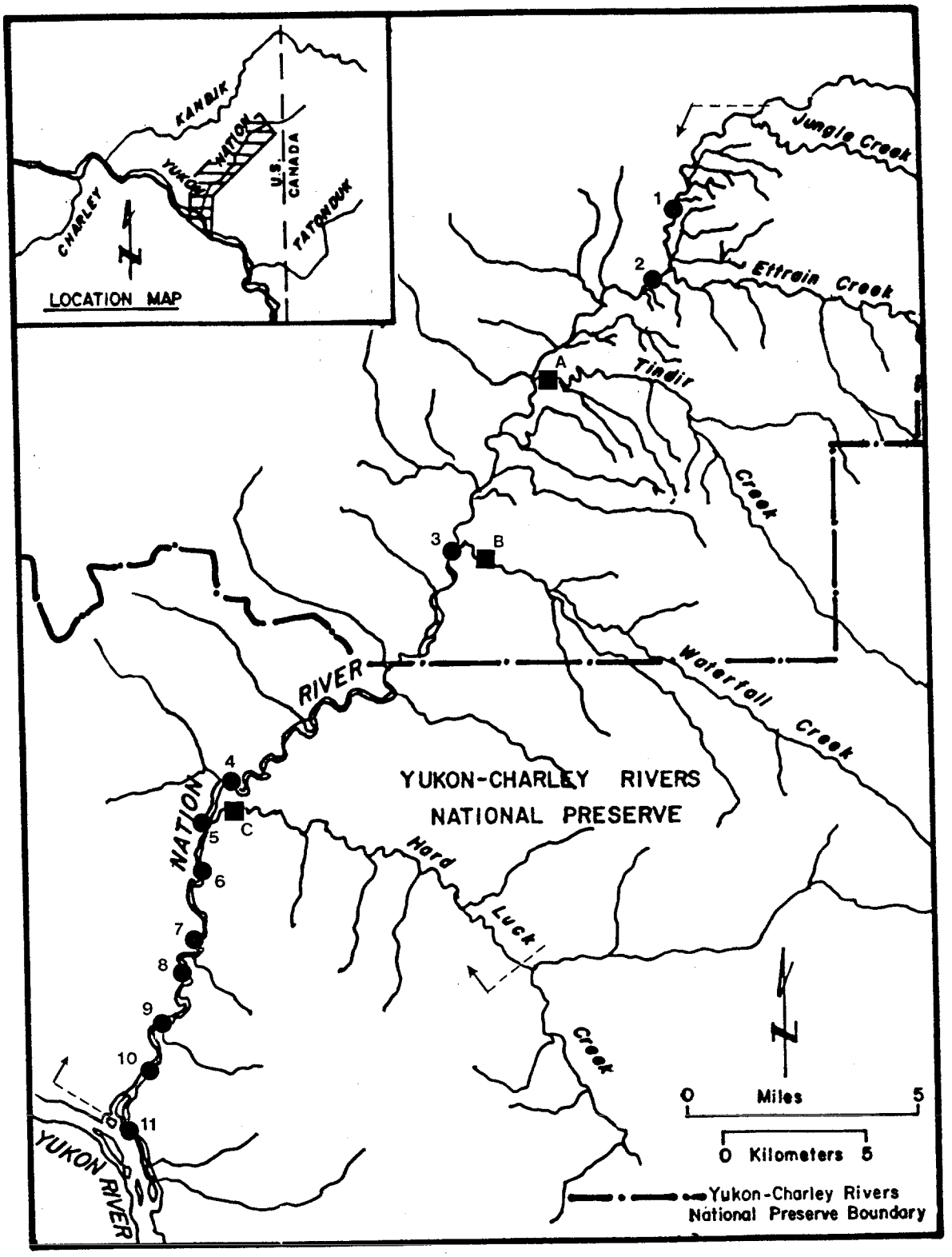

Figure 4. Mainstem (●) and tributary (■) sampling site locations and aerial survey boundaries (– – –) on the Nation River, Yukon-Charley Rivers National Preserve. Site locations are from this study along with previous fisheries investigations.

Tatonduk River

Of the eight fish species found in the Tatonduk River, longnose suckers had the widest distribution, being found at all five sites (Table 6; Figure 5). The mouth (site 5) showed the greatest diversity with seven species present. Slimy sculpin and young-of-the-year chinook salmon, Arctic grayling, and round whitefish were captured throughout the study area indicating the abundance of spawning and rearing habitats for these species. A small run of chum salmon also spawns in the system.

During the August 17-23, 1988 sampling period, six fish species were captured, including 112 young-of-the-year chinook salmon at site 2 (Table 6; Figure 5). Four adult chum salmon (first documentation) were captured at site 3 on August 19 in spent and spawning condition. No chum salmon were observed during the September 24, 1988 aerial survey (Figure 5).

Past studies (Alt 1965, 1969, 1979; Welp *in preparation*; Barton 1984) have documented seven species in the Tatonduk River (Table 6; Figure 5). Welp (*in preparation*) captured 143 young-of-the-year grayling at site 2. A few chinook salmon were observed moving upstream on August 1, 1985 (Calvin Fifield, Bureau of Land Management, Anchorage, personal communication).

Table 6. Distribution of young-of-the-year (Y,y) and post-yearling (A,a) fish species in the Tatonduk River. Uppercase letters denote information gathered from this study in 1988, whereas lowercase letters represent data from other sources[a].

	Mainstem sites				
Species	1	2	3	4	5
Chinook salmon		Y	Y	Yy	y
Chum salmon			A		
Arctic grayling		YA	YA	YyAa	y
Round whitefish		Y	A	Yy	y
Inconnu					ya
Longnose sucker	a	Y	A	A	a
Slimy sculpin		YA	YA	yAa	ya
Lake chub					a

[a]Alt 1965, 1969, 1979; Welp *in preparation*; Barton 1984 (Appendix 1).

Relative Abundance

Kandik River

Eighty fish were captured during the two sampling periods (Tables 7 and 8), including 35 slimy sculpin (44%) and 32 Arctic grayling (40%). A total of 169.5 gill net hours were spent during the July-August sample period with a combined CPUE of 0.09 fish/net hour. Of the two species captured, grayling had the highest total CPUE (0.06 fish/net hour). Grayling were most abundant at site 5. In September, 80.9 gill net hours resulted in a combined catch rate of 0.23 fish/net hour. Of the three species captured, grayling had the highest total CPUE (0.19 fish/net hour). Grayling were most abundant at site 8.

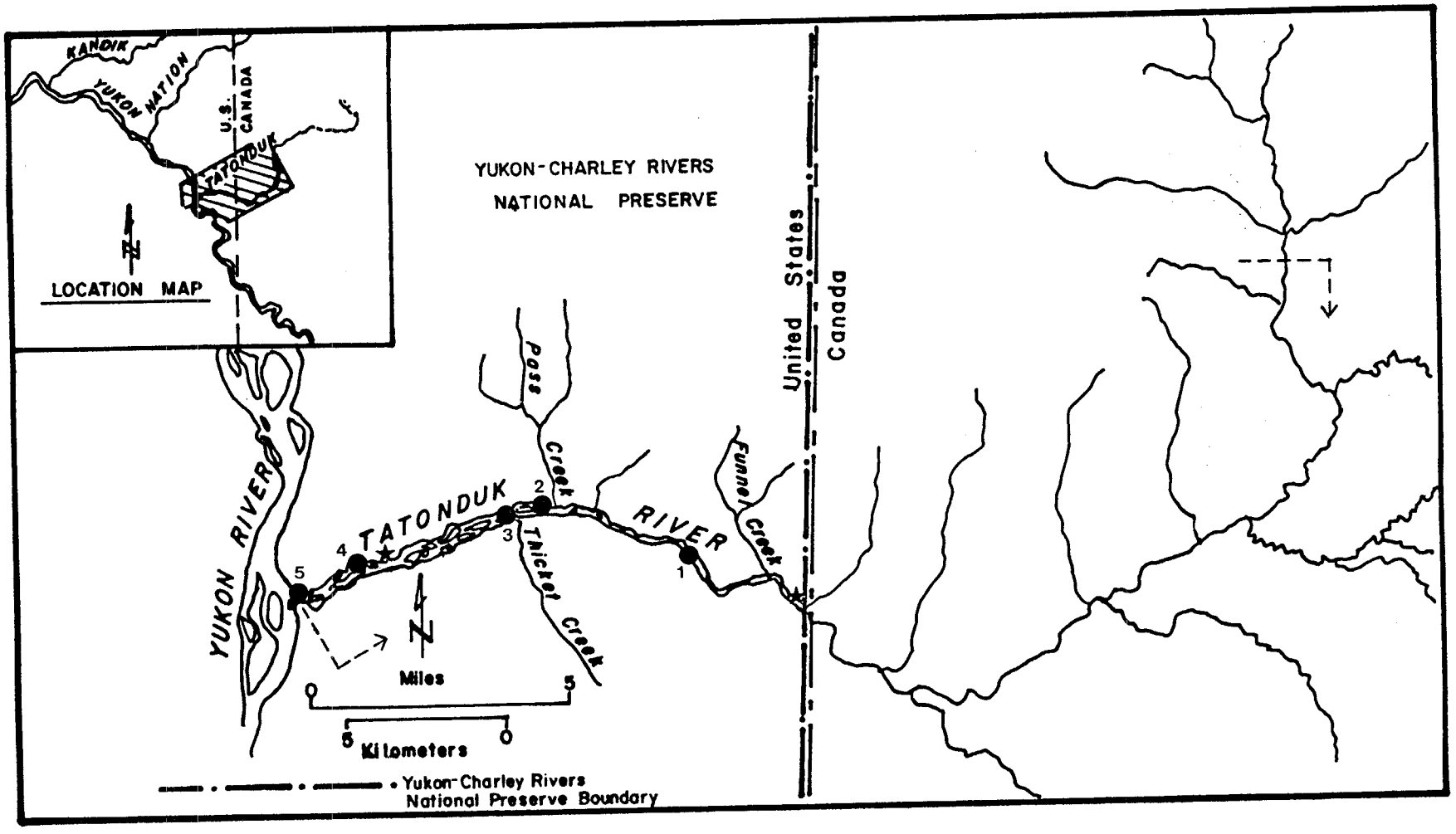

Figure 5. Mainstem (●) sampling site locations, spring areas (★) and aerial survey boundaries (- - -) on the Tatonduk River, Yukon-Charley Rivers National Preserve. Site locations are from this study along with previous fisheries investigations.

Table 7.—Effort, number of fish collected (N), and catch-per-unit-effort (CPUE) of all fish species captured from July 29 to August 8, 1987, on the Kandik River.

Site	Effort	Species[a]	N	CPUE
		Experimental gill net		
2	9.9 h	--	0	0 /h
3	6.5 h	--	0	0 /h
5	37.5 h	AG	8	0.21 /h
		LS	2	0.05 /h
7	40.3 h	AG	1	0.02 /h
		LS	1	0.02 /h
8	38.5 h	AG	2	0.05 /h
		LS	1	0.03 /h
10	36.8 h	--	0	0 /h
Total	169.5 h	AG	11	0.06 /h
		LS	4	0.02 /h
		Minnow trap		
2	18.0 h	--	0	0 /h
3	54.3 h	SS	6	0.11 /h
5	16.3 h	--	0	0 /h
7	86.3 h	SS	1	0.01 /h
8	154.3 h	KS	1	0.01 /h
		BB	1	0.01 /h
10	46.3 h	KS	3	0.06 /h
Total	375.5 h	KS	4	0.01 /h
		SS	7	0.02 /h
		BB	1	< 0.01 /h
		Electrofishing		
C	7.3 min	--	0	0 /min
5	7.4 min	SS	2	0.27 /min
F	14.3 min	AG	1	0.07 /min
		SS	4	0.28 /min
G	14.0 min	AG	2	0.14 /min
		SS	12	0.86 /min
10	11.6 min	--	0	0 /min
Total	54.6 min	AG	3	0.05 /min
		SS	18	0.33 /min
		Beach seine		
5	5 hauls	--	0	0 /haul
7	6 hauls	--	0	0 /haul
Total	11 hauls	--	0	0 /haul

[a]SS=slimy sculpin, AG=Arctic grayling, LS=longnose sucker, KS=chinook salmon, BB=burbot.

Table 8.—Effort, number of fish collected (N), and catch-per-unit-effort (CPUE) of all fish species captured from September 10-16, 1987, on the Kandik River.

Site	Effort	Species[a]	N	CPUE
		Experimental gill net		
2	12.3 h	--	0	0 /h
4	12.8 h	AG	1	0.08 /h
		LS	2	0.16 /h
6	16.5 h	AG	4	0.24 /h
		LS	1	0.06 /h
8	20.5 h	AG	8	0.39 /h
		LC	1	0.05 /h
9	18.8 h	AG	2	0.11 /h
Total	80.9 h	AG	15	0.19 /h
		LS	3	0.04 /h
		LC	1	0.01 /h
		Minnow trap		
2	30.0 h	--	0	0 /h
4	31.2 h	--	0	0 /h
6	33.0 h	--	0	0 /h
8	81.0 h	--	0	0 /h
9	72.7 h	--	0	0 /h
Total	247.9 h	--	0	0 /h
		Electrofishing		
8	10.0 min	--	0	0 /min
9	8.8 min	AG	3	0.34 /min
		SS	10	1.14 /min
Total	18.8 min	AG	3	0.16 /min
		SS	10	0.53 /min

[a]SS=slimy sculpin, AG=Arctic grayling, LS=longnose sucker, LC=least cisco.

The difference in combined gill net catch rates between the two sampling periods on the Kandik River should be viewed with caution since different sites were used during each period.

Baited minnow traps were used at six sites during the July-August period with a combined CPUE of 0.03 fish/hour. The traps were set for a total of 375.5 hours, yielding slimy sculpin, young-of-the-year chinook salmon, and one young-of-the-year burbot. During September, minnow traps were set for a total 247.9 hours with no fish captured.

Electrofishing effort totaled 54.6 minutes on the Kandik River during July and August, capturing slimy sculpin and three Arctic grayling (one adult, two young-of-the-year). The September sampling period yielded slimy sculpin and three Arctic grayling (one adult and two young-of-the-year) from 18.8 minutes of effort. Eleven seine hauls yielded no fish.

Charley River

Twenty-one (64%) of the 33 fish captured on the Charley River were Arctic grayling (Table 9). A total of 121.6 gill net hours yielded Arctic grayling and longnose suckers with a combined CPUE of 0.21 fish/net hour. Grayling had the highest total CPUE (0.17 fish/net hour) and were most abundant at station 4.

One slimy sculpin was captured at site 3 using baited minnow traps set for a total of 198.3 hours during the August sampling period. Six slimy sculpin were caught during 9.9 minutes of electrofishing.

Nation River

During the two sampling periods, 422 fish were captured (Tables 10 and 11), including 152 Arctic grayling (36%), 96 young-of-the-year chinook salmon (23%), and 95 slimy sculpin (23%). A total of 430.0 experimental gill net hours were spent during the July-August sample period with a combined CPUE of 0.14 fish/net hour and seven species captured. Grayling had the highest total catch rate (0.07 fish/net hour) and were most abundant at site 2. In September, 452.0 experimental gill net hours at site 8 resulted in a combined CPUE of 0.06 fish/net hour. Of the three species captured, grayling were most abundant (0.04 fish/net hour).

Two multifilament gill nets (10.4 cm bar mesh) were employed during the July-August sampling period to catch adult chinook salmon. One male chinook salmon was captured at site 7 during 208.0 hours of gill netting. Two multifilament gill nets (7.4 cm bar mesh) were used in September to capture chum salmon. No fish were captured after 480.5 hours effort.

Baited minnow traps were used at seven sites during the July-August period with a combined CPUE of 0.06 fish/hour. The traps were set 1,061.5 hours with a catch of young-of-the-year chinook salmon, lake chubs, and slimy sculpin. During September, minnow traps were set 1,574.5 hours with a combined CPUE of 0.03 fish/hour. Three species were captured with chinook salmon being the most abundant.

Beach seining was used at six stations during the July-August period with a combined catch of 3.2 fish/haul. Fifty-three hauls resulted in a catch of slimy sculpin and young-of-the-year grayling, chinook salmon, and round whitefish. The September sampling at site 8 (combined catch of 2.7 fish/haul) yielded slimy sculpin and young-of-the-year Arctic grayling, round whitefish, and chinook salmon.

Table 9.—Effort, number of fish collected (N), and catch-per-unit-effort (CPUE) of all fish species captured from August 9-20, 1987, on the Charley River.

Site	Effort	Species[a]	N	CPUE
		Experimental gill net		
1	15.0 h	AG	1	0.07 /h
3	23.0 h	LS	1	0.04 /h
4	46.5 h	AG	20	0.43 /h
		LS	3	0.06 /h
6	22.3 h	--	0	0 /h
8	14.8 h	LS	1	0.07 /h
Total	121.6 h	AG	21	0.17 /h
		LS	5	0.04 /h
		Minnow trap		
1	30.5 h	--	0	0 /h
3	46.3 h	--	0	0 /h
4	47.2 h	SS	1	0.02 /h
6	44.0 h	--	0	0 /h
8	30.3 h	--	0	0 /h
Total	198.3 h	SS	1	0.01 /h
		Electrofishing		
1	6.4 min	--	0	0 /min
C	3.5 min	SS	6	1.71 /min
Total	9.9 min	SS	6	0.61 /min

[a]SS=slimy sculpin, AG=Arctic grayling, LS=longnose sucker.

Table 10.—Effort, number of fish collected (N), and catch-per-unit-effort (CPUE) of all fish species captured from July 19 to August 5, 1988, on the Nation River.

Site	Effort	Species[a]	N	CPUE
		Experimental gill net		
2	69.0 h	AG	16	0.23 /h
		RWF	1	0.01 /h
		DV	3	0.04 /h
		LS	2	0.03 /h
3	31.5 h	--	0	0 /h
B	56.0 h	AG	2	0.04 /h
5	29.5 h	--	0	0 /h
C	58.0 h	AG	1	0.02 /h
7	77.0 h	AG	9	0.12 /h
		RWF	3	0.04 /h
		LS	13	0.17 /h
11	109.0 h	CS	2	0.02 /h
		AG	2	0.02 /h
		LS	4	0.04 /h
		IN	1	0.01 /h
		NP	1	0.01 /h
Total	430.0 h	CS	2	< 0.01 /h
		AG	30	0.07 /h
		RWF	4	0.01 /h
		DV	3	0.01 /h
		LS	19	0.04 /h
		IN	1	< 0.01 /h
		NP	1	< 0.01 /h
		Multifilament gill net (10.4 cm bar mesh)		
3	29.0 h	--	0	0 /h
5	49.0 h	--	0	0 /h
7	65.5 h	KS	1	0.02 /h
11	64.5 h	--	0	0 /h
Total	208.0 h	KS	1	< 0.01 /h

[a]KS=chinook salmon, CS=chum salmon, AG=Arctic grayling, DV=Dolly Varden char, RWF=round whitefish, SS=slimy sculpin, LS=longnose sucker, IN=inconnu, NP=northern pike, LCH=lake chub.

Table 10.—Continued.

Site	Effort	Species[a]	N	CPUE
		Minnow trap		
2	172.0 h	KS	1	0.01 /h
		SS	3	0.02 /h
3	111.0 h	KS	1	0.01 /h
		SS	1	0.01 /h
B	86.0 h	KS	1	0.01 /h
		SS	1	0.01 /h
5	96.0 h	KS	2	0.02 /h
C	88.0 h	KS	6	0.07 /h
		SS	4	0.05 /h
7	229.5 h	KS	25	0.11 /h
11	279.0 h	LCH	19	0.07 /h
Total	1,061.5 h	KS	36	0.03 /h
		SS	9	0.01 /h
		LCH	19	0.02 /h
		Beach seine		
2	4 hauls	AG	15	3.75 /haul
B	11 hauls	KS	2	0.18 /haul
		AG	33	3.00 /haul
		RWF	1	0.09 /haul
		SS	8	0.73 /haul
5	5 hauls	SS	3	0.60 /haul
C	11 hauls	KS	1	0.09 /haul
		AG	3	0.27 /haul
		SS	34	3.09 /haul
7	11 hauls	KS	7	0.64 /haul
		AG	37	3.36 /haul
		RWF	1	0.09 /haul
		SS	11	1.00 /haul
11	11 hauls	AG	3	0.27 /haul
		RWF	2	0.18 /haul
		SS	8	0.73 /haul
Total	53 hauls	KS	10	0.19 /haul
		AG	91	1.72 /haul
		RWF	4	0.08 /haul
		SS	64	1.21 /haul

[a]KS=chinook salmon, CS=chum salmon, AG=Arctic grayling, DV=Dolly Varden char, RWF=round whitefish, SS=slimy sculpin, LS=longnose sucker, IN=inconnu, NP=northern pike, LCH=lake chub.

Table 11.—Effort, number of fish collected (N), and catch-per-unit-effort (CPUE) of all fish species captured from September 9-22, 1988, on the Nation River.

Site	Effort	Species[a]	N	CPUE
		Experimental gill net		
8	452.0 h	AG	16	0.04 /h
		RWF	9	0.02 /h
		LS	1	< 0.01 /h
		Multifilament gill net (7.4 cm bar mesh)		
8	480.5 h	--	0	0 /h
		Minnow trap		
8	1,574.5 h	KS	47	0.03 /h
		SS	2	< 0.01 /h
		BB	2	< 0.01 /h
		Beach seine		
8	19 hauls	KS	3	0.16 /haul
		AG	15	0.79 /haul
		RWF	13	0.68 /haul
		SS	20	1.05 /haul

[a]KS=chinook salmon, AG=Arctic grayling, RWF=round whitefish, SS=slimy, sculpin, LS=longnose sucker, BB=burbot.

Tatonduk River

During the August 17-23, 1988 sampling period, 269 fish were captured (Table 12), including 139 young-of-the-year chinook salmon (52%) and 59 Arctic grayling (22%). A total of 212.0 experimental gill net hours resulted in a catch of four species with a combined CPUE of 0.17 fish/net hour. Grayling had the highest total CPUE (0.11 fish/net hour). Grayling were most abundant at site 3, with three chum salmon also being captured.

One multifilament gill net (10.4 cm bar mesh) was employed at sites 3 and 4 to capture chinook salmon. After 114.5 hours of effort, no chinook salmon were captured. One chum salmon was captured at site 3.

Baited minnow traps were used at two sites with a combined CPUE of 0.06 fish/hour. The traps were set for a total of 543.0 hours with a catch of slimy sculpin and young-of-the-year chinook salmon.

Seining was used at sites 3 and 4 with a combined catch of 8.8 fish/haul. Twenty-three hauls resulted in the capture of 202 young-of-the-year fish. Young-of-the-year chinook salmon were most abundant at site 2.

Length-at-age Relationships

Arctic grayling length-at-age relationships were similar among the four river stocks (Table 13). Of the 160 grayling captured, 31 (19%) had unreadable scales. Ninety-four percent of the unreadable scales were from fish with fork lengths over 320 mm. The oldest captured round whitefish was age-9 (Appendix 2). Four of the five adult chum salmon were age 0.4. Young-of-the-year chinook salmon ranged in fork length from 63-86 mm. Scales from longnose suckers were unreadable.

Weight-length relationships

Growth curves generated from captured Arctic grayling data were similar between the Kandik and Charley rivers (Figure 6) and between the Nation and Tatonduk rivers (Figure 7). A 300 mm grayling would have the highest predicted weight on the Tatonduk River (293 g) and the lowest predicted weight on the Kandik and Charley rivers (264 g). Correlation coefficients for the regressions of logarithms of weight and length ranged from 0.97 to 0.99.

Chemical and Physical Characteristics

Kandik River

Chemical characteristics did not change greatly between the July-August and September sampling periods (Table 14; Figure 2). The range of total alkalinity was 68.4-85.5 mg/L $CaCO_3$ on the mainstem and 34.2-85.5 mg/L $CaCO_3$ on the tributaries of the Kandik River. Total hardness for mainstem sites ranged from 68.4-102.6 mg/L $CaCO_3$, whereas tributaries ranged from 34.2-171.0 mg/L $CaCO_3$.

Mainstem conductivity ranged from 94-160 uS/cm. Conductivity readings for tributaries were more variable than those measured for mainstem sites with a range of 45-180 uS/cm. The pH values ranged from 7.0-7.5 throughout the mainstem and tributaries of the Kandik River.

Table 12.—Effort, number of fish collected (N), and catch-per-unit-effort (CPUE) of all fish species captured from August 17-23, 1988, on the Tatonduk River.

Site	Effort	Species[a]	N	CPUE
		Experimental gill net		
3	137.5 h	CS	3	0.02 /h
		AG	20	0.15 /h
		RWF	2	0.01 /h
		LS	6	0.04 /h
4	74.5 h	AG	3	0.04 /h
		LS	2	0.03 /h
Total	212.0 h	CS	3	0.01 /h
		AG	23	0.11 /h
		RWF	2	0.01 /h
		LS	8	0.04 /h
		Multifilament gill net (10.4 cm bar mesh)		
3	69.0 h	CS	1	0.01 /h
4	45.5 h	--	0	0 /h
Total	114.5 h	CS	1	0.01 /h
		Minnow trap		
3	280.5 h	KS	22	0.08 /h
		SS	4	0.01 /h
4	262.5 h	KS	4	0.02 /h
Total	543.0 h	KS	26	0.05 /h
		SS	4	0.01 /h
		Beach seine		
2	12 hauls	KS	112	9.33 /haul
		AG	28	2.33 /haul
		RWF	10	0.83 /haul
		SS	3	0.25 /haul
		LS	2	0.17 /haul
4	11 hauls	KS	1	0.09 /haul
		AG	8	0.73 /haul
		RWF	13	1.18 /haul
		SS	25	2.27 /haul
Total	23 hauls	KS	113	4.91 /haul
		AG	36	1.57 /haul
		RWF	23	1.00 /haul
		SS	28	1.22 /haul
		LS	2	0.09 /haul

[a]KS=chinook salmon, CS=chum salmon, AG=Arctic grayling, RWF=round whitefish, SS=slimy sculpin, LS=longnose sucker.

Table 13.—Fork length (mm)-at-age for Arctic grayling collected from Yukon-Charley Rivers National Preserve, 1987 and 1988.

River	Age (years) 0	1	2	3	4	5	6	7	8
Nation River									
Mean	105.0	206.4	238.7	270.2	304.7	334.4	345.8	364.7	367.0
N	6	5	3	4	13	7	9	3	1
SD	37.7	9.9	2.3	15.5	16.8	14.9	18.7	5.0	
Range	57-145	191-215	236-240	254-288	282-346	310-351	328-383	360-370	367
Tatonduk River									
Mean	100.9	199.7	234.4	256.7	282.3	328.0	340.7	351.5	
N	8	3	7	4	3	1	3	2	
SD	32.2	20.6	9.2	16.8	22.0		8.1	0.7	
Range	64-134	176-214	222-247	237-278	260-304	328	335-350	351-352	
Charley River									
Mean			224.5	252.7	280.0	311.0	349.0	353.7	
N			2	10	1	1	3	3	
SD			3.5	9.9			12.1	9.5	
Range			222-227	237-268	280	311	336-360	344-363	
Kandik River									
Mean				261.3	304.7	333.8	349.0	337.0	
N				6	3	5	10	3	
SD				10.4	28.4	20.5	13.4	3.6	
Range				249-274	273-328	300-354	328-365	333-340	

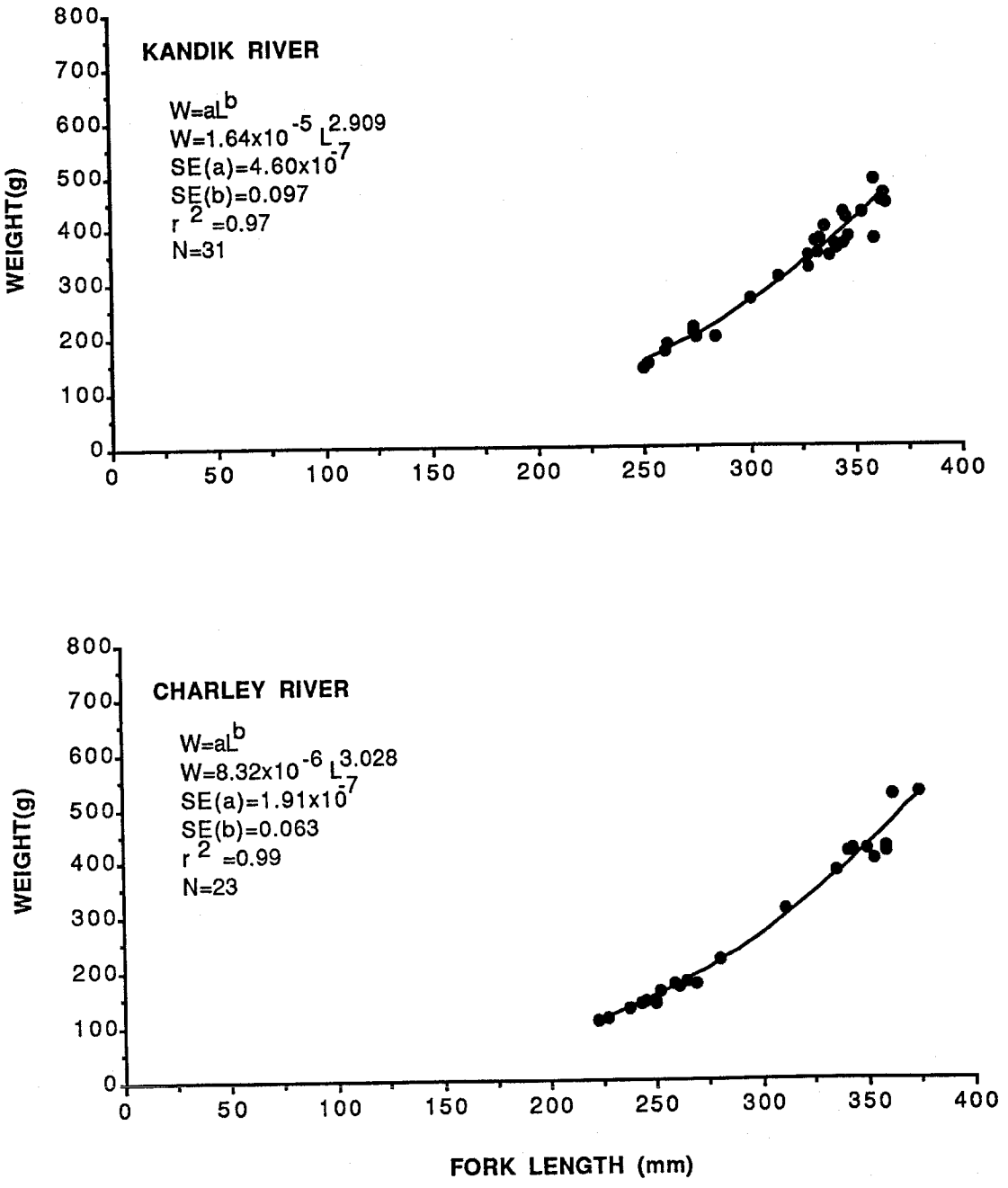

Figure 6.—Weight-length relationships for Arctic grayling captured on the Kandik and Charley rivers, 1987.

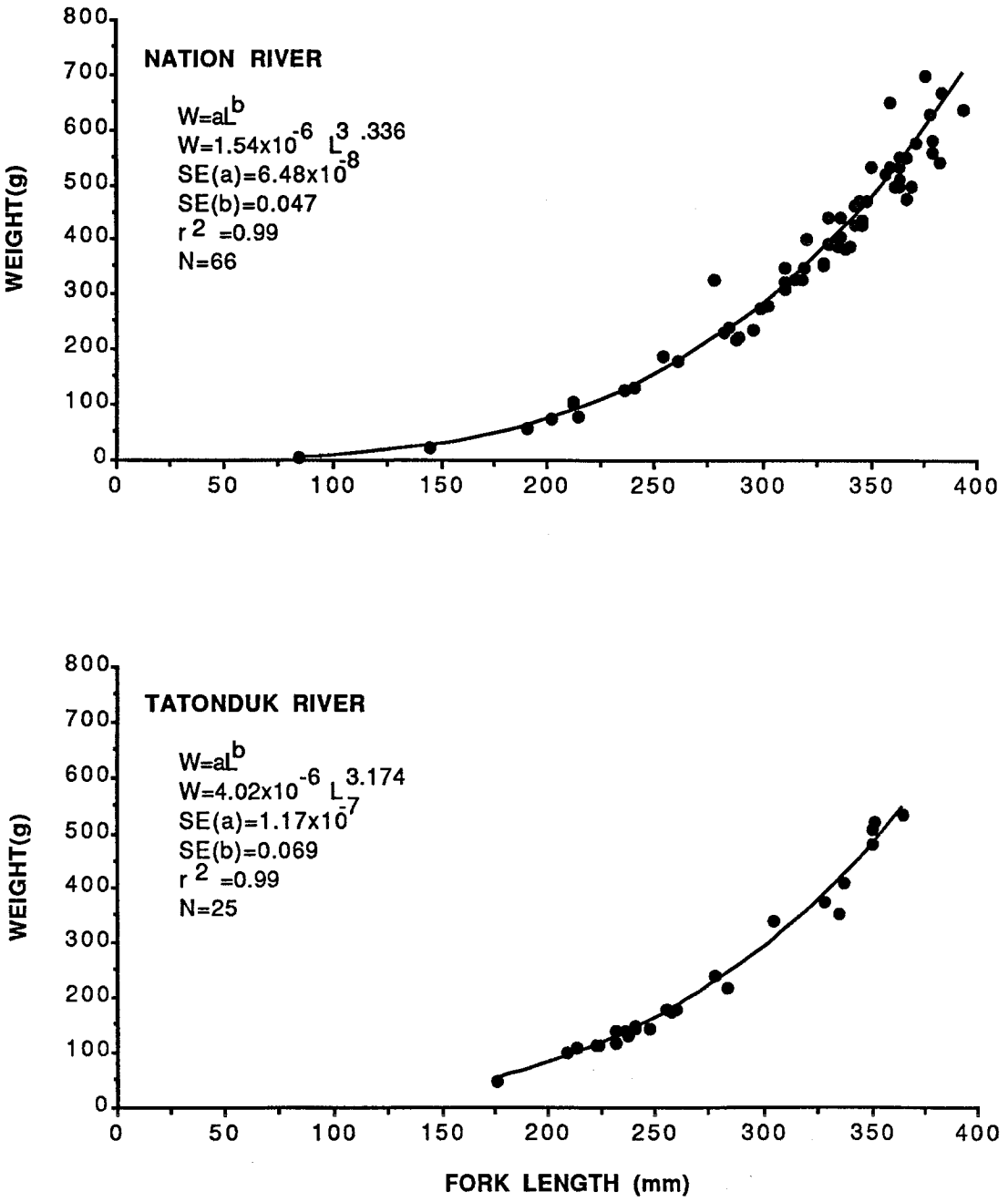

Figure 7.—Weight-length relationships for Arctic grayling captured on the Nation and Tatonduk rivers, 1988.

Table 14.—Water quality parameters for sites on the Kandik River, 1987.

Site (date)	Total alkalinity (mg/L $CaCO_3$)	Total hardness (mg/L $CaCO_3$)	Conductivity (uS/cm)	pH	Water temperature (°C)
		Mainstem			
2 (07/29)	68.4	85.5	120	7.5	10
3 (07/31)	85.5	68.4	110	7.5	11
5 (08/01)	85.5	85.5	135	7.5	12
7 (08/04)	85.5	85.5	140	7.5	13
8 (08/06)	85.5	102.6	140	7.5	14
10 (08/07)	85.5	85.5	150	7.5	13
2 (09/10)	68.4	68.4	130	7.5	4
3 (09/12)	68.4	68.4	94	7.0	3
4 (09/12)	68.4	68.4	120	7.5	5
5 (09/13)	68.4	85.5	120	7.0	3
6 (09/14)	68.4	85.5	100	7.5	3
8 (09/14)	85.5	102.6	160	7.5	5
9 (09/15)	68.4	102.6	140	7.5	4
10 (09/16)	85.5	102.6	140	7.5	4
		Tributaries			
A (07/30)	34.2	34.2	45	7.0	6
B (07/30)	34.2	85.5	140	7.0	5
C (07/31)	68.4	51.3	82	7.0	5
D (08/01)	68.4	102.6	160	7.5	8
E (08/01)	85.5	136.8	150	7.5	6
F (08/06)	68.4	119.7	180	7.0	7
G (08/06)	68.4	119.7	130	7.5	7
A (09/11)	34.2	34.2	52	7.0	3
B (09/11)	51.3	68.4	140	7.0	3
C (09/12)	68.4	51.3	76	7.0	2
D (09/12)	68.4	85.5	150	7.0	3
E (09/13)	85.5	171.0	160	7.0	1
F (09/14)	68.4	119.7	160	7.0	3
G (09/14)	68.4	85.5	120	7.0	2

Mainstem temperatures decreased from 10-14°C in August to 3-5°C in September as the water began to freeze near shallow shore areas. The tributaries feeding the Kandik River were colder than the mainstem during both sampling periods with the greatest differences occurring in the summer months (mean temperature difference of 5.9°C).

The mainstem Kandik River was a fourth order stream at all areas sampled; tributaries were stream orders 2 and 3 (Table 15). Gradients varied from 0.16-0.23% for mainstem sites. Mainstem percent pool area was greatest at the farthest downstream site. Substrate size did not change with stream order. The predominant substrate throughout the mainstem and tributaries was gravel and small cobble, but sand was more common in tributaries. The mainstem discharge at site 7 (Figure 2) measured 24.8 m^3/s. Strong currents prevented flow measurements at most sites. River stage was medium during both sampling periods.

Charley River

Chemical characteristics on Charley River tributaries were more variable than the mainstem, with Dewey Creek (site C) having the lowest values (Table 16; Figure 3). This stream is unique compared to the other sample sites in that it flows through a heavily vegetated sphagnum moss area. Total alkalinity varied from 68.4 mg/L $CaCO_3$ on the mainstem to 34.2-85.5 mg/L $CaC0_3$ at tributary sites. Mainstem total hardness was 51.3-85.5 mg/L $CaCO_3$ compared to 17.1-85.5 mg/L $CaCO_3$ for the tributaries. Conductivity measurements varied from 30-130 uS/cm, with tributaries showing the greatest variability.

Mainstem Charley River sample sites were fourth and fifth order streams, with tributary stream orders varying from 1 to 4 (Table 17). Gradients varied from 0.21-0.61% for mainstem sites. Percent riffle areas increased as stream order decreased at mainstem sites, but sampled tributaries did not exhibit this tendency. The predominant substrate throughout the Charley River varied greatly. The mainstem substrate was large cobble and boulder in the upper reach, above Crescent Creek, but was gravel and sand downstream. Dominant substrate size for the tributaries decreased in size as distance to the Yukon River decreased. The mainstem discharge at site 1 (Figure 3) measured 12.4 m^3/s. Strong currents prevented flow measurements at the other sites. River stage was medium during the sampling period.

Nation River

Chemical characteristics on Nation River tributaries were more variable than in the mainstem, with Hard Luck Creek (site C) having the highest values (Table 18; Figure 4). Total alkalinity measured 126.0-149.0 mg/L $CaCO_3$ on the mainstem and 113.0-154.5 mg/L $CaCO_3$ for tributary sites. Mainstem total hardness was 168.0-224.0 mg/L $CaCO_3$ compared to 156.0-268.5 mg/L $CaCO_3$ for the tributaries. Conductivity measurements varied from 295-490 uS/cm, with tributaries showing the greatest variability. Mainstem temperatures decreased from 10.0-14.0°C in summer to 4.3-6.2°C in September.

Mainstem Nation River was a fourth order stream at all sampling sites, with tributary sites having stream orders of 2 and 3 (Table 19). Gradients ranged from 0.20-0.40% for mainstem sites. Percent pool and riffle areas were low for all sites, except site C (Figure 4). The substrate throughout the Nation River varied greatly. The mainstem substrate consisted primarily of gravel and small cobble with the middle reach (sites 3 and 5) having large cobble and boulder. The dominant substrate types for the tributaries were small cobble and gravel. Discharge measured 8.2-22.3 m^3/s for mainstem sites and 0.8-4.8 m^3/s for the tributaries. Mainstem river stage was low throughout the sampling period with water levels 0.46 to 1.13 m below bankfull at sample sites.

Table 15.—Selected physical parameters for sites on the Kandik River, 1987.

Site (date)	Stream order	Gradient (%)	% Pool: riffle: run:	Predominant substrate[a]	Discharge (m^3/s)	Stream width (m)	Mean water velocity (cm/s)
				Mainstem			
2 (07/29)	4	0.23	25:25:50	SC/GL			
3 (07/31)	4	0.21	25:10:65	GL/SC			
5 (08/01)	4	0.22	50:40:10	GL/SA			
7 (08/04)	4	0.20	40:10:50	GL/SC	24.8	85.4	66.4
8 (08/06)	4	0.19	30:20:50	GL/SC			
10 (08/07)	4	0.16	60:10:30	GL/SC			
				Tributaries			
A (07/30)	3		50:25:25	GL/SA			
B (07/30)	2		25:35:40	GL/SC			
C (07/31)	3		30:20:50	GL/SA			
D (08/01)	3		20:50:30	SC/SA			
E (08/01)	2		50:20:30	GL/SC			
F (08/06)	3		60:20:20	SA/SC			
G (08/06)	3		20:50:30	GL/SC			

[a]LC=large cobble, SC=small cobble, GL=gravel, SA=sand.

Table 16.—Water quality parameters for sites on the Charley River, 1987.

Site (date)	Total alkalinity (mg/L $CaCO_3$)	Total hardness (mg/L $CaCO_3$)	Conductivity (uS/cm)	pH	Water temperature (°C)
		Mainstem			
1 (08/10)	68.4	51.3	94	7.5	10
3 (08/14)	68.4	51.3	80	7.5	11
4 (08/14)	68.4	51.3	76	7.5	9
6 (08/17)	68.4	51.3	78	7.5	9
8 (08/20)	68.4	85.5	130	7.5	8
		Tributaries			
A (08/13)	68.4	51.3	97	7.5	10
B (08/14)	51.3	51.3	87	7.5	8
C (08/18)	34.2	17.1	30	6.5	5
D (08/19)	68.4	51.3	87	7.5	9
E (08/20)	85.5	85.5	120	7.5	8

Table 17.—Selected physical parameters for sites on the Charley River, 1987.

Site (date)	Stream order	Gradient (%)	% Pool: riffle: run:	Predominant substrate[a]	Discharge (m^3/s)	Stream width (m)	Mean water velocity (cm/s)
				Mainstem			
1 (08/10)	4	0.42	25:50:25	LC/SA	12.4	42.1	75.9
3 (08/14)	4	0.61	05:50:45	BR/LC			
4 (08/14)	5	0.39	25:25:50	GL/SC			
6 (08/17)	5	0.38	50:25:25	GL/SC			
8 (08/20)	5	0.21	40:30:30	SA/GL			
				Tributaries			
A (08/13)	2		10:70:20	BR/LC			
B (08/14)	4		20:70:10	BR/LC			
C (08/18)	1		25:25:50	SC/GL			
D (08/19)	1		00:25:75	LC/SC			
E (08/20)	3		05:50:45	GL/SC			

[a]BR=boulder, LC=large cobble, SC=small cobble, GL=gravel, SA=sand.

Table 18.—Water quality parameters for sites on the Nation River, 1988.

Site (date)	Total alkalinity (mg/L $CaCO_3$)	Total hardness (mg/L $CaCO_3$)	Conductivity (uS/cm)	pH	Water temperature (°C)
		Mainstem			
1 (07/20)	134.5	180.0	338	8.2	11.5
2 (07/23)	126.0	168.0	308	8.2	10.0
3 (07/25)	138.5	175.5	340	8.4	12.2
5 (07/28)	137.0	195.5	370	8.3	12.0
7 (08/01)	145.0	215.5	395	8.5	14.0
11 (08/04)	149.0	224.0	410	8.4	12.1
8 (09/14)	135.0	197.7	360	8.4	4.3
(09/21)	144.0	212.3	400	8.5	6.2
		Tributaries			
A (07/24)	124.0	156.0	295	8.4	10.5
B (07/25)	113.0	161.5	300	7.9	12.6
C (07/28)	154.5	268.5	490	8.5	14.0

Table 19.—Selected physical parameters for sites on the Nation River, 1988.

Site (date)	Stream order	Gradient (%)	% Pool: riffle: run:	Predominant substrate[a]	Discharge (m^3/s)	Stream width (m)	Mean water velocity (cm/s)	River stage (m)[b]
				Mainstem				
1 (07/20)	4	0.40	05:05:90	GL/SC	8.2	30.5	55.5	0.46
2 (07/23)	4	0.40	05:10:85	GL/SC				
3 (07/25)	4	0.35	10:30:60	LC/SC	20.0	51.2	88.4	0.73
5 (07/28)	4	0.28	05:20:75	LC/BR	20.7	58.0	69.8	0.82
7 (08/01)	4	0.26	30:20:50	SC/GL	21.7	56.1	77.4	0.52
11 (08/04)	4	0.20	05:20:75	GL/LC	17.2	44.8	64.9	1.13
8 (09/14)	4	0.26	10:10:80	GL/SC	22.3	39.0	75.6	
				Tributaries				
A (07/24)	3		20:20:60	SC/LC	3.1	23.5	41.1	0.73
B (07/25)	2		05:30:65	GL/SC	0.8	11.0	36.3	0.49
C (07/28)	3		05:50:45	SC/LC	4.8	35.1	61.6	0.40

[a]BR=boulder, LC=large cobble, SC=small cobble, GL=gravel.
[b]Elevation difference between water surface and bank full level.

Tatonduk River

Chemical characteristics were similar among the mainstem Tatonduk River sample sites (Table 20; Figure 5). Total alkalinity ranged from 109.5-114.0 mg/L $CaCO_3$ on the mainstem Tatonduk River. Mainstem total hardness measured 150.0-173.5 mg/L $CaCO_3$. Conductivity varied from 290-340 uS/cm. Mainstem temperatures were 9.0-9.5°C.

Mainstem Tatonduk River was a fifth order stream at all sample sites, with gradients of 0.29% (Table 21). Percent pool and riffle areas were low for all sites. The predominant mainstem substrate was gravel and small cobble. Discharge measurements were not taken due to high water conditions.

Aquatic Macroinvertebrates

Forty-seven aquatic macroinvertebrate taxa were identified from the drainages (Table 22). The Tatonduk River had the greatest number of taxa with 31. The Nation and Tatonduk river samples had higher average invertebrate density and biomass than did the Kandik and Charley river samples (Table 23; Appendix 3). The average diversity index (Sequential Comparison Index) value was highest for the Charley River samples. Taxonomic composition of the samples was also different. The Kandik and Charley river samples had proportionally more Oligochaetes and fewer Ephemeroptera (mayflies), Diptera (true flies), and Trichoptera (caddisflies). In all four drainages, greater than 90% of the samples were composed of Diptera, Oligochaeta, and Ephemeroptera. Amphipods were only found on the Kandik River. The collector-gatherer functional group was the most common in all four streams.

DISCUSSION

Fish Distribution

Fifteen fish species have been documented in streams of the Yukon-Charley Rivers National Preserve. Coho salmon and broad whitefish have not been captured, though Scott and Crossman (1973) list the occurrence of the two species in the Yukon River, upstream and downstream of the study area. McPhail and Lindsey (1970) report that most coho salmon in the Yukon River stay in freshwater two complete seasons before smolting. Our surveys and Welp (*in preparation*) found no pre-smolt coho salmon after extensive sampling with minnow traps and minnow seines during the summer season. Reports of coho salmon far up the Yukon River should be viewed with some skepticism (Morrow 1980) since no upper Yukon River spawning populations have been documented and the term "silver salmon" used by many fishermen to describe chum salmon may be misleading. In contrast, the absence of documented broad whitefish captures in preserve streams is probably due to seasonal differences between sampling dates and species distribution. Spawning runs up tributary streams last into November with fry moving downstream in spring shortly after hatching (Morrow 1980), while fish sampling occurred during the summer and early fall.

The upstream range of chinook salmon spawning and rearing in all four drainages was extended from information gathered in this study. Range extensions were submitted to the Alaska Department of Fish and Game for inclusion in the Catalog of Waters Important for Spawning, Rearing, or Migration of Anadromous Fishes (Alaska Department of Fish and Game 1989). Spawning habitat appeared abundant, though few

Table 20.—Water quality parameters for sites on the Tatonduk River, 1988.

Site (date)	Total alkalinity (mg/L $CaCO_3$)	Total hardness (mg/L $CaCO_3$)	Conductivity (uS/cm)	pH	Water temperature (°C)
		Mainstem			
3 (08/20)	114.0	173.5	340	8.4	9.0
4 (08/22)	109.5	150.0	290	8.4	9.5

Table 21.—Selected physical parameters for sites on the Tatonduk River, 1988.

Site (date)	Stream order	Gradient (%)	% Pool: riffle: run	Predominant substrate[a]
		Mainstem		
2 (08/17)	5	0.29	05:15:80	GL/SC
3 (08/20)	5	0.29	05:15:80	SC/GL
4 (08/24)	5	0.29	05:20:75	GL/SC

[a]SC=small cobble, GL=gravel.

Table 22.—Density (number of organisms/0.1 m^2) of aquatic macroinvertebrates collected from the Yukon-Charley Rivers National Preserve, 1987 and 1988.

Taxa	River			
	Kandik	Charley	Nation	Tatonduk
Phylum Arthropoda				
Class Arachnida				
Order Acarina	2.1	2.3		
Family Sperchonidae				
Sperchion sp.			3.3	0.1
Family Lebertidae				
Lebertia sp.			2.7	0.1
Class Crustacea				
Order Amphipoda				
Family Gammaridae				
Synurella sp.	1.9			
Order Ostracoda			0.1	
Class Insecta				
Order Collembola	0.2	0.1	1.3	0.1
Order Coleoptera				
Family Haliplidae (larva)	0.1			
Family Dytiscidae (larva)		0.1		
Family Staphylinidae (larva)	<0.1	0.1		0.1
Order Ephemeroptera				
Family Baetidae				
Baetis sp.	1.3	0.9	6.1	2.5
Family Ephemerellidae				
Ephemerella sp.	0.7	0.7	8.7	10.7
Drunella sp.			1.3	4.1
Family Siphlonuridae				
Ameletus sp.	2.4	0.1		
Family Heptageniidae				
Epeorus sp.	0.2	0.4	5.5	0.1
Cinygmula sp.	1.7	1.9	2.3	0.1
Rhithrogena sp.	2.2	0.7	25.9	15.8
other Heptagenid	1.4	2.3	1.5	0.5
Order Plecoptera				
Family Chloroperlidae				
Alloperla sp.				0.4
Plumiperla sp.	0.9	0.9		
Neaviperla sp.	0.2	0.2	4.6	0.9
other Chloroperlid	1.3	0.1	6.2	7.1
Family Perlodidae				
Arcynopteryx sp.	0.1	0.1		
Isoperla/Clioperla sp.			0.2	0.1
other Perlodid	0.1	0.1	0.3	0.9
Family Nemouridae				
Zapada sp.			0.2	0.1

Table 22.—Continued.

Taxa	River			
	Kandik	Charley	Nation	Tatonduk
Order Diptera				
Family Chironomidae	37.2	25.6	211.5	95.7
Family Simuliidae	0.4			
Simulium sp.			3.0	6.3
Family Ceratopogonidae	0.1	0.1		3.2
Family Empididae	0.1	0.6		
Oreogeton sp.			0.9	0.4
Chelifera sp.			6.3	0.5
Family Tipulidae				
Dicranota sp.	0.3	1.0	1.2	1.9
Tipula sp.	<0.1		0.6	0.1
Family Deuterophlebidae		0.1		
Family Blepheroceridae		0.1		
Agathon sp.			0.1	0.1
Family Psychodidae				
Pericoma/Telmatoscopus sp.			0.9	
Order Trichoptera				
Family Brachycentridae				
Brachycentrus sp.	0.3		0.9	0.5
Famiy Limnephilidae				
Ecclisomyia sp.	0.1			
Apatania sp.		0.2	0.3	3.3
Family Glossosomatidae				
Glossosoma sp.		0.1	3.8	2.4
Family Hydropsychidae				
Arctopsyche sp.	<0.1		0.3	0.1
Order Hymenoptera (adult)		0.1		
Phylum Annelida				
Class Oligochaeta	28.6	10.2	43.1	14.3
Phylum Mollusca				
Class Gastropoda	<0.1			
Phylum Aschelminthes				
Class Nematoda	0.1	0.5	0.6	0.6

Table 23.—Summary of sample size (N), biomass, density, diversity, and composition of aquatic macroinvertebrates collected from the Yukon-Charley Rivers National Preserve, 1987 and 1988.

Macroinvertebrate characteristic	River			
	Kandik	Charley	Nation	Tatonduk
N	33	15	15	14
Biomass (mg/0.1 m^2)				
Mean	8.4	4.2	66.5	28.0
SE	1.1	0.9	24.1	4.1
Range	1-23	1-13	12-384	1-48
Density (number/0.1 m^2)				
Mean	87.0	49.8	344.1	175.4
SE	12.1	7.5	97.8	28.6
Range	4-336	11-98	61-1,285	19-345
Diversity index (SCI)				
Mean	6.7	8.0	6.7	6.2
SE	0.5	1.2	0.6	0.7
Range	1-14.5	1.8-16.2	2.0-11.3	1.8-10
Percent composition by order (based on density)				
Diptera	44.0	55.0	65.3	61.4
Oligochaeta	36.0	21.0	12.5	8.1
Ephemeroptera	11.0	14.0	14.9	20.8
Plecoptera	3.0	3.0	3.4	5.5
Trichoptera	0.7	0.5	1.6	3.7
Other	5.3	6.5	2.3	1.5
Percent composition by functional group (based on density)				
Collector-gatherers	92.3	81.3	53.8	49.2
Scrapers	6.6	7.4	39.0	41.2
Predators	0.5	11.3	6.0	5.7
Collector-filterers	0.5	0.0	1.1	3.8
Shredders	0.1	0.0	0.1	0.1

adults were captured. These rivers may be capable of supporting higher chinook salmon densities before density dependent factors become limiting (i.e., spawning, overwintering, and rearing habitats). From observations of live chinook salmon adults and carcasses, run timing appears to be from late-July to mid-August with spawning occurring between August 10 and 20.

Spawning and post-spawning chum salmon were captured on the Tatonduk River on August 19, 1988. This is the first documentation of chum salmon spawning in preserve streams. No chum salmon were caught after extensive fall sampling on the Nation River. The Kandik, Charley, and Tatonduk rivers have not been extensively sampled during the fall and may contain small runs of chum salmon (Barton 1984). Since any young-of-the-year fish would have left these tributary streams before sampling began, documentation of chum salmon spawning relied exclusively on adult captures and observations.

Resident fish species appeared scarce throughout the four drainages. Populations are mostly unexploited and appear limited by habitat requirements or some unknown factor. The most common adult resident species found in upstream sites were Arctic grayling, slimy sculpin, round whitefish, and longnose suckers. Northern pike were found on the Kandik River and resident Dolly Varden char (first documentation) occurred in small numbers on the Nation River. Many young-of-the-year chinook salmon, grayling, round whitefish, and slimy sculpin were captured, indicating that these upstream areas contain important spawning and rearing habitats for these species. Very few young-of-the-year longnose suckers were captured in this study though adults were common, suggesting downstream movement of young-of-the-year fish in late spring (Morrow 1980) before sampling began. Areas at or near the confluence with the Yukon River had the greatest fish species diversity, with 15 species reported. These areas provide important rearing habitat for most of these species. Inconnu have been reported using the mouths of upper Yukon River tributaries for feeding and rearing (Alt 1965, 1969, 1971, 1979). It is not known if inconnu spawn in these tributary streams or in the mainstem Yukon River.

Relative Abundance

Catch-per-unit-effort information can be a useful tool in comparing fish population densities at a given site through time. Factors influencing relative abundance estimates in lotic habitats include site and gear selectivity, season, water temperature, water level, turbidity, current, and fish mobility (Hubert 1983). The CPUE information presented in this study is an initial baseline estimate for site specific fish densities. To measure fluctuations in fish population densities through time, future investigations should concentrate effort at sample sites used in this study with similar gear types.

Experimental gill nets were most effective in capturing post-yearling Arctic grayling. Beach seining was most effective in capturing young-of-the-year fish (5 species totaling 407 individuals). Young-of-the-year chinook salmon were captured in greatest abundance adjacent to or in riffle areas associated with underwater debris, while adult grayling catch rates were highest in deep pools associated with riffle areas.

Length-at-age Relationships

Growth (length-at-age) of Arctic grayling in the streams studied appeared faster than for most interior Alaskan stocks (Armstrong 1982; Clark and Ridder 1988; Glesne et al. *in preparation*). However, time of collection, variable sample sizes, and different methods

of analysis and interpretation between researchers may influence these comparisons. The reliability of aging Arctic grayling from scales decreases substantially for fish over 320 mm fork length. Roguski and Winslow (1969), Roguski and Tack (1970), and Engel (1973) reported difficulty in aging grayling scales over age-5. Age composition analysis was not attempted because of this inherent bias and the selective nature of the various gear types used. Aging techniques for subarctic and arctic fish populations need to be validated before age information can be meaningfully interpreted.

Weight-length Relationships

Predicted weights of Arctic grayling were highest on the Nation and Tatonduk rivers. These streams also had the highest macroinvertebrate production. However, regression parameter estimates can deviate substantially from true population values when observations are not evenly distributed among length and weight groups, and there is only a partial representation of younger ages (Ricker 1975). Because of small sample sizes, observations were not evenly distributed among all size groups during this study which may have biased these results.

Chemical Parameters

The Charley River had the lowest average water quality values (alkalinity, hardness, and conductivity) of the four study drainages, probably due to differing lithologies between watersheds. The Yukon River divides the study area into two distinct geological districts. The northern district consists of mainly unmetamorphisized sediments (U.S. Department of the Interior 1985) while the southern district (Charley River) has large areas of metamorphosed rock (Stern 1978). Sedimentary rocks (e.g. limestone) are associated with higher alkalinities in surface and ground waters. The high edaphic values found on the Nation River are probably due to abundant localized sedimentary formations found in the watershed. The lowest edaphic values were found on Dewey Creek, a Charley River tributary. The creek flows through a large sphagnum moss area, causing a loss of salts and a gain of hydrogen ions, thereby lowering edaphic values.

O'Brien (1975) and Welp (*in preparation*) reported water quality values for the Charley, Nation, and Tatonduk rivers. These values were within ranges found in this study.

Physical Parameters

According to Platts et al. (1983), the Nation and Tatonduk rivers would be predicted to have the lowest densities of fish and aquatic macroinverebrates since they had the lowest percentages of pool and riffle areas. However, the relative abundance of fish species appeared similar among all four study drainages, and invertebrate densities and biomass measurements were higher (not lower) on the Nation and Tatonduk rivers. The high macroinvertebrate production (food) capacity of the Nation and Tatonduk rivers may overshadow the physical habitat effects of pool and riffle areas. Other unknown factors i.e., spawning and overwintering habitats may be predominantly responsible for the observed fish relative abundances. Different individuals collected habitat data in 1987 and 1988 and may have biased the results since measurements can be highly subjective (Platts et al. 1983).

Aquatic Macroinvertebrates

Macroinvertebrate mean density and biomass measurements were highest for sample sites on the Nation and Tatonduk rivers. These two streams also had the highest water quality values. LaPerriere et al. (1989) found that algal productivity is related to alkalinity, since available carbon derived from carbonate alkalinity is an algal macronutrient. Increased primary production would be expected to increase macroinvertebrate standing crop. An abundance of scrapers on the Nation and Tatonduk rivers is probably associated with an increase in algal production.

Aquatic macroinvertebrate diversity and abundance data can be a useful tool in detecting water quality changes (Connell and Miller 1984; Canter 1985). This study provides baseline indices to measure gross changes in macroinvertebrate community structure; paying attention to duplicating methods, sites, season, river stage, and data analysis procedures.

FUTURE STUDY NEEDS

1. *Chum salmon investigations on the Charley, Nation, and Tatonduk rivers.* One sample site should be located at least three miles upstream from the confluence with the Yukon River and be operational from September 1 to September 30. Multifilament gill nets (7.4 cm bar mesh) should be used and checked frequently to reduce mortality. If fish are found, radio transmitters should be used to track fish to spawning areas.

2. *Identification of chinook salmon spawning grounds from helicopter observations.* Surveys should be flown during or slightly after the peak spawning period (estimated around August 20). Ground surveys did not identify specific spawning areas due to low numbers of fish and possible spawning in tributary streams where ground access was limited. Extensive aerial surveys would greatly increase coverage of study drainages.

3. *Fishery investigation on the Seventymile River with emphasis on species distribution.* Very little fisheries data exists for this large drainage. A local resident reported chum salmon historically using this system (Barton 1984).

4. *Baseline water quality and fish tissue (liver and muscle) analysis on all Yukon River tributaries within the Yukon-Charley Rivers National Preserve.* The potential for off-preserve development affecting water quality in preserve streams exists (U.S. Department of the Interior 1985). A comprehensive baseline database is needed to ensure that present water quality conditions are maintained. The following trace elements and substances should be included in the analysis: Antimony, Arsenic, Asbestos, Beryllium, Boron, Cadmium, Calcium, Chromium, Copper, Iron, Lead, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Selenium, Silver, Thallium, Uranium, Vanadium, and Zinc. Water samples should include turbidity and total suspended solids measurements. Samples should be preconcentrated with sampling taking place during high water (break-up), low water, and storm events. Sites should be marked for replicate sampling and located at preserve boundaries and at confluences with major tributaries in each system. Analytical methods should follow Environmental Protection Agency criteria.

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Appendix 1.—Site references for fish distribution in the Kandik, Charley, Nation, and Tatonduk rivers, Yukon-Charley Rivers National Preserve, 1987 and 1988.

Site	Reference									
	This study	Alt 1965	Alt 1969	Alt 1971	Alt 1979	Barton 1984	Barton personal communication	O'Brien & Huggins 1975	Tepley 1981	Welp *in preparation*
Kandik River										
1				X						
2	X									
3	X									
4	X									
5	X			X						
6	X									
7	X						X		X	
8	X									
9	X									
10	X									
11				X						
12		X		X	X					
C	X									
F	X									
G	X									
Charley River										
1	X									
2										X
3	X									
4	X									
5										X
6	X									
7										X
8	X									X
9							X			
10								X		X
11		X	X	X		X		X		
C	X									

Appendix 1.—Continued.

Site	Reference									
	This study	Alt 1965	Alt 1969	Alt 1971	Alt 1979	Barton 1984	Barton personal communication	O'Brien & Huggins 1975	Tepley 1981	Welp *in preparation*
Nation River										
1	X									
2	X									
3	X									
4							X			X
5	X									X
6										X
7	X									X
8	X						X			X
9										X
10										X
11	X	X	X		X					X
B	X									
C	X									
Tatonduk River										
1										X
2	X									
3	X									
4	X									X
5		X	X		X					X

Appendix 2.—Fork length (mm)-at-age for round whitefish and chum and chinook salmon collected from Yukon-Charley Rivers National Preserve, 1987 and 1988.

River	Age (years) 0	1	2	3	4	5	6	7	8	9
					Round whitefish					
Nation River										
Mean		133.0		261.5		328.0	336.0	364.2	382.0	462.0
N		1		2		2	2	4	1	1
SD				19.1		31.1	35.4	28.5		
Range		133		248-275		306-350	311-361	342-399	382	462
Tatonduk River										
Mean	88.7	129.7							344.0	396.0
N	3	3							1	1
SD	16.3	3.2								
Range	76-107	126-132							344	396
					Chum salmon					
Nation River										
Mean						599.0				
N						2				
SD						1.4				
Range						598-600				
Tatonduk River										
Mean					590.0	515.0				
N					1	2				
SD						7.1				
Range					590	510-520				
					Chinook salmon					
Nation River										
Mean	68.8									
N	22									
SD	6.5									
Range	57-86									
Tatonduk River										
Mean	73.5									
N	11									
SD	4.8									
Range	66-81									
Kandik River										
Mean	65.7									
N	3									
SD	4.6									
Range	63-71									

Appendix 3.—Biomass, density, diversity, and number of taxa of aquatic macroinvertebrates collected from the Yukon-Charley Rivers National Preserve, 1987 and 1988 (3 samples per site).

River (date)	Site	Biomass (mg/0.1 m^2) Mean	Biomass (mg/0.1 m^2) Range	Density (number/0.1 m^2) Mean	Density (number/0.1 m^2) Range	Diversity index Mean	Diversity index Range	Number of taxa
Kandik River (07/29/87 to 08/07/87)	2	5.0	2-9	46.3	30-79	9.0	7.4-11.6	9
	3	11.0	8-15	86.7	69-99	10.0	6.9-12.5	10
	5	1.0		129.7	107-161	4.3	3.1-5.3	6
	7	4.3	1-8	32.3	13-44	6.2	5.2-7.7	10
	8	17.3	6-23	124.3	57-163	9.6	6.9-14.5	15
	10	1.7	1-3	11.3	4-16	5.7	1.0-9.1	9
Total		6.8	1-23	71.8	4-163	7.5	1.0-14.5	23
Kandik River (09/10/87 to 09/15/87)	2	10.3	6-17	79.3	53-126	3.8	3.1-4.6	9
	4	6.3	1-17	81.3	36-141	4.2	2.9-5.0	11
	6	14.0	7-22	209.0	53-336	8.1	5.4-9.7	15
	8	11.0	10-12	74.0	52-90	6.0	3.9-7.5	11
	9	9.3	7-13	82.3	36-134	7.4	4.7-8.9	10
Total		10.2	1-22	105.2	36-336	5.9	2.9-9.7	23
Kandik River Combined Total		8.4	1-23	87.0	4-336	6.7	1.0-14.5	29

Appendix 3.—Continued.

River (date)	Site	Biomass (mg/0.1 m^2) Mean	Biomass (mg/0.1 m^2) Range	Density (number/0.1 m^2) Mean	Density (number/0.1 m^2) Range	Diversity index Mean	Diversity index Range	Number of taxa
Charley River (08/11/87 to 08/20/87)	1	10.0	8-13	69.3	66-76	12.2	5.1-16.2	18
	3	3.7	1-8	77.7	40-98	9.0	7.5-9.8	10
	4	2.3	1-4	60.3	48-74	5.5	1.8-9.5	10
	6	2.7	1-5	21.3	12-34	3.9	1.9-6.9	10
	8	2.3	1-3	20.3	11-26	9.4	6.2-15.2	11
Total		4.2	1-13	49.8	11-98	8.0	1.8-16.2	27
Nation River (07/19/88 to 08/05/88)	2	190.3	88-384	968.3	445-1285	3.2	2.0-5.0	25
	3	76.7	59-92	325.3	217-400	7.6	6.5-8.2	21
	5	19.0	12-29	122.7	61-236	6.1	5.2-6.7	23
	7	27.3	19-40	185.7	123-218	8.4	7.5-9.3	25
	11	19.3	18-21	118.7	94-153	8.3	6.1-11.3	19
Total		66.5	12-384	344.1	61-1285	6.7	2.0-11.3	30

Appendix 3.—Continued.

River (date)	Site	Biomass (mg/0.1 m^2) Mean	Biomass (mg/0.1 m^2) Range	Density (number/0.1 m^2) Mean	Density (number/0.1 m^2) Range	Diversity index Mean	Diversity index Range	Number of taxa
Tatonduk River (08/17/88 to 08/23/88)	2A[a]	36.0	30-40	223.7	194-247	7.7	6.1-9.2	22
	2B	43.0	36-48	265.3	176-345	8.2	5.3-10.0	23
	3[b]	37.5	37-38	147.0	30-264	3.7	1.8-5.6	12
	4A	22.3	18-27	149.3	28-299	7.3	6.3-9.1	20
	4B	4.3	1-11	82.3	19-139	3.3	1.8-4.8	15
Total		28.6	1-48	173.5	19-345	6.0	1.8-10.0	31

[a]Two different riffle areas were sampled at sites 2 and 4, denoted by "A" and "B".
[b]One of the three samples was lost prior to analysis.