Volume 22 Study G-I-I

STATE OF ALASKA

Jay S. Hammond, Governor

Annual Performance Report for

INVENTORY AND CATALOGING OF ARCTIC AREA WATERS

by

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TABLE OF CONTENTS

STUDY NO. G-I INVENTORY AND CATALOGING Page

Job No. G-I-I Inventory and Cataloging of Arctic Area Waters
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Abstract 1
Background 2
Recommendations 3
  Research 3
  Management 3
Objectives 3
Techniques Used 6
  Lake and Stream Surveys 6
  Winter Sampling 7
  Radio Telemetry 7
Findings 8
  North Slope Haul Road 8
  Arctic Char Aerial Counts 9
  Killik River 9
  Colville River Winter Sampling 11
  Anaktuvuk River Char Studies 17
  Systematics 20
  Distribution and Migrations 22
  Spawning 22
  Radio Telemetry and Overwintering Habitats 24
  Age and Growth 25
  Food Habits 30
Literature Cited 32

LIST OF FIGURES

Figure 1. Arctic study area 5
Figure 2. Locations and species captured at under-ice netting sites in the Colville River during 1978 through 1980 14
Figure 3. Map of the Anaktuvuk River Drainage showing locations of major aufeis fields taken from aerial photographs in June 1980 21
Figure 4. Locations and numbers of Arctic char estimated by aerial survey in the Anaktuvuk River drainage during Sept. 1980 . . 23
Figure 5. Length frequency of Arctic char captured in the Anaktuvuk River 1980 27

LIST OF TABLES

Table 1. Fish species found along the haul road and central North Slope 4
Table 2. Aerial estimates of char in index areas of Sagavanirktok and Anaktuvuk River Systems 10

TABLE OF CONTENTS (Cont'd.)

		Page
Table 3.	Grayling from the Killik River, July 19-22, 1980	12
Table 4.	Physical characteristics and species present at each winter net site in the Colville River	15
Table 5.	Number of each species captured during each winter sampling period	18
Table 6.	Mean Fork lengths, weights and condition factors for male grayling captured in the Colville River during three time periods, 1978-1979	19
Table 7.	Fork-length, weight, sex and spawning condition of twelve char radio-tagged in the Anaktuvuk River, 1980	26
Table 8.	Age-length Frequency of 84 Arctic char captured in the Anaktuvuk River, 1980	28
Table 9.	Mean fork lengths, weights and condition factors for spring and fall caught char in the Anaktuvuk River, 1980	31

LIST OF TABLES

Table 1.	List of common names, scientific names and abbreviations of fish found in study area	36

Volume 22 Study No. G-I

RESEARCH PROJECT SEGMENT

State: ALASKA Name: Sport Fish Investigations of Alaska

Project No.: F-9-13

Study No.: G-I Study Title: INVENTORY AND CATALOGING

Job No.: G-I-I Job Title: Inventory and Cataloging of Arctic Area Waters

Cooperator: Terrence N. Bendock

Period Covered: July 1, 1980 to June 30, 1981

ABSTRACT

This report presents baseline information on the North Slope haul road sport fishing effort, aerial population estimates of Arctic char, Salvelinus alpinus (Linnaeus), discussion of the Killik River, winter fish habitats in the Colville River and Arctic char life history in the Anaktuvuk River.

Sport fishing pressure along the haul road north of the Yukon River was light and was concentrated in the vicinity of Alyeska pump stations. Small numbers of Arctic char were captured in the lower Sagavanirktok River and in Prudhoe Bay; however, Arctic grayling, Thymallus arcticus (Pallas), are the most frequently captured species within the region.

Aerial population estimates of Arctic char have been attempted annually in the Sagavanirktok River since 1971. Char counts were not conducted during 1980 due to adverse weather conditions, however, information on previous counts is presented.

The Killik River is increasing in popularity as a scenic float trip. Data are presented on the physiography and fish species of the Killik River obtained during a survey in July 1980.

Eleven sites were netted under the ice throughout a 60-mile stretch of the Colville River from below the confluence with the Anaktuvuk River to Ninuluk Creek. Netting was conducted over a 3-year period and data are presented on the species present and physical descriptions of the overwintering habitat. A total of 1,260 net hours yielded a catch of 435 fish comprised of six species. Grayling accounted for 88 percent of the total catch and were found at all eleven sampling sites. Overwintering habitats are greatly reduced compared to summer habitats. The composition of

species in the Colville River remains the same throughout the year; however, the relative abundance of fish shifts in favor of grayling during the winter months. None of the fish captured appear to segregate by size or by species into separate overwintering habitats.

Preliminary information on the first year's investigation of Arctic char in the Anaktuvuk River is presented. Information on the life history patterns, migration timing, and post-spawning activities is included. Radio-telemetry was used for studying char activity under the ice. Arctic char from the Anaktuvuk River experience a similar longevity, greater mean fork length at ages beyond Age V and larger ultimate size than char sampled in the Sagavanirktok River drainage.

BACKGROUND

The Alaska Department of Fish and Game, Sport Fish Division, has conducted fisheries investigations on the North Slope since 1968. Emphasis of this work has varied between drainages and species in an effort to meet the changing patterns of use and activities within this region. Construction of the North Slope haul road has tied the North Slope into the existing state highway system. Improved access has increased the demand for sport fishing, as well as other recreational, municipal, and commercial endeavors in this remote region of the state.

Petroleum exploration and development is the overriding force that is shaping the future on the North Slope; municipalities are viewing the newly-found state oil wealth as the key to funding capital improvement projects with costs that have long been out of reach. Many of these activities place increasing demands on the aquatic resources of the region and point to the need for more knowledge of the fish species inhabiting North Slope waters.

The report findings for this study are presented in five sections, each treated as a separate phase of the project. The North Slope haul road, while remaining closed to public access, provides excellent sport fishing for residents of the area. An informal creel census was conducted to monitor sport fishing effort.

Aerial counts of Arctic char have been conducted in the Sagavanirktok River drainage since 1971 in an effort to monitor the general stability of char populations. In 1979, char in the Anaktuvuk River were included in the survey effort. In 1980, extreme weather conditions prevented the aerial surveys; however, data from previous surveys are included in this section.

In a continuing effort to survey remote waters within the region, the Killik River was investigated in 1980. The Killik River is the largest tributary to the Colville River and headwaters in the newly-established Gates of the Arctic National Park. It is receiving increasing interest for scenic float-trips and provides excellent sport fishing for Arctic grayling.

Section four of this report summarizes 3 years of under-ice test netting in the Colville River. Increased concern over the lack of information on the winter biology of fish and their habitats has prompted the Division to accelerate investigations of overwintering fish on the North Slope. Sampling was conducted over a 60-mile stretch of the middle Colville River.

Section five of this report presents preliminary information on the first year's investigation of Arctic char in the Anaktuvuk River and includes data on life history, migration timings and winter biology. While Arctic grayling represent the "backbone" of North Slope sport fishing activities, Arctic char are the most highly publicized and sought-after fish in the region and in many ways are more vulnerable to the activities of industry and sport fishermen. These studies help delineate critical habitats and patterns in the life history of this valuable sport fish resource.

Table 1 lists the species of fish inhabiting waters of the North Slope and along the haul road north of the Yukon River. A map of the study area is presented in Figure 1.

RECOMMENDATIONS

Research

1. Lake and stream surveys should continue on North Slope waters with emphasis on the haul road corridor and the National Petroleum Reserve -Alaska.

2. Assessment of overwintering fish habitats in North Slope waters should continue with emphasis on spring-fed systems and the winter biology of Arctic char.

3. Fall populations of Arctic char in the Sagavanirktok and Anaktuvuk Rivers should be enumerated.

Management

1. Assessment of the fishing potential of area waters adjacent to the North Slope haul road should continue.

2. Sport fishing pressure on area waters should be monitored.

OBJECTIVES

1. To conduct fall aerial surveys of selected waters on the North Slope to determine locations and estimate the abundance of Arctic char stocks with emphasis on the Sagavanirktok and Colville River drainages.

Table 1. Fish species found along the haul road and central North Slope.

Common Name	Scientific Name and Author	Abbreviation
Arctic char	Salvelinus alpinus (Linnaeus)	AC
Arctic cisco	Coregonus autumnalis (Pallas)	ACI
Arctic grayling	Thymallus arcticus (Pallas)	GR
Broad whitefish	Coregonus nasus (Pallas)	BWF
Burbot	Lota lota (Linnaeus)	BB
Chum salmon	Oncorhynchus keta (Walbaum)	CS
Humpback whitefish	Coregonus pidschian (Gmelin)	HWF
King salmon	Oncorhynchus tshawytscha (Walbaum)	KS
Lake trout	Salvelinus namaycush (Walbaum)	LT
Least cisco	Coregonus sardinella Valenciennes	LCI
Longnose sucker	Catostomus catostomus Forster	LNS
Ninespine stickleback	Pungitius pungitius (Linnaeus)	NSB
Northern pike	Esox lucius Linnaeus	NP
Pink salmon	Oncorhynchus gorbuscha (Walbaum)	PS
Round whitefish	Prosopium cylindraceum (Pallas)	RWF
Sheefish	Stenodus leucichthys (Güldenstadt)	SF
Slimy sculpin	Cottus cognatus Richardson	SSC

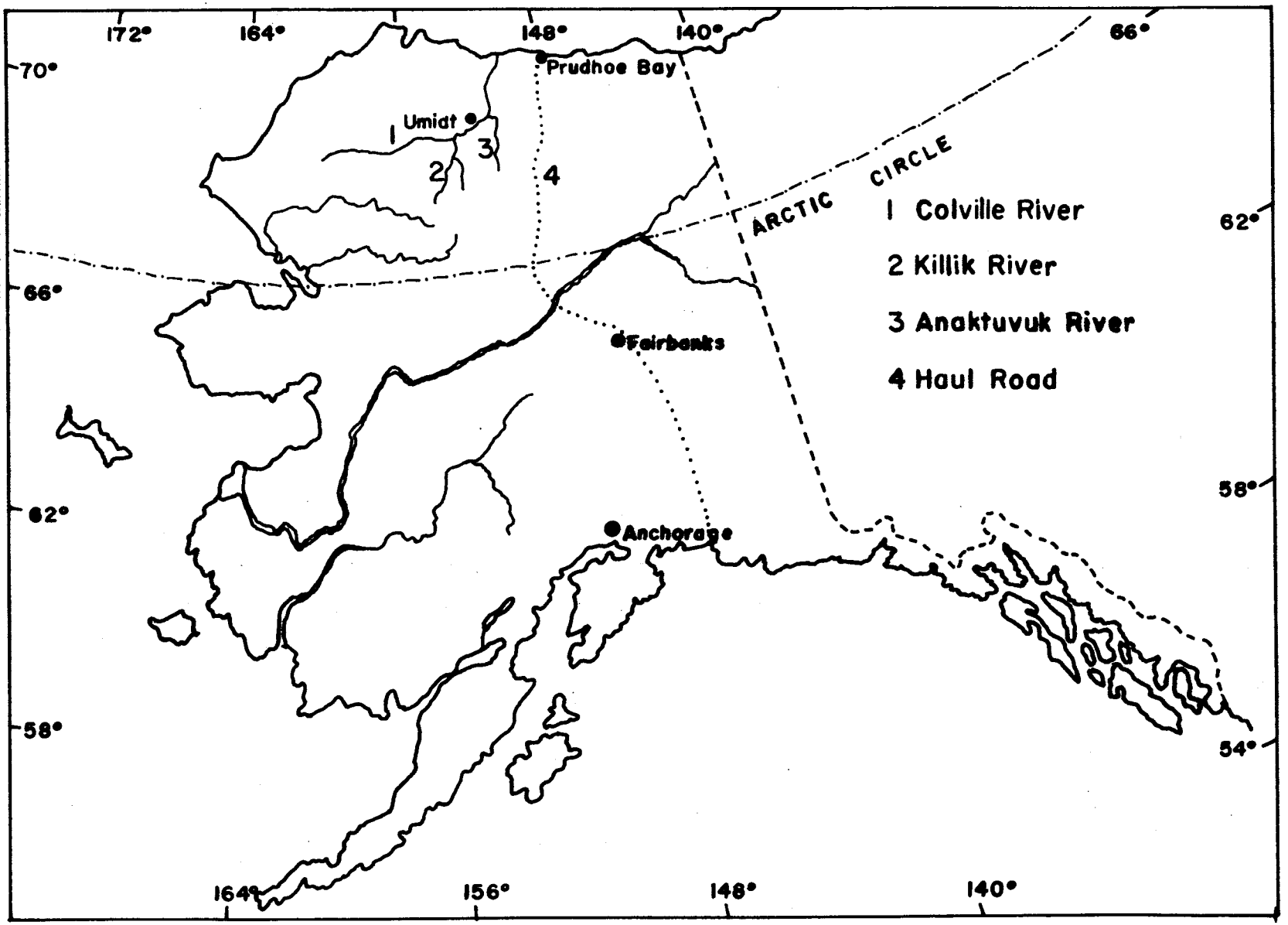

Figure 1. Arctic study area.

2. To continue monitoring sport fishing pressure on selected waters of the North Slope with emphasis on the North Slope haul road corridor.

3. To determine the availability and use of overwintering fish habitat in lakes and streams of the North Slope with emphasis on the Sagavanirktok and Colville River drainages.

4. To continue inventory and cataloging of potential sport fish waters on the North Slope.

5. To provide recommendations for the management of sport fish resources of the job area.

TECHNIQUES USED

Lake and Stream Surveys

A float-equipped Cessna 185 aircraft was used to transport field crews and equipment to remote lakes within the study area. Waters adjacent to the haul road were surveyed using an Avon raft which was carried to the lake from the nearest access road. For the Killik River survey, a Grumman Super Widgeon aircraft was used to transport the field crew to Tululik Lake at the junction of the Killik River and Easter Creek.

Physiographic data, as well as latitude and longitude, were calculated from 1956 U.S. Geological Survey (USGS) 1:250,000 maps and sectional aeronautical charts.

Water chemistry data were measured using a Hach AL-36B field test kit. Water depths were determined with a Lowrance fathometer and a standard 10-in Secchi disc was used for water clarity.

Multifilament and monofiliment graduated mesh sinking or floating gill nets, measuring 125 x 6 ft and consisting of five 25-ft panels of 1/2-in through 2-1/2-in bar mesh, were used to capture fish. Other sampling gear included 25 x 4-ft beach seines, and 25 x 6 ft x 1/2-in mesh multifilament gill nets. Hook and line sampling was used to capture burbot and Arctic char.

All data were recorded on standard Alaska Department of Fish and Game stream and lake survey forms.

All fish samples were grouped by date and location. Weights were recorded to the nearest gram using a Chatillon spring scale. Fork lengths were measured to the nearest millimeter, and sex and stage of maturity were determined by examining gonads.

Ages of Arctic char, lake trout and burbot were determined from otoliths wetted in glycerine and alcohol and viewed under a binocular miscroscope.

All other fish were aged by reading scales. Scales were cleaned and impressed on 20 mil acetate sheets. A Bruning 200 microprojector was used to read scales.

Winter Sampling

Deep holes in the Colville River were located in the fall using a fathometer mounted in a riverboat and were marked with surveyors' tape, as well as recorded on USGS 1:63,360 maps. Snow machines were then used to transport personnel and equipment to these locations during the sampling periods.

Ice, water and snow depths were measured to the nearest inch. Dissolved oxygen levels were measured using a Hach AL-36B field test kit and the low range titration procedure.

Holes were drilled through ice using a gasoline-powered portable digger with a 10-in bit. Monofilament graduated mesh sinking gill nets, measuring 125 x 6 ft (or individual 50 ft and 25 ft panels from these nets), were used to capture fish under the ice. A "Murphy stick" (Bendock, 1980) was used to string net lines under the Colville River ice. Burbot were captured using large baited hooks attached to lines set under the ice.

Radio Telemetry

Twelve Telonics RB-5 radio transmitters were inserted into the stomachs of Arctic char captured in the Anaktuvuk River near Rooftop Ridge. The transmitters ("tags") were imbedded in wax and had 18" red teflon wire external antennae. The frequencies of the transmitters ranged from 151.000 MHz to 151.220 MHz.

The signals from the transmitters were received using a Telonics RA-2AK antenna mounted on the wing strut of a Cessna 185 aircraft, a Telonics TS-1 Scanner/Processor, and a Telonics TR-2 Biomedical Telemetry Receiver.

Field crews were transported to the Anaktuvuk River by fixed-wing aircraft. A holding pen was formed from a 25' beach seine closing off a back water area. To capture Arctic char, a 100' x 4' beach seine was used initially but proved to be too shallow to prevent the fish from escaping. Hence, the majority of the fish that were tagged were captured with rod and reel and placed in the holding pen until tagging.

Before removing a fish from the holding pen, the frequency of the transmitter to be used was confirmed with the scanner/processor-receiver. A fish was then taken from the holding pen and anesthetized with MS-222. Fork length of each fish was measured to the nearest millimeter and the weight was taken to the nearest gram. The posterior end of the radio "tag" was dipped in glycerine and inserted through the fish's mouth into the stomach. The external antenna, which trailed out of the mouth along the side of the fish was secured to the upper maxillary with a monel size 1 Jiffy wing band (National Band and Tag Co.). The fish was returned to the

holding pen and revived from the anesthetic. The frequency of the radio signal was again checked, corrected for and programmed into the scanner/ processor. After approximately 1 hour, the fish was released.

In addition to the 12 fish that were radio-tagged, 39 fish were tagged with yellow numbered Floy FD-67 internal anchor tags.

To relocate the radio-tagged fish, a Cessna 185 was used to fly tracks perpendicular to or parallel with the Anaktuvuk River valley. In this way, fish moving both up and down stream, as well as into alternate channels could be located. Movements of the radio-tagged fish were monitored by this method at approximately 2-week intervals following the tagging procedure. Radio signals were received within a 2-mile radius of the fish when flying approximately 800 ft above ground level.

FINDINGS

North Slope Haul Road

The North Slope haul road was built in 1974 by Alyeska Pipeline Service Company to service construction of the Trans-Alaska Pipeline and was transferred to the State in 1978. In May of 1974, by emergency field announcement, the Alaska Department of Fish and Game closed to sport fishing a strip within 5 miles on each side of the pipeline between the Yukon River and Prudhoe Bay. The closure was enacted because of the unknown impacts of construction camps, and the lack of biological information on affected fish populations. In the spring of 1979, as a result of a proposal initiated by Alyeska Pipeline Service Company, the Alaska Board of Fisheries rescinded the haul road closure, opening sport fishing for all species except sheefish and salmon. The State of Alaska controls use of the haul road north of the Yukon River. Use is presently limited to people associated with Alyeska, Prudhoe Bay oil companies and their subcontractors, State employees involved with highway maintenance and public safety, and several other commercial users such as guides and miners. A security check station located just north of the Yukon River bridge ensures that only "qualified" users gain access to the haul road.

During the summer of 1980, sport fishing effort and harvest information was obtained through angler interviews and a voluntary creel census at Pump Station 5. Sport fishing pressure was light throughout the haul road corridor north of the Yukon River and was concentrated at locations near the Alyeska pump stations. As in 1979, the most frequented locations south of Atigun pass were Grayling Lake and the Jim River. North of Atigun pass the lakes in the vicinity of Pump Station 4, as well as the upper Kuparuk River, were most frequently fished. Small catches of Arctic char were made in Prudhoe Bay and the lower Sagavanirktok River. Sport fishing pressure is restricted by limited public access to the haul road.

Arctic Char Aerial Counts

Aerial counts of Arctic char have been attempted annually in the Sagavanirktok River system since 1971. All of the major tributaries to the Sagavanirktok River determined to be char spawning areas were counted between 1971 and 1975. Since 1976, only the Ivishak and Echooka Rivers have been counted. The Ivishak River contains the largest aggregation of char in the system and is considered an index to overall population levels. Prior to 1977, counts were conducted by helicopter; however, subsequent counts have been made using fixed wing (Piper PA18) aircraft. All of the estimates have been made during the second or third week of September.

Arctic char at two locations in the Anaktuvuk River drainage were counted in addition to the Sagavanirktok River in 1979. Adverse weather conditions in 1980 prevented the char counts in either system. Table 2 lists the values for previous estimates in the Sagavanirktok and Anaktuvuk River drainages.

Killik River

The Killik River heads in the Brooks Range at the junction of April and Kakivilak Creeks and flows north 169 km (105 mi) to the Colville River, 83.6 km (52 mi) southwest of Umiat. The upper section of the Killik River from Easter Creek to Sunday Rapids is a broad meandering channel that cuts through the northern edge of the Brooks Range.

Water velocity in Easter Creek was 5 fps on July 19, 1980. Water chemistry data were: hardness 120ppm, PH 8 and water temperature 49°F.

The middle Killik River valley is 4.8 to 6.4 km (3 to 4 mi) wide and the floodplain contains numerous lakes. Exposed and vegetated sand dunes border this stretch of the Killik and the bars are composed of sand and assorted gravel. The bottom is primarily mud and sand with many shallow areas. Below Akalik Creek down to Sunday Rapids, the valley broadens and the bars are primarily mud. During July 1980 the water was clear.

Sunday Rapids begins a section of swift water through boulder fields enclosed in relatively steep hillsides. Sunday Rapids is one of a series of shoots that occur frequently down to the mouth of Okokmilaga Creek. In this section, the river has a steep gradient and is usually a single or split channel.

From Okokmilaga Creek to the mouth, the Killik is heavily braided with broad gravel bars consisting primarily of large material. Spring areas and aufeis fields are present in this section and the river flows through a broad valley bordered by low ridges. Turbidity varies with precipitation; however, the water is usually brown and clears up only for brief periods during mid and late summer. During clear water periods, fair angling for grayling is found in this part of the river in the pools below riffles.

able 2. Aerial estimates of char in index areas of Sagavanirktok and Anaktuvuk River Systems.

System	Location	1971	1972	1973	1974	1975	1976	1977*	1978*	1979	1980*
agavanirktok iver	Echooka R.	1,137	1,688	1,883	2,160	852	2,254	...	...	814	...
	Ivishak R.	13,958	11,937	10,009	13,140	8,643	8,570	...	...	24,403	...
naktuvuk iver	"Tuluga"	...	...	...	...	...	...	...	...	15,717	...
	Nanushuk R.	...	...	...	...	...	...	...	...	934	...

Poor weather conditions prevented char counts during late September.

Grayling, lake trout, round whitefish, burbot, longnose suckers, ninespine stickleback, and slimy sculpin have been captured in the lower reaches of the Killik River (Bendock 1979). Northern pike, broad whitefish, and least cisco are present in lakes of the upper Killik drainage, however, none were captured in the mainstem of the river. In addition, stream resident Arctic char have been reported in the Killik River (Morrow 1973).

During a river survey conducted during July from Easter Creek to the mouth, only grayling and round whitefish were captured above the mouth of the Okomilaga River. Age, weight and length data from grayling captured in the Killik River are presented in Table 3. Good net sites were scarce throughout the Killik River.

Colville River Winter Sampling

Fisheries investigations on the North Slope during the past decade have concentrated on the biology of fish during the relatively short open water season. Consequently, the location and significance of overwintering areas for fish in northern waters is poorly understood. At the same time, domestic and commercial demands for fresh water, gravel, and other resources that affect aquatic habitats during winter months have been steadily increasing since the advent of petroleum development in the late 1960s. Past fisheries studies during winter months have included aerial surveys or observations during late fall and early spring (Craig and McCart 1974), or have emphasized the delineation of potential overwintering habitat by observing the physical characteristics of water bodies such as ice thickness, water depth, and dissolved oxygen levels, (Aquatic Environments, 1973 and Sloan, 1976. Furniss and Ward (1976) and Jones (1976) assessed winter water availability along two proposed natural gas pipeline routes in northern Alaska. State and Federal agencies have addressed "instream flows" and water availability in an effort to establish guidelines or criteria for mitigating conflicting winter water uses in northern Alaska (Ott and Tarbox, 1977; and Wilson et. al, 1977).

Few studies to date, however, have included a winter sampling program to add perspective to the descriptive habitat accounts. Mann (1975) sampled overwintering fish in the Mackenzie River delta, while Kogl and Schell (1975), Bendock (1979 and 1980), and Craig and Haldorson, (1979) netted sections of the Colville River during winter months. Unfrozen pools under thick ice in the Sagavanirktok River were netted by Alt and Furniss (1976), and Bendock (1977) netted the lower Kuparuk and Sagavanirktok Rivers.

The above studies indicate that overwintering habitats on the North Slope are much more restricted than summer habitats. The majority of streams freeze to the bottom or freeze intermittently, providing unsuitable space, quality of water, or dissolved oxygen levels to support populations of fish. Even the largest streams in Arctic Alaska (Colville and Sagavanirktok Rivers) freeze to the bottom intermittently and cease discharging during late winter months. Four types of habitat have been shown to provide suitable overwintering conditions for various species of North Slope fish. These are: (1) intermittent pools under river ice, (2)

Table 3. Grayling from the Killik River, July 19-22, 1980.

Age Class	n	Fork Length (mm) Range	Fork Length (mm) $\bar{x}$	Weight (g) Range	Weight (g) $\bar{x}$	Maturity
III	1	210	210	80	80	Immature
IV	3	240-260	250	130-170	146.6	Immature
V	3	282-293	287.6	200-240	216.6	Mature
VII	3	209-325	314.6	280-320	300	Mature
VIII	5	331-366	348	340-430	368	Mature
IX	2	335-343	329	320-360	340	Mature

brackish river deltas, (3) spring or ground water areas, and (4) deep lakes. Due to their limited size, these areas appear to be more vulnerable to extremes in weather conditions and the adverse impacts of human activity than are summer habitats.

This report summarizes 3 years of netting in intermittent pools under the ice in the middle reaches of the Colville River. Results from summer and fall netting in the same area are reported in Bendock (1979).

Under Ice Netting:

Eleven sites were netted under the ice throughout a 60-mile stretch of the Colville River from below the confluence with the Anaktuvuk River to Ninuluk Creek (Fig. 2). Gill netting was conducted during March and April of 1978 and 1979 and during March of 1980. All of the sites represent habitats of standing water in deep pools under river ice. Fish movement was restricted at each site by grounded ice at the upper and lower ends of the pools and gill netting was usually conducted in the deepest water available. Several of the sites had extensive areas of slush under the river ice which further reduced the available fish habitat. At all sites, there was no measurable flow and the water was transparent and odorless. Frozen or layered overflow varied among sites; however, there was no apparent ground water activity as evidenced by aufeis or open leads. Table 4 lists the species present, physical parameters and dissolved oxygen values obtained at each site during the sampling periods.

Sunlight increases rapidly at the study area during the sampling period. March begins with almost 12 hours of sunlight (including civil twilight), while April ends with continuous sunlight. Air temperatures during the sampling periods ranged from 35°F to -60°F. Umiat, centrally located within the study area, receives 6 in of precipitation per year, including 33 in of snow.

Ice thickness at the sampling sites averaged 51.7 in and ranged from 36 in to 70 in. Snow depths were usually shallow and averaged 9.7 in for the combined sampling period at all sites. In 1979, there was approximately half as much snow ($\bar{x}$=8 in vs. 15.5 in) but an average of 6 in more ice than in 1978. Water depths ranged from 23 in to 192 in and averaged 103.5 in. At all sites, water temperature was approximately 32°F.

Bottom material was either cobble, gravel or sand, and was determined by observation through the end holes in the ice. Cobble bottoms were characteristic of sites located near high bluffs or cliffs. Gravel bottoms were characteristic of deep holes in the floodplain, and a single sandy bottom was noted at a site along a cutbank in the floodplain. No correlation was found between substrate type and the fish species present.

Dissolved oxygen levels ranged from 0.6 ppm to 5.6 ppm and averaged 2.3 ppm. Some pools maintained consistently higher levels of dissolved oxygen than others (i.e. Prince Creek Bluff vs. Umiat Bar). In those holes for which we have comparable data, dissolved oxygen averaged 2.6 ppm in 1978 and 1.5 ppm in 1979.

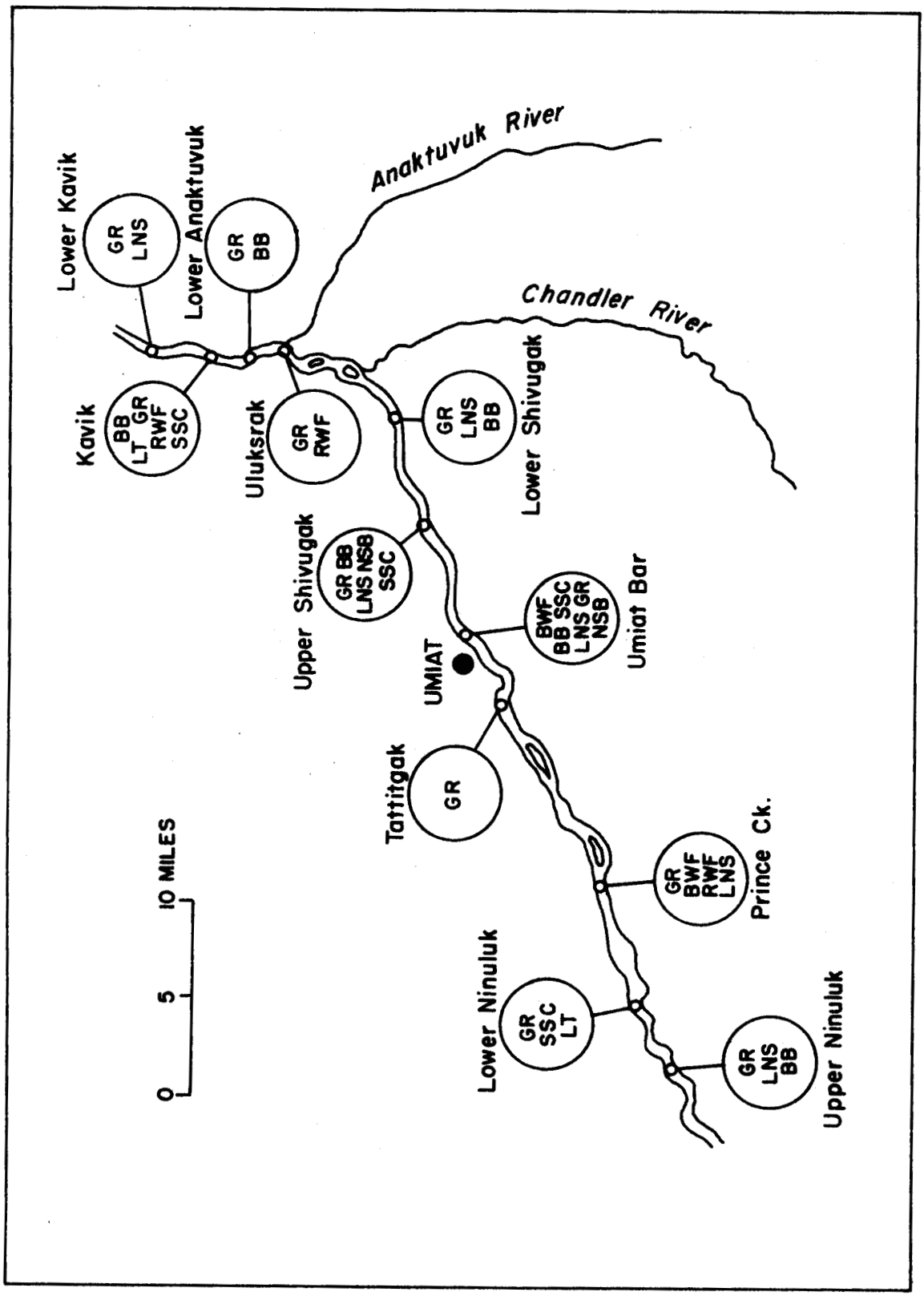

Figure 2. Locations and species captured at under-ice netting sites in the Colville River during 1978 through 1980.

Table 4. Physical characteristics and species present at each winter net site in the Colville River.

Location	Date	D.O. (ppm)	Snow Depth (inches)	Ice Depth (inches)	Water Depth (inches)	Water Temp (¼F)	Bottom Material	Species Present
Upper Ninuluk	4-09-79	1.2	4	52	72	32	Gravel	GR, BB, LNS
Lower Ninuluk	4-08-79	2.4	12	48	96	32	Rubble	GR, LT, SSC
Prince Cr. Bluff	4-16-78	4.6	12	48	144	32	Rubble	GR, BWF, RWF, LNS
	3-09-79	3.2	10	48	126	32	Rubble	No net
	4-13-79	2.2	9	48	104	32	Rubble	No net
	3-20-80	1.2	6	60	78	32	Rubble	No net
Tattitgak Bluff	3-07-79	1.0	10	39	123	32	Sand	GR
	4-07-79	0.6	16	44	58	32	Sand	GR
	3-20-80	2.4	11	60	23	32	Sand	No net
Umiat Bar	3-21-78	1.4	23	36	120	32	Gravel	GR, BWF, LNS, NSB, SSC, BB
	3-07-79	0.8	1	55	75	32	Gravel	No net
	4-14-79	1.0	5	67	99	32	Gravel	LNS, GR
	3-20-80	4.2	20	49	84	32	Gravel	No net
Upper Shivugak	3-21-78	1.6	18	39	192	32	Rubble	GR, BB, LNS, NSB
	4-13-78	2.4	16	37	180	32	Rubble	GR, BB, SSC
	3-12-79	1.4	10	36	132	32	Rubble	GR, BB, LNS

Table 4. (cont.) Physical characteristics and species present at each winter net site in the Colville River

Location	Date	D.O. (ppm)	Snow Depth (inches)	Ice Depth (inches)	Water Depth (inches)	Water Temp (½F)	Bottom Material	Species Present
Lower Shivugak	4-14-78	2.8	14	42	48	32	Rubble	No net
	3-11-79	1.6	3	67	173	32	Rubble	GR, LNS, BB
Uluksrak Bluff	4-14-78	2.6	10	62	112	32	Rubble	GR, RWF
Lower Anaktuvuk	3-21-80	4.0	0	65	67	32	Gravel	GR, BB
VABM Kavik	3-21-80	5.6	0	65	103	32	Rubble	GR, LT, RWF, BB, SSC
Lower Kavik	3-22-80	3.0	4	70	69	32	Gravel	GR, LNS
$\bar{x}$ values	...	2.3	9.7	51.7	103.5	32	...	...
Range	...	0.6-5.6	0-23	36-70	23-192		...	...

Capture Effort and Species Present:

A total of 1,260 net hours yielded a catch of 435 fish comprised of six species. An additional two species (ninespine stickleback and slimy sculpin) were found as food items in burbot and lake trout. Table 5 lists the numbers of each species captured during monthly sampling periods.

All sites of an adequate depth for sampling contained one or more species of fish. Similarly, previous work conducted in the lower Kuparuk and Sagavanirktok Rivers showed the same result (Bendock, 1977); thus it is likely than non-migratory fish utilize all areas of free-standing water under river ice as overwintering habitat. Many overwintering sites, particularly in braided river deltas, appear to be susceptible to seasonal changes in conformation or depth due to riverbank and bed instability and erosion. This process can be dramatically accelerated by human activities such as road construction and gravel extraction.

The species composition of fish inhabiting the Colville River near Umiat remains the same throughout the year. The predominant fish species captured during open water periods (grayling, broad whitefish, round whitefish, burbot, longnose sucker, ninespine stickleback, and slimy sculpin) were also taken during the 3 years of winter sampling. Humpback whitefish, which migrate upstream past Umiat during the fall, were not captured during the winter netting.

Grayling accounted for 88% of the total catch and were found at all eleven sampling sites. The relative abundance of grayling, as evidenced by the catch per unit effort, increased during the winter netting as a result of fish moving into the Colville River from summer habitats that freeze to the bottom. When locations were netted in consecutive months, the catch per unit effort dropped sharply, which may suggest that the total number of fish overwintering in each hole is low.

All of the principal species except broad whitefish contained food in their stomachs throughout the sampling periods. Mayfly and stonefly larvae were the predominent food items found in grayling, while burbot and lake trout were feeding on ninespine stickleback and slimy sculpins. Chironomid larvae were the principal food item in round whitefish. Using a t-test at the 90% confidence level, the coeficient of condition for a sample of male grayling captured in the Colville River was lower in March than in October (Table 6).

Burbot, which spawn in the main reaches of the Colville River during winter, had completed spawning prior to our March sampling periods.

None of the fish captured appear to segregate by size or by species into separate overwintering locations.

Anaktuvuk River Char Studies

Background:

The Anaktuvuk River, second largest tributary to the Colville River, heads in the Endicott Mountains and flows north northwest for 132 mi. It enters

Table 5. Number of each species captured during each winter sampling period.

SPECIES	MAR 3-78	APR 4-78	MAR 3-79	APR 4-79	MAR 3-80	Total	% of Total
GR	155	14	123	45	45	382	88
LNS	8	5	5	2	1	21	5
RWF	0	3	0	0	8	11	3
BB	2	2	2	2	2	10	2
BWF	1	6	0	0	0	7	1
LT	0	0	0	1	3	4	1
Total	166	30	130	50	59	435	100
fish/net hr.	0.65	0.08	0.77	0.12	0.61	0.34	..

Table 6. Mean Fork lengths, weights and condition factors for male grayling captured in the Colville River during three time periods, 1978-1979.

Month	n	Mean FL (mm)	Mean Wt. (g)	Mean Condition Factor*
March	10	325	368	1.08
July	10	323	382	1.13
Oct.	10	320	365	1.13

* Condition factor = $(K) = \frac{\text{weight}}{\text{length}^3} \times 10^5$

the Colville River 91 mi inland from Harrison Bay. The Anaktuvuk River drainage is 2,839 sq. mi and the estimated mean annual flow rate is 1,420 cfs. The Nanushuk River, largest of three main tributaries entering the Anaktuvuk River, flows north for 94 mi and drains an area of 896 sq. mi. There are numerous lakes in the Anaktuvuk River drainage. Shainin Lake, the largest, is 2.7 mi long and has a maximum depth of 56 ft. Deep lakes within the drainage are typically inhabited by lake trout, Arctic char and grayling.

The Anaktuvuk River is heavily braided throughout most of its length and has bottom material ranging from fine sand in the upper and foothills region to large gravel and boulders in the middle and lower reaches. Spring areas, perennial sources of ground water, are abundant adjacent to and within the River valley, creating large fields of aufeis that remain throughout most of the open water season (Fig. 3). Spring areas also maintain open leads in the river throughout the winter months.

Anaktuvuk Pass, a small Nunamiut village, is located at the head of the Anaktuvuk River. There are two gravel airstrips constructed for exploratory oil drilling adjacent to the Anaktuvuk River. Fishing pressure within the drainage is light.

Arctic char, lake trout, grayling, round whitefish, broad whitefish, burbot, slimy sculpin, and ninespine stickleback inhabit the Anaktuvuk River. Pink salmon, chum salmon and humpback whitefish have been captured at the mouth of the Anaktuvuk River. Bendock (1979) presented survey information obtained in the lower reaches of the river.

Arctic char were first reported in the Anaktuvuk River by Winslow and Roguski (1970). Kogl (1971) reported capturing anadromous char in the Colville River and rearing char in the upper Anaktuvuk River. Bendock (1980) reported on two fall concentrations of Arctic char in the Anaktuvuk River and estimated (by aerial survey) the largest group to contain over 15,000 fish, comprised of both spawning and non-spawning individuals. Following these earlier observations, the Sport Fish Division initiated an investigation to examine the distribution, migration timing and patterns and overwintering habitats of Arctic char in the Anaktuvuk River. This section of the report presents preliminary findings of this investigation.

Systematics

The present taxonomy of Arctic char inhabiting Alaskan and Northern Canadian waters is in debate; however, for the purposes of this report, all anadromous char investigated in the Anaktuvuk River are considered to be Salvelinus alpinus as described by McPhail (1961). Arctic char captured within the study area have low mean gill raker counts on the first arch. A sample of 50 char taken in the Anaktuvuk River showed a mean gill raker count of 21.9 (range 18-25). This further delineates them as being the western form of Salvelinus alpinus as discussed by McCart (1980). The gill raker counts and general life history pattern of anadromous char in the Anaktuvuk River coincides closely with char investigated in other eastern Arctic drainages in Alaska.

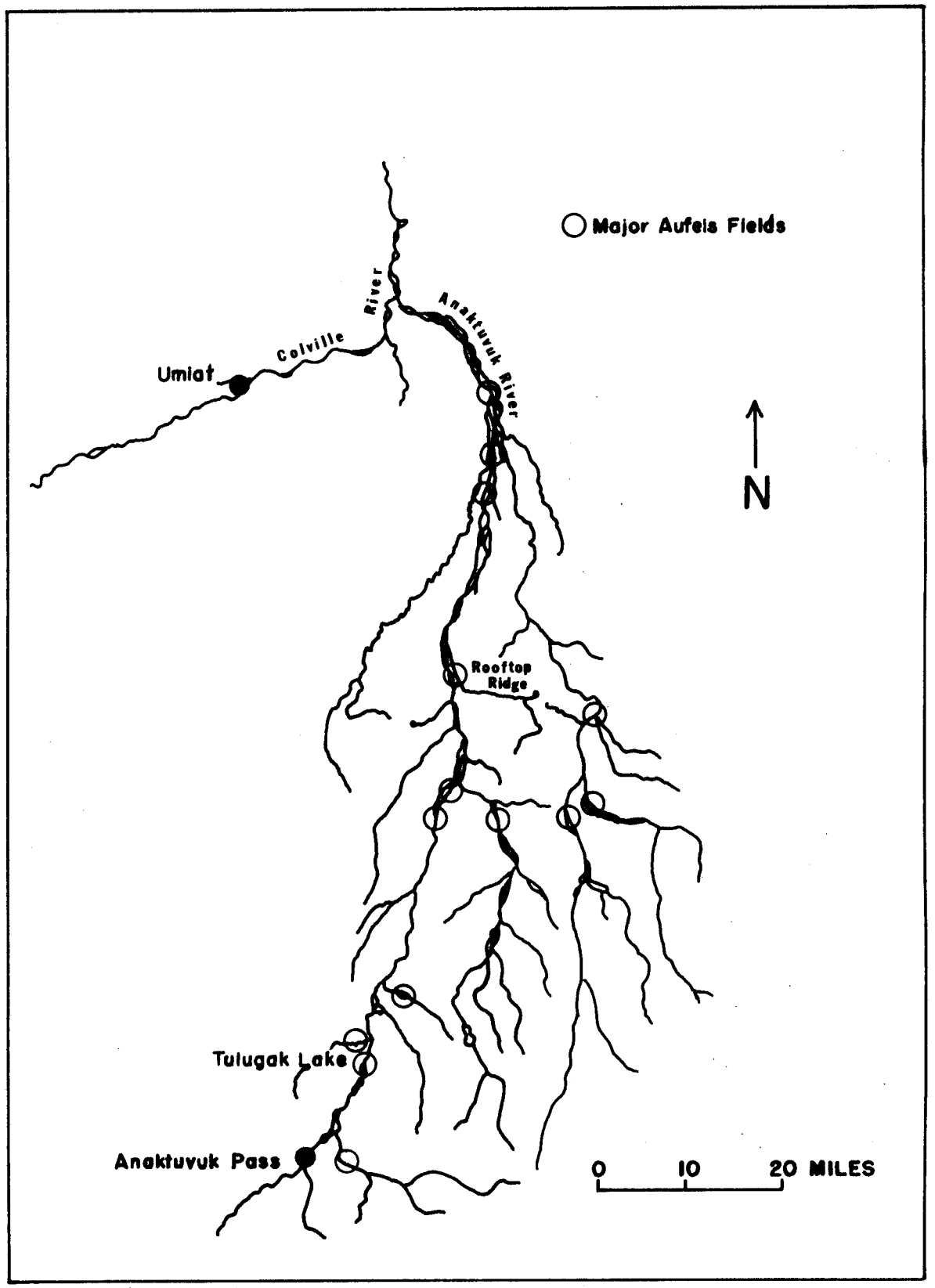

Figure 3. Map of the Anaktuvuk River Drainage showing locations of major aufeis fields taken from aerial photographs in June 1980.

Distribution and Migrations

Breakup occurs on the Anaktuvuk River between the last week of May and the first week of June. The river is usually ice-free (except for aufeis fields) by the end of the first week in June. Gill net sampling on June 9 and 10, 1980 showed large numbers of char in the lower 15 mi of the Anaktuvuk, as well as at the mouth. These fish were presumably out-migrants destined for the lower Colville River and the Beaufort Sea. The lower Anaktuvuk River does not have large fall concentrations of char; thus, it was further presumed that these out-migrants had overwintered some distance upstream from their place of capture. Out-migrating char ranged in fork length from 375 mm to 750 mm and in weight from 500 g to 3,000 g (N=40). The male:female ratio was 1:1.5. Twenty-seven percent of the catch was judged to be immature, while 68% were mature and 5% had spawned the previous fall, as evidenced by retained eggs. The Anaktuvuk River was turbid and the water level dropping during this sampling period. The water temperature was 43°F.

Throughout late June and July catches of Arctic char in the lower Colville and Anaktuvuk Rivers are infrequent (Kogl and Schell, 1975; Bendock, 1979). In-migrating char were first captured in the lower Colville River during mid-August. Between August 11 and 15, mature Arctic char were captured in the Colville River within 15 mi of the Anaktuvuk River. Char began ascending the Anaktuvuk River on August 15th and catches remained high through September 8, at which time sampling ended. As indicated in other studies (McCart, 1980), the in-migration of char to the Anaktuvuk River occurs over a wider period of time than the downstream migration. Adult spawners and non-spawners preceeded the immature fish. Migrating Arctic char captured in mid-August averaged 507 mm in fork length (N=9) while char captured on September 9th averaged 295 mm (N=23) and were comprised exclusively of immature fish.

Adult spawning and non-spawning char were first observed concentrating in the middle reaches of the Anaktuvuk River during the first week of September. Paired spawners were occupying redds as early as September 5 and by September 12 large concentrations were observed near the "Tuluga" spawning area. By the third week of September concentrations of spawners and non-spawners were widely distributed throughout the Anaktuvuk River drainage. Figure 4 shows the locations and estimated numbers of char observed in the Anaktuvuk River during the fall of 1980. Slush ice began forming in the Anaktuvuk River on September 22.

Spawning

Spawning char were observed and captured in a channel adjacent to Rooftop Ridge on September 20. Males were aggressively defending territories; however, most of the fish captured were either partially of fully/spent. Spent fish leaving the redds moved in with groups of non-spawning individuals occupying pools in adjacent channels of the main river.

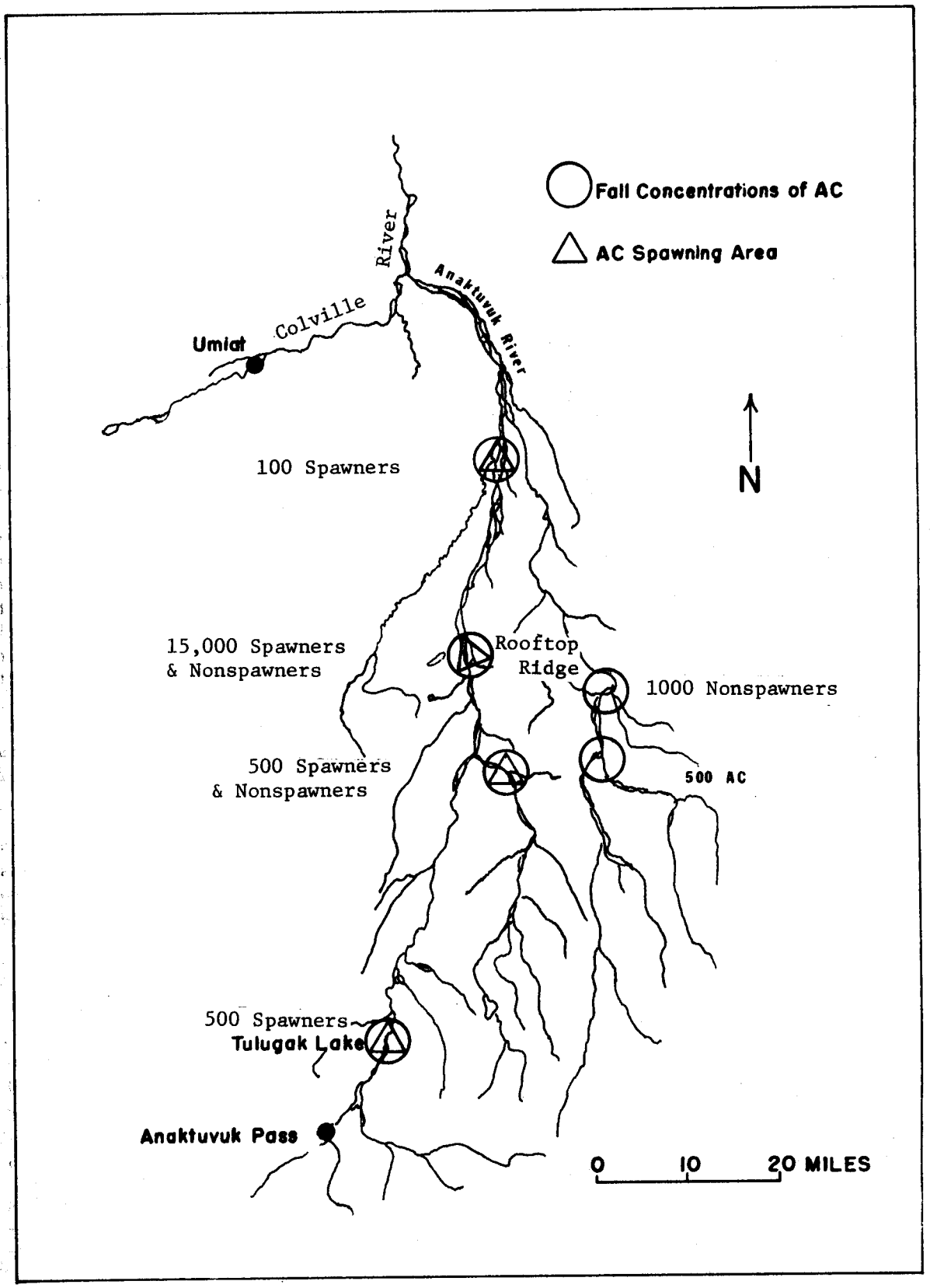

Figure 4. Locations and numbers of Arctic char estimated by aerial survey in the Anaktuvuk River drainage during Sept. 1980.

The spawning channel was a dead-ended spring area measuring less than 50 ft wide by approximately 1/3 mi long. Water discharged into the mainstem of the Anaktuvuk where large numbers of non-spawners and spent fish were congregated. The spawning channel had a maximum depth of 3 ft and velocity of less than 1 fps. The water was colorless with a temperature of 33°F. Bottom material was mixed, ranging from sand to gravel up to 3 in in diameter. Paired fish were uniformly distributed throughout the spawning channel. Males appeared to defend an area of approximately 100 sq ft. Redds were small oval areas of washed gravel measuring approximately 1 ft x 2 ft with a single depressed nest in the center. Spawning males captured on the redds were as small as 550 g with only moderately developed secondary sexual characteristics and dark coloration, as large as 5 kg with bright coloration, lateral compression, humpback, large kype with corresponding notch on the upper jaw and enlarged teeth. None of the spawning fish were feeding.

Four spawning locations were identified in the Anaktuvuk River drainage during 1980 (Fig. 3). Observations from low flying aircraft indicated the presence of paired fish in spawning coloration as well as freshly excavated redds seen as oval areas of washed gravel against the surrounding algae-covered substrate. All of the spawning locations were closely associated with spring areas (and summer aufeis fields). Two of the locations were adjacent to the mainstem of the Anaktuvuk River. A third location was in the lower Kanayut River, an eastern tributary to the Anaktuvuk. The fourth spawning location was in the outlet to Tulugak Lake in the upper Anaktuvuk River Valley. Two large springs enter Tulugak Lake along the eastern shore and their influence keeps the outlet ice-free through November. It is not known at this time whether the char observed in the outlet to Tulugak Lake are anadromous, or lake residents that drop out to spawn in the outlet. Additional areas of Arctic char concentration may also include spawners that were not readily observed from the air. The largest concentration of non-spawners is adjacent to Rooftop Ridge.

Spawning occurs over an extended period of time. The first spawning was observed on September 5th and the last observation in the same channel was November 4th. Poor light, turbidity or ice hampered observations before and after those dates. It appears that many successive pairs "share" the same spawning channel throughout this period.

Radio Telemetry and Overwintering Habitats

The location and significance of overwintering areas for fish in Northern waters is poorly understood. Few studies to date have included a winter sampling program to add perspective to descriptive habitat accounts of spring and fall aerial survey data. In this report we have presented data on under-ice test netting over a 60 mi stretch of the Colville River. While the confluence of the Anaktuvuk River lies within the area netted, Arctic char were not found to utilize the Colville River for overwintering. The presence of char in spawning areas until November or early December, as well as a large seaward migration at breakup, further suggests that overwintering takes place within lake or stream habitats in the Anaktuvuk River

drainage. Furthermore, if overwintering habitat in spring-fed systems is as limited as that in runoff streams and char remain as concentrated as observed in the fall, then populations may be extremely vulnerable to pollution and habitat degradation during winter months. Other species such as grayling, round whitefish and burbot may utilize the same winter habitats, creating very dense concentrations of fish.

Due to the inaccessibility of the Anaktuvuk River, Radio-telemetry was used as a method for monitoring the post-spawning activity of Arctic char in the Anaktuvuk River. The techniques section of this report describes the equipment, and procedure for implanting the radio transmitters. Twelve char were radio-tagged, of which six were non-spawners and six were spawners (spent). Of the spawners, three were male and three were female. The sex of the non-spawners could not be determined by examining external characteristics. The tagged fish ranged from 560 mm to 820 mm in fork length and averaged 662 mm. Weights ranged from 2,100 g to 5,000 g and averaged 2,750 g (6.1 lbs).

All of the char were tagged and released in the Anaktuvuk River adjacent to Rooftop Ridge on Sept. 20-21. In addition to the radio tags, 39 char were tagged with Floy FD-67 internal anchor tags and released. Table 7 shows the length, weight and sex of the radio-tagged char.

An attempt was made to locate the radio tagged fish at 2-week intervals using a fixed-wing aircraft. Observations were also made of ice and water conditions, as well as any char observed from the air. As of this date all of the radio tags were functioning properly and all of the char have remained within a 1-mile radius of the capture and release site. Slight movements within this limited area have been noted for eleven of the twelve tagged char. More detailed results of the telemetry program, as well as results of winter sampling at this site, will be presented in a future report.

Age and Growth

Eighty-four Arctic char from the Anaktuvuk River were sampled for age and growth data. A length frequency for all samples combined, including the char tagged and released, is presented in Fig. 5. Table 8 shows an age-length frequency for Anaktuvuk River char. Arctic char from the Anaktuvuk River experience a similar longevity, greater mean fork length at age beyond Age V and larger ultimate size than char sampled in the Sagavanirktok River drainage (Yoshihara 1973). Char between Ages I through III were not captured during 1980. Fork lengths ranged from 238 mm to 820 mm, with a mode between 500 mm and 580 mm, and a mean of 501 mm (N=112). Female char ranged from 238 mm to 678 mm and averaged 492 mm (N=65), while male char ranged from 240 mm to 820 mm and averaged 513 mm (N=47). Weights for the combined sexes ranged from 130 g to 5,000 g and averaged 1,640 g (N=106). The male to female ratio of 112 char was 1:1.4.

Adequate data were not obtained to determine the age at first seaward migration; however, Age IV char were well represented in the returning fall

Table 7. Fork length, weight, sex and spawning condition of twelve char radio-tagged in the Anaktuvuk River, 1980.

No.	Date	(MHz) Frequency	Fork Length (mm)	Weight (g)	sex	Spawning Condition
1	9-21	151.000	575	2,100	...	Non spawne
2	9-21	151.020	660	2,500	...	Non spawne
3	9-20	151.040	586	2,200	...	Non spawne
4	9-20	151.060	600	2,500	...	Non spawne
5	9-20	151.080	740	3,800	...	Non spawne
6	9-20	151.100	630	2,100	Fem	Spent
7	9-20	151.120	645	2,100	Fem	Spent
8	9-20	151.140	560	2,100	...	Non spawne
9	9-21	151.160	820	5,000	Male	Spent
10	9-21	151.180	740	3,500	Male	Spent
11	9-21	151.200	710	3,000	Male	Spent
12	9-21	151.220	678	2,100	Fem	Spent

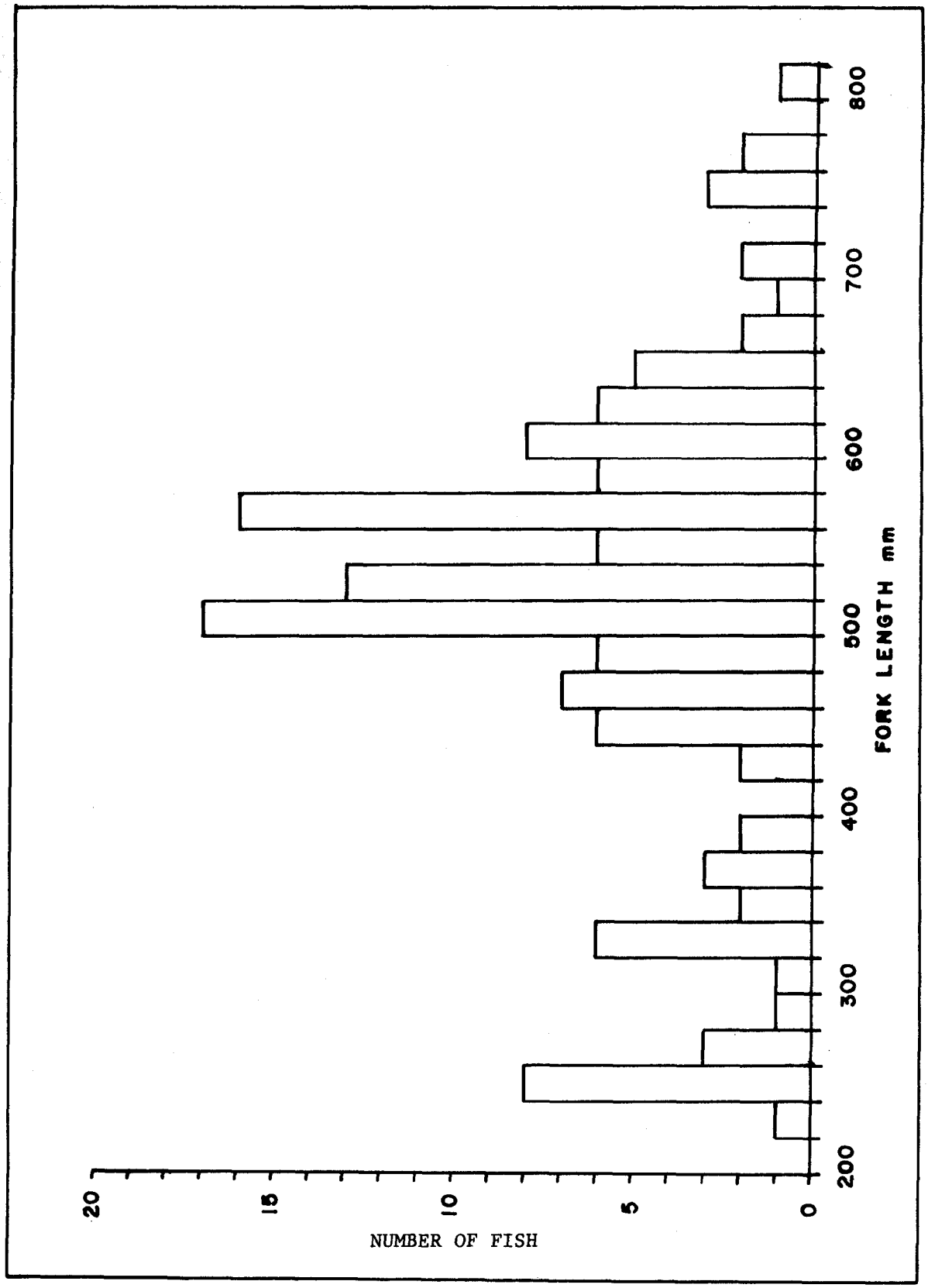

Figure 5. Length frequency of Arctic char captured in the Anaktuvuk River 1980.

Table 8. Age-Length Frequency of 84 Arctic char captured in the Anaktuvuk River, 1980.

Length Group	Age Classes									
	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
220-239	1									
240-259	3	4	1							
260-279		3								
280-299										
300-319			1							
320-339		3	3							
340-359		1	1							
360-379	1		1		1					
380-399		2		1						
400-419										
420-439			2							
440-459				2						
460-479			1	4						
480-499			2	2						
500-519			3	4	3	2				
520-539				3	4					
540-559				2			1			
560-579				1	3	3	1	1		
580-599				1			1			
600-619						1		1		
620-639						1	2			1

Table 8. (cont.) Age-Length Frequency of 84 Arctic char captured in the Anaktuvuk River, 1980.

Length Group	Age Classes										
	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	Total
640-659								2	1	1	4
660-679											
680-699											
>700									1		1
n	5	13	15	20	11	7	5	4	2	2	84
$\bar{x}$	242	287	405	471	535	568	591	620	705	635	468

migration. All Ages IV and V Arctic char were sexually immature. Female char were first maturing at Age VI, while the youngest mature males were Age VII.

Food Habits

All of the char captured during late summer and fall had empty stomachs. Thirty-eight percent of the char captured during the seaward migration (June) had been feeding. Of this sample, 80% were feeding on slimy sculpins, while 13% were feeding on caddis larvae and 7% contained unidentified vegetable matter. Relative condition of the char decreased during their winter residency in fresh water. Table 9 shows the condition factors for char sampled during the spring out-migration and the fall in-migration.

Table 9. Mean fork lengths, weights and condition factors for spring and fall caught char in the Anaktuvuk River, 1980.

Sample Period	Sex	N	Fork Length (mm) Range	Fork Length (mm) $\bar{n}$	Weight (g) Range	Weight (g) $\bar{n}$	Condition Factor* Range	Condition Factor* $\bar{n}$
Spring	M	15	395-655	519	560-3000	1405	0.743-1.068	0.895
	F	22	375-640	491	500-2500	1086	0.655-1.115	0.895
Fall	M	13	516-632	567	1300-2600	2000	0.911-1.196	1.084
	F	8	520-652	587	1500-2950	2181	1.014-1.149	1.065

* Condition factor = $K = \frac{\text{Weight}}{\text{Length}^3} \times 10^5$

LITERATURE CITED

Alt, K. T. and R. Furniss. 1976. Inventory and cataloging of North Slope waters. Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1975-1976, Project F-9-8, 17(G-I-O): 129-150.

Aquatic Environments Ltd. 1973. Late Winter Surveys of Lakes and Streams in Canada and Alaska along the gas pipeline routes under consideration by Canadian Arctic Gas Study Limited. Data report prepared for: Northern Engineering Services Company Limited. 183p.

Bendock, T. N. 1977. Beaufort Sea estuarine fishery study. In: Alaskan OCS Principal Investigators Annual Reports, U.S. Dept. of Commerce, NOAA. Research Unit 233.

_____. 1979. Inventory and cataloging of Arctic area waters. Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1978-1979, Project F-9-11, 20(G-I-I): 64p.

_____. 1980. Inventory and cataloging of Arctic area waters. Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, Project F-9-12, 21(G-I-I): 1-31.

Craig, P. and L. Haldorson. 1979. Ecology of fishes in Simpson Lagoon, Beaufort Sea, Alaska in Beaufort Sea Barrier Island-Lagoon Ecological Process Studies. U.S. Dept. of Commerce, NOAA. Research Unit 467. 100p.

Craig, P. and P. J. McCart. 1974. Fall spawning and overwintering areas of fish populations along routes of proposed pipeline between Prudhoe Bay and the Mackenzie Delta 1972-1973. Canadian Arctic Gas Study Limited, Biological Report Series 15 (3) 37.

Furniss, R. and D. Ward. 1976. Comparison of water availability for use in construction of proposed gas pipelines on the Alaskan North Slope. Alaska Biological Consultants. 70p.

Jones, M. L. 1976. Water availability along the proposed Arctic Gas Pipeline Route from Prudhoe Bay, Alaska to the Mackenzie Delta, Northwest Territories. Aquatic Environments, Ltd. 85p.

Kogl, D. 1971. Monitoring and evaluation of Arctic waters with emphasis on the North Slope drainages: Colville River Study. Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1970-1971, Project F-9-3, 12(G-III-A): 23-61.

Kogl, D. and D. Schell. 1975. Colville River delta fisheries research. In: Environmental Studies of an Arctic Estuarine System, Final Report. Institute of Marine Science, University of Alaska, Fairbanks. Chapter 10. 483-504.

Mann, G. J. 1975. Winter fisheries survey across the Mackenzie Delta. Canadian Arctic Gas Study Limited. Geological Report Series 34(3). 54p.

McCart, P. J. 1980. A review of the systematics and ecology of Arctic char, Salvelinus alpinus, in the Western Arctic. Can. Tech. Rep. Fish. Aquat. Sci. 935: vii + 89p.

McPhail, J. D. 1961. A systematic study of the Salvelinus alpinus complex in North America. Journal Fisheries Research Board Canada, Vol. 18, No. 5. 793-816.

Morrow, J. E. 1973. A new species of Salvelinus from the Brooks Range, Northern Alaska in Studies of Alaskan Fishes. University of Alaska, Biological Paper 13. 1-9.

Ott, A. and K. Tarbox. 1977. "Instream Flow" applicability of existing methodoligies for Alaskan waters. Final report prepared for Alaska Dept. of Fish and Game by Woodward-Clyde Consultants, Anchorage, Alaska. 70p.

Sloan, C. E. 1976. Anadromous fish study. Fresh water fish and their winter habitat in NPR-4. Report to the Officer in charge, Naval Petroleum Reserve No. 4. 26p.

Wilson, W., E. Buck, G. Player, and L. Dreyer. 1977. Winter water availability and use conflicts as related to fish and wildlife in Arctic Alaska - A synthesis of information. Arctic Environmental Information and Data Center, University of Alaska, Anchorage, Alaska. 222p.

Winslow, P. C. and E. A. Roguski. 1970. Monitoring and evaluation of Arctic Waters with emphasis on the North Slope drainages. Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1969-1970, Project F-9-2, 11: 279-302.

Yoshihara, H. 1973. Monitoring and evaluation of Arctic waters with emphasis on the North Slope drainages; Part A: Some Life Histroy aspects of Arctic char. Alaska Dept. of Fish and Game. Federal Aid in Fish restoration, Annual Report of Progress, 1972-1973, 14(G-III-A): 63 pp.

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