Volume 18 Study G-I-P

STATE OF ALASKA

Jay S. Hammond, Governor

Completion Report

INVENTORY AND CATALOGING OF SPORT FISH AND SPORT FISH WATERS OF WESTERN ALASKA

by

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LIST OF TABLES

LIST OF TABLES (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

COMPLETION REPORT

State:	ALASKA	Name:	Sport Fish Investigations of Alaska
Project No.	F-9-9		
Study No.:	G-I	Study Title:	INVENTORY AND CATALOGING
Job. No:	G-I-P	Job Title:	Inventory and Cataloging of Sport Fish and Sport Fish Waters of Western Alaska

Period Covered: July 1, 1976 through June 30, 1977

ABSTRACT

Sport fishing pressure on remote areas of Alaska is beginning to increase but to date little biological data on sport fish populations has been collected.

This two year study of 10,250 square miles of a remote area of the lower Kuskokwim River and Kuskokwim Bay was conducted to collect base line information on the waters and fish populations.

Streams surveyed were the Aniak, Tuluksak, Kisaralik, Kasigluk, Kwethluk and Eek rivers which enter the lower Kuskokwim River from the south and the Kanektok, Arolik and Goodnews rivers which drain into Kuskokwim Bay. Fifteen lakes, the majority in the Kuskokwim Bay drainage, were also surveyed.

The streams, all heading in the Kilbuck and Ahklun mountains, are swift flowing, clear streams with gravel bottoms, providing excellent spawning habitat for salmonids. The westernmost natural range of rainbow trout, Salmo gairdneri Richardson, in the world is included in the study area.

Physical, chemical and biological data were collected from all lakes and streams surveyed. Rainbow trout were found in all streams except the Eek and Tuluksak rivers. Fish associations in streams included five species of salmon, Oncorhynchus sp.; rainbow trout; Arctic char, Salvelinus alpinus (Linnaeus); round whitefish, Prosopium cylindraceum (Pallas); grayling, Thymallus arcticus (Pallas); and slimy sculpin, Cottus cognatus Richardson. Whitefish, Coregonus sp.; sheefish, Stenodus leucichthys (Guldenstadt); pike, Esox lucius Linnaeus; and burbot, Lota lota (Linnaeus), were less abundant and found only in lower reaches of streams of the lower Kuskokwim drainage. Lake populations consisted mainly of lake trout, Salvelinus namaycush (Walbaum); Arctic char and round whitefish. Red salmon, Oncorhynchus nerka (Walbaum), spawned in most lakes of Kuskokwim Bay streams and a few king, O. tshawytscha (Walbaum); chum, O. keta

(Walbaum); and silver, O. kisutch (Walbaum), salmon were also captured. Grayling were absent in most lakes of the Kuskokwim Bay drainage but are present in lakes of the lower Kuskokwim River. Pike were absent from all lakes except a single individual was caught in Goodnews Lake.

Arctic char, round whitefish and rainbow trout are year-round residents of streams in the lower Kuskokwim River drainage but are anadromous in streams of Kuskokwim Bay. Grayling of the lower Kuskokwim River study area may enter the Kuskokwim to overwinter, but grayling from Kuskokwim Bay probably overwinter in fresh water. Populations of grayling appeared lower in streams of Kuskokwim Bay than in the Kuskokwim River drainage.

Fishes in Kuskokwim Bay lakes and streams generally grew faster than Kuskokwim River fish, especially anadromous char and grayling. Rainbow trout from the Kuskokwim Bay streams reached a slightly larger size and a few fish up to 600 mm (23.6") and 2.8 kg (6 lbs 3 oz) were found. Lake trout from most lakes averaged 440-470 mm and only four fish over 700 mm (27 1/2") and 5 kg (11 lbs) were taken. Ages of these large fish were 19-27 years. No lake trout under 270 mm (10 1/2") were captured.

Longevity of fishes was similar in both sections of the study area. Growth of fishes in the study area, especially Kuskokwim Bay, compared favorably with growth of fishes in Interior Alaska. Sexual maturity is reached at Age V to VII for rainbow trout, Age IX to X for lake trout, Age VI to VII for Arctic char, Age IV to V for grayling and Age VI to VII for round whitefish. Consecutive spawning is the rule for most fish except lake trout.

Fishes of the study area could be termed opportunistic feeders and a wide variety of organisms were found in stomachs examined. Stream residents fed mainly on insects, especially Diptera and Tricoptera larvae, but fish, voles, snails and clams were also eaten. Char, grayling and rainbow trout fed heavily on salmon eggs and flesh in late summer. Lake residents fed mainly on insects, snails and clams and occasionally on fish.

Salmon in the study area have subsistence, commercial and some sport value, while light to moderate sport fishery pressure is exerted on rainbow trout, lake trout, Arctic char, pike and grayling.

INTRODUCTION

Scope

The lakes and streams of the mountainous areas of the lower Kuskokwim River and Kuskokwim Bay contain populations of fish that presently support a light sport fishery as well as subsistence and commercial fishing activities. No fisheries research other than salmon studies has been conducted on these waters. In anticipation of increased sport fishing pressure on these populations, the Sport Fish Division of the Alaska Department of Fish and Game undertook a two year fishery resource investigation of the lakes and streams of the lower Kuskokwim River and Kuskokwim Bay.

Major emphasis was placed on sport species such as rainbow trout, Salmo gairdneri Richardson; lake trout, Salvelinus namaycush (Walbaum); grayling, Thymallus arcticus (Pallas); and Arctic char, S. alpinus (Linnaeus); but information was also collected and analyzed on non-sport species. Observations were made of salmon, Oncorhynchus sp., numbers, run timing and sport fishing potential, but little life history data of salmon are given in this report as the Division of Commercial Fisheries, Alaska Department of Fish and Game has been studying salmon of this area for years and have amassed a large volume of data. The salmon (five species) are the most important subsistence and commercial fish of the region.

Study Area

The Kuskokwim River, nearly 800 miles long, is the second largest drainage in Alaska. Tributaries that enter from the south, drain the Alaska Range as well as the Chulinuk, Taylor and the Kilbuck and Ahklun mountains; while those entering from the north drain the Kuskokwim Mountains and the area between the Yukon and Kuskokwim rivers.

The study area (Fig. 1) includes those lakes and streams draining the Kilbuck and Ahklun mountains and waters flowing generally north and west into the lower Kuskokwim River and directly into Kuskokwim Bay. The study area is roughly 320 x 180 km (200 x 112 miles) and includes 9 major rivers and numerous lakes, 15 of which were surveyed. Bethel is the population, communication and transportation center of the area, but small villages are located near mouths of many of the tributary rivers. Size of the study area was determined by three factors: (a) presence of rainbow trout, (b) number of streams draining Kilbuck and Ahklun mountains and flowing into the Kuskokwim River or Kuskokwim Bay, and (c) amount of country that could adequately be surveyed by a small crew in two summers.

The main Kuskokwim River must be considered part of the study area as many fish of this area utilize the Kuskokwim as a feeding or overwintering area or migration route. Only limited sampling was conducted in the Kuskokwim River.

For purposes of data analysis the study area was divided into two regions: (a) Kuskokwim Bay and (b) lower Kuskokwim River. The Kuskokwim Bay drainage is 2,360 square miles and the Goodnews, Kanektok and Arolik rivers are the major tributaries. The Goodnews River system contains numerous lakes; but only Goodnews, Canyon, Asriguat, Kukaktlim, North Middle Fork and South Middle Fork lakes were surveyed. Other lakes were either too small to land on with a float plane or were close to larger surveyed lakes and could be expected to contain the same species of fish.

The lower Kuskokwim River study area contains 7,890 square miles. The major tributaries include the Aniak, Tuluksak, Kisaralik, Kasigluk, Kwethluk and Eek rivers. This area has numerous shallow lakes on the Kuskokwim River lowlands but most of these become anoxic in the winter and do not support year-round populations of sport fish. The headwater lakes were the principal lakes surveyed in the study area and Aniak,

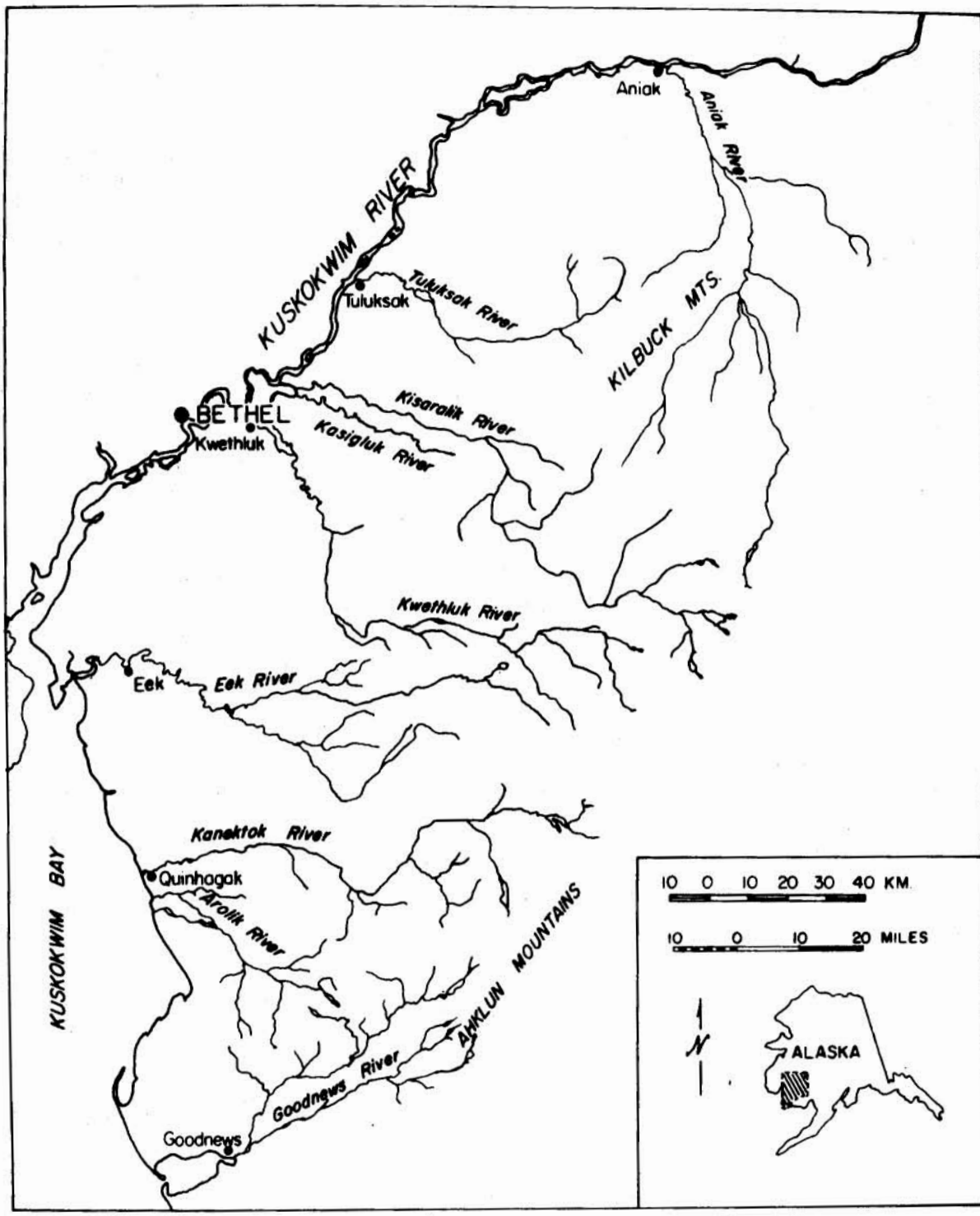

Figure 1. Lower Kuskokwim River and Kuskokwim Bay study area. Inset shows Alaskan location.

Kisaralik and Kisaralik #2 lakes are deep mountain lakes while Eek Lake is a shallow foothills lake.

The vegetation of the study area is tundra with a narrow band of spruce, birch and cottonwood trees along the watercourse in the lower reaches of streams of the Kuskokwim River and a band of willows along the lower reaches of streams of Kuskokwim Bay.

Climatic Data

The waters of the study area fall within two of the four Alaskan climatic zones. The Kuskokwim River below Bethel and the lower few miles of Kuskokwim Bay are in the Transitional Zone, while the Kuskokwim River above Bethel and the upper 80%-90% of all streams of Kuskokwim Bay are in the Continental Zone (Selkregg, 1976).

Temperatures are more moderate than in Interior Alaska but summers are colder, resulting in a shorter growing season for fish. Dates of freeze-up on the Kuskokwim River at Bethel average October 17; Aniak River at Aniak, October 19; and Kanektok River, October 21. Breakup dates for the Kuskokwim River at Aniak is approximately May 16; Bethel, May 18; the Aniak River, May 2; and the Kanektok River, May 3. July mean maximum temperatures range from 16°C (60°F) near Bethel to 19°C (66°F) at Aniak. Aniak average yearly temperature is -2°C (28°F) and it has 227 days when the temperature goes below freezing (U.S. Weather Bureau, Anchorage). Further climatic data on the study area is presented by Selkregg (1976).

Historical Data

The second half of the nineteenth century was important for Alaskan fisheries research as many military and scientific expeditions were sent to Alaska. Robert Kennicott, W. H. Dall, and T. H. Bean did much collecting and publishing on the freshwater drainages and coastal areas to the north as well as Bristol Bay drainages but none on the Kuskokwim. Mention of fish in the Kuskokwim River drainages was first made by Lt. Zagoskin who traveled throughout the lower Kuskokwim River area in the years 1794-1797 (Michael, 1957). He mentioned the location of Aniak Lake and gave physical characteristics of the river. Zagoskin noted the heavy spring upstream migration of sheefish, Stenodus leucichthys; broad whitefish, Coregonus nasus; Bering cisco, C. laurattae; and humpback whitefish, C. pidschian and also the early summer movement of salmon on the Kuskokwim.

The Alaska Department of Fish and Game, Commercial Fish Division, has been conducting research on fishes of the Kuskokwim River and Kuskokwim Bay since 1960 but most of the work has involved enumeration, utilization, and basic life history studies of the five species of Pacific salmon. Rae Baxter, Alaska Department of Fish and Game, Division of Commercial Fisheries, Bethel, has done considerable research on whitefish in the lower Kuskokwim River (Baxter, 1969-1974, unpublished MS in Bethel office). The author has conducted research on sheefish, and to a lesser degree whitefish, in the Holitna River and upper Kuskokwim tributaries between 1967 and 1971. No other information has been published

on the freshwater and anadromous fishes, other than salmon, of the waters of the study area. Lake trout, grayling, northern pike, rainbow trout and Arctic char are found in the Bristol Bay drainages just to the south of the Kuskokwim Bay drainages and information has been published by Metsker (1967), Yanagawa (1967) and Russell (1974). Scott and Crossman (1973) and McPhail and Lindsey (1970) have published general distributional and life history notes of fish found in the study area.

OBJECTIVES

1975

1. To survey the principal tributaries of the lower Kuskokwim River and Kuskokwim Bay, including major headwater lakes. In 1975, the Aniak, Kisaralik, Kanektok, and Goodnews river systems will be surveyed as time permits.

2. To assess the fish species composition of these waters with emphasis on sport fish species.

3. To determine life history parameters of these fish, including age and growth, reproduction, and migration timing.

4. To determine the present sport fishing utilization of these waters and their potential for supporting a sport fishery.

5. To evaluate other waters and sport fisheries in the job area as demand warrants.

1976

1. To complete surveys of the principal tributaries of the lower Kuskokwim River and Kuskokwim Bay, including major headwater lakes. In 1976, the Aniak, Kisaralik, Kwethluk, Tuluksak and Arolik river system will be surveyed as time permits.

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3. To determine life history parameters of these fish, including age and growth, reproduction, and migration timing.

4. To determine the present sport fishing utilization of these waters and their potential for supporting a sport fishery.

5. To evaluate other waters and sport fisheries in the job area as demand warrants.

METHODS AND MATERIALS

This study, the first detailed study of the remote lower Kuskokwim area of Alaska, entailed prior planning including discussions with residents of the area and a review of records of the Division of Commercial Fisheries. Logistics was a major problem but was eased somewhat with the setting up of base camps in Aniak and Bethel.

The study included over 2,000 miles of travel by raft and riverboat and over 10,000 miles by airplane during the two year project.

Lake Surveys

Maps of lakes to be surveyed were drawn from U.S.G.S. quadrangle maps and inch to the mile maps. Standard Alaska Department of Fish and Game lake survey and catch statistics forms were used to record data. The maps, showing major inlets and outlets, were field corrected. Shoal areas, net sites and water depths were indicated on the maps. These forms are in the Sport Fish Division office in Fairbanks.

Transportation to the lakes was by a float equipped, four place airplane. Sampling gear, camping gear and a 12' rubber raft with a 4 hp outboard motor were transported to a central lake where a base camp was set up. The raft was used to set nets, take depth profiles, survey inlets and outlets, and as transportation to different areas of the lakes. The perimeter of the lake was flown to note shoal areas and the location of inlets.

In three lakes of the Kanektok drainage (Kanuktik, Klak and Ohnlik) the airplane was used to set nets and take depth soundings. A Lowrance LFP300 depth finder was used to take bottom soundings. Since most of the lakes were typical rapid drop-off lakes, only one transect was run down the longitudinal axis of 1975 surveyed lakes. Readings were taken every minute at a constant motor speed, then later transferred to the map. The depth finder broke during surveys of Klak, Kanuktik and Ohnlik lakes so they were sounded with fishing line. In the 1976 survey of Kuskokwim River lakes, more than one transect was run. Water chemistry analysis was carried out with a Hach Kit # AL-36B. Alkalinity, total hardness and pH readings were taken. Water temperatures were only taken 6" beneath the surface with a Taylor pocket thermometer with a range of -35°C to 50°C. Water clarity was determined with a Secchi disc. Notes were made of spawning gravel, rearing areas, vegetation, camping areas, indications of past uses and fish observation.

Fish populations were sampled using gill nets, hook and line, seine, and dipnet.

For purposes of comparing gill net catches of various lakes, a standard graduated mesh gill net 125' long and 6' deep containing five panels of

mesh size varying from 1/2" (12 mm) to 2 1/2" (62 mm), and fishing overnight was called a net night. The nets were monofilament and generally a floater (hung to float) was set near the outlet streams and a sinker (hung to fish on the bottom) was set in some other part of the lake. In most cases the net was tied on shore with the largest mesh in the deepest water. In a few lakes (Kagati, Klak, Arolik, Kisaralik, Kisaralik #2) a net was sunk in a deeper part of the lake and not tied to shore. These sets are indicated on the maps. In addition to the long nets, short, fine mesh 25' and 50' nets, 4' and 6' deep were set in likely areas around the lakes in an effort to capture young of lake trout, char, whitefish, salmon and grayling. An effort was made to get a sample of up to 20 of each species in the lake. If larger samples were caught, the fish were counted, measured and released. Fish were selected so that a wide size range was present in each sample. Normally two nets were set in a lake for one night, but during the 1976 season more time was available so nets were set longer. Hook and line fishing was employed to collect samples for biological data and to determine sport fishing potential.

Stream Surveys

All larger streams in the study area from the Aniak to the Eek and the Goodnews to the Kanektok were surveyed. Both quadrangle and inch to the mile maps of the stream were used in the field. Rivers were flown with fixed wing aircraft for familiarization.

All rivers in the Kuskokwim drainage study area were ascended as far as possible with a 24' aluminum riverboat using an outboard motor with either a propeller or a jet unit. Sampling gear, fuel and camp gear, along with a crew of two or three biologists were carried. Supply points were usually Aniak or Bethel. All rivers in the Kuskokwim Bay portion of the study area were floated from their headwater lake to the ocean in a 12' rubber raft with a 4 hp motor. The floats took from 3 to 5 days.

The Aniak River received more sampling effort than other rivers, with surveys run during May of 1975 and 1976 and August of 1976. Other rivers in the Kuskokwim drainage were surveyed twice (June and late July or early August). The Eek River was surveyed only once in late July and the Tuluksak only once in early August. The rivers of Kuskokwim Bay were floated only once each, in mid to late July. Thus all rivers were surveyed during at least one period of clear normal summer water levels.

Streams were divided into sections with Section I always near the mouth. Section division was usually based on change in stream characteristics rather than miles. Each section was identified on the maps. For each section, an attempt was made to sample the fish population using gill net, hook and line or seine. Water chemistry data were taken in each section. All major tributaries to each section were noted and often surveyed in the lower reaches. Physical characteristics of each section were noted, including shore vegetation, gravel composition, water color, flow, meandering and stream blockages. Bottom composition was noted by percentage of each of the following materials by volume.

1. Sand and silt
2. Fine gravel - 1/8" to 1" diameter (3.5-25 mm)
3. Medium gravel - 1" to 2" in diameter (25-50 mm)
4. Coarse gravel - 2" to 10" (50-250 mm)
5. Rock, boulder or bedrock - over 10" diameter (250 mm)

Stream width was measured with a 100' tape where possible. Depth was measured with a marked oar or paddle, and velocity was determined by floating a stick over a 100' stretch of water. Usually three readings were taken. Flow in cfs was determined by the following formula:

$$Q = V \times W \times d \times 0.85.$$

Where:

V = a measured distance (100') divided by the time (in seconds) required for a float to travel that distance
W = average width of the stream in feet
d = average depth of the stream in feet
0.85 = average corrective factor for rough bottom

These measurements were estimates, at best, and subject to change depending on stream level.

Gill nets were used for sampling in early summer before salmon arrived, but later small mesh gill nets were set in areas where salmon were absent and most sampling was done with hook and line. Salmon and other species counted or observed in each section were noted.

Most net sampling was done in lower reaches of Kuskokwim River tributaries in an effort to capture whitefish. Considerable May gill netting was conducted in the Aniak River, and index areas were set up at the mouth (Grassy and Dead End sloughs), Doestock River, 18 Mile and 60 Mile to compare catches in May of 1975 and 1976 and August of 1976. For stream sampling, graduated mesh nets of 125' hung to float were used; but smaller mesh nets, minnow traps, dip nets, and seines were used to capture small fish.

Standard Fish and Game, Sport Fish Division stream survey forms together with catch statistics were completed for each stream and placed in the Fairbanks office.

Biological Sampling

Fish sampled were measured in millimeters with a steel tape or measuring board and weighed to the nearest 50 grams with a Chatillon spring balance scale. Small specimens were preserved in 10% formalin and brought back to the laboratory for sampling. Otoliths were collected from char and some of the lake trout. Scale samples were collected from lake trout, and all other species except char and burbot. General condition of the fish and incidence of parasitism were noted. (Stomach contents were identified, insects to order and fish to species). Snails, clams,

annelids and crustaceans were not further identified. Stomachs were categorized as being empty, 1/4, 1/2, 3/4 or full. Sex and state of maturity were determined through gross examination of the gonads. Size of fish, color and other secondary sexual characteristics were also used in determining state of maturity.

The general scale of maturity used was:

1. Immature - gonad only a thread; hard to tell if male or female.

2. Developing - gonad shows some development; easy to tell if male or female; never has spawned before; will not spawn during current season.

3. Mature - will spawn this year or has spawned before

    a. Prespawner - size of eggs such that female will spawn during the current spawning season; testes large, beginning to turn white. Secondary sex characteristics may be evident.

    b. Ripe - eggs or milt can be expelled with pressure; fish colored or kype formed in trout, char and salmon.

    c. Spent - spawned out.

    d. Redeveloping consecutive spawner - contains retained eggs; eggs growing in size indicating it will spawn in next spawning season. Would not be called a prespawner until next year.

    e. Redeveloping non-consecutive spawner - fish that shows evidence of having spawned in past year (retained eggs) but will not spawn in current year.

This maturity scale will identify non-consecutive spawners, especially if they are examined 3-5 months before the current spawning season. Arctic char from the Kuskokwim River study area remain colored and generally in poor condition for up to 10 months after spawning.

Most char and rainbow trout over 400 mm (15 1/2")were mature, and often when doubt about maturity existed the size criterion was used to arrive at a decision.

Identification of small fish was made in the laboratory. Gill raker counts of the first excised left arch were made under magnification.

Scales were either mounted whole between glass slides and read with an Eberbach scale reader or impressed in plastic and read with a microfilm reader. Otoliths were placed in xylene and read with a binocular microscope. Otoliths from older fish sometimes had to be polished. In analysis of data, age and length at capture were used in constructing the tables. All fish captured in May were in the process of forming an annulus but had very little 'plus' growth, while those captured in July or August had a considerable amount of 'plus' growth. Thus an August

caught Age II rainbow trout would be expected to be nearly as long as an Age III late May caught trout.

A large percentage of rainbow trout scales was regenerated and many other scales were partially broken so a large sample had to be cleaned in order to find one or two that could be aged.

Lake trout collected in 1975 were aged using scales, but scales of fish older than 14 years were very difficult to read and the ages should be taken as approximations. About 80% of all scales were regenerated and sometimes 20 scales were mounted before one readable scale was found. In 1976 both scales and otoliths were taken from all fish collected. There was close agreement with scale age and otolith age for fish of all age groups including those of 20 years of age. Many of the otolith aged lake trout were 1 year older than scale aged fish and occasionally 2 years older. All age related lake trout computations used in this report are based on scale ages.

Only those stomachs containing food were used in constructing food habits tables. Frequency of occurrence (number of stomachs containing that food item) was used to construct the tables.

Spelling of names of lakes, streams or locations are from the Dictionary of Alaska Place Names (Orth, 1971). Local names of lakes in the Kanektok and Goodnews drainage were used when the lake was unnamed on quadrangle maps. The Calista Corporation supplied the names. North Middle Fork and South Middle Fork lakes and Kisaralik Lake #2 were unnamed and we could find no local names for them. Size of drainages was determined with a polar planimeter. Climatic data are from the U.S. Weather Bureau, Fairbanks and Anchorage.

FINDINGS

Lake and Stream Surveys, Kuskokwim River

Aniak River System:

The *Aniak River* has its headwaters in Aniak Lake and flows in a northerly direction for 100 miles to enter the Kuskokwim River at Aniak at 159°30' N and 61°34' W (Fig. 2). The Aniak drainage is 2,230 square miles and includes as major tributaries the Doestock, Buckstock, Salmon and Kipchuk rivers. The Aniak, except in its lower reaches, is a swift flowing river and not confined to a specific channel. The river flows through a narrow band of thick timber, with large numbers of submerged and partly submerged downed trees and log jams. This together with the fast current and shallow water, tend to make riverboat travel very difficult past 20 miles upriver. A jet unit is generally needed for navigation in mid to late summer. At very high water it is possible to boat to Aniak Lake. The water is dirty colored from breakup in early May until mid summer, then takes on a green color and normally doesn't become clear enough for angling until August. The Kuskokwim River represents the northern and westernmost distribution of natural stocks of rainbow trout in the world

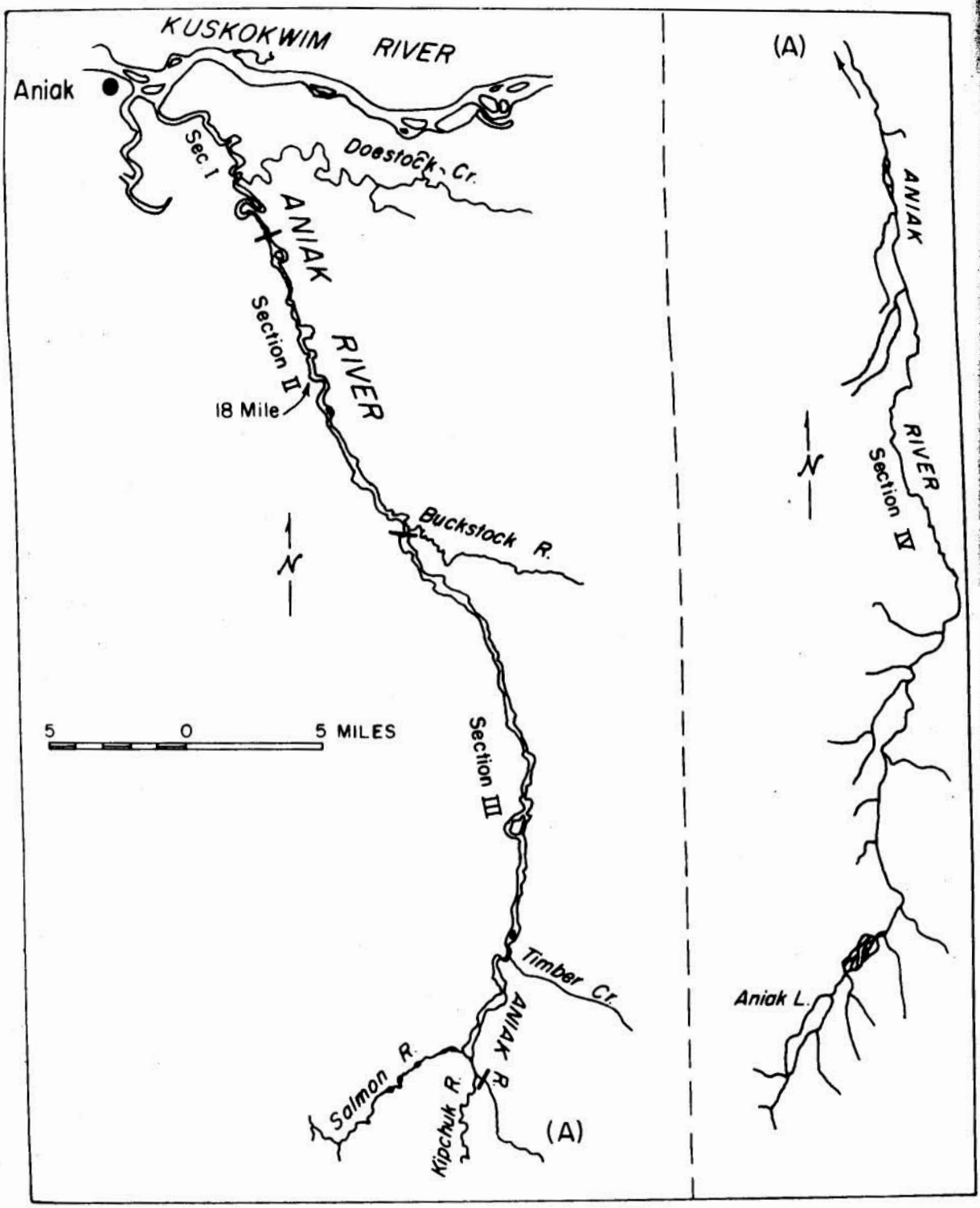


Figure 2. Aniak River Drainage. Upper Aniak River on right half of map. Drawn from Russian Mission and Bethel 1-250,000 quadrangle map.

Checking gill net set in Grassy Slough (Lower Aniak River) in May.

of Aniak River
almon River
This was a
area for rainbow
rctic char and
itefish after
.

Small, shallow side channel entering Aniak River in vicinity of 55 Mile.

and in the Aniak River they reach their upstream limit of distribution. Rainbow trout probably are more abundant in the Aniak River than in any other river of the study area. The stream also has large numbers of grayling, Arctic char, round whitefish and five species of salmon.

Of all rivers in the study area, major survey emphasis was placed on the Aniak. It was surveyed from May 23 through 30 in 1975, and from May 6 through 21, and August 6 through 14 in 1976. We were on the stream immediately after breakup and information gathered on fish immigration can be expanded to provide information on other streams in the study area. Attempts at making spawning observations on rainbow trout were unsuccessful because spring runoff caused streams to rise and become turbid before the fish spawned. In 1976 the downstream movement of salmon fry during the period of May 6-20 was observed. During this time many species of fish, several species of ducks and mergansers, gulls, loons, terns, and kingfishers were feeding heavily on salmon fry. The Aniak River has a large number of sloughs, tiny side channels, oxbows and quiet pools that provide excellent rearing habitat for young fish.

The Aniak River was divided into four sections (Fig. 2) although most of Section IV was not surveyed. Aniak Lake was surveyed July 10-12, 1976.

Section I included the lower 11 miles where the bottom was generally silt covered. The current is still quite swift (2-3 mph) down to the mouth, and the stream is a single, meandering channel within a defined mud banked channel. The river bank is heavily forested with willows, alder, birch, aspen and large spruce trees. The river is over 200' wide in its lower reaches. Grassy Slough, 2 miles upstream on the right; Dead End Slough, 2.5 miles upstream on the left; and Doestock Creek are the major tributaries in Section I and are used as feeding and resting areas for many species of fish found in the Aniak River. These areas were netted in May of 1975 and 1976 and August of 1976 (except Doestock Creek) to provide comparative data concerning run timing and abundance (Table 1). Whitefish, especially humpback and least cisco, Coregonus sardinella Valenciennes, were captured in good numbers in both sloughs in late May and it is suspected that this is an in-migration from the Kuskokwim. Their numbers had decreased by August. In May both Arctic char and grayling and a single rainbow trout were captured in the lower river but in August none were taken. A sheefish and Bering cisco were caught in Dead End Slough in both 1975 and 1976.

On May 5, 1976 the Kuskokwim River was almost completely frozen, but the Aniak River was nearly open. Aniak residents had been catching grayling and pike on hook and line in a narrow open lead in the Kuskokwim River. It is only a short distance to the mouth of the Aniak River and evidently the fish were migrating into the Aniak River. No Arctic char or rainbow trout were taken. A gravel bar at the mouth of the Aniak River was seined on May 6 and 7, and grayling, pike, Esox lucius Linnaeus, suckers, Catostomus catostomus (Forester), round whitefish, sculpin, Cottus cognatus Richardson, and salmon smolts and fry were captured. Due to solid ice pushed up into the lower 5 miles of the Aniak River by the breakup of the Kuskokwim River, no further observations were made until May 11 when the Aniak River was again clear of ice. Then large numbers

Table 1. Comparative test net results Aniak River, 1975 and 1976. Effort in the various areas during the three periods was essentially similar. A small number of blackfish, burbot and salmon smolts were also captured.

Location	May 23-29, 1975											May 11-20, 1976											August, 1976					
	RT	AC	GR	RWF	HWF	BWF	LCI	NP	SF	BCI	S	RT	AC	GR	RWF	HWF	BWF	LCI	NP	SF	BCI	S	HWF	BWF	LCI	NP	CS	S
Kuskokwim R.																												
1 mi above Aniak					2	4	3	1	3	2			2				3	1	2				Not Sampled					
Aniak R. mouth																												
Dead End Slough		3	4		6	3	26	14	1				13	5	1	23	1	26		1	1	4	2	1	10	6	11	3
Grassy Slough		1	7			2	15	12			1	1	14	4	1	6	4	16	13			8				7	7	6
Doestock Cr.	1	1	2			2		1				1	6	5		1	2	1	4				Not Sampled					
16 mi Aniak R.	1	10	20	10		2		2				2	5	15	17				2				Not Sampled					
18 mi Aniak R.	3	35	20	7								4	15	17	15								Not Sampled					
Buckstock R. 1 mi		6	7	7																			Not Sampled					
60 mi Aniak R.																												
Slough 1/2 mi below Salmon R.	7	15	14	5								2	6	1	20								Not Sampled					
Slough 1/4 mi below Salmon R.	3	2	3										1		8								Not Sampled					
Slough 1/4 mi above Salmon R.	4	1	3	4								2	1		14								Not Sampled					

of grayling and whitefish were observed feeding on out-migrating salmon fry. Water temperature was 1°C (34°F). The next sampling done in the lower Aniak was by gill net in late May of both years and large numbers of Arctic char, grayling, suckers, chum salmon, Oncorhynchus keta (Walbaum), pike, broad whitefish, least cisco and humpback whitefish were captured. A few sheefish, Bering cisco, and rainbow trout, Salmo gairdneri Richardson, were taken. The sheefish upstream migration, mainly of prespawning fish, takes place on the Kuskokwim River past Aniak about two weeks after breakup, and a subsistence fisherman took over 100 sheefish in three days of fishing. A gill net set in the Kuskokwim River upstream from Aniak for one night in late May each year caught three sheefish in 1975 but none in 1976. Few of these sheefish enter the Aniak River. It is also suspected that most other whitefish species only use the lower Aniak for feeding and probably spawn in other rivers. A few rainbow trout evidently spend the summer in the lower Aniak as Aniak residents mention capturing an occasional trout there while angling for king salmon. Small mesh gill nets set in the main Aniak River and in Grassy Slough took juvenile grayling, char, pike, salmon and suckers. Silver salmon, O. kisutch (Walbaum), had not yet entered the stream during the August sampling but began arriving in mid August and were captured on hook and line in the lower river by Aniak residents.

Doestock Creek, about 9 miles upstream, is called Rusty Creek locally because of the brown stained tundra water. It is a slow moving, meandering, 70'-90' wide stream with a mud bottom in the lower reaches. Shore vegetation is grass, willows and spruce trees. The water temperature on May 28 was 9°C (48°F) and water chemistry data were: alkalinity 34 ppm, hardness 51 ppm and pH 7.0. Gill net sets in the mouth of Doestock Creek took rainbow trout, char, grayling, pike and some whitefish (Table 1). The few sheefish captured by anglers in the Aniak River are taken in the lower Doestock. Sheefish evidently do not go further up the Aniak River.

Section II begins above Doestock Creek, where the Aniak has a gravel bottom and begins to leave the confined single channel, and ends at the Buckstock River. This section could have ended 4-5 miles downstream where the channel first became heavily braided but landmarks are hard to find.

Bottom composition throughout most of this section is 10% sand and silt, 30% fine gravel, 40% medium gravel and 20% coarse gravel. The section is heavily wooded and has many downed trees in the water. The current is quite swift at 4-5 fps and gravel bars are common on the inner curves of the channel. The channel becomes very braided below the Buckstock River and travel beyond this point is difficult at periods of normal or low water. Section II has an abundance of sloughs and tiny side channels that are braids of the main river; these areas are rich in insect life and provide rearing areas for fish. Pools are formed in the main channel when two currents come together, or behind downed timber. Juvenile salmon, rainbow trout and char were taken in these areas. Water temperature on May 27, 1975 was 4°C (39°F) and grayling and northern pike were

spawning. The following year water temperature was only 1.5°C (35°F) on May 13 and fish were not yet spawning. In 1975 rainbow trout were nearly ready to spawn but in 1976 the milt could not be pressed out of any of the males.

Most sampling in Section II was done at 16 Mile and 18 Mile Aniak River. Gill nets set in a slough system at 16 Mile took northern pike and broad whitefish. In 1975 pike were spawning in this slough. A net set in a slough on the east side of the river at 18 Mile in May of 1975 and 1976 took large numbers of rainbow trout, char, grayling and round whitefish (Table 1). Blackfish, Dallia pectoralis Bean, sculpins and salmon smolts were abundant in these slough areas. No pike or other whitefish were captured or observed at 18 Mile or in a slough area 3 miles upstream.

Buckstock River, the main tributary in Section II, heads in the Buckstock Mountains, flows to the west for 37 miles and joins a slough of the Aniak River at Mile 26.5. Part of the runoff is from the tundra so the water has a stained color all summer. The stream is 50'-60' wide in the lower reaches and quite shallow. A gravel bottom extends to the mouth and bottom composition is 20% sand and silt, 40% small gravel, and 40% medium gravel. Stream flow on August 11, 1976 was 164 cfs with a velocity of 2.5 fps. Water chemistry was: total alkalinity 26 ppm, hardness 34 ppm and pH 7.0. Water temperature was 11°C (52°F). The stream has a slow, even flow in the lower mile with deep pools (60%) alternating with riffles. The stream banks are overhung with willow and alder which provide cover for resident fish. Because of its shallow nature, riverboat travel beyond the first mile is difficult except during high water. The river has a spawning population of king, O. tshawytscha (Walbaum), chum and silver salmon. Grayling, Arctic char, round whitefish and rainbow trout are numerous and possibly also spawn there.

Section III extends from the Buckstock River to the Kipchuk River, a distance of approximately 33.5 miles. The river in this section is relatively straight, has no defined channel, a limited amount of braiding and is very swift. A heavy timber cover and the ever changing channel are responsible for numerous log jams and a large amount of slash in the water. Boating is difficult and dangerous. Gravel bars are common and the section has numerous tiny clear streams, side channels and sloughs. These areas as well as deep pools in the main river provide excellent rearing habitat for rainbow trout, salmon and char. The Salmon and Kipchuk rivers and Timber Creek are major tributaries in this section. Some salmon spawning occurs in the main Aniak River but most king and chum salmon spawn either in the Kipchuk or Salmon river. A minimum of 3,500 chum salmon were observed in the lower 20 miles of the Salmon River in late July, 1970; and 2,500 king salmon were counted in 1959. Counts in the Kipchuk River were 200-600 king salmon and 3,000-6,000 chum salmon.

On May 23, 1975 when Section III was first surveyed, the river had risen considerably from snow melt and the water was turbid. For the next three days, because of cold weather, water levels dropped and the water cleared somewhat. Rainbow trout and Arctic char were taken by hook and line and gill net in sloughs below the Salmon River (Table 1). Grayling and round whitefish were also taken by gill net. Grayling and rainbow trout were also captured by hook and line in the lower Salmon River.

In 1976 we arrived at the mouth of Salmon River on May 15 shortly after breakup and the water was dropping rapidly and becoming clearer because of cold weather. Again rainbow trout and char were taken by hook and line in sloughs of the Aniak below Salmon River, and round whitefish, Arctic char and rainbow trout were taken in gill nets (Table 1). The index nets were set two nights each in 1976 but few rainbow trout and char were caught because large numbers were caught on hook and line before nets were put in. In 1976 grayling had not yet arrived at 60 Mile Aniak so none were taken by hook and line or seine; only one immature individual was taken by gill net. No grayling were taken in the Salmon River. Round whitefish, rainbow trout and Arctic char were very abundant, indicating overwintering in this stretch of the Aniak.

Timber Creek is a small clear gravel bottomed tributary entering the Aniak from the east. It is 30' wide with a slow moving current. It is suspected that rainbow trout spawn in this stream.

The Salmon River, a major tributary in Section III, enters the Aniak River from the southwest at approximately Mile 60. In May it was 80'-100' wide in the lower 1/3 mile with a current of 2-4 mph. The pool riffle ratio was nearly 1:1. The bottom composition is 10% sand and silt, 20% fine gravel, 50% medium gravel and 20% coarse gravel. No flow determinations were made in May but in August, 1976 at low water a flow of 393 cfs was computed. Water temperature on May 26 was 3°C (37°F). Water chemistry data were: total alkalinity 43 ppm, total hardness 43 ppm and pH 7.5. In May of 1975, Arctic char, rainbow trout and grayling were captured in the lower Salmon on hook and line. In May, 1976, only round whitefish and juvenile char were taken in three net nights of gill netting and on hook and line. The Salmon River narrows and is contained in a defined channel extending from 1/2 to 2-1/2 miles upstream where a complete log jam halts upstream navigation. This section of the river was nearly all riffle, the current was slower than at the mouth and the bottom contained more silt than in the lower reaches. The Salmon River is an important salmon spawning stream, with most spawning occurring between the mouth and Marvel Creek.

The Kipchuk River also enters from the southwest about 2 miles upstream from the Salmon. This river is slightly larger than the Salmon and in August at low water had a flow of 453 cfs. Bottom composition and water chemistry were similar to that of the lower Salmon River. Little sampling was conducted in the Kipchuk, but rainbow trout and grayling were taken in the lower reaches in August.

Section IV includes the Aniak River from above the Kipchuck, where the Aniak is locally called the East Fork, up to Aniak Lake. Because of extremely low water in May and August of both years, little survey work was conducted. No rainbow trout were captured above the Kipchuck River confluence and according to Aniak residents both rainbow trout and salmon are rare in Section IV. The lower reaches of Section IV have slow moving water and a bottom composed of smaller gravel and more silt than the bottom in Section III. Water temperature on May 16 was 1.5°C (35°F).

Aniak Lake is located at the head of the Aniak River at 800' above sea level, 60°20' N and 159°12' W. Aniak Lake is 3.5 miles long x 1/2 mile wide (Fig. 3). The lake is tightly enclosed by mountains up to 4,500' elevation. They were still snow covered on July 10. The lake drops off rapidly to a maximum depth of 124' and has little shoal area except near inlet streams entering near the narrow central part of the lake and the extreme southern inlet stream. The lake is in mountain tundra habitat with a heavy band of willows around the shore. The inlet shoal areas have a bottom of mainly medium gravel to cobble while gravel size in other shoal areas ranges from fine to coarse. Cobble predominates as the water deepens. The lake outlet, the Aniak River, is 100' wide and 1'-2' deep with a current velocity of 3-4 fps. The bottom is algae covered and composed mainly of medium gravel to cobble. Three major inlets enter the lake. The largest at the southern end of the lake is 100' wide, with an average depth of 18" and a velocity of 1 fps. Beaver activity is responsible for some holes up to 8' deep. The bottom is composed of silt and fine and medium sized gravel which provides spawning habitat. This inlet has many sloughs and side channels but grayling were not abundant in this area. Water temperature on July 10 was 7°C (45°F). The inlet on the east central part of the lake is approximately 30' wide, 10"-18" deep and has a velocity of 4 fps. This inlet has a bottom of medium to coarse gravel, many sloughs and much beaver activity. The third inlet on the west central part of the lake is only 4' wide.

Water temperature of Aniak Lake on July 10 was 12°C (54°F) and water chemistry data were: alkalinity 34 ppm, total hardness 51 ppm and pH 7.5. The Sechii disc reading was 30'.

Grayling were more abundant in Aniak Lake than in any other lake in the study area and 26 were taken during four net nights of fishing. Grayling comprised 54% of the total catch in Aniak Lake. In addition, two grayling were caught on hook and line; one Arctic char, 2 round whitefish, and 21 lake trout were taken by gill net and 32 lake trout were captured during 4 hours of hook and line fishing. Lake trout ranged from 275 to 590 mm fork length and weighed 275 to 2,250 g.

Char are rare in Aniak Lake and only one was captured. A silver salmon smolt was captured, but it is not known how abundant they are or if any other salmon species are present. The few red salmon, O. nerka (Walbaum), observed in the Aniak River probably spawn in the main Aniak river below the Kipchuk River and do not reach the lake.

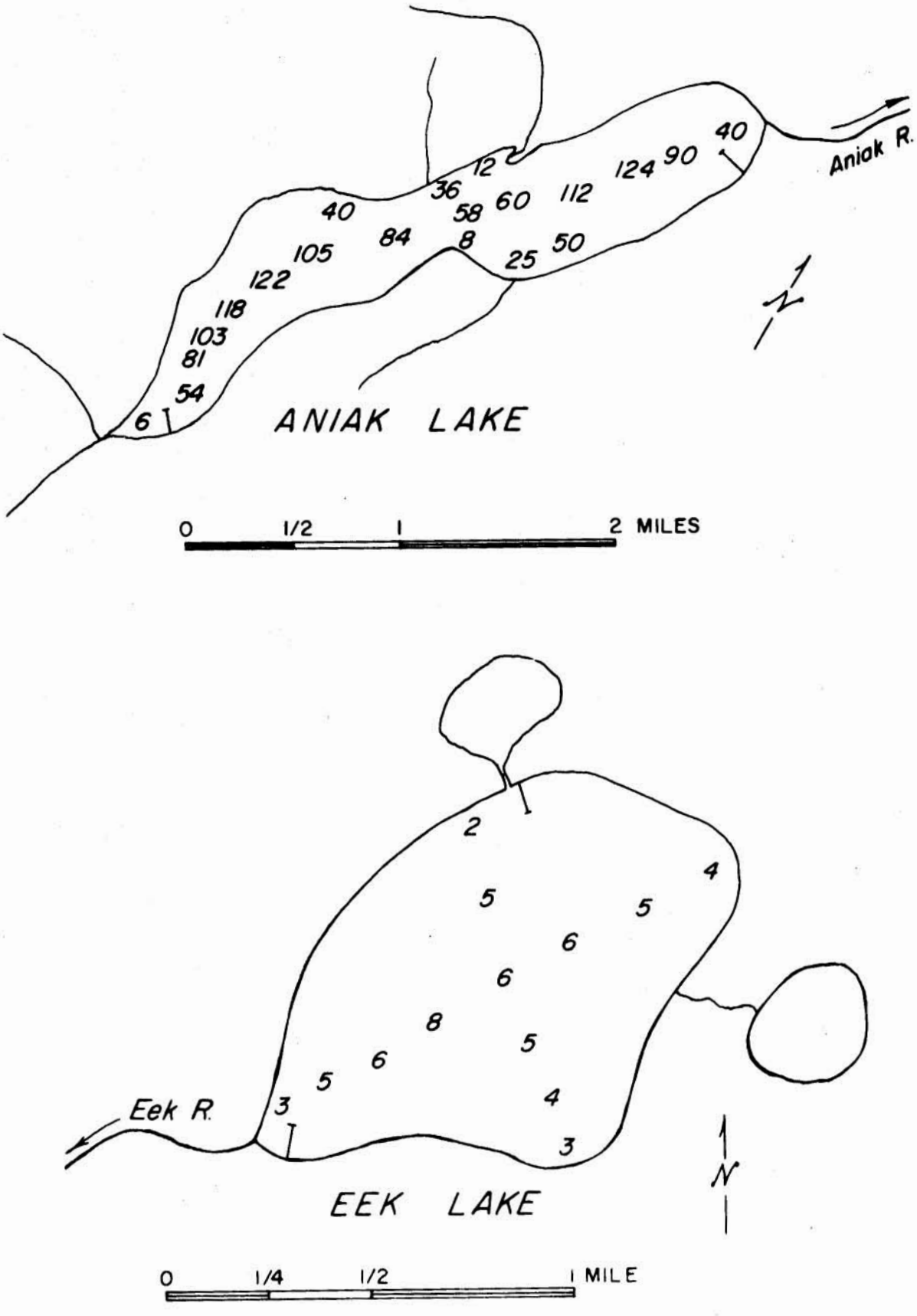


Figure 3. Aniak Lake (above) and Eek Lake (below).

Tuluksak River:

The *Tuluksak River* (Fig. 4) drains the northwest part of the Kilbuck Mountains and flows 85 miles to enter the Kuskokwim River at Tuluksak village at 61°6' N and 160°59' W. Drainage area is 810 square miles. It is a slow moving meandering stream over most of its length. A placer gold mine is still in operation in the upper Tuluksak at Nyac.

The river is fairly easy to navigate, although there are many sweepers and log jams. Shallowness of water is the major factor limiting small boat navigation beyond 40 miles. The Tuluksak is smaller than the Kwethluk and is about 85' wide in the lower reaches. The lower 60 miles of the river were surveyed by boat in early August.

Section I consists of the lower 30 miles and ends where the two channels again join to form one channel at 60°03' N and 160°35' W. The first gravel is found about a half mile below this section. The bottom in the rest of the section is composed of mud and sand. The banks are willow covered with some spruce, birch, willow and cottonwood.

Fog River, a major tributary in Section I, drains a large area of tundra and contributes significantly to the brown color of the water in the lower river.

The Tuluksak is slow moving with a velocity of 1.1 fps above Fog River. The average depth was 4.6' and the calculated flow was 386 cfs. Water chemistry data from Section I are: alkalinity 34 ppm, hardness 43 ppm and pH 7.5.

Two graduated mesh gill nets set overnight near the mouth of the Fog River in early August took only two northern pike, while three northern pike and one grayling were taken in 1 hour of hook and line fishing.

Section II begins at the single channel and extends through the upper boundary surveyed (Mile 60). This section has a gravel bottom and the current is swifter than in Section I (4 fps in upper reaches). Bottom composition in the upper reaches of Section II is 20% sand, 40% fine gravel and 35% medium gravel and 5% coarse gravel. This section cuts through several tundra areas which contribute siltation to the river but the river clears up considerably in the upper reaches of the survey area. Section II meanders less than Section I and has considerable downed trees and log jams. Average width was 52' and average depth was 1.6'. Water temperature was 9°C (48°F) and chemical analysis was: alkalinity 34 ppm, hardness 34 ppm and pH 7.5.

This section contains excellent spawning habitat for grayling, char and salmon. Thirty to fifty thousand chum salmon and approximately 1,500 king salmon were observed spawning in this section. It is not known if pink, O. gorbuscha (Walbaum), or silver salmon spawn in this section.

Arctic char and grayling were abundant throughout this section especially in areas where salmon were spawning. Ninety grayling, 27 char, 2 chum salmon and 1 northern pike were taken in 12 hours of hook and line

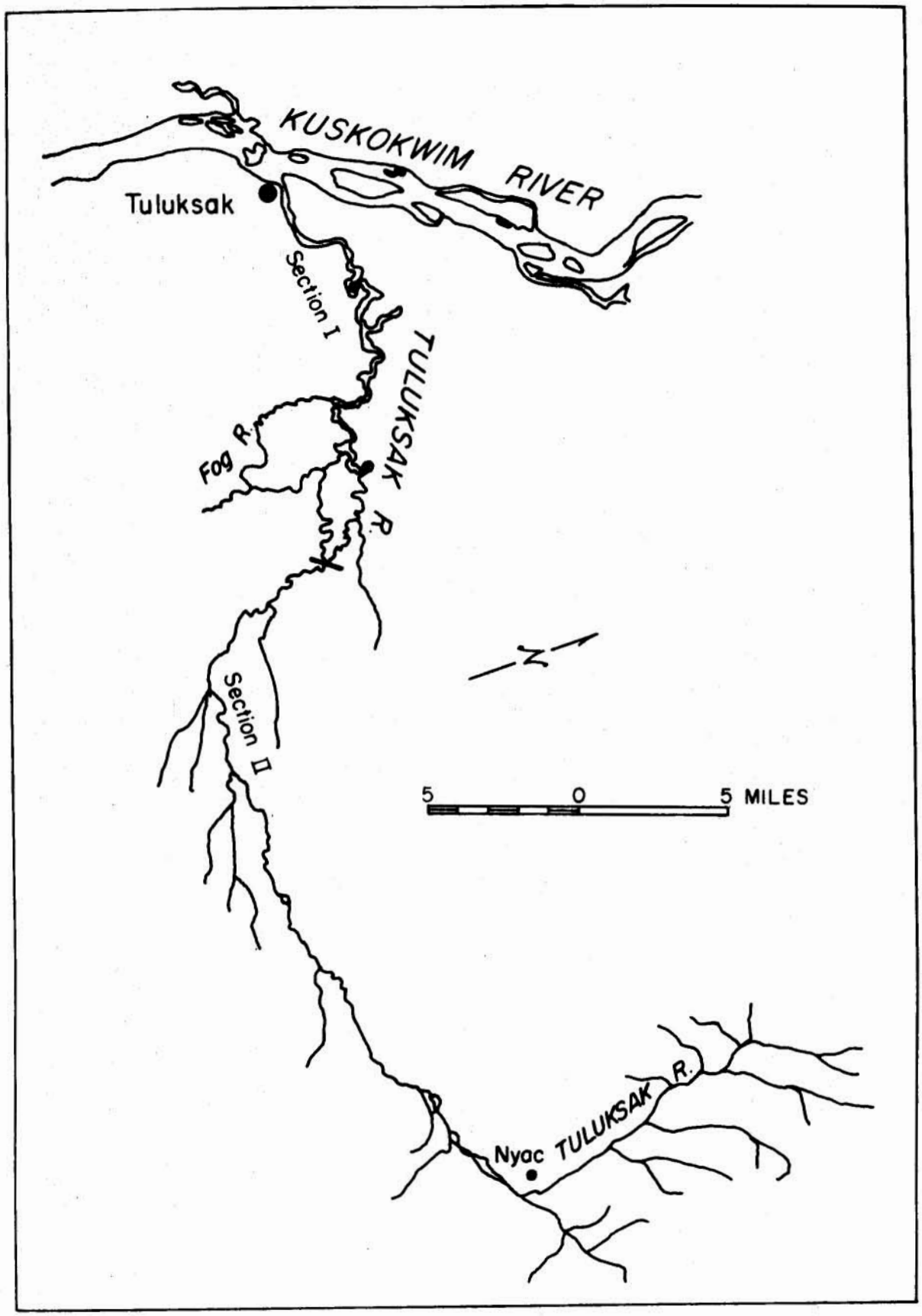


Figure 4. Tuluksak River Drainage. Drawn from USGS Russian Mission and Bethel 1-250,000 map.

fishing; and 10 northern pike, 2 grayling, 2 char, 1 humpback whitefish and 11 chum salmon were taken in two small mesh 25' nets set overnight. Round whitefish were also observed feeding on salmon eggs, but none were taken. No rainbow trout were captured on hook and line or by gill net and none were observed. I am assuming that rainbow trout are not present in this stream. Rae Baxter (pers. comm.) had heard of an angler catching rainbow trout in the Tuluksak River but the authenticity of the catch has not been verified.

The river above the survey point is much swifter and provides less fish habitat. Some salmon spawn in the area up to Nyac, but considerably fewer than spawn in Section II. Some king salmon spawn up to Nyac and grayling are abundant beyond Nyac.

There are no lakes at the head of the Tuluksak River. The Tuluksak River receives light subsistence and sport fishing pressure, mainly from residents of Tuluksak. Northern pike, grayling and Arctic char are the most important sport species.

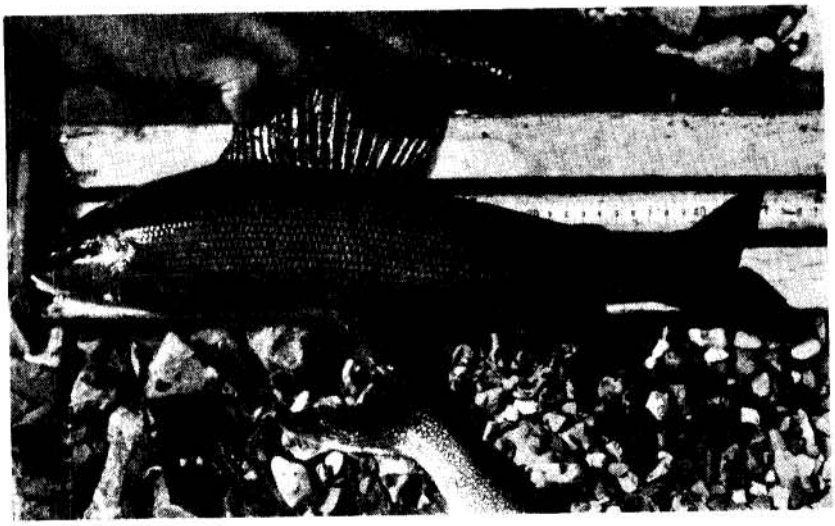
Kisaralik River System:

The 120 mile long *Kisaralik River* (Fig. 5) rises in the Kilbuck Mountains at the Bristol Bay divide and flows northwest to empty into the Kuskokwim River 40 miles above Bethel at 60°52' N and 161°14' W. The channel in the Kuskokwim Flats is poorly defined, with many meandering channels and sloughs. It has two major headwater lakes and seven major tributaries. The drainage area is 1,070 square miles. It is a swift, rapid drop river over most of its course. The river has a narrow band of trees from the lower reaches up to Quartz Creek. The lower 52 miles of the river were surveyed by boat in June and late July. Aerial flights were made of the upper Kisaralik River from Golden Gate Falls at 60°30' N and 160°10' W. This section is almost entirely rapids and possesses little good fish habitat. Grayling and round whitefish are probably present.

The Kisaralik River was divided into three sections for survey purposes:

Section I consisted of the lower 19 miles of the stream where the single channel shows considerable meandering and has many mud banks. Bottom composition throughout most of this section is mud and sand but fine gravel is encountered at Mile 16. Velocity was quite slow, 2.2 fps, with an average depth of 4.5' and average width of 120'. Flow was computed at 1,079 cfs on July 30. At high water some of the Kisaralik flow enters the Kasigluk River at Mile 29. The water is brown colored in most of Section I but clears up considerably at the start of Section II. Gill net catches in Section I for four net nights in June consisted of 25 grayling, 3 broad whitefish, 2 round whitefish, 1 burbot, 1 least cisco, 4 humpback whitefish, 4 northern pike and 3 Arctic char. Salmon fry were observed in this section and northern pike and grayling were captured on hook and line in slough areas. In late July only small mesh nets of 1/2" and 3/4" bar mesh were set in an effort to capture juvenile fish. Six net nights of fishing these small nets captured two Arctic char, five rainbow trout, four grayling, three pike, one humpback whitefish, two round whitefish, three king salmon, and seven chum salmon.

Kisaralik Lake



Grayling
Kisaralik Lake

26½ Pound Lake Trout
from Kisaralik Lake #2

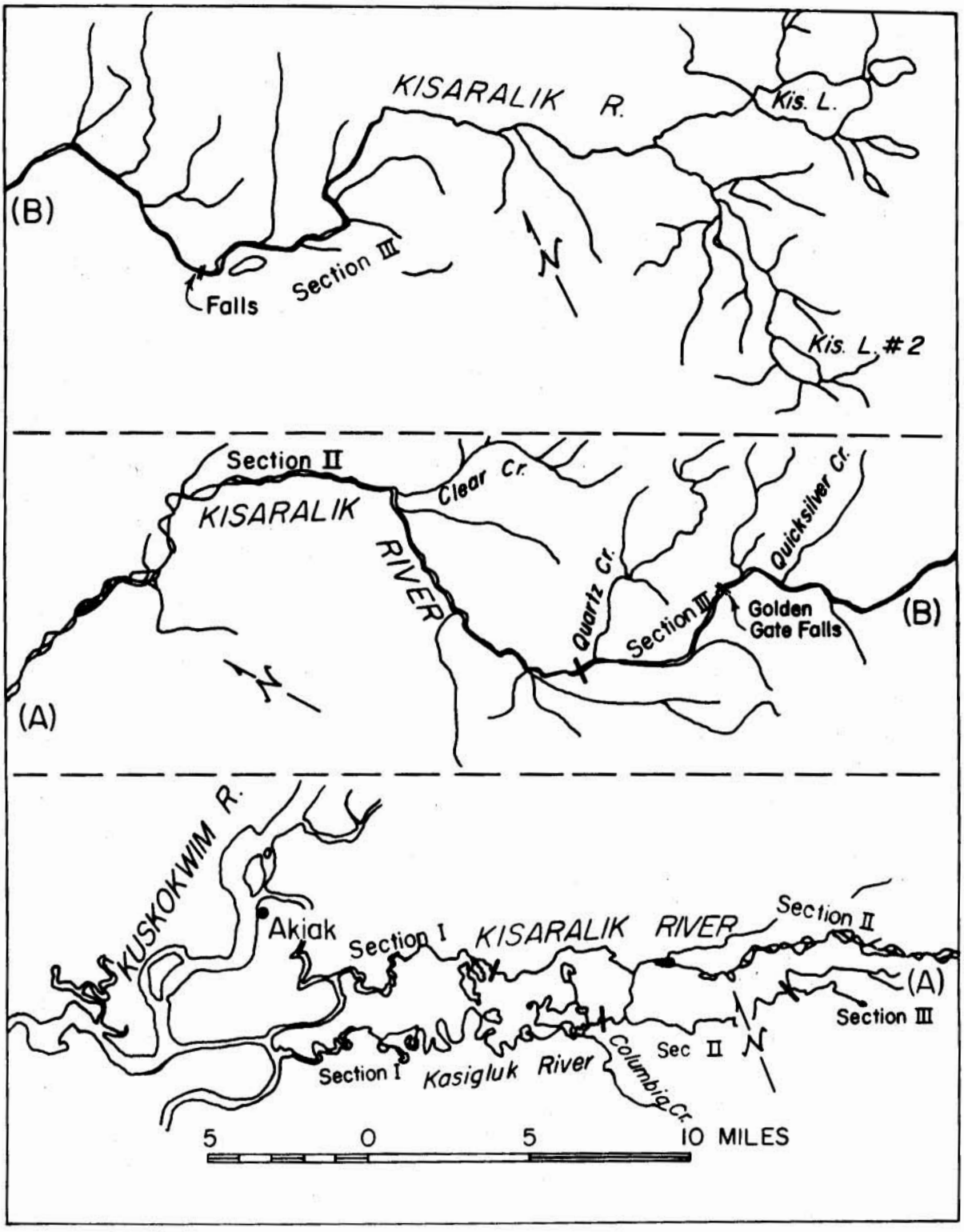


Figure 5. Kasigluk and Kisaralik river drainages showing major lakes and tributaries. Kasigluk River on bottom of page; headwaters of Kisaralik River on top of page.

Section I has little spawning habitat for fish other than pike. Few rainbow trout are encountered here during the summer, but some may overwinter in the deep holes. Few whitefish and suckers and no sheefish are encountered in this area, probably because of the swift current. Water temperature on June 3 was 7°C (45°F) and on July 30 was 14°C (57°F). Water chemistry analysis on July 30 was: alkalinity 43 ppm, hardness 51 ppm and pH 7.5.

Browns and Reindeer sloughs enter the Kisaralik in Section I and bring in considerable silty water.

Section II starts at 19 Mile where the Kisaralik begins braiding and ends below Quartz Creek where it again becomes a single channel, a distance of about 33 miles. The river channel is constantly changing. Numerous log jams, submerged trees and overhanging willow banks provide cover for rainbow trout and grayling but make boat travel difficult.

Gravel size in Section II consisted of 10% silt and sand, 20% fine gravel, 20% medium, 40% coarse and 10% rubble. The water was a light greenish color on July 29 and water temperature was 11°C (52°F). The current is swift in this section, averaging 6.5 fps. The river was quite shallow (10"-15" deep) and channels were 40'-60' wide. Water chemistry was the same as in Section I. Small side channels provided habitat for juvenile rainbow trout and char. The lower part of Section II is nearly 90% riffles with small eddies and pools being found at the cut banks and behind log jams and submerged trees. The upper part of Section II is nearly 100% riffles with very little habitat for char, grayling and rainbow trout. The narrow band of spruce, cottonwood and willow continued along Section II.

Section II contains most of the Kisaralik River spawning habitat for king, chum and silver salmon as well as grayling, round whitefish, Arctic char and rainbow trout, especially from Mile 24 to 42.

Two gill nets set in Section II in early June took 3 round whitefish, 19 grayling, 2 rainbow trout, 2 broad whitefish, 6 northern pike and 1 Arctic char. The pike and broad whitefish were taken in the lower part of Section II. In July only small mesh nets of 25' length were set and eight chum salmon, one pink salmon, five grayling, one round whitefish, and one Arctic char were taken in four nights of fishing. Seven rainbow trout, 32 grayling and 1 Arctic char were taken during 6.5 hours of hook and line fishing. Silver salmon had not yet entered the stream, but 1,500 king salmon and many chum salmon were observed in Section II. Commercial Fish Division aerial surveys in July enumerated 5,000-10,000 chum salmon and 200-600 king salmon. No adult salmon were observed in Kisaralik Lake. July 20 is the peak of king salmon spawning.

Nukluk Creek and Clear Creek are the major tributaries entering the Kisaralik River in Section II. These streams and numerous tiny side channels provide rearing areas for young salmon, trout, char, grayling and round whitefish.

The Kisaralik River in *Section III* is a single swift, boulder strewn channel all the way to Kisaralik Lake. The bottom is covered mainly with large gravel and rocks, and few fish are found there. Golden Gate Falls, 7 miles above Quartz Creek, is a partial barrier to fish movement, but some salmon have been observed spawning above it. The Kisaralik River was surveyed by foot for a mile below Kisaralik Lake but no fish were observed. A hydroelectric dam, having a reservoir of approximately 10 square miles has been proposed for Golden Gate Falls.

The Kisaralik is an important sport fishing stream in the lower Kuskokwim River. Fishermen, mainly from Bethel and villages upstream, have been observed on weekends in late July and August. Rainbow trout, grayling, char and silver salmon are the most important sport species and most fishing is done in Section II from Mile 20 to 40. Access is by boat only although an old airstrip and cabin are present at Mile 34.

Kisaralik Lake (unnamed on the 1950 U.S.G.S. Bethel quadrangle map) is located at the northern headwaters of the Kisaralik River at 60°18' N and 159°22' W (Fig. 6). The lake, at an elevation of 1,600', is ringed by snow covered mountains rising to 4,000' and is roughly 3.8 x 1.8 miles with a maximum depth of 135'. The lake became ice free on July 9 although two small connecting lakes (on the east and southeast side of the lake and 0.8 and 1.8 miles in length) had considerable ice cover on that date. The lake has six inlet streams, two each at the northeast, southeast, and north sides, all of which are 15'-30' wide, with moderate to swift current and have fine gravel bottoms. The outlet (Kisaralik River) at the western end is 80' wide with an average depth of 2.5' and a discharge of 1,116 cfs. Velocity was 5.8 fps. The lake has 5% shoal area, much of it located on the north side of the lake. Considerable spawning habitat is available, in the forms of rubble in the lake bottom and gravel in the inlet streams and along the lake shore. Rearing salmon fry were observed in the pool areas of the inlet stream on the northeast edge of the lake. No adult salmon were seen. The watershed type is alpine tundra with a few willows present. Water temperature on July 9 was 4°C (39°F) and water chemistry was: hardness 34 ppm; alkalinity 34 ppm and pH 7.5. The lake was clear with a Secchi disc reading of 40' plus. Four nights of fishing a 125' graduated mesh gill net between July 9 and 11 took 7 lake trout, 10 Arctic char, and 5 grayling. Small mesh 50' gill nets took 10 Arctic char. Lake trout from Kisaralik Lake were all in the same size group and ranged from 465 to 535 mm (18" to 21") with one exceptional fish of 700 mm (28"). No gill nets were set in the two small connecting lakes draining into the east end of Kisaralik Lake, but lake trout were caught on hook and line and Arctic char were observed. No grayling or char were caught on hook and line. Sport fishing for lake trout was successful at inlet streams and at the edge of shoal areas. During 11 hours of fishing 19 lake trout were taken.

Kisaralik Lake #2 (unnamed on the Bethel quadrangle map) is located approximately 7.2 miles southeast of the main Kisaralik Lake at 60°13' W and 159°28' N and 1,800' above sea level (Fig. 6). The lake drains into the Kisaralik River via an 8.4 mile stream. The lake is 1.8 by 0.9 miles wide. It is situated in mountainous terrain and has very little shoal

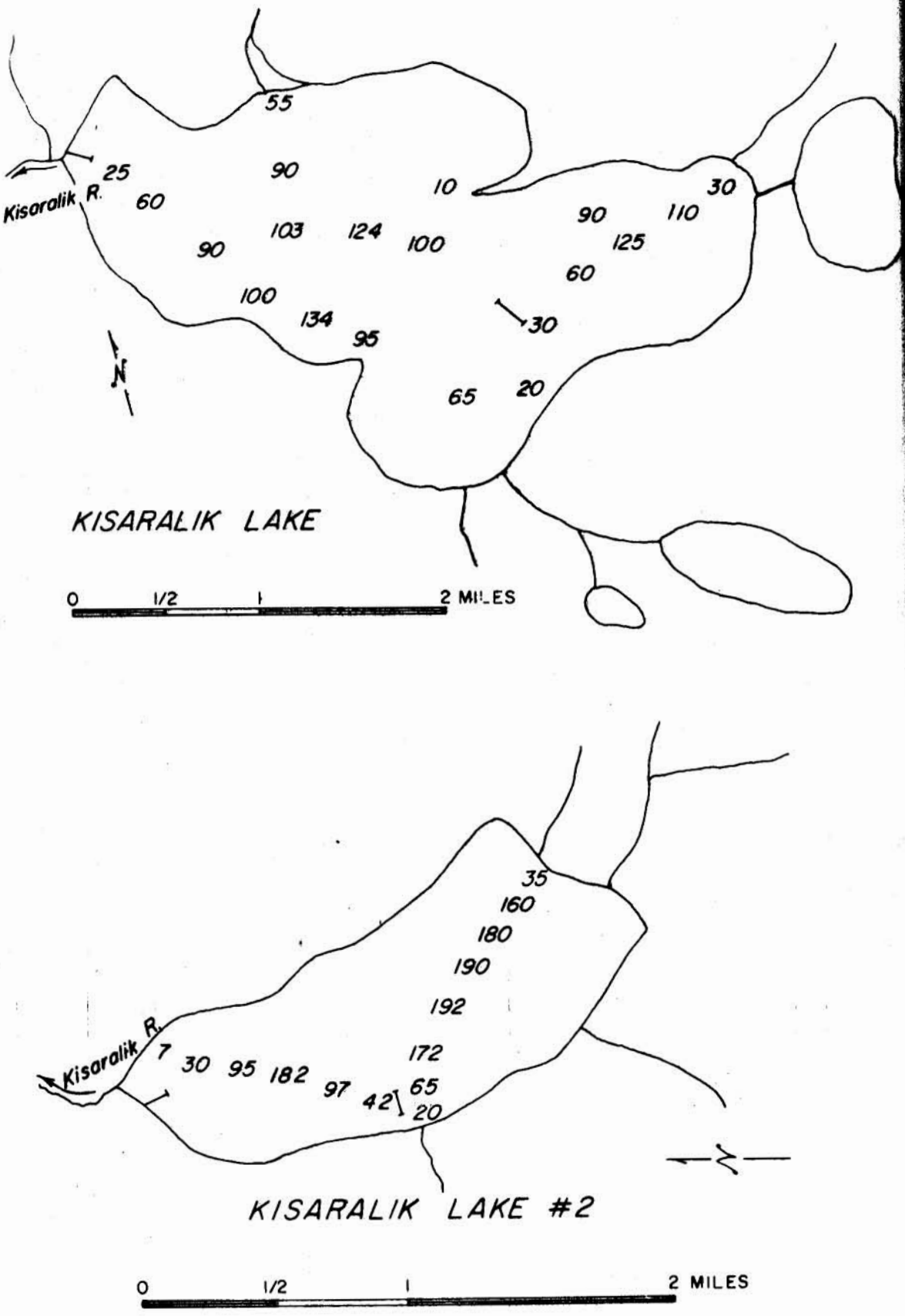


Figure 6. Kisaralik Lake (above) and Kisaralik Lake #2 (below).

area. Vegetation is alpine tundra with small cottonwood trees present along inlet streams. Maximum recorded depth was 192'. Three inlet streams, 15'-25' wide and 8"-18" deep, have fast current (4-5 fps) with gravel and rock bottoms that might provide spawning areas but little in the way of rearing areas.

The outlet stream is 35' wide with an average depth of 18". Velocity was 2.5 fps and the flow on July 10 was 131 cfs. Water temperature was 8.5°C and the Secchi disc reading 39'. Water chemical data were: total alkalinity 25 ppm, total hardness 25 ppm and pH 7.5.

A 125' graduated mesh gill net set overnight near the outlet took two grayling, six Arctic char and six lake trout, while a net set in 40' of water off an inlet stream took only six lake trout. Four Arctic char, one grayling and two lake trout were taken in a small mesh net 50' long. Hook and line fishing off inlet streams was moderately successful and 14 lake trout, 6 grayling and 3 Arctic char were taken in 11 hours of fishing. A 12 kg (26.5 lb) lake trout caught on hook and line in this lake was the largest lake trout captured during the two-year study.

Kasigluk River:

The Kasigluk River has its origin in the Kilbuck Mountain Range at 60°23' N and 160°04' W and 580' above sea level. It flows generally northwest for approximately 100 miles and empties into the Kuskokwim River 20 miles above Bethel (Fig. 5). It has no headwater lakes. The river parallels the Kisaralik River and receives overflow water from it at Mile 29 and Mile 39. The drainage is 250 square miles.

The lower part of the river is slow moving and the river meanders along its entire length. The river was in flood stage when first surveyed in June 1975 but had cleared considerably by the second trip in August. The river was surveyed by boat to the mouth of the Little Kasigluk River.

Section I (mouth to Mile 27) had a mud (90%) and fine gravel (10%) bottom. Stream flow was 240 cfs in June and 120 cfs in August. Bank vegetation was composed of willow and alder along the shore with tundra beyond that. There were many side sloughs and ponds off the main channel where northern pike and grayling were found. Water temperature on August 15 was 8°C (46°F).

Section II (Mile 27 to Mile 50) has a bottom composed of 20% fine gravel and 80% medium gravel. Birch and spruce are dominant shore trees. The river is navigable through this section with a propeller driven boat in periods of high water. There are sweepers and snags in the water which occasionally hinder progress and the stream narrows to 50'. The water in Section II was clear green in August. The area above Columbia Creek (Mile 29) is a major spawning area for salmon, northern pike, grayling, rainbow trout and possibly humpback whitefish. Major tributaries are Columbia Creek and Griddle Creek. Water data on August 11, 1975 in Section II were: alkalinity 34 ppm, hardness 51 ppm, pH 7.5 and water temperature 6.0°C (43°F).

The Kasigluk above its junction with the Little Kasigluk was termed *Section III* (Mile 50 to Mile 110). It winds through a narrow, shallow valley with many sharp bends. The bottom is mainly medium gravel with some coarse gravel present and the water is clear at normal flows. The upper section is shallow, with many riffle areas, and is difficult to navigate by boat.

Gill nets set in Section I and II on June 11-13 (3 net nights) took 1 sheefish, 5 broad whitefish, 7 humpback whitefish, 24 northern pike, 26 grayling, 2 least cisco, 1 rainbow trout, 1 Arctic char, 15 round whitefish and 2 sculpins. The rainbow trout, most of the Arctic char, grayling and silver salmon were taken above Columbia Creek in Section II. Nineteen grayling and 45 northern pike were taken in 9 hours of hook and line sampling. In August, 15 broad whitefish, 11 humpback whitefish, 44 northern pike and 1 Arctic char were taken in four net nights of fishing in Section I.

Presently there is sport fishing pressure from residents of Bethel, Kwethluk and possibly Akiak and Akiachak. Rainbow trout which are found above the Kisaralik-Kasigluk slough (Mile 30) are the target species for sport fishermen. Anglers also capture grayling, northern pike, char and silver salmon. Northern pike were abundant in the sloughs off the lower river in June but little fishing pressure was noted.

Kwethluk River:

The Kwethluk River rises in the Kilbuck Mountain Range between the boundary of the Kuskokwim River and Bristol Bay. It flows generally northwest for 138 miles and enters a slough of the Kuskokwim River at 60°50' N and 161°20' W approximately 20 miles upstream of Bethel (Fig. 7) The Kwethluk River has a drainage area of 1,300 square miles. It meander considerably in the lower reaches until it reaches the foothills of the Kilbuck Mountains. The entire watershed is tundra but a narrow band of willow, spruce, cottonwood and birch is found along the river. The Bethel 1950 quadrangle map shows a large lake at the head of Canyon Creek (Crooked Creek on 1954 Bethel B-6 map) at 60°05' W and 159°40' N, but ground inspection showed that this lake and another smaller lake to the east both flow into the Bristol Bay drainage. Another small lake on Akoswift Creek was not surveyed.

The river was surveyed by boat in the lower 62 miles in early June and in the lower 72 miles by boat in August. The river is considerably easier to travel than the Kisaralik as the channels and water are deeper and the current slower with fewer log jams.

Section I consists of the lower 29 miles of the river where the bottom is mud covered, the channel deep and up to 175' wide. The water in this section is brown colored even in July. Shore vegetation is mainly willow but some birch and spruce are present farther up this section. Water temperature in early June was 10°C (50°F). Water chemistry readin were: alkalinity 34 ppm, hardness 51 ppm, pH 7.7.

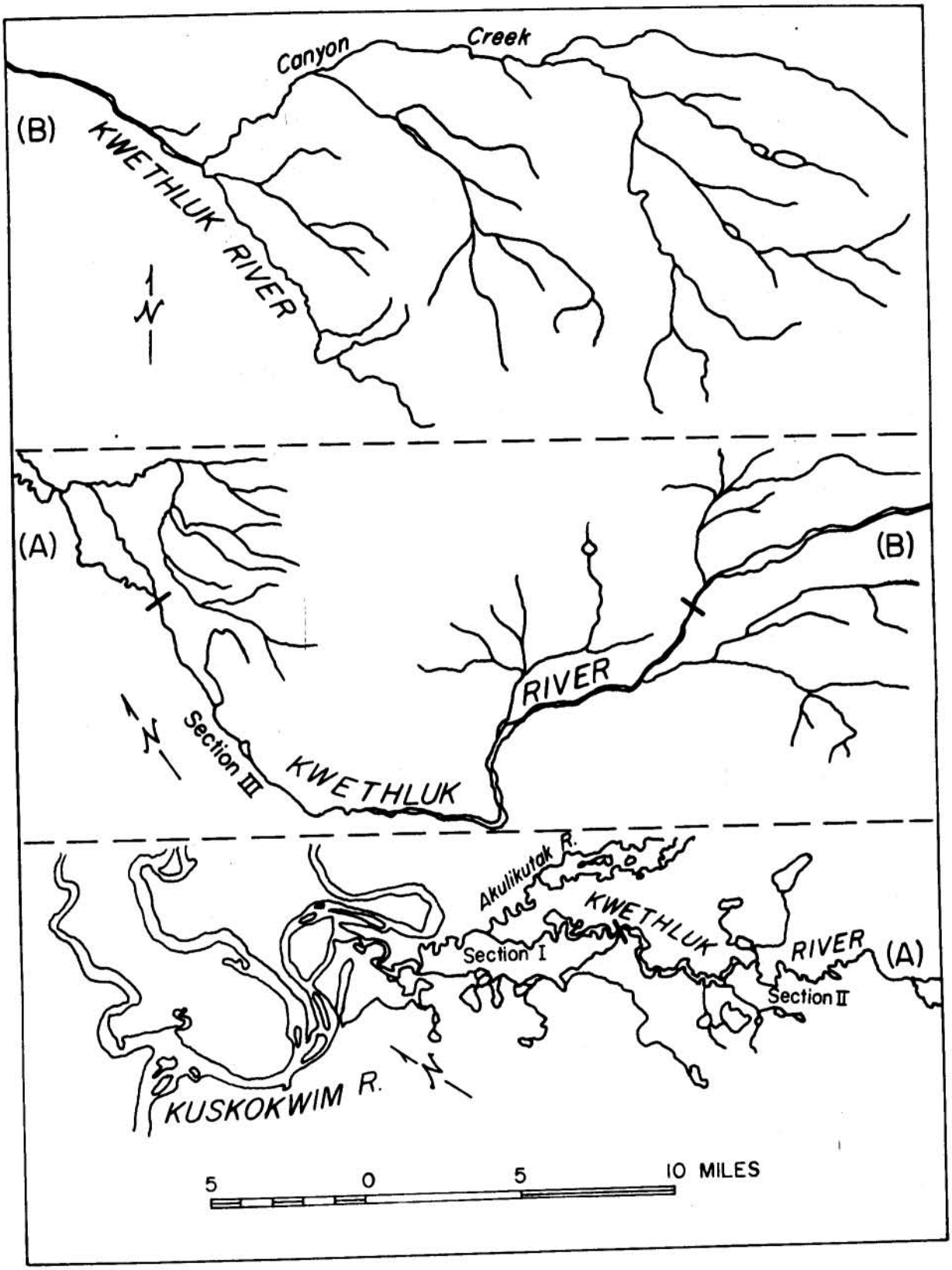


Figure 7. Kwethluk River drainage. Mouth of Kwethluk River is in lower section, mid-section in the middle and headwaters at top of page. Drawn from USGS Bethel quadrangle.

Gill nets set in the lower Kwethluk near Akulikutak River took 10 northern pike, 1 burbot, 2 grayling and 2 humpback whitefish in June (one net night), and three nets set overnight in the lower Akulikutak River in late July took 14 pike, 2 char, 10 least cisco, 5 broad whitefish and 3 humpback whitefish. Sheefish are occasionally captured in the lower Kwethluk River. Nineteen northern pike and 3 grayling were caught on hook and line in 7 hours.

Section II from Mile 29 to Mile 50 has a gravel bottom and is generally a single channel with mud banks. The water is silty all summer due to the channel cutting through mud banks near Mile 49-50. Dominant shore vegetation is spruce, willow, birch and cottonwood. Water temperature in late July was 14°C (57°F) and water chemestry results were: alkalinity 43 ppm, hardness 51 ppm, and pH 7.5. Bottom composition was 10% silt and sand, 30% fine gravel, 50% medium gravel and 10% coarse gravel.

Four net nights of fishing in June took 18 northern pike, 4 round whitefish, 8 rainbow trout, 6 humpback whitefish, 1 Arctic char, 12 grayling, and 2 broad whitefish. Northern pike and grayling were caught on hook and line. There is little salmonid spawning occurring in this area because there is little suitable habitat.

Section III from Mile 50 to approximately Mile 86 consists of braided active channels with large trees along the shores and has excellent habitat for rainbow trout, grayling and Arctic char. The water in late summer is clear to light green. The main channel is 100' wide with an average depth of 1.9', a velocity of 6.25 fps and a flow of 1,084 cfs in July. Water temperature in late July was 11.5°C, and water chemistry data were the same as in Section II. Bottom composition is 10% sand and silt, 20% fine gravel, 50% medium gravel, and 20% coarse gravel. This section contains excellent spawning habitat for king, chum, pink and silver salmon. An aerial survey on July 22 counted 800 king salmon and 3,900 chum salmon. A few pink salmon and six red salmon were also observed in Section III. Most spawning occurs in the main channels but some chum salmon, were observed spawning in side channels. These small, gravel-bottomed side channels provide rearing areas for rainbow trout, grayling, Arctic char and salmon.

During 12 hours of angling in Section III in late July, 22 rainbow trout, 19 grayling, 11 Arctic char, 1 king salmon and 3 chum salmon were taken. Silver salmon had not as yet entered the river.

The Kwethluk River receives the heaviest fishing pressure of the lower Kuskokwim streams, and 18 fishermen in seven boats were observed fishing during the weekend in Section III. Rainbow trout is the main sport species but char, grayling, and silver salmon are also sought.

The upper Kwethluk was not surveyed but Division of Commercial Fisheries surveys indicated that salmon spawn in this section up through lower Canyon (Crooked) Creek. It is not known how far rainbow trout are found up the Kwethluk River but they are probably found at least in the lower reaches of *Section IV*. A number of tiny tundra lakes are found near the

head of Canyon (Crooked) Creek but probably are not used for salmon spawning.

Eek River System:

The *Eek River*, with a watershed of 2,080 square miles flows generally west and northwest for 110 miles then joins the Eenayarak River to form Eek Channel of the Kuskokwim at 60°12' N and 162°15' W (Fig. 8). It is the major drainage south of the Kwethluk and north of the Kanektok River. The North Fork contains a small lake, Eek Lake, near its headwaters. The Middle Fork and North Fork head in the Eek Mountains, and the river empties into the Kuskokwim Delta south of 60° N, 45 miles southwest of Bethel. It is considered the southernmost tributary of the Kuskokwim River. The village of Eek is located approximately 20 miles upstream of the point where Eek Channel enters Kuskokwim Bay. The lower river drainage consists of lake dotted tundra of the Kuskokwim Delta.

The river was surveyed by boat in mid July from Eek village to a point 12 miles up the Middle Fork and 6 miles up the North Fork. The junction of the North and Middle Fork is approximately 55 miles up from the mouth. There is tidal influence up to 40 miles above the mouth.

Section I consisted of the part of the river with tidal influence (about 40 miles). This section has excessive meandering, few tundra banks, deep, slow moving and silty water. The bottom is mud covered except some fine gravel is encountered in the upper part of Section I. The first willows appear about 6 miles above Eek village and a narrow band lines the river throughout the area surveyed. The river is over 300' wide and over 5' deep near the village of Eek. No flow measurements were taken in Section I. Two 125' graduated mesh gill nets set overnight took 3 humpback whitefish, 2 Arctic char, 2 northern pike, 2 chum salmon and 1 pink salmon. Small northern pike were also taken in 25' small mesh gill nets set in sloughs of the Eek River.

Section II included 18 miles from the end of tidal influence to the forks. The river was still slow moving and had a silt and fine gravel bottom through the entire section. The bottom was mostly covered with a mat of algae. Mud banks lined the shore in many areas but seemed to contribute little to the turbidity of the water. No gill nets were set in Section II but grayling were occasionally observed along the shore. No sport fishing was done in this section. Because of uniformity of habitat, it appeared that few fish were resident in this section. Most fish in the area were migrating further upstream. The Ugaklik River is the major tributary entering the Eek River from the south in this section. This slow moving, silty river is 75' wide at the mouth and about 2.5' deep. The bottom is mud covered. Two northern pike and two grayling were taken in 1 hour of angling.

The upper limits of the survey in the main fork (North Fork) and the Middle Fork were included in *Section III*. The lower 12 miles of the Middle Fork had a fine gravel bottom similar to that in Section II but had a considerably faster current. Flow measurements taken 10 miles up the Middle Fork on July 20 were as follows: width 90', average depth

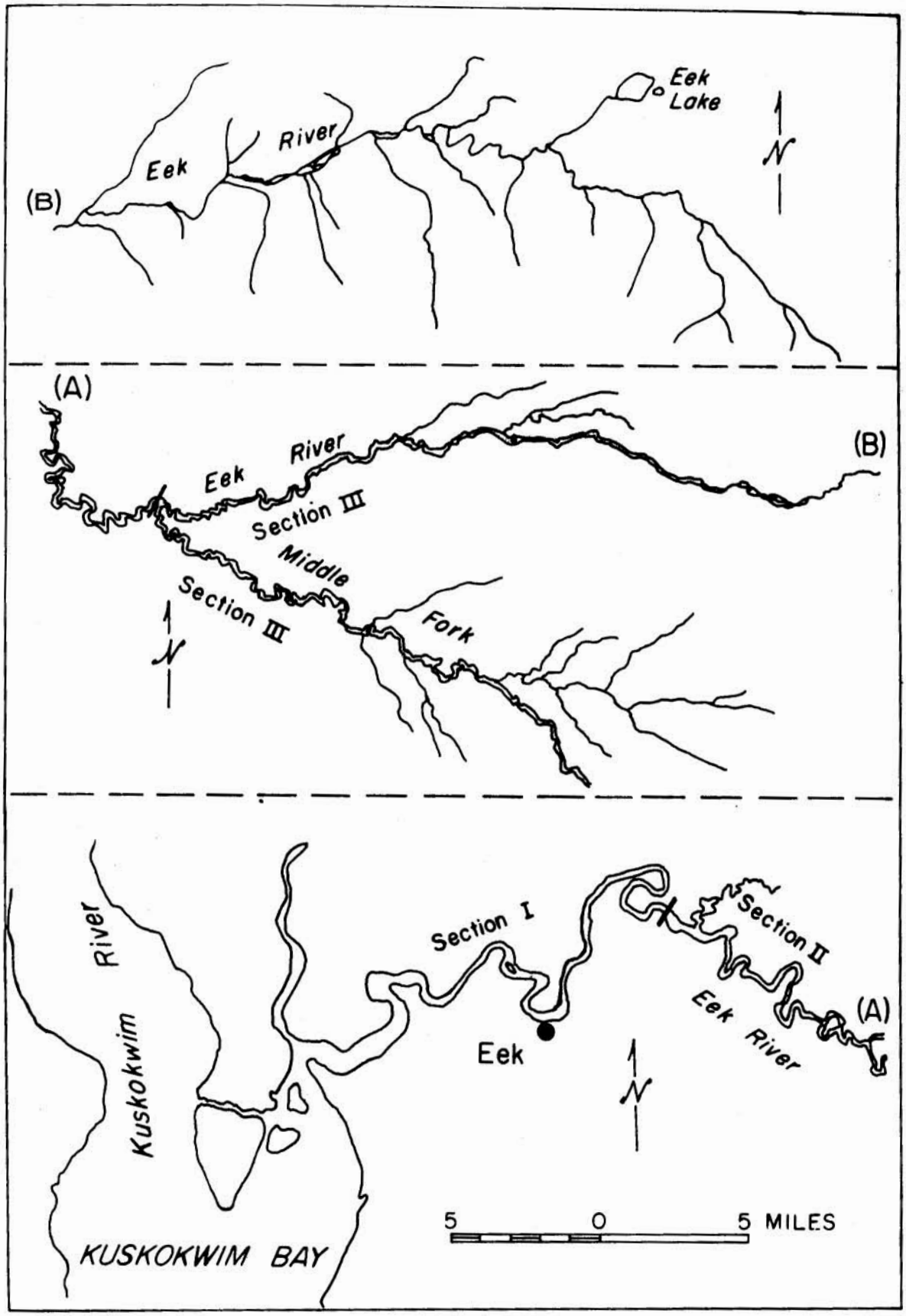
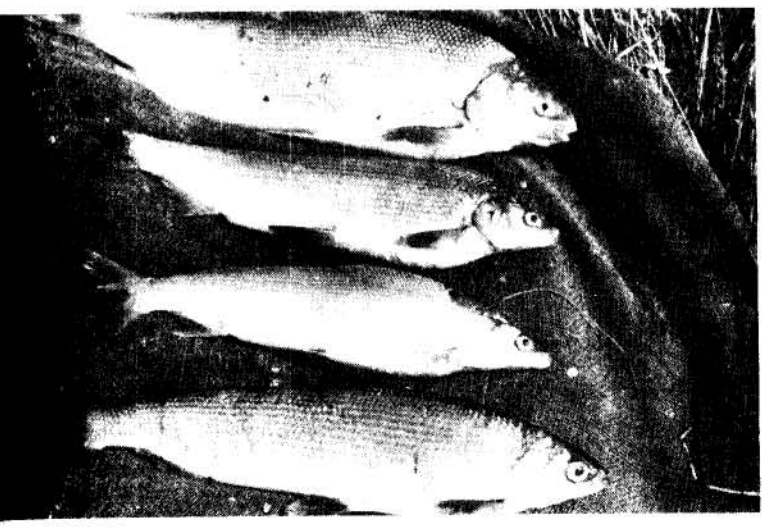


Figure 8. Eek River drainage. Headwater sections on middle and top of page. Drawn from USGS Bethel quadrangle map.

Sampling gill net caught fish from Goodnews Lake

ıer Eek River
ɔwing lake and
ɔugh area of
skokwim Delta



Top to bottom:
Broad whitefish 480 mm
Humpback whitefish
Bering cisco
Least cisco

Note: Pectoral fins black on least cisco, clear on Bering cisco

1.67', velocity 3 fps and flow 491 cfs. Water temperature was 12°C (54°F). The river meanders considerably but is still somewhat silty. The Middle Fork had a heavy willow bank cover.

Navigation beyond Mile 10 on the Middle Fork with a conventional motor is extremely difficult at low water.

Two net nights of fishing 10-12 miles up the Middle Fork took 10 chum salmon, 1 king salmon, 1 pink salmon, 1 Arctic char, 8 grayling and 4 northern pike. No fish were caught on hook and line up the Middle Fork as there were few deep holes where fish could rest. There were very few eddies, and also an absence of willows in the water.

The main fork or North Fork of the Eek River (Section III) was a larger fork than the Middle Fork with an average width of 100', 5 miles above the junction. Average depth was 1.94' and velocity was 4 fps. Flow was calculated at 776 cfs. Water chemistry data were: alkalinity 43 ppm, hardness 43 ppm, and pH 7.5. Water temperature was 11°C. The North Fork was considerably less turbid than Middle Fork water. The six mile section surveyed had many deep pools, eddies, riffles and submerged willows in the stream, all providing good habitat for grayling, pike, char and salmon. The habitat 6 miles up the North Fork was similar to habitat in other rivers having rainbow trout but none were found in the North Fork. The bottom is 20% sand and silt, 40% fine gravel and 40% medium gravel. A few pink salmon were observed spawning 5 miles up the North Fork on July 21 but most salmon spawning probably occurs above the area surveyed in Section III. The first Arctic char taken on hook and line were captured 6 miles up on the North Fork. The char taken in the Eek River all appeared to be the resident variety, and there is little indication that an anadromous run enters the river. Grayling are abundant in the North Fork and readily took lures. Four hours of angling in deep holes at the junction of the North and Middle Forks took three king salmon, four chum salmon and two pink salmon. Five gill nets (two 125' nets and three 25' nets) set 2-4 miles up the North Fork overnight took 11 grayling, 3 northern pike, 2 Arctic char, 6 chum salmon and 1 round whitefish.

In August 1976 the upper North Fork was surveyed by raft by Rae Baxter, Commercial Fish Division, Alaska Department of Fish and Game, from the Rainy Creek airstrip to the Middle Fork junction, and all five species of salmon were observed as well as many char and grayling. Salmon were noted up to Mile 165 on the river and grayling and char were distributed throughout the river. No rainbow trout were captured or observed.

Sport fishing pressure on the Eek River is low and comes mainly from residents of Eek. Subsistence fishing, mainly for salmon, occurs near the village of Eek.

Eek Lake is located between the Eek and Kwethluk Rivers on the open plain at 1,000' above sea level. It is 53 miles southeast of Bethel at 60°14' N and 160°19' W (Fig. 3). The 1.4 mile long by 1 mile wide lake connects to the North Fork of the Eek River via a 3 mile long channel. The water is brown color, the bottom is mud and ooze, and emergent

vegetation is present in a band 100' wide around the outer surface of the lake with submergent vegetation and pondweed present out to the center of the lake. Maximum depth was 8' and a large portion of the lake was 6' deep or less. The lake could be considered a foothills lake as the mountains are a considerable distance away. Bank cover along the lake is tundra, grass and some willow. A gravel beach is found around the lake margin.

Pike is the only species present in the lake. Four were taken in 1 hour of angling and 23 were taken in two net nights of fishing. This lake is little utilized and because of the very small size of the pike present, probably has very little sport fishing potential.

Two tiny ponds to the north and east of the lake have tiny inlet streams with almost no flow. The outlet stream of Eek Lake is very boggy and had virtually no flow. It is probable that fish access to the Eek River is only at periods of high water. Water temperature on July 11 was 15°C (59°F) and water chemistry data were: alkalinity 17 ppm, hardness 25 ppm and pH 7.5.

Lake and Stream Surveys, Kuskokwim Bay

Kanektok River System:

The *Kanektok River* with its source at Kagati Lake, drains the Eek and Aklun mountains and flows west for approximately 85 miles before emptying into Kuskokwim Bay at Quinhagak at 59°45' N and 161°55'W (Fig. 9). Total drainage is 910 square miles. The current averages 3-4 mph and the river has a gravel bottom over most of its course. The Kanektok River drops approximately 1,000' in 85 miles.

With the exception of the upper reaches, the Kanektok River has a thick band of willows and some cottonwood trees along its entire course. The river is extremely braided and has many unstable channels. It is navigable by propeller driven boat during normal water levels only upstream 10 miles. With a jet unit it might be possible to travel to Kagati Lake. The major tributaries are Takshilik, Nukluk, Klak, Kanuktik, Amakatatee and Paiyun creeks.

The Kanektok River was surveyed from Kagati Lake to the mouth by raft in late July of 1975 and a preliminary float trip was made in mid July of 1973.

Section I includes the lower 11 miles (18 km) of the river. The stream is 200' wide, with a current of 2-4 mph. The water is generally a dirty green color, mainly from the river cutting into mud banks. The vegetation is coastal tundra and there are few willows present. The river is a single channel through most of this section with wide gravel bars along shore. The lower 5.5 miles of the stream has considerable sand and silt overlaying the gravel bottom, while the remainder has a bottom composed of 50% fine gravel, 40% medium gravel and 10% sand and silt. Pink salmon were spawning in this section. Arctic char, chum salmon, and an

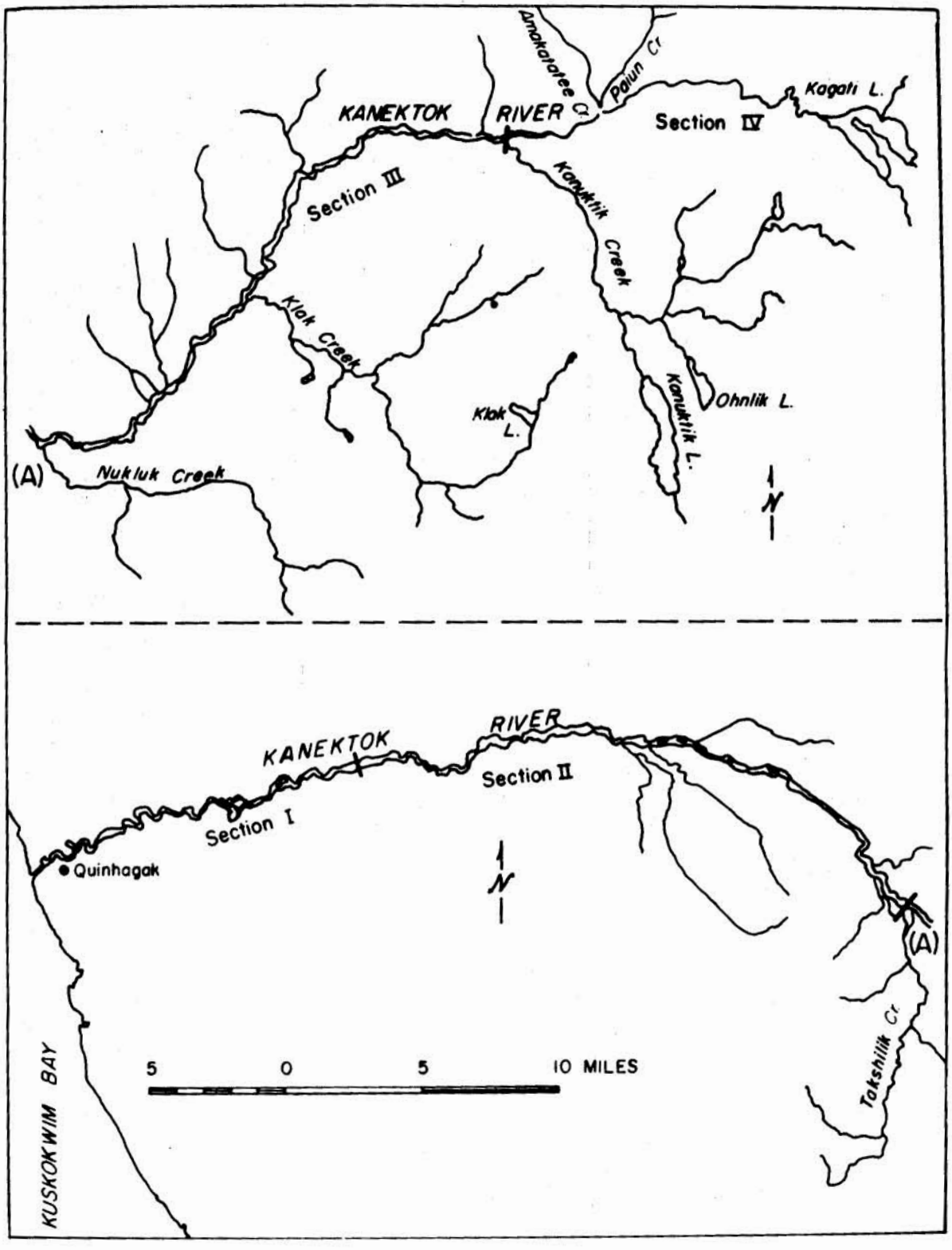


Figure 9. Kanektok River drainage showing major tributaries and lakes. Headwater section of river on top of page.

occasional king salmon were available to the angler but fishing was generally poorer here than in the sections upstream.

In *Section II* (Mile 12 to Mile 33) the river channel is very braided and has a deep, thick band of willows along its course. This section, located on the coastal plain, had many cottonwood trees along shore and in the stream, forming navigational hazards but also furnishing cover for grayling and rainbow trout. Water current is 2 to 4 mph and pool to riffle ratio is 3:1, with many backwaters and deep pools providing habitat for rainbow trout and grayling. Water was quite high, and a clear green in color during the survey. Water temperature on July 24 was 6°C (43°F), and water chemistry data were: total alkalinity 34 ppm, hardness 51 ppm and pH 7.5. This section had the best fishing for rainbow trout and over 20 were taken on hook and line. Pink salmon, chum salmon and grayling were abundant in this section.

Section III is from Mile 33 to Mile 59, or 26 miles, with Kanuktik Creek as the upper boundary. Other tributaries were Nukluk, Takshilik and Klak creeks. These tributaries have lakes at their upper reaches. The entire section runs through mountainous areas with some canyons where the river is confined mainly to a single channel. Current is generally 3-5 mph, although faster in some of the canyons. There are many large boulders scattered throughout the streambed. The pool to riffle ratio is nearly even, and there are many deep holes and eddies that provide good habitat for grayling. Grayling were abundant in this section, but there were fewer rainbow trout in the upper reaches of this section than farther downstream. The first chum and pink salmon were observed in the area of Klak Creek, and king salmon were found throughout the section. A gill net set above Nukluk Creek took four small Arctic char and a slimy sculpin. Bottom composition is 20% fine gravel, 20% medium gravel, 40% large gravel and 20% rubble and bedrock. Water temperature on July 25 was 6°C (43°F) and stream flow taken above Nukluk Creek was 1,882 cfs. The tributaries were not surveyed but probably have grayling and rearing salmon. Aerial surveys by Division of Commercial Fish biologists in various years counted 125 king salmon and 25 red salmon in Kanuktik Creek (July 1961), 24 king salmon in Nukluk Creek (July 6), and 200 silver salmon in lower Takshilik Creek (August 25, 1968).

Section IV includes the upper 27 miles of the river from Kanuktik Creek to Kagati Lake. The river valley widens and the current decreases. The river is clear and shallow, and the banks are mostly tundra. The current is 2-4 mph and pool to riffle ratio is approximately 1:1. The bottom is composed of 10% fine gravel, 40% medium gravel, 40% large gravel and 10% rubble. The river meanders considerably in the upper reaches of this section. Three small tributaries enter the Kanektok in Section IV: Amaktatee, Paiyun and Tsayagtulek creeks. Sport fishing in this section was the least productive of the entire river and only 2 rainbow trout, 2 Arctic char, and 20 grayling were taken in 6 hours of fishing. No king salmon were observed in this section.

Fishing success in the Kanektok River was similar in 1973 and 1975 although water levels were slightly higher in 1975. The species composition taken by hook and line in 1975, during a 4-day float, was 148 grayling

(74%), 37 rainbow trout (18%), and 16 Arctic char (8%). Grayling were even more numerous than the catch records indicated because an effort was made to capture rainbow trout and char. In all sections except Section I, grayling were more abundant than rainbow trout and char.

By contrast the Goodnews River species composition was 190 grayling (52%), 156 rainbow trout (43%), and 17 Arctic char (5%). In addition 21 lake trout, 5 king salmon, 5 red salmon and 3 pink salmon were taken in the Goodnews River. There was approximately twice the amount of effort spent on the Goodnews River but approximately four times the number of rainbow trout were taken. Grayling appeared to be less abundant in the Goodnews than in the Kanektok River. In both rivers few grayling under 300 mm were taken by hook and line or gill net or observed in the streams. Some young-of-the-year grayling were captured in lakes of the Goodnews River and Kanektok River.

The Kanektok River has a traditional subsistence fishery, mainly for salmon, and a commercial fishery was begun in 1960. King salmon commercial harvests have been as high as 18,000 fish (1972), and escapement counts have ranged from 935 to 6,047 fish. The silver salmon five year average commercial catch was 11,360. The five year commercial harvest for pink salmon is 18,777. They are an even-year fish and in 1968 one million pinks were estimated to have spawned in the Kanektok. The 5-year chum salmon average commercial catch is 30,342 fish.

The chum salmon run starts in mid June and is at its peak in early July, much as is the king salmon run. The red salmon catch from 1968 to 1972 averaged 4,293 fish. Most red salmon caught in the commercial fishery spawn in the Arolik or Kanektok systems. The red salmon escapement into the lakes of the Kanektok system has been approximately 10,000 fish during the past few years.

The Kanektok River has excellent sport fishing for king, chum, pink and red salmon from late June to mid July and excellent silver salmon fishing in August. The average size of the commercially caught king salmon in 1972 was 27 lbs, the largest in the state. Lake trout fishing is good in the lakes in the upper Kanektok River. Grayling up to 22" and Arctic char are plentiful throughout the river and lakes, but anadromous Arctic char probably do not reach the upper sections of the stream.

The Kanektok system has four major lakes that have potential for sport fishing. There are also 11 smaller lakes; two at the head of Nukluk Creek, one near Nuklunuk Mountain and eight on inlet streams entering Kagati Lake, that have questionable access and were not surveyed. Since no barriers to fish passage were observed in aerial flights, these lakes could be expected to have char, round whitefish, and possibly lake trout. The four major lakes, Kagati, Kanuktik, Klak and Ohnlik, were surveyed in 1975.

Kagati Lake located at 59°53' N and 160°05' W, is the head of the Kanektok River (Fig. 10). Situated at 900' elevation, this lake is one of the most scenic of all lakes in the Kuskokwim Bay drainage. It is 168' deep and has very little littoral zone. The lake has two arms,

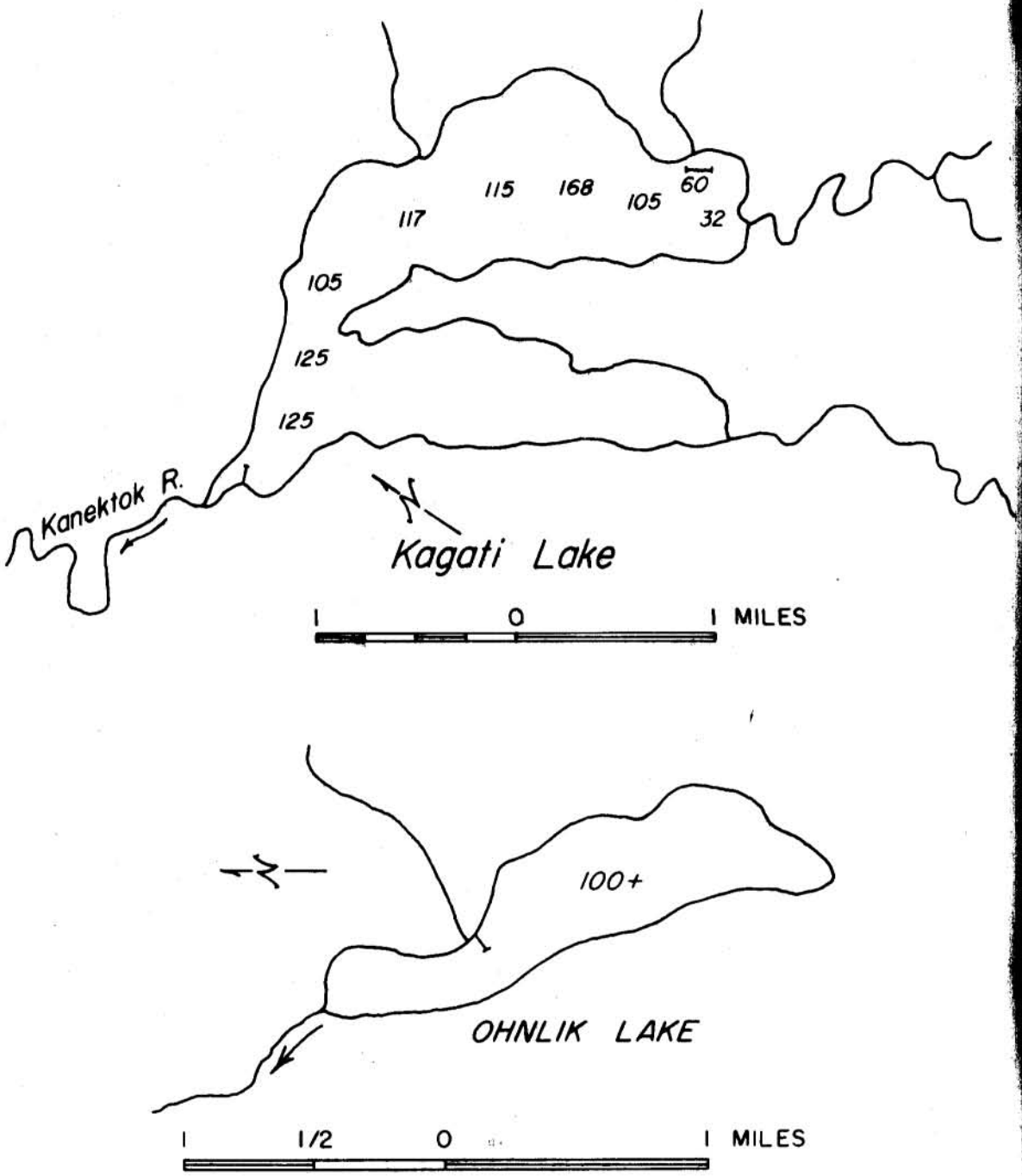


Figure 10. Kagati Lake (above) and Ohnlik Lake (below). (See Figure 9 for orientation)

each 2.7 to 3 miles long and 0.7 miles wide. The lake has three inlets at the east end of the lake, all originating from their own small lakes. Water temperature on July 22 was 7°C (45°F) and the Secchi disc reading was 27'. Water chemistry data were: total alkalinity 34 ppm, total hardness 51 ppm and pH 7.5. The outlet and inlets have a bottom composed of fine and medium gravel and the lake margin generally has small and medium gravel quickly grading to large gravel and rubble.

Two gill nets overnight took 6 Arctic char, 4 lake trout, 5 round whitefish, 1 burbot and 14 red salmon. The char and burbot were taken in a net fished in 54' of water; while the salmon, lake trout and round whitefish were taken in a net fishing on the surface. One grayling and five lake trout were taken in 1.5 hours angling. Evidently the char are not available to the angler at this time of the summer.

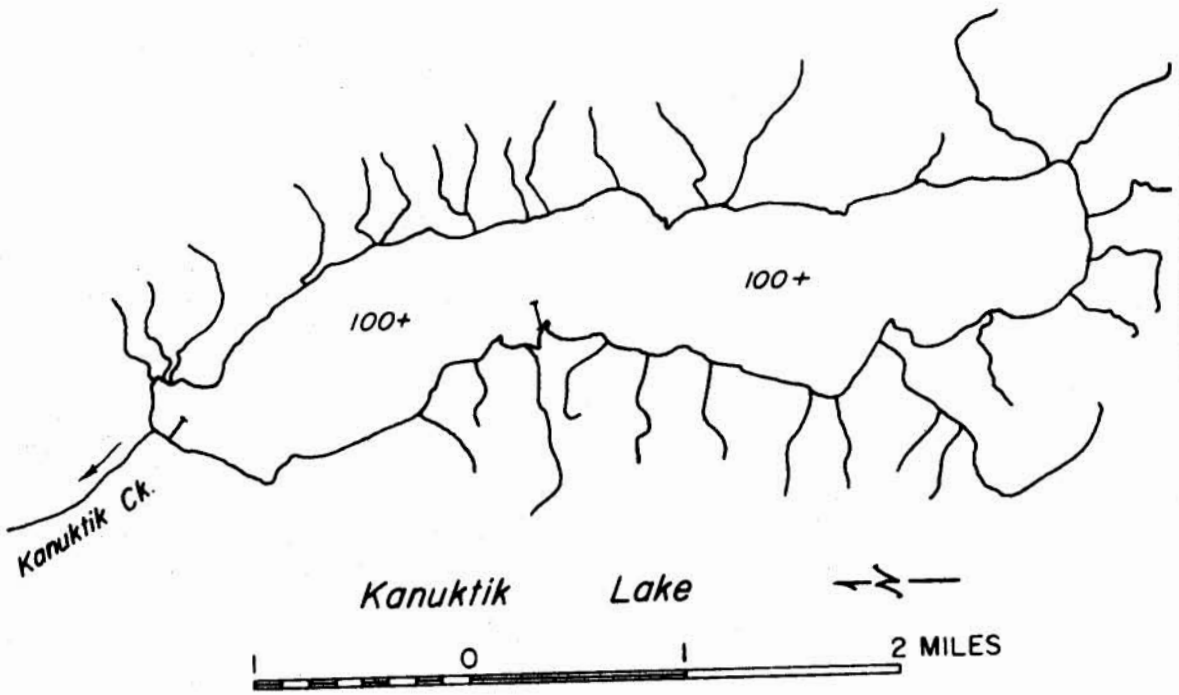
Kagati Lake is an important sport fishing lake mainly because of its close proximity to Bethel. There is much evidence of angler use but no permanent facilities on the lake. It is a very important red salmon spawning lake. Escapement counts from 1968 to 1972 ranged from 6,438 to 20,700.

Ohnlik Lake is located 1.5 miles east of Kanuktik Lake at 59°44' N and 160°16' W (Fig. 10). It drains into the Kanektok River via Kanuktik Creek. The lake is 1.9 miles long by 0.6 mile wide and is situated at 1,000' above sea level. It is a clear, deep, mountain lake in a tundra setting. Limited sounding indicated a maximum depth of over 100'. The Secchi disc reading was 40'. The lake has three major inlets and these together with the outlet to Kanuktik Creek provide the main spawning habitat.

A gill net set overnight captured nine lake trout, eight red salmon, two Arctic char, and two round whitefish. Four lake trout and one Arctic char were taken during two hours angling with rod and reel.

Kanuktik Lake enters the Kanektok from the south via the 12 mile long Kanuktik Creek (Fig. 11). The lake is situated at 50°43' N and 160°19' W at an elevation of 1,150'. Kanuktik Lake is 4 miles long by 0.9 mile wide and has a maximum depth of over 100'. This mountain lake has little shoal area. Bottom composition along the shore is sand and gravel that changes quickly to a rock and boulder bottom. The shoal area near the southern inlets have a bottom composed of fine sand and gravel while the outlet shoal contained fine gravel mixed with the boulders. Water temperature on July 31 was 8°C (46°F) and the Secchi disc reading was 35'. Water chemistry data included: total alkalinity 34 ppm, total hardness 51 ppm, and pH 7.5. A few willows lined the shoreline followed by alpine tundra.

There are five major and numerous minor inlet streams and one outlet stream, Kanuktik Creek, which is 45' wide and 12" deep. The current in the outlet stream was 2-3 mph and water temperature on July 31 was 9°C (48°F).



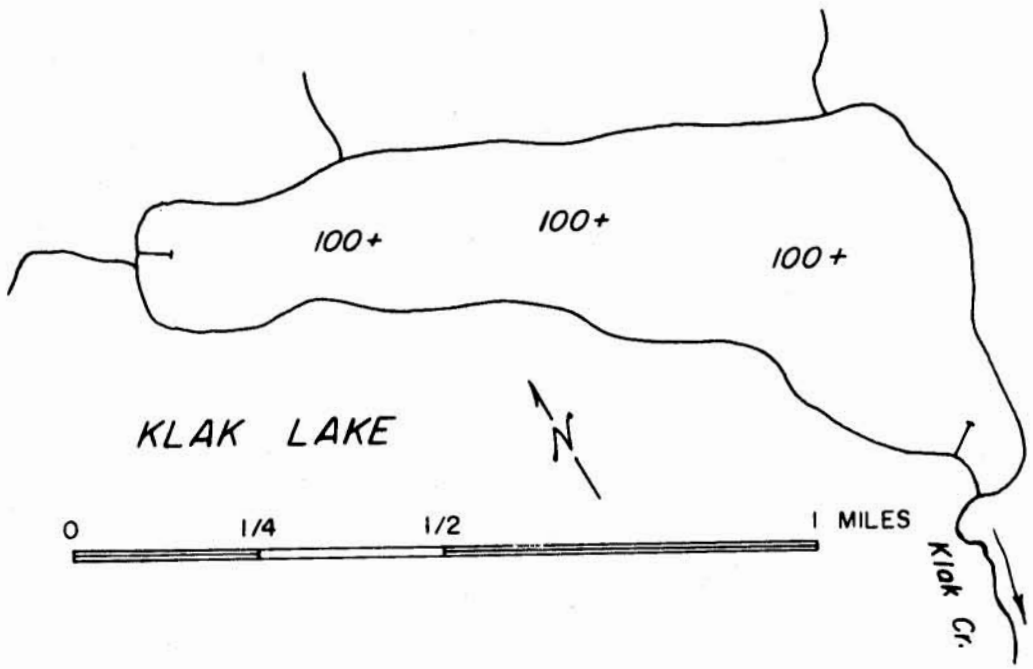


Figure 11. Kanuktik Lake (above) and Klak Lake (below). (See Figure 9 for orientation)

Two overnight gill net sets took 18 lake trout, 13 char, 1 king salmon and 2 round whitefish. Two large lake trout weighed 11 and 13 lbs, respectively; and many of the char were large, deep bodied fish of 5-7 lbs. All char and the two large lake trout were caught in the net set in 60' of water. Six lake trout were taken by hook and line in 3 hours of angling. Red salmon probably use the lake or its outlet for spawning and rearing but none were taken by gill net. The lake has probably received little fishing pressure.

Klak Lake located at 59°44' N and 160°28' W and 1,050' above sea level, flows into the Kanektok River from the south via Klak Creek (Fig. 11). The lake is 1.2 miles long and 0.6 mile wide. No soundings were taken but since it is in a mountainous valley similar to Kanuktik Lake it is probably over 100' deep. It is siltier than the other lakes mainly because of hanging tundra banks falling into the lake. The Secchi disc reading was 20'. Shore vegetation was willow and open tundra, and rocks in the outlet stream were covered with algae. The lake has two major inlets and one outlet, and most gravel that would be suitable for spawning is located in these areas. The lake has very little shoal area and it is generally covered with boulders with an overlay of silt and sand. Water temperature on July 31 was 10°C (50°F) and water chemistry data were: total alkalinity 34 ppm, hardness 51 ppm and pH 7.5.

No hook and line fishing was conducted but two gill nets were set overnight and took 11 Arctic char, 4 lake trout and 4 king salmon. Red salmon probably utilize the lake but none were taken.

Arolik River System:

The *Arolik River,* (Fig. 12) draining a watershed of 573 square miles, is situated between the Goodnews and Kanektok river drainages. It flows generally northwest for approximately 69 miles and the North Mouth empties into Kuskokwim Bay at 59°42' N and 61°53' W. The main stem, the South Fork Arolik, heads in Tatlignagpeke Mountain at 59°21' N and 161°22' W; while the East Fork Arolik heads at Arolik Lake at 59°27' N and 160°15' W. The mouth is located 5 miles south of Quinhagak. The river has a gravel bottom over most of its course; has a moderate current; and because of its shallow depth, navigation with a propeller driven boat is difficult during most of the summer except for the lower few miles. Air access is via an unimproved landing strip at a mining camp near Snow Gulch 9 miles downstream from the junction of the East and South Forks or by landing on Arolik Lake and floating down the East Fork in a raft or canoe.

The Arolik River was surveyed by raft July 14-18, 1976 with Arolik Lake as the starting point. The river was divided into four sections.

Section I which included the lower 10 miles of the North Mouth is under tidal influence and has a mud and fine gravel bottom. The river is 200' wide and the current quite slow. No sampling was done in this section. The bankside vegetation consists mainly of tall grass.

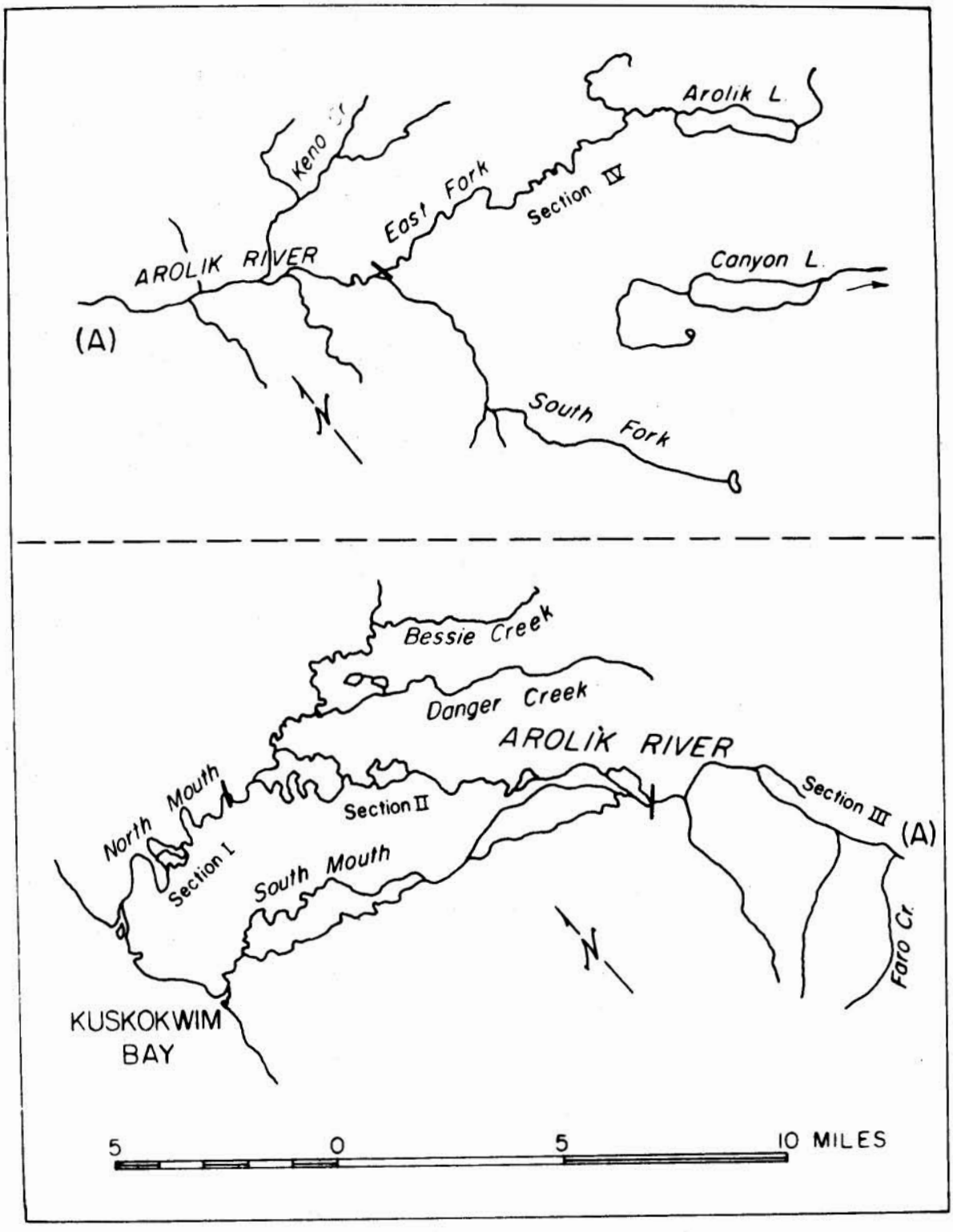


Figure 12. Arolik River drainage including Arolik Lake. Headwaters section at top of page.

Section II comprised the upper 19 miles of the North Mouth of the Arolik River. The current averages 2 mph and the bottom composition is 20% sand and silt, 60% fine gravel and 20% medium gravel. The streambed meanders considerably and the pool to riffle ratio is 2:3. Submerged willow roots, braided channels and overhanging willows, in addition to the favorable pool to riffle ratio, provide excellent habitat for rainbow trout. Eleven trout were caught in 10 hours of angling but many more were observed. Eleven grayling, 10 pink salmon, 3 chum salmon, 3 Arctic char and 1 king salmon were also taken on hook and line. Thousands of pink salmon were spawning in this section on July 17, and pink salmon were observed resting or moving further upstream. Round whitefish were observed in Section II. The stream in this section has a thick band of willows along shore and, because of the active channel has few earth banks. The water was clear during the float trip and temperature was 10.5°C (50°F). Bessie Creek is the major tributary in this section; but because of its slow current and small size, it is probably not much utilized by fish. The South Mouth of the Arolik takes approximately 30% of the water volume. It was not surveyed, but residents of Quinhagak said it has very few salmon or rainbow trout.

Section III is a 24 mile section from the North and South Mouth junction upstream to the East Fork-South Fork junction. This section is characterized by a relatively straight channel, swift current, willow band along shore, clear water and a clean gravel bottom. The upper reaches of this section are swift and have a large gravel and rock bottom. There were few pools in the upper part of Section III; consequently, little rainbow trout habitat was present above Keno Creek.

The average width of the stream 3 miles below the junction of the East and South Fork was 120' and average depth was 14". Velocity was 5.26 fps and flow was 720 cfs. Velocity is considerably slower in the lower end of this section. The pool to riffle ratio is 3:7. Bottom composition is 10% sand, 30% fine gravel, 50% medium gravel, 10% coarse gravel in the lower end of Section III; but 10% sand, 10% fine gravel, 20% medium gravel, 40% coarse gravel and 20% rock and rubble in the upper part of Section III. This bottom provides spawning habitat for king and chum salmon throughout the entire section. Water temperature in this section ranged from 11°C (51°F) to 13°C (55°F) and water chemistry data were: hardness 17 ppm, alkalinity 25 ppm and pH 7.5.

Three small mesh gill nets set overnight in small, shallow, side-slough areas of the Arolik River took six chum salmon, four Arctic char and one grayling. Round whitefish were observed. Thirty-three hours of hook and line angling throughout the entire section yielded 21 rainbow trout, 32 grayling, 6 lake trout, 2 Arctic char, and 3 chum salmon. Numerous small yearling and young-of-the-year char, chum, silver, red and king salmon were captured by dip net, but only a few young rainbow trout and grayling were observed.

Section III is the main spawning area for king and chum salmon, although red and silver salmon may also spawn here. Pink salmon were spawning only in the lower end of Section III. This section is probably used for spawning by rainbow trout, char, round whitefish and grayling.

The two large tributaries entering Section III are Keno and Faro creeks. Keno Creek is clear, about 20' wide and 4" deep with a velocity of approximately 3 fps and a bottom composed of fine and medium gravel. Chum salmon were found at the mouth of the creek but no grayling or rainbow trout were observed or captured. Water temperature was 9.5°C (49°F). Faro Creek was similar to Keno Creek except slightly larger with larger gravel.

The South Fork Arolik was surveyed on foot in the lower half mile. The South Fork is quite swift with a velocity of 4 fps. It is 60'-80' wide and the lower reaches have a bottom composed mainly of coarse gravel and rock. Two rainbow trout were captured near the mouth and grayling were captured further upstream. King and chum salmon were observed at the mouth of the South Fork and chum salmon were spawning 1/2 mile up the South Fork on July 11.

Section IV is comprised of the East Fork of the Arolik, a section approximately 19 miles in length. The lower 13 miles of the section had swiftly flowing water (more than 5 fps) and a bottom composed mainly of large rocks and rubble. The channel was relatively straight, 20'-30' wide, and lined with willows. Twenty-five chum salmon, six king salmon and four red salmon were observed in this section.

The upper 6 miles of Section IV contain very slow moving water in braided meandering channels with overhanging willows. Numerous spring areas contribute to the total flow in the upper section, as the flow at the outlet of Arolik Lake was only 19 cfs. The bottom composition is 40% silt and sand, 50% fine gravel and 10% medium gravel. The bottom is covered with a thick mat of algae, and often the water was so shallow that a raft could not be floated through. The channel was often less than 20' wide. Red salmon were observed in this section and would probably spawn here. Grayling and round whitefish were found 2 miles down from the lake outlet. Grayling and lake trout were taken on hook and line in this area. Numerous salmon fry were observed or captured in the slow moving water.

The Arolik River, in comparison with the Goodnews and Kanektok rivers, appeared to contain excellent habitat for rainbow trout and grayling but had a paucity of fish. Excellent holes and grassy banks, that on the Goodnews would have consistently yielded trout, contained no fish on the Arolik River.

In the Arolik River, 31 rainbow trout and 45 grayling were captured in 45 hours of effort; while in the Goodnews River, with only slightly more effort, 190 grayling and 156 rainbow trout were captured on hook and line. In the Arolik River, no rainbow trout were found on the East Fork; but in the Goodnews, rainbows were found within 2 miles of the lake. Arolik River grayling were all large with only four fish less than 400 mm (15 1/2") taken or observed.

Arolik Lake (Figure 13) is located at the head of the East Fork Arolik at 59°29' N and 161°06' W and is 440' above sea level. It is 2.3 miles long by 0.4 mile wide. The lake is oriented in a southeast to northwest

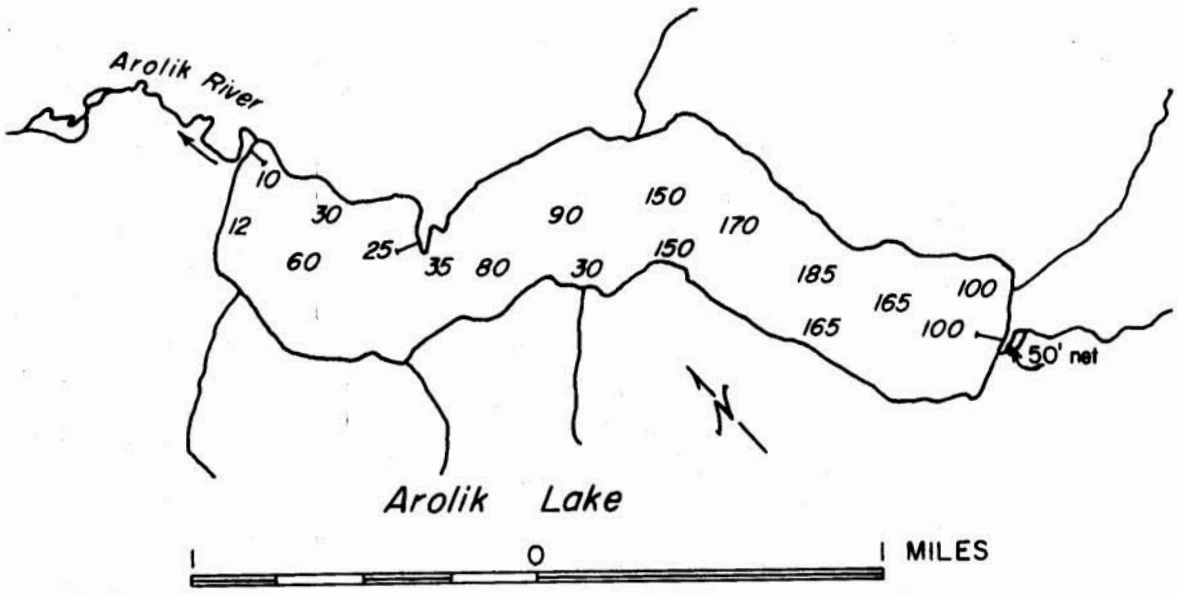


Figure 13. Arolik Lake (see Figure 12 for orientation).

axis; and the outlet stream, the East Fork Arolik River, is in the extreme northwest corner of the lake. The lake is tightly ringed by mountains so the drainage is small. Four inlet streams, all less than 2 miles long, enter the lake. The inlet at the southern end of the lake disappears into the tundra, while the other three are rapid runoff streams with gravel bottoms but little fish habitat. The vegetation is alpine tundra with a few willows present near inlet and outlet streams. The lake drops off rapidly in the southern end, but the northern end has considerable shoal area. Total shoal area is about 10%. The outlet and lake shore have an abundance of fine gravel. The maximum depth recorded was 185' in the center of the south part of the lake and almost the entire southern half of the lake was over 100' deep. Water chemistry data on July 13, 1976 at the outlet were: total hardness 17 ppm, alkalinity 25 ppm and pH 7.5. Water temperature of the lake and outlet was 10.5°C (51°F). The Secchi disc reading was 30'.

The lake was surveyed both in 1975 and 1976, and in both years lake trout were abundant. A total of four net nights of fishing took 39 lake trout, 8 round whitefish and 1 red salmon. Two small mesh gill nets took one silver salmon smolt, one round whitefish and one dwarf Arctic char. The Arctic char, ready to spawn at 140 mm, was taken in a tiny channel off the inlet stream at the southern end of the lake. Two grayling and 59 lake trout were taken by hook and line during 12 hours of angling. The lake trout captured on hook and line were all small and seldom exceeded 2 lbs. There is little evidence of past sport fishing utilization. Most effort comes from local Bethel and Dillingham residents.

Goodnews River System:

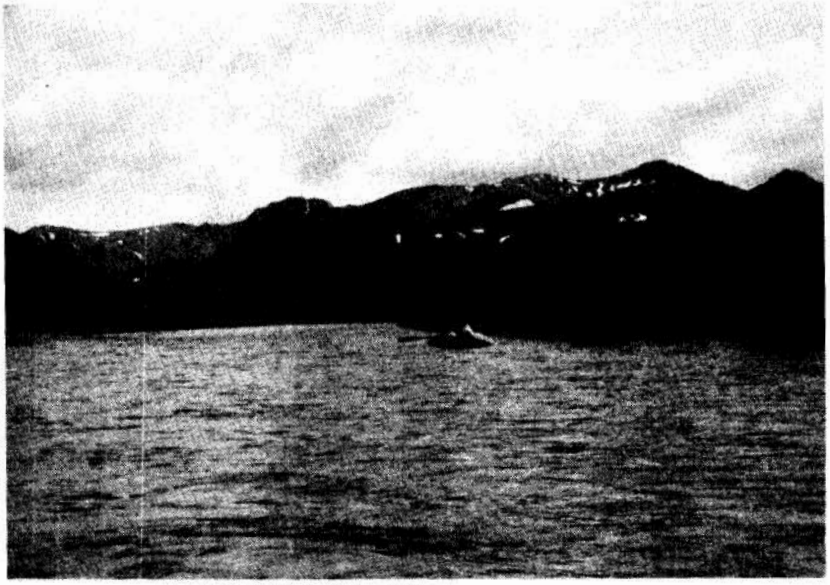
The Goodnews River is the most southerly river in Kuskokwim Bay and forms part of the dividing line between Bristol Bay streams and the Arctic-Yukon-Kuskokwim region (Fig. 14). Its headwaters are in the Ahklun Mountains and it flows southeast approximately 60 miles to Goodnews Bay at 59°07' N and 161°35' W. The Middle Fork is a major tributary which parallels the mainstem Goodnews River for its entire length and joins it near the mouth. The South Fork enters in the same area. The Goodnews system has an area of 910 square miles and contains numerous lakes. It is a good producer of red salmon.

Three lakes of the mainstem Goodnews River and three lakes of the Middle Fork, as well as the Goodnews River itself were surveyed in July.

The *Goodnews River* was floated from Goodnews Lake to the mouth using a 12' rubber raft from July 18 to 21. The river is slow moving (less than 2 mph) as it leaves the lake, and the rocky bottom was heavily covered with algae. The current in the middle section of the river is faster but there are no areas that are dangerous to a raft or canoe. Except for a few isolated stands of cottonwood and narrow bands of willows along the waterways, the shore vegetation is tundra-like.

The river was divided into five sections.

Rapids on Upper Section of Goodnews River



Survey of Goodnews River (below
Awayak Creek) by Raft - July 1975

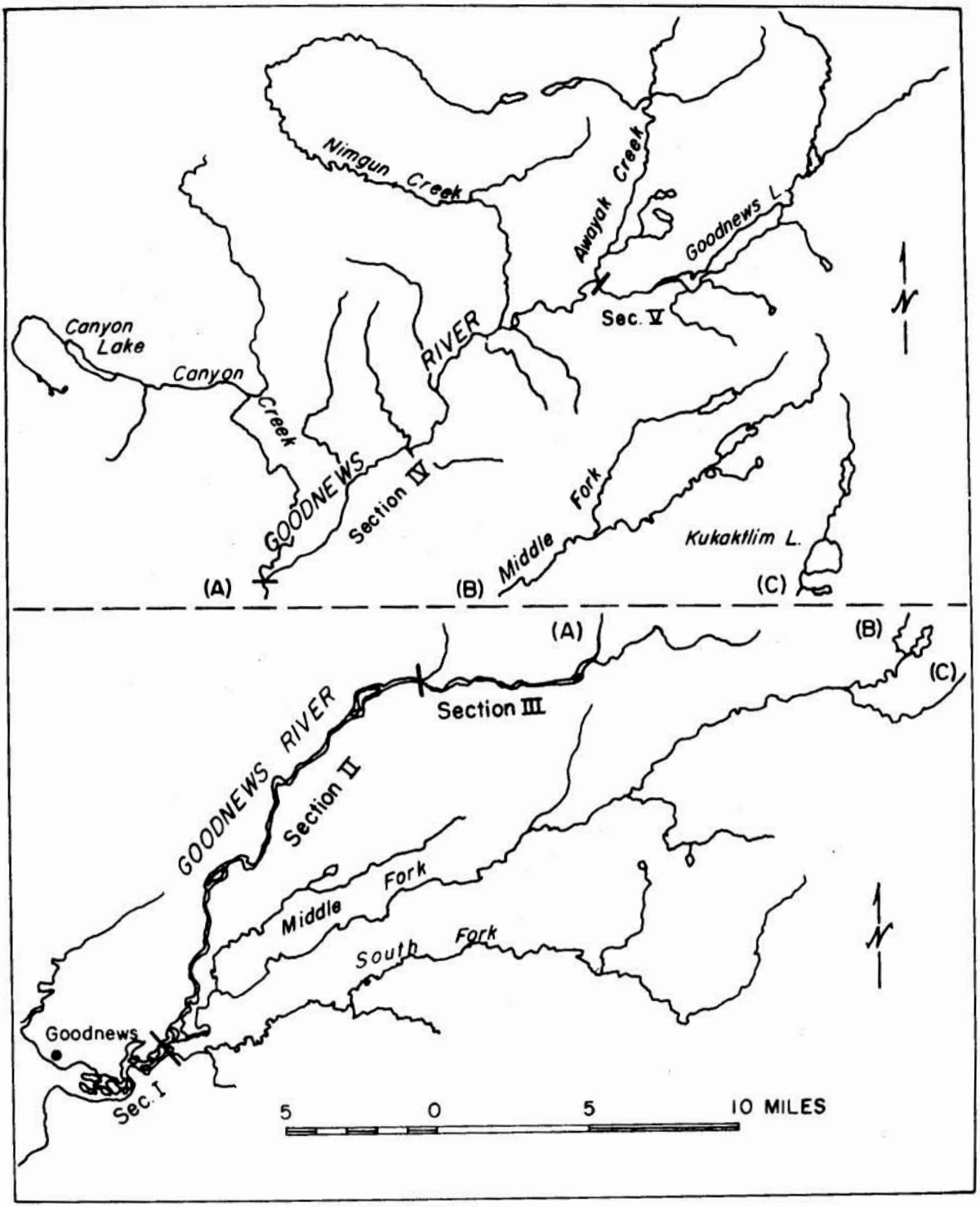


Figure 14. Goodnews River drainage. (A-A = mainstream Goodnews River, B-B = northern sections of Middle Fork and C-C = Kukatlim Lake drainage).

Section I included the mouth to the Middle Fork confluence, a distance of 10 miles. Tidal influences were noticeable up to the Middle Fork. The river in Section I is slow moving with a mud and fine gravel bottom. The river is braided with many sloughs. The Middle Fork and South Fork are major tributaries entering Section I. The Middle Fork drainage is approximately 50% as large as the main Goodnews. The South Fork is considerably smaller. These were not surveyed but residents of Goodnews reported that rainbow trout were as abundant in the Middle Fork as in the main Goodnews. The large eddy at the confluence of the Middle Fork and Goodnews River is an important resting area for king, silver, chum, red and pink salmon as well as rainbow trout, lake trout and Arctic char. Rainbow trout were taken to within 3 miles of the mouth, and lake trout were taken by hook and line all along the river with the exception of the lower 6 miles. No grayling were seen in Section I.

Section II is a 12-mile section from the Middle Fork to Barnum Creek. The stream is somewhat braided in the area above the Middle Fork, then becomes essentially a single channel up to its headwaters. Water color on July 20 was clear, even though the channel had cut through some fairly deep mud banks. The stream is 120' wide and has a velocity of 2-3 mph. Stream flow measured below Barnum Creek was 1,344 cfs. Bottom as in sections downstream. composition was 10% silt and sand, 40% fine gravel, and 50% medium gravel. Water chemistry data on July 20 were: total alkalinity 34 ppm, total hardness 51 ppm and pH 7.5. Water temperature was 6.5°C (44°F). Grayling were absent from the lower part of Section II but rainbow trout were numerous. A few pink salmon were caught on hook and line near Barnum Creek as were king salmon males of 2-3 lbs.

Section III, 17 miles long, included the area from Barnum Creek to Canyon Creek. The current was fairly swift (approximately 3-4 mph) which kept the bottom free of sand and silt. Bottom composition was 30% fine gravel, 50% medium gravel and 20% rubble. Pool to riffle ratio was 1:3. The river funnels between bluffs and high gravel cutbanks in some areas. The course of the river meanders more than the sections upstream and willows are common along the stream edge and on gravel islands. Water temperature was 5.5°C (42°F). Rainbow trout were caught at the same frequency as grayling in this section. Immature rainbow trout 320-350 mm (12"-14") were caught on hook and line. Grayling captured on hook and line were all over 300 mm (12") fork length. Young-of-the-year grayling were observed in this section. Adult prespawner dwarf resident Arctic char, 130 mm (5") fork length were again taken by gill net in this section. Few salmon other than reds and chums were observed.

The major tributaries above Barnum Creek were Slate, Isuruk, and Canyon creeks. Hook and line fishing in lower Slate and Isuruk creeks failed to capture any fish and none were observed. Slate Creek had a fine gravel bottom, current of 4 mph and a width of 20'. Canyon Creek was one of the largest tributaries and had a bottom composed of 50% fine gravel and 50% medium gravel. The stream was 30' wide with a current of 5-6 mph. Water temperature at the mouth was 11°C (52°F). Rainbow trout and grayling were captured in the lower mile of the stream and round whitefish and red salmon were observed.

460 mm Rainbow Trout
from Goodnews River

Section IV included the area from Canyon Creek to Awayak Creek, a distance of approximately 13 miles. This section included the swiftest water through the canyons below Nimgun Creek where current reached 7-8 mph. The canyon area contained many large boulders but they were no hindrance to navigation. Bottom composition was 10% fine gravel, 40% medium gravel, 40% coarse gravel, and 10% rubble. There was little shoreline vegetation and the river generally ran in a straight single channel. The flow of the Goodnews below Nimgun Creek was 1,066 cfs on July 19. The river was 110' (33.5 m) wide and water temperature was 6°C (43°F). The entire section contained good rainbow trout habitat, especially in the lower reaches of long pools. A yearling rainbow trout, two yearling round whitefish and two resident Arctic char, 170 mm (7") in length (one a prespawner), were taken by gill net. The first anadromous Arctic char were taken 5 miles above Canyon Creek. Red salmon were abundant in this section and a few chum salmon were also observed. Red salmon were entering a small stream coming into the Goodnews from the south located approximately 5 miles above Canyon Creek.

Two major tributaries, Nimgun Creek and Awayak Creek, enter in this section. Nimgun Creek in the lower reaches is 32'-98' (10-30 m) wide, very swift, and has a bottom composed of large gravel and rubble. Rainbow trout and grayling were taken on hook and line in Nimgun Creek. Awayak Creek drains three lakes and is slightly smaller than Nimgun Creek. The bottom is composed of fine and medium gravel in the lower section. Water temperature was 9.5°C (49°F). Rainbow trout were taken on hook and line in Awayak Creek and red salmon and round whitefish were observed. More than 100 red salmon were milling at the mouth of Awayak Creek.

In *Section V* from Awayak Creek to the outlet of Goodnews Lake, the river is slow moving and the bottom is covered with a thick mat of algae over most of the 6 miles distance. Water temperature was 10°C (50°F). The bottom is composed mainly of medium and large gravel with some sand and silt present. The stream is less than 80' (24 m) wide. Only round whitefish and red salmon were observed in the upper mile of the river as it left Goodnews Lake. A few grayling and rainbow trout were taken closer to Awayak Creek when they became more abundant, but never as abundant as in sections downstream.

There are six lakes in the *Mainstem Goodnews* with sport fishing potential. Access to the lake at the head of Nimgun Creek and the southernmost of the Awayak Lakes (1.0 mile (3 km) from Goodnews Lake) is probably only by a Supercub type aircraft. Only three of the six lakes were surveyed, and red salmon, lake trout and Arctic char were the main species found. It is probable that the other three lakes have similar species composition. There are other small lakes in the system that have small runs of red salmon and possibly also char and trout, but because these lakes are small and inaccessible, they have limited sport fishing potential. Surprisingly, grayling were not captured on hook and line or gill net in any of the lakes of the Goodnews system. A northern pike was captured and another observed in Goodnews Lake, the first record of northern pike in waters of Kuskokwim Bay. Although sport fish are abundant, no trophy

size lake trout, char or rainbow trout were captured. Some of the largest red salmon in Alaska enter the Goodnews River, and fish over 13 lbs were taken. None of the lakes of the Goodnews River system receive heavy fishing pressure. A small number of float plane pilots from Bethel and Dillingham fish on Canyon and Goodnews lakes each year. No data are available on catch.

Goodnews Lake, located at 59°29' N and 160°32'W is 400' above sea level and 4.5 miles long by 0.6 mile wide (Fig. 15). The lake has a maximum depth of 130' (40 m) and a shoal area of 10%. The lake is clear and had a Secchi disc reading July 7 of 40'. There are mountains on both sides and vegetation is alpine tundra with a small band of willows and isolated stands of cottonwood. There are one major and four minor inlets and one major outlet, the Goodnews River. The inlet and outlet as well as the narrows and much of the shoal area of the lake have an abundance of fine and medium gravel. The southwest section of the lake below the narrows is shallow with two deep holes, and the gravel and silt bottom is covered with algae. Water chemistry data on July 7, 1975 were: total alkalinity 34 ppm, hardness 51 ppm, and pH 7.5. Temperature was 9°C (48°F).

Gill nets set near the inlet and on the north side of the lake (Fig. 15) took two red salmon, eight Arctic char, seven lake trout and three round whitefish in two net nights of fishing.

Twenty-five hours of angling took 28 lake trout, 6 Arctic char, 5 red salmon, 1 rainbow trout, 1 northern pike and 1 blackfish. A chum salmon was hooked but lost. Sculpin and threespine stickleback were numerous in the shoal areas. Silver salmon probably enter the lake in the fall. Most red salmon were near the outlet and were not ready to spawn.

Asriguat Lake, located at 59°31' N and 160°33' W, is the northernmost of two lakes drained by a 3 mile long tributary to Awayak Creek and is 3.3 miles north of Goodnews Lake (Fig.15). It is 850' in elevation and is rimmed by mountains on three sides. The lake measures 0.7 mile by 0.3 mile and has a maximum depth of 75'. It has little shoal area. The water is clear with a Secchi disc reading of 35'. Water chemistry data on July 4, 1975 were: total alkalinity 51 ppm, total hardness 51 ppm and pH 7.5. The lake has three small inlets and one outlet which is 10' (3 m) across and 5' (1.5 m) deep. The inlets have muck bottoms, the outlet and shoal areas of the lake have a bottom composed of 25% fine gravel, 50% medium gravel, and 25% coarse gravel and rock.

The only recorded aerial survey of this lake enumerated 350 red salmon. Evidently silver salmon spawn in the vicinity of the lake as 5 silver salmon smolts as well as 40 Arctic char, 5 red salmon and 1 lake trout were captured in two net nights of fishing. Five char but no lake trout were taken in three hours of angling.

Located at 59°26'N and 161°10' W at 483' above sea level, *Canyon Lake* is drained by the 12 mile long Canyon Creek (Fig. 16). It is hemmed in by mountains up to 2,400' high along both sides but the ends are open providing good float plane access. The lake is 2.1 miles long by 0.3 mile wide and has a maximum depth of 150', with very little shoal

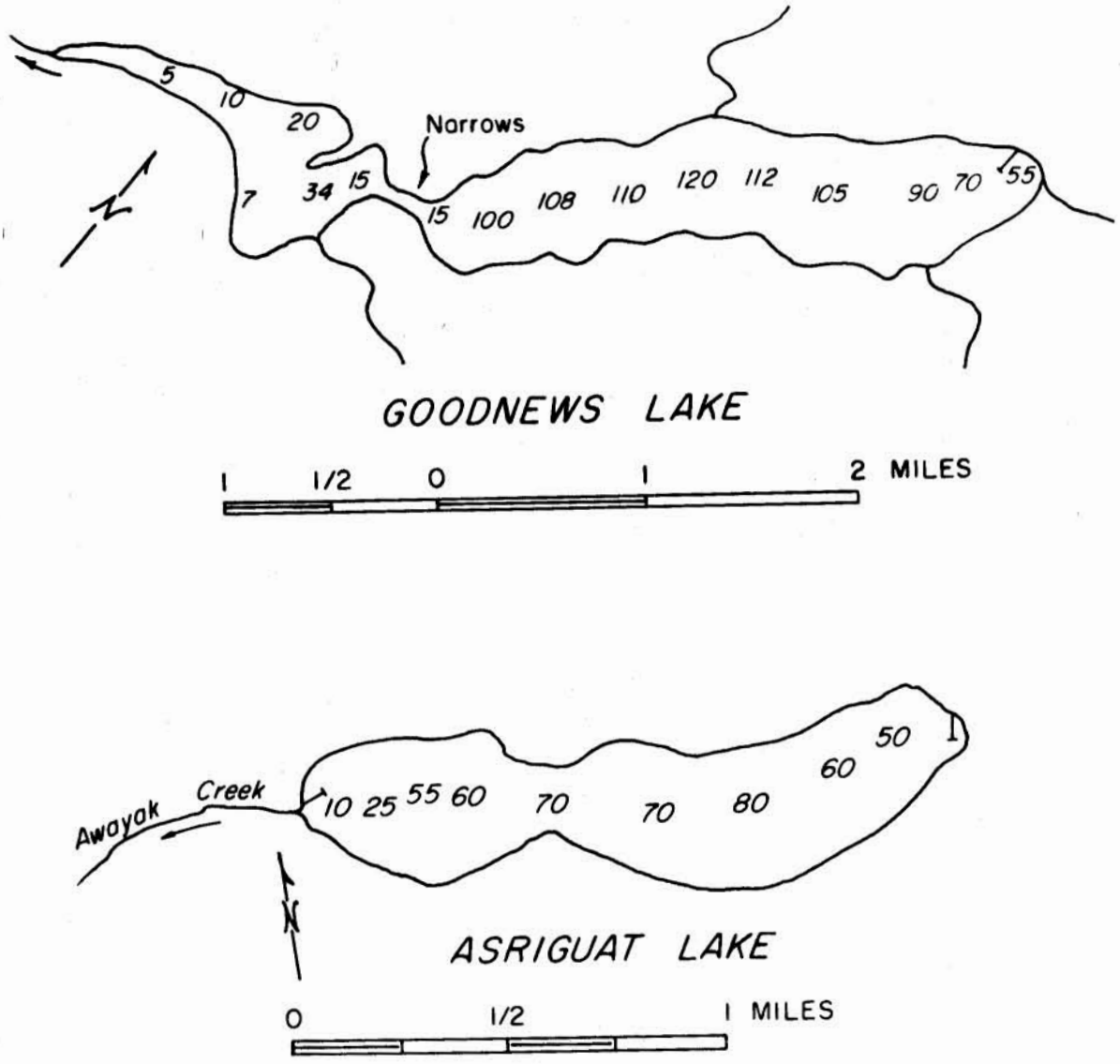


Figure 15. Goodnews Lake (above) and Asriguat Lake (below)
(For orientation see Figure 14)

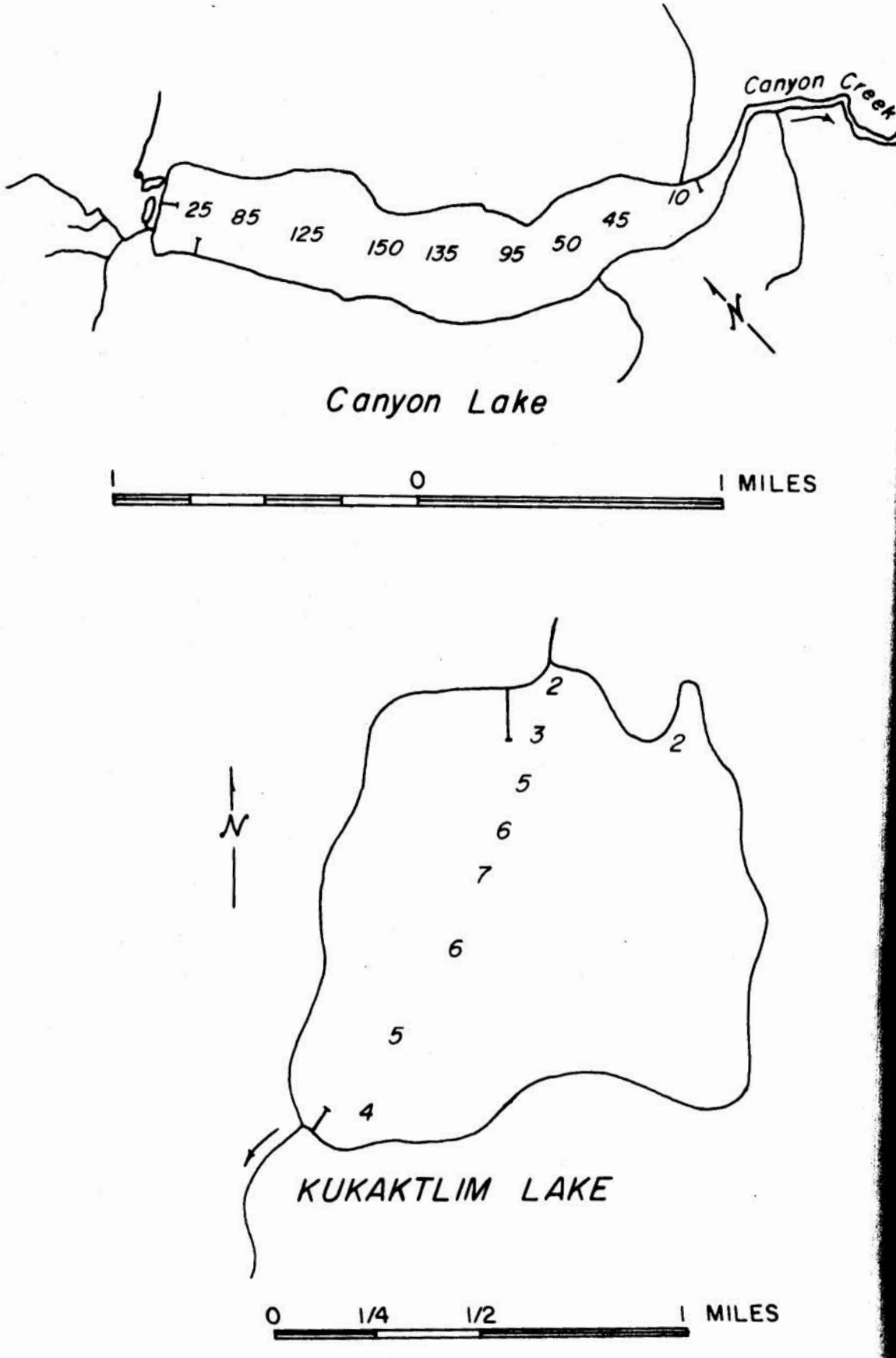


Figure 16. Canyon Lake (above) and Kukaktlim Lake (below) (for orientation see Figure 14).

area. This tundra mountain lake has a band of willows along the shoreline. Canyon Lake has one major inlet (25' wide and 18" deep), and one major outlet (30' wide). The lower end of the main inlet as well as the outlet stream and the shoal area of the lake have suitable gravel for spawning. Water chemistry data on July 16 were: total alkalinity 34 ppm, hardness 51 ppm and pH 7.5. Water temperature was 5°C and the Secchi disc reading was 40'. Gill net sets overnight in 1975 and 1976 near the major inlet took 30 lake trout, 29 Arctic char and 3 round whitefish. A Commercial Fish Division aerial survey enumerated 40 silver salmon and 1,000 red salmon in the lake and observed some pink salmon spawning in the outlet stream.

There are five lakes in the *Middle Fork drainage* that are accessible by float plane. The lake 1.8 miles upstream from Kukaktlim Lake and the lake at 59°10' N and 160°46' W were not surveyed but they could be expected to have the same species as other lakes in the area.

Kukaktlim Lake is in the southeast corner of the Middle Fork drainage, 20 miles north of Togiak Bay at 59°20' N and 160°29' W (Fig. 16). The surface elevation is 400' above sea level and the lake is shallow and circular in shape with mountains not as close as other lakes. The lake is 1.2 miles by 1.5 miles in area and the maximum recorded water depth is only 6.5' (2 m). The outlet stream, 20' (6 m) wide and 1.5' (.46 m) deep, has good spawning gravels. The main inlet has many slow moving channels with deep pools and some channels blocked by beaver dams in the lower end. The upper end of the inlet has swift current near the outlet of the upper Kukaktlim Lake. Upper Kukaktlim was not surveyed but appeared to be a rapid dropoff, clear mountainous lake similar to Canyon Lake. Access may be limited to smaller aircraft. Kukaktlim Lake, probably because of its shallowness, had the warmest surface water temperature of any lake studied, 13°C (55°F). Water chemistry data on July 16 were: total alkalinity 34 ppm, hardness 51 ppm, pH 8. The bottom was gravel overlain with sand and silt. A gill net was set on July 16 but due to extremely bad weather could not be picked up until July 21. It contained 20 Arctic char, 15 red salmon, 1 lake trout, 2 round whitefish, 1 slimy sculpin and 1 unidentifiable salmon smolt. Three hours of angling on July 16 took three Arctic char, one lake trout, and two red salmon. Aerial surveys by the Division of Commercial Fish counted 2,000 red salmon in the Kukaktlim Lake area, the majority spawning in the outlet stream in August.

North Middle Fork Lake is located 3.6 miles south of Goodnews Lake at 59°22'N and 160°31' W at 850' above sea level (Fig. 17). It is 0.8 mile by 0.3 mile in size. The lake was not sounded but probably has a depth profile similar to South Middle Fork Lake which had a maximum depth of 75'. The Secchi disc reading was 30'. The lake has 20% shoal area with one major inlet and several small inlet springs and one outlet 50' wide and 1.8' (.55 m) deep. Two gill nets set overnight took 24 lake trout, 11 Arctic char, 11 round whitefish and 1 red salmon. On September 2, 1970, 300 red salmon were enumerated in North Middle Fork Lake.

South Middle Fork Lake is located 1.1 miles south of North Middle Fork Lake at 59°20' N and 160°31' W (Fig. 17). It is 1.4 miles long and

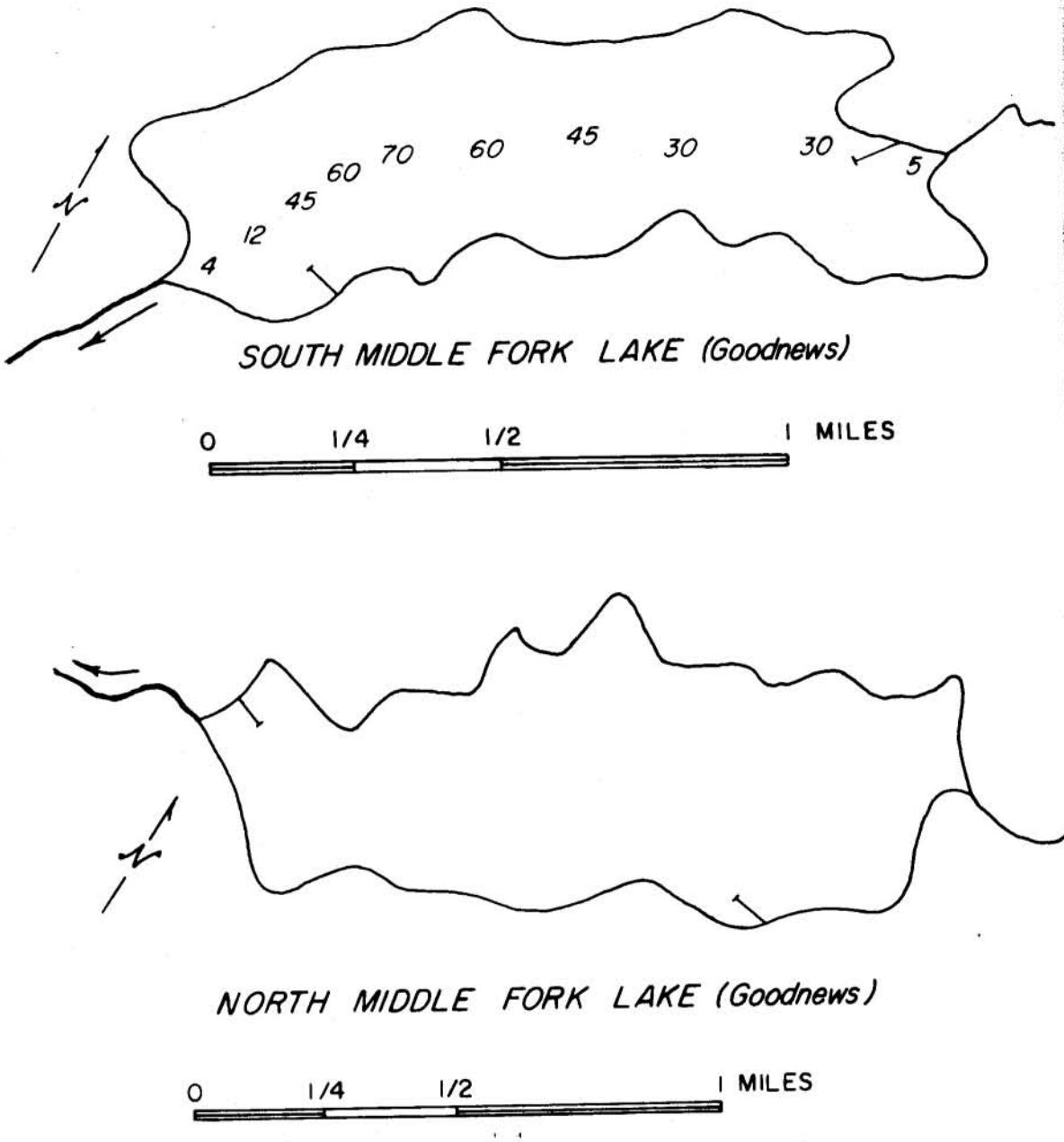


Figure 17. South Middle Fork Lake (above) and North Middle Fork Lake (below). (See Figure 14 for orientation)

0.5 miles wide. This clear deep lake has a maximum depth of 70' and the Secchi disc reading was 42'. The shoal area was approximately 10%. The lake is closely surrounded by mountains and the vegetation is tundra associated. The main inlet stream was 20' (6 m) wide and 2' (0.6 m) deep and the outlet was 30' (9 m) wide and 2' (0.6 m) deep. The shoal area of the lake had a bottom composed of 20% sand, 40% fine gravel, and 40% medium gravel. Water chemistry data taken on July 5 were: total alkalinity 17 ppm, hardness 34 ppm and pH 7.

Two gill nets set for 24 hours took 15 lake trout, 3 Arctic char, 24 round whitefish and 3 red salmon. Twenty lake trout were captured in four hours of angling. An estimated 1,100 red salmon were counted in this lake on September 2, 1970.

Life History Data

The Kuskokwim River contains 25 species of freshwater fish and all have been captured in the study rivers of the lower Kuskokwim. These species with scientific names and abbreviations are presented in Table 2. Other species such as Pacific herring, Clupea harengus pallasi Valenciennes; starry flounder, Platichthys stellatus (Pallas); saffron cod, Eleginus gracilis (Tilesius); capelin, Mallotus villosus (Muller); and fourhorn sculpin, Myoxocephalus quadricornis (Linnaeus), occasionally enter the lower Kuskokwim.

Only 18 species were encountered during the present study in the tributaries of Kuskokwim Bay; of these, northern pike could be considered rare. While round whitefish are abundant in both drainages, the other five whitefish species (sheefish, humpback whitefish, broad whitefish, least cisco, Coregonus sardinella Valenciennes, and Bering cisco were not captured in the Kuskokwim Bay drainages so are considered absent (Table 3). Rae Baxter reported taking Bering cisco in the lower reaches of the Arolik and Kanektok rivers. With a more concentrated survey effort covering an entire year on each water a few more species might be found.

Arctic Char

The Arctic char, Salvelinus alpinus (Linnaeus), is one of the most widely distributed fish in the study area and was found in nearly all lakes and streams surveyed (Table 4). There are three life history forms of this char in waters of the study area: (1) resident lake char, (2) anadromous stream char, and (3) resident stream char. Resident stream char in streams of Kuskokwim Bay are dwarf forms. Dwarf refers to char that are sexually mature at 130-160 mm fork length. They are usually dark colored. Anadromous char are found only in streams of Kuskokwim Bay.

Taxonomy:

The char found within the study area have been called both Dolly Varden, Salvelinus malma (Walbaum), and Arctic char. Mean total gill raker

Table 2. List of common and scientific names of fish found in the study area. Abbreviations used in the tables are also included. Common and scientific names follow Bailey, 1970.

Arctic lamprey	Lampetra japonica (Martens)	AL
Chinook (king) salmon	Oncorhynchus tshawytscha (Walbaum)	KS
Sockeye (red) salmon	Oncorhynchus nerka (Walbaum)	RS
Coho (silver) salmon	Oncorhynchus kisutch (Walbaum)	SS
Chum (dog) salmon	Oncorhynchus keta (Walbaum)	CS
Pink (humpback) salmon	Oncorhynchus gorbuscha (Walbaum)	PS
Rainbow trout	Salmo gairdneri Richardson	RT
Lake trout	Salvelinus namaycush (Walbaum)	LT
Arctic char	Salvelinus alpinus (Linnaeus)	AC
Inconnu (sheefish)	Stenodus leucichthys (Guldenstadt)	SF
Round whitefish	Prosopium cylindraceum (Pallas)	RWF
Least cisco	Coregonus sardinella Valenciennes	LCI
Bering cisco	Coregonus laurettae Bean	BCI
Humpback whitefish	Coregonus pidschian (Gmelin)	HWF
Broad whitefish	Coregonus nasus (Pallas)	BWF
Arctic grayling	Thymallus arcticus (Pallas)	GR
Boreal smelt	Osmerus mordax (Mitchill)	SM
Pond Smelt	Hypomesus olidus (Pallas)	PSM
Northern pike	Esox lucius Linnaeus	NP
Blackfish	Dallis pectoralis Bean	BL
Longnose sucker	Catostomus catostomus (Forester)	SU
Burbot	Lota lota (Linnaeus)	BB
Threespine stickleback	Gasterosteus aculeatus Linnaeus	TST
Ninespine stickleback	Pungitius pungitius (Linnaeus)	NST
Slimy sculpin	Cottus cognatus Richardson	SC

Table 3. Distribution and relative abundance of freshwater fish in waters of the lower Kuskokwim River and Kuskokwim Bay, Alaska.

	Arctic lamprey	King salmon	Chum salmon	Red salmon	Pink salmon	Silver salmon	Rainbow trout	Arctic char	Lake trout	Sheefish	Round whitefish	Humpback whitefish	Broad whitefish	Least cisco	Bering cisco	Arctic grayling	Boreal smelt	Pond smelt	Burbot	Longnose sucker	Northern pike	Blackfish	Ninespine stickleback	Threespine stickleback	Slimy sculpin
Kuskokwim Bay																									
Goodnews River System																									
Asriguat L.	O	O	O	+	O	+	O	+	X	O	P	O	O	O	O	O	O	O	P	O	O	P	P	P	+
Canyon L.	O	O	O	+	P	P	O	+	+	O	+	O	O	O	O	X	O	O	P	O	O	P	P	P	+
Goodnews L.	P	X	X	+	X	X	X	+	+	O	+	O	O	O	O	X	O	O	+	O	X	P	+	+	+
North Middle Fork L.	O	O	O	+	O	P	O	+	+	O	+	O	O	O	O	O	O	O	P	O	O	P	P	+	X
South Middle Fork L.	O	O	O	+	O	P	O	+	+	O	+	O	O	O	O	O	O	O	P	O	O	X	P	P	P
Kukaktlim L.	O	O	O	+	O	P	O	+	X	O	X	O	O	O	O	O	O	O	P	O	O	P	P	P	+
Goodnews R.	P	+	+	+	+	+	+	+	+	O	+	O	O	O	O	+	O	P	P		O	X	+	+	+
Kanektok River System																									
Kagati L.	O	+	+	+	+	+	X	+	+	O	+	O	O	O	O	X	O	O	X	O	O	P	P	P	+
Klak L.	O	X	O	P	O	X	O	+	+	O	P	O	O	O	O	O	O	O	P	O	O	P	P	P	+
Kanuktik L.	O	X	O	P	O	P	O	+	+	O	X	O	O	O	O	O	O	O	P	O	O	P	P	P	+
Ohnlik L.	O	P	O	+	O		O	+	+	O	X	O	O	O	O	O	O	O	P	O	O	P	P	P	+
Kanektok R.	O	+	+	+	+	+	+	+	X	O	+	O	O	O	X	+	X	P	P	O	O	P	P	P	+
Arolik River System																									
Arolik L.	O	O	O	+	O	X	X	X	+	O	+	O	O	O	O	+	O	O	O	O	O	O	P	P	+
Arolik R.	O	+	+	+	+	+	+	+	X	O	+	O	O	O	X	+	X	X	P	O	C	X	P	P	+

Table 3. (Cont.) Distribution and relative abundance of freshwater fish in waters of the lower Kuskokwim River and Kuskokwim Bay, Alaska

	Arctic lamprey	King salmon	Chum salmon	Red salmon	Pink salmon	Silver salmon	Rainbow trout	Arctic char	Lake trout	Sheefish	Round whitefish	Humpback whitefish	Broad whitefish	Least cisco	Bering cisco	Arctic grayling	Boreal smelt	Pond smelt	Burbot	Longnose sucker	Northern pike	Blackfish	Ninespine stickleback	Threespine stickleback	Slimy sculpin
Kuskokwim River																									
Aniak River System																									
Aniak L.	0	X	X	0	0	+	0	X	+	0	X	0	0	0	0	+	0	0	0	0	0	0	0	0	X
Aniak R.	+	+	+	X	+	+	+	+	0	X	+	+	+	+	X	+	0	+	+	+	+	+	+	0	+
Tuluksak River System																									
Tuluksak R.	X	+	+	0	X	+	X	+	0	P	X	+	+	X	P	+	P	P	P	+	+	+	P	0	+
Kisaralik River System																									
Kisaralik L	0	+	0	0	0	X	0	+	+	0	P	0	0	0	0	+	0	0	0	0	0	0	0	0	+
Kisaralik L. #2	0	0	0	0	0	X	0	+	+	0	P	0	0	0	0	+	0	0	0	0	0	0	0	0	+
Kisaralik R.	X	+	+	P	X	+	+	+	0	P	+	X	+	X	P	+	X	P	P	+	+	+	P	0	+
Kasigluk River System																									
Kasigluk R.	X	+	+	P	X	+	+	+	0	X	+	+	+	X	P	+	X	P	P	+	+	+	P	0	+
Kwethluk River System																									
Kwethluk R.	X	+	+	P	X	+	+	+	0	P	+	+	+	X	P	+	X	P	P	+	+	+	P	0	+
Eek River System																									
Eek L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0	0	0
Eek R.	P	+	+	+	+	+	0	+	0	X	+	+	+	+	X	+	X	P	P	P	+	+	P	X	+

+ abundant, X low-abundance, P thought to be present but not captured, 0 absent

Table 4. Arctic char catch statistics for various lakes, July, 1975 and 1976.

Lake	Net Nights	Total AC*	AC/ Net Night	% Char in Total Catch	Length (mm) $\bar{x}$	Length (mm) Range	Weight (g) $\bar{x}$	Weight (g) Range	Hook and Line Catch
Kuskokwim Bay									
Goodnews R. System									
Asriguat	2	36	18.0	72.0	342	108-547	740	16-1,750	5 in 2 hrs
Canyon	3	29	9.7	46.8	392	263-485	744	200-1,250	9 in 8 hrs
Goodnews	2	8	4.0	28.6	345	119-509	718	18-1,600	6 in 5 hrs
N. Middle Fork	2	11	5.5	23.4	352	249-475	680	250,1,250	0 in 1 hr
S. Middle Fork	2	3	1.5	06.6	397	260-479	625	125-1,250	0 in 1 hr
Kukaktlim**	2	20	10.0	51.3	455**	330-543	1,000	550-1,450	3 in 1 hr
Kanektok R. System									
Kagati	2	6	3.0	23.1	540	443-626	2,175	1,200-3,200	0 in 2 hrs
Kanuktik	2	13	6.5	38.2	357	128-640	1,001(n=9)	250-1,750	0 in 3 hrs
Klak	2	11	5.5	57.9	399	115-640	2,007(n=7)	500-2,750	0 in 1 hr
Ohnlik	1	2	2.0	09.5	400	350-451	1,175	850-1,500	1 in 2 hrs
Arolik R. System									
Arolik	5	1	0.2	02.5	...	...	...	...	0 in 22 hrs
Kuskokwim R. Tributaries									
Aniak	3	1	0.3	02.0	166	...	...	...	0 in 12 hrs
Kisaralik	4	10	2.5	45.0	...	-620	...	50-2,500	0 in 10 hrs
Kisaralik #2	2	6	3.0	30.0	...	340-505	...	510-1,300	3 in 7 hrs
Eek	1	0	...	...	...	...	...	...	...

* AC = Arctic char

** 18 AC were eaten by bear and not measured.

counts for char in this study range from 21.5 to 24.9 and counts on the lower arch range from 11.6 to 13.9 (Table 5). My counts fall within the range of counts for both Dolly Varden and Arctic char but in most cases are closest to the form described by McPhail and Lindsey (1970) as Arctic char. This form is distributed from the Kuskokwim River to the Mackenzie River and has 13-14 gill rakers on the lower limb of the first gill arch.

Counts of dwarf residents from the Arolik River and Arolik Lake are the same as counts for anadromous forms. The stream forms from the Aniak, Tuluksak, Kwethluk and Kisaralik rivers have lower counts while lake residents have slighly higher counts.

Char gill raker counts from lakes in Kuskokwim Bay and the Kuskokwim River are also similar. In 1975 gill raker counts were taken on 14 Arctic char from the Holitna River, 75 miles up the Kuskokwim from the Aniak River. Mean lower limb count was 13.1 and the mean total count was 21.9. Until further research is completed it is suggested calling fish having total gill raker counts ranging from 21.5 to 24.9 Arctic char.

Gill raker counts for Arctic char from the Sagavanirktok River (McCart and Craig, 1971) are similar to counts for fish of the study area.

Movements:

The stream residents of the tributaries of the Kuskokwim evidently spend all of their lives in these tributary rivers and seldom venture into the Kuskokwim River. Rae Baxter (pers. comm.*) mentioned that few Arctic char are taken by either summer or winter subsistence gill net fishermen in the Kuskokwim River. He said that there is no noticeable upstream migration during the summer as there is with whitefish, sheefish, and salmon. Residents of villages in the study area as well as the Holitna River outside the study area report capturing Arctic char through the ice in deep holes of the tributary rivers throughout the winter. In the Aniak River, Arctic char were taken by gill net and hook and line 60 miles upstream on May 12. They were abundant 18 miles upstream and also taken in the slower moving water of the lower 6 miles of the Aniak River as late as May 21.

During summer, char congregate where salmon are spawning and feed on eggs and carcasses. Only two dwarf stream residents were encountered in the lower Kuskokwim River tributaries. These fish, from the Aniak River, were mature at a length of 144 mm (5.7").

Anadromous Arctic char in the Arolik, Kanektok, and Goodnews rivers begin entering the rivers in late June and early July after the main run

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*Baxter, Rae. 1975, pers. comm. Alaska Dept. of Fish and Game Bethel, AK

Table 5. Gill raker counts for char from selected waters in Kuskokwim River and Kuskokwim Bay.

Drainage	n	Gill rakers on upper arch limb			Total gill rakers		
		$\bar{x}$	Range	S.D.	$\bar{x}$	Range	S.D.
Kuskokwim River							
Aniak R.	13	11.5	10-12	.66	21.5	19-23	1.33
Aniak R. dwarf	3	11.3	11-12	.58	20.3	19-21	1.15
Kisaralik L.	20	13.9	12-15	.97	24.9	23-28	1.53
Kisaralik L. #2	6	13.8	12-15	.75	24.7	24-26	.82
Kisaralk R.	11	12.5	12-13	.52	22.6	22-24	.92
Kwethluk R.	10	11.8	10-13	.79	21.4	20-24	1.24
Tuluksak R.	21	12.3	11-13	.56	22.2	20-24	1.06
Holitna R.*	14	13.1	11-17	1.88	21.9	21-28	5.80
Kuskokwim Bay							
Kanektok R.	10	12.0	11-13	.75	21.9	20-24	1.20
Goodnews R. dwarf							
Canyon L.	13	13.5	12-15	.88	24.5	22-27	1.61
Arolik L. (dwarf)	1	12.0			22		
Arolik R. (anadromous)	3	12.0	12.0		22	22	
Arolik R. (dwarf)	1	12.0			23.0		

*Not in study area

of red, chum, king and pink salmon. On July 21, 1975, the first anadromous char in the Goodnews River were encountered 25 miles downstream from Goodnews Lake. The char probably move further upstream but it is not known if they enter Goodnews Lake. On July 19, 1973 and on July 26, 1975, anadromous char were taken approximately 36 miles downstream from Kagati Lake. Six anadromous char were captured between July 14 and 17, 1976 in the lower 30 miles of the Arolik River. They evidently had just begun to enter the stream.

In all three rivers, dwarf stream residents were taken upstream of the silvery anadromous char. The anadromous char seemed to be associated with swift running water and few were concentrated with the salmon. Thus, their upstream migration is probably a spawning migration rather than a feeding migration (see section on food habits).

No information on the upstream migration of nonspawners is available but they may enter the streams later in the fall, as village residents report large numbers of char going upstream with silver salmon in August and September. In the Sagavanirktok River of Alaska's North Slope the immature and nonconsecutive spawning char enter the stream generally after the spawners and concentrate in deep pools (Yoshihara, 1972).

The lake dwelling char were darker colored than the anadromous stream char. They were generally in fine condition and relatively free of parasites. Lakes of the Goodnews system generally contained more char than lakes of the Kanektok system but the larger size char were found in the Kanektok River lakes - Kagati, Kanuktuk and Klak (Table 4). These char attained a maximum length of 640 mm (26"). Arctic char made up a large percentage of the total species catch in many of the lakes. Only in Oknlik and South Middle Fork, Arolik and Aniak lakes were they less than 10% of the total catch. Lake trout and round whitefish were the other common species captured. Red salmon had begun to enter the lakes when the netting program began and they are included in the species composition tabulations. Test net results indicated that the larger size char were in deeper water (up to 40') and smaller char were found closer to shore in shallow water.

Age and Growth:

Arctic char sampled ranged in length from 26 to 700 mm (1" to 28") and in age from 0+ to XIII. In most areas sampled fish ranged from 300 to 475 mm (12" to 19"). A special effort was made to capture juvenile char by using small mesh gill nets, but large samples, consisting mainly of Age II and III fish, were collected only at Asriguat and Kisaralik lakes and the Aniak and Kisaralik rivers. Fork lengths given in Table 6 are length at capture. Young-of-the-year char were captured only in the Arolik River in mid July when they averaged 30 mm (1.2") fork length.

All fish from lakes were taken in July but a larger portion of the Aniak River sample was taken in May at annulus formation. The remaining Aniak River fish were collected in August, and fish from the Tuluksak, Kwethluk, Kisaralik and Kanektok rivers were collected in July.

Table 6. Length-age relationships of Arctic char from Kuskokwim River and Kuskokwim Bay.

Location		Age at Capture I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
		Fork length (mm) at capture												
Kuskokwim Bay														
Asriguat L.	$\bar{x}$	...	115	126	191	287	365	334	425	441	465	497	515	510
n=39	n	...	n=2	n=7	n=4	n=2	n=1	n=2	n=4	n=7	n=4	n=2	n=3	n=1
	Range	...	108-122	118-154	118-300	244-330	365	308-360	421-433	421-461	448-488	496-498	492-547	510
Canyon L.	$\bar{x}$	...	...	137	199	...	271	325	375	396	395	437	469	480
n=29	n	...	...	n=1	n=1	...	n=2	n=2	n=3	n=6	n=3	n=4	n=5	n=2
	Range	...	...	137	199	...	263-279	325	350-386	370-430	380-410	428-448	444-484	475-485
Goodnews L.	$\bar{x}$	...	122	...	286	313	398	...	469	...	486	509	...	...
n=13	n	...	n=3	...	n=1	n=3	n=2	...	n=1	...	n=2	n=1	...	...
	Range	...	119-126	...	286	293-353	395-400	...	469	...	472-500	509	...	...
N. Middle Fork L.	$\bar{x}$	...	...	...	...	278	316	397	405	441	...	...	...	...
n=11	n	...	...	...	...	n=3	n=3	n=2	n=1	n=2	...	...	...	...
	Range	...	...	...	...	249-322	295-342	389-405	405	408-475	...	...	...	...
S. Middle Fork L.	$\bar{x}$	...	...	...	...	260	...	...	435	...	497	...	...	...
n=3	n	...	...	...	...	n=1	...	...	n=1	...	n=1	...	...	...
	Range	...	...	...	...	260	...	...	435	...	497	...	...	...
Kukatlim L.	$\bar{x}$	...	...	...	...	...	370	...	...	...	...	...	...	...
n=1	n	...	...	...	...	...	n=1	...	...	...	...	...	...	...
	Range	...	...	...	...	...	370	...	...	...	...	...	...	...
Kagati L.	$\bar{x}$	...	...	...	...	...	443	...	...	...	520	...	556	...
n=4	n	...	...	...	...	...	n=1	...	...	...	n=1	...	n=2	...
	Range	...	...	...	...	...	443	...	...	...	520	...	552-559	...
Kanuktik L.	$\bar{x}$	...	137	191	270	250	...	...	...	466	478	...	595	640
n=12	n	...	n=2	n=2	n=1	n=1	...	...	...	n=3	n=1	...	n=1	n=1
	Range	...	128-145	172-210	270	250	...	...	...	464-468	478	...	595	640

Table 6. (Cont.) Length-age relationships of Arctic char from Kuskokwim River and Kuskokwim Bay.

Location		Age at Capture												
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
		Fork length (mm) at capture												
Klak L.	$\bar{x}$	...	118	...	...	...	...	274	...	490	502	568	640	630
n=9	n	...	n=2	...	...	...	...	n=1	...	n=1	n=2	n=1	n=1	n=1
	Range	...	115-155	...	...	...	...	274	...	490	490-514	568	640	630
Ohnlik L.	$\bar{x}$	...	...	...	...	...	350	...	...	451	...	...	...	...
n=2	n	...	...	...	...	...	n=1	...	...	n=1	...	...	...	...
	Range	...	...	...	...	...	350	...	...	n=1	...	...	...	...
Arolik R.	$\bar{x}$	30*	100	...	149	...	...	...	413	505	450	615	595	...
n=19	n	n=8	n=2	...	n=1	...	...	...	n=3	n=1	n=1	n=2	n=1	...
	Range	26-36	96-104	...	149	...	...	...	380-450	505	450	610-630	595	...
Kanektok R.	$\bar{x}$	...	122	...	...	...	444	408	430	...	...	...	...	...
n=14	n	...	n=4	...	...	...	n=8	n=1	n=1	...	...	...	...	...
	Range	...	115-128	...	...	...	410-484	408	430	...	...	...	...	...
Goodnews R.	$\bar{x}$	...	135	138	133	...	453	491	...	...	577	553	700	...
n=18	n	...	n=2	n=2	n=2	...	n=2	n=1	...	...	n=4	n=4	n=1	...
	Range	...	124-145	130-146	130-137	...	417-489	491	...	...	553-652	521-580	700	...
Kuskokwim R.														
Aniak R.	$\bar{x}$	109	135	164	193	267	348	363	410	425	461	486	...	...
n=129	n	n=1	n=25	n=31	n=9	n=10	n=7	n=5	n=7	n=20	n=12	n=2	...	...
	Range	109	114-141	120-192	130-230	235-300	327-370	352-389	402-453	357-544	389-656	475-496	...	...
Kasigluk R.	$\bar{x}$	...	...	...	...	...	395	395	429	468	...	...	...	...
n=9	n	...	...	...	...	...	n=1	n=3	n=4	n=1	...	...	...	...
	Range	...	...	...	...	...	395	375-408	422-436	468	...	...	...	...
Kisaralik R.	$\bar{x}$	86	126	...	...	...	397	378	433	456	480	...	...	...
n=25	n	n=5	n=8	...	...	...	n=1	n=2	n=4	n=4	n=1	...	...	...
	Range	79-117	94-121	...	...	...	397	375-382	400-510	425-510	480	...	...	...

Table 6. (Cont.) Length-age relationships of Arctic char from Kuskokwim River and Kuskokwim Bay.

Location		Age at Capture I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
		Fork length (mm) at capture												
Kwethluk R.	$\bar{x}$	...	110	...	...	...	...	370	405	425	425	450	485	...
n=13	n	...	n=1	...	...	...	...	n=1	n=2	n=4	n=2	n=2	n=1	...
	Range	...	110	...	...	...	...	370	385-425	410-430	415-420	435-465	485	...
Tuluksak R.	$\bar{x}$	...	...	...	...	...	...	...	390	403	430	445	470	490
n=21	n	...	...	...	...	...	...	...	n=2	n=3	n=6	n=4	n=5	n=1
	Range	...	...	...	...	...	...	...	380-400	400-405	395-495	415-475	445-495	490
Kisaralik L.	$\bar{x}$	...	125	142	...	186	255	...	395	410	...	...	...	620
n=17	n	...	n=2	n=6	...	n=1	n=3	...	n-3	n=1	...	...	...	n=1
	Range	...	118-131	131-157	...	186	244-275	...	370-420	410	...	...	...	620
Kisaralik #2	$\bar{x}$	...	...	...	...	...	...	335	372	461	435	455	...	...
n=9	n	...	...	...	...	...	...	n=1	n=3	n=3	n=1	n=1	...	...
	Range	...	...	...	...	...	...	335	340-415	440-485	435	455	...	...

*Aniak L. one char FL 166 mm - Age IV
Arolik L. one char 150 mm - Age IV

In general, growth of all life history forms of char is similar and very slow during the first 4 years of life. At approximately Age V the anadromous forms had an acceleration in growth rate. This is probably the age at first seaward migration. The river and lake residents grow more slowly than anadromous fish and do not reach as large a maximum size. The lake and stream residents and anadromous forms have similar life spans. Char up to 700 mm (27 1/2") were captured from the Kanektok River during a 1973 reconnaissance survey, but none were sampled, so it can be assumed that a large sample of anadromous char from each river in Kuskokwim Bay would yield fish up to 700 mm (27 1/2") and Age XII.

Because of the small sample from each location and the great overlap in length for each of the older age groups, it is difficult to make comparative statements concerning growth of lake and stream forms or growth of char from the Kuskokwim River section of the study area versus growth from Kuskokwim Bay lake char. Lake fish apparently grow slower than stream fish up to about Age IX and then grow faster with exceptional growth being shown by char from Age X to XII (Fig. 18). Canyon Lake char are considerably slower growing than char from other lakes and are the slowest growing of all char sampled. The older char captured in the lakes of the Kanektok River were fat, deep bodied individuals caught in deep sets and these fish exhibited good growth in their later years.

In general, stream residents did not grow as large as lake or anadromous forms and very few over 500 mm (19 1/2") were taken in gill nets or on hook and line. The larger stream residents also weighed less and generally were in poorer condition than the larger lake or anadromous forms and very few stream fish weighed over 1,000 g (2 lbs 3 oz). Average weight of a 520 mm (20 1/2") fish from Klak Lake was 2,250 g (4 lbs 15 oz) from the Aniak River 1,500 g (3 lbs 5 oz), and anadromous char from the Arolik River 1,700 g (3 lbs 12 oz), and from the Goodnews River 1,700 g (3 lbs 12 oz). The largest anadromous char taken was a 700 mm (27 1/2"), 4.8 kg (10 lbs) spawner from the Goodnews River. The heaviest lake resident char taken was a 626 mm (24 1/2"), 3.2 kg (7 lbs) spawner from Kagati Lake and the heaviest stream fish was 656 mm (25 1/2"), 1.6 kg (4.6 lbs) spent male from the Aniak River. In nearly all waters the largest fish in length and weight were males. Because of the small samples no attempt was made to compare growth of males and females, but Yosihara (1972) considered it fairly even in the Sagavanirktok River. Age and growth studies of Arctic char in watersheds close to the study area have not been published but data from the Sagavanirktok River in Northern Alaska is included in Fig. 18 for comparison. Their growth is slower than growth of char from the study area during the first 3 years.

Dwarf resident char grew only slightly slower than the normal sized stream forms but none were found over 5 years of age.

Age at Maturity:

Arctic char reached first sexual maturity at varying sizes and ages according to life history form represented. The resident stream forms became mature at a size as small as 350 mm (13 1/2") and Age VI for

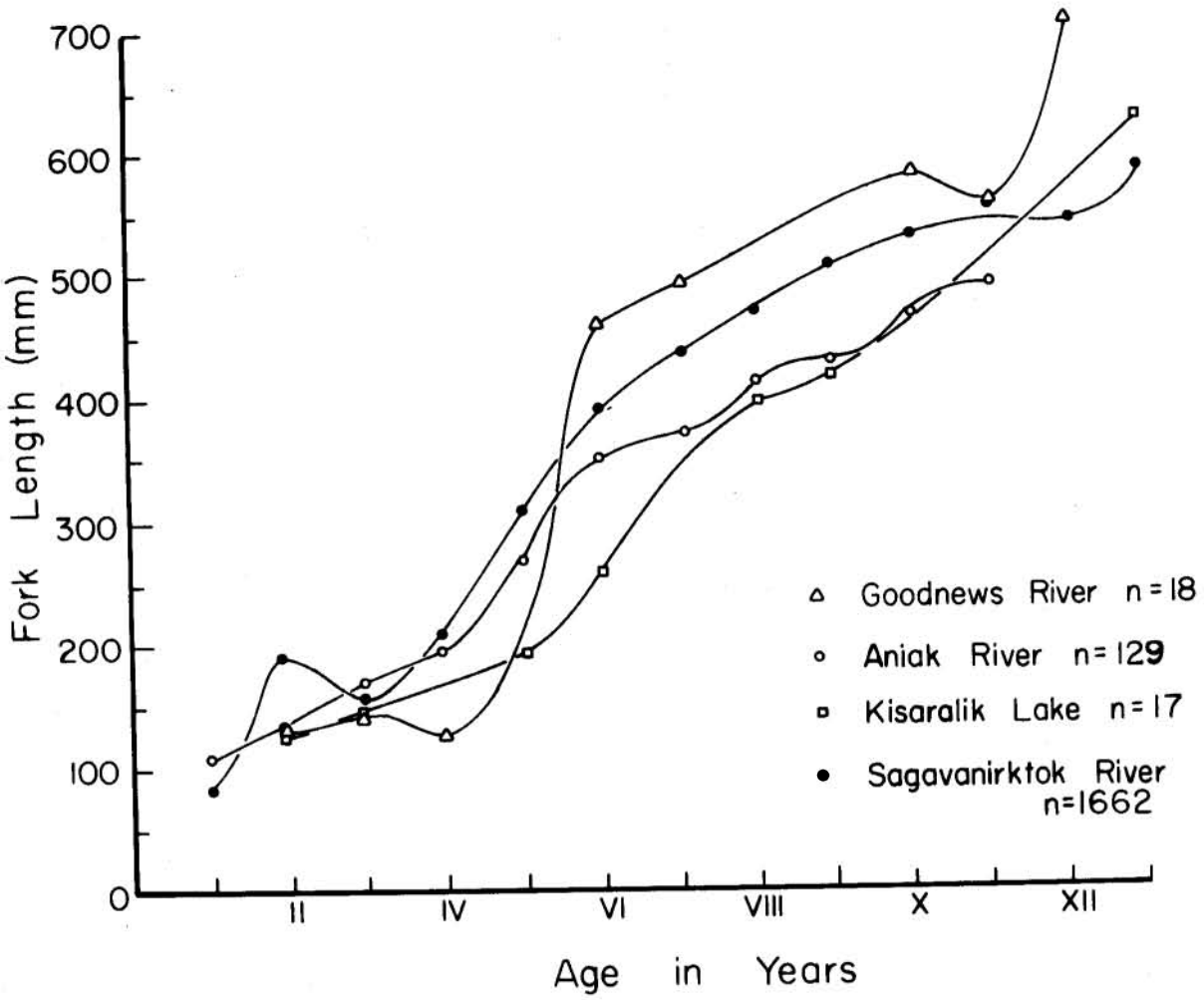

Figure 18. Comparative age-length data for Arctic char from Kuskokwim Bay, Kuskokwim River and Sagavanirktok River. Sagavanirktok River data are from Furniss, 1974.

Aniak River char, but generally at 360-400 mm (14"-15 1/2") which corresponded to Age VII to IX. Anadromous char matured at a larger size, generally 410 mm (16") but some were still immature at 490 mm (19"). The lake resident char generally did not mature until 410-430 mm (16"-17") fork length and Age VII to X. A few Canyon Lake fish were mature at a fork length less than 400 mm (15 1/2") but these fish are slower growing. Length and age at maturity of Kuskokwim Bay and Kuskokwim River char are similar.

Examination of char ovaries indicated that 20% of the lake char were nonconsecutive spawners and 50% of the Aniak River fish were nonconsecutive spawners, but only 10% of the Kwethluk River, Tuluksak and Kisaralik females were nonconsecutive spawners. The Aniak River was sampled mainly in early May and many of the females that I categorized as nonconsecutive spawners at that time possibly would develop rapidly through the summer and spawn consecutively.

Food Habits:

Fish, insects, snails and clams were eaten by char in the study area (Table 7).

Snails and clams were the most important food items of lake dwelling char and in many cases stomachs of feeding char were gorged with snails. Lake char fed very little on fish, and only a few salmon fry, sculpin and stickleback were identified in stomachs. The few insects eaten were mainly larvae of the order Tricoptera.

Stream char captured in the spring and early summer fed mainly on insects, while those captured in late July and August fed mainly on salmon eggs and salmon flesh. The exception occurred in May of 1976 when most char captured in the Aniak River were feeding heavily on salmon fry. Some of the char from the Aniak River taken in May were feeding on dead salmon eggs.

Char taken in late July and August were concentrated in areas of salmon spawning and could easily be captured with hook and line. Most char that had fed on salmon eggs also contained a number of stones in their stomachs presumably picked up while eating salmon eggs. Insects were important summer food items in streams of the study area and probably assume more importance during winter. Diptera and Tricoptera larvae constituted the major food items but stonefly larvae (Plecoptera), and Mayfly larvae (Ephemeroptera) were also eaten.

Approximately 80% of the anadromous char from the Arolik, Goodnews, and Kanektok rivers had empty stomachs. Stomachs of over 50% of the stream resident char taken in May were half full or more, while over 50% of late July and August stomachs were half full or less. Stomachs of feeding lake char were generally less than half full, but these fish were captured in gill nets and much of the food may have been digested by the time the fish were autopsied. There was little observable difference in food habits of small and large char.

Table 7. Food items eaten by Arctic char in waters of Kuskokwim Bay and lower Kuskokwim River.

Food Item	Asriguat L. n=38	Canyon L. n=31	Goodnews L. n=11	N. Middle Fork L. n=11	S. Middle Fork L. n=3	Kagati L. n=5	Kanuktik L. n=11	Klak L. n=10	Ohnlik L. n=2	Kanektok R. n=8	Arolik R. n=10	Aniak R. n=88	Tuluksak R. n=21	Kisaralik L.* n=20	Kisaralik R. n=22	Kasigluk R. n=4	Kwethluk R. n=13
	Frequency of Occurrence																
Fish																	
Salmon fry	4	...	1	...	1	...	...	...	...	1	...	25	...	...	...	...	1
Sculpin	1	...	...	1	...	...	...	...	...	...	...	7	...	...	...	...	...
Grayling	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...
Stickleback	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Salmon eggs	...	...	4	...	...	...	1	...	...	2	4	29	10	...	10	3	9
Salmon flesh	...	...	...	...	...	...	...	...	...	...	...	9	1	...	1	...	2
Fish remains	9	2	1	1	1	...	...	...	...	3	...	...	...	2	...	...	4
Insects																	
Diptera	3	2	...	2	1	...	...	...	1	...	4	37	10	9	10	...	...
Tricoptera	12	14	...	1	...	...	5	3	...	2	3	31	2	7	2	...	1
Plecoptera	...	2	...	...	1	...	...	...	2	2	4	12	1	2	...	...	...
Ephemeroptera	...	...	...	...	...	...	...	...	...	1	...	6	3	4	3	...	...
Coleoptera	...	...	...	1	1	...	...	...	...	...	...	2	...	2	...	...	1
Homoptera	...	...	...	...	...	...	...	...	...	...	...	4	...	1	...	1	...
Insect remains	...	4	...	2	...	...	...	...	...	2	1	16	2	1	3	...	...
Other																	
Snails	14	24	5	7	1	5	9	7	1	...	...	...	...	15	...	...	...
Clams	12	3	4	1	...	3	...	1	...	...	...	...	...	...	...	...	...
Annelids	...	...	...	...	...	...	...	...	...	...	...	3	...	...	...	...	...
Vole	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Debris	2	1	...	...	...	1	...	1	...	....	3	21	5	2	...	2	4

* Includes Kisaralik and Kisaralik #2 Lakes.

Rainbow Trout

Rainbow trout, Salmo gairdneri Richardson, is probably the most important sport fish in the study area. Many anglers fishing these streams come specifically for rainbow. Rainbow trout is found in all major streams in the Kuskokwim River drainage except the Tuluksak and Eek rivers. It is not found in the tributary streams outside the study area that enter the Kuskokwim from the north. The Kuskokwim River represents the most northerly and westerly distribution of natural populations of rainbow trout in the world. The Aniak River marks the farthest upstream location in the Kuskokwim River of a naturally reproducing population of rainbows at 61°36' N, 159°30' W. In 1971, a 2 kg (4 1/4 lbs) rainbow trout was captured at the junction of the Holitna and Kuskokwim rivers, 125 miles upstream from Aniak. The residents of Sleetmute and Mellick's Trading Post capture one or more trout each summer. Rainbow trout do not enter the slow moving water of the Holitna but rather stay in the swift water of the Kuskokwim. Extensive test netting and angling in the lower 100 miles (160 km) of the Holitna between 1967 and 1975 failed to take any rainbow trout, and conversations with residents of villages of the middle and upper Kuskokwim indicated that rainbow trout are not present in this area. The rainbow trout in the study area is associated with swift running streams from their headwaters to nearly their mouths, and this may be the reason rainbow are not found in the slower streams of the Kuskokwim above the Aniak River.

Taxonomy Notes:

Many of the rainbow trout examined during the course of the study had some red pigment in the hyoid grooves beneath the lower jaw. On the Aniak River in May of 1976, 18 of 19 trout examined had some degree of hyoid color, ranging from pale orange to dark red. This phenomenon has been noted by Scott and Crossman, 1971. It was noted on males and females and mature and immature individuals.

Movements and Distribution:

Rainbow trout populations in the study area are all stream dwellers. No anadromous (steelhead) populations exist; they very seldom enter lakes. A spent male was captured on hook and line in Goodnews Lake near the outlet on July 18. This fish had either spawned in the upper Goodnews River and moved into the lake to rest or possibly had spawned in the lake. Both the distribution and movements of rainbow trout in streams of the study area appear to be related to the distribution of salmon. In the Aniak River, salmon and rainbow trout are seldom encountered above the East Fork (65 miles from the mouth). The rainbow trout feed on salmon fry and also follow the spawning salmon to feed on eggs and rotting carcasses. The trout congregate in deep holes of the rivers during the winter and are usually distributed farther downstream than in the summer. The residents of Aniak go upstream near the area of Buckstock River (21 Mile) and capture rainbow trout through the ice during winter. Rainbow trout are occasionally found in deeper holes all the way down to the mouth of the Aniak (Table 1). After breakup the trout begin dispersing and generally begin an upstream movement. Large numbers of trout were

captured (by gill nets and hook and line) during May and August in dead water sloughs of the Aniak River between the mouth of Doestock Creek and the Salmon River. Scattered individuals were also captured by hook and line in the main Aniak and Salmon rivers in tiny bankside eddies next to the swift waters. Throughout the summer rainbow trout are scattered and difficult to catch with gill net or hook and line. In fall after the silver salmon migration has slowed and water levels drop, the trout become more concentrated, especially in the area near the mouth of the Salmon River. Rainbow trout movements and distribution in the Kisaralik, Kasigulk, and Kwethluk rivers are similar to those in the Aniak River. June test netting took rainbow trout, pike, grayling and broad whitefish in the lower 15 miles of these rivers, but by August the fish were distributed further upstream in the swift flowing sections of the rivers. Rainbow trout were not found in the Tuluksak River where suitable habitat similar to rainbow trout habitat of other streams does not exist. They were not found in the Eek River although suitable habitat was available in the Main Fork Eek River beginning about 3 river miles upstream from the main North Fork-Middle Fork junction. The Eek River is slow moving in the lower section and this may have been responsible for their absence. In Kuskokwim Bay streams, the residents of villages at the mouth of the Kanektok and Goodnews rivers mention capturing rainbow trout closer to the mouth of the rivers during the winter and early spring than during the summer.

No concentrations of young were found, but it appeared that young age classes were distributed throughout the rivers. In August of 1976, a special effort was made to capture juveniles in the Kisaralik, Kwethluk and Aniak rivers. Hand dip nets, small mesh gill nets, and hook and line fishing captured approximately 20 fish on the three rivers. They were found in slower moving water of the main river, mainly under tangled roots of downed trees but also at the edge of gravel bars in shallow water and in small side streams. These fish were 96-180 mm in length and no young-of-the-year were found.

Age and Growth:

Length-weight relationships of rainbow trout from streams of the study area are presented in Table 8. In general, rainbow trout from the study area grew slowly the first 3 years of life. Then growth became much more rapid, with fish reaching 400 mm (15 1/2") fork length for Kuskokwim River fish by Age VIII and over 500 mm (19 1/2") fork length for Kuskokwim Bay fish. The Kuskokwim Bay fish grew faster, generally lived longer and attained a larger maximum size than trout of the Kuskokwim River tributaries. The Goodnews River trout grew slightly faster than Kanektok River fish but attained considerably larger size.

Growth of rainbow trout from the four tributaries of the Kuskokwim River was similar. Nearly all Aniak River trout were captured at the time of annulus formation while over 75% of the other Kuskokwim River trout were captured in August and had an additional 20-50 mm of "plus" growth. The Aniak sample represented 12 age classes and contained the only trout of Age Class XII in the study area. In the Aniak as in other Kuskokwim River tributaries Age Classes VII, VIII, and IX made up most of the

Table 8. Rainbow trout age-length data for rivers of lower Kuskokwim River and Kuskokwim Bay, 1975-76. Fork length in mm.

Location	Fork Length	Age I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Kuskokwim R.													
Aniak R.	$\bar{x}$	116	146	215	280	290	337	405	437	458	480	482	524
	n	n=4	n=7	n=2	n=1	n=1	n=10	n=13	n=27	n=24	n=5	n=3	n=1
	Range	96-123	118-193	210-220	280	290	304-360	357-438	385-487	400-500	465-499	471-490	524
Kisarolik R.	$\bar{x}$	97	147	180	...	312	398	398	438	483	...	...	...
	n	n=1	n=3	n=1	...	n=1	n=2	n=5	n=4	n=2	...	...	...
	Range	97	122-160	180	...	312	375-420	370-425	415-465	476-490	...	...	...
Kasigluk R.	$\bar{x}$	...	...	...	...	301	...	369	...	483	493	...	...
	n	...	...	...	...	n=1	...	n=1	...	n=3	n=2	...	...
	Range	...	...	...	...	301	...	369	...	442-515	475-512	...	...
Kwethluk R.	$\bar{x}$	98	155	150	...	305	346	376	412	453	479	...	...
	n	n=1	n=3	n=1	...	n=3	n=5	n=4	n=12	n=6	n=2	...	...
	Range	98	149-165	150	...	265-365	312-375	326-405	365-450	420-495	465-493	...	...
Kuskokwim Bay													
Arolik R.	$\bar{x}$	...	...	...	...	395	428	455	500	533	570	...	...
	n	...	...	...	...	n=1	n=2	n=10	n=4	n=3	n=4	...	...
	Range	...	...	...	...	395	380-475	420-490	450-540	520-540	505-605	...	...
Kanektok R.	$\bar{x}$	...	...	...	...	339	380	445	501	507	509	...	...
	n	...	...	...	...	n=3	n=1	n=7	n=11	n=7	n=1	...	...
	Range	...	...	...	...	292-364	380	402-468	450-541	465-520	509	...	...
Goodnews R.	$\bar{x}$	127	174	296	299	370	425	456	510	520	537	630	...
	n	n=2	n=1	n=1	n=3	n=9	n=11	n=12	n=13	n=10	n=3	n=1	...
	Range	124-130	174	296	270-329	349-382	378-470	410-520	464-538	414-560	515-567	630	...

catch. The largest Kuskokwim River fish taken were from the Aniak River and only three were larger than 500 mm (20"). Weights of Kuskokwim River rainbow trout ranged from 11 to 2,381 g (5 1/2 lbs) with the majority ranging from 900-1,500 g or 2-3 lbs. Many of the Aniak rainbows were taken prior to spawning while still feeding and were in much better condition than spent trout captured in other rivers. Aniak residents mentioned catching rainbow trout over 3.6 kg (8 lbs) from the Aniak River in past years. It is remotely possible that such large trout still exist but with a life span of only 12 years or less, it seems unlikely.

The largest rainbow of the survey 630 mm (25") and 3 kg (6.25 lbs) came from the Goodnews River in July. This fish was spent and would have been much heavier had it been taken in the fall. In the Goodnews River, trout of Age Class I, II and III were captured by gill nets set in small sloughs. A young-of-the-year rainbow trout (Age Class 0) was taken in the Goodnews River on July 19. This fish was 32 mm (1 1/4") fork length and had not yet formed a scale.

Because of the small sample no effort was made to compare growth of males and females so it was considered equal. Russell (1975) had no data for comparison of growth and considered it equal. The only northern stream-dwelling rainbow trout population for which age-length data are available is in the Bristol Bay drainage. Talarik Creek (drainage of Lake Iliamna) rainbows grow more slowly than Kuskokwim Bay fish to Age V but at Age VI the Talarik Creek trout have an explosive growth rate (Russell 1974) and soon outdistance the Kuskokwim fish (Fig. 19). The Talarik fish spend much time in the rich environment of Lake Iliamna.

Age at Maturity:

Most rainbow trout from the study area are mature at a fork length of 450 mm (18") (Table 9). For the faster growing populations from the Kuskokwim Bay drainages, age at maturity is Age VII and VIII with a small number not maturing until Age IX. In the streams of the Kuskokwim River the trout reach maturity generally at Age VIII and IX with only a few Age VII fish being mature. Only one Age VI mature fish was found. Age and size at maturity agree closely with data from Talarik Creek in Bristol Bay (Russell, 1975).

The spawning population is represented mainly by three age classes (VIII, IX and X) in the rivers of the lower Kuskokwim and four age classes (VII-X) in the Kuskokwim Bay Streams. Russell (1975) found that fish of Age VIII, IX and X represented 92% of the spawning population in lower Talarik Creek in the Bristol Bay drainage. Some rainbow trout are nonconsecutive spawners. In the Aniak River 4 out of 12 female mature rainbow trout would not spawn the current year and 5 of 13 males appeared to be nonconsecutive spawners. Fish from other drainages were taken mainly in July so it was difficult to determine the percentage of nonconsecutive spawners.

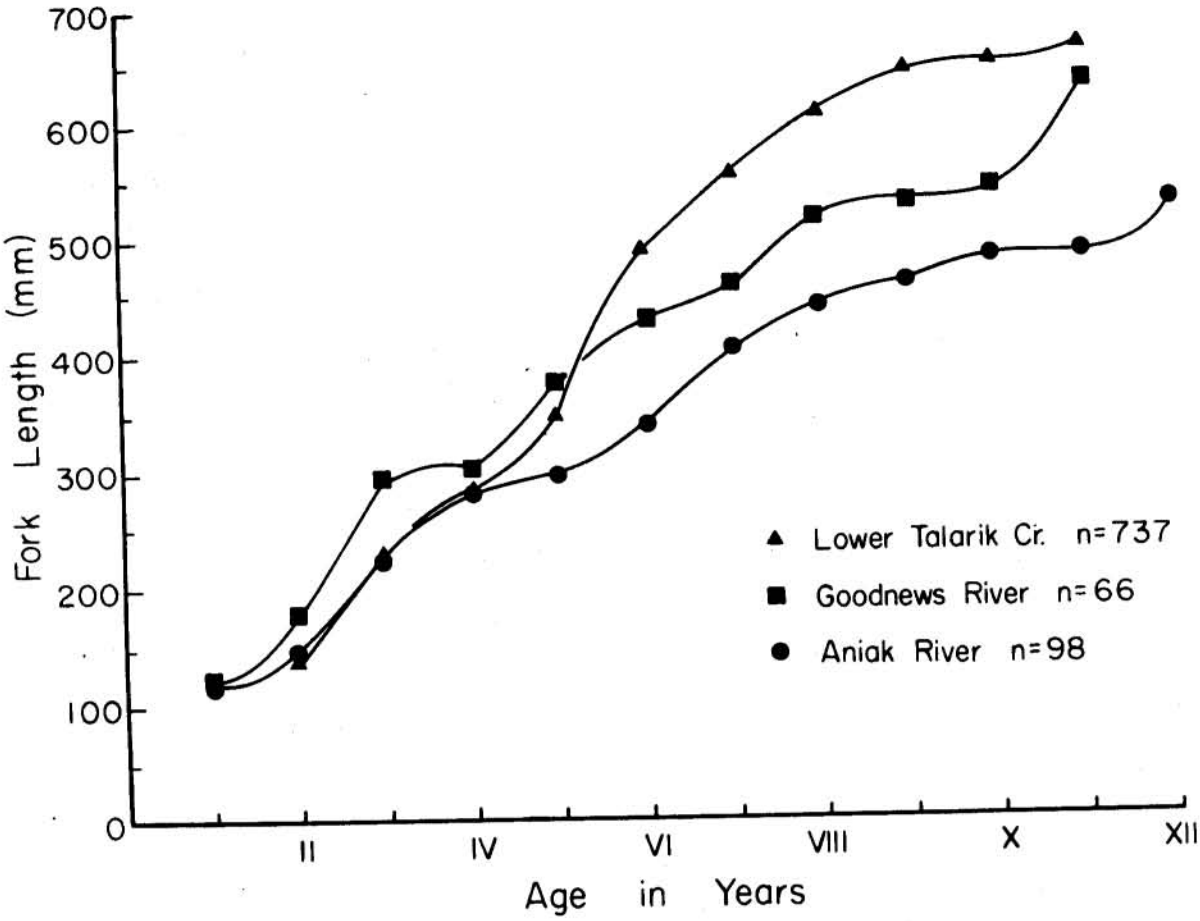

Figure 19. Comparative age-length data for rainbow trout from Kuskokwim study area and Talarik Creek in Bristol Bay drainage. Talarik Creek data from Russell, 1974.

Table 9. Maturity of rainbow trout from various rivers of lower Kuskokwim River and Kuskokwim Bay. Number of mature fish of each age group is given followed by number of immature fish (in parentheses).

Location	Age at Capture									
	<VII		VII		VIII		IX		X and over	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Kuskokwim Bay										
Arolik R. n=17	...	...	1(2)	0(3)	2(0)	2(0)	2(0)	1(0)	1(0)	3(0)
Kanektok R. n=29	0(3)	0(1)	2(2)	2(1)	5(0)	5(0)	6(0)	1(0)	1(0)	0(0)
Goodnews R. n=47	0(10)	0(9)	1(1)	3(1)	5(1)	5(0)	7(1)	2(0)	1(0)	0(0)
Kuskokwim R.										
Aniak R. n=57	0(12)	0(8)	0(2)	0(4)	1(3)	5(2)	7(0)	5(3)	4(0)	1(0)
Kasigluk R. n=7	0(1)	0(1)	...	...	2(1)	...	1(0)	1(0)	...	...
Kisarolik R. n=16	0(3)	1(5)	1(1)	1(0)	2(0)	...	2(0)	...	...	...
Kwethluk R. n=26	0(5)	0(3)	0(1)	0(1)	5(0)	3(0)	3(1)	2(0)	2(0)	1(0)

Spawning:

Research on the Aniak River in late 1975 indicated that rainbow trout had not begun to spawn as late as May 28. A 495 mm (19 1/2") male had milt dripping but all prespawning ripe females examined were still tight. Water temperature was 3.5°C (38°F) in the lower Salmon River, 3.5°C (38°F) in the Aniak river 59 yards below the mouth of the Salmon River, 3°C (37°F) in a small side channel of the Aniak River and 2°C (35°F) in a small tributary entering the Aniak approximately 1.8 miles downstream from the mouth of Salmon River. In 1976 between May 15 and 19 the water temperatures were 1° to 3°C (32° to 37°F) and rainbow trout were not ripe. These latter two streamlets with water depths of 3" to 28" and widths of 2' to 15' were typical of many such tributaries entering the Aniak River in the area between Salmon River and down to 18 Mile. These streamlets had a pea size gravel bottom and it is suspected that these are spawning areas for rainbow trout. Prespawning rainbow trout were often found at or near the mouths of these tiny streams but only two were observed in the streams. On May 26 the water level rose 1' (25.4 mm) from snow melt. The rise in water level continued as did a rise in water temperatures. At 18 Mile the water temperature was 3.5°C (38°F) on May 27 and none of the rainbow trout had yet spawned.

All mature rainbow trout examined on the Kasigluk, Kisaralik and Kwethluk rivers between June 6 and 13 had spawned. Water temperatures in side sloughs and small tributaries ranged from 7° to 9°C (45° to 48°F) and the main Kasigluk River on June 11, 1975 had a temperature of 9°C (48°F).

Food Habits:

Rainbow trout late summer distribution in the study area is closely allied to salmon distribution, probably because rainbow trout feed on salmon fry, eggs and carcasses (Table 10). The majority of the Aniak River trout were captured in early summer (May) and caddis fly larvae were the most important food item even though large numbers of fry were outmigrating. Fish captured in late July and August had fed more on salmon eggs and flesh. The Goodnews River fish fed on the greatest variety of food items including fish, insects, voles, snails and clams. These fish had not fed on salmon eggs but this was probably because salmon spawning was just beginning when the fish were captured (July 17-20). It was difficult to identify salmon fry in rainbow trout stomachs but most were chum, silver and king salmon. The maggots and grubs found in trout stomachs were from decaying salmon and were ingested along with salmon flesh. The only other fish eaten were char and sculpins. Stomachs of over 50% of the rainbow trout captured in the lower Kuskokwim tributaries of the study area were judged to be half full or more and over 50% of stomachs from Kuskokwim Bay fish were a quarter full or empty.

Lake Trout

Lake trout, Salvelinus namaycush Walbaum, are distributed throughout the lakes of the study area. They were not captured in Eek Lake because

Table 10. Stomach Contents of Feeding Rainbow Trout from Lower Kuskokwim River and Kuskokwim Bay Streams.

Stomach Contents	Aniak n=53	Kisaralik n=17	Kasigluk n=7	Kwethluk n=28	Arolik n=11	Kanektok n=22	Goodnews n=47
	Frequency of Occurrence						
Fish							
Sculpins	4	...	...	...	2	2	9
Salmon fry	9	4	2	4	4	17	22
Char	2	...	...	...	...	...	1
Salmon eggs	4	10	4	11	1	3	...
Blackfish	1	...	...	...	...	...	...
Salmon flesh	8	2	...	6	...	...	...
Grayling	1	...	...	...	...	...	...
Insects							
Tricoptera	28	6	2	10	6	2	6
Plecoptera	6	2	1	1	1	...	2
Ephemeroptera	4	1	...	1	...	...	3
Hemiptera	2	...	...	...	1	1	1
Homoptera	2	...	...	...	4	1	3
Diptera	12	1	...	2	...	1	...
Maggots and grubs	...	1	2	2	...	...	1
Insect remains	7	2	...	5	...	6	10
Other							
Snails	...	...	...	...	...	...	4
Clams	...	...	...	...	...	...	2
Voles and shrews	1	2	3	3	...	5	9
Debris	5	...	...	5	3	...	...

of the low elevation, shallow depth and mud bottom, and there are probably none in Eek or other similar foothill lakes. Lake trout catch per gill net night ranged from 0.5 (Asriguat Lake) to 12 (North Middle Fork Lake) (Table 11).

Movements and Distribution:

In most lakes of the study area both floating and sinking gill nets were set. Generally, the floating gill net took considerably more lake trout than the sinker. However, all lake trout larger than 3.4 kg (8 lbs) were caught in sinking nets. Water temperatures were only taken at the surface and ranged from 3°C to 10°C (37° to 50°F) except for Kukaktlim Lake (8' maximum depth) which was 13°C (55°F) . Lake trout were generally more abundant near inlet and outlet streams in July probably because of cooler water temperatures and greater abundance of food. Lake trout were the most abundant species in the lakes of the study area, based on gill net catches, and in four lakes made up over 50% of the total catch. In lakes of Kuskokwim Bay the total gill net and hook and line catch was: 288 lake trout, 28 Arctic char, 6 red salmon, 1 northern pike, 2 grayling and 1 rainbow trout. In lakes of the lower Kuskokwim River 99 lake trout, 20 Arctic char, 3 round whitefish, and 39 grayling were captured. In most areas lake trout are confined solely to lakes and the reaches of streams nearest the lakes. The Goodnews River was an exception and lake trout were found along the entire length of the river to within 10 miles of the ocean. Approximately 20 were caught on hook and line while floating the river. These fish were mainly 400-500 mm (16"-20") fork length and included both immature and prespawning individuals. They were found in deep pools, swift riffles and sometimes undercut banks.

The smallest lake trout captured was 219 mm (8 1/2") fork length from Kisaralik Lake #2 and very few lake trout under 390 mm (15") were captured in the study area. A 190 mm (7") lake trout was found in the stomach of a gill net caught lake trout but the depth of capture was not noted. Thus, the whereabouts of Age Class 0 to Age Class VII and VIII fish are still unknown. Miller and Kennedy (1948), and Johnson (1975), captured some young-of-the-year and juvenile lake trout in the shallow water in a rocky habitat in Great Bear Lake but very few fish in the 150-250 mm (6"-10") size range were seen. Johnson believed that juvenile lake trout may be restricted to rocky areas which provide protection from predators and biological sampling. During this study an effort was made to capture the young trout by seining and setting fine mesh nets, but only juvenile Arctic char were captured.

Age and Growth:

From Kuskokwim Bay lakes, 175 lake trout were used in age determinations. These fish ranged from 277 to 773 mm (11" to 30"), although most fish were between 400 and 500 mm (Table 12). Only five fish from 700 to 780 mm (28"-31") were captured. The largest sample (n=39) came from Arolik Lake. Other large individuals probably exist but were not captured. Age groups VI to XV were represented in the sample but only two fish were less than 8 years old and only five were older than 13 years. Age

Table 11. Lake trout catch statistics for lakes of Kuskokwim River and Kuskokwim Bay, 1975-1976.

Lake	Net Nights	Total LT	LT/Net Night	% Composition of Catch	Fork Length (mm)		Weight (g)		H & L* Catch	
					$\bar{x}$	Range	$\bar{x}$	Range	n	Hrs
Kuskokwim Bay										
Asriguat L.	2	1	0.5	2.5	...	...	...	...	0	2
Canyon L.	3	30	10.0	48.6	437	277-485	927	250-1,250	44	8
Goodnews L.	2	7	3.5	25.0	517	432-576	1,835	1,200-2,600	28	11
N. Middle Fork L.	2	24	12.0	51.0	461	405-533	1,177	1,000-2,275	...	...
S. Middle Fork L.	2	15	7.5	33.3	487	387-773	1,613	600-6,500	11	3
Kukaktlim L.	1	1	1.0	2.5	...	...	...	...	1	1
Kagati L.	2	4	2.0	13.3	454	357-521	1,000	450-1,650	6	2
Kanuktik L.	2	18	9.0	52.9	465	367-730	1,398	500-5,700	16	3
Klak L.	2	4	2.0	21.1	458	425-523	1,360	1,050-1,800	1	1
Ohnlik L.	1	9	9.0	42.9	415	400-447	872	750-1,200	3	2
Arolik L.	4	38	9.5	73.1	425	359-735	1,150	500-6,100	59	14
Kuskokwim R.										
Aniak L.	4	21	5.3	43.7	454	275-590	1,116	275-2,250	32	4
Kisaralik L.	4	8	2.0	36.0	498	465-700	1,550	1,000-3,900	19	10
Kisaralik L. #2	3	17	5.7	63.0	495	219-860	2,186	250-12,040	14	11
Eek L.	1	0	...	...	...	...	...	...	0	1

*H & L = hook and line

Table 12. Lake trout age-length data for lakes of the lower Kuskokwim River and Kuskokwim Bay. Fork length (mm).

Location		Age at Capture															
		V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	>XIX
Asriguat L.	$\bar{x}$	...	...	...	...	410	...	...	...	...	...	...	...	...	...	...	...
n=1	n	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Range	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Canyon L.	$\bar{x}$	...	277	318	312	413	431	462	456	425	...	...	...	...	...	...	...
n=32	n	...	n=1	n=1	n=1	n=2	n=5	n=12	n=9	n=1	...	...	...	...	...	...	...
	Range	...	277	318	312	395-428	395-464	420-485	440-468	425	...	...	...	...	...	...	...
Goodnews L.	$\bar{x}$	...	...	...	420	466	470	506	549	576	...	...	...	...	...	...	...
n=24	n	...	...	...	n=2	n=2	n=3	n=9	n=7	n=1	...	...	...	...	...	...	...
	Range	...	...	...	400-440	428-504	432-530	481-558	503-632	576	...	...	...	...	...	...	...
N. Middle Fork L.	$\bar{x}$	...	...	...	...	405	449	473	...	533	...	...	...	...	...	...	...
n=17	n	...	...	...	...	n=1	n=6	n=9	...	n=1	...	...	...	...	...	...	...
	Range	...	...	...	...	405	431-488	435-502	...	533	...	...	...	...	...	...	...
S. Middle Fork L.	$\bar{x}$	...	...	...	404	432	472	511	529	550	...	...	640	...	773	...	...
n=24	n	...	...	...	n=1	n=4	n=6	n=8	n=2	n=1	...	...	n=1	...	n=1	...	...
	Range	...	...	...	404	387-502	450-495	499-520	520-537	550	...	...	640	...	773	...	...
Aniak L.	$\bar{x}$	290	...	...	410	416	436	457	480	530	558	590	...	...	...	...	...
n=25	n	n=2	...	...	n=1	n=3	n=6	n=5	n=3	n=2	n=2	n=1	...	...	...	...	...
	Range	285-295	...	...	410	405-440	425-450	425-494	465-506	495-565	530-585	590	...	...	...	...	...
Kisarolik L.	$\bar{x}$	...	...	...	...	...	...	476	481	500	530	...	...	...	700	...	...
n=21	n	...	...	...	...	...	...	n=4	n=11	n=3	n=2	...	...	...	n=1	...	...
	Range	...	...	...	...	...	...	470-480	465-500	495-505	425-435	...	...	...	700	...	...
Kisarolik L. #2	$\bar{x}$	...	219	...	380	415	445	453	...	510	...	...	...	...	725	...	840
n=20	n	...	n=1	...	n=1	n=1	n=2	n=9	...	n=3	...	...	...	...	n=1	...	n=2
	Range	...	219	...	380	415	440-450	450-480	...	500-515	...	...	...	...	725	...	820-860*

Table 12. (Cont.) Lake trout Age-length Data for Lakes of the Lower Kuskokwim River and Kuskokwim Bay. Fork Length (mm).

Location		Age at Capture															
		V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	>XIX
Ohnlik L.	$\bar{x}$	...	...	...	404	417	424	...	...	...	...	...	...	...	...	...	...
n=9	n	...	...	...	n=3	n=3	n=3	...	...	...	...	...	...	...	...	...	...
	Range	...	...	...	400-410	401-447	410-437	...	...	...	...	...	...	...	...	...	...
Klak L.	$\bar{x}$	...	...	...	...	433	452	523	...	...	...	...	...	...	...	...	...
n=5	n	...	...	...	...	n=2	n=2	n=1	...	...	...	...	...	...	...	...	...
	Range	...	...	...	...	425-441	442-461	523	...	...	...	...	...	...	...	...	...
Kagati L.	$\bar{x}$	...	...	...	357	444	...	492	521	...	...	...	...	...	...	...	...
n=4	n	...	...	...	n=1	n=1	...	n=1	n=1	...	...	...	...	...	...	...	...
	Range	...	...	...	357	444	...	492	521	...	...	...	...	...	...	...	...
Kanuktik L.	$\bar{x}$	...	...	...	369	404	424	461	509	533	...	...	705	...	...	730	...
n=20	n	...	...	...	n=2	n=4	n=6	n=4	n=1	n=1	...	...	n=1	...	...	n=1	...
	Range	...	...	...	367-370	395-409	410-460	430-504	509	533	...	...	705	...	...	730	...
Arolik L.	$\bar{x}$	...	...	...	384	377	395	409	423	465	...	...	540	...	...	705	735**
n=39	n	...	...	...	n=1	n=5	n=6	n=13	n=9	n=2	...	...	n=1	...	...	n=1	n=1
	Range	...	...	...	384	359-490	384-410	395-425	400-445	460-470	...	...	540	...	...	705	735

* one 820 mm Age XXV
one 860 mm Age XXVII
** Age XX

Classes IX, X and XI were represented by the most individuals and these three age groups made up 70% of the population sampled. Lake trout weights ranged from 250 g (.5 lb) to 6,500 g (14.3 lb) and mean lake trout weight for each lake ranged from 927 to 1,835 g (2.3 lbs to 4 lbs).

Sixty-six lake trout, ranging in length from 219 to 860 mm, were aged from lakes at the headwaters of streams flowing into the Kuskokwim River. Age groups V through XXVII were represented, but again nearly all specimens were over 9 years of age. In Kisaralik Lake, in spite of considerable fishing effort, no lake trout smaller than 465 mm (18") and Age XI were taken. Growth of lake trout from Kisaralik Lake #2 was similar to Kisaralik Lake but the length range was wider, 219-860 mm (8"-34"). The 860 mm fish was the oldest and largest taken during the 2-year project (27+ years, 26.5 lbs). Lake trout from Kuskokwim River lakes averaged 1,116 g (2.5 lbs) from Aniak Lake; 1,550 g (3.4 lbs) from Kisaralik Lake and 2,186 g (4.8 lbs) from Kisaralik Lake #2. Many dead lake trout were observed floating on the surface of Kisaralik Lake and along shore. These fish of fork length 470-495 mm (18 1/2"-19 1/2") had probably reached their maximum size and died of natural causes.

Growth of lake trout in the study area is variable, with fish from Aniak and Goodnews lakes the fastest growing and fish from Arolik Lake being the slowest (Fig. 20). Generally, lake trout of the Kuskokwim River drainage grow faster than fish from lakes of Kuskokwim Bay, but the difference is small. Growth of lake trout from the study area is generally slower than that reported from other waters in Interior Alaska and Great Slave Lake but more rapid than growth of lake trout in lakes of the Brooks Range, Alaska and Great Bear Lake, Northwest Territories

Lake trout from the study area generally do not live as long as slower growing populations in northern Alaska and Great Bear Lake. A 27-year-old specimen from Kisaralik Lake #2 was the oldest fish captured. Lake trout from Chandler Lake, Alaska generally reached 450 mm fork length at Age XV and a 927 mm specimen was aged at 42 years (Furniss 1974). Dalke et al. (1974) calculated maximum ages of Great Bear Lake fish at 53 years and Great Slave Lake fish at 30 years. They used otoliths for aging.

Age at Maturity:

Age at first maturity for Kuskokwim Bay lake trout is generally reached at 430-440 mm fork length and Age IX-X, and most fish are mature by Age XII. This corresponds to a weight of 1.5-3.1 lbs (Table 13). Only two Age VIII trout were mature, both from Ohnlik Lake (fork length 400-410 mm). Over 50% of Age IX fish were mature and at Age XI nearly all were mature. The small sample from each lake precludes calculating maturity data by sex but generally both sexes mature at the same age. Fish from Aniak and the Kisaralik lakes mature between 415 and 435 mm or Age IX-X. Data of Furniss (1974) suggest age of maturity for Chandler Lake fish of XIII-XIV (fork length 430-500 mm) and for Itkillik Lake fish Age XIII-XV (450 mm fork length). Similar size at maturity for Paxon Lake trout was reported by Van Wyhe and Peck (1968) except that these faster growing fish were only VII-VIII years old at 450 mm.

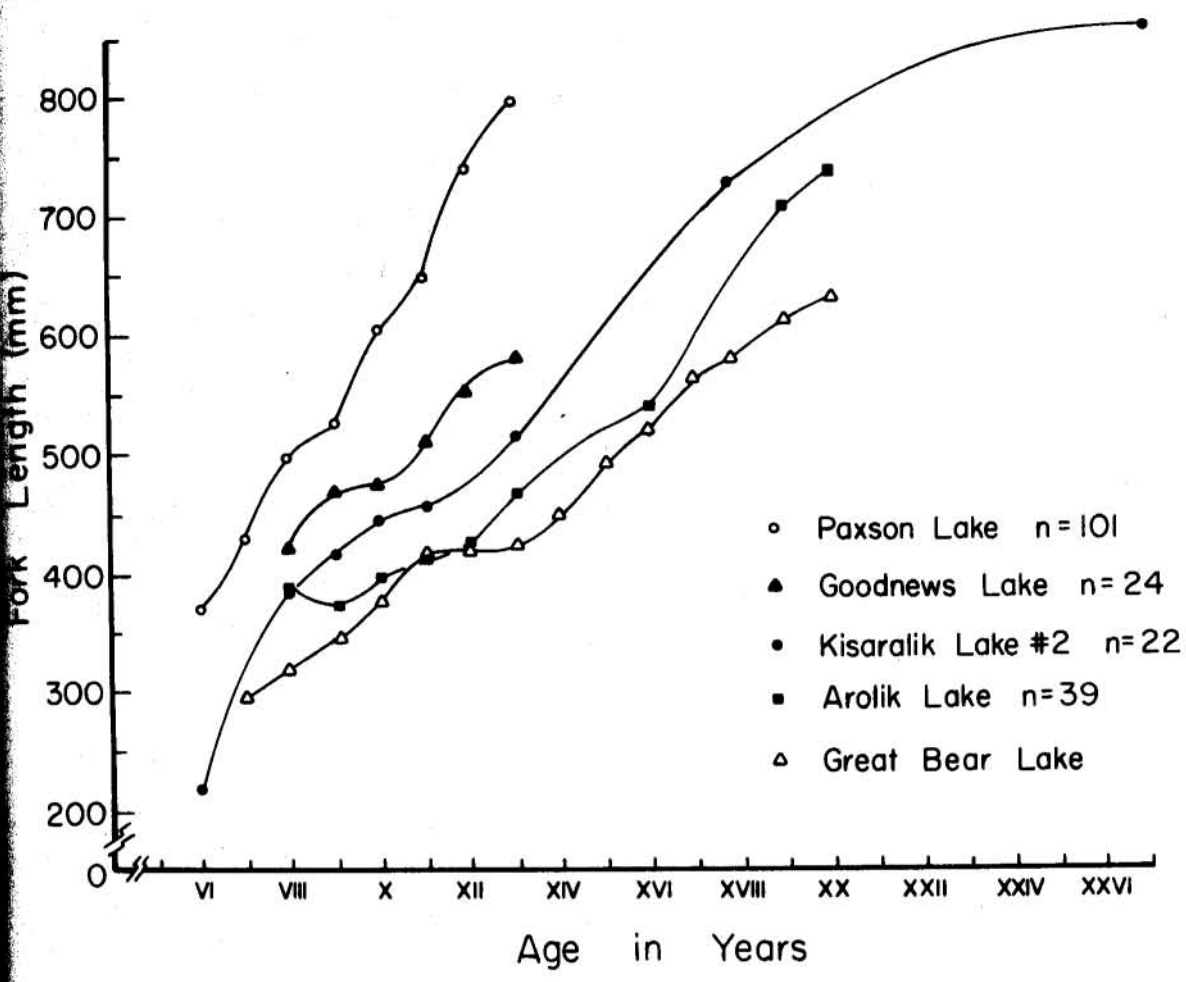

Figure 20. Comparative age-length data for lake trout. Paxon Lake data from Peck and Van Wyhe, 1968; Great Bear Lake from Miller and Kennedy, 1948.

Table 13. Age at first maturity of lake trout from Kuskokwim River and Kuskokwim Bay Lakes. Percent of fish mature by Age X or older are given in parentheses.

Lake	Age at first maturity			
	n	♂♂	n	♀♀
Goodnews	14	9+ (100)	9	10+ (100)
Canyon	12	9+ (100)	11	10+ (100)
N. Middle Fork	12	10+ (18)	11	10+ (27)
S. Middle Fork	11	9+ (90)	15	10+ (90)
Klak	2	9+ (100)	3	9+ (100)
Kagati*	2	11+ (100)	2	12+ (100)
Kanuktik	8	9+ (100)	13	10+ (50)
Ohnlik	7	8+ (100)	2	9+ (100)
Arolik	24	9+ (48)	17	11+ (60)
Aniak	16	9+ (100)	9	9+ (100)
Kisarolik**	6	11+ (100)	15	11+ (100)
Kisarolik #2***	8	11+ (100)	12	10+ (100)

* Only two fish < Age II captured
** No fish < Age II captured
*** No ♂♂ < Age II captured

Many lake trout do not spawn consecutively, especially in the more northern lakes. Thus, Furniss, 1974, reports that of 33 lake trout over 17 years of age only 14 would spawn in the current year. Kennedy (1954) reported that Great Slave Lake trout spawned every other year. In lakes of Kuskokwim Bay 25 of 100 mature female lake trout (25%) were judged to be nonconsecutive spawners, i.e. would not spawn in the current year although they had spawned in a previous year. In lakes of the Kuskokwim River, 17 of 32 (53%) mature females were nonconsecutive spawners.

Food Habits:

Lake trout in Kuskokwim Bay lakes are opportunistic feeders and they feed on a wide variety of organisms including insects, molluscs, crustaceans and fish (Table 14). Sculpin were the most commonly eaten fish, similar to the situation in Great Bear Lake (Johnson, 1975). Red salmon spawn in most of the lakes sampled but no red salmon fry were identified in lake trout stomachs. It is probable that many of the fish remains consisted of red salmon fry. Insects, especially of the order Tricoptera, Diptera and Hemiptera were important food items as were snails and clams.

Many Kuskokwim Bay trout containing food were less than half full. The few stomachs that were full contained either snails or large fish. In general, hook and line caught fish had fed on the same proportion of food items as gill net caught specimens. Lake trout caught in the deep sets had a higher proportion of fish in their stomachs and also a higher proportion of empty stomachs. Thirty of 160 stomachs (19%) of Kuskokwim Bay fish were empty, and only one fish from the Kuskokwim River was empty. In lakes of the lower Kuskokwim River food habits and food items eaten were similar to Kuskokwim Bay lakes in that insects, snails and sculpin were the most important food items. Diptera larvae were the most common insect food item in both areas.

Adult lake trout are classified as piscivorous in more southern lakes, often feeding on 80%-90% fish. In Alaska and northern Canada this situation is reversed with fish usually making up less than 50% of the diet of adult lake trout. Furniss (1975) who studied food habits of lake trout from five northern Alaska lakes found that fish made up 10%-30% of the diet, and Miller and Kennedy (1948) reported that fish made up less than 33% of the diet of Great Bear Lake.

Grayling

Grayling, Thymallus arcticus (Pallas), were present in all streams surveyed in the study area and usually were more abundant in streams of the lower Kuskokwim River.

Only two grayling were taken during gill net and hook and line sampling of the 11 lakes in the Kuskokwim Bay system (one each in Kagati and Arolik lakes). They would be expected to be more abundant in the lakes with large outlets e.g., Canyon, Goodnews, Kagati and Arolik as they are found in the upper reaches of the outlet streams, but evidently they do

Table 14. Food items of lake trout in lakes of Kuskokwim Bay and lower Kuskokwim River (Lakes with less than two fish samples not included).

Food Items	Canyon	Goodnews*	N. Middle Fork	S. Middle Fork	Kagati	Kanuktik	Klak	Ohnlik	Arolik	Aniak	Kisaralik	Kisaralik #2
	Frequency of Occurrence											
Insects												
Tricoptera	3	1	1	1	...	4	...	2	3	6	3	3
Diptera	9	1	4	...	1	2	1	1	7	16	6	10
Hemiptera	7	...	1	...	...	...	...	...	3	1	1	4
Plecoptera	6	...	1	2	...	...	...	...	...	1	1	...
Hymenoptera	3	...	...	...	1	1	...	...	1	...	4	5
Homoptera	2	...	1	...	...	...	...	...	...	...	2	1
Ephemoptera	2	...	...	...	...	...	...	...	1	9	16	11
Insect remains	...	...	3	...	...	3	...	1	1	...	1	3
Molluscs												
Clams	5	5	6	3	...	...	1	...	2	...	...	...
Snails	8	6	2	5	...	1	1	...	27	4	9	6
Crustaceans	...	...	...	1	...	...	...	...	...	...	1	1
Fish												
Blackfish	...	...	...	1	...	...	...	...	...	...	...	...
Char	...	...	1	...	...	...	...	...	...	...	...	1
Lake trout	...	...	...	...	...	1	...	...	1	...	...	1
Round whitefish	1	2	1	...	...	...	...	...	...	...	...	...
Lamprey	...	1	...	...	...	...	...	...	...	...	...	...
Salmon	...	1	...	...	...	...	...	...	...	...	...	...
Burbot	...	1	...	...	...	...	...	...	...	...	...	...

Table 14. (Cont.) Food items of lake trout in lakes of Kuskokwim Bay and lower Kuskokwim River (Lakes with less than two fish samples not included).

Food Items	Canyon	Goodnews*	N. Middle Fork	S. Middle Fork	Kagati	Kanuktik	Klak	Ohnlik	Arolik	Aniak	Kisaralik	Kisaralik #2
	Frequency of Occurrence											
Fish (cont.)												
Sculpin	...	2	2	2	1	4	2	1	...	3	8	4
Stickleback	...	1	...	1	...	...	...	...	...	...	...	...
Fish remains	9	5	10	8	1	4	2	...	7	9	6	8
Other												
Voles and shrews	4	1	3	1	...	3	...	1	5	1	...	...
Debris	3	...	...	1	...	...	...	...	2	3	4	3

* Includes five lake trout from Goodnews R.

not frequent lakes at least during mid summer. In the Kuskokwim River part of the study area, grayling were captured in Aniak, Kisaralik and Kisaralik Lake #2 and made up 48%, 22% and 18% respectively of the total fish gill net catch in each lake. They were captured on hook and line in Aniak and Kisaralik #2 lakes.

Movements:

Most information on movements of grayling came from the Aniak River. Grayling in this stream evidently overwinter in the Kuskokwim River and the lower section of the Aniak. Residents of Aniak begin capturing grayling on hook and line below the mouth of the Aniak River before breakup in early May. These fish are evidently entering the Aniak. Grayling (Age Class I and II) were taken by seine at the mouth of the Aniak on May 6. The fish move upstream after breakup and distribute themselves along the river and up most of the tributaries. Both adult and juvenile grayling undertake this migration and they have been taken 60 miles up the Aniak River two weeks after breakup. On May 23, 1975 grayling were present in the Aniak River at 60 Mile and also in the Salmon River. On May 16, 1976 grayling had not yet reached the area of 60 Mile Aniak, and during 4 days of gill netting (8 net nights) in both the Aniak and Salmon rivers and 10 hours of hook and line fishing only one juvenile grayling was taken.

In late summer grayling congregate near spawning salmon. During the July and August surveys grayling were seldom encountered in the lower reaches of the rivers but were distributed in the mid to upper reaches of the swifter flowing sections of the stream.

Grayling of all size groups were captured or observed in streams of the Kuskokwim River. Few grayling under 300 mm were captured in Kuskokwim Bay streams. During the float of the Arolik River, from July 14 to 17, only 44 grayling were captured in 45 hours of fishing; and it is felt that, at most, only several hundred large grayling inhabited the river at the time of the float. Other grayling may have been up tributary streams. The smallest grayling taken in the Arolik River was 330 mm.

Spawning:

Grayling were actively spawning at 18 Mile Aniak River on May 27 and 28, 1975 when the water temperature was 4°C. Fish examined two days earlier at 60 Mile Aniak River had not yet spawned (water temperature was 3°C). Actual spawning grounds were not located nor were spawning observations made. Grayling with running eggs and milt were taken at the mouths of sloughs near 18 Mile; thus the fish were either spawning off gravel bars in the main channel or in the slough itself over a grass and mud bottom. On May 13, 1976 grayling were not spawning at 18 Mile (water temperature 1.5°C (34.7°F)) and had not yet arrived at 60 Mile. In 1975 in early June over 90% of the grayling captured in the Kasigluk, Kisaralik and Kwethluk rivers had already spawned.

The rearing grayling observed in the Kuskokwim River streams were found in the mainstem stream as well as small gravel side streams. In the

streams of Kuskokwim Bay rearing grayling were only found in the Goodnews River.

Age and Growth:

Grayling from the study area ranged in age from Age I to XI (Table 15). Very few grayling older than Age IX were found and these were in the Kuskokwim River drainages. The majority of fish captured were Age Classes VI, VII and VIII. Most of the younger grayling (< than 300 mm) were taken by gill net or seine.

Grayling from streams of Kuskokwim Bay grew faster and reached a larger maximum size than Kuskokwim River grayling. Few grayling from Kuskokwim River streams exceeded 400 mm (18") while a large percentage of Kuskokwim Bay fish were over 400 mm. In the Arolik River the smallest grayling captured or observed was 330 mm (15") and Age V. Arolik River grayling were larger than grayling from other streams. All grayling caught in the three streams were measured, but scale cards of the Goodnews River fish were lost. Mean fork lengths of grayling were: Goodnews River, 375 mm; Arolik River, 445 mm; and Kanektok River, 376 mm. Since grayling from the Arolik and Kanektok rivers had similar growth rates, it can be expected that growth of Goodnews River fish would also be similar.

Growth of grayling from all streams and lakes in the Kuskokwim River is similar. The oldest grayling found (Age XI) came from Aniak Lake. No juvenile grayling were found in any of the Kuskokwim River lakes. They may have been rearing in inlet streams but none were observed during foot surveys.

Grayling of Kuskokwim Bay obtained a maximum weight of 1,265 g (2.8 lbs) in the Arolik River, 1,320 g (2.9 lbs) in the Goodnews and 1,150 g (2.5 lbs) in the Kanektok River. Fish over 900 g (2 lbs) were very common and some grayling over 3 lbs are probably present. Fish from Kuskokwim River lakes and streams seldom reached 900 g (2 lbs) and only one fish from the Eek, and Tuluksak rivers and five fish from the Kisaralik Lakes were 900 g or larger.

Comparison of grayling growth from the Arolik and Aniak rivers and Goodpaster River, an interior Alaska stream, indicated that Arolik grayling grow faster than most other populations (Fig. 21). Growth of Aniak and Goodpaster grayling (Tack 1974) are similar. Grayling from the Kuparuk River on Alaska's North Slope grow slightly slower than grayling from the Aniak River and Age X was the oldest fish found in the Kuparuk (Alt and Furniss 1976) Grayling from the South Fork of the Koyukuk River have length-age relationships similar to grayling from the Aniak and Goodpaster River (Netsch 1975).

Age at Maturity:

Size at first spawning for grayling of the lower Kuskokwim River is approximately 300 mm (12") with a range of 285-330 mm. Most fish are mature by Age VI with a few not maturing until Age VII.

Table 15. Age-length relationships for grayling from waters of Kuskokwim Bay and lower Kuskokwim River.

Drainage		Age at Capture I	II	III	IV	V	VI	VII	VIII	IX	X	XI
						Fork Length in mm						
Kuskokwim Bay												
Arolik R.	$\bar{x}$					330	405	425	457	403		
n=41	n					n=1	n=4	n=12	n=18	n=6		
	Range					330	355-450	395-450	426-480	470-495		
Kanektok R.	$\bar{x}$				257	326	402	426	459	463		
n=33	n				n=1	n=13	n=10	n=7	n=1	n=1		
	Range				257	299-367	342-438	387-454	459	463		
Kuskokwim River												
Aniak L.	$\bar{x}$					269	278	341	352	388	400	415
n=25	n					n=2	n=4	n=3	n=6	n=8	n=1	n=1
	Range					250-288	260-305	325-352	325-370	360-400	400	415
Aniak R.	$\bar{x}$	119	137	230	241	284	308	344	365			
n=85	n	n=2	n=10	n=1	n=4	n=16	n=23	n=22	n=7			
	Range	112-125	110-200	230	239-264	216-350	254-347	316-368	336-403			
Kisaralik L.	$\bar{x}$					330		400	407	420		
n=5	n					n=1		n=1	n=2	n=1		
	Range					330		400	385-430	420		
Kisaralik L. #2	$\bar{x}$								372	413		
n=9	n								n=3	n=6		
	Range								355-400	400-430		
Kisaralik R.	$\bar{x}$	112	173	195	239	280	303	315	347	373	395	
n=85	n	n=2	n=3	n=1	n=6	n=8	n=15	n=23	n=18	n=6	n=1	
	Range	112	165-180	195	221-265	245-295	280-348	300-330	300-401	360-405	395	
Tuluksak R.	$\bar{x}$				267	278	313	331	366	382	403	
n=33	n				n=2	n=2	n=3	n=11	n=11	n=2	n=2	
	Range				265-270	270-285	290-340	290-365	350-400	380-385	400-405	
Kasigluk R.	$\bar{x}$	111	140	202	214	269	313	335	351	384	387	
n=38	n	n=5	n=4	n=2	n=1	n=5	n=6	n=10	n=3	n=1	n=1	
	Range	105-116	121-163	179-224	214	232-306	280-350	307-375	341-380	384	387	
Kwethluk R.	$\bar{x}$	112	169	225	245	284	313	330	351	366	392	
n=47	n	n=3	n=10	n=4	n=2	n=2	n=3	n=7	n=7	n=7	n=2	
	Range	109-118	150-185	205-220	226-265	277-290	305-320	320-345	335-370	340-394	370-410	
Eek R.	$\bar{x}$	95					324	353	370	393		
n=17	n	n=1					n=5	n=5	n=4	n=2		
	Range	95					305-335	345-365	355-380	390-395		

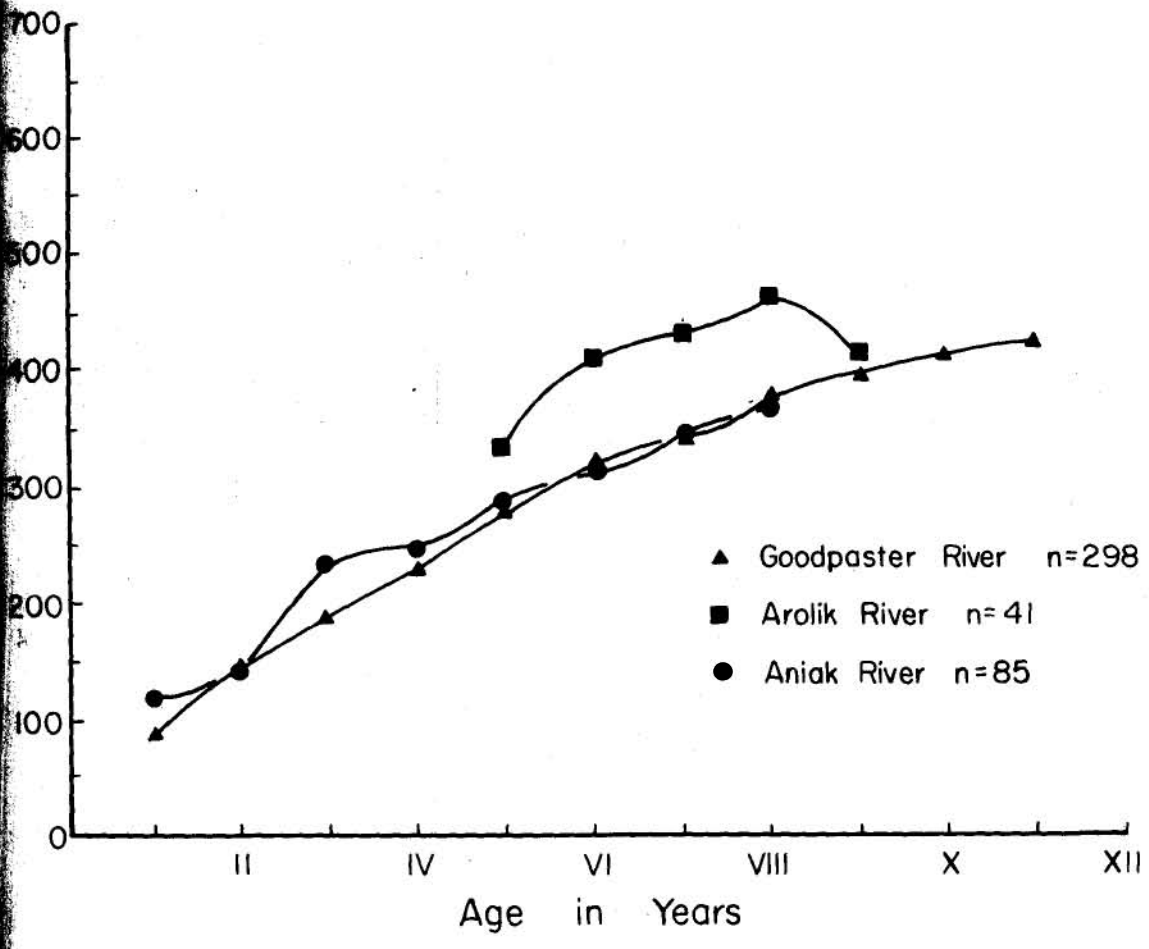

Figure 21. Comparative age-length data for grayling from Kuskokwim study area and other waters. Goodpaster River back calculated data from Tack, 1974.

In the Kanektok and Arolik rivers nearly all fish captured were mature although a few 5-year old fish up to 350 mm had not previously spawned. Males and females generally mature at the same size and age. There is no evidence for nonconsecutive spawning of grayling from the study area.

Food Habits:

Insects of the orders Tricoptera and Diptera were the most important food items for grayling taken in the study area (Table 16). Most insects eaten were larvae except for insects of the orders Coleoptera, Hemiptera, Homoptera and Hymenoptera. Adult bees were the most important food item eaten by grayling in the two Kisaralik lakes.

Grayling taken during the salmon spawning season feed heavily on salmon eggs. White grubs and maggots were probably mainly from decaying fish. Fish, almost exclusively salmon fry, were an important part of the diet of grayling from the Aniak River in mid May 1976.

Food items eaten by grayling from lakes and streams and from streams in the lower Kuskokwim River and Kuskokwim Bay were essentially similar.

With the exception of stomachs from Kisaralik and Kwethluk river grayling taken immediately after spawning, there were few empty stomachs found; and over 75% of stomachs from other waters were half full or more.

Juvenile and adult grayling ate simlar food items except that smaller grayling ate no fish or voles.

Northern Pike

The northern pike, Esox lucius Linnaeus, is abundant in the Kuskokwim Delta through the entire drainage of the Kuskokwim River and is an important sport and subsistence fish.

Populations of pike occur in all Kuskokwim River tributaries in the study area, but in the entire Kuskokwim Bay drainage only one pike was taken. The deeper Kuskokwim River lakes had no northern pike; but in shallow Eek Lake, northern pike is the only fish present. By habitat preference, the pike is found in slow moving water of sloughs, interconnected lakes, and the lower reaches of larger rivers. In the Aniak River they were only captured as far upstream as 16 Mile. There are probably few pike upstream of 16 Mile as the current is quite swift. In the other rivers they are also found only in the lower reaches. They are present at least 70 miles up the Eek River, at the upper limits of our survey in both the Main Fork and the Middle Fork; but this stream does not have the mountainous nature of some of the other tributaries.

Little is known about seasonal movement of pike, but it is probable that they move out of tributary rivers and into the Kuskokwim River in late fall and winter. Large numbers are caught in the main Kuskokwim by residents of lower Kuskokwim villages. In early May before breakup, residents of Aniak capture northern pike in the Kuskokwim below the mouth of the Aniak and it is assumed they were entering the Aniak. In

Table 16. Occurrence of food items in feeding grayling taken in waters of lower Kuskokwim River and Kuskokwim Bay, 1975-1976.

	Aniak L. n=25	Aniak R. n=81	Tuluksak R. n=20	Kisaralik R. n=52	Kisaralik L. n=14*	Kasigluk R. n=38	Kwethluk R. n=32	Eek R. n=16	Kanektok R. n=34	Arolik R. n=17
	Frequency of Occurrence									
Insects										
Tricoptera	17	66	13	35	7	16	20	7	19	17
Diptera	22	21	11	24	13	9	19	16	10	11
Plecoptera	...	19	2	3	2	3	6	2	7	9
Coleoptera	2	3	1	8	12	9	10	7	5	11
Hemiptera	...	7	...	...	...	...	...	...	...	...
Homoptera	1	2	...	2	...	...	5	...	2	...
Ephemeroptera	4	7	2	9	9	1	5	5	...	9
Hymenoptera	...	1	...	...	12	...	...	...	...	1
Insect remains	...	9	...	2	...	5	7	1	19	...
Fish										
Fish eggs	1	7	4	1	3	1	1	2	1	6
Salmon fry	...	18	...	...	...	...	...	...	...	...
Sculpins	...	...	...	...	...	1	...	...	2	1
Fish remains	2	8	2	...	2	...	1	...	6	4
Vegetation	...	...	9	12	...	3	14	6	1	4
Snails	4	1	...	1	2	1	...	5	5	2
White grub and maggots	...	12	1	5	1	5	1	1	...	...
Vole	...	...	...	...	...	...	...	1	...	...

*Includes Kisarolik and Kisarolik #2 lakes.

both 1975 and 1976 they were abundant in the lower Aniak and taken in smaller numbers at 16 Mile Aniak River. They are mainly found in the sloughs of the lower Aniak and Doestock Creek.

Eek Lake was the only surveyed lake containing any number of northern pike but other shallow lakes on the Kuskokwim River floodplain probably contain pike during the summer. Since Eek Lake has an outlet flow only at extreme high water, it is likely that pike remain in the lake year-round.

Spawning:

Northern pike are spring spawners and generally spawn soon after breakup. In the Aniak River at 16 Mile on May 27, 1975 two northern pike, both spent, were taken by gill net. Water temperature in this grass and mud covered slough off the Aniak River was 4° to 5°C. In 1975 pike had nearly completed spawning in sloughs of the lower river by May 30 (water temperature was 6° to 7°C). On May 13, 1976 northern pike taken in Grassy and Dead End slough were not quite ready to spawn (water temperature was 1.5°C) and on May 20 the pike taken in the sloughs were either ripe or had already spawned (water temperature was 5° to 6°C).

It can be assumed that pike in other tributary rivers of the lower Kuskokwim spawn about the same time or a bit later than Aniak pike. In the Kisaralik River survey of June 4-6, 1975, 80% of the pike had spawned and the remainder had free running eggs or milt. All fish examined in the Kwethluk River June 18-20 and in the Kasigluk River June 11-13 had spawned.

Age and Growth:

Northern pike in the study area do not reach as large a size as pike in the middle and upper Kuskokwim River. The largest pike taken during two years of sampling was 800 mm fork length and weighed 4,750 g (10.5 lbs). Very few pike over 3,000 g (6.6 lbs) are present in the study area. In contrast, the present state record of 28 1/2 lbs comes from the upper Kuskokwim River; and I have taken a 28 1/2 lbs pike and numerous pike over 10 lbs from the Holitna River, 125 miles up the Kuskokwim from the Aniak mouth. No age and growth studies have been conducted on populations in the upper Kuskokwim River. The reason for smaller maximum size of lower Kuskokwim River pike may be slower growth rate and shorter life span.

Pike sampled ranged in size from 137 to 800 mm and from Age I to XVI (Table 17). Most pike were Age IV to IX.

The scales were very difficult to read and little confidence can be placed in their accuracy. This may account for the great length range for each age group.

Generally, pike from rivers of the study area have similar growth rates. The Eek River fish may grow slightly faster. The pike from Eek Lake were nearly all the same size; most were Age VII and IX, indicating

Table 17. Age-length relationships of northern pike from tributary waters of the lower Kuskokwim River.

Location		Age at Capture												
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XVI
Aniak R.	$\bar{x}$		137	262	296	336	403	444	599	583	654	696	724	
n=45	n		n=1	n=2	n=3	n=5	n=6	n=10	n=1	n=3	n=8	n=5	n=1	
	Range		137	252-272	280-307	288-392	348-440	381-510	599	564-605	584-730	620-784	724	
Tuluksak R.	$\bar{x}$					360	405	450	510	540	593			
n=16	n					n=1	n=2	n=7	n=1	n=2	n=3			
	Range					360	400-410	420-485	510	535-545	550-645			
Kisaralik R.	$\bar{x}$					434	455	511	529	570	623			
n=14	n					n=1	n=5	n=3	n=2	n=2	n=1			
	Range					434	405-489	503-525	498-560	538-602	623			
Kasigluk R.	$\bar{x}$	140			348	414	453	487	520	581	607	604	650	800
n=49	n	n=1			n=5	n=5	n=4	n=11	n=6	n=5	n=6	n=2	n=3	n=1
	Range	140			293-380	382-447	448-460	461-530	479-520	561-610	576-640	581-628	615-705	800
Kwethluk R.	$\bar{x}$				345	389	463	484	520	599	645			
n=45	n				n=2	n=4	n=9	n=10	n=11	n=3	n=6			
	Range				335-355	370-400	404-545	417-565	454-610	588-620	625-664			
Eek R.	$\bar{x}$	145		300	385	425	455	543	540	605				
n=1	n	n=1		n=1	n=2	n=1	n=2	n=2	n=1	n=1				
	Range	145		300	380-390	425	425-485	540-545	540	605				
Eek L.	$\bar{x}$							470	501	520	530	575		
n=35	n							n=3	n=18	n=10	n=3	n=1		
	Range							465-475	485-520	500-540	520-540	575		

most of the present inhabitants entered the lake at the same time and that reproduction and immigration are not able to establish younger age classes. These fish grow somewhat slower than pike from Eek River.

Growth of pike from the Minto Flats in interior Alaska (Cheney 1972) and Lake Aleknagik in Bristol Bay (Chihuly, unpublished manuscript, 1977) is faster than growth of pike from the study area.

Age at Maturity:

Age at maturity of pike from the study area is extremely variable with some males spawning at 280 mm and Age IV while other males were still immature at 417 mm and Age VIII. Generally males matured at Ages V and VI and lengths of 340-370 mm while females matured between Ages VI and VII at lengths of 380-420 mm. No cases of nonconsecutive spawning were observed.

Food Habits:

Northern pike in streams of the Kuskokwim River fed mainly on fish; while those in Eek Lake ate mainly snails, insects, leeches, freshwater shrimp and small pike (Table 18). A wide variety of fish were found in pike stomachs but no single species formed a major part of the diet.

Northern pike containing smelt were captured at mouths of tributary rivers but the smelt may have been eaten in the main Kuskokwim River.

Insects formed an insignificant part of the diet. Few juvenile pike were captured and thus food habits data represent items eaten by larger fish during spring and summer.

Pike in the study area were feeding during the spawning period. The number of pike stomachs containing food and the percentage of fullness was greater in May and June than in late July and August. Twenty-six of 30 pike stomachs from the Aniak River taken in May contained food while 9 of 18 taken in August contained food. In the Tuluksak River 12 of 16 pike captured in August had empty stomachs.

Round Whitefish

Round whitefish, Prosopium cylindraceum (Pallas), are found in both lakes and streams of the study area. They may move from lake to stream, as they were observed in lake outlets of the Kuskokwim Bay drainages but were not observed in outlets of lakes of the Kuskokwim River. During lake surveys they were taken in all lakes except Asigruat, Klak, Kisaralik and Kisaralik #2; but with a more intensive sampling program, might have been taken in these lakes. Round whitefish are usually found in the upper water column so the majority of captures were in less than 10' of water.

The round whitefish usually is less abundant in lakes than lake trout and Arctic char, the two dominant species; and only in South Middle Fork Lake did they comprise over 50% of the gill net catch (Table 19).

Table 18. Occurrence of food items in stomachs of feeding northern pike.

	Aniak R. n=35	Tuluksak R. n=4	Kisaralik R. n=7	Kasigluk R. n=15	Kwethluk R. n=21	Eek R. n=5	Eek L. n=23
Fish							
Lamprey	3	1	...	1	3	...	...
Salmon fry	6	...	1	...	...	...	...
Salmon smolt	4	...	...	3	1	2	...
Arctic char	6	...	...	...	...	...	...
Round whitefish	2	...	1	1	...	...	...
Whitefish (*Coregonus* sp.)	2	...	...	1	...	...	...
Blackfish	2	...	1	...	...	...	...
Sucker	7	...	...	...	...	...	...
Sculpin	1	...	...	3	5	...	...
Burbot	...	1	...	...	1	...	...
Grayling	2	...	...	...	2	1	...
Ninespine stickleback	1	...	...	...	...	1	...
Pike	...	...	...	...	...	...	5
Smelt	...	...	1	...	1	...	...
Fish remains	12	3	4	6	11	2	...
Insects							
Diptera	1	...	...	...	1	1	...
Plecoptera	...	...	...	...	...	...	...
Homoptera	...	...	...	2	...	...	...
Odonata	...	...	...	...	1	...	...
Crustaceans							
Gammarus sp.	...	...	...	...	...	...	9
Other							
Snails	...	...	...	...	...	...	5
Clams	1	...	...	...	...	...	2
Leeches	...	...	...	...	...	...	11
Voles	...	...	...	...	...	...	...

Table 19. Catch statistics for round whitefish from waters of Kuskokwim Bay and lower Kuskokwim River. One round whitefish was captured in both the Goodnews and Kanektok rivers but many were observed in each river.

	Net Nights	Round Whitefish	Round Whitefish/ Net Night	% Composition of Total Net Catch	Length mm		Weight g	
					$\bar{x}$	Range	$\bar{x}$	Range
Kuskokwim Bay								
Canyon L.	3	3	1.0	4.6	459	425-419	983	900-1,050
Goodnews L.	2	11	5.5	39.3	396	174-471	653	125-950
Kukaktlim L.	1	2	2.0	5.0	...	...	...	...
N. Middle Fork L.	2	11	5.5	23.4	308	260-378	380	240-650
S. Middle Fork L.	2	24	12.0	53.3	385	265-482	561	200-1,000
Arolik L.	5	9	1.8	16.0	368	168-500	784	46-1,275
Kagati L.	2	5	2.5	13.9	367	279-406	525	200-700
Ohnlik L.	1	2	2.0	9.5	468	468	1,159	1,159
Kanuktik L.	2	2	1.0	4.0	417	400-435	900	800-1,000
Arolik R.	5	7	0.4	5.0	375	265-480	700	150-1,250
Kuskokwim R.								
Eek L.	1	0	...	...	...	...	...	...
Aniak L.	4	3	0.8	6.8	446	385-490	1,167	600-1,500
Aniak R.	9	47	5.2	1.0	332	140-477	462	15-1,200
Kisaralik R.	6	20	3.3	20.0	285	238-380	313	121-675
Kasigluk R.	5	13	2.6	8.0	288	152-450	400	18-1,300
Kwethluk R.	8	6	0.8	5.0	172	154-195	59	40-73
Eek R.	6	3	0.5	5.0	315	200-390	410	80-600

Round whitefish found in lakes generally reached a larger size than stream whitefish.

Round whitefish were observed or captured in every stream of the study area. They are most abundant in the swifter flowing sections of streams and, except for the period immediately after breakup, were seldom taken in the lower reaches of the rivers. They are seldom captured in the main Kuskokwim River and may overwinter in tributary streams. On May 13, 1976 round whitefish were taken by gill net in the area of 60 Mile Aniak River and the lower 2 miles of the Salmon River. No other fish were in the Salmon River at this time and only resident rainbow trout, Arctic char and round whitefish were in the Aniak River.

Age and Growth:

Round whitefish sampled ranged in length from 60 to 509 mm and Age I to XIII (Table 20). Most lake caught fish were Age VIII or older while most stream caught fish were Age VII to X.

In the Kasigluk River five young-of-the-year round whitefish were captured in mid August. These fish ranged from 40 to 70 mm. The Aniak River was the only stream where fish of all ages classes were taken.

The round whitefish of the study area are slow growing, especially after Age V and VI. The small samples for each age group make comparisons difficult, but in general round whitefish from the lakes grew faster than stream forms. Round whitefish from the Kuskokwim River study area grow slightly faster than round whitefish from the Delta Clearwater River in Interior Alaska (Pearse, 1974).

Mean weight of the various samples of round whitefish are given in Table 19. The largest fish weighed 1,500 g (3.3 lbs).

Age at Maturity:

Size at first sexual maturity of round whitefish from the study area is 300-320 mm at corresponding ages of VI to VII. Females occasionally mature a year later than males. No Age V fish were mature. Consecutive spawning appears to be the rule and every female containing retained eggs of the previous year's spawning would again spawn the current fall.

Food Habits:

Round whitefish of the study area feed mainly on insects especially diptera and caddis fly larvae (Table 21). Many of the dipteran larvae were of the family Chironomidae. In lakes, snails and clams were also eaten. Stomachs of over 90% of the round whitefish sampled contained food, although most of these were only a quarter to a half full. A small number of round whitefish in the sample had fed on salmon or blackfish fry.

Table 20. Length-age relationships of round whitefish from waters of Kuskokwim Bay and lower Kuskokwim River.

Drainage		Age at Capture												
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Kuskokwim Bay														
Goodnews L.	$\bar{x}$		174			306	314	391	392	404	424	444	471	
n=15	n		n=1			n=1	n=1	n=1	n=1	n=2	n=1	n=6	n=1	
	Range		174			306	314	391	392	385-422	424	434-451	471	
North Middle Fork L.	$\bar{x}$						273	290	352	347				
n=8	n						n=2	n=1	n=2	n=3				
	Range						260-284	290	325-378	326-368				
South Middle Fork L.	$\bar{x}$					273		364	367	369	382	401	414	482
n=25	n					n=2		n=1	n=2	n=2	n=6	n=4	n=6	n=1
	Range					265-280		304	355-378	358-380	370-390	395-415	400-426	482
Canyon L.	$\bar{x}$							425					458	495
n=3	n							n=1					n=1	n=1
	Range							425					458	495
Kagati L.	$\bar{x}$					279		378	386		406			
n=5	n					n=1		n=1	n=2		n=1			
	Range					279		378	378-394		406			
Kanektok R.	$\bar{x}$								400		435			
n=2	n								n=1		n=1			
	Range								400		435			
Arolik L.	$\bar{x}$		154	265		330		400	460	460		452	435	
n=10	n		n=2	n=1		n=1		n=1	n=1	n=2		n=1	n=1	
	Range		140-168	265		330		400	460	420-500		452	435	

Table 20. (Cont.) Length-age relationships of round whitefish from waters of Kuskokwim Bay and lower Kuskokwim River.

Drainage		Age at Capture												
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Kuskokwim River														
Aniak L.	$\bar{x}$								385		465			590
n=3	n								n=1		n=1			n=1
	Range								385		465			590
Aniak R.	$\bar{x}$	67	138	180	259	261	288	321	343	371	386	388	431	
n=59	n	n=7	n=4	n=1	n=1	n=2	n=6	n=6	n=7	n=9	n=10	n=3	n=3	
	Range	60-75	125-160	180	259	260-262	278-295	300-362	325-386	345-393	365-411	380-395	405-477	
Kisaralik R.	$\bar{x}$			230	238	262	282	319	367	380	429		452	
n=23	n			n=1	n=1	n=2	n=2	n=2	n=2	n=1	n=9		n=3	
	Range			230	238	254-270	265-298	273-364	354-380	380	365-411		445-458	
Kasigluk R.	$\bar{x}$		147					309	305					
n=11	n		n=7					n=3	n=1					
	Range		132-150					297-320	305					
Kwethluk R.	$\bar{x}$		164	195										
n=6	n		n=5	n=1										
	Range		154-190	195										

Table 21. Occurrence of food items in stomachs of feeding round whitefish from waters of Kuskokwim Bay and lower Kuskokwim River.

Food Items	# Stomachs Item Occurred in						
	Goodnews L. n=10	South Middle Fork L. n=21	North Middle Fork L. n=11	Kagati L. n=5	Aniak R. n=54	Kisaralik R. n=10	Kasigluk R. n=12
Fish							
Salmon fry	...	...	...	...	4	1	...
Blackfish	...	1	...	...	...	...	...
Fish eggs	...	...	...	...	3	...	1
Insects							
Diptera	...	8	8	2	30	7	9
Tricoptera	...	10	1	...	33	6	4
Plecoptera	...	...	...	...	5	2	...
Insect remains	...	...	...	...	1	...	3
Snails	...	6	1	4	1	...	1
Clams	...	3	1	...	...	...	...
Worms or grubs	...	...	...	...	3	...	2
Debris	...	2	...	7	...	1	3

Sheefish

Sheefish, Stenodus leucichthys (Guldenstadt), occasionally enter lower reaches of tributary rivers of the lower Kuskokwim but are absent from Kuskokwim Bay streams. During the survey sheefish were taken only in the lower Aniak and Kasigluk rivers; but feeding fish probably also enter the lower sections of the Eek, Kwethluk, Kisaralik and Tuluksak rivers.

A large run, composed mainly of prespawning adults, migrates upstream in the Kuskokwim River past Aniak in late May and early June, two to three weeks after breakup. In 1975 between May 28 and 30, a subsistence fisherman took 103 sheefish, all prespawners, in a 150' gill net set in an eddy 10 miles below Aniak. The fish averaged 10 kg (22 lbs) with a mean length of 84 cm and the largest fish was 13 kg (29 lbs). This is considerably larger than the average size of spawners found on the spawning grounds at Highpower Creek in the uppper Kuskokwim River (Alt, 1972), and I suspect that the high subsistence effort expended toward sheefish all along the upstream migration route selectively removes the large spawners from the population. Most fishing is being done with king and chum salmon gear.

For a more detailed summary of the life history and ecology of the sheefish in the lower Kuskokwim River the reader is referred to Alt, 1972, 1973 and 1977.

Humpback Whitefish

The humpback whitefish, Coregonus pidschian (Gmelin), is found in the lower reaches of all Kuskokwim River tributaries but is not present in Kuskokwim Bay.

The late May catches in the lower Aniak River indicate immigration from the Kuskokwim River and then dispersion to summer feeding areas in the lower Aniak River. The situation is probably similar in other tributary rivers, but few humpback whitefish were captured. August catches in the same sites on the lower Aniak River were lower, indicating dispersal into feeding areas or spawning movements, either back out into the Kuskokwim River or further up the tributary rivers. Many humpback whitefish captured in the Aniak River and all humpback whitefish captured in the Kisaralik, Tuluksak, Kasigluk, Kwethluk and Eek rivers were prespawners. On August 18, 12 prespawners were taken in the lower 10 miles of the Kasigluk River, offering indirect proof of spawning. However, no fish younger than Age Class IV were taken in the study area indicating they spawned in another system and moved into the tributary streams of the lower Kuskokwim only for feeding. Tagging studies by Baxter (unpublished manuscript, Alaska Department of Fish and Game, Bethel) indicate that humpback whitefish may travel over 400 miles up the Kuskokwim River to spawning grounds.

Taxonomy:

Considerable confusion exists concerning the species identification of the humpback whitefish complex in Alaska; and some authors, i.e. McPhail

and Lindsey (1970), indicate that Coregonus pidschian, C. nelsoni and C. clupeaformis may be separate species. Gill raker counts have been used in species separation, with C. pidschian reported to have modal gill raker counts of 20-23.

Modal gill raker counts of 14 humpback whitefish from the lower Aniak River were 21 with a mean count of 21.5. This is in close agreement with counts obtained from humpback whitefish in the middle and upper Kuskokwim River (Alt, 1974) and indicates that the humpback whitefish in the study area should be called C. pidschian.

Age and Growth:

Humpback whitefish from different parts of the study area have similar growth patterns. These include widely spaced annuli, indicating rapid growth for the first 5 years, then closely spaced annuli during later years of life. Fish sampled ranged in size from 239 to 509 mm and in age from IV to XI (Table 22). One Age VI (355 mm) fish was captured from the Tuluksak River but was not included in the table. Few immature whitefish were captured, even though small mesh nets were set in likely areas. Most fish captured were Age Class VI, VII and VIII. Weight of humpback whitefish captured ranged from 55 to 2,000 g and population means were: Aniak River (n=36) 759 g, Eek River (n=3) 1,217 g, and Kasigluk River (n=18) 983 g.

Growth of fish from the study area and the Holitna River (middle Kuskokwim) is similar but slower than growth of Chatanika River (Interior Alaska) fish (Alt 1974).

Age at Maturity:

All fish captured in the study area with the exception of four Age IV fish and one Age VI female were mature. Apparently males and females both reach sexual maturity at Ages V and VI. Only one instance of a nonconsecutive spawning female was found--that of a 509 mm fish from the Aniak River.

Food Habits:

Humpback whitefish from the study area feed mainly on snails, clams and insects during the summer (Table 23). Diptera larvae were the most commonly occurring insect.

Broad Whitefish

Broad whitefish, Coregonus nasus (Pallas), are abundant in the Kuskokwim River and Kuskokwim Delta but seldom enter tributary streams of the lower Kuskokwim River. They are absent from the Kuskokwim Bay area.

By habitat preference the broad whitefish is an inhabitant of slow moving water and interconnected lake and slough systems. Movements into streams of the study area in the spring are probably for feeding and resting. The species probably does not spawn in the study area as no juvenile fish have been taken.

Table 22. Age-length relationships for humpback whitefish from streams of the lower Kuskokwim River.

Drainage		Age IV	V	VI	VII	VIII	IX	X	XI
					Fork Length at Capture (mm)				
Aniak R.	$\bar{x}$	247	358	368	390	412	434	470	490
n=36	n	n=4	n=3	n=11	n=11	n=1	n=3	n=2	n=1
	Range	239-251	339-394	330-412	348-412	412	415-465	430-509	490
Kisaralik R.	$\bar{x}$				390	397			
n=7	n				n=5	n=2			
	Range				360-413	381-417			
Kasigluk R.	$\bar{x}$		372	388	411	431	424	440	473
n=18	n		n=1	n=4	n=4	n=3	n=2	n=3	n=1
	Range		372	340-417	341-490	416-437	409-439	435-450	473
Kwethluk R.	$\bar{x}$			390	402	397	453	426	
n=12	n			n=1	n=5	n=2	n=3	n=1	
	Range			390	350-438	355-439	426-480	426	
Eek R.	$\bar{x}$						450	455	
n=3	n						n=1	n=2	
	Range						450	445-465	
Tuluksak R.	$\bar{x}$			355					
n=1	n			n=1					
	Range			355					

and Lindsey (1970), indicate that Coregonus pidschian, C. nelsoni and C. clupeaformis may be separate species. Gill raker counts have been used in species separation, with C. pidschian reported to have modal gill raker counts of 20-23.

Modal gill raker counts of 14 humpback whitefish from the lower Aniak River were 21 with a mean count of 21.5. This is in close agreement with counts obtained from humpback whitefish in the middle and upper Kuskokwim River (Alt, 1974) and indicates that the humpback whitefish in the study area should be called C. pidschian.

Age and Growth:

Humpback whitefish from different parts of the study area have similar growth patterns. These include widely spaced annuli, indicating rapid growth for the first 5 years, then closely spaced annuli during later years of life. Fish sampled ranged in size from 239 to 509 mm and in age from IV to XI (Table 22). One Age VI (355 mm) fish was captured from the Tuluksak River but was not included in the table. Few immature whitefish were captured, even though small mesh nets were set in likely areas. Most fish captured were Age Class VI, VII and VIII. Weight of humpback whitefish captured ranged from 55 to 2,000 g and population means were: Aniak River (n=36) 759 g, Eek River (n=3) 1,217 g, and Kasigluk River (n=18) 983 g.

Growth of fish from the study area and the Holitna River (middle Kuskokwim) is similar but slower than growth of Chatanika River (Interior Alaska) fish (Alt 1974).

Age at Maturity:

All fish captured in the study area with the exception of four Age IV fish and one Age VI female were mature. Apparently males and females both reach sexual maturity at Ages V and VI. Only one instance of a nonconsecutive spawning female was found--that of a 509 mm fish from the Aniak River.

Food Habits:

Humpback whitefish from the study area feed mainly on snails, clams and insects during the summer (Table 23). Diptera larvae were the most commonly occurring insect.

Broad Whitefish

Broad whitefish, Coregonus nasus (Pallas), are abundant in the Kuskokwim River and Kuskokwim Delta but seldom enter tributary streams of the lower Kuskokwim River. They are absent from the Kuskokwim Bay area.

By habitat preference the broad whitefish is an inhabitant of slow moving water and interconnected lake and slough systems. Movements into streams of the study area in the spring are probably for feeding and resting. The species probably does not spawn in the study area as no juvenile fish have been taken.

Table 23. Occurrence of food in stomachs of feeding humpback whitefish from streams of lower Kuskokwim River.

	Aniak R. n=31	Kisaralik R. n=10	Kasigluk R. n=10	Kwethluk R. n=12	Eek R. n=3
Fish					
Fish remains	...	...	...	...	1
Insects					
Tricoptera	5	4	2	3	...
Diptera	21	3	...	1	...
Coleoptera	1	1	...	...	1
Homoptera	3	...	3	...	...
Ephemeroptera	1	...	2	...	1
Insect remains	2	1	...	...	...
Snails	15	4	3	5	1
Clams	15	3	1	10	...
Detritus	5	2	4	...	1

Only 42 broad whitefish were captured by gill net during the two year study. The majority were taken in May in the Aniak River and in mid August in the Kasigluk River. They were taken as far as 16 miles up the Aniak River and 29 miles up the Kasigluk River.

Age and Growth:

Broad whitefish ranged in size from 319 to 399 mm and in age from IV to X (Table 24). Most fish were Age Classes V-VIII. These fish grow rapidly the first 4 or 5 years and slowly thereafter. Growth of broad whitefish from the five rivers is similar, which is expected, since they all probably belong to the same population. Four broad whitefish taken from the Kuskokwim had similar age-length relationships as fish from the study area.

Broad whitefish from the study area grow faster than broad whitefish from Imuruk Basin and the North Slope of Alaska but somewhat slower than fish from the Holitna River and Interior Alaska (Alt, 1976). Weights of broad whitefish ranged from 300 to 2,250 g and 440-470 mm fish averaged 1,350 g.

Broad whitefish from the study area generally mature at Age VI at a length of approximately 400 mm and a weight of 1,000 g. Males and females mature at approximately the same age. Three of 15 mature females were judged to be nonconsecutive spawners.

Food Habits:

Broad whitefish from the study area fed mainly on clams and diptera larvae (Table 25). In fish from the Kwethluk River some whitefish had fed on snails. The only full stomachs noted were in those fish feeding on clams. Stomachs of four whitefish caught in the Kuskokwim River in May were empty.

Least Cisco

The least cisco, Coregonus sardinella Valenciennes, is widely distributed in the area of the Kuskokwim Delta and throughout the entire course of the Kuskokwim River. They are abundant in lakes in the Kuskokwim Delta but are absent from the higher elevation lakes of the study area. The least cisco prefers slow moving water. Since all rivers of the study area are swift, except for their lower reaches, least cisco are not abundant and probably do not spawn in streams of the study area. They were not found in Kuskokwim Bay tributaries.

In the study area least cisco were abundant only in the lower 2 miles of the Aniak River. A sample of 36 of these fish was aged. Fish ranged in length from 105 to 379 mm and Age I to VIII (Table 26). Most were Age IV and V. Maximum weight was 650 g.

The least cisco of the study area grow faster than least cisco from the Point Barrow area (Wohlschlag, 1954) and somewhat slower than least cisco from the Minto Flats in Interior Alaska (Alt, 1971). The fish

Table 24. Age-length relationships for broad whitefish from streams of lower Kuskokwim River.

Location		Age at Capture							
		III	IV	V	VI	VII	VIII	IX	X
					Fork Length (mm)				
Aniak R.	$\bar{x}$		345	372	437	458			499
n=14	n		n=2	n=3	n=3	n=5			n=1
	Range		340-349	340-399	433-444	439-487			499
Kisaralik R.	$\bar{x}$	319	350		421		457		
n=8	n	n=1	n=1		n=3		n=3		
	Range	319	350		412-428		455-460		
Kasigluk R.	$\bar{x}$		327	364	391	446	461	464	
n=20	n		n=1	n=6	n=2	n=2	n=6	n=3	
	Range		327	355-385	380-402	443-448	444-478	443-476	
Kwethluk R.	$\bar{x}$			367	370	445	465		
n=7	n			n=3	n=1	n=2	n=1		
	Range			338-390	370	425-465	465		
Kuskokwim R.	$\bar{x}$			332		426		496	
n=4	n			n=1		n=2		n=1	
	Range			332		417-435		496	

Table 25. Food items from stomachs of feeding broad whitefish from lower Kuskokwim River tributary streams.

Food Item	Aniak R. n=10	Kisaralik R. n=8	Kasigluk R. n=12	Kwethluk R. n=7
	Frequency of Occurrence			
Insects				
Diptera	10	8	7	1
Tricoptera				1
Insect remains	2			1
Clams	6	5	5	4
Snails	1		1	5
Debris	2		4	1

Table 26. Length, age and maturity of 36 least cisco from Aniak River.

Age	n	FL* at Capture (mm) $\bar{x}$	FL* at Capture (mm) Range	Maturity No. Mature	Maturity No. Immature
I	1	105	105	0	1
II					
III	1	246	246	0	1
IV	13	265	220-290	5	8
V	12	289	264-334	7	5
VI	4	307	290-345	3	1
VII	2	325	324-325	2	0
VIII	3	372	365-379	3	0

*FL = fork length

mature at Age IV, and by Age V nearly all are mature. Males and females mature at the same size and age.

Least cisco collected in the lower Aniak River in 1975 as well as in other Kuskokwim tributaries in early June had fed mainly on insects but had also taken a few snails, clams and freshwater shrimp. The May 20, 1976 sample was feeding on salmon fry, freshwater shrimp and some insects. One cisco, 379 mm fork length had eaten 50 salmon fry.

Bering Cisco

Bering cisco, Coregonus laurettae Bean, are only occasional visitors to the lower reaches of rivers flowing into the Kuskokwim. They are abundant in slower moving water of the lower Kuskokwim River and in estuarine situations. The fish found as far upstream as Aniak were all spawners and evidently proceed further up the Kuskokwim River to spawn. One Age VI specimen taken on the lower Aniak River in May was 331 mm in length and weighed 500 g while a 377 mm female from the Kuskokwim River weighed 700 g and was Age VII. The Aniak River fish had eaten salmon fry. For more information on taxonomy and age and growth of Bering cisco from the Kuskokwim River see Alt (1973).

Salmon

All five species of Pacific salmon are found in the study area. As a group, they are the most abundant fish and the most important to residents of the area in terms of subsistence and commercial value. They are lightly to moderately used as a sport fish. All commercial fishing and most subsistence fishing for salmon takes place in the Kuskokwim River or in Kuskokwim Bay. Most sport fishing is done in tributary rivers.

Observations of salmon abundance in the various streams and lakes have been recorded in the section on lake and stream surveys. The Division of Commercial Fisheries, Alaska Department of Fish and Game, has information on run timing, escapements, commercial harvest and basic life history; therefore, little will be mentioned in this report.

Sport Fishery:

All five species of salmon are important in the sport fishery.

Pink salmon are the most abundant species in the Kuskokwim Bay streams, especially in even years, and a few individuals will take a lure. They are usually found in the lower gravel bottom section of the rivers where they spawn in July. Females from the Arolik, Goodnews and Kanektok rivers may weigh between 2 and 3 lbs while males weigh between 2 and 5 lbs.

King salmon are usually the first species to enter tributary streams of the lower Kuskokwim River and are in rivers of the study area from mid June to early July. The king run is considerably later in Kuskokwim Bay and the fish usually do not enter the streams until early July. By mid July they are approaching the spawning areas. The average size of king

salmon in the Kanektok River is among the largest in the state and 30 to 40 lb fish are common. The Goodnews system has a good run of large size red salmon, with many fish over 10 lbs. They reach the lakes of the Goodnews system by early July.

Chum salmon are abundant in all streams of the study area and spawn over a wide stretch of the river and occasionally in lakes (Goodnews). They run slightly later than the king salmon. Their size is generally from 4 to 10 lbs.

Silver salmon are the latest running fish, usually entering tributary streams of the study area in August. They ascend the rivers of the Kuskokwim Bay study area up into the lakes; while in the lower Kuskokwim, they are found a considerable distance up the main streams and their smaller tributaries. Size of silver salmon varies from 3 to 10 lbs. They are highly sought by sport fishermen.

Burbot

Burbot, Lota lota (Linnaeus), were captured in only a few lakes and streams of the study area and then not in abundance (Table 3). Less than 10 were taken during the 2-year study. They were probably more widespread in the study area than test netting results indicate, but their capture is difficult. In 1976, burbot sets utilizing dead fish for bait were deployed in the lakes surveyed, but no burbot were captured. They are abundant in the lowland area of the lower Kuskokwim River where they are utilized as a subsistence food.

Burbot are scavengers and predators on other fish; and in turn, their young provide food for pike, sheefish, Arctic char and lake trout.

Sucker

The sucker, Catostomus catostomus (Forster), is found in the Kuskokwim River and the lower reaches of tributary rivers of the lower Kuskokwim. They were not found in Kuskokwim Bay. They are usually associated with warm, slow moving water with a mud or grassy bottom. Twelve suckers were caught in Grassy Slough in the lower Aniak in May of 1976 and 9 in August. The August fish were aged and nearly all were Age VIII with two of Age VI and one of Age VII. The sample ranged from 375 to 465 mm in length and weighed 700 to 1,225 g.

The sucker is a spring spawner and probably spawns in Grassy Slough in the Aniak River. The fish taken in May of 1976 were ripe but had not yet spawned.

Other Species

Other species present in the study area include the Arctic lamprey, Lampetra japonica (Martens); blackfish, Dallia pectoralis Bean; ninespine stickleback, Pungitius pungitius Linnaeus; threespine stickleback,

Gasterosteus aculeatus Linnaeus, and slimy sculpin, Cottus cognatus Richardson.

These species were caught infrequently and their true distribution in the study area is not fully known. The lamprey is abundant in the Kuskokwim River and has an upstream spawning migration under the ice (Baxter, pers. comm.).

Blackfish were captured in some of the lakes and streams in both Kuskokwim Bay and the lower Kuskokwim River. It was most often found in stomachs of other fish, except a considerable number were taken by gill net in May of 1976 in slough areas of the Aniak River where they were feeding on salmon fry. They could not be considered abundant in any section of the study area.

Sticklebacks are uncommon in the streams of the study area and only a few of both species were found. None were noted in the lake of the lower Kuskokwim River study area, but most lakes of Kuskokwim Bay contained large populations of threespine and a few ninespine sticklebacks. In Goodnews Lake, large schools of threespine sticklebacks were observed swimming along the edge of the lake; and many dead sticklebacks were present. Because of their great abundance in the lakes and complete absence in stomachs of feeding lake trout and char, one can assume that they are in direct competition with these fish for the little available food.

The slimy sculpin was found in many of the lakes and streams of both regions, usually in stomachs of fish, and is probably distributed throughout the study area. By habitat preference it is found in swift water streams with a gravel or rocky bottom or along gravel shores in lakes. In lakes of Kuskokwim Bay they were observed and captured along shore but may be present as deep as 60', as lake trout taken at that depth had fed on sculpins. The sculpin is one of the most important food items in the lakes and streams of the study area. In lake situations it is the only fish food item regularly eaten by lake trout and char.

Sculpins rarely exceeded 50 mm in length but some over 100 mm in length were taken in the Aniak River.

UTILIZATION

Fish found in the study area are subjected to commercial, subsistence and sport utilization. The salmon species are valuable to the three user groups while lake trout are taken only by sport fishermen.

Salmon, pike, burbot and whitefish (mainly broad and humpback) are utilized for subsistence to a small degree in tributary streams of the study area, but are heavily utilized in the main Kuskokwim River. In the Kuskokwim Bay section of the study area salmon are the main subsistence fish. Residents of villages in the vicinity of tributary rivers of the

study area take rainbow trout and Arctic char by hook and line during the winter. Present commercial fisheries exist for salmon.

Sport fishing pressure in the entire study area could be classed as light to moderate. Stream fishermen exert the greatest pressure but this is limited to the lower, easily navigable sections of streams. Most fishermen are local (i.e. from Aniak, Bethel, Quinhagak) and travel by boat to the fishing locations. There are small guiding operations on the lower Aniak and Kanektok rivers. A small number of fishermen fly into lakes at the head of Kuskokwim Bay streams and float the rivers in rafts. Rainbow trout are the most sought after fish in streams of the study area; but Arctic char, silver and king salmon, grayling and northern pike are also pursued. Very few sheefish are available to sportsmen and up to 20 per year are caught in the lower Aniak River. Pike are utilized in the area near Bethel. There is a large under-ice fishery in the Kuskokwim. In the streams of the study area they are taken on hook and line during open water. Because of their small size and supposed lack of fight, they rank far below rainbow trout, salmon, grayling and char as a desirable sport fish in the lower reaches of the tributary rivers.

Most summer stream sport fishing is conducted during the clear water periods of July, August and September. Low water levels, and swift water conditions often restrict boat travel to the lower reaches of rivers during periods of good fishing. Conditions in most streams are not suitable for landing float or wheel planes during the open water period.

The sport fishing pressure exerted on lakes of the study area is light at present. Many fishermen are local and fly their own plane or charter into lakes. A few non-resident and guided fishermen visit the lakes but this use can be expected to increase. Fishermen floating the Kanektok and Goodnews rivers begin their trips on lakes at the head of these rivers. Lake trout is the main sport species taken in the lakes; but some Arctic char, grayling (Aniak and Kisaralik lake) and red salmon (Kuskokwim Bay lakes) are taken. Little information on catch and effort is available. During July 1975 only three planes (6 fishermen) were observed on lakes of the study area and in July 1976 only one plane (1 fisherman) was observed.

MANAGEMENT CONSIDERATIONS

Fish populations of the study area are characterized by fairly slow growth, late age at maturity and a fairly long life span. Population levels of some species are high but population dynamics of all species are not fully understood. Variations in life history patterns must be taken into account before proper management procedure can be established. Some fish are lake residents, some are stream residents and others are anadromous. Arctic char have all three life history forms. Those species found only in streams (rainbow trout, grayling and pike), Kuskokwim

River tributary Arctic char and those species found in lakes (lake trout and the lake form of Arctic char) will need more stringent harvest regulations than anadromous species such as salmon and possibly Kuskokwim Bay Arctic char. The five species of salmon now support commercial, subsistence and sport fisheries.

Rainbow trout, the most desirable and sought after sport fish in the study area, is found only in tributary streams. Population levels are probably not high. This fish has a late age of sexual maturity and the spawning population in any given year is made up of only three or four age classes. The fish are recruited into the fishery for three or four years before spawning for the first time. In many streams of the Kuskokwi River the upstream segments of the summer populations are protected because of access difficulties, but in Kuskokwim Bay all segments of the population are vulnerable during the summer. Populations in all streams are extremely vulnerable during winter months because of their concentrations in holes in lower reaches of the streams.

Populations of grayling are apparently more abundant in the Kuskokwim River section of the study area (than grayling from Kuskokwim Bay streams) and could withstand a higher harvest. Grayling from Kuskokwim Bay were nearly all over Age V and over 300 mm in size. Fish of younger age classes were not located; they could have been up tributary streams.

Very few Arctic char were caught on hook and line or gill net during the lake surveys, probably reflecting both low abundance and difficult catchability. Stream char are apparently more abundant than rainbow trout in the Kuskokwim River tributaries but rarely exceed 2-3 lbs. These fish are widely distributed in the tributary streams and evidently are not as vulnerable as rainbow trout. Anadromous char normally enter streams of Kuskokwim Bay before and during the silver salmon migration, thus little information on their abundance was gathered. It is, however, believed that they are much more abundant than stream resident Arctic char.

Lake trout populations contain few young fish under 380 mm (15") with most fish belonging to Age Classes IX through XIII. Competition is severe and the lakes are unable to support large numbers of juvenile fish.

Limited harvest of the 9-11 year old fish might have little effect on the populations but increased harvest might seriously disrupt population structure. Johnson (1976) feels that lake trout in northern waters have a low turnover rate and would not be able to recoup population losses brought about by heavy harvest. Large, old fish of over 600 mm and over Age XVI are very uncommon, contribute little to lake trout reproduction and would likely contribute little to the sport harvest.

Trophy size fish in waters of the study area are uncommon. Only 2% of the lake trout catch weighed over 10 lbs. A very few lake trout of over 20 lbs are probably present in the lakes. Kuskokwim Bay streams contain some large size red, king, and pink salmon and anadromous Arctic char.

It is recommended that since no traditional subsistence or commercial fisheries exist on lakes of the study area their establishment be discouraged. It is further recommended that commercial fisheries not be allowed in tributary streams of the study area but be confined, as at present, to Kuskokwim Bay and the Kuskokwim River; that traditional subsistence needs be met by capture of the more abundant anadromous species of salmon and Arctic char in Kuskokwim Bay and possibly the lower reaches of the Goodnews and Kanektok rivers and by capture of salmon, whitefish, burbot and pike in the Kuskokwim River.

Sport fishing pressure, being exerted mainly by residents of the study area and, a few guided fishermen, will be sufficient to crop available surplus sport fish.

ACKNOWLEDGEMENTS

The help and assistance of residents of the study area, Commercial Fisheries personnel (Rae Baxter and Fritz Kuhlman) at Bethel and LaMont Albertson and the Aniak school is appreciated.

LaMont Albertson, Richard Curtis, Fred DeCicco, Michael Doxey, Ronald Regnart, and Eugene Roguski assisted in data collection.

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