Fairbanks Fishery Resources Progress Report Number FY84-1

# FISHERIES STUDIES ON THE NORTH SLOPE OF THE ARCTIC NATIONAL WILDLIFE REFUGE, 1983

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2 February 1984

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## ABSTRACT

During 1983, the Fairbanks Fishery Resource Station conducted fisheries studies on the coastal plain of the Arctic National Wildlife Refuge. The major emphasis in 1983 was fall and winter movement and spawning areas of arctic char and general species distribution and life history in the Hulahula River. Fish distribution and life history in the Okpilak and Jago River drainages, and several smaller rivers were also studied. Char movement and overwintering was again studied on the Canning River. Physical characteristics of these drainages were examined and related to potential overwintering habitat. During the study period, char movement into the Lower Hulahula River ranged from the beginning of August through the beginning of September. The peak movement in numbers of fish appeared to occur around the last week of August.

Fall concentrations of char on the Hulahula River were located by aerial survey in mid-September. The fish appeared to be concentrated in three sites which are consistent with the three fish holes used historically for subsistence fishing. Major spawning areas were located at the upper two fish holes. Overwintering pools appear to be limited. Hulahula River radio-tagged char showed little movement during late fall and early winter. A few tagged fish remained at the original site and the remaining fish had moved no further than 5 km downstream into a large aufeis field.

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## INTRODUCTION

Section 1002c of the Alaska National Interest Lands Conservation Act (ANILCA) of 1980 included provisions for a 5 year assessment of the fish and wildlife resources of the coastal plain of the Arctic National Wildlife Refuge (ANWR). This assessment was to include the following: an assessment of the size range, and distribution of fish and wildlife populations; a determination of the extent, location and carrying capacity of fish and wildlife habitat; an assessment of the impacts of human activities and natural processes on fish and wildlife and their habitat; and an analysis of potential impacts from oil and gas exploration, development, and production. During 1983 the Fairbanks Fishery Resources Station conducted aquatic studies in accordance with the fishery portion of this mandate.

The study area established by ANILCA includes most of the coastal plain of the ANWR from the Aichilik River on the east to the Canning River on the west. It covers an area of approximately 630,000 hectares (2520 sq. miles) and includes 135 km of coastline, barrier islands and lagoons along the Beaufort Sea. Eight major drainages and several smaller coastal streams either flow or are contained within the study area. Relatively few lakes, compared to the western Alaska coastal plain, are found in the study area and the majority of these are shallow thaw lakes supporting only a seasonal summer fishery at best.

Very little is known about fish populations and their habitats on the coastal plain of the ANWR. Craig (1977a; 1977b) conducted studies on arctic char life history on the Canning River and Sadlerochit Springs during 1972 and 1973. Previous fish distribution studies have reported only two species, grayling and char, in fresh water on the coastal plain east of the Canning River (Ward and Craig, 1974).

This study reports the results of the aquatic surveys on the coastal plain during 1983. Specific objectives were to: 1) Assess general distribution and life histories of major fish species on Okpilak, Jago and Hulahula Rivers and smaller drainages between the Katakturuk River and the Aichilik River; 2) Identify and describe char overwintering movements and habitat requirements on the Canning and Hulahula Rivers; 3) Monitor anadromous char migration patterns on the Hulahula River; 4) Identify and describe char spawning grounds and habitat requirements for the Hulahula River.

## METHODS

Access into the survey areas consisted of a variety of fixed wing and rotor wing aircraft including: Cessna 185, Super Cub, and Bell 206 and Hughes 500D helicopters. Aircraft type depended on availability and site accessibility. Surveys at the sites were conducted on foot or by inflatable Zodiac rafts.

Fish capture techniques depended on the location and included the following: 125 X 6ft. monofilament experimental gill nets with five 25 ft. panels of 1/2 in. to 2 1/2 in. bar mesh; 30 X 6ft. monofilament experimental gill nets with five 6ft. panels of 1/2 in. to 2 1/2 in. bar mesh; baited minnow traps; Type XI Smith-Root backpack electrofisher; beach seines from 30 X 4ft. to 100 X 8ft.; and hook and line.

Fork length of fish was measured to the nearest millimeter from the tip of the snout to the fork in the caudal fin. Weights of fish were determined using Pesola spring scales with ranges of 0 to 250 g, 0 to 500 g and 0 to 2500 g. Coefficient of condition (K) was determined for char and grayling according to the following equation:

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

Ages were determined from otolith samples taken from grayling and char. Otoliths were cleaned and soaked in liquid detergent, ground on 400 grit wet sanding paper and read under a Bausch and Lomb binocular microscope, using reflected light, at 30-40X magnification. The first year of growth was defined as 0 age class using Nordeng's (1961) explanation that a hyaline zone between the center and the first annulus is formed during the first summer after hatching.

Numbered Floy FD-67 anchor tags were implanted in fish in the Hulahula to gain information on movement patterns. The adipose fin was clipped on fish too small to tag. Water chemistry measurements for total alkalinity, total hardness, and pH were made with Hach AL-36B kits. Conductivity was determined with Hach Mini Conductivity Meters. Water and air temperatures were also taken at each sampling site.

USGS, 1:63,350 and 1:250,000 scale maps were used to determine stream order, extent of channel braiding and gradient characteristics of the Hulahula, Jago and Okpilak Rivers and small tributaries of these rivers. Strahler's method (1957) was used to determine stream order. Stream orders ranged from 1 to 5. After all streams that were surveyed were ordered, they were broken down into reaches.

A radio telemetry study was conducted on arctic char in the Canning River during the winter of 1982-1983 to locate and describe overwintering habitat and to monitor winter movements. Another telemetry project was initiated on char in the Hulahula River in September 1983 to compare results to a different area. Radio transmitters were implanted in fifteen arctic char on the Canning River in September 1982.

In addition, 29 arctic char in the upper Hulahula River were implanted with radio tags during September 1983. Relocations of the Canning River fish was accomplished periodically through the winter. Aerial relocation for the

Hulahula River fish will be attempted on a bi-monthly basis throughout the winter and early spring of 1983-1984.

Telonics equipment was utilized for the telemetry studies and included: 1) RB-5 transmitters, weight 27g, diameter 1.7 cm, length 5.6 cm; 2) TR-2 Receiver with the TS-1 Scanner/Programmer; and 3) RA-2AK Antennaes. The frequency range selected for the above equipment was 151.000 MHz to 153.999 MHz. Pulse rate for the transmitters was selected at 55 per minute to extend the operational life of the lithium batteries to 8 months. Antennaes were mounted during aerial tracking on the wing struts of a Cessna 185.

In the Canning River study, 12 fish of the 15 collected for tagging were caught by seine and three were caught by angling. Twenty-seven fish, collected for tagging in the Hulahula River were captured by angling. One fish was collected by electrofishing and one char was collected by experimental gill net. Fish were anesthetized in MS-222, weighed and measured, tagged and returned to a holding pen for a 24 hour period for observation. Tagging was accomplished by sliding the tag through the mouth into the stomach cavity. The 10.5 in. external antennae on the radio tag was attached to the upper maxillary with a wing band and left trailing along the fishes body.

The minimum size of fish in which tags were implanted was determined, in part, from the 1982 implants and from necropsy analysis on eight fish of different sizes implanted with the tags and then held for 1 to 2 days in a holding pen. The stomach was ruptured on three fish, 514 mm and 1250 g and smaller. Fish over 500 and 1400 g appeared healthy with no apparent damage to stomach cavity. Attempts were made to limit the minimum size to 500 mm and 1400 g. During both studies, the size range was 507 mm and 1200g to 664 mm and 2900g. The smallest fish tagged, 507mm and 1200g, was one being held for necropsy analysis that escape from the holding pen.

Aerial tracking is accomplished by parallel flights along the river at altitudes of 500-1000 feet above ground level. Specific locations are determined by monitoring pulse volume.

## OKPILAK RIVER

### Physical - Chemical Characteristics

The Okpilak River, at its mouth is a fifth order stream with a 0.95 percent gradient. Braided channel area is primarily found throughout the river with irregular channel configurations in the upper reaches. There are two springs feeding into the Okpilak River, one of which is thermal. Neither spring is within the 1002c study area. The upper watershed contains landlocked lakes. Okpilak Lake was sampled during July, 1983. Seven sites were sampled; three in the main channel, one unnamed tributary in the lower portion, and three sites on the Akutoktak River (Figure 1).

Discharge was determined for three of the sample areas from July 2-6, 1983 (Table 2). Discharge ranged from 0.16 cms, in the lower portion, to 0.28 cms in the upper Akutoktak River. The channel width averaged 10.7 m with an average depth of 0.35 m. Discharge and depth were not taken for the main channel due to water levels too high to wade through.

Water chemistry sampling for all seven sites can be found in Table 1. Water temperature averaged 9.5°C, pH ranged from 6.8 to 7.5 and conductivity ranged from 30 umhos/cm in the lower main channel to 120 umhos/cm in Akutoktak River. Total alkalinity was lowest on the Upper Akutoktak River and highest in a tributary to the lower Okpilak River (35 mg/l and 87 mg/l respectively). Total hardness ranged from 70.4 mg/l in Upper Akutoktak River to 154 mg/l in the middle section of the main channel.

Table 1. Chemical characteristics of sample areas on the Okpilak River, July 1983.

| | Total Alkalinity (mg/l) | Total Hardness (mg/l) | Conductivity (umhos/cm) | $H_2O$ Temp. (°C) | Air Temp. (°C) | pH |
|---|---|---|---|---|---|---|
| Lower River | | | | | | |
| A | 68.4 | 119.7 | 80 | 7.0 | 9.0 | 7.5 |
| B | 86.5 | 102.6 | 44 | 6.5 | 13.0 | 7.0 |
| Akutoktak River | | | | | | |
| C | 85.5 | 153.9 | 30 | 8.0 | 10.0 | 7.5 |
| D | 68.5 | 136.8 | 120 | 14.0 | 11.0 | 7.5 |
| E | 35.2 | 70.4 | 115 | 10.0 | 16.0 | 6.8 |
| Upper River | | | | | | |
| F | 68.4 | 68.4 | 94 | 11.5 | 17.0 | 7.3 |
| G | 34.2 | 51.3 | 120 | - | - | 6.9 |

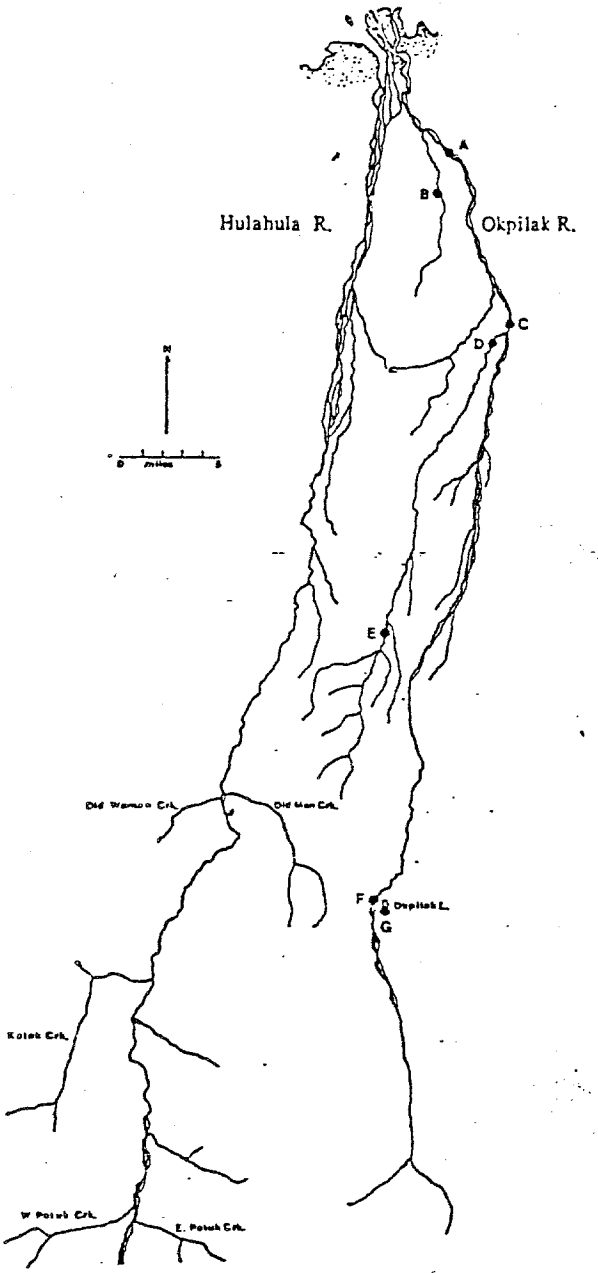


Figure 1. Chemical and physical sampling locations in the Okpilak River, July 1983.

Table 2. Physical characteristics of sample areas on the Okpilak River, July 1983.

| | Stream Order | % Gradient | Channel Configuration | Wetted Perimeter (m) | Average Depth (m) | Discharges (cms) | Average Velocity (m/s) | % Pool Area | % Riffle Area | Predominant Substrate |
|---|---|---|---|---|---|---|---|---|---|---|
| Lower River | | | | | | | | | | |
| A | 5 | .95 | Braided | 3.05 - 61.0 | - | - | - | 90 | 10 | Small and Large Gravel |
| B | 3 | .69 | Irregular | 7.3 | .26 | .16 | .09 | 80 | 20 | Small and Large Gravel |
| Akutoktak River | | | | | | | | | | |
| C | 5 | .92 | Braided | 3.05 - 30.5 | - | - | - | 10 | 90 | Small and Large Gravel |
| D | 4 | .61 | Irregular | 15.4 | .52 | .23 | .03 | 60 | 40 | Small and Large Gravel |
| E | 3 | .64 | Irregular | 9.4 | .26 | .28 | .12 | 40 | 60 | Boulder and Rubble |
| Upper River | | | | | | | | | | |
| F | 4 | .36 | Braided | 3.05 - 61.0 | - | - | - | 20 | 80 | Small and Large Gravel |

## Fish Distribution and Abundance

Figure 2 presents fish sampling locations and spring areas for the Okpilak River drainage. Distribution of fish species collected from various sample areas is found in Table 3.

Grayling were not found in the Okpilak River above the confluence of the Akutoktak River during the 1983 summer sampling period. Grayling were well distributed throughout the clear water tributaries studied. The lower tributary and main channel (sites H & J) had small numbers of adult grayling present. Middle reaches of the Okpilak were not sampled during this study (between sites B & J). Ward and Craig (1974) seined site E on July 23, 1974 with no fish captured. Future investigations in this portion of the river should reveal a better understanding of fish species occurance. The Akutoktak River (sites C, D, F & G) has a wide distribution of grayling throughout. Adults and juveniles were found mostly in pool areas at sites C and G. Fry were observed on August 6, 1982 at site F.

Okpilak Lake (site A), which is landlocked, has populations of grayling and lake trout. Juveniles and adults were captured for both species.

Aerial surveys were flown for the Okpilak River in September 1982 and 1983 by USFWS personnel. Survey boundaries are shown in Figure 2. No fish were spotted during these flights.

Relative abundance and mean length of fish collected in the Okpilak River drainage during July 1983 are shown in Table 4. Grayling were found in greatest numbers near the mouth of the Akutoktak River (site G) and in Okpilak Lake (site A). Gill net catch rates were 0.30 and 0.42 fish per hour respectively, while angling catch rates were higher at 6.0 and 2.67 fish per angling hour. Elsewhere in the sample area, adult and juvenile grayling were found in relatively low numbers. Minnow traps were least effective with a catch rate of 0.007 fish per hour for the Okpilak River. Grayling fry were found in large numbers at site F on August 6, 1982. Grayling fry were probably just beginning to emerge during the 1983 sampling period (July 2-6) therefore not found. Craig and Poulin (1974) and USFWS (1983) predicted fry emergence for nearby rivers as occuring between the last 2 weeks of June and 1st week of July.

Lake trout were found in low numbers at Okpilak Lake with a gill net catch rate of 0.08 fish per hour.

## Length Frequency

Length frequency histograms for grayling collected from the Okpilak River and Okpilak Lake are presented in Figures 3 and 4. Both sampling areas consisted predominantly of similar length groups when comparing gillnet catch results. The mean fork lengths of grayling caught in Okpilak Lake and the Okpilak River system are similar, 235 mm and 264 mm respectively.

## Age and Growth

Age and growth of grayling collected in the Okpilak River area are presented in Table 5 and 6. A comparison of length-age relationships for grayling from

Okpilak Lake with the Okpilak River system stock are similar. These figures fall within the ranges given by Craig and Poulin (1974) for Weir Creek and the Kavik River, which are both in close proximity to the study area.

Table 3. Fish distribution in the Okpilak River drainage.*

| Sample Area | Sample Date(s) | Fish Species | Life Stage(s) | Comments |
|---|---|---|---|---|
| A | July 5-6, 1983 | Gr<br>Lt | J,A<br>J,A | USFWS, Fishery Resources, Fairbanks |
| B | July 6, 1983 | No fish collected | | USFWS, Fishery Resources, Fairbanks |
| C | July 4-5, 1983 | Gr | J,A | USFWS, Fishery Resources, Fairbanks |
| D | July 23, 1974 | No fish collected | | Ward & Craig (1974) |
| E | July 23, 1974 | No fish collected | | Ward & Craig (1974) |
| F | August 6, 1982 | Gr | F | USFWS, Fishery Resources, Fairbanks |
| G | July 2-4, 1983 | Gr | J,A | USFWS, Fishery Resources, Fairbanks |
| H | July 2, 1983 | Gr | A | USFWS, Fishery Resources, Fairbanks |
| I | July 2, 1983 | Gr | A | USFWS, Fishery Resources, Fairbanks |

Gr - Grayling
Lt - Lake trout
A - Adult, J - Juvenile, F - Fry

*See figure 2 for sample site locations.

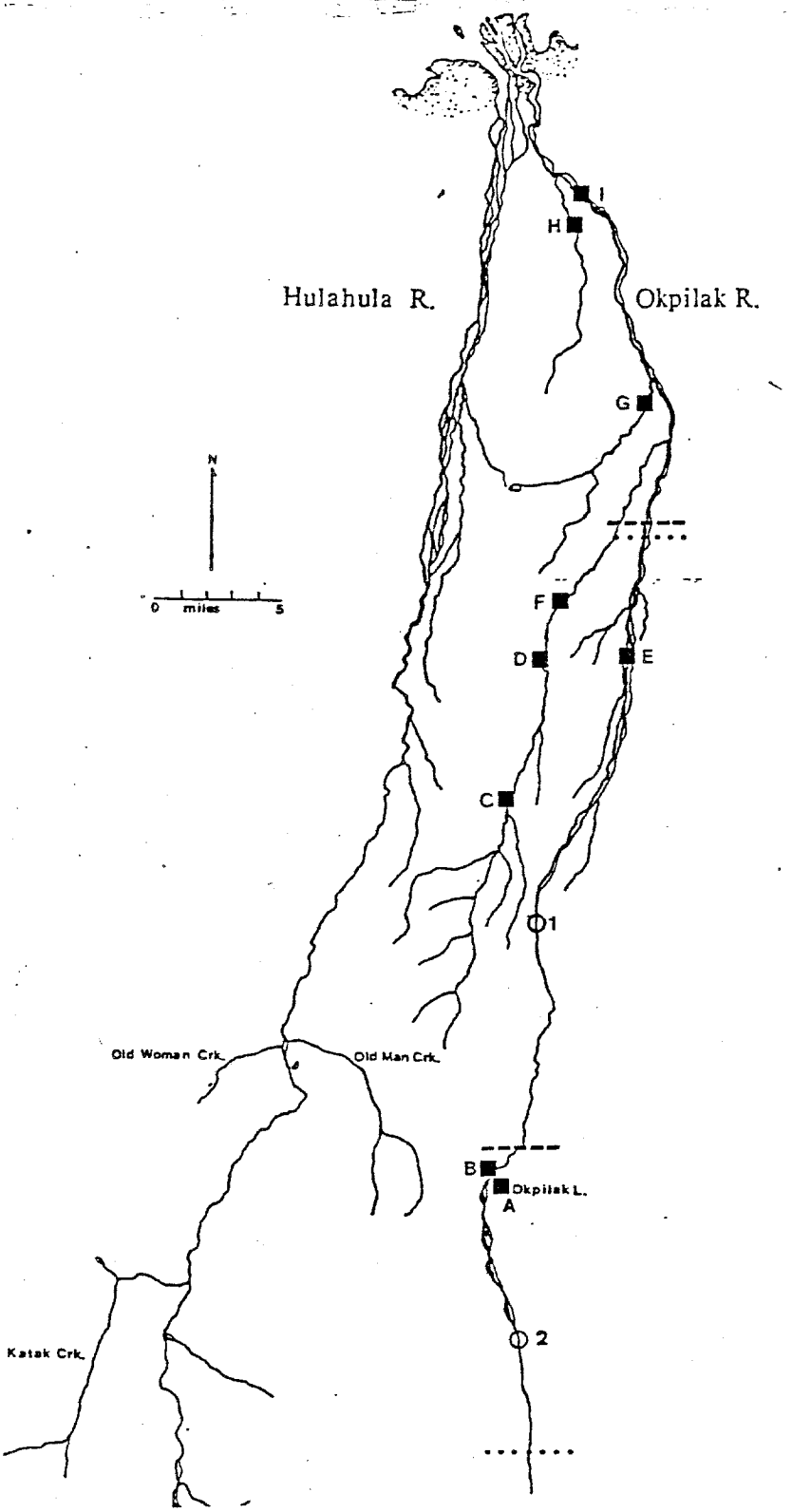


Figure 2. Fish sampling locations (■), spring areas(○), and aerial survey boundaries (----1982)(....1983) in the Okpilak River system. 1974-1983.

Table 4. Catch-per-unit-effort and mean fork length of grayling and lake trout collected in the Okpilak River drainage, July 2 - July 6, 1983.

| Sample Location | Fish Species | # of Fish Collected | Total Effort | Mean Fork Length (mm) | Length Range (mm) | Catch per-unit Effort |
|---|---|---|---|---|---|---|
| | | | 30' Experimental Gill Net | | | |
| A | Gr | 15 | 36.0 hrs. | 234 | 126-328 | 0.42/hr. |
| A | Lt | 3 | 36.0 hrs. | 265 | 123-395 | 0.08/hr. |
| B | - | 0 | 36.0 hrs. | - | - | - |
| C | Gr | 4 | 42.0 hrs. | 255 | 235-274 | 0.09/hr. |
| G | Gr | 24 | 79.5 hrs. | 254 | 135-375 | 0.30/hr. |
| H | Gr | 2 | 34.0 hrs. | 306 | 306-307 | 0.06/hr. |
| I | Gr | 2 | 32.0 hrs. | 360 | 335-385 | 0.06/hr. |
| All (without A) | Gr | 32 | 187.5 hrs. | 264 | 135-385 | 0.17/hr. |
| | | | Angling | | | |
| A | Gr | 4 | 1.5 hrs. | 360 | 281-405 | 2.67/hr. |
| C | Gr | 1 | 0.5 hrs. | 334 | - | 2.00/hr. |
| G | Gr | 18 | 3.0 hrs. | 323 | 260-286 | 6.00/hr. |
| All (without A) | Gr | 19 | 3.5 hrs. | 324 | 260-386 | 5.43/hr. |
| | | | 30' Seine | | | |
| G | Gr | 8 | 8 hauls | 195 | 119-327 | 1.0/haul |
| | | | Minnow Trap | | | |
| A | - | 0 | 51 | - | - | - |
| G | Gr | 2 | 198.0 hrs. | 108 | 95-122 | 0.01/hr. |
| B | - | 0 | 36 | - | - | - |
| H | - | 0 | 51 | - | - | - |
| All (without A) | Gr | 2 | 285 | 108 | 95-122 | 0.007/hr. |

The oldest fish caught was from Okpilak Lake, a grayling, with a fork length of 354 mm and aged over 15 years. The majority of fish fell between the 2 and 7 year age classes. Grayling matured sooner in Okpilak Lake than from the Okpilak River. By age 4 all the lake population sampled had matured, while the river fish were not all mature until age 5. Small sample sizes for Okpilak Lake make these comparisons less conclusive but still provide a general relation- ship. Grayling from the Tamayariak River (USFWS 1983) were all mature by the seventh year of growth.

Sex ratios for Okpilak River and lake resident grayling show some differences. Compositions are presented in the following table.

| Area | Total Number of Fish | Percent Immature | Percent Male | Percent Female |
|---|---|---|---|---|
| Okpilak Lake | 19 | 15.8 | 36.8 | 47.4 |
| Okpilak River | 51 | 25.5 | 47.0 | 27.5 |

Table 5. Age specific length (otolith) of grayling collected from the Okpilak River, July 2 - July 5, 1983.

| Age | Sample Number | Mean Fork Length (mm) | Standard Deviation | Length Range (mm) | % Mature |
|---|---|---|---|---|---|
| 2 | 6 | 131.2 | 5.2 | 122 - 135 | 0 |
| 3 | 1 | 235.0 | - | - | 100 |
| 4 | 11 | 235.5 | 17.5 | 195 - 260 | 30 |
| 5 | 5 | 278.2 | 12.9 | 263 - 295 | 100 |
| 6 | 7 | 291.7 | 42.8 | 242 - 365 | 100 |
| 7 | 9 | 310.7 | 31.0 | 254 - 358 | 100 |
| 8 | 2 | 341.0 | 48.1 | 307 - 375 | 100 |
| 9 | 1 | 359.0 | - | - | 100 |
| 10 | 1 | 344.0 | - | - | 100 |

Three lake trout were captured from Okpilak Lake. The age specific lengths are presented in Table 6. The youngest fish was an immature in its 6th year and the oldest was over 13 years old with a fork length of 394 mm.

Table 6. Age specific length (otolith) of fish collected from Okpilak Lake, July 5 - July 6, 1983.

| Age | Sample Number | Mean Fork Length (mm) | Standard Deviation | Length Range (mm) | % Mature |
|---|---|---|---|---|---|
| | | Arctic Grayling | | | |
| 2 | 3 | 131.3 | 6.8 | 126 - 139 | 0 |
| 3 | 0 | - | - | - | - |
| 4 | 4 | 230.2 | 5.3 | 223 - 235 | 100 |
| 5 | 1 | 252.0 | - | - | 100 |
| 6 | 3 | 270.0 | 14.2 | 254 - 281 | 100 |
| 7 | 0 | - | - | - | - |
| 8 | 0 | - | - | - | - |
| 9 | 1 | 220.0 | - | - | 100 |
| 10 | 1 | 369.0 | - | - | 100 |
| 11 | 0 | - | - | - | - |
| 12 | 1 | 405.0 | - | - | 100 |
| 13 | 1 | 385.0 | - | - | 100 |
| 15 | 1 | 354 | - | - | 100 |
| | | Lake Trout | | | |
| 6 | 1 | 123 | - | - | 0 |
| 10 | 1 | 277 | - | | 100 |
| 13 | 1 | 394 | - | | 100 |

## Weight and Condition

The following length-weight relationship was calculated for grayling collected from Okpilak Lake, July 5 - July 6, 1983.

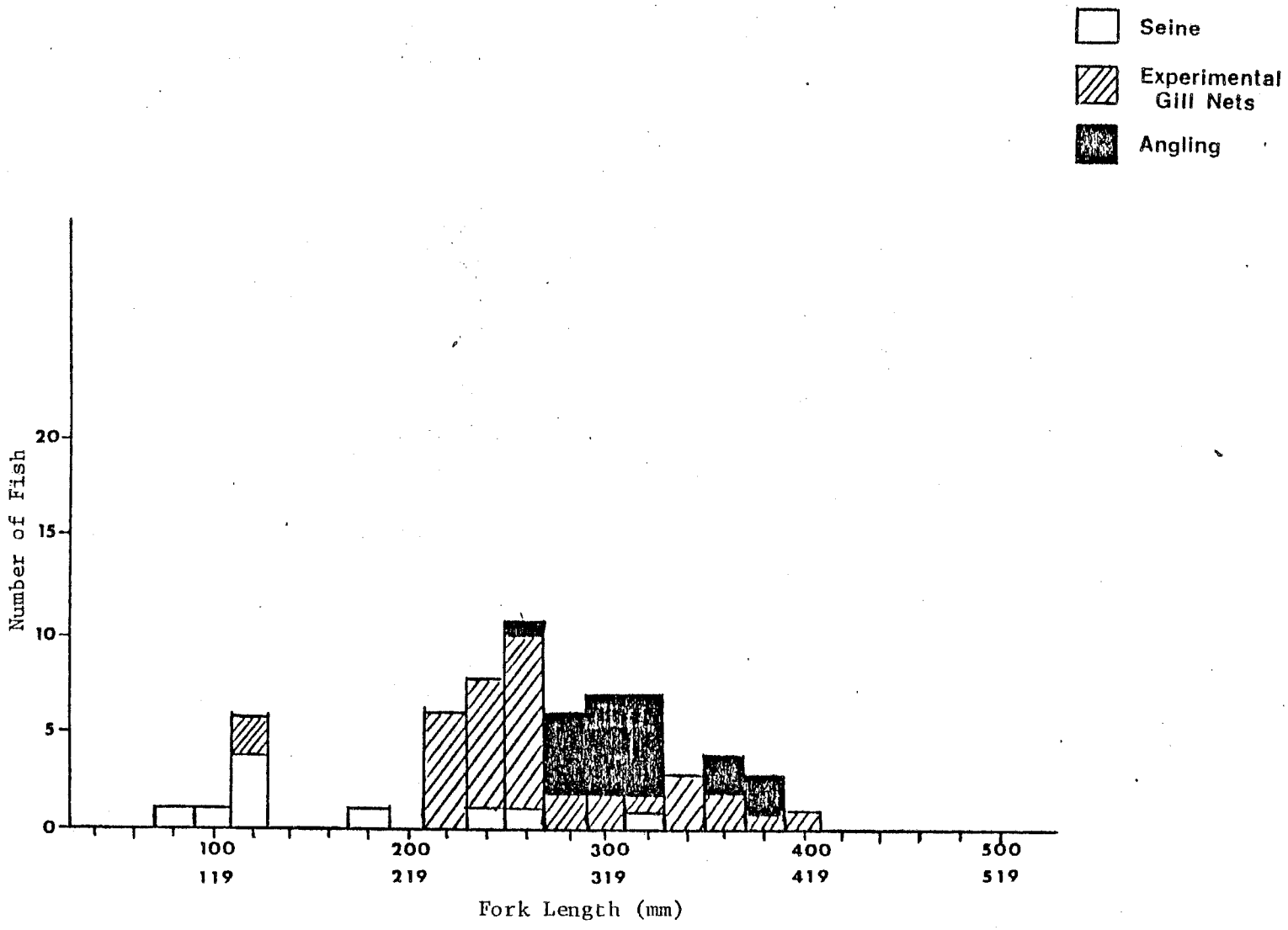


Figure 3. Length frequency of 65 arctic grayling collected by seine, experimental gill net, and angling in the Okpilak River system, July 1983.

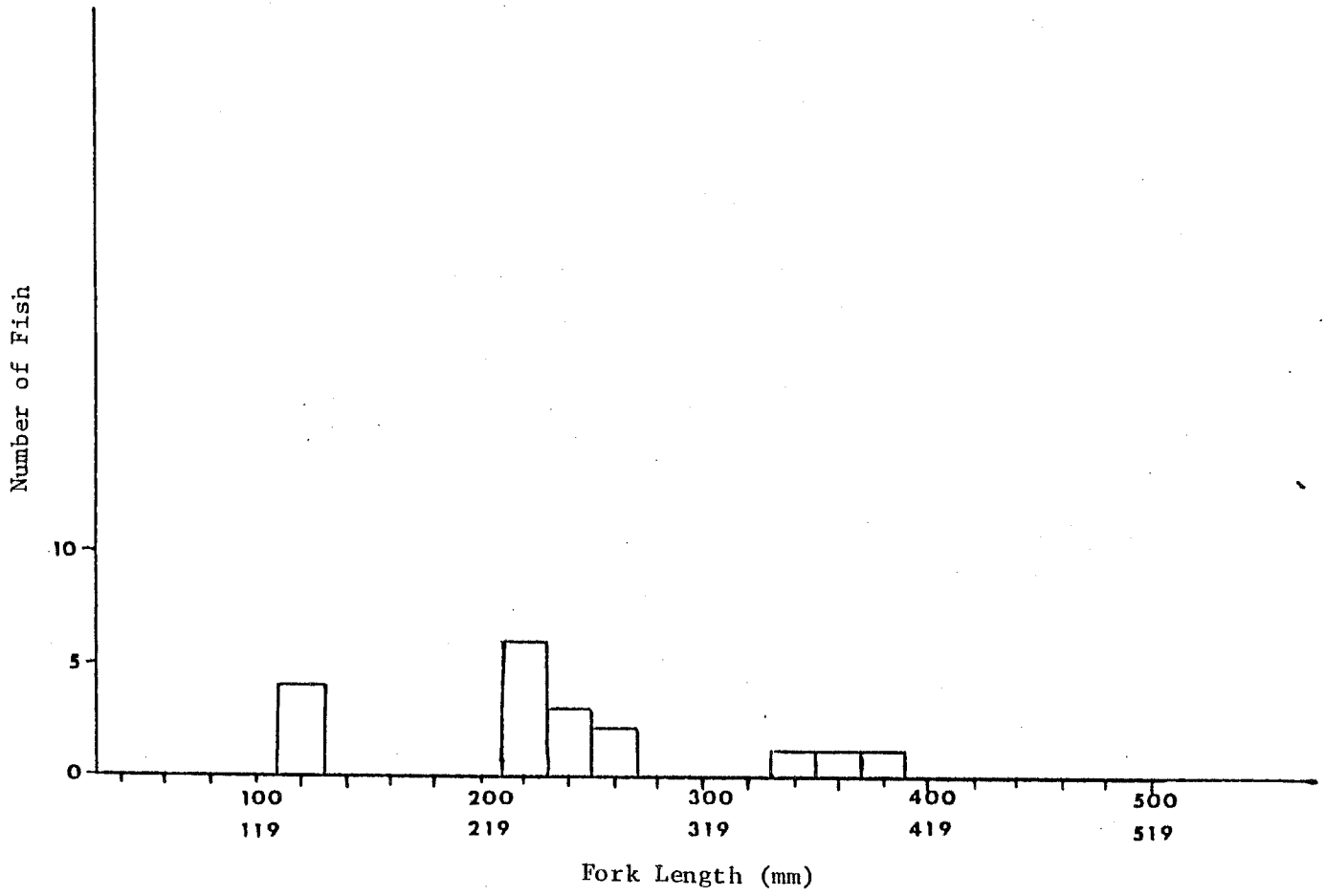


Figure 4. Length frequency of 18 arctic grayling collected by experimental gill net in Okpilak Lake, July 1983.

Grayling (n = 19, r = 0.993, fork length range = 123-405 mm, weight range = 14-645 gms):

$$\text{Log}_{10}\ W_{(g)} = 3.180\ \text{Log}_{10}\ L_{(mm)} - 5.422.$$

The following length-weight relationship was calculated for grayling collected from the Okpilak River, July 2 - July 5, 1983.

Grayling (n = 60, r = 0.986, Fork length range = 95-386 mm, weight range = 3-505 gms):

$$\text{Log}_{10}W_{(g)} = 3.174\ \text{Log}_{10}(L) - 5.46$$

Condition factors (K) for grayling collected from the Okpilak River drainage during July, 1983 are reported in Tables 7 and 8. The mean K values for length groups above 200 mm are greater for Okpilak River. K values for grayling collected from the Tamayariak and Sadlerochit Rivers (USFWS 1983) are similar to the results from the Okpilak Lake population. The significance of these differences has not been determined.

Spawning and Overwintering

Little is known about the spawning and overwintering of grayling in the Okpilak River. The large concentrations of grayling fry observed on August 6, 1982 in the middle sampling area F of the Akutoktak River indicates that this portion of the river is being heavily used for spawning. By comparing movement patterns of grayling from Weir Creek (Craig & Poulin, 1974) and Tamayariak River (USFWS, 1983), the adults captured in early July at the mouths of Okpilak River tributaries (site G, H, J) probably were moving downstream from spawning areas located up these tributaries.

Overwintering habitat for the Okpilak River system is most likely very limited. No suitable habitat has been described for the drainage. Since the Okpilak River is highly braided through most of its lower reaches and shallow water depths occur in the upper areas, grayling probably overwinter in the small isolated pools that are available.

Table 7. Coefficient of condition (K) for grayling from Okpilak Lake, July 5 - July 6, 1983.

| Length Group (mm) | Number in Sample | Mean K | Standard Deviation |
|---|---|---|---|
| 100 - 149 | 3 | 0.83 | 0.11 |
| 150 - 199 | 0 | - | - |
| 200 - 249 | 6 | 1.12 | 0.11 |
| 250 - 299 | 5 | 1.05 | 0.10 |
| 300 - 349 | - | - | - |
| 350 - 399 | 4 | 1.05 | 0.15 |
| 400 - 449 | 1 | 0.97 | - |

Table 8. Coefficient of condition (K) for grayling from the Okpilak River, July 2 - July 5, 1983.

| Length Group (mm) | Number in Sample | Mean K | Standard Deviation |
|---|---|---|---|
| 50 - 99 | 1 | 0.35 | - |
| 100 - 149 | 7 | 0.96 | 0.31 |
| 150 - 199 | 1 | 0.74 | - |
| 200 - 249 | 12 | 0.96 | 0.08 |
| 250 - 299 | 18 | 0.90 | 0.07 |
| 300 - 349 | 15 | 0.93 | 0.05 |
| 350 - 399 | 6 | 0.91 | 0.10 |

## JAGO RIVER

### Physical - Chemical Characteristics

The Jago River, at its lower reaches, is a fourth order stream with a 0.56 percent gradient. A braided channel is primarily found throughout the river. The main channel of the Jago River was sampled August 8, 1975 and found to have a discharge of 7.6 cms (Childers et.al., 1977). There are several lakes in the upper watershed. Three of these lakes were sampled during the summer period. Five sites were sampled for physical and chemical characteristics throughout the Jago drainage during July 1983 (Figure 5).

Table 9. Chemical characteristics of sample areas on the Jago River, July 1983.

| | Total Alkalinity (mg/l) | Total Hardness (mg/l) | Conductivity (umhos/cm) | $H_2O$ Temp. (°C) | Air Temp. (°C) | pH |
|---|---|---|---|---|---|---|
| Lower River | | | | | | |
| A | 51.3 | 51.3 | 68 | 13.0 | 19.0 | 6.8 |
| Okpirourak Creek | | | | | | |
| B | 70.4 | 70.4 | 130 | 15.0 | 20.0 | 7.5 |
| C | 17.1 | 34.2 | 37 | 20.0 | 22.0 | 6.5 |
| Okerokovik Springs | | | | | | |
| D | 136.8 | 205.3 | 380 | 8.0 | 21.0 | 8.0 |
| Jago Lake | | | | | | |
| E | 34.2 | 85.5 | 78 | 19.0 | 22.0 | 7.5 |

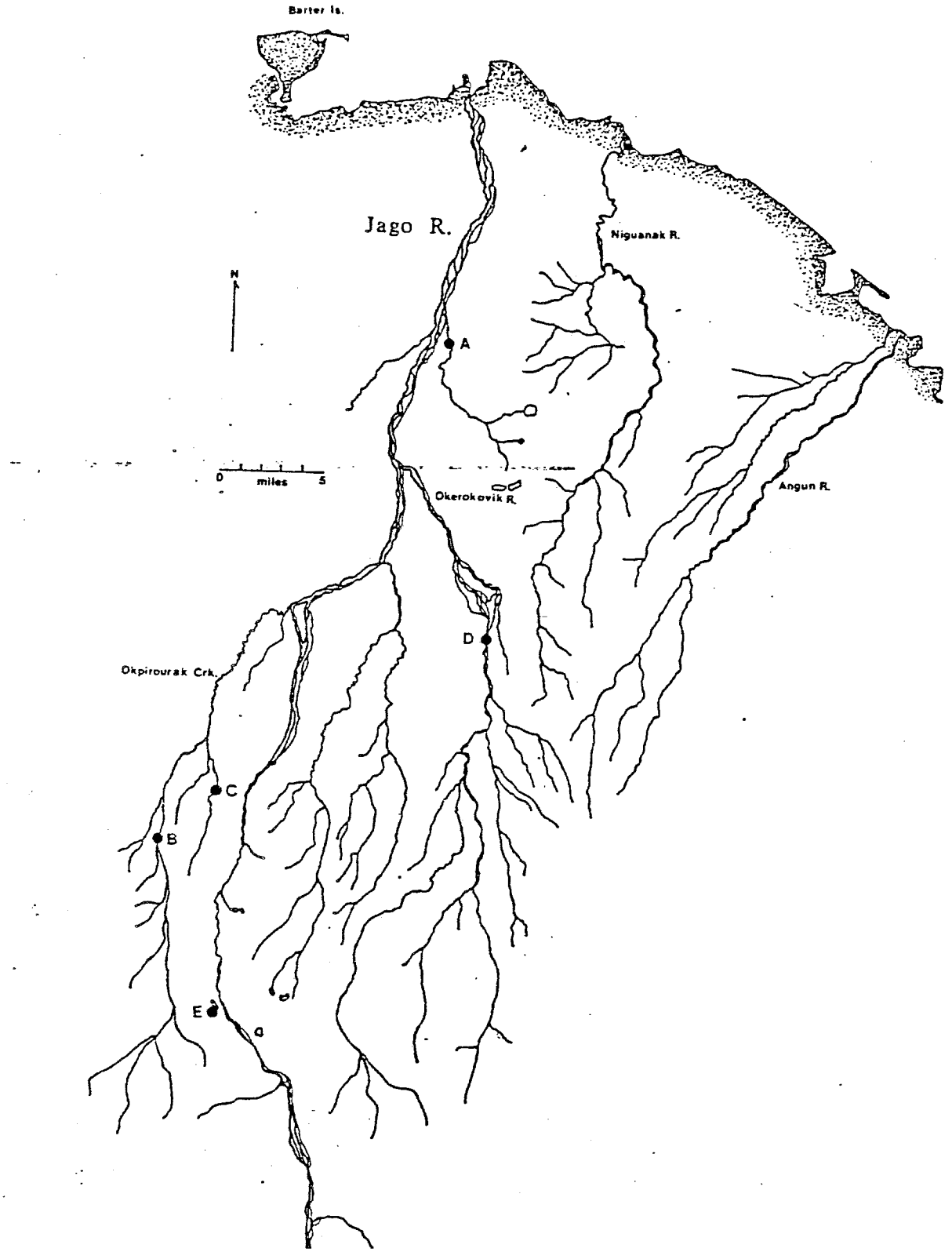


Figure 5. Chemical and physical sampling locations in Jago River, July 1983.

Table 10. Physical characteristics of sample areas on the Jago River, July 1983.

| | Stream Order | % Gradient | Channel Configuration | Wetted Perimeter (m) | Average Depth (m) | Discharges (cms) | Average Velocity (m/s) | % Pool Area | % Riffle Area | Predominant Substrate |
|---|---|---|---|---|---|---|---|---|---|---|
| Lower River | | | | | | | | | | |
| A | 4 | .56 | Irregular | 1.5 | .55 | .14 | .18 | - | - | - |
| Okpirourak Creek | | | | | | | | | | |
| B | 3 | .23 | Irregular | 16.8 | .21 | 1.14 | .34 | - | - | - |
| C | 3 | .47 | Straight | - | - | - | .03 cms | - | - | - |
| Okerokovik Springs | | | | | | | | | | |
| D | 3 | .30 | Braided | 10.1 | .12 | .14 | .12 | - | - | - |

Discharge was determined for four of the 1983 field sites (Table 10). Discharge ranged from less than .03 cms in an upper reach of Okpirourak Creek to 1.14 cms in the lower Okpirourak. One spring is located on the Okerokovik River. Discharge was measured during the July sampling period showing discharge at 0.14 cms. Discharge was also measured during a earlier study on August 8, 1975 with results of 2.4 cms (Childers et.al., 1977). The average width and depth were 9.5 m and 0.29 m respectively. Water chemistry sampling was conducted for all sites and is shown in Table 9. The pH range was from 6.5 to 8.0 and conductivity fell to a low of 37 umhos/cm in Okpirourak Creek. Total alkalinity and total hardness were lowest in the Okpirourak Creek (17 mg/l and 34 mg/l, respectively) and highest in the Okerokovik River (137 mg/l and 222 mg/l).

Fish Distribution and Abundance

Fish sampling locations and spring area for the Jago River drainage are found in Figure 6. Table 11 shows fish distribution for the various sample locations.

Table 11. Fish distribution in the Jago River drainage.*

| Sample Area | Sample Date(s) | Fish Species | Life Stage(s) | Comments |
|---|---|---|---|---|
| A | 7/8/83 | No fish collected | | USFWS, Fishery Resources, Fairbanks |
| B | 7/9/83 | AC-LR | A,J | USFWS, Fishery Resources, Fairbanks |
| C | 7/8/83 | AC-LR | A | USFWS, Fishery Resources, Fairbanks |
| D | 7/7/83 | No fish collected | | USFWS, Fishery Resources, Fairbanks |
| E | 7/7/83 | No fish collected | | USFWS, Fishery Resources, Fairbanks |
| F | 7/23/74 | No fish collected | | Ward & Craig (1974) |
| G | 7/1/82, 7/6/83 | NSB | A | USFWS, Fishery Resources, Fairbanks |
| H | 7/23/74 | No fish collected | | Ward & Craig (1974) |
| I | 7/23/74, 7/8/83 | No fish collected<br>No fish collected | | Ward & Craig (1974)<br>USFWS, Fishery Resources, Fairbanks |
| J | 7/2/82 | No fish collected | | USFWS, Fishery Resources, Fairbanks |
| K | 7/3/82 | No fish collected | | USFWS, Fishery Resources, Fairbanks |
| L | 7/3/82 | No fish collected | | USFWS, Fishery Resources, Fairbanks |
| M | 7/8/83 | No fish collected | | USFWS, Fishery Resources, Fairbanks |

AC - Arctic char LR - Lake resident
NSB - Ninespine Stickleback
A - Adult J - Juvenile

*See figure 5 for sample site locations.

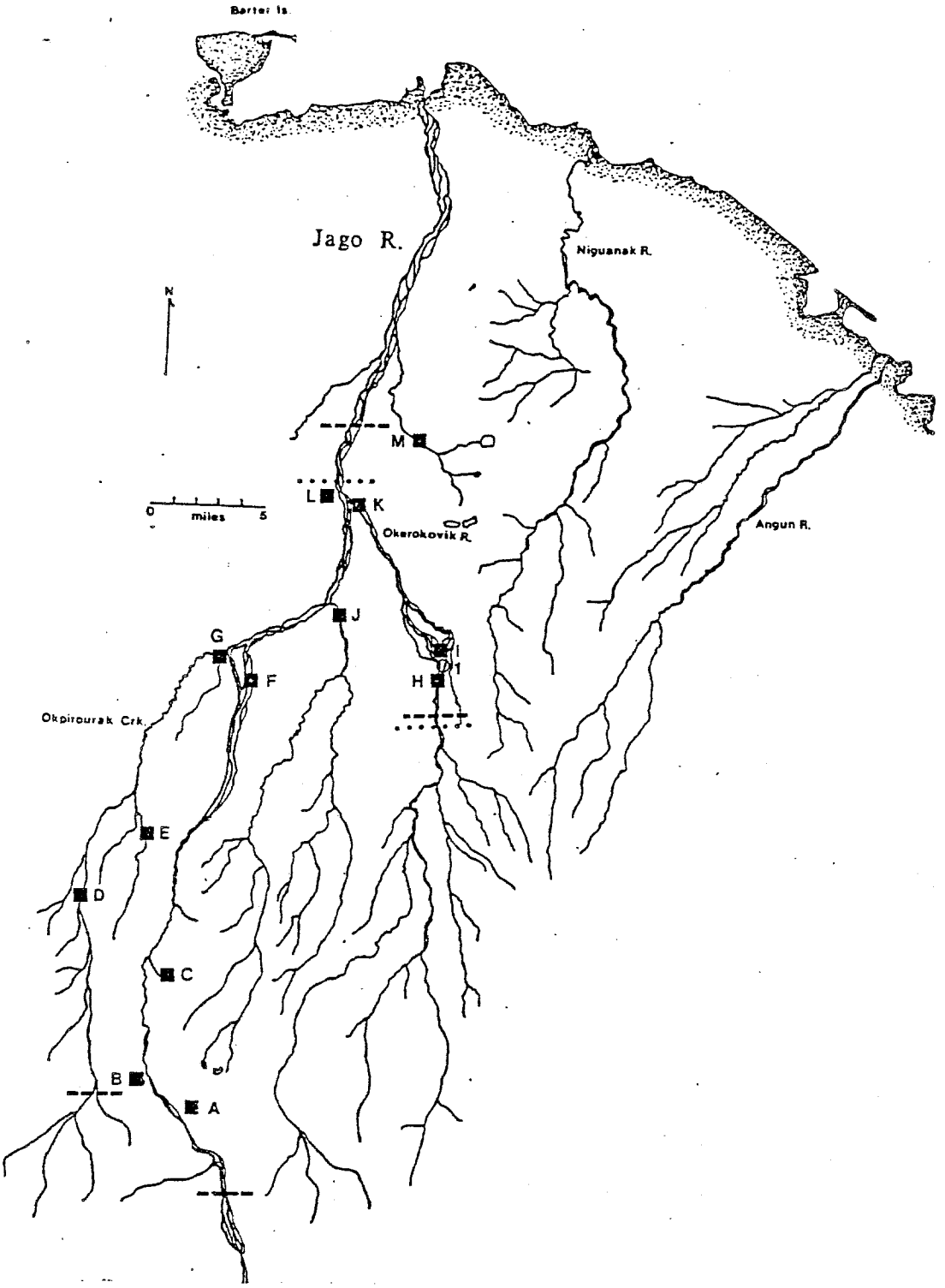


Figure 6. Fish sampling locations (■), spring area (O), and aerial survey boundaries (---- 1982)(.... 1983) in the Jago River drainage, 1974-1983.

The Jago River and tributaries were sampled by USFWS personnel on June 30 to July 6, 1982 and July 7-8, 1983. A total of 20 hours of E-125 gill net effort, 93 hours of E-30 gill net effort and 34.6 minutes of electrofishing effort resulted in no fish collected. Two ninespine sticklebacks were captured after 102 hours of minnow trap effort at the mouth of Okpirourak Ck. (site G). Ward and Craig (1974) seined sites F, H, and I with no fish caught.

Three lakes (site A, B, C), isolated from the Jago River system, were investigated July 7-9, 1983 by USFWS personnel. Resident populations of arctic char were found in Lakes B and C. No fish were collected in Lake A after 46 hours of E-30 gill net effort. One resident char was caught in Lake C after 48 hours of E-30 gill net effort. Forty-eight resident char were captured in Jago Lake (Lake B); 22 from 23 hours of E-125 gill net effort, 18 from 69 hours of E-30 gill net effort, and 8 from 9.3 minutes of electrofishing effort.

Aerial surveys of the Jago River system were flown on September 25, 1982 and September 13, 1983. Survey boundaries are depicted in Figure 6. No fish were spotted during these flights.

Length Frequency

A length frequency histogram for lake resident arctic char from Jago Lake (site B) is presented in Figure 7. Sixty-five percent of the sample had fork lengths between 280 and 379 mm. The largest char caught was 525 mm.

Age and Growth

Age specific lengths (determined by otoliths) for Jago Lake resident arctic char collected July 9, 1983 are found in Table 12. The youngest fish collected were in their 5th season of growth (4+ years old). The oldest char was aged at greater than 16+ years old with a fork length of 370 mm. Growth rates were similar to populations of lake resident arctic char in Northern Alaska summarized by McCart (1980).

Table 12. Age specific length (otolith) of arctic char collected from Jago Lake, July 9, 1983.

| Age | Sample Number | Mean Fork Length (mm) | Standard Deviation | Length Range (mm) | Percent Mature |
|---|---|---|---|---|---|
| 4+ | 4 | 139.5 | 5.4 | 135 - 147 | 0 |
| 5+ | 1 | 260.0 | - | - | 100 |
| 6+ | 4 | 274.7 | 16.0 | 253 - 289 | 100 |
| 7+ | 3 | 280.7 | 24.9 | 252 - 297 | 100 |
| 8+ | 7 | 327.7 | 29.0 | 284 - 366 | 100 |
| 9+ | 1 | 337.0 | - | - | 100 |
| 10+ | 3 | 364.3 | 17.2 | 349 - 383 | 100 |
| 11+ | 1 | 395.0 | - | - | 100 |
| 12+ | 1 | 398.0 | - | - | 100 |
| 13+ | 2 | 417.0 | 18.4 | 404 - 430 | 100 |
| 17 - 18+ | 1 | 370.0 | - | - | 100 |

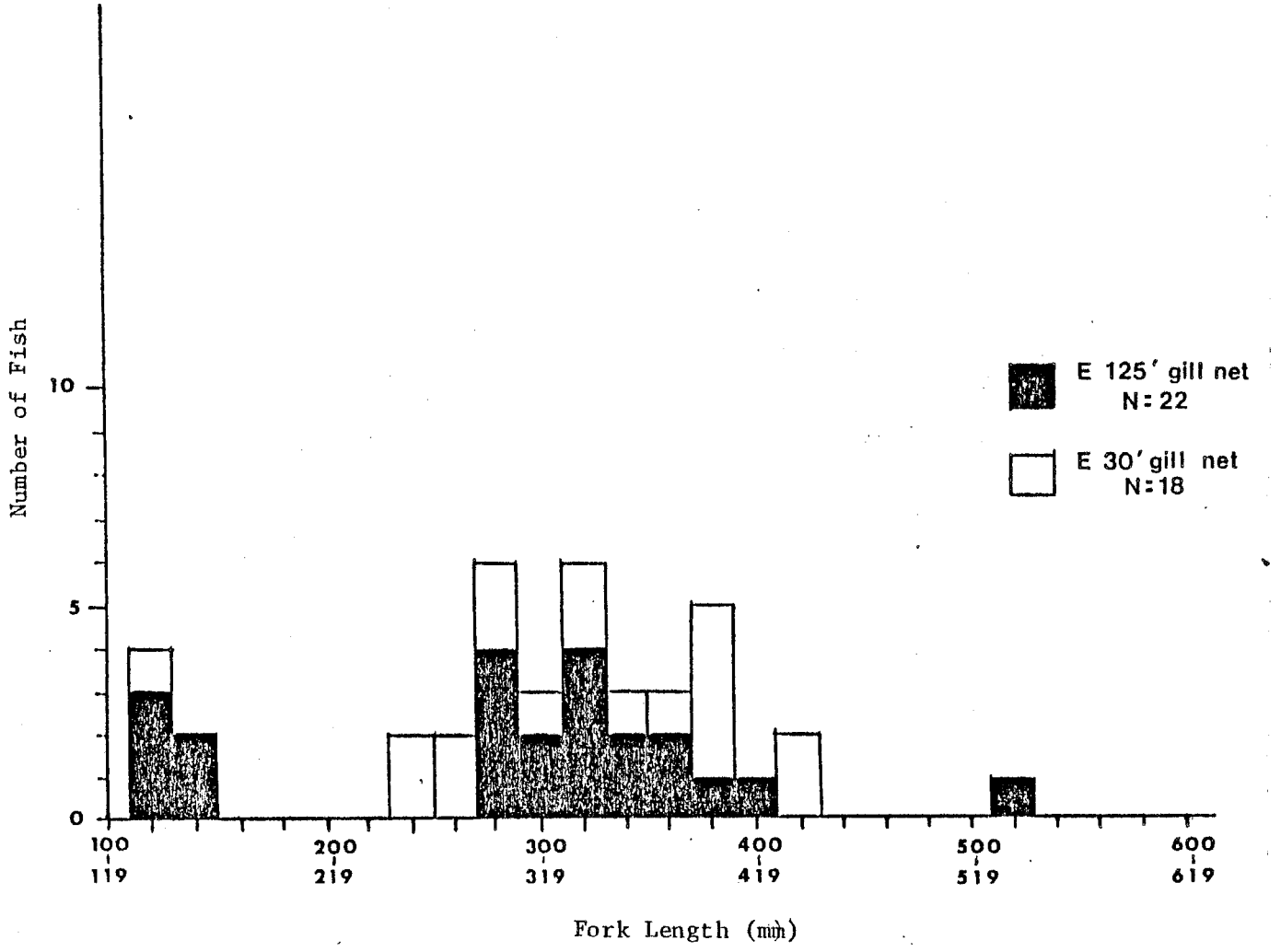


Figure 7. Length frequency of 40 arctic char collected by experimental gill net in Jago Lake, July 9, 1983.

The Jago Lake residents collected reached sexually maturity after the age of 4 years old. From Table 12, all 4+ aged fish were immatures with older age classes consisting of 100% sexually mature individuals. These results are similar to data collected from Canning Lake CT-28, Alaska (Craig, 1977). McCart and Bain (1972) described a north slope population of lake resident char at Campsite Lake, Alaska which did not begin to spawn till 9 years of age.

From the total sample of 40 char, 15% were immature, 42.5% mature males, and 42.5% mature females.

Since sample size for the Jago Lake population is small, comparisons with other studies should be examined in general terms.

The following length-weight relationship was calculated for arctic char collected from Jago Lake, July 9, 1983.

Lake resident arctic char (n = 40, r = 0.992, fork length range = 126-528 mm, weight range = 10-875 gms) =

$$\text{Log}_{10} W_{(g)} = 3.278 \text{ Log}_{10} L_{(mm)} - 5.768.$$

Table 13. Coefficient of condition (K) for arctic char collected from Jago Lake, July 9, 1983.

| Length Group (mm) | Number in Sample | Mean K | Standard Deviation |
|---|---|---|---|
| 100 - 149 | 6 | 0.60 | 0.06 |
| 150 - 199 | 0 | - | - |
| 200 - 249 | 0 | - | - |
| 250 - 299 | 10 | 0.90 | 0.04 |
| 300 - 349 | 11 | 0.93 | 0.09 |
| 350 - 399 | 9 | 0.87 | 0.06 |
| 400 - 449 | 3 | 0.78 | 0.16 |
| 450 - 499 | 0 | - | - |
| 500 - 549 | 1 | 0.59 | - |

## HULAHULA RIVER

### Physical - Chemical Characteristics

The Hulahula River is a third order stream. In the lower reaches the stream is braided with over a 0.38 percent gradient. The upper tributaries consist of straight channel configurations and steeper gradients increasing to 9.5 %. Three springs were found in the Hulahula River. Only one of these springs is within the study area. Five sites on the Hulahula River main channel were sampled during July and September 1983 and four tributaries in the upper Hulahula and one in the lower river were sampled in July 1983 (Figure 8).

Discharge was determined for the upper Hulahula River site and the five tributaries (Table 14). Discharge ranged from 0.03 cms in the lower tributary to 8.87 cms in the upper Hulahula River. Discharge of the main river approximately 40 km from the mouth was also measured at 20.9 cms on August 7,

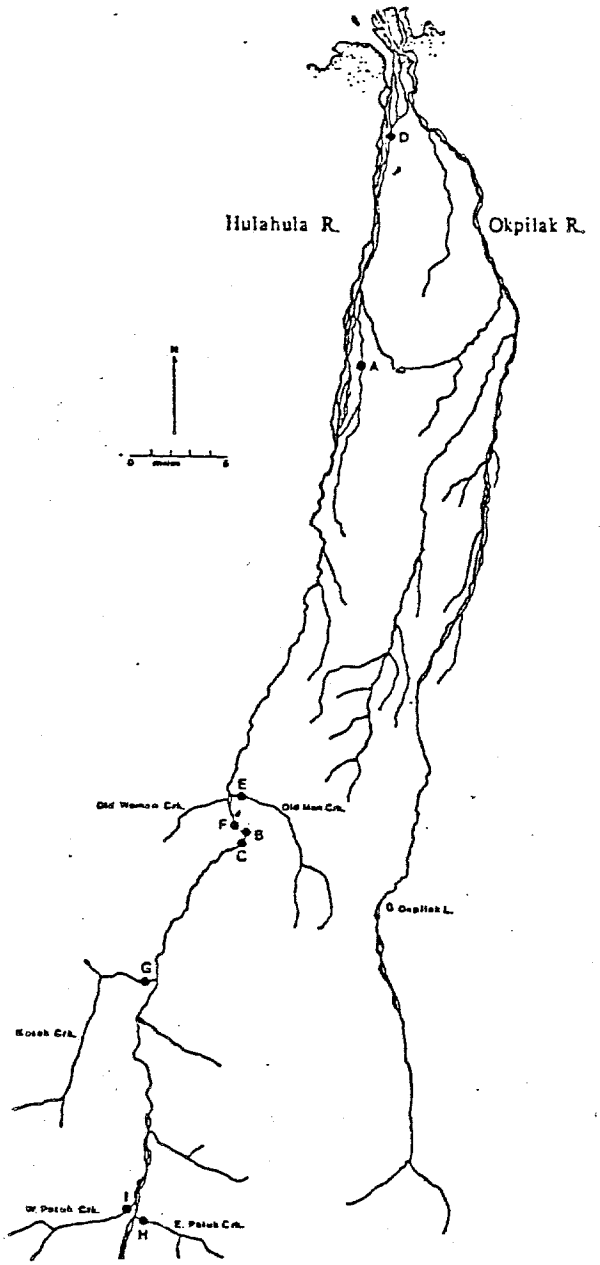


Figure 8. Chemical and physical sampling locations in the Hulahula River, July and August 1983.

Table 14. Physical characteristics of sample areas on the Hulahula River, July and August 1983.

| | Stream Order | % Gradient | Channel Configuration | Wetted Perimeter (m) | Average Depth (m) | Discharge (cms) | Average Velocity (m/s) | % Pool Area | % Riffle Area | Predominant Substrate |
|---|---|---|---|---|---|---|---|---|---|---|
| Hulahula River | | | | | | | | | | |
| A | 3 | 0.38 | Irregular | 2.7 | .21 | .03 | .06 | - | - | - |
| F | 3 | 0.53 | Irregular | 49.4 | .45 | 8.87 | .42 | 40 | 60 | Cobble and Boulder |
| Patuk Creek | | | | | | | | | | |
| H | 3 | 3.8 | Straight | 13.4 | .34 | 3.4 | .79 | 5 | 95 | Small and Large Gravel |
| I | 2 | 9.5 | Straight | 14.6 | .15 | 1.02 | .49 | 10 | 90 | Small and Large Gravel |
| Katak Creek | | | | | | | | | | |
| G | 3 | 3.25 | Straight | 16.5 | .18 | 1.47 | .52 | - | - | - |
| Old Man Creek | | | | | | | | | | |
| E | 2 | 2.84 | Straight | 10.2 | .27 | .78 | .30 | - | - | - |

1975 (Childers, et.al., 1977). The main channel width, at the upper river site was 49.4 m with an average depth of 0.45 m. The tributaries ranged from a width of 2.7 m in the lower tributary to 16.5 in Katak Creek. The average depth for the tributaries was 0.23 m.

Water chemistry sampling for all sites is shown in Table 15. The pH ranged from 7.5 to 8.5 and conductivity fell to a low of 140 umhos/cm in Katak Creek and a high of 440 umhos/cm in the Springs in the upper Hulahula River. Total alkalinity ranged from 68.4 mg/l in Katak Creek to 153.9 mg/l in the springs. Total hardness ranged from 68.4 mg/l in West Patuk Creek to 273.6 mg/l in East Patuk Creek.

Table 15. Chemical characteristics of sample areas on the Hulahula River, July and August 1983.

| | Total Alkalinity (mg/l) | Total Hardness (mg/l) | Conductivity (umhos/cm) | $H_2O$ Temp. (°C) | Air Temp. (°C) | pH |
|---|---|---|---|---|---|---|
| Hulahula River (July) | | | | | | |
| A | 119.7 | 153.9 | 270 | 6.0 | 6.0 | 8.0 |
| B | 153.9 | 222.3 | 440 | 7.0 | 9.0 | 7.8 |
| C | 85.5 | 102.6 | 180 | 8.0 | - | 7.5 |
| Lower Hulahula River (August) | | | | | | |
| D | 102.6 | 173.9 | 320 | 9.5 | 9.0 | 8.5 |
| Old Man Creek (July) | | | | | | |
| D | 102.6 | 119.7 | 155 | 10.0 | 14.0 | 8.0 |
| Upper Hulahula River (August) | | | | | | |
| F (Aug. 14) | 102.6 | 136.8 | - | 7.0 | 10.0 | 7.8 |
| F (Aug. 31) | 119.7 | 222.3 | 360 | 4.0 | 2.0 | 8.0 |
| Katak Creek (July) | | | | | | |
| G | 68.4 | 85.5 | 140 | 7.0 | 16.0 | 7.5 |
| Patuk Creek (July) | | | | | | |
| H | 102.6 | 273.6 | 340 | 5.0 | 6.0 | 8.0 |
| I | 68.4 | 68.4 | 150 | 5.5 | 5.0 | 7.5 |

Fish Distribution and Abundance

Figure 9 presents fish sampling locations and spring areas for the Hulahula River drainage. Distribution of fish species collected from various sample areas is found below in Table 16.

Table 16. Fish distribution in the Hulahula River drainage.*

| Sample Areas | Sample Date(s) | Fish Species | Life Stage(s) | Comments |
|---|---|---|---|---|
| A | July 14, 1983 | No fish collected. | | USFWS, Fishery Resources, Fbks. |
| B | Aug. 3- Sept. 1, 1983 | AC | J,A | USFWS, Fishery Resources, Fbks. |
| | | GR | J,A | |
| | July 16, 1983 | No fish collected. | | |
| C | July 11, 1983 | AC | J | USFWS, Fishery Resources, Fbks. |
| D | July 11-16, 1983 | No fish collected. | | USFWS, Fishery Resources, Fbks. |
| E | Aug. 12- Sept. 21, 1983 | AC | J,A | USFWS, Fishery Resources, Fbks. |
| | | Gr | A | |
| F | July 11, 1983 | Gr | J,A | USFWS, Fishery Resources, Fbks. |
| G | July 16, 1983 | AC | J | USFWS, Fishery Resources, Fbks. |
| H | July 15, 1983 | AC | J | USFWS, Fishery Resources, Fbks. |
| I | July 15, 1983 | AC | J | USFWS, Fishery Resources, Fbks. |

Gr - Grayling AC - Arctic Char A - Adult J - Juvenile

*See figure 9 for sample site locations.

Sixty fish, 57 arctic char and 3 grayling, were collected during the sampling period of July 1-16, 1983. Electrofishing was used to collect the majority of the fish, with two grayling caught in a 30 ft. experimental gill net, in the main channel of the upper Hulahula. Arctic char were widely distributed throughout the drainage. They were collected in almost all of the areas sampled. Grayling were not found in the tributaries of the upper Hulahula. Of the 60 fish collected, 59 were juvenile char and grayling and one was an adult grayling from the main channel of the upper Hulahula.

During the August-September survey of the main channel Hulahula, 2788 fish were collected. 1046 fish were caught in the lower river. Of those fish, only one grayling was collected. The majority of the char were collected from pool areas and calm side waters. 1742 fish were collected from the main channel of the upper river; 47 grayling and 1695 char. Arctic char distribution was consistent throughout the reach sampled with larger concentrations in deep pools.

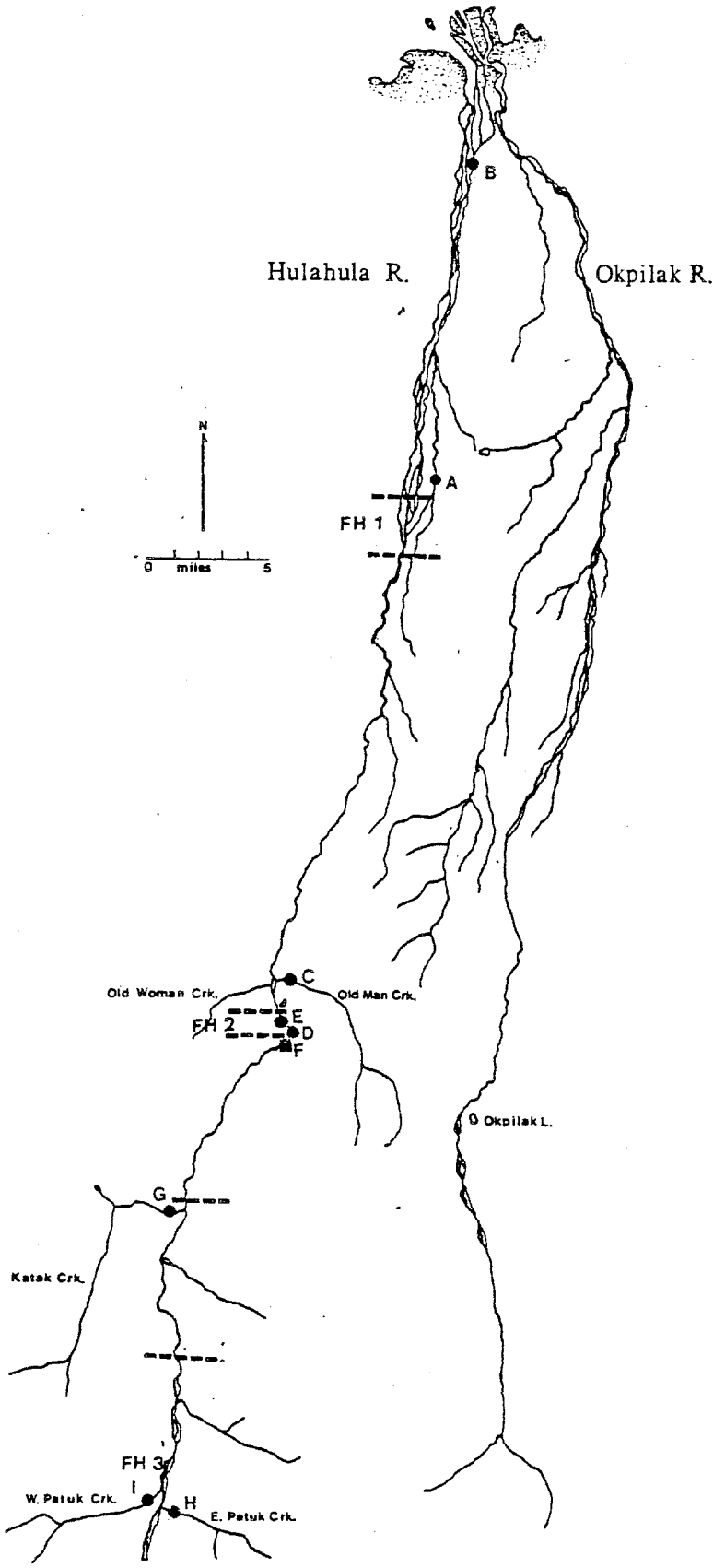


Figure 9. Fish sampling locations (●), spring area (■), and aerial survey boudaries (----1983) in the Hulahula River system, 1983.

Relative abundance and length ranges of fish collected in the Hulahula River during August and September, 1983 is shown in Table 17. Graphs depicting the various catch-per-unit-effort rates are found in Figure 10 through 15. Arctic char were abundant throughout the sampling areas. Electrofishing was the main sampling technique during the July sampling. Catch rates on the lower river tributary, Katak Creek, East and West Patuk Creeks were 0.26/min., 1.3/min., 0.8/min. and 0.8/min., respectively. A 30' experimental gill net was set on Katak Lake for four hours with no fish caught.

Several sampling techniques were used during the August and September, 1983 sampling. Gillnets were used only in the lower river with catch rates of 0.41/hr. for 30' nets and 0.37/hr. for the 125' net. Angling catch rates were 0.49/hr. and 4.5/hr. for the lower and upper river, respectively. One hundred foot seine haul catch rates for the lower river was 2.6/haul and 3.8/haul for the upper river. Electrofishing was used on the upper river, with a catch rate of 0.26/min. Minnow trap sampling in the lower Hulahula resulted in a catch rate of 0.3/hr.

Table 17. Catch-per-unit-effort and fork length range of grayling and arctic char collected in the Hulahula River drainage, July 1-16 and August 1 - September 21, 1983.

| *Sample Location | Fish Species | # of Fish Collected | Total Effort | Length Range(mm) | Catch per Unit Effort |
|---|---|---|---|---|---|
| | | 30' Experimental Gill Net | | | |
| B | AC | 164 | 404.3 hrs. | 123-658 | .41/hr. |
| G | - | 0 | 4.0 hrs. | - | - |
| | | 125' Experimental Gill Net | | | |
| B | AC,Gr | 229 | 617.9 hrs. | 114-568 | .37/hr. |
| | | Angling | | | |
| B | AC | 11 | 22.3 hrs. | 70-576 | .49/hr. |
| E | AC,Gr | 1029 | 263.6 hrs. | 209-701 | 4.5 /hr. |
| | | 100' Seine | | | |
| B | AC | 582 | 225 hauls | 54-623 | 2.6 /haul |
| E | AC,Gr | 34 | 9 hauls | 172-303 | 3.8 /haul |
| | | Electrofishing | | | |
| A | - | 0 | 10 min. | - | - |
| C | AC | 2 | 7.8 min. | - | .26/min. |
| E | AC,Gr | 679 | 12.7 hrs. | 197-727 | .97/min. |
| G | AC | 13 | 10.2 min. | - | 1.3 /min. |
| H | AC | 7 | 8.6 min. | - | .8 /min. |
| I | AC | 23 | 28.6 min. | - | .8 /min. |
| | | Minnow Trap | | | |
| B | AC | 60 | 189 hrs. | 63-162 | .3 / hr. |

AC - Arctic Char Gr - Grayling

*See Figure 9 for sample locations.

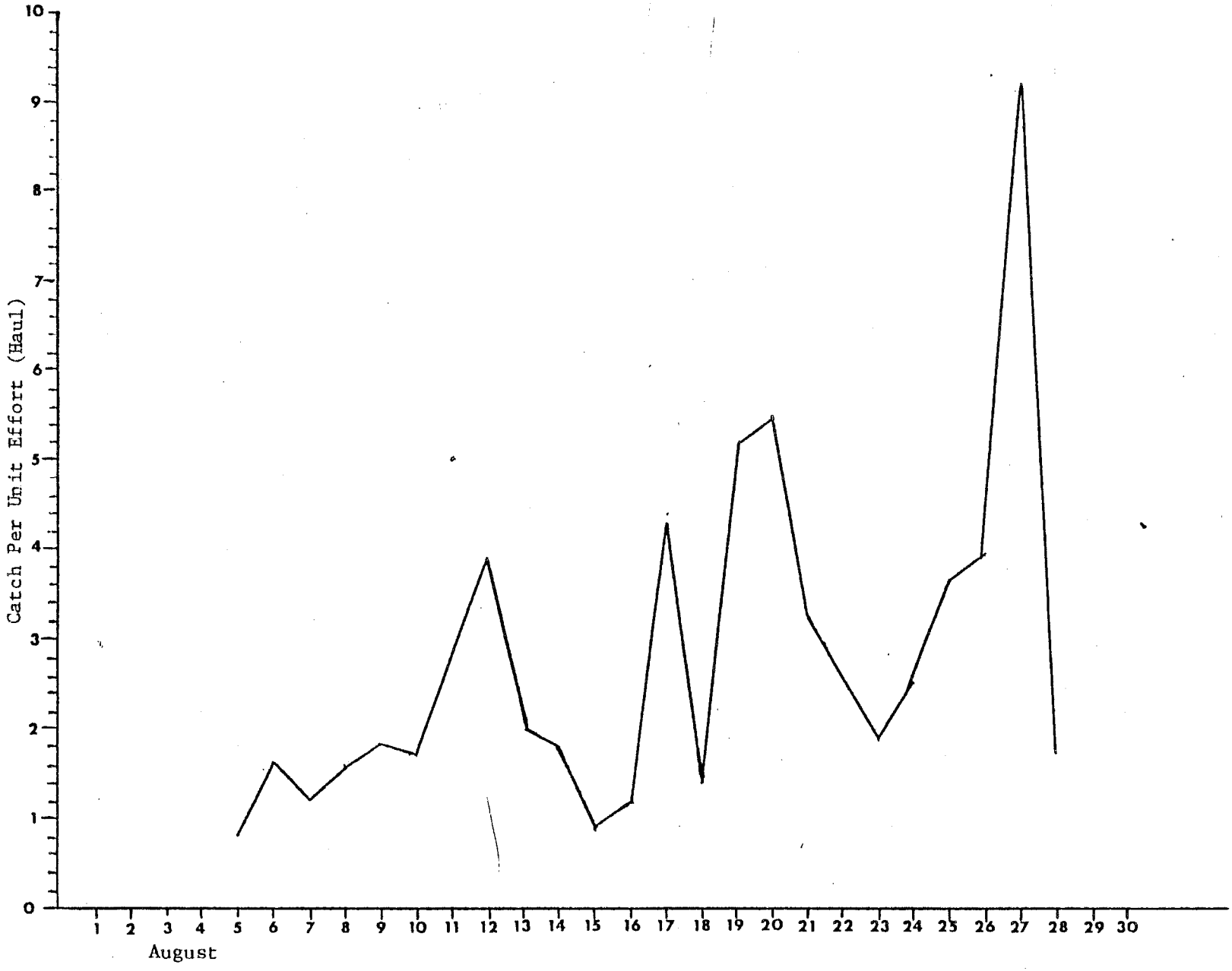


Figure 10. Daily catch rates of 582 arctic char collected by seine in the Lower Hulahula River, August 1 - 28, 1983.

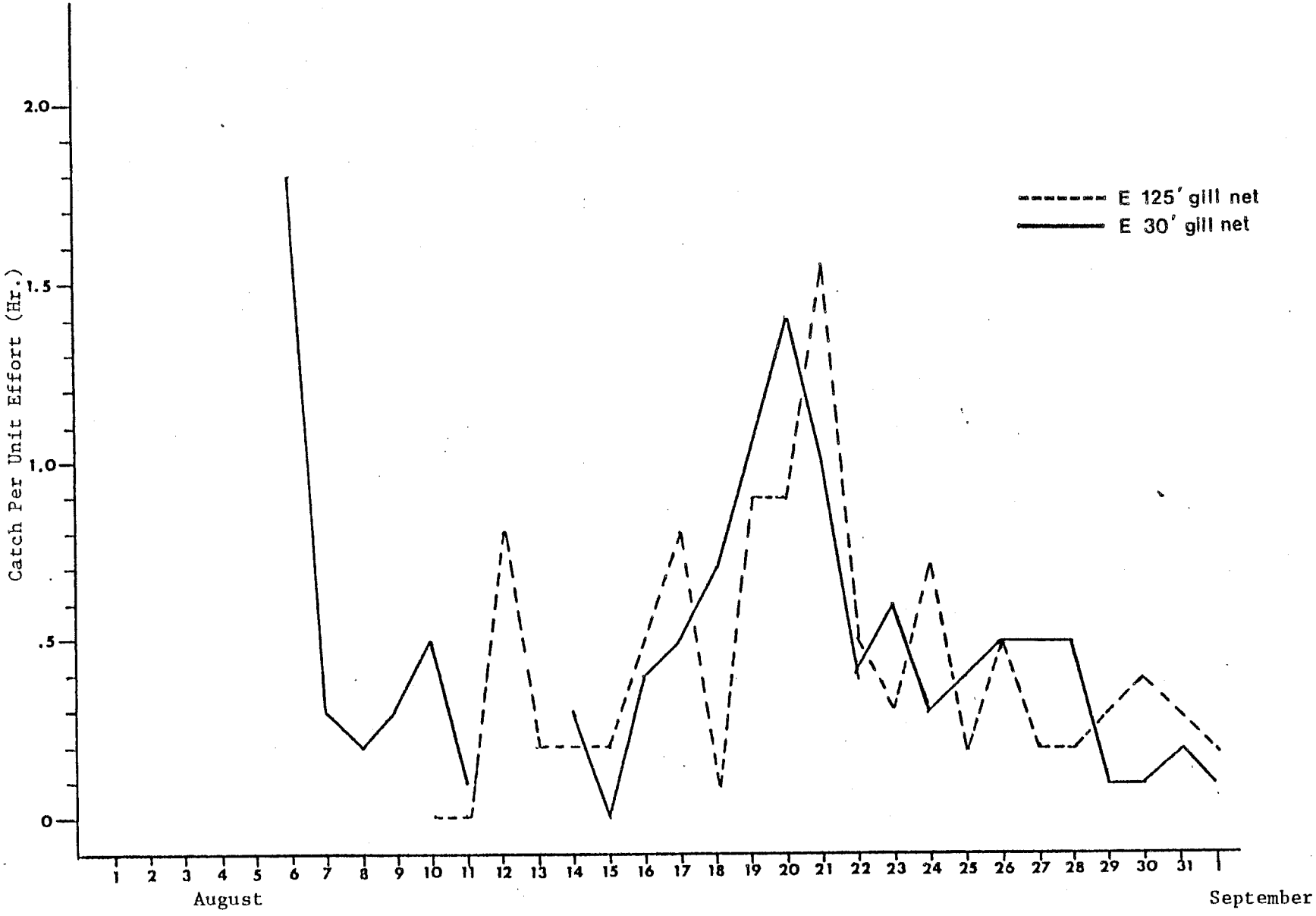


Figure 11. Daily catch rates of 393 arctic char collected by experimental gill nets in the Lower Hulahula River, August 1 - September 1, 1983.

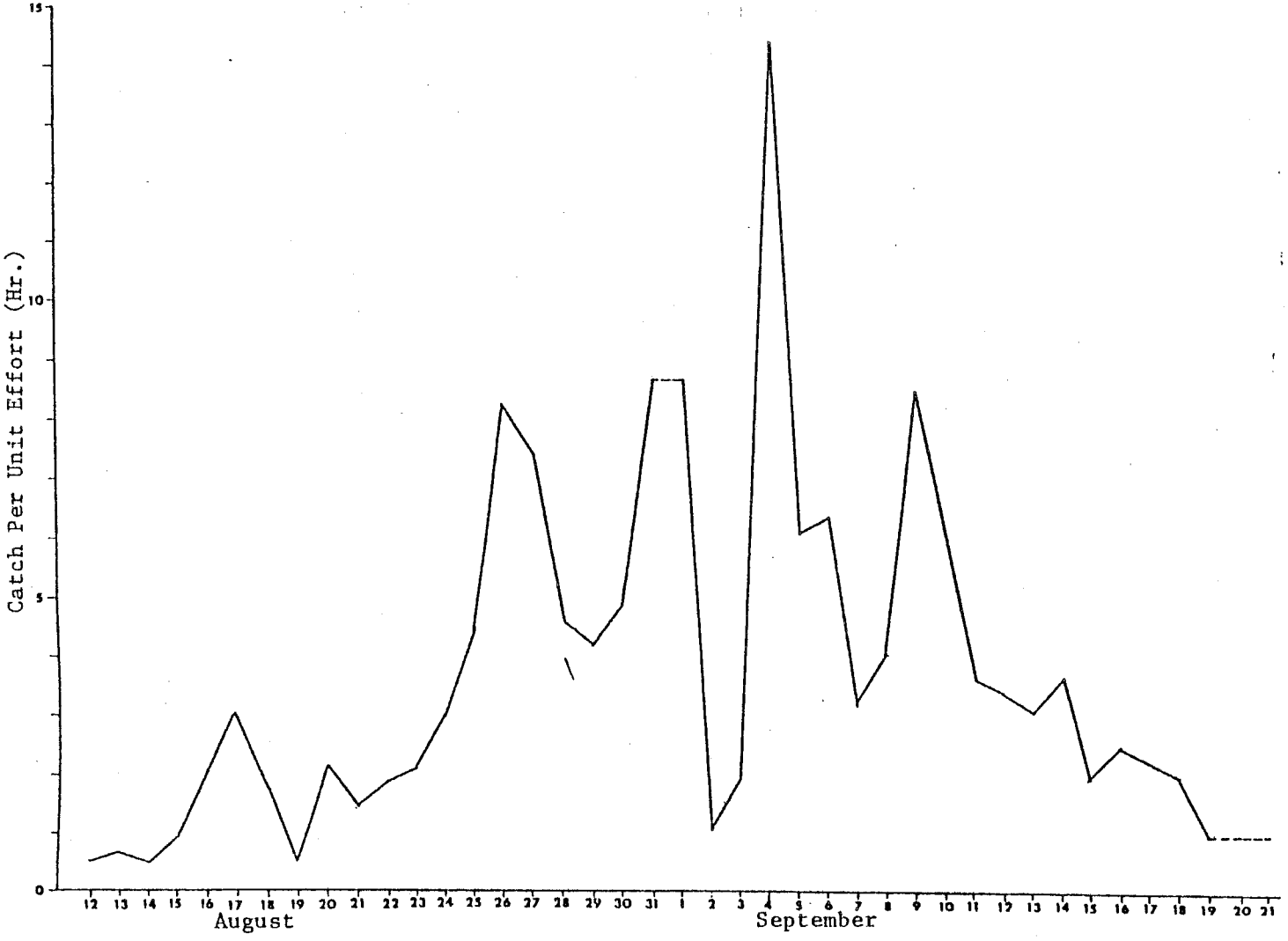


Figure 12. Daily catch rates of 1003 arctic char by angling in the Upper Hulahula River, August 12 - September 21, 1983.

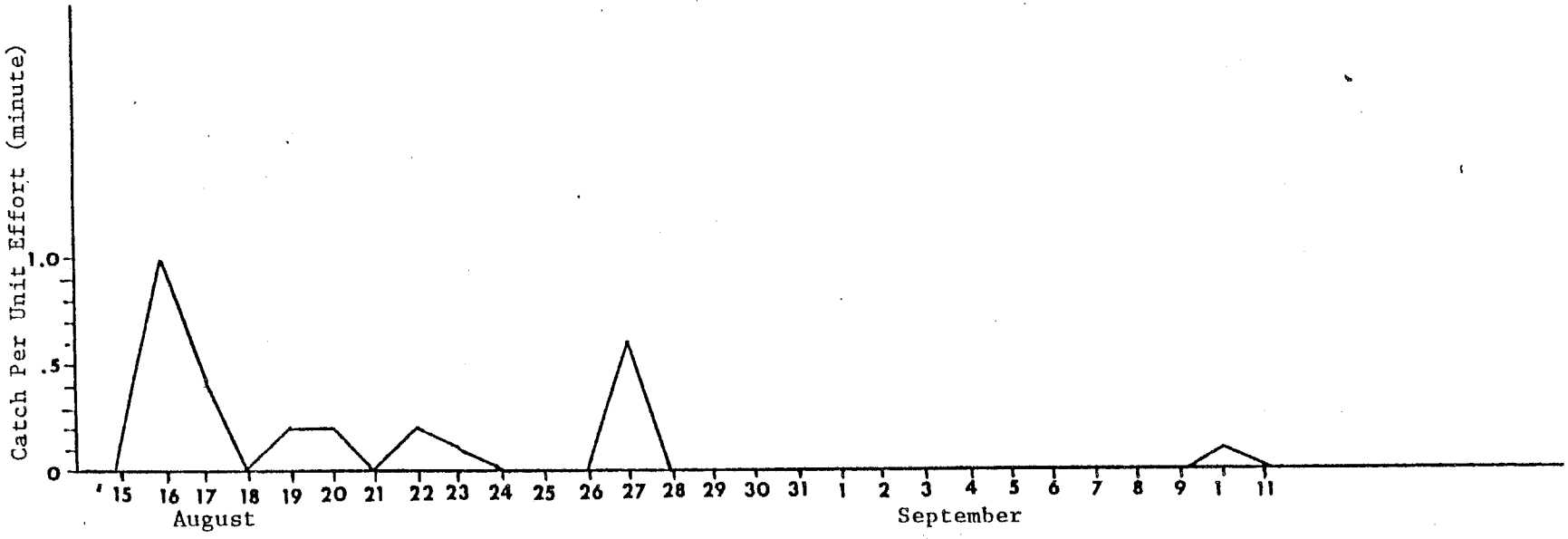


Figure 13. Daily catch rates of 16 arctic grayling by electrofishing in the Upper Hulahula River, August 15 - September 11, 1983.

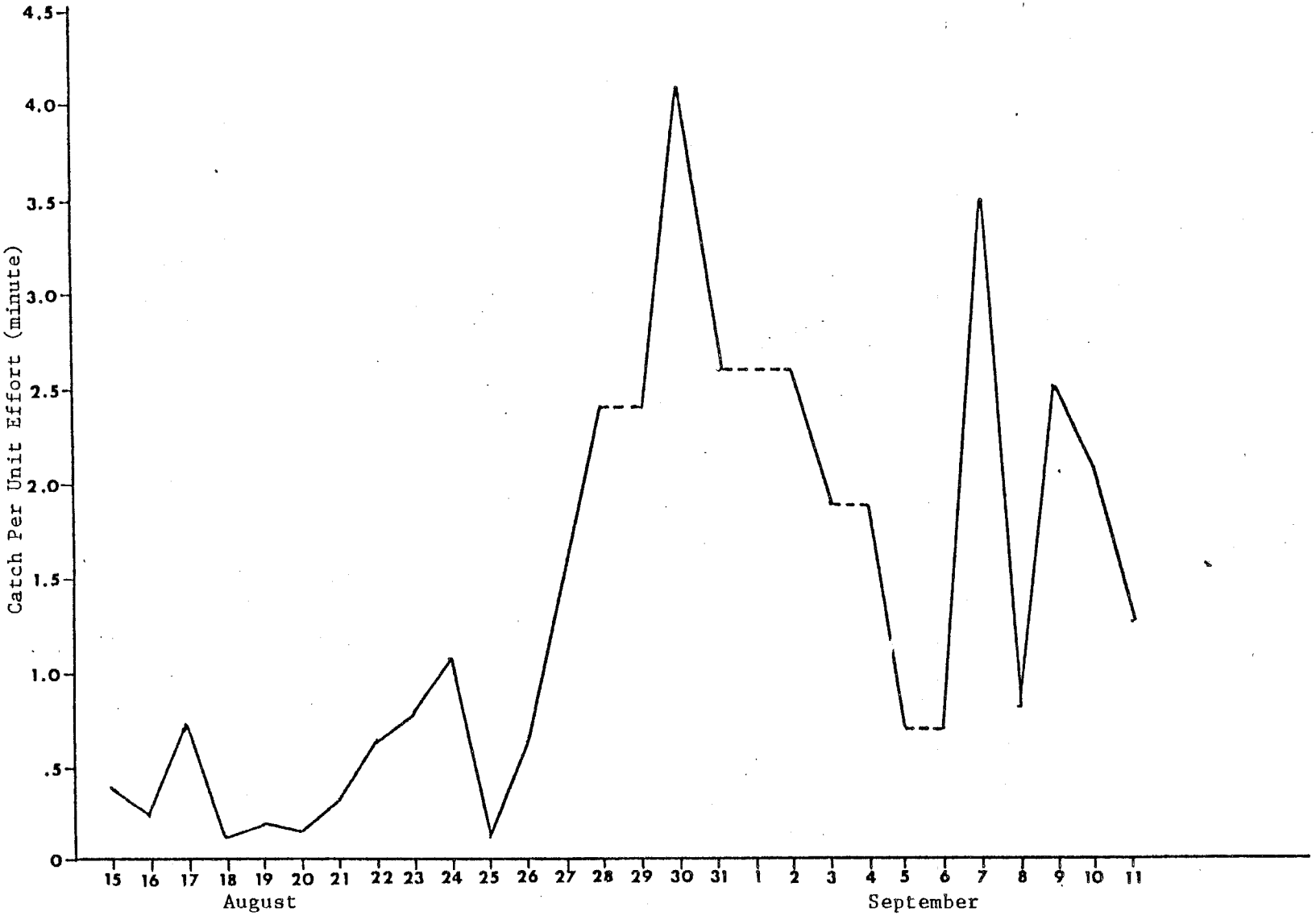


Figure 14. Daily catch rates of 663 arctic char by electrofishing in the Upper Hulahula River, August 15 - September 11, 1983.

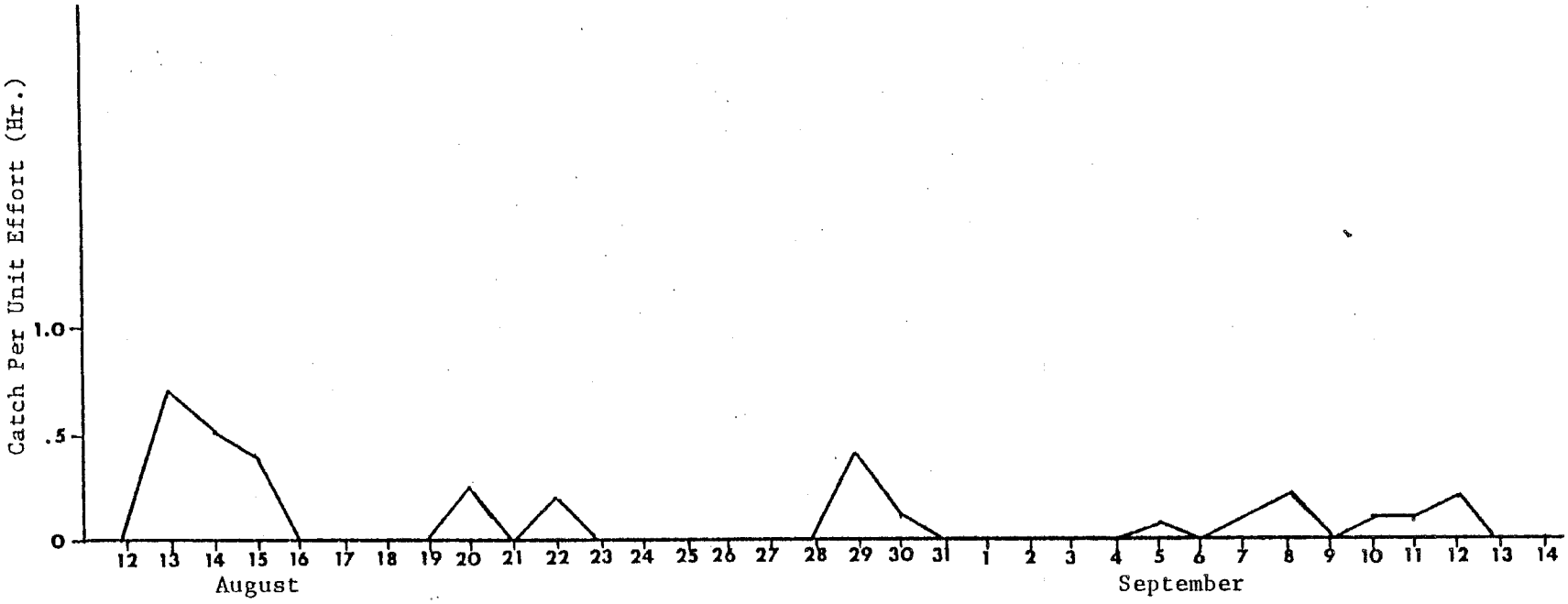


Figure 15. Daily catch rates of 26 arctic grayling collected by angling in the Upper Hulahula River, August 12 - September 20, 1983.

## Length Frequency

Length frequency histograms for char and grayling collected from the Hulahula River are presented in Figures 16 through 19. In the lower site the char were predominantly within the 280 to 320 mm length group. The length increased in the upper river to where the majority fell between 420 and 460 mm.

## Age and Growth

Age and growth information for char is shown in Table 18 and Figure 20. In a comparison of length-age relationships for char from the Hulahula River and the Sadlerochit and Itkilyariak Rivers (USFWS, 1983) the stocks are similar. These figures are higher than most of the Canning River (USFWS, 1983) figures. Only the main channel of the Canning, near Shublik Springs had length-age ranges larger than the Hulahula River. Char were aged from two sampling locations; lower and upper Hulahula (map location B and E). Age classes 0 to 12+ were represented in the sampled group. Otoliths were used to age all char sampled. The oldest fish caught was from the upper Hulahula with a fork length of 494 mm and in age class 12. The majority of the fish in the Hulahula River fell between age classes 3 and 8. By age class 5 100% of the char sampled had matured.

Table 18. Age specific length (otolith) of arctic char collected from the Hulahula River, August 6 - September 21, 1983.

| Age | Sample Number | Mean Fork Length (mm) | Standard Deviation | Length Range (mm) |
|---|---|---|---|---|
| 0+ | 2 | 67.0 | 2.83 | 65 - 69 |
| 1+ | 3 | 100.7 | 3.79 | 98 - 105 |
| 2+ | 5 | 133.0 | 8.09 | 115 - 150 |
| 3+ | 17 | 242.71 | 20.07 | 200 - 269 |
| 4+ | 14 | 269.71 | 20.33 | 237 - 319 |
| 5+ | 22 | 334.59 | 40.06 | 265 - 388 |
| 6+ | 26 | 415.04 | 56.79 | 290 - 511 |
| 7+ | 14 | 458.67 | 60.38 | 362 - 518 |
| 8+ | 14 | 533.00 | 42.50 | 451 - 577 |
| 9+ | 2 | 519.00 | 48.08 | 485 - 553 |
| 10+ | 2 | 517.00 | 16.97 | 505 - 529 |
| 11+ | 1 | 343.00 | - | - |
| 12+ | 1 | 494.00 | - | - |

## Weight and Condition

The following length-weight relationships were calculated for char from the lower and upper Hulahula River sampling sites, collected during August 6-September 21, 1983.

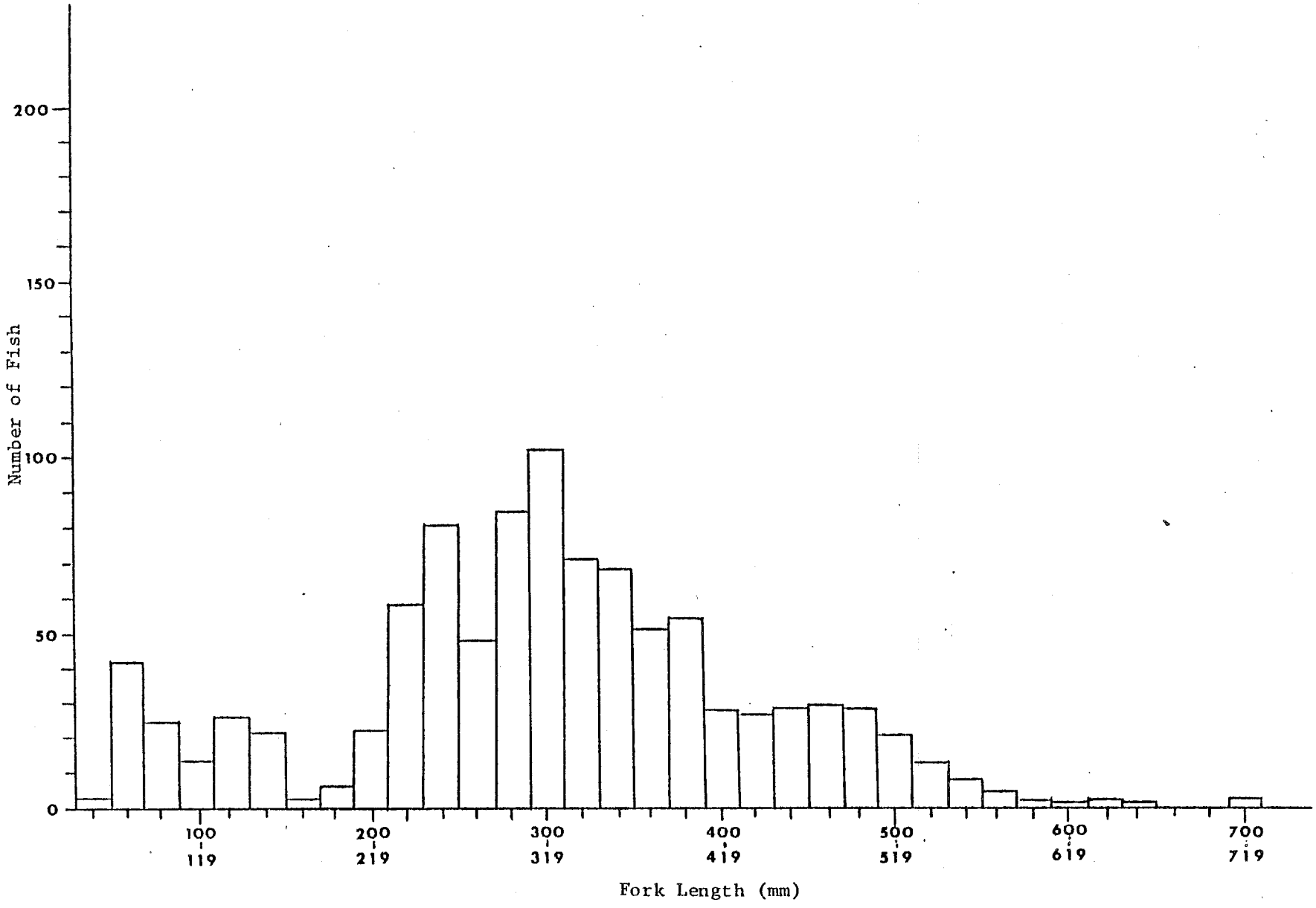


Figure 16. Length frequency of 989 arctic char collected by minnow trap, experimental gill net, seine and angling in the Lower Hulahula River, August 1 - September 1, 1983.

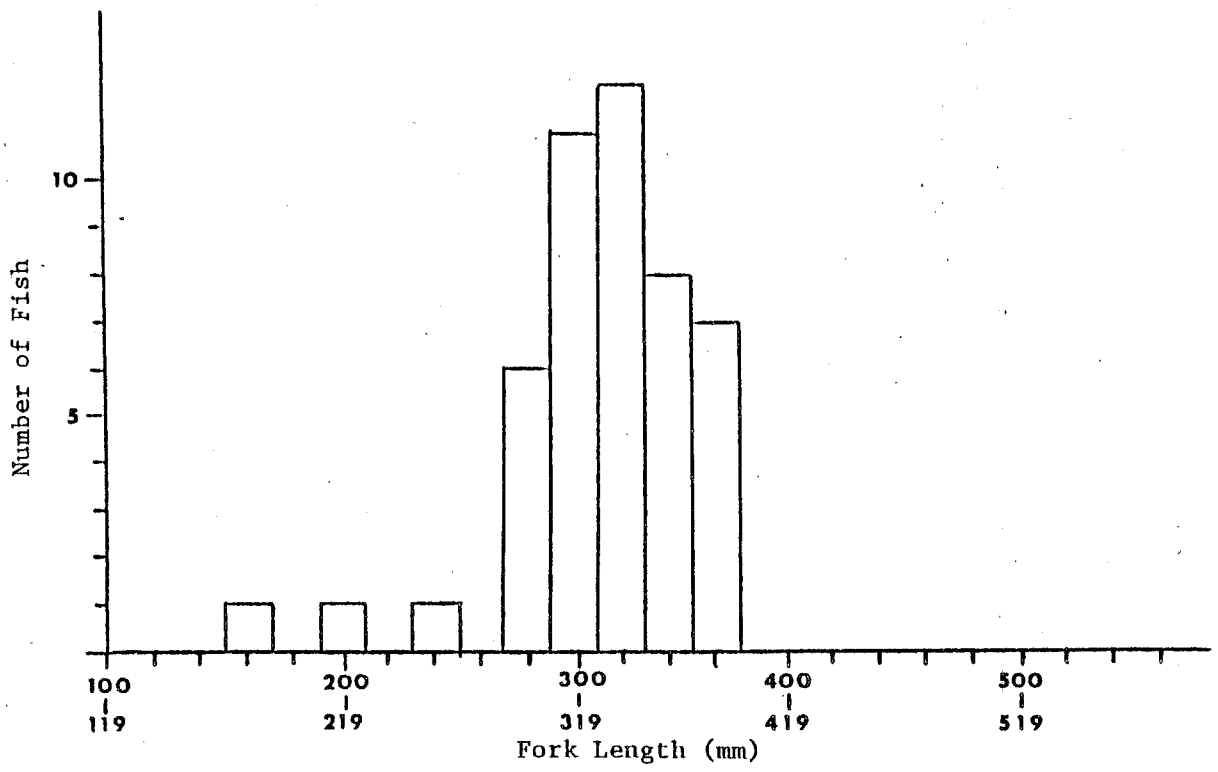


Figure 17. Length frequency for 47 arctic grayling collected by angling and electrofishing in the Upper Hulahula River, August 12 - September 20, 1983.

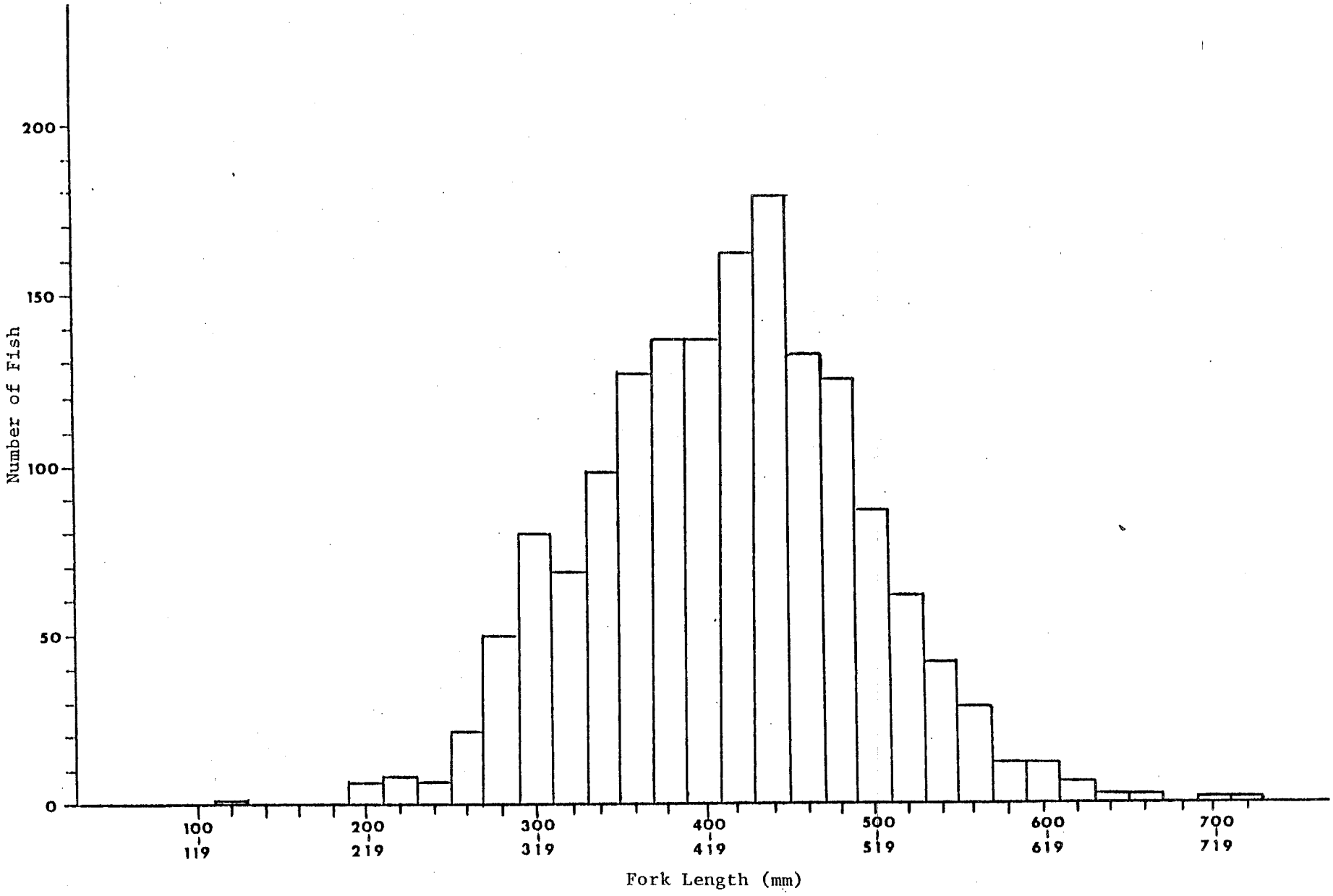


Figure 18. Length frequency of 1590 arctic char collected by electrofishing and angling in the Upper Hulahula River, August 11 - September 20, 1983.

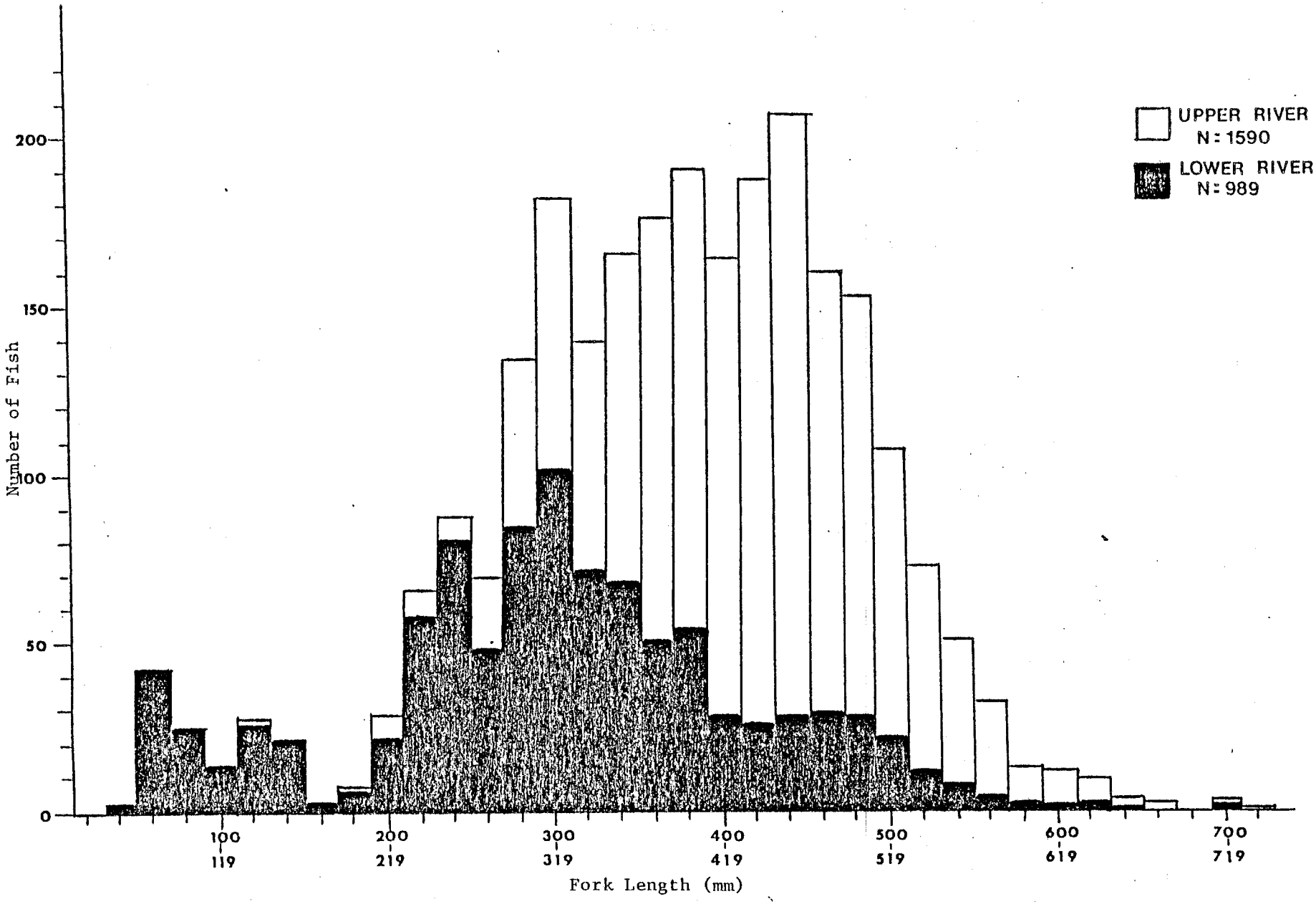


Figure 19. Length frequency of 2579 arctic char collected by minnow trap, experimental gill net, seine, electrofishing and angling in the Lower and Upper Hulahula River, August 1 - September 20, 1983.

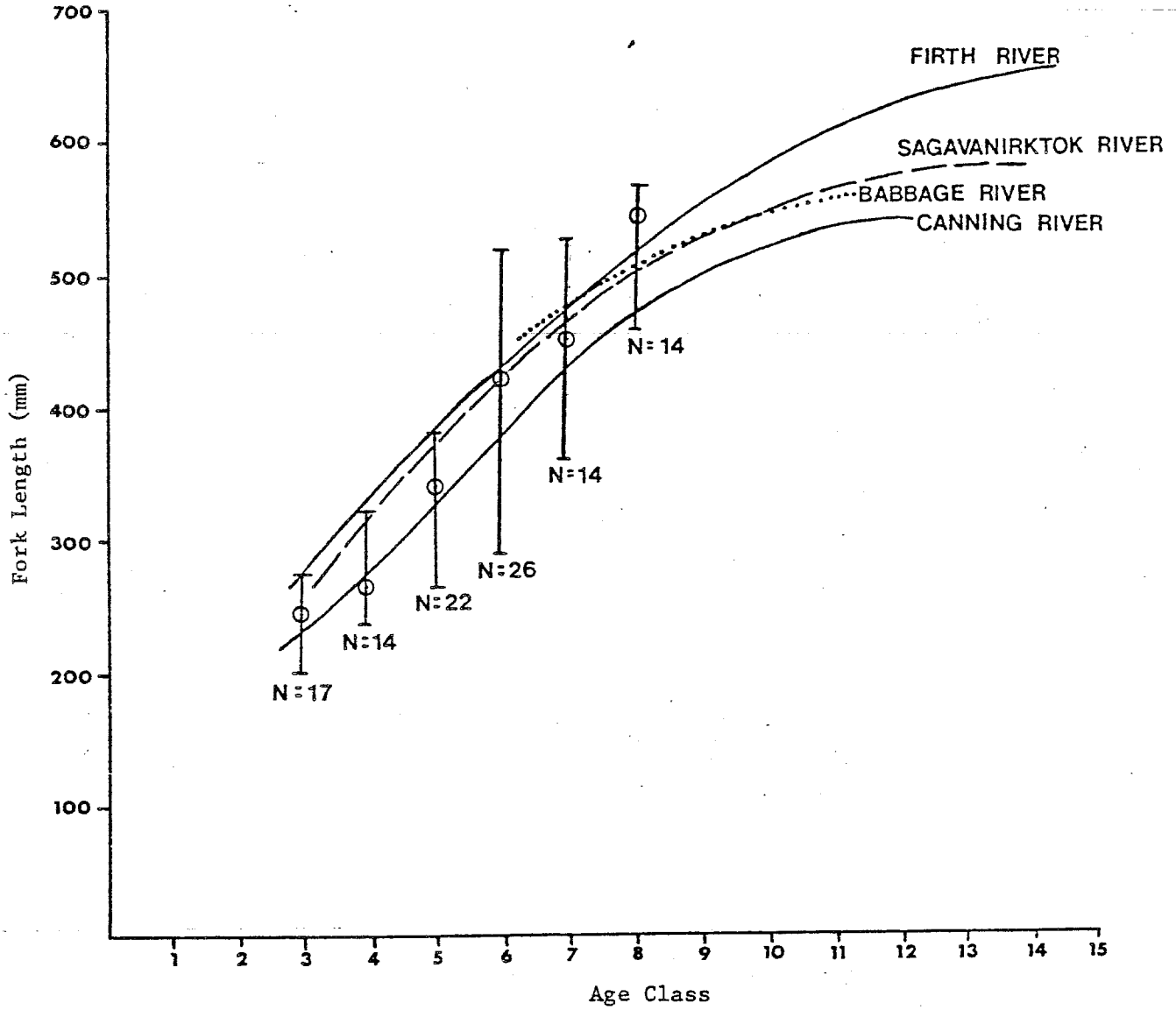


Figure 20. Comparison of growth rates of sea-run char from the Hulahula River (0 = mean, I = range) with those of other char populations in Beaufort Sea drainages.

The following length-weight relationship was calculated for arctic char collected from the Hulahula River during August 6 - September 21, 1983.

Anadromous non-spawners (n = 106, r = 0.975, fork length range = 351 to 638 mm, weight range = 340 - 2700 gms):

$\text{Log}_{10}\ W(g) = 3.345\ \text{Log}_{10}\ L(mm) - 5.947$

Anadromous spawners (n = 99, r = 0.986, fork length range = 351 to 727 mm, weight range = 440 - 3400 gms):

$\text{Log}_{10}\ W(g) = 2.959\ \text{Log}_{10}\ L(mm) - 4.917$

Anadromous male spawners (n = 53, r = 0.987, fork length range = 369 - 727 mm, weight range = 475 - 3400 gms):

$\text{Log}_{10}\ W(g) = 2.923\ \text{Log}_{10}\ L(mm) - 4.822$

Anadromous female spawners (n = 32, r = 0.979, fork length range = 417 - 604 mm, weight range = 660 - 1990 gms):

$\text{Log}_{10}\ W(g) = 3.067\ \text{Log}_{10}\ L(mm) - 5.197$

Total anadromous char (n = 205, r = 0.978, fork length range = 351 - 727 mm, weight range = 340 - 3400 gms):

$\text{Log}_{10}\ W(g) = 3.157\ \text{Log}_{10}\ L(mm) - 5.446$

Resident arctic char (n = 73, r = 0.992, fork length range = 60 - 375 mm, weight range = 3 - 450 gms):

$\text{Log}_{10}\ W(g) = 2.884\ \text{Log}_{10}\ L(mm) - 4.776$

Coefficient of condition (K) was determined for char and grayling from the lower and upper sampling locations (Tables 19 and 20). The mean K values for grayling collected from the Hulahula are similar to those collected in the Canning River (USFWS, 1983) and slightly higher than grayling found in the Tamayariak River (USFWS, 1983). The mean K values for char length groups over 250 mm are similar to those collected in the Canning River (USFWS, 1983).

Table 19. Coefficient of condition (K) for grayling from Upper Hulahula River, August 15 - September 21, 1983.

| Length Group (mm) | Number in Sample | Mean K | Standard Deviation |
|---|---|---|---|
| 150 - 199 | 1 | 0.81 | - |
| 200 - 249 | 2 | 1.04 | 0.18 |
| 250 - 299 | 7 | 0.97 | 0.06 |
| 300 - 349 | 23 | 0.97 | 0.09 |
| 350 - 399 | 11 | 0.93 | 0.06 |
| 400 - 449 | 1 | 0.57 | - |

The following length-weight relationship was calculated for grayling collected from the Upper Hulahula River during August 15 - September 21, 1983.

Grayling (n = 49, r = 0.963, fork length range = 172-410 mm, weight range = 41-500 gms):

$\text{Log}_{10}\ W(g) = 2.884\ \text{Log}_{10}\ L(mm) - 4.733$

Table 20. Coefficient of condition (K) for arctic char from the Hulahula River, August 6 - September 21, 1983.

| Length Group (mm) | RESIDENT | | | | | | | | | ANADROMOUS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Presmolt & Residuals | | | Residuals | | | Nonspawner & Immature | | | Spawner Total | | | Male Spawner | | | Female Spawner | | | Spawner Out | | |
| | n | $\bar{K}$ | S.D. | n | $\bar{K}$ | S.D. | n | $\bar{K}$ | S.D. | n | $\bar{K}$ | S.D. | n | $\bar{K}$ | S.D. | n | $\bar{K}$ | S.D. | n | $\bar{K}$ | S.D. |
| 50 - 99 | 20 | 1.08 | 0.23 | | | | | | | | | | | | | | | | | | |
| 100 - 149 | 24 | 0.87 | 0.18 | | | | | | | | | | | | | | | | | | |
| 150 - 199 | 4 | 0.87 | 0.10 | | | | | | | | | | | | | | | | | | |
| 200 - 249 | | | | 10 | 0.96 | 0.14 | 21 | 0.96 | 0.08 | | | | | | | | | | | | |
| 250 - 299 | | | | 7 | 0.94 | 0.21 | 44 | 0.97 | 0.11 | | | | | | | | | | | | |
| 300 - 349 | | | | 8 | 0.90 | 0.16 | 34 | 0.91 | 0.12 | 1 | 0.84 | - | 1 | 0.84 | - | | | | | | |
| 350 - 399 | | | | 2 | 0.81 | 0.06 | 37 | 0.87 | 0.09 | 7 | 0.93 | 0.11 | 5 | 0.94 | 0.12 | | | | | | |
| 400 - 449 | | | | | | | 40 | 0.90 | 0.13 | 26 | 0.99 | 0.17 | 8 | 0.94 | 0.08 | 15 | 1.04 | 0.21 | | | |
| 450 - 499 | | | | | | | 37 | 0.98 | 0.12 | 56 | 0.95 | 0.06 | 8 | 0.94 | 0.09 | 40 | 0.95 | 0.06 | | | |
| 500 - 549 | | | | | | | 37 | 0.98 | 0.10 | 70 | 0.95 | 0.08 | 14 | 0.93 | 0.05 | 48 | 0.97 | 0.07 | 2 | 0.66 | 0.02 |
| 550 - 599 | | | | | | | 31 | 1.01 | 0.10 | 16 | 0.96 | 0.05 | 8 | 0.93 | 0.05 | 6 | 1.00 | 0.04 | 1 | 0.64 | - |
| 600 - 649 | | | | | | | 6 | 0.98 | 0.06 | 9 | 0.88 | 0.07 | 8 | 0.89 | 0.07 | 1 | 0.82 | - | | | |
| 650 - 699 | | | | | | | | | | 3 | 0.91 | 0.09 | 3 | 0.91 | 0.09 | | | | | | |
| 700 - 749 | | | | | | | | | | 2 | 0.92 | 0.06 | 2 | 0.92 | 0.06 | | | | | | |

Spawning and Overwintering

Little is known about the spawning and overwintering of grayling in the Hulahula River. Grayling juveniles were not captured at any of this year's sample sites and adult grayling were relatively rare in fall sampling at the lower river. Several adult grayling were observed at Fish Hole 2 during August and September. Grayling were also reported in the winter subsistence catch at this site (Furniss, 1975).

Char overwintering areas are based on observations of fall concentrations during aerial surveys. Char appeared to be concentrating at Fish Holes 1, 2 and 3. (FH1, FH2, FH3 on site location map). Kaktovik villagers historically fish these three holes. The upper hole (3) is at the confluence of the Hulahula and East and West Patuk Creeks. The second hole is located one mile above Old Man Creek and receives the majority of subsistence use. The first fish hole is about 25 miles downstream of Fish Hole 2. Furniss (ADF&G, 1975) measured 34 char from the subsistence fishery at Fish Hole 2 in April 1974. Char lengths in this sample ranged from 12 to 570 mm with most fish between 200-300 mm.

Twenty-nine char were implanted with radio tags in September in an attempt to monitor fall and winter movements and to locate overwintering areas. These radio-tagged fish that were located in large concentrations at Fish Hole 2 in the fall were dispersed downstream over a 5 km section of river by November. The final results from this study will be reported in January 1985.

Anadromous char spawning habitat on the north slope is associated with springs and ground water sources that insure an adequate winter water supply for egg and fry survival. Char spawning habitat is limited on the Hulahula River. Aerial surveys in September revealed three main areas of char concentrations. These areas were associated with the subsistence Fish Holes mentioned above. Spawning was observed at Fish Hole 2. The fish observed around Fish Hole 3 were spread along a 5 km reach between Katak and East and West Patuk Creeks and are most likely spawning in this area. Although fish were observed at Fish Hole 1 during the aerial surveys, it is not known whether this area is used for spawning.

Fish Movement

Char migration was observed on the Hulahula River during August and September 1983. Timing of movement into the river was recorded by catch-per-unit-effort and is reported on Figures 10 and 11. Timing of arrival at Fish Hole 2 in the upper river was also recorded by catch-per-unit-effort and is depicted on Figures 12 through 15. Based on these results, it appears the peak movement of char into the river occurred in late August. These fish consisted primarily of non-spawning and immature char. Relatively few adult spawners were captured in the lower river. Only 8.3% of a sample of 120 fish were determined to be spawners. This may be because these fish had already moved past the area by August 5 when sampling was started or because the adults remained in fresh water during the year in which they spawn. Further work is planned next year to determine if these spawning adults do remain in the river through summer.

Char were tagged with numbered floy tags in the lower sample area during August 1983. Twelve of these fish were recaptured at the upper sample area

in late August and September (Table 21). The average time between tagging and recapture for these fish was 26 days, with the shortest time 15 days and the longest, 35 days. Distance traveled was approximately 75 kilometers.

Table 21. Char migration over a 75 kilometer section of the Hulahula River, August and September 1983.

| Tag # | Fork Length | Date Tagged | Recaptured Date | Total Days | Average Distance Per Day (km) |
|---|---|---|---|---|---|
| 3504 | 444 | 8-7 | 9-11 | 35 | 2.1 |
| 2743 | 357 | 8-8 | 9-8 | 31 | 2.4 |
| 2696 | 434 | 8-10 | 8-30 | 20 | 3.8 |
| 2691 | 447 | 8-10 | 9-6 | 27 | 2.8 |
| 2629 | 300 | 8-11 | 9-3 | 23 | 3.3 |
| 2647 | 323 | 8-11 | 9-8 | 28 | 2.7 |
| 2640 | 363 | 8-11 | 9-11 | 31 | 2.4 |
| 2538 | 362 | 8-12 | 8-27 | 15 | 5.0 |
| 2553 | 377 | 8-17 | 9-13 | 27 | 2.8 |
| 2842 | 363 | 8-20 | 9-6 | 17 | 4.4 |
| 2832 | 378 | 8-20 | 9-11 | 22 | 3.4 |
| 2807 | 308 | 8-20 | 9-16 | 26 | 2.9 |

## OTHER SITES

### Physical - Chemical Characteristics

Physical and chemical characteristics were taken on several small drainages on the arctic coastal plain. The Niguanak and Angun Rivers are second order streams with gradients of 0.25 percent in the Niguanak to 0.54 percent in the Angun. Carter Creek and Upper-Lower Marsh Creek are third order streams with gradients of 0.38%, 0.63% and 0.21%, respectively. Irregular channel area was primarily found throughout these systems. A map of these sites can be found in Figures 21 and 22.

Discharge was determined for all sites during the study period (Table 23). Discharge was estimated at 0.42 during a previous study by Childers (1977) on August 10, 1975. Discharge ranged from a low of 0.10 cms in the Carter Creek and a high of 0.89 cms in the Niguanak River. The average channel width in these areas was 10.6 m with an average depth of 0.15 m.

Water chemistry sampling for these sites is found below in Table 22. Water temperature averaged 8°C with a low of 3°C in Angun River and a high of 10.0°C in Niguanak River. The pH averaged 8.0 and conductivity ranged from 74 umhos/cm in Angun River to 400 umhos/cm in upper Marsh Creek. Total alkalinity was lowest in Angun River at 34.2 mg/l, and highest in upper Marsh Creek (119.7 mg/l). Total hardness ranged from 51.3 mg/l in Niguanak River to 289 mg/l in Upper Marsh Creek.

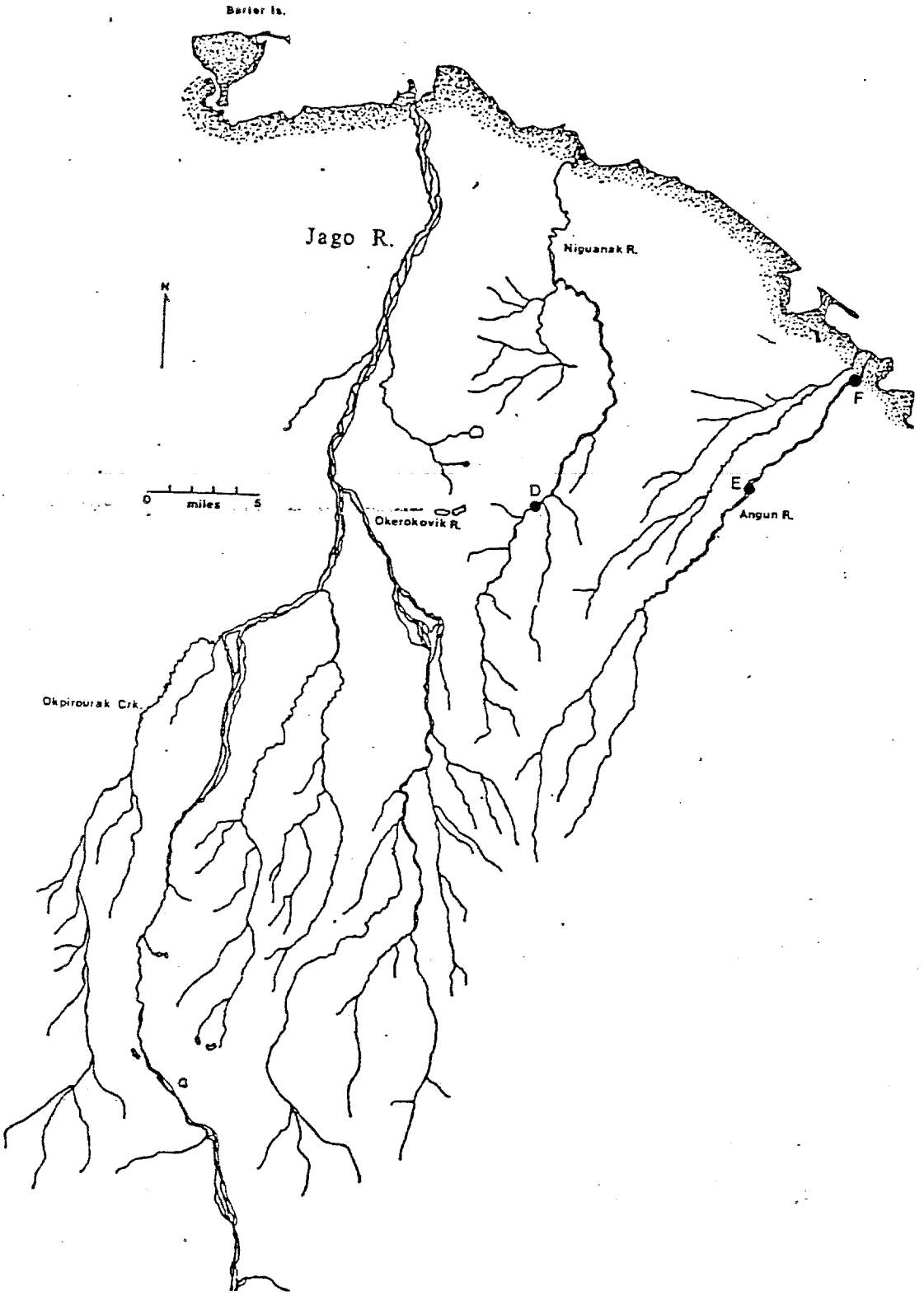


Figure 21. Chemical and physical sampling locations in the Niguanak and Angun Rivers, July 1983.

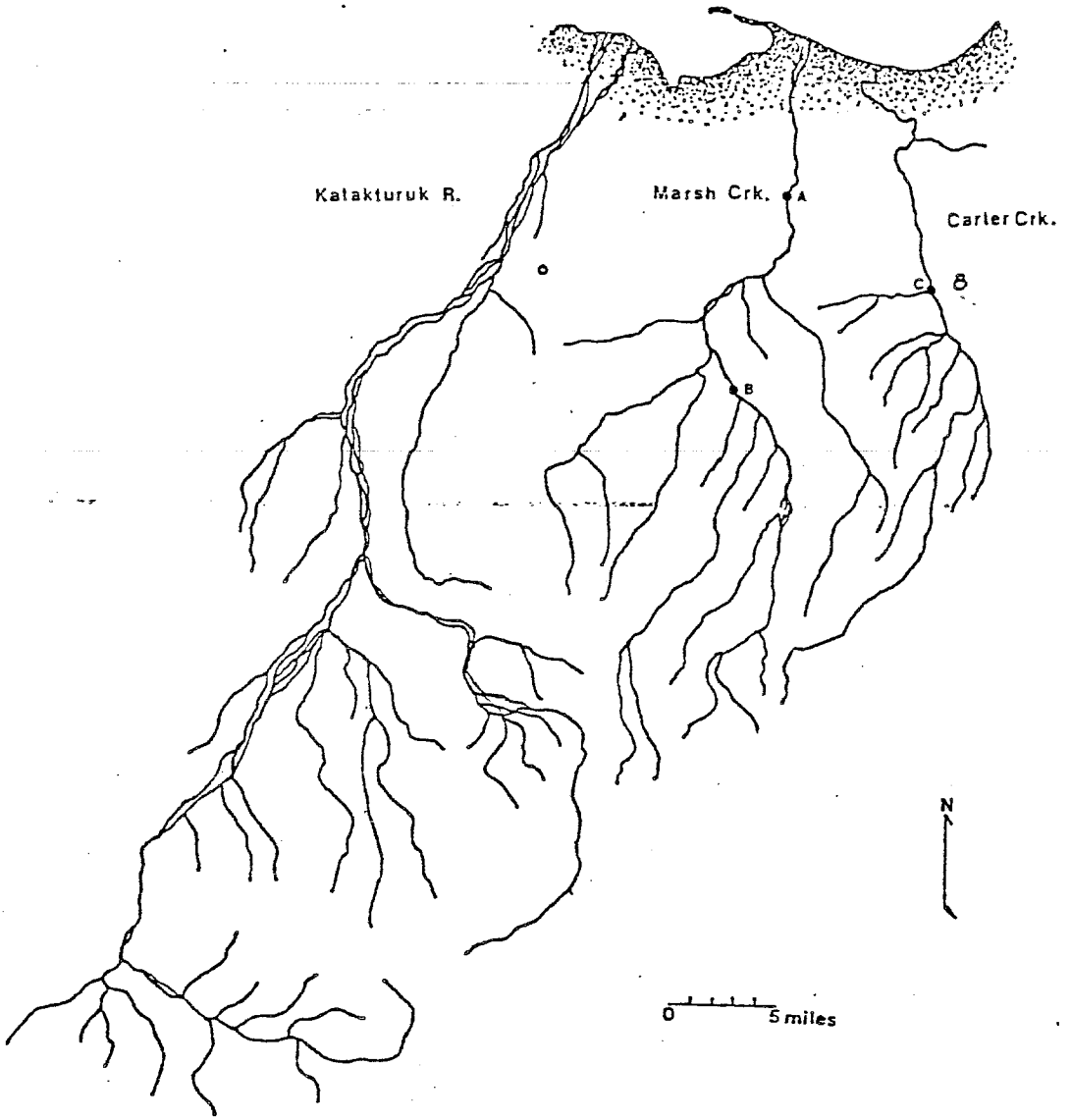


Figure 22. Chemical and physical sampling locations in Marsh and Carter Creek, July 1983.

Table 22. Chemical characteristics of sample areas on arctic coastal plain rivers, July 1983.

| | Total Alkalinity (mg/l) | Total Hardness (mg/l) | Conductivity (umhos/cm) | $H_2O$ Temp. (°C) | Air Temp. (°C) | pH |
|---|---|---|---|---|---|---|
| Upper Marsh Creek (A) | 119.7 | 289 | 400 | 8 | - | 8.5 |
| Lower Marsh Creek (B) | 119.7 | 273 | 340 | 8 | - | 8.5 |
| Carter Creek (C) | 102.6 | 85.5 | 170 | 7.0 | 5.0 | 7.5 |
| Niguanak River (D) | 68.4 | 51.3 | 95 | 10.0 | 9.0 | 8.0 |
| Angun River Site 1 (E) | 51.3 | 68.4 | 74 | 3.0 | 5.0 | 8.0 |

Fish Distribution

Fish sampling locations for the Niguanak River, Angun River, Marsh Creek and Carter Creek are presented in Figures 23 and 24. All sites were surveyed by USFWS personnel in either 1982 or 1983.

The Niguanak River was sampled on July 1-2, 1983 at two locations with no fish captured. A total of 10 hours of E-125 gillnet effort, 10 hours of E-30 gillnet effort and 11.3 minutes of electrofishing effort were used.

Two locations on the Angun River were electrofished on July 2-3, 1983 with a total of 10.2 minutes of effort. No fish were found.

Carter Creek was investigated at two sites on July 14, 1983 and site G on August 6, 1982. No fish were discovered after 17.5 minutes of electrofishing effort and 50 hours of E-30 gillnet effort.

One male anadromous char (275 mm fork length) was captured by an E-30 gillnet on July 14, 1983 in Marsh Creek (site F). Total sampling effort for both sites was 9.1 minutes of electrofishing and 74 hours of gillnet effort.

Aerial investigations of small rivers in the study areas were conducted in July of 1982 and 1983.

No fish were spotted during these flights. Many of the small streams on the coastal plain dry up by August and offer very limited seasonal fish habitat. It is unlikely that these areas support yearly populations of fish other than an occasional or accidental excursion.

Only one fish was found in these rivers. This is probably related to the lack of suitable overwintering habitats. All of these streams flow directly into the Beaufort Sea with long distances between major river drainages making migration into larger and suitable overwintering rivers difficult.

Table 23. Physical characteristics of sample areas on the Arctic coastal plains river systems, July, 1983.

| | Stream Order | % Gradient | Channel Configuration | Wetted Perimeter (m) | Average Depth (m) | Discharges (cms) | Average Velocity (m/s) | % Pool Area | % Riffle Area | Predominant Substrate |
|---|---|---|---|---|---|---|---|---|---|---|
| Upper Marsh Creek | | | | | | | | | | |
| (A) | 3 | .63 | Irregular | 11.3 | .18 | .46 | .24 | 10 | 90 | Small and Large Gravel |
| Lower Marsh Creek | | | | | | | | | | |
| (B) | 3 | .21 | Irregular | 22.6 | .21 | .68 | .15 | 20 | 80 | Small and Large Gravel |
| Carter Creek | | | | | | | | | | |
| (C) | 3 | .38 | Irregular | 4.3 | .12 | .10 | .21 | - | - | - |
| Niguanak River | | | | | | | | | | |
| (D) | 2 | .25 | Irregular | 14.0 | .18 | .89 | .37 | - | - | - |
| Angun River | | | | | | | | | | |
| (E) | 2 | .54 | Irregular | 12.2 | .15 | .21 | .12 | - | - | - |
| (F) | 2 | .38 | Irregular | 14.5 | .15 | .56 | .27 | - | - | - |

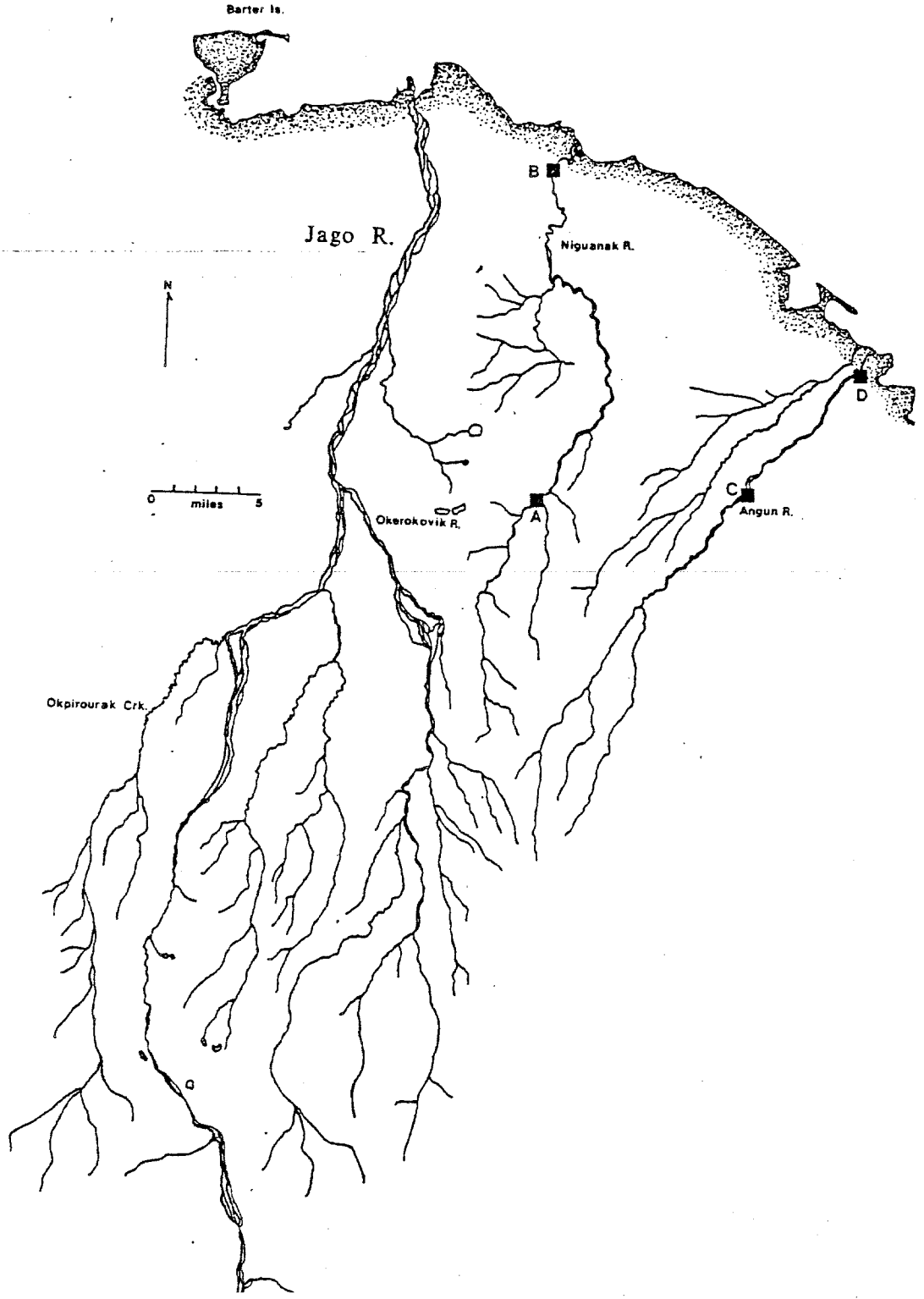


Figure 23. Fish sampling location for Niguanak and Angun Rivers, 1983.

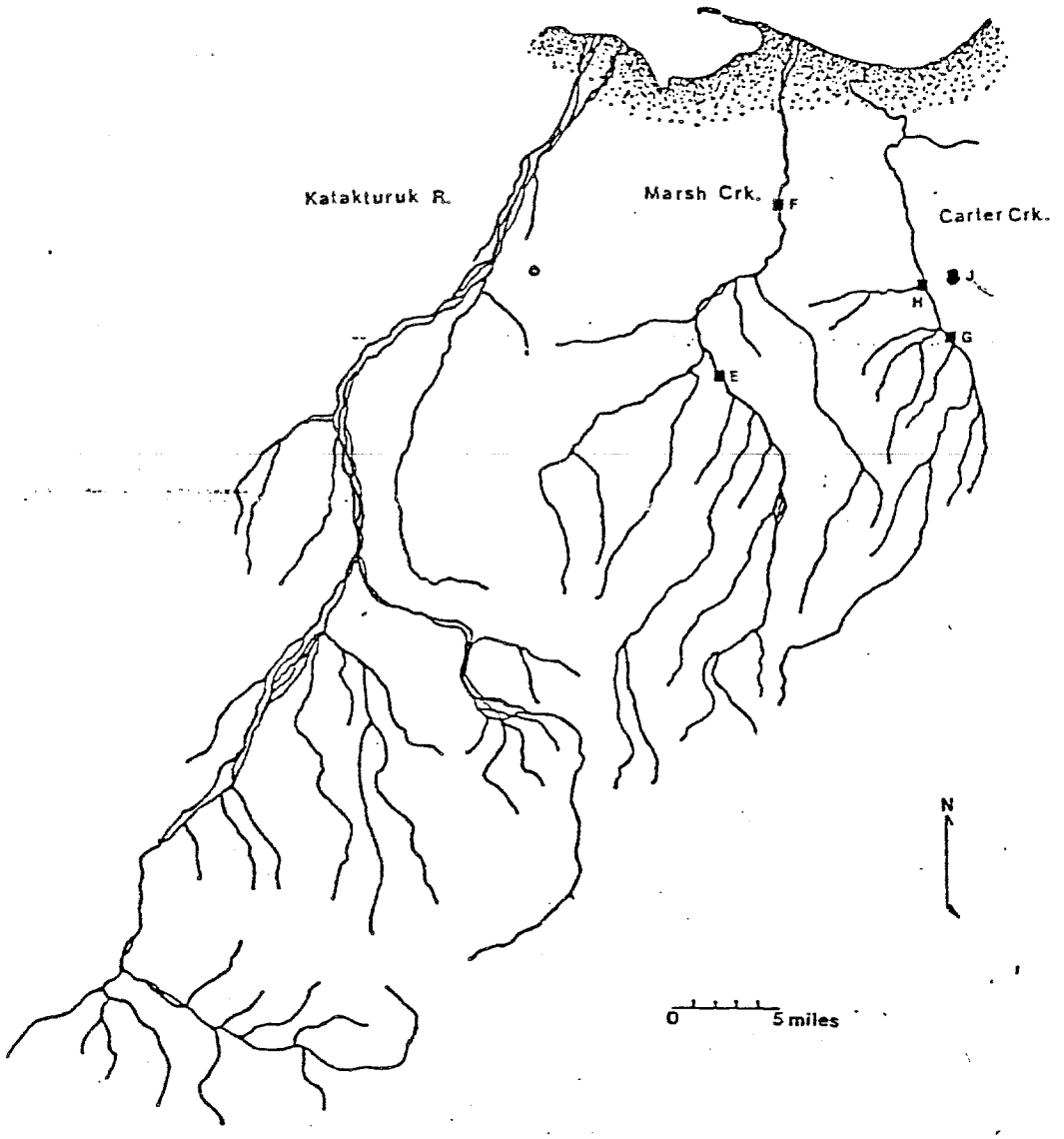


Figure 24. Fish sampling locations for Marsh and Carter Creeks, 1982-1983.

From an oil and gas development aspect, it is significant to point out that the following rivers lacked fish populations: Katakturuk River, Marsh Creek, Carter Creek, Jago River, Angun River, Sikrelurak River, and Kogotpak River. The fisheries will not be affected by mining or other floodplain development.

## CANNING RIVER

### Overwintering

In September 1982, a radio telemetry study was initiated on the Canning River to monitor fall and winter movements and to locate and describe winter habitat of arctic char. This was the second year of telemetry studies on char overwintering in the Canning River. In 1981, nine char were implanted with tags and relocated periodically during the winter of 1981-1982 (USFWS, 1983).

In the 1982 study, radio transmitters were implanted in char at two sites on the main river within two kilometers downstream from the confluence of Shublik Springs. The Shublik Springs area on the Canning River was chosen as the study site because of the large fall concentration of char in the main river. These fish are one of the northern most fall concentrations on the Canning River and are closest to the 1002c study area. Most anadromous char in the Shublik area are non-spawners and immatures.

Shublik is one of the largest springs on the north slope of the Arctic National Wildlife Refuge with a continuous annual discharge of 0.72 $m^3$/sec. at a temperature of 5.5°C. It maintains a large open water section throughout the winter for approximately 1 km downstream where it empties into the main river. Aufeis is extensive in this section of river. By late winter the aufeis field below Shublik Springs covers the entire floodplain and is over 2 km in width in some areas. It is continuous for over 25 km of river below the spring confluence. Depth of the ice is uncertain but is in excess of three meters in several areas.

Summer channel configuration is extremely braided and shallow with few pools. During a depth survey of the Canning River in August 1981 using a recording fathometer, only two pools were observed over 2 meters in depth in a 25 km reach of river below the Shublik Springs confluence.

Although adult char are concentrated in a two kilometer section of river below the spring during fall, none have been captured from the open water in this area during late winter. Their movements and distribution from freeze-up through the winter has been largely unknown.

Fifteen char were implanted with radio tags between September 23 to 25, 1982 and were relocated periodically during the winter. All fish tagged were adult non-spawners and ranged in fork length from 515 mm up to 667 mm (Table 24). Locations observed during aerial tracking were recorded and are reported on Figure 25. All identified sites are estimations because of the difficulties in correlating exact locations in winter ice conditions to maps depicting braided channel configurations and because of the imprecision of aerial relocation under these conditions. These sites should be considered general areas of fish overwintering and not specific pool or point locations.

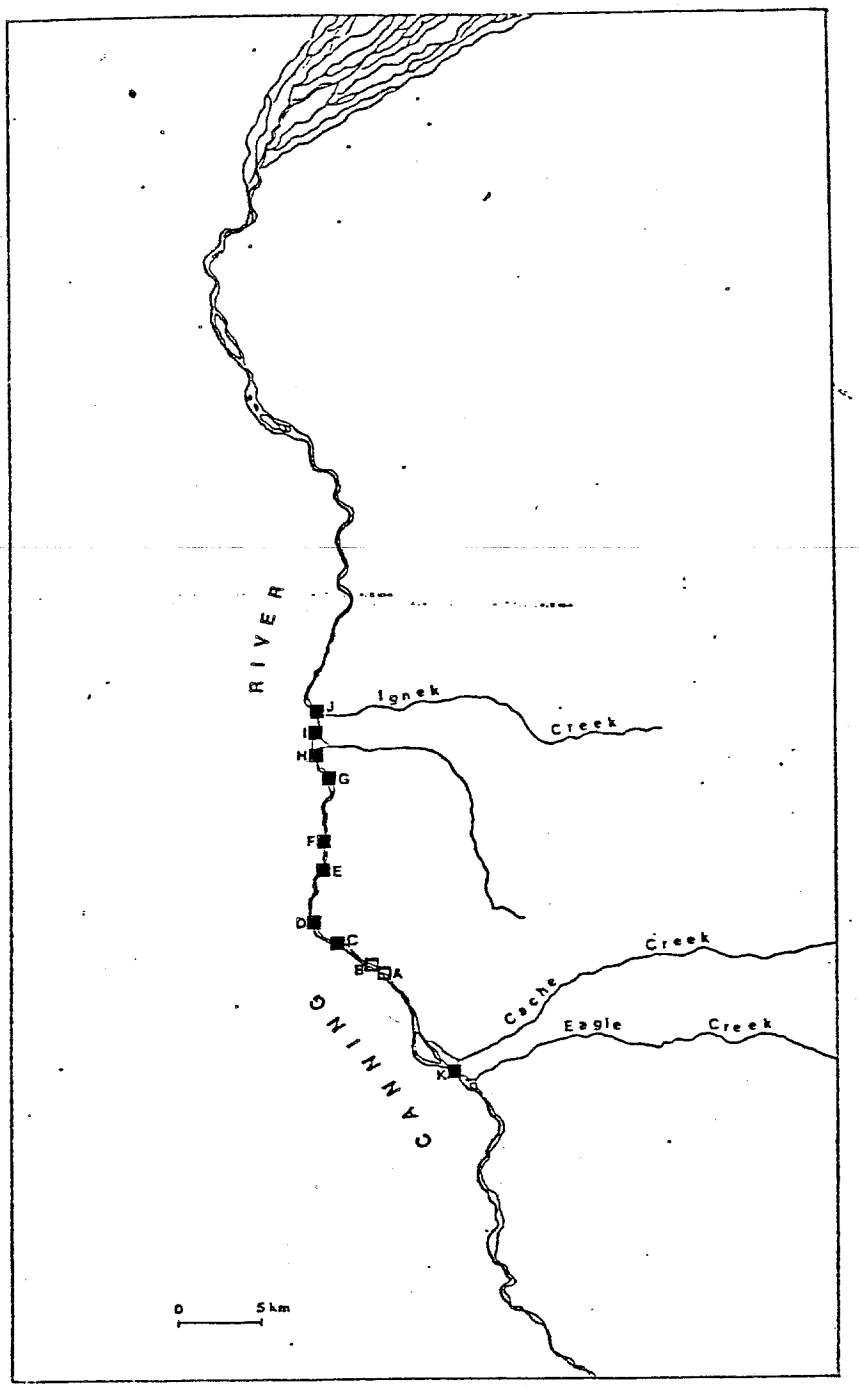


Figure 25. Overwintering locations (■) of 15 radio tagged char in the Canning River, 1982-1983. Locations A and B (□) are tagging and release sites for all fish.

Table 24. Length and weight of char radio-tagged in the Canning River, September 1982.

| No. | Date Released | Frequency (MHz) | Fork Length (mm) | Weight (gm) | FWS Floy Tag No. | Release Site* |
|---|---|---|---|---|---|---|
| 1 | 9/22/82 | 151.730 | 557 | 1550 | 002985 | A |
| 2 | 9/23/82 | 151.630 | 530 | 1425 | 002996 | A |
| 3 | 9/23/82 | 151.750 | 537 | 1475 | 002999 | A |
| 4 | 9/24/82 | 151.690 | 595 | 1950 | - | B |
| 5 | 9/24/82 | 151.910 | 549 | 1550 | - | B |
| 6 | 9/24/82 | 151.840 | 537 | 1475 | - | B |
| 7 | 9/25/82 | 151.720 | 559 | 1900 | 003067 | B |
| 8 | 9/25/82 | 151.870 | 667 | 2800 | 003068 | B |
| 9 | 9/25/82 | 151.740 | 555 | 1925 | 003069 | B |
| 10 | 9/25/82 | 151.770 | 600 | 1975 | 003070 | B |
| 11 | 9/25/82 | 151.790 | 582 | 1950 | 003071 | B |
| 12 | 9/25/82 | 151.880 | 525 | 1550 | - | B |
| 13 | 9/25/82 | 151.900 | 519 | 1450 | - | B |
| 14 | 9/25/82 | 151.850 | 515 | 1375 | - | B |
| 15 | 9/25/82 | 151.890 | 532 | 1400 | - | B |

*Relocation sites depicted on Figure 25.

All radio-tagged fish overwintered within the aufeis area below the spring. By November 17, 1982 all fish had moved at least 3 km away from the original tagging site. The longest movement was downstream 23.5 km by one fish and five out of the 15 tagged had moved 18 km or more by this date. As mentioned earlier, this entire area is overlain by an extensive aufeis field. The reasons for preference of this aufies area over the open water near the spring or the ice covered river immediately below is unknown. Location C (Figure 25) was the most heavily utilized by the tagged sample of fish. Nine fish were in this location in November and four of these remained at this site through February 1983. Location E had the second highest number of fish at any one observation with four recorded on February 25. Two or more fish were recorded at each location at some time during the winter with the exception of locations F, I, J, and K where only 1 fish was recorded at the locations during the winter.

There appeared to be some consistency from the two years of study. Of the five overwintering sites identified in this area in the 1981-1982 study, four were again utilized in 1982-1983. These locations were C, D, E, and G on Figure 25. A total of 12 locations have been recorded from radio-tagged fish during the two year study.

During the period April 12 to 17, 1983, attempts were made to locate and describe the overwintering habitat characteristics of several of the radio-tagged fish below Shublik Springs. By this time only 5 tags were still functioning probably as a result of battery failure. The remaining tags were located from ground tracking and holes were drilled into the aufeis in close proximity to the tag signals. At all locations, the ice thickness was more than 2.7 meters, the limit of our ice auger. One 30 foot gill net was set in an ice covered section of river just below the open water of the spring for

approximately five hours but no fish were caught. Grayling and small char were observed in the open water.

There was considerable movement recorded from the radio-tagged fish through most of the winter (Table 25). Although most movement was early in the winter, 5 out of 15 fish were still moving during February. Of the early movement from October to November 17, 14 fish moved downstream away from the tagging site while one fish moved upstream 9 km where it remained throughout the winter. Movement decreased after the November 17 relocation and became varied in direction up or downstream. Only six fish had moved between November 17 and February 3. Four of these six were recorded moving downstream from 7 to 17 km while the other two moved upstream 2 and 4 km. Movement in February further decreased but became primarily upstream in direction. Five fish were recorded moving, four of which were upstream from 3.5 to 10 km. One fish moved downstream 3 km from location C to D.

Movement in February is significant in that the aufeis field is extensive by this time. Movement through this area indicates that overwintering locations within this aufeis field are not as isolated as previously thought. Evidently channels are maintained throughout the aufies permitting access over large distances. During February, movement was recorded from 5 different fish from location C to H over a total distance of 17 km. Any disturbances to such areas from water withdrawals or other developmental activities would not be restricted to an isolated pool but could affect overwintering fish for considerable distances.

One radio-tagged char from the 1981-1982 study was recaptured in 1983. This fish was recaptured by angling near Bullen Point on July 22, 1983. The fish, which was originally radio-tagged near Shublik Spring on October 1, 1982, had moved 56 km west along the coast from the mouth of the Canning River. The fish was reported in apparently healthy condition with the radio tag still well seated in its stomach.

Table 25. Winter movement of radio-tagged char[1] in the Canning River, 1982-83.

| Tag Frequency MHz | Fork Length (mm) | Weight (gms) | Date Tagged | Tagging Location | Locations[2] Nov. 17 | Feb. 3 | Feb. 25 | Apr. 14[3] |
|---|---|---|---|---|---|---|---|---|
| 151.630 | 530 | 1425 | 9/23 | A | C(-4) | E(-7) | E(0) | E(0) |
| 151.690 | 595 | 1950 | 9/24 | B | H(-20) | H(0) | E(+0) | - |
| 151.720 | 559 | 1900 | 9/25 | B | J(-23.5) | J(0) | H(+3.5) | - |
| 151.730 | 557 | 1550 | 9/22 | A | C(-4) | E(-7) | E(0) | E(0) |
| 151.740 | 555 | 1925 | 9/25 | B | C(-3) | C(0) | C(0) | C(0) |
| 151.750 | 537 | 1475 | 9/23 | A | C(-4) | F(-9.5) | D(+6.5) | - |
| 151.770 | 600 | 1975 | 9/25 | B | K(+9) | K(0) | K(0) | K(0) |
| 151.790 | 582 | 1950 | 9/25 | B | C(-3) | C(0) | D(-3) | - |
| 151.840 | 537 | 1475 | 9/24 | B | C(-3) | C(0) | C(0) | - |
| 151.850 | 515 | 1375 | 9/25 | B | C(-3) | C(0) | C(0) | - |
| 151.870 | 667 | 2800 | 9/25 | B | G(-18) | G(0) | G(0) | - |
| 151.880 | 535 | 1550 | 9/25 | B | C(-3) | C(0) | C(0) | C(0) |
| 151.890 | 532 | 1400 | 9/25 | B | H(-20) | G(+2) | E(+8) | - |
| 151.900 | 519 | 1450 | 9/25 | B | I(-22) | G(+4) | G(0) | - |
| 151.910 | 549 | 1550 | 9/24 | B | C(-3) | H(-17) | H(0) | - |

[1] All char tagged were adult non spawners.
[2] Locations are depicted on Figure 8. Number in parenthesis indicates movements in km from previous relocation. Upstream movement is indicated by (+) and downstream by (-).
[3] Unable to locate several fish, probably due to tag battery failure.

Acknowledgements

Appreciation is extended to the following individuals who assisted in the collection of data in this report: E. Nelson, L. Miyoshi-Daum, M. Sigman, D. Williamson, E. Friedman, M. Matz, and K. Troyer. Pilots D. Ross and W. Audi provided most of the aircraft support. Additional thanks go to R. Glesne and S. Deschermeier who provided assistance and advise with data collection and analysis. Thanks also go to J. Hawkinson for work on data analysis and graph preparation. S. Mang typed for many hours on several drafts.

Literature Cited

Childers, J.M., C.E. Sloan, J.P. Meckel, and J.W. Nauman. 1977. Hydrologic reconnaissance of the eastern North Slope, Alaska, 1975. U.S.G.S. Open-File Rep. 77-492. 65pp.

Craig, P.C. 1977a. Ecological studies of anadromous and resident populations of arctic char in the Canning River drainage and adjacent waters of the Beaufort Sea, Alaska. Canadian Arctic Gas Co. Ltd./Alaskan Arctic Gas Co., Bio. Rpt. Series 41(1):116pp.

Craig, P.C. 1977b. Arctic char in Sadlerochit Spring, Arctic National Wildlife Range. Canadian Arctic Gas Co. Ltd./Alaskan Arctic Gas Co., Bio. Rpt. Series 41(2):28pp.

Craig, P.C. and V. Poulin. 1974. Life history and movements of grayling and juvenile arctic char in a small tundra stream tributary to the Kavik River, Alaska. Canadian Arctic Gas Co. Ltd./Alaskan Arctic Gas Co., Bio. Rpt. Series 20:51pp.

Furniss, R.A. 1975. Inventory and cataloging of Arctic area waters. Ann. Prog. Rpt. 1974-1975. Fed. Aid in Fish Restoration. Alaska Dept. of Fish and Game. Project F-9-7, Job G-I-I. 30pp.

McCart, P.J., P.C. Craig, and J. Bain. 1972. Report on fisheries investigations in the Sagavanirktok River and neighboring drainages. Report for Alyeska Pipeline Service Co. 170pp.

Nordeng, H. 1961. On the biology of char (Salmo alpinus L.) in Salangen, North Norway. 1. Age and spawning frequency determined from scales and otoliths. Nytt Mag. Zool. 10:67-123.

Strahler, A.N. 1957. Quantitative analysis of watershed geomorphology. Amer. Geophys. Union Trans., Vol. 38, pp. 913-920.

U.S. Fish and Wildlife Service. 1983. Arctic National Wildlife Refuge Coastal Plain resource assessment - 1982 update report baseline study of the fish, wildlife, and their habitats. USDI, USFWS, Region 7, Anchorage, Alaska. 379pp.

Ward, P. and P.J. Craig. 1974. Catalogue of streams, lakes, and coastal areas in Alaska along routes of the proposed gas pipeline from Prudhoe Bay, Alaska to the Alaskan/Canadian border. Canadian Arctic Gas Co. Ltd./ Alaskan Arctic Gas Co., Bio. Rpt. Series. 19:38pp.