STATE OF ALASKA

Bill Sheffield, Governor

Annual Performance Report for

# INVENTORY AND CATALOGING OF SPORT FISH AND SPORT FISH WATERS OF WESTERN ALASKA WITH EMPHASIS ON ARCTIC CHAR LIFE HISTORY STUDIES

by

Alfred L. DeCicco

ALASKA DEPARTMENT OF FISH AND GAME
Don W. Collinsworth, Commissioner

DIVISION OF SPORT FISH
E. Richard Logan, Director

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ABSTRACT

This report summarizes data on the life history of char (Dolly Varden, *Salvelinus malma*, and Arctic char, *S. alpinus*) collected from 1981 through 1984 in northwestern Alaska. The Noatak, Wulik and Kivalina Rivers support important char populations.

Major char spawning streams in the Noatak system include the Eli, Kelly, Kugururok and Nimiuktuk Rivers; all major tributaries of the Wulik and Kivalina Rivers are used for spawning. Physical descriptions of these waters are provided.

Char remain in fresh water from 1 to 6 years prior to making their first seaward migration, and return to fresh water to overwinter. After becoming anadromous, the char spend the summers feeding at sea and the winters in fresh water. Summer spawners remain in fresh water during the year of spawning, and spend two consecutive winters and the intervening summer without traveling to sea. Fall spawners travel to sea every year. Tag recoveries have indicated single-and multiple-system movements and demonstrated interchange of fish among the Wulik, Kivalina and Noatak River systems. Char home to spawn, but not to overwinter.

Kotzebue Sound-Chukchi Sea char grow rapidly, averaging 515 mm in fork length at Age V and 611 mm at Age VIII. Fish measuring up to 870 mm in fork length were captured in this study. Growth is more rapid than that of North Slope char.

Length-weight relationships are given for male and female spawners from the various spawning streams. The mean condition factor of prespawning char was 0.968 for males and 1.004 for females. Overwintering nonspawners showed a condition factor of 1.054, while spent char averaged 0.7663.

The mean length of spawners increased from 515 mm in fork length in 1981 to 585 mm in 1984. Length frequencies by sex for all years are given.

Summer spawning takes place from mid-August through mid-September, and fall spawning from mid-September through freeze-up in early October. Most char are summer spawners. The number of summer spawners in the Noatak system increased from 9,268 in 1982 to 10,183 in 1984. Counts are given by stream for all years. The number of eggs per female ranged from 3,556 to 10,558 for char from 478 to 760 mm in length. Alternate-year spawning is the rule for repeat spawners.

The sex composition of spawners on the Noatak River ranged from 26% males in 1984 to 35% males in 1982. Sex ratios are given by river by year.

Counts of char overwintering in the Wulik River decreased from 101,826 in 1981 to 30,923 in 1984, and on the Kivalina River from 45,355 to 5,474 over the same period. Char are important to the subsistence economy of the region, particularly the villages of Noatak and Kivalina. The fall subsistence catch at Kivalina ranged from 18,500 in 1982 to 12,000 in 1984, reflecting a slight lowering of effort rather than a decline in catch per effort. Recreational fishing pressure has remained light. Char are taken incidentally in the Kotzebue commercial salmon fishery; sales ranged from 367 to 7,746 fish over the past 18 years.

KEY WORDS

Char, Arctic char, Dolly Varden, spawning, overwintering movements, life history, Wulik River, Kivalina River, Noatak River, Kotzebue, Chukchi Sea.

## BACKGROUND

Several forms of the Dolly Varden-Arctic char complex (*Salvelinus malma - S. alpinus*) are known to exist in Alaskan waters. Anadromous forms are the most widespread in distribution, occurring in coastal drainages from southeast Alaska to the Beaufort Sea. River resident forms exist in the Kuskokwim and Yukon River drainages of western Alaska, and possibly in the Kanektok River and some Norton Sound streams (Alt, 1978, 1981). Stream and isolated spring populations of dwarf char occur in the Aniak River, Yanert River and Hutlinana Creek, and at several locations on the North Slope (McCart and Craig, 1973; Alt, 1977; Morrow, 1980). Lake resident populations occur in North Slope, Kuskokwim Bay and Bristol Bay drainages (Alt, 1978; Morrow, 1980; Russell, 1980). The char of northwestern Alaska are of the anadromous form and have recently been shown to be Dolly Varden, *S. malma* (Walbaum) (Behnke, 1980, 1983; Morrow, 1980).

The Noatak, Wulik and Kivalina Rivers have long been known to support large populations of anadromous char. These populations are important to the subsistence economies of Kivalina, Noatak, and Kotzebue, and also sustain a relatively light sport fishery of recognized quality. The current Alaska state record char of 17 lb 8 oz was caught in the Wulik River, and over the last 17 years of the trophy fish program, 11 of 69 entries have come from drainages in this area.

The Wulik and Kivalina Rivers drain a 1,520-sq-mi area of the western slopes of the Brooks Range and empty into the Chukchi Sea at lat. 67°54' N, long. 160°31' W, near the village of Kivalina. The Noatak River, the ninth largest river in the state, drains a 12,597-sq-mi area of northwestern Alaska and enters Kotzebue Sound at lat. 67°00' N, long. 162°30" W, about 5 mi north of Kotzebue.

Previous work in the area focused primarily on the Wulik and Kivalina Rivers. Sarrio and Kessel (1966), as part of the Cape Thompson study, reported information on harvest and subsistence use of fish by Kivalina residents. They gave harvest levels of 97,600 lb of char for the fall of 1959 and 124,000 lb of char for the fall of 1960. They also provided data on the annual subsistence cycle and gave a detailed explanation of fishing methods, locations and use of other species. Winslow (1969) documented the 1968 fall subsistence harvest on the Wulik River by residents of Kivalina, and reported an estimated harvest of 120,000 lb of char. He also reported the first biological data on Wulik River char, giving age and growth for a sample of 139 fish and gill raker counts for 3 fish. Roguski and Winslow (1970) estimated the Wulik River spring subsistence harvest at 8,402 char weighing 18,912 lb and sampled 24 fish for age at maturity. Alt (1978) reported information on various life history aspects of Wulik and Kivalina River char, including delineation of major spawning and overwintering areas, and giving data on migrations and spawning. Aerial surveys conducted by the Division of Commercial Fisheries in 1968 counted 90,235 char overwintering in the Wulik River and 27,460 in the Kivalina River. From these counts they estimated that 180,000 to 225,000 char were present in the Wulik and 46,000 in the Kivalina. A survey in 1969 by the Division of Commercial Fisheries showed 297,257 char present in the Wulik River. Alt (1981) estimated over-wintering populations from aerial survey data as 137,545 for the Wulik River and 39,360 for the Kivalina River in 1979; and 124,908 for the Wulik and 43,661 for the Kivalina in 1980.

Foote and Williamson (1966) investigated use of resources in the village of Noatak, and reported that autumn seining in 1960 accounted for 35,000 lb of char and whitefishes, with char making up the majority of the catch. The winter-spring ice fishery took an additional 10,800 lb of char. Most of these fish were taken within 4 mi of the village.

In 1966, 1967, and 1968 the Division of Commercial Fisheries tagged 143 char near Sheshalik Spit and along the Baldwin Peninsula in Kotzebue Sound. Of a total of 33 tag recoveries 19 were from the tagging area, 7 were from the Noatak River, 4 were from the Wulik River, 2 were from the Kobuk River and 1 was from Port Clarence on the Seward Peninsula. These tagging data indicated a mixing of char stocks in Kotzebue Sound.

Young (1973) surveyed some lakes and streams in the Noatak basin and reported taking char in the Eli and Cutler Rivers and in a small lake in the Cutler River drainage.

Recent mineral exploration and development in the area have prompted environmental studies and focused attention on the Wulik River, where the Red Dog heavy metals deposit is located. EVS Consultants of Vancouver, British Columbia, did water quality and in-situ bioassay work in Red Dog Creek under contract to the State of Alaska; and Dames and Moore of Seattle, Washington, did environmental assessment work for Cominco American on the Red Dog Mine and a proposed road to the coast. Their work included surveys of proposed stream crossing sites, habitat preferences of juvenile fishes, and general fish distribution and abundance in the Wulik and Kivalina Rivers (Houghton and Hilgert, 1983).

Residents of Noatak and Kivalina take char for subsistence use by hook and line and gill net in the spring, by seine and gill net in the fall and by "hooking" through the ice in winter. Methods and locations are traditional and have remained similar to those first reported in the early 1960's.

The Alaska National Interest Lands Conservation Act in 1980 withdrew vast areas of land in western Alaska, creating the Noatak National Preserve and Cape Krusenstern National Monument within the study area. The creation of these units has drawn the attention of recreationists to these areas, especially to the Noatak, which is rapidly gaining a reputation for its wilderness float trip qualities.

In anticipation of increased sport fishing pressure and proposed mineral development, the Sport Fish Division of the Alaska Department of Fish and Game undertook a 4-year study to investigate various life history aspects of char populations in northwestern Alaska. No biological information on movements, discreteness of populations, system interchange, spawning or early life history existed for the Noatak River or the many smaller coastal streams in the area. This study addresses this informational gap and complements existing information in previously studied areas.

Although the Kobuk River was not included in this study due to budget and manpower limitations, some information exists on char in that system and these fish probably contribute to the Kotzebue Sound-Chukchi Sea population. Anadromous char occur in the Kobuk River. On June 13, 1978, Ken Alt (pers. comm.) captured five out-migrating char smolts in Melvin Channel on the lower Kobuk River. Residents of Ambler and Kiana villages report taking char in early summer on hook and line and in subsistence nets near the mouths of the Ambler and Squirrel Rivers. They indicate that char run into the Kobuk River from these tributary streams and are destined for the ocean. They also report taking fresh-run in-migrating char in the fall at these same locations. John Cooper (pers. comm.) observed the capture of two prespawning male char 60 mi up the Ambler River in August 1976. He indicated that these highly colored fish weighed 4 to 5 lb and had pronounced kypes. Judging by their size and color, they were probably anadromous prespawners. Jerry Covey (pers. comm.), a Kobuk resident, stated that a few char are taken on sport gear each year in Akpelik, Killak

and Dahl Creeks, small Kobuk River tributaries. Small stream-resident char, called "old-man fish," have been reported in Dahl Creek by Kobuk residents. Anadromous char up to 8 lb are taken by Kobuk residents in the fall above Kobuk village during subsistence seining for sheefish and whitefishes, and sport anglers also take some in this area of the main Kobuk (Ken Alt, pers. comm.). In 1968 two tagged char were recovered at Noorvik; both of these fish had been tagged by the Commercial Fisheries Division in Kotzebue Sound, one in 1967 and one in 1968.

On August 28, 1980 an aerial survey of the Squirrel River system was conducted and only 54 char were observed. To confirm the low aerial count of 20 char in the Omar River, the river was floated, and its side channels walked, in early September 1980. Twenty-nine char were observed; of these, five were captured and tagged.

U.S. Park Service personnel working on the Kobuk in 1983 and 1984 reported catching prespawning char in the Nikok River (a Salmon River tributary) in August and in the lower Hunt River in June. Two char were taken near Onion Portage in September. All these fish were fairly large and probably anadromous.

The present study began in 1981 after preliminary survey work in 1980 (Alt, 1981), including location of char spawning and rearing areas. Aerial surveys showed that Noatak River tributary streams supported more spawning activity than either the Wulik or the Kivalina. Char were tagged in spawning areas on the Noatak system and in overwintering areas on the Kivalina River. Data on char movements, angling effort and harvest were collected as time permitted.

Parts of this study have already been published (DeCicco 1981, 1982, 1983). This report is a completion report of the 4-year study. The study area includes the drainages of the Noatak, Wulik and Kivalina Rivers and the smaller coastal streams between Kotzebue and Kivalina (Fig. 1). Twenty-six species of freshwater, anadromous and brackish-water fish occur in the study area (Table 1); char and chum salmon are the most important to man.

## RECOMMENDATIONS

### Management

1. Recreational and subsistence fisheries should continue to be monitored.

2. Development of the Red Dog Mine and other mining activities in the area should be monitored, with emphasis on possible impacts on char and char habitat.

### Research

An intensive population study should be conducted on one tributary of the Noatak River, utilizing a weir to sample all char.

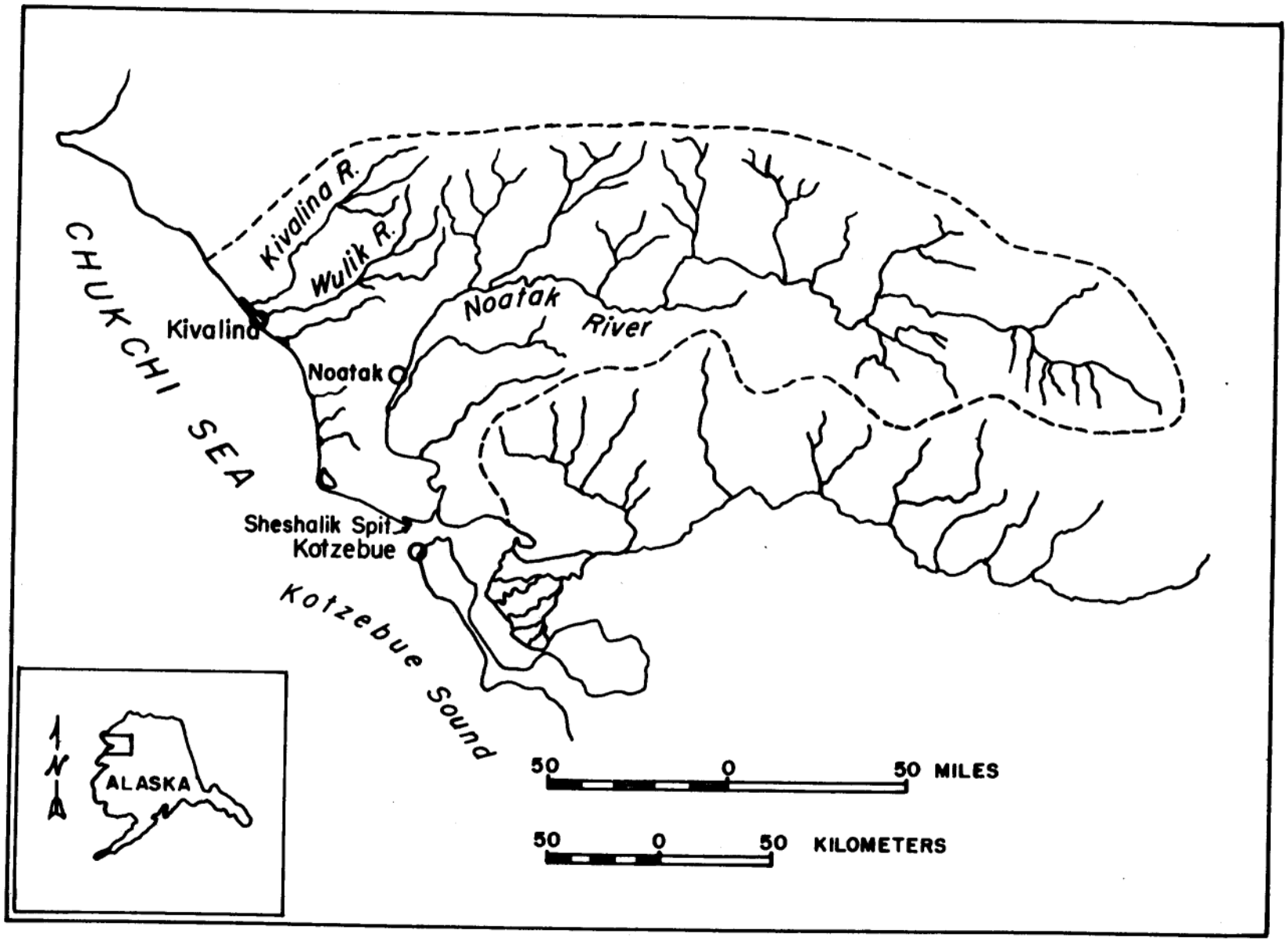


Figure 1. Study Area.

Table 1. List of common names, scientific names and abbreviations of fishes found in the study area.

| Common Name | Scientific Name and Author | Abbreviation |
|---|---|---|
| Alaska blackfish | *Dallia pectoralis* Bean | BF |
| Arctic char | *Salvelinus alpinus* (Linnaeus) | AC |
| Arctic grayling | *Thymallus arcticus* (Pallas) | GR |
| Arctic flounder | *Liopsetta glacialis* (Pallas) | AF |
| Arctic lamprey | *Lampetra japonica* (Martens) | AL |
| Bering cisco | *Coregonus laurettae* Bean | BCI |
| Broad whitefish | *Coregonus nasus* (Pallas) | BWF |
| Burbot | *Lota lota* (Linnaeus) | BB |
| Chinook salmon | *Oncorhynchus tshawytscha* (Walbaum) | KS |
| Chum salmon | *Oncorhynchus keta* (Walbaum) | CS |
| Coho salmon | *Oncorhynchus kisutch* (Walbaum) | SS |
| Dolly Varden | *Salvelinus malma* (Walbaum) | DV |
| Fourhorn sculpin | *Myoxocephalus quadricornis* (Linnaeus) | FSC |
| Humpback whitefish | *Coregonus pidschian* (Gmelin) | HWF |
| Inconnu (sheefish) | *Stenodus leucichthys* (Güldenstadt) | SF |
| Lake trout | *Salvelinus namaycush* (Walbaum) | LT |
| Least cisco | *Coregonus sardinella* Valenciennes | LCI |
| Longnose sucker | *Catostomus catostomus* Forster | LNS |
| Ninespine stickleback | *Pungitius pungitius* (Linnaeus) | NSB |
| Northern pike | *Esox lucius* Linnaeus | NP |
| Pacific herring | *Clupea harengus pallasi* Vallenciennes | PH |
| Pink salmon | *Oncorhynchus gorbuscha* (Walbaum) | PS |
| Round whitefish | *Prosopium cylindraceum* (Pallas) | RWF |
| Slimy sculpin | *Cottus cognatus* Richardson | SSC |
| Sockeye salmon | *Oncorhynchus nerka* (Walbaum) | RS |
| Starry flounder | *Platichthys stellatus* (Pallas) | SFL |

OBJECTIVES

1. To monitor spring seaward migration of Arctic char in the Wulik and Noatak Rivers.

2. To investigate the movement and run timing of summer spawning char in the Kugururok and Kelly Rivers.

3. To investigate the fall spawning segment of the char population in the Kugururok River.

4. To survey overwintering char in the Wulik and Kivalina Rivers and spawning populations of char in the Wulik, Kivalina and Noatak Rivers.

5. To collect angler and subsistence harvest information on Arctic char in the Wulik, Kivalina and Noatak Rivers.

6. To analyze and compile all findings from this 4-year study into a Completion Report.

Note: Objectives are not exactly as in Job Description because G-I-P Job Objectives cover Job G-I-P, parts A and B. Those objectives not referred to in Part A are omitted.

TECHNIQUES

Float-equipped Cessna 185 and wheel-equipped Piper PA-18 aircraft were used to transport field personnel and equipment to and from a base camp near the mouth of the Kugururok River.

Surveys to locate spawning grounds and to count spawning fish were conducted from a Piper PA-18 aircraft flying at low level. Spawning areas were delineated on U.S. Geological Survey 1:250,000 topographic maps. Numbers of fish were determined by counting individual fish and estimating larger concentrations by tens or hundreds. Surveys to count summer spawners were flown in early August prior to the onset of spawning, and fall spawning surveys were flown at the end of September after completion of summer spawning.

Counts of overwintering char were conducted on the Wulik and Kivalina Rivers in late September using a PA-18 aircraft. Large concentrations of fish were estimated to the nearest thousand. Counts are given as minimum counts only.

Char were captured for tagging using hook and line, an 80-ft x 10-ft x 3/4-in bar measure seine and a 90-ft x 6-ft x 1¼-in bar measure seine. An inflatable boat equipped with an outboard jet motor was used for transportation on the Nimiuktuk, Kugururok, Kelly and Kivalina Rivers. The Eli and Kugururok Rivers were surveyed using an inflatable raft. Char captured on spawning grounds in the Noatak drainage and in overwintering areas in the Kivalina River were tagged using Floy FD 67 internal anchor

tags. Tags were numbered, color-coded to major streams in the study area and inscribed with "ADF&G Kotz." A $2.00 reward for char tags was paid by the Division of Commercial Fisheries, which staffs a permanent office in Kotzebue. Posters indicating the presence of tagged char in the area were circulated to all the villages in the study area and radio spots regarding tagged char were broadcast on the local Kotzebue radio station. All char tagged were measured to the nearest millimeter from the upper snout to the fork of the tail and weighed to the nearest 25 g using a 6-kg Chatillon spring scale and a basket net. Tagged char were recovered by commercial fishermen in Kotzebue Sound, subsistence fishermen from Noatak and Kivalina, sport anglers, and ADF&G personnel. Additional tags were placed in char in the Wulik River by Dames and Moore personnel.

Spawning female char were captured for fecundity data using hook and line and a 90-ft x 6-ft x 1¼-in seine. Ovaries were weighed to the nearest 0.1 g on an Ohaus Dial-a-gram balance. Egg diameters were taken by measuring 10 eggs to the nearest millimeter in the field. Ovaries were then preserved in 10% formalin and stored in 36-oz Whirl Pacs. Ovaries were boiled in the laboratory and separated for counting. The number of ova was determined by weighing a sample of about one-fourth the ovary and counting the eggs. Checks by counting the complete ovary showed an error of less than 3% using this method.

Water chemistry data were obtained with a Hach AL36B field test kit. Stream velocities were measured by timing a wooden block through a 100-ft section of stream.

Age was determined from sagittal otoliths taken in the field and stored dry in coin envelopes. The otoliths were cleared in loess solution (51 parts 95% alcohol, 7 parts glycerin, 42 parts distilled water) in the laboratory, and then the hyaline (translucent) zones were counted under a dissecting microscope. Otoliths were examined whole, and some were ground on a fine carborundum stone to facilitate interpretation. Age at first seaward migration was determined by noting the presence of the first opaque zone that was wider than previous opaque zones, indicating increased growth while at sea (Nordeng, 1961; Yoshihara, 1973; Bain, 1974).

Juvenile char were captured with a small-mesh dip net and in minnow traps baited with fish eggs, preserved in 10% formalin and stored in 36-oz Whirl Pacs for laboratory analysis. The fish were measured to the nearest millimeter, and weighed to the nearest 0.1 g using an Ohaus Dial-a-gram balance. Stomachs were examined for food items under a dissecting scope.

The first left gill arch was removed from char sampled in the field and stored with corresponding otoliths in coin envelopes for later counting of gill rakers in the laboratory.

Fall spawners were radio-tagged using Telonics RB-5 radio transmitters; these were inserted into the stomachs of four char, and by surgical implant methods using a blunt needle to thread the antenna out of the abdominal cavity of four other char. Tracking was done using a Cessna 185 aircraft with a wing-mounted Telonics RA-2AK antenna, TS-1 Scanner/Processor and a Telonics TR-2 Telemetry Receiver.

Fish were captured for radio tagging using hook and line and 100-ft x 4-ft beach seine and were anesthetized with MS-222 prior to transmitter implant. Fish were then placed in a holding area with slow current, cordoned off with a 50-ft x 4-ft x ¼-in bar measure beach seine for recovery. Before release from the holding pen, the frequency of each transmitter was confirmed using the TR-2 Telemetry Receiver. Fish were released after a 20-to 30-min recovery time.

Radio-tagged fish were located twice during the first 2 months after tagging and again in March.

Use data statistics on the Noatak River were acquired from the National Park Service in Kotzebue. Noatak and Kivalina subsistence harvest information was acquired from Braund and Burnham (1982), Burch (1983) and by personal interviews with subsistence users.

The incidental char harvest in the Kotzebue Sound commercial fishery was monitored by interviewing fishermen as they made deliveries to tenders and buyers in Kotzebue and Sheshalik in 1983 and 1984.

Fecundity of Kotzebue Sound-Chukchi Sea char was compared to that of Sagavanirktok River char by comparing the slope of the linear regressions of the number of eggs to fork length, as described by Zar (1974).

Taxonomy

The taxonomic status of the char of northwestern Alaska remains somewhat unclear. Various authors support classification of these fishes as the western form of the Arctic char (McCart and Craig, 1973), or as the northern form of the Dolly Varden (Morrow, 1980).

Morrow shows by canonical variable discriminate function analysis that there are two distinct forms --northern and southern-- of Dolly Varden char, *S. malma*, and that they are different from the lake resident Arctic char, *S. alpinus*.

Savvaitova (1980), however, believes that *S. alpinus* and *S. malma* are synonomous; that the differences in taxonomic characteristics, namely in numbers of pyloric caecae and gill rakers, are a function of environmental conditions. She states that secretory enzymes produced by the pyloric caecae vary with the number of caecae and are directly related to ambient temperature. In higher temperatures, optimal enzyme production can be achieved with fewer caecae. She also believes that the number of gill rakers depends on the local abundance and size of food items, and therefore ascribes the ranges of observed characteristics to habitat differences and not species differences.

Behnke (1981) considers that the western Arctic char should be recognized as *S. malma malma* because it is synonomous with *S. malma* from Kamchatka as first described by Walbaum in 1792, and that Kamchatka is the type locality for the name "malma."

Total gill raker counts from 283 anadromous char in the study area ranged from 19 to 25, with a mean of 22.3 and a mode of 23. Pyloric caecae counts

from 37 char ranged from 23 to 33, with a mean of 28.2 and a mode of 31. These counts would place these fish within the range of the low-count char considered by Behnke to be *S. malma*, and these fish should thus be considered to be Dolly Varden.

What the fish is called is a matter for the taxonomists and has little impact on the fish itself, its life history or its management. It is important that nomenclature be determined that is acceptable to North American, European, and Asian researchers, so that work may be shared without confusion. Fish considered in this paper will be referred to as "char."

## FINDINGS

### Surveys of Char Spawning Streams

Noatak River System:

Eli River. The Eli River is 78 mi long and drains a 514-sq-mi area of the western slopes of the Baird Mountains (Fig. 2). It runs westward through a narrow mountain valley for about 24 mi to the confluence of Ahaliknak Creek at lat. 67°43' N, long. 16°59' W. Six mi past this point the Eli enters the broad floodplain of the Noatak. The river is mostly a single channel until this point, where it begins to braid for the next 10 mi. Past this braided section the Eli again becomes a single channel stream and meanders through the Noatak floodplain, draining many small lakes. It roughly parallels the Noatak until their junction about 56 mi from the Noatak mouth. Bottom composition grades from large gravel, cobble and bedrock in the upper reaches, through medium-size gravel where it enters the Noatak floodplain, to mud, sand, and silt in its lower reaches. Bank vegetation is open spruce forest and willow, with tundra banks predominating in the higher areas of the floodplain. The lower river is intermittently forested with spruce.

Char, Arctic grayling and slimy sculpin occur in the upper reaches of the Eli drainage. The lower Eli is an important chum salmon spawning area. Lakes drained by the lower Eli probably have a species composition similar to nearby lakes surveyed by Bureau of Land Management (BLM) fisheries biologists (Webb, 1980). These lakes contained northern pike, longnose suckers, broad whitefish, humpback whitefish, least cisco and grayling. Pink salmon probably spawn in the lower Eli.

Char spawn in the lower 4 mi of Ahaliknak Creek, in the Eli River about ¼ mile above its confluence with Ahaliknak Creek and for about 3 mi downstream. Spawning also occurs in the braided section of the Eli as it flows into the Noatak Flats. The greatest concentration of spawning char is in the vicinity of the confluence of the Eli River and Ahaliknak Creek, and in Ahaliknak Creek proper, which is characterized by the presence of many small spring areas. Rearing juvenile and young-of-the-year char were present in lower Ahaliknak Creek and the mainstem of the Eli River during late July. Grayling are present throughout the river.

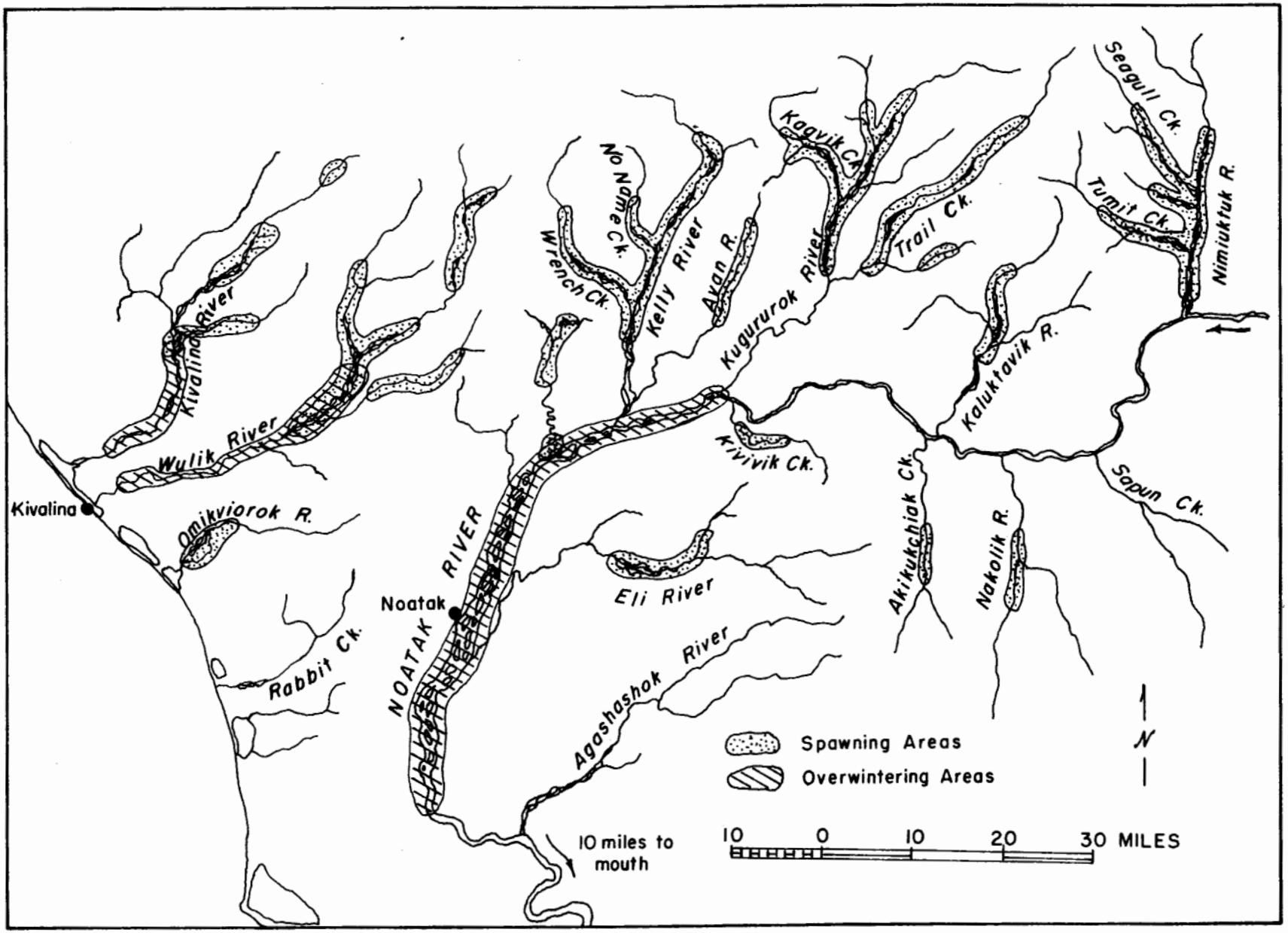


Figure 2. Lower Noatak, Wulik and Kivalina Rivers with major char spawning and overwintering areas.

Water quality parameters are similar to other streams of the Noatak (Table 2).

Between 100 and 400 char spawn annually in the Eli River.

Kelly River. The Kelly River drains a 582-sq-mi area of the south slope of the De Long Mountains; it is 48 mi long and enters the Noatak River from the north at Mile 103 (Fig. 2). The Kelly River is moderately braided throughout most of its length, with most braiding occurring in the lower 15 mi. Bottom composition varies from fine to medium gravel in the lower reaches, to a mix of medium-size gravel, cobble and boulders in the upper reaches. The lower 15 mi drain a broad valley of open spruce forest and muskeg with numerous small lakes. Fifteen miles upstream, the river valley becomes more confined as mountains rise to 3,000 ft on both sides of the valley. In this middle section of the river, spruce trees become more scattered and bank vegetation grades from willow to open gravel bars.

The Avan River enters the Kelly River from the east about 1 mi from its mouth. The lower 10 mi of the Avan River meanders through open spruce forest and muskeg, draining many small lakes. Above this area the river flows at a steep gradient through boulder fields as it drains the mountains to the north. Water in the Avan River is stained a clear greenish brown.

Wrench Creek is 32 mi long and enters Kelly River from the west about 15 mi from its mouth. The lower 4 mi is mostly a meandering single channel through the spruce and willow of the Kelly River valley. Above this area Wrench Creek is heavily braided. Spring areas are abundant throughout this area and aufeis (ice sheet) fields created by perennial groundwater sources are present well into the summer.

No Name Creek enters the Kelly River from the west approximately 10 mi above Wrench Creek mouth. No Name Creek is a small stream, approximately 25 mi in length, with many spring areas. This creek represents the upper distribution of intermittent spruce stands on the Kelly River.

Moderate braiding continues on the Kelly River as it bends to the northwest about 12 mi above No Name Creek. There are numerous spring areas with associated aufeis fields in this part of the Kelly drainage. Upstream, the Kelly is quite small as it branches and drains mountain slopes to the north.

Char, grayling, chum salmon, round whitefish, pink salmon and slimy sculpin inhabit the Kelly River; with northern pike have been reported from Tagakvik Lake in the lower Avan drainage. Chum salmon have been observed spawning in the lower reaches of Kelly River and the lower few miles of Wrench Creek and the Avan River. Pink salmon spawn in the lower Kelly and Avan Rivers. Grayling are distributed throughout the Kelly River drainage.

Char spawn throughout most of the middle area of Kelly River, Wrench Creek, No Name Creek and the upper Avan (Fig. 2). No fall char spawning has been observed in the Kelly River system.

Young-of-the-year and juvenile char have been observed in small tributary

Table 2. Chemical data from Noatak River spawning streams, 1982.

| Stream | Date | pH | Hardness (ppm) | Alkalinity (ppm) |
|---|---|---|---|---|
| Tumit Creek | July 09 | 7.7 | 76 | 43 |
| Kukukpilak Creek | July 10 | 6.8 | 128 | 86 |
| Seagull Creek | July 10 | 7.6 | 154 | 94 |
| Nimiuktuk River | July 10 | 7.6 | 120 | 86 |
| Kaluktavik River | July 13 | 7.9 | 86 | 86 |
| Kugururok River (mouth) | July 14 | 7.9 | 154 | 120 |
| Kugururok River (above Trail Cr.) | July 16 | 7.9 | 205 | 137 |
| Kagvik Creek | July 18 | 7.6 | 205 | 137 |
| Trail Creek | July 19 | 7.9 | 154 | 103 |
| No Name Creek | July 22 | 7.8 | 154 | 137 |
| Kelly River (above No Name Cr.) | July 22 | 7.9 | 154 | 120 |
| Avan River | July 23 | 7.9 | 120 | 137 |
| Wrench Creek | July 23 | 7.9 | 145 | 128 |
| Ahaliknak Creek | July 25 | 7.9 | 214 | 154 |
| Eli R.-Main Fork | July 25 | 7.9 | 154 | 120 |
| Kugrak River | Aug. 07 | 7.7 | 342 | 154 |
| Igning River | Aug. 07 | 7.7 | 376 | 154 |

streams, spring areas, side channels and along the main channel of the Kelly River system.

Kugururok River. This river is 61 mi long, drains a 940-sq-mi area of the south slope of the De Long Mountains, and enters the Noatak from the north, 119 mi from its mouth (Fig. 2). The Kugururok River is confined to a single channel for its lower 20 mi. This section of the river is swift, and has a bottom composition varying from fine gravel to bedrock, with many large boulders where it cuts through a steep-walled canyon for several miles. The lower Kugururok drains several lakes, the largest of which is Lake Narvakrak, near its confluence with the Noatak. Bank vegetation on the lower river is a mixture of open spruce forest, willow and tundra.

For the next 27 mi upstream, numerous spring areas and extensive braiding characterize the Kugururok River. Aufeis persists well into summer. The stream bottom is mostly small to medium-size gravel, with some larger rocks and cobble. Bank vegetation is willow, and there are many open gravel bars. Water flow measured in April 1978 showed a discharge rate of 12 cfs in the Kugururok above Trail Creek, and a discharge rate of 35 cfs near its mouth (Childers and Kernodle, 1981).

Trail Creek enters from the east at Mile 20, and at, 47 mi long is the largest tributary of the Kugururok. Its headwaters drain the south slope of Nucleus Mountain and its valley is confined by mountains for much of its length. The lower reaches drain Misheguk Mountain, and Okatak Creek enters below Misheguk Mountain from the east, where the valley broadens. Trail Creek then continues in a southeasterly direction, and enters the Kugururok River near Lake Kaiyak.

Kagvik Creek enters the Kugururok from the west 10 mi above the confluence of Trail Creek and is its second largest tributary. Its lower 12 mi are extensively braided and contain many spring areas. Bank vegetation is mostly willow, and there are many open gravel bars. Kagvik Creek drains the south slopes of Inaccessible Ridge and is confined to a narrow mountain valley for much of its 23-mi length.

Nunaviksak Creek enters the Kugururok River 8 mi above Kagvik Creek, and drains the many small side valleys of Inaccessible Ridge and Copter Peak. Nunaviksak Creek is confined to a single channel for most of its 17 mi length.

Cairn Creek enters the Kugururok from the north 9 mi above the mouth of Nunaviksak Creek. Cairn Creek is a small, single-channel stream about 7 mi long and is confined to a steep, narrow valley.

Above the mouth of Nunaviksak Creek, the Kugururok is a small, mostly single-channel stream whose headwaters drain Echo Mountain and Mount Bastille.

Fish species present in the Kugururok include char, chum salmon, pink salmon, Arctic grayling, round whitefish, humpback whitefish and slimy sculpin. Chum salmon spawn as far as 25 mi upstream in the lower river. Pink salmon have been observed spawning in the lower 3 mi. Char spawn throughout the Kugururok, from the mouth of Trail Creek to just above Cairn

Creek, during the summer spawning period. They also spawn in Cairn Creek, Nunaviksak Creek, Kagvik Creek, Trail Creek and Okatak Creek. Fall spawning occurs on the Kugururok, but is restricted to several spring areas near the mouth of Kagvik Creek and Kingaviksak Mountain and in Nunaviksak Creek. On Trail Creek, fall spawning occurs in a small spring about 32 mi upstream from its mouth and in spring areas near Misheguk Mountain. Young-of-the-year and juvenile char have been observed throughout most of the Kugururok and its tributaries. Grayling occur throughout the watershed.

Kaluktavik River. This river enters the Noatak from the north, 36 mi upstream of the Kugururok River at Mile 155 (Fig. 2). The Kaluktavik River is 36 mi long and drains the western slopes of the Poktovik Mountains and the Imikneyak Mountains between the drainages of the Kugururok and the Nimiuktuk Rivers. The Kaluktavik has two major tributaries, Imikneyak Creek, entering from the east at Mile 12, and Analak Creek, entering from the west at Mile 16. The Kaluktavik has not been surveyed on the ground, but water chemistry data have been collected at its mouth, and aerial spawning surveys were conducted in 1982 and 1984. Char spawn in the Kaluktavik in both summer and fall. Most char spawning occurs from the mouth of Analak Creek upstream for a distance of about 12 mi. A survey for fall spawning in 1982 showed that flow in the Kaluktavik stopped about 6 mi above Analak Creek and resumed again from a spring area about ½ mi below this interruption. Fall spawning was located downstream of this interruption. Chum salmon were seen spawning in the lower 12 mi of the river.

Nimiuktuk River. This river drains a 564-sq-mi area of the south slope of the De Long Mountains in the vicinity of Black Mountain. The Nimiuktuk is 41 mi in length and enters the Noatak from the north at Mile 197. It is extensively braided for most of its length, is bordered on the west by mountains and opens on the east to the central Noatak basin for the lower half of its length. The western mountains are interrupted by river valleys of the three major Nimiuktuk tributaries. Tumit Creek enters at Mile 8, Kukukpilak Creek at Mile 12.5 and Seagull Creek at Mile 15.5. Bottom composition of the Nimiuktuk is mainly small to medium gravel, with some large cobble. Bank vegetation is mainly willow. A large, braided spring area about 2 mi from the mouth builds an extensive aufeis field which is present throughout most of the summer. Several other aufeis areas occur on the main Nimiuktuk and on both Tumit and Seagull Creeks. The lower Nimiuktuk drains many lakes, of which Aniralik Lake is the largest.

Tumit Creek is approximately 25 mi long and flows through a narrow mountain valley for all but its lower 4 mi. The stream channel exhibits moderate braiding throughout most of its length. There are two extensively braided aufeis areas, one about 4 mi and the other about 10 mi from its mouth. Vegetation is mostly willow, with some tundra and open gravel bars.

Kukukpilak Creek is a small, spring-fed stream which enters the Nimiuktuk from the west 4.5 mi above Tumit Creek. This drainage is only 15 mi long and during low rainfall years, such as 1982, is dry throughout its lower reaches, while maintaining flow in most of its upstream areas.

Seagull Creek is 23 mi long and enters the Nimiuktuk from the west 3 mi above Kukukpilak Creek. Its valley is narrow and bordered by mountains for much of its length. In the upper 13 mi Seagull Creek is confined to a single channel with some slight braiding, while the lower 10 mi are extensively braided and contain many spring areas which create two large aufeis fields. Bank vegetation is mostly willow. Many open gravel bars occur within the braided section.

Fish species present in the Nimiuktuk system include char, grayling, lake trout, round whitefish, slimy sculpin, chum salmon and pink salmon. Aniralik Lake contains populations of round whitefish and grayling (Alt, 1978).

Chum salmon spawn in the lower 13 mi of the Nimiuktuk River, and two were seen in lower Tumit Creek. In 1982, salmon were noted in the river as early as July 12. About 3,500 chum salmon were observed in the Nimiuktuk during an early August aerial survey. Pink salmon were also seen in the lower Nimiuktuk in August, but no estimate of numbers was made.

Char spawn during the summer in the lower 21 mi of the Nimiuktuk River. Spawning also occurs in the lower 15 mi of Seagull Creek, the lower 16 mi of Tumit Creek and in Kukukpilak Creek. No fall spawning has been observed in the Nimiuktuk.

Young-of-the-year and juvenile char were seen in many areas throughout the Nimiuktuk mainstem and tributaries in 1982, and like other Noatak tributary rivers, char rearing seems to occur throughout the system.

Arctic grayling occur throughout the Nimiuktuk drainage and were captured in all areas.

Other Noatak Tributaries. Reports of char occurring near the mouths of Noatak river tributaries as far as 400 mi upstream have been received from sport anglers, river floaters and area guides. Overflights of the upper Noatak in late winter of 1980 and 1981 have shown extensive aufeis areas in the upper reaches of the river and some open water. These features indicate the possibility of suitable overwintering habitat for juvenile fish and spawning areas. An aerial reconnaissance survey of many smaller tributary streams of the middle and upper Noatak River was flown in August 1982 to locate spawning fish in previously unsurveyed areas. Char were observed spawning in Kivivik Creek, Akikukchiak Creek, Nakolik Creek, Aklumayuak Creek, a small nameless spring creek to the south of the Noatak at about Mile 330, Kavachurak Creek, Igning River and Kugrak River. Young (1973) reported taking several large char in the Cutler River. Char were located on the Anisak River in 1980 and reported from another area of the upper Anisak River in September 1984 (Jim Rood, pers. comm.). No fish were seen in Nakolikurok Creek, Sapun Creek, Makpik Creek, Cutler River or Imelyak Creek (Figs. 2 and 3).

Wulik-Kivalina System:

Wulik River. The Wulik River is a clearwater system draining an 880-sq-mi area of the western slopes of the De Long Mountains (Fig. 2). It is 89 mi long and empties into Kivalina Lagoon and the Chukchi Sea near the village of Kivalina. For its lower 18 mi the Wulik meanders through coastal

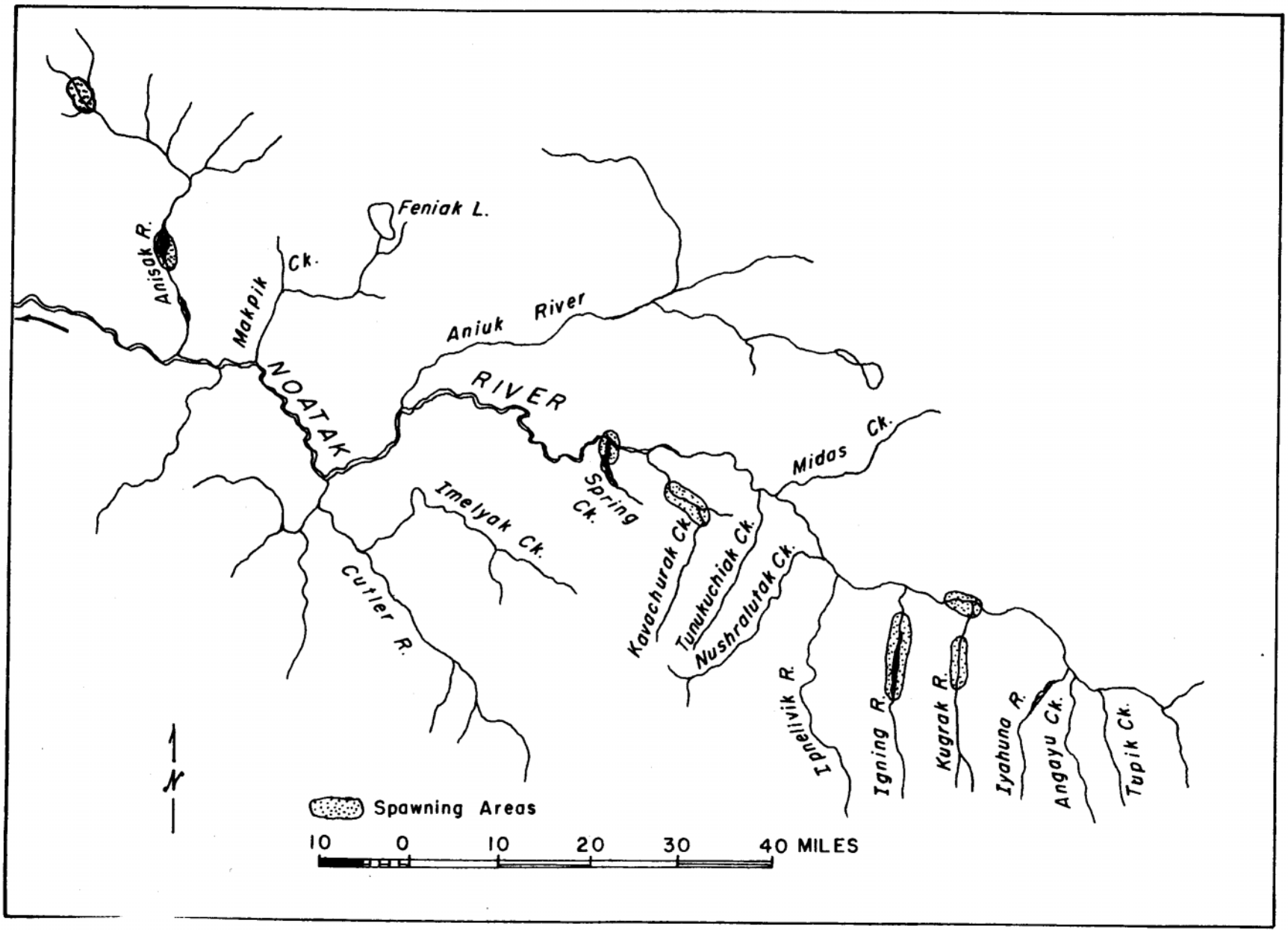


Figure 3. Upper Noatak River with known char spawning areas.

tundra; it is fairly slow-moving and mostly confined to a single channel, and some sloughs and old river channels are evident in its lower reaches. From Mile 18 to the forks at Mile 42 (lat. 68°00' N. long. 163°28' W), the river drains tundra uplands. Here the channel is extremely braided. Its bottom is composed of small to medium gravel and some larger cobble. Salmon spawning occurs sporadically throughout this section and char spawn in the upper 9 mi. Bank vegetation is mostly willow, with some tundra cutbanks and open gravel bars.

Tutak Creek is a small tundra stream about 20 mi long which enters the Wulik from the east about 2 mi below Ikalukrok Creek. Its many small tributaries drain the northwest slopes of the Mulgrave Hills. The water is stained brown from the tundra it drains, and the bottom is mostly small to medium-size gravel, with some larger cobble. The proposed road from the Red Dog Mine to the coast crosses the mainstem of Tutak Creek and its tributary, Left Tak. Dames & Moore, in their work on stream crossing sites, collected grayling adults and fry and char fry from this stream. They also identified char spawning areas, and in 1984 counted 265 spawning char in Tutak Creek, the majority of which were above the stream crossing site (Cominco Alaska Inc., 1984).

Ikalukrok Creek enters the Wulik from the east 10 mi below the forks. This creek is 42 mi long and drains the mountains along the western boundary of Noatak National Monument north of the Noatak River. The headwaters of Ikalukrok Creek are heavily mineralized, and it is on Red Dog Creek, a tributary stream entering Ikalukrok Creek about 28 mi from its mouth, that the Red Dog Mine will be located. The lower 20 mi of Ikalukrok Creek drain tundra uplands and contain several groundwater sources. Bank vegetation is mostly tundra or willow and bottom composition is small to medium gravel. Above 20 Mile, the area drained by Ikalukrok Creek becomes mountainous.

The West Fork of the Wulik River drains the south slopes of the Wulik Peaks. Approximately 16 mi upstream it flows through a steep-walled canyon cut into the bedrock. There are several waterfalls in this area, that probably serve as a barrier to the upstream movement of fish.

The mainstem of the Wulik extends for 47 mi above the forks and drains an area of the De Long Mountains in the vicinity of Sheep Mountain. The lower 4 mi are quite braided as the Wulik flows out of the mountains. A canyon with several rapids is located approximately 15 mi upstream from the forks where the Wulik cuts through a bedrock area. These rapids do not serve as a barrier to fish movement, as some important char spawning areas are located above this area on Sheep Creek and in the main river. Bank vegetation is willow and tundra. Above the canyons the Wulik again braids out for about 10 mi to the confluence of Sheep Creek, which enters from the east. Bottom composition is mostly small to medium-size gravel, with larger cobble in headwater areas.

Fish species present in the Wulik drainage include char, grayling, ninespine stickleback, chinook salmon, chum salmon, pink salmon, sockeye salmon, coho salmon, round whitefish, humpback whitefish, Bering cisco, blackfish and least cisco.

Salmon spawning occurs in the lower Ikalukrok and in the Wulik from the forks downstream. A major chum salmon spawning area is in the lower 5 mi of the Wulik in the channels above Kivalina Lagoon. Char spawning occurs in Ikalukrok Creek, the west fork of the Wulik to below the falls, the main Wulik above the forks, Sheep Creek, the mainstem of the Wulik below the forks and Tutak Creek. The middle section of the Wulik, from the forks downstream, serves as important overwintering habitat for char (Fig. 2).

Char rear throughout the Wulik and its tributaries and grayling occur throughout the system.

Whitefishes and ciscos occur in Kivalina Lagoon and the lower reaches of the Wulik.

Kivalina River. This is a clearwater system draining a 640-sq-mi area of the western slopes of the De Long Mountains. The Kivalina River is 64 mi long and empties into the Chukchi Sea through Kivalina Lagoon (Fig. 2). A breach in the beach barrier at lat. 67°46' N, long. 164°40' W serves as the primary entrance of Kivalina water to the sea. From its mouth upstream to Simik Hill, approximately 12 mi, the Kivalina River is slow and deep, with a bottom of medium-size gravel grading to fine sand and silt near its mouth. Above this point the river current is progressively faster and the channel becomes more braided to Mile 27, lat. 68°1' N, long. 164°15' W, where the three major forks forming the lower mainstem converge. Bottom composition through this area is mostly medium-size gravel, with some larger-than-fist-size cobble. Bank vegetation is willow or tundra, and some open gravel bars are present.

Grayling Creek, the most easterly of the forks, drains the south slope of the Wulik Peaks and flows for 24 mi through tundra before entering the Kivalina. Grayling Creek has many spring areas in its lower 10 mi, and a bottom composed of small to medium-size gravel.

The Main Fork of the Kivalina River is 34 mi long and drains the northwest slopes of the Wulik Peaks. It is extremely braided in its lower 12 mi and has extensive groundwater sources near the upper end of this section. Above Mile 12 the main fork is mostly a single channel banked with willow, alpine tundra and open gravel bars.

The West Fork of Kivalina River, or Little River, is a slow-moving, single-channel, meandering tundra stream. Its bottom is stained dark brown and its tea-colored waters drain an alpine tundra area between the Kukpuk River and the Main Fork of the Kivalina.

Fish species present in the Kivalina River include char, grayling, chum salmon, sockeye salmon, coho salmon, chinook salmon, pink salmon, round whitefish and slimy sculpin. Bering cisco, least cisco and humpback whitefish occur in Kivalina Lagoon and probably in the lower river.

Char spawn in Grayling Creek, the main fork of the Kivalina and in the mainstem below the forks. Spawning has also been reported in Kisimilat Creek, a small tributary entering from the east downstream of Grayling Creek (Houghton and Hilgert, 1983).

Grayling are abundant throughout all areas of the Kivalina River and show a general movement out of tributaries into the main river in September.

Most salmon spawning occurs downstream of the forks in the mainstem. In August 1982, over 26,000 pink salmon were seen spawning in the Kivalina River.

Omikviorok River:

The Omikviorok River drains an area of 192 sq mi between the Wulik River and the Mulgrave Hills. It is approximately 38 mi long and enters Ipiavik Lagoon on the Chukchi Sea coast at lat. 67°37' N, long. 164°12' W (Fig. 2).

Except for the lower 5 mi, the Omikviorok is mostly a single-channel stream. Most tributaries drain the north slopes of the Mulgrave Hills and enter the Omikviorok from the south. From Mile 2 to Mile 5 the channel exhibits extensive braiding through an area with many groundwater sources. For the lower 2 mi and a 2-mi section immediately above the braiding, the Omikviorok meanders through coastal wetland. Bank vegetation throughout the lower third of the stream consists of coastal tundra with some willows. There are a few small gravel bars. The upper reaches of the stream flow through upland tundra with some willow-covered banks.

Char, Arctic grayling, Bering cisco, pink salmon, chum salmon, humpback whitefish, starry flounder, Arctic flounder, Pacific herring and ninespine stickleback have been documented from the Omikviorok system (Houghton and Hilgert, 1983). Other species probably present include fourhorn sculpin, slimy sculpin, least cisco and round whitefish.

Char, chum salmon and pink salmon spawn in the braided section between Mile 2 and Mile 5. Aerial counts in 1981, 1982, and 1983 showed 114, 37, and 138 char spawning in this section of the river. In 1983 the major tributaries and mainstem were surveyed up into the hills, and large fish were observed only in the lower braided area; 300 pink salmon and 60 chum salmon were seen in this lower section.

Char smolts, adult char and grayling were captured in gill nets set in Ipiavik Lagoon and the mouth of the Omikviorok on June 15, 1983. Some adult char overwinter in this small system, as shown by the capture during this same netting period of a spent female which had not yet been to sea. Two other large fish, observed from the air in the lower 200 yd of the Omikviorok on June 15, were probably spent char moving seaward.

Other Coastal Streams:

Char have been reported to occur or observed in several other small coastal streams, including the Asikpak River (aerial survey) and Kavrorak Lagoon (Blaylock and Erikson, 1983), both located north of Kivalina. Rabbit, Jade and Kilikmak Creeks and the Situkuyok River, all south of Kivalina, also contain char. Detailed on-site surveys of these streams have not been conducted.

Char are also known to occur in the Kukpuk River. Foote and Williamson (1966) reported that people in Point Hope fish in the ocean with seines and gill nets for trout and salmon in summer and that they fish with hooks and nets at fish camps on the Kukpuk River in the autumn, catching mainly char, salmon and grayling. Point Hope residents still fish for char in the Kukpuk in the fall (Jim Rood, pers. comm.).

Movements

Presmolts and Smolts:

After emerging sometime in June, young-of-the-year char disperse throughout their natal stream and can be found intermixed with other year class presmolts in a variety of habitat types including slow-moving side channels, spring areas, deep holes in mainstem streams and small, steep-gradient tributary streams. They remain in these areas, virtually all parts of the stream, throughout the summer, then probably move into spring areas where sufficient flow is ensured for the winter. Springs are scattered throughout all of the streams in the study area and are important for spawning, as well as providing overwintering habitat for juveniles.

Most juvenile char remain in spawning streams for 2 to 5 years before making their first seaward migration, which usually occurs in mid-June. Out-migrating smolts have been captured on June 15-18, 1983 in Ipiavik and Kivalina Lagoons and on June 14, 1981 and June 15, 1983 in the lower Noatak River. Immature char return to fresh water from mid-August to late September after having spent the summer feeding at sea. They continue to make annual spring journeys to sea for feeding while returning to fresh water to overwinter.

This annual movement continues for 3 to 5 years until fish reach sexual maturity, at which time there is a change in the seasonal migrational pattern relating to spawning.

Data from 136 recoveries of 4,620 tagged char show complex movements involving single and multiple river systems by mature and immature fish for spawning and overwintering. Table 3 shows locations and numbers of tagged and recovered fish. Table 4 shows a more detailed description of recovery data broken out by year and sexual condition of fish tagged and recovered.

Single-System Movements:

Nonspawners. Immature and mature nonspawners, after having overwintered in their system of origin, move seaward in the spring. The timing of this movement is variable, depending on sea ice conditions near the mouth of the river involved. During normal years the ice in the Chukchi Sea in the vicinity of the Wulik and Kivalina Rivers breaks up and moves offshore by June 10, leaving a band of open water between the coast and the ice edge. The movement of char out of streams is coincident with this condition and usually occurs during the first week of June. In the cold spring of 1984 the Chukchi Sea ice did not break up until late June, but the Wulik and Kivalina Rivers had cut open channels offshore by June 12. Char began moving out of the Wulik River on June 15 and the movement continued until June 25. At this time the river outlet temperature varied between 9 and

Table 3. Locations and numbers of char tagged and recovered.

| | Location of Tagging | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Wulik River | Kivalina River | Eli River | Kelly River | Kugururok River | Nimiuktuk River | Kugrak River | Total |
| Total tags placed | 677 | 971 | 131 | 1,000 | 996 | 838 | 7 | 4,620 |
| Total tags recovered | 23 | 20 | 4 | 46 | 27 | 16 | 0 | 136 |
| Percentage recovered | 3.4 | 2.1 | 3.1 | 4.6 | 2.7 | 1.9 | 0 | 2.9 |
| Recovery Location: | | | | | | | | |
| Wulik R/Kivalina Village | 18 | 16 | 2 | 6 | 4 | 1 | 0 | 47 |
| Kivalina River | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 3 |
| Noatak Mainstem | 1 | 0 | 2 | 22 | 8 | 9 | 0 | 42 |
| Noatak Mouth/Sheshalik | 3 | 1 | 0 | 6 | 11 | 5 | 0 | 26 |
| Eli River | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kelly River | 0 | 1 | 0 | 12 | 0 | 0 | 0 | 13 |
| Kugururok River | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 3 |
| Nimiuktuk River | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Point Hope | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |

Table 4. Tag recovery by location, year and sexual condition. OW = overwintering fish when tagged, SP = spawner when tagged.

| Recovery Location Fishery & Number | Year and Number tagged in - - Kivalina River (OW) | Wulik River (OW) | Wulik River (SP) | Eli River (SP) | Kelly River (SP) | Kugururok (SP) | Nimiuktuk River (SP) |
|---|---|---|---|---|---|---|---|
| **Wulik/Kivalina Lagoon** | | | | | | | |
| 1981 - n = 0 | | | | | | | |
| 1982 Spring - n = 2 | | 1982 (2) | | | | | |
| 1982 Fall - n = 5 | | 1982 (3) | | | | 1981 (2) | |
| 1983 Spring - n = 11 | 1981 (2)<br>1982 (6)<br>1983 (1) | 1982 (1) | | | | | 1982 (1)[a] |
| Summer n = 4[b] | | | 1981 (1)<br>1983 (3) | | | | |
| Fall n = 17 | 1981 (1)<br>1982 (3) | 1982 (2)[a] | 1983 (3) | 1982 (2) | 1982 (4) | 1982 (2) | |
| Winter n = 1 | | 1982 (1) | | | | | |
| 1984 Fall n = 7 | 1981 (1)<br>1982 (2) | | 1983 (2) | | 1983 (2) | | |
| **Kivalina River** | | | | | | | |
| 1981-n = 0 | | | | | | | |
| 1982 Fall - n = 2 | 1981 (1) | | | | | 1981 (1) | |
| 1983 Summer[b] n = 1 | 1981 (1) | | | | | | |
| 1984 - n = 0 | | | | | | | |

Table 4. (Cont.) Tag recovery by location, year and sexual condition. OW = overwintering fish when tagged, SP = spawner when tagged.

| Recovery Location Fishery & Number | Year and Number Tagged in - - Kivalina River (OW) | Wulik River (OW) | Wulik River (SP) | Eli River (SP) | Kelly River (SP) | Kugururok (SP) | Nimiuktuk River (SP) |
|---|---|---|---|---|---|---|---|
| **Noatak River** | | | | | | | |
| 1981 Fall n = 11 | | | | | 1981 (9) | 1981 (1) | 1981 (1) |
| 1982 Winter/Spring n = 1 | | | | | | 1981 (1) | |
| Fall n = 7 | | | | | 1982 (3) | 1981 (2) | 1982 (1) |
| 1983 Spring n = 2 | | | | 1982 (1) | | | 1982 (1) |
| Fall n = 16 | | | | 1982 (1) | 1980 (1) | 1983 (1) | 1982 (3) |
| | | | | | 1981 (3) | | 1983 (3) |
| | | | | | 1983 (4) | | |
| 1984 Fall n = 5 | | 1982 (1) | | | 1983 (2) | 1982 (1) | |
| | | | | | | 1983 (1) | |
| **Noatak Mouth/Sheshalik** | | | | | | | |
| 1981 Summer - n = 4 | | | | | 1980 (2) | | 1981 (2) |
| 1982 Spring n = 6 | | | | | 1981 (1) | 1981 (3) | 1981 (2) |
| Summer/Fall n = 9 | | 1982 (1) | 1981 (1) | | 1981 (2) | 1981 (4) | 1981 (1) |
| 1983 Spring n = 1 | | | 1982 (2) | | | | |
| Fall n = 2 | | | | | | 1982 (2) | |
| 1984 Summer n = 4 | 1982 (1) | | | | 1981 (1) | 1983 (2) | |
| **Noatak River Tributaries** | | | | | | | |
| **Eli River - n = 0** | | | | | | | |

Table 4. (Cont.) Tag recovery by location, year and sexual condition. OW = overwintering fish when tagged, SP = spawner when tagged.

| Recovery Location Fishery & Number | Year and Number Tagged in- - Kivalina River (OW) | Wulik River (OW) | Wulik River (SP) | Eli River (SP) | Kelly River (SP) | Kugururok (SP) | Nimiuktuk River (SP) |
|---|---|---|---|---|---|---|---|
| **Kelly River** | | | | | | | |
| 1982 Summer[b] n = 11 | | | | | 1980 (3)<br>1982 (8) | | |
| 1983 Summer[b] n = 1 | | | | | 1981 (1) | | |
| 1984 Summer[b] n = 1 | 1981 (1) | | | | | | |
| **Kugururok River** | | | | | | | |
| 1982 Summer[b] n = 1 | | 1982 (1) | | | | | |
| 1983 Summer[b] n = 1 | | | | | | 1981 (1) | |
| 1984 Summer[b] n = 1 | | | | | | 1982 (1) | |
| **Nimiuktuk River** | | | | | | | |
| 1983 Summer[b] n = 1 | | | | | | | 1981 (1) |
| **Point Hope** | | | | | | | |
| 1982 Summer n = 1 | | | | | | 1981 (1) | |

[a] One of these fish was recovered in the ocean off Kivalina.

[b] Recaptured as spawners.

10°C. In some years the sea ice may break up normally, but onshore winds will pile up large masses of ice, effectively blocking stream and lagoon outlets. Under these conditions, char move from streams into lagoons and mill there until channels are broken through ice-cluttered outlets to allow escape. Such was the case in 1983 when char moved into the lagoon in mid-May, but would not move through the ice-blocked channel, remaining in Kivalina Lagoon until ice conditions allowed movement to the sea in mid-June. Most char had left the lagoon by June 20. This accounted for a larger than normal spring subsistence catch at Kivalina (Burch, 1983). Breakup in 1975 was very late, with ice hard on shore well into June (Alt, 1977); out-migrating char were still being taken at Kivalina on July 6.

The spring out-migration from Kivalina Lagoon to sea is also influenced by ocean tidal changes. When the tide nears its highest level there is little current in the channel opening to the sea and there is no observable seaward movement of fish. As soon as the tide crests and begins lowering, a current starts flowing seaward and fish immediately begin moving with the current to the ocean.

The situation on the lower Noatak is different from the Wulik in that the river channel through Kotzebue Sound is sheltered on the seaward side by extensive sandbars which serve to keep sea ice away from the open river current. The timing of the spring out-migration of char is more stable, dependent only on seasonal temperature and the timing of river ice breakup. The seaward movement usually occurs from the last week of May through the first week of June. During late breakup years, it may extend into late June.

The fall migration of char from the sea into fresh water occurs between mid-August and late September. Alt (1978) reported four overlapping runs of overwintering char into the Wulik and Kivalina Rivers, with the size of fish increasing in subsequent runs which continue until after freeze-up. Kivalina residents report this same movement pattern (Bob Hawley, pers. comm.). Small numbers of char were still being caught in Kivalina Lagoon on October 3, 1984. The same run timing holds true for the Noatak River, except that there is no evidence for overlapping runs of increasing-size fish. The incidental catch of char in the Kotzebue Sound commercial salmon fishery peaks during the third or fourth week of August, and some fish are usually 100 mi up the Noatak by August 20. A second run, peaking in mid-September, has been reported in some years (Bob Uhl, pers. comm.).

In-migrating char have been caught in Kotzebue Sound near the mouth of the Noatak River as late as September 25 (DeCicco, 1982).

Summer Spawners. Mature summer prespawners, after having overwintered in their home system, do not migrate to sea in spring, but travel to the mouth of their spawning stream as nonspawners are moving seaward. They begin entering their spawning stream in mid-to late June and by early July are distributed throughout the stream. They then hold in the vicinity of spawning areas until spawning commences in mid-August. Glova and McCart (1974) found mature prespawners in the upper reaches of the Firth River in July, and recaptured one mature fish which had been tagged in the same area in early June. They speculated that spawning fish either go to sea for only a short period or do not go to sea at all.

In the Noatak River the major spawning streams (Kelly, Kugururok and Numiuktak Rivers) enter the river within the area of overwintering, but several streams used for spawning to a lesser degree (Kugrak and Igning Rivers) are up to 280 mi upriver from known overwintering areas (Fig. 3). Although these streams have not been surveyed in the late June- early July period, it is assumed that there is some delay in arrival of spawners to these areas, and that spawners probably do not enter these streams until mid-July.

Char home for spawning. All tag recoveries (n = 8) from spawning fish that were tagged as spawners were made in the same stream in which they were tagged (Table 4). No recoveries were made from spawners in streams other than those in which they were tagged, even though recovery efforts were made in all streams. There is no direct evidence that char return to the same pool or spawning location for repeat spawnings. Armstrong (1974) found that imprinting takes place during the last day of the smolt out-migration. Upon releasing smolts from two streams into a third after holding them in that stream for 24 hours, 10.5% returned to the third stream to spawn upon reaching maturity, almost equalling the portion (9.4%) of native smolts that returned. He also found that mature Dolly Varden only migrated between an overwintering stream and their spawning stream.

A midsummer upstream movement of prespawning char in the Noatak River has been demonstrated through test netting in the lower river by the Commercial Fisheries Division. Spawners made up the majority of their gill-net catches of char from July 3 through August 10, 1983 and were 100% of their catch from July 15 through August 6. Some of these fish moving into the Noatak may have overwintered in the Noatak and moved to sea for a short period before returning to spawn. A similar summer upstream movement occurs on the Wulik River, where two silvery prespawners were captured 32 mi from its mouth on July 30, 1983. These fish had recently left the sea and were mixed with other prespawning fish which had not gone to sea that summer. Some of these midsummer migrants had undoubtedly overwintered in other systems.

After spawning, most summer spawners move to overwintering areas. In the Noatak system spent char move from tributary streams down into the mainstem of the river. On August 27, 1983, spent char were captured in the Noatak near the mouth of the Kugururok River. On September 13, 1983, no char were seen in summer spawning areas on the Nimiuktuk, Kugururok or Kelly Rivers, but large numbers of spent fish were observed in the lower 15 mi of the Kugururok, well downstream of areas used for spawning. Spent summer spawners mix with overwintering fish newly arrived from the sea and overwinter in the same areas. Spent and overwintering char were captured together near the mouth of the Kugururok River on September 19, 1979, August 27, 1983, and October 3, 1984. Spent and nonspawning overwintering char also occur together in the subsistence catches in both Noatak and Kivalina during the last week of September. Twenty-six tag recoveries from subsistence-caught char in overwintering areas on the Noatak and Wulik Rivers were from fish tagged in spawning areas earlier the same year (Table 4). Spent char have also been taken near the mouth of the Nimiuktuk River in September (Ray Hodges, pers. comm.).

Summer spawners that spawn early have time to move to sea for feeding during the year of spawning. Two tag recoveries from the mouth of the Noatak, one on July 28 and one on August 8, were of fish tagged as spawners in the Nimiuktuk River in early July of the same year and one char, taken in Kotzebue Sound on August 22, 1981, had retained eggs. This also occurs on the Kivalina River, where some char were observed spawning in early July, but were absent from the area by the end of July (Phil Driver, pers. comm.). This group of fish may contribute to the late segment of the fall in-migration from the sea.

Fall Spawners. After having overwintered in fresh water, fall spawners move seaward in the spring with nonspawners and immature char. They reenter fresh water with the first group of overwintering fish in mid-August, but instead of remaining in overwintering areas, travel upstream to spawning areas and spawn from mid-September through early October. A prespawning female was captured 20 mi up the Kugururok River on September 17, 1979. Judging by its silvery color, it had only recently entered fresh water. On September 13, 1983, fall spawners were observed in spawning areas on the Kugururok and Kaluktavik Rivers and no fish were observed in summer spawning areas that were occupied in mid-August. The same situation was observed on October 5, 1981. On August 20, 1981, eight prespawning female char were taken about 15 mi upstream from the mouth of the Kivalina River. They were silvery, just having entered from the sea, and were at the upper limit of distribution of overwintering char in the river. These fish were probably en route to a spawning area in the upper Kivalina River, where 51 summer spawners were observed on August 20, 1981, and 245 fall spawners were seen on September 25, 1981.

It appears that most fall spawners remain to overwinter in spring areas used for spawning or remain in spring areas on the tributary stream in which they spawn rather than moving downstream into mainstem overwintering areas. Partially spent char were observed in a spring area above building aufeis on Trail Creek on October 5, 1981. The presence of aufeis usually indicates a stream blockage causing overflow. There was little chance that flows were adequate to allow downstream passage of fish into Trail Creek at that time.

Postspawning movements of fall spawning char radio-tagged on October 1, 1984, were monitored in the Kugururok River during October and November. Of the eight fish tagged, seven remained in the Kugururok and one moved into the Noatak by October 26. Positions of the fish did not appreciably change by November 29. Of the four males tagged, one was within 1 mi of its tagging location and three were grouped about 3 mi downstream. Three of the four females were grouped just downstream of a spring-fed tributary stream about 18 mi below the tagging location in the mainstem of the Kugururok and one was about 5 mi below the Kelly River mouth in the Noatak River, a distance of about 50 mi downstream from where it was tagged. On March 23 the fish were still in the same general locations, although the order of individuals changed and movements up to 1.5 mi were noted. Spatial segregation by sex is probably due to the fact that males tend to stay on spawning grounds longer than females. Females leave spawning sites soon after completion of spawning, whereas males remain to spawn with additional females. Toward the end of spawning, males outnumber females on the spawning grounds.

Residual Char. Residual char are an exclusively male segment of the population that do not go to sea, but remain in fresh water all their lives. These fish mature at a young age and spawn with large anadromous char. Their movements are similar to those of pre-smolt char, and may be limited to the spring area in which they were spawned. Their only occurrence in samples has been in and around spring areas used for spawning.

Multiple-System Movements:

Selection of an overwintering stream is nonspecific and may be based more on convenience than on any homing tendency. Homing is apparent only in the selection of a spawning stream.

Immature char and mature nonspawners do not necessarily overwinter in their river system of origin. Fifteen adult nonspawners that were tagged spawning in the Noatak River were captured overwintering in both the Wulik and Kivalina Rivers during the year after tagging (Table 4). Seven char that were tagged overwintering on the Kivalina were recaptured overwintering on the Wulik River in later years. One char, tagged while overwintering in the Wulik River, was caught two winters later in the Noatak River, and one char, tagged as a juvenile overwintering on the Kivalina River in 1981, was recaptured spawning in the Kelly River in 1984.

Based on a scheme involving nonspecific overwintering and homing for spawning, it would be expected that some maturing prespawners will find themselves in a system other than their home stream during the spring prior to spawning. These fish move to sea, then migrate up their spawning stream in summer prior to spawning. One fish, recovered spawning on the Kugururok River in July, had been tagged at the end of May on the Wulik River prior to spring out-migration (Table 4). Circumstantial evidence for this movement also exists from the spring subsistence catch at Sheshalik Spit where locals report catching "fat Kivalina trout" with maturing gonads moving eastward along the coast toward the mouth of the Noatak in June (Bob Uhl, pers. comm.). At the same time, they catch "skinny Noatak trout" moving in the opposite direction along the coast. Thin char are probably spent fish leaving the Noatak for feeding areas in the Chukchi Sea. Six tag recoveries from this fishery in 1982 were of char that had been tagged as spawners in the Noatak in 1981 (Table 4).

The movement of prespawners from the Wulik River to the Noatak River probably accounts for much of the midsummer in-migration documented in the lower Noatak. A similar movement may be taking place in the opposite direction; i.e., overwintering char from the Noatak moving north along the coast to spawn in the Wulik River. This movement has not been documented by tag recovery, and is probably smaller than the Wulik to Noatak movement because few "fat trout" are caught in June at Sheshalik moving west and because the number of spawners in the Wulik-Kivalina system is much smaller than the number of char spawning in the Noatak system (see section on spawning). But there is limited summer movement of prespawners into the Wulik River, as mentioned earlier, which may be made up in part of fish from other systems such as the Omikviorok, Jade Creek, Rabbit Creek, Kukpuk River, or the Noatak.

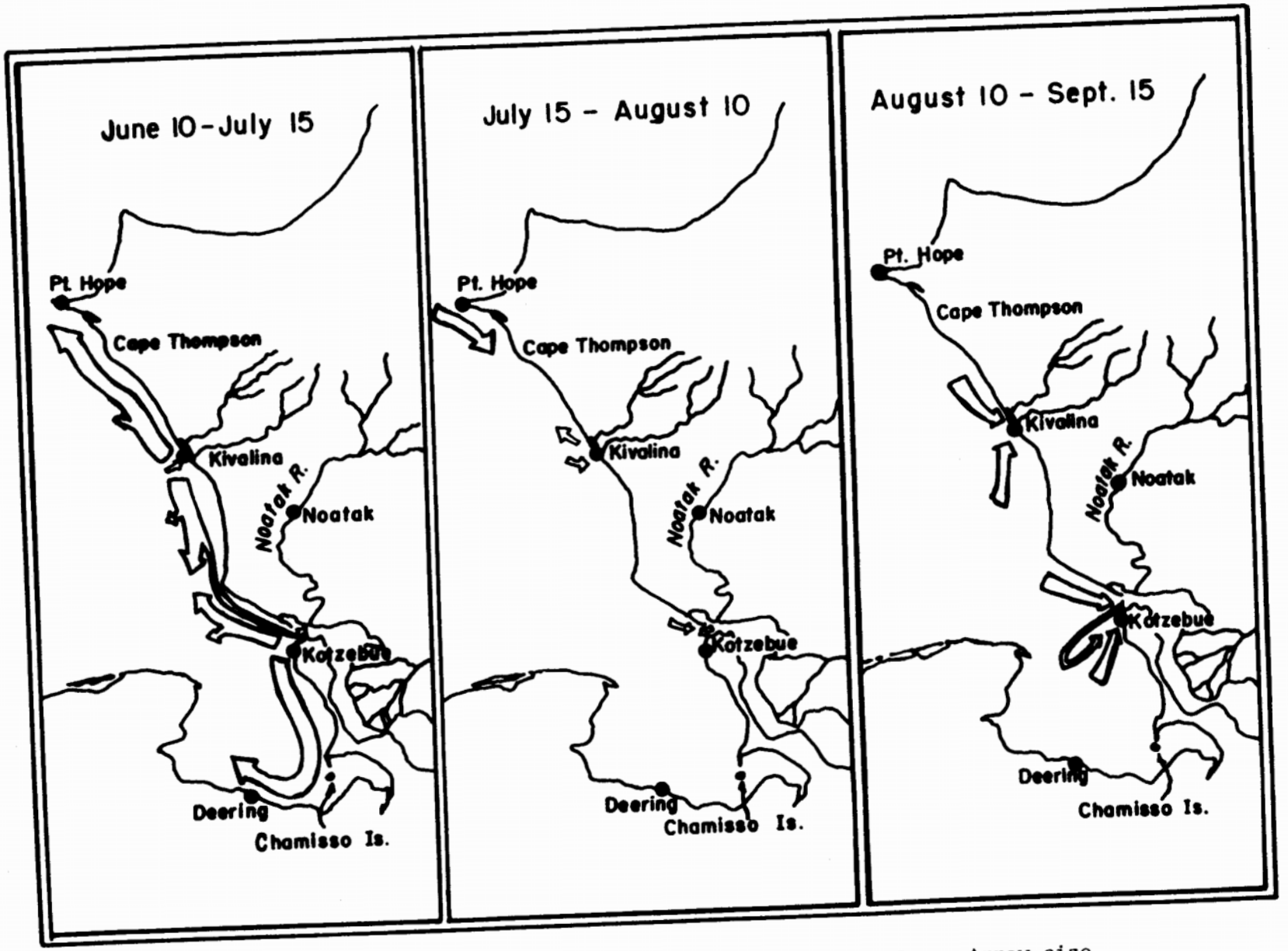


Figure 4. Known summer movements of char in Kotzebue Sound/Chukchi Sea. Arrow size indicates relative movement size in each period, but are not necessarily proportional to each other.

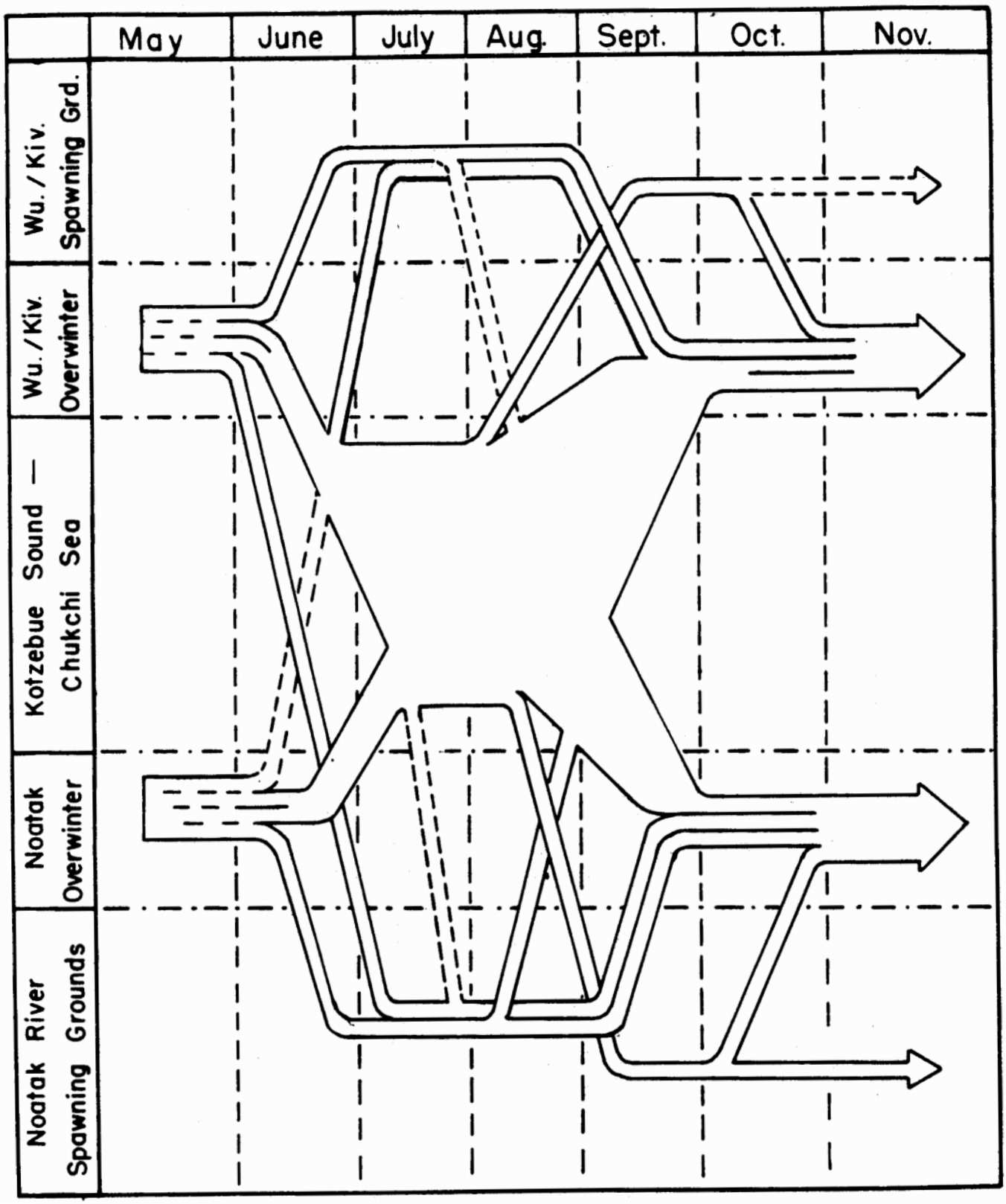


Figure 5. Movements of char between Wulik/Kivalina and Noatak Rivers spawning and overwintering areas and the sea over time. Path width indicates temporal distribution of movement rather than relative numbers of fish involved. Dashed lines indicate probable but undocumented movements.

Discussion:

It is not known what triggers the spring seaward migration. It may be dependent on factors such as increasing water temperatures, either increasing or decreasing stream flows in relation to ice breakup and spring floods, changes in the diurnal cycles of sunlight, or these factors in combination. Whatever the cause, the timing of the downstream movement is very similar in the Noatak and the Wulik Rivers, usually occurring just after or with high turbid spring runoff. The time of entry to the sea, however, differs depending on ice conditions along the Chukchi Sea coast, which primarily influences the Wulik and Kivalina Rivers, as described earlier in this section.

The timing of the fall migration is variable; it usually starts around August 10 and continuing through the end of September. This movement is probably dependent on ocean feeding conditions and time spent at sea, rather than onshore climatic conditions, river flows or temperature. Almost all postsmolt feeding takes place at sea, and enough time must be spent at sea to acquire condition sufficient to sustain individuals throughout the winter.

Alt (1978) reported a late spring out-migration on the Wulik River in 1975 with not all fish leaving the lagoon until July 14, and a correspondingly late fall in-migration (no date given). A late fall in-migration was also noted in 1983; fish began entering the Wulik on August 25, but were not present in substantial numbers in the vicinity of Sivu (12 mi up the Wulik) until September 5. This corresponded to a slightly late spring out-migration that occurred from June 14 through June 20, 1983.

A similar out-migration in 1984 (June 15-20) did not show a correspondingly late fall return. Char were being taken at Kivalina on August 12, 1984, and were present in large numbers at Sivu on August 25.

The timing of the fall in-migration to the Noatak can be estimated from records of char sold in the Kotzebue Sound commercial salmon fishery Table 5. The catch usually peaks during the third or fourth week of August, with fish first being taken between the 10th and 15th. The first char taken in this fishery are usually kept by commercial fishermen for their own consumption and occur in the catch a few days before char are sold.

In an average year char spend approximately 68 days at sea (June 14-August 20), with a possible range of 41 days (July 6-August 5) to 116 days (June 1 -September 24).

Arctic char at Nauyuk Lake in the Canadian Arctic spent 35 to 59 days at sea (Johnson, 1980). Johnson (1980) found that fish outmigrating earlier in the year spent a longer period at sea than those moving to sea later.

The single system movements of summer spawners, in which fish remain in the vicinity of spawning areas for approximately 50 days prior to spawning, present an interesting situation. It would seem that the time spent without feeding would not be advantageous to the fish involved. They could easily enter the sea in June for more than a month of feeding and then move

Table 5. Timing and number of incidental char caught in the Kotzebue commercial fishery.

| | August | | | | | |
|---|---|---|---|---|---|---|
| | 1-5 | 6-10 | 11-15 | 16-20 | 21-25 | 26-31 |
| 1979 | 25 | 12 | 0 | 319 | 1,125 | 1,042 |
| 1980 | 12 | 38 | 123 | 1,279 | 1,181 | 412 |
| 1982 | 0 | 0 | 0 | 434 | 2,924 | 89 |
| 1983 | 0 | 0 | 0 | 835 | Closed | Closed |
| 1984 | 0 | 0 | 0 | 0 | 1,090 | Closed |

during the year of spawning. Two tag recoveries from the mouth of the Noatak, one on July 28 and one on August 8, were of fish tagged as spawners in the Nimiuktuk River in early July of the same year and one char, taken in Kotzebue Sound on August 22, 1981, had retained eggs. This also occurs on the Kivalina River, where some char were observed spawning in early July, but were absent from the area by the end of July (Phil Driver, pers. comm.). This group of fish may contribute to the late segment of the fall in-migration from the sea.

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into streams by August 20 for spawning. Although this probably does occur, it happens to a small degree compared to the numbers of fish that remain in spawning areas throughout the summer. This may be an adaptation to allow for fluctuating rates of flow in some spawning areas. In low rainfall years some upstream spring areas used for spawning are isolated from downstream reaches of rivers. Kukukpilak Creek, a small spring-fed tributary of the Nimiuktuk River, had a strong flow in early July 1982, but by August 5 the lower 2 mi were dry. At this time 56 char were observed in upstream spawning areas. Had these fish not been holding in the stream since early summer they would not have been able to reach their spawning grounds. In September 1976 and in 1977, Alt (pers. comm.) observed char in isolated spring areas in the upper Kelly River.

These instances would explain in part the time spent in streams during spawning, but most areas used for summer spawning are in the mainstems of fairly large Noatak River tributary streams, areas which are not subject to dewatering even during low rainfall years.

There is some evidence that summer spawners move within their spawning stream, searching out spawning sites. In 1982, six prespawning char tagged in the Kelly River approximately 5 mi above Wrench Creek on July 22 were recaptured several miles up Wrench Creek during the first week of August. This may indicate instream searching for spawning sites, or it may be attributable to stress induced by tagging.

Age and Growth

Age determinations were made on 1,253 char from the study area; they ranged in age class from 0 to XVI and in fork length from 25 to 835 mm (Table 6). Because of difficulty in obtaining fish of all age classes from known stocks, samples from all systems were grouped and treated as one areawide population. Age data include a sample of 130 collected by Winslow (1969). Growth rates of Kotzebue Sound-Chukchi Sea char are more rapid than those found by Yoshihara (1973) for char in the Sagavanirktok River (Fig. 6).

Presmolt Growth:

In the Noatak system young-of-the-year char emerge from the gravel during mid-June at 23 to 25 mm in length. They averaged 28 mm (n = 11) in the first week of July and 33 mm (n = 5) by the second week of July. In early August they were 40 mm in length (n = 10) and reached 51 mm (n = 6) by early October and ranged to 62 mm (Fig. 7).

Houghton and Hilgert (1983) found early growth to be slightly faster on the Wulik River; fry emerged in mid-June at 25 mm, and reached 38.4 mm in mid-July (n = 9) and 69.9 mm by mid-September (n = 34). In a mid-August sample from the Wulik River Age 0 fry averaged 56 mm (n = 91); Age I, 93 mm (n = 31); and Age II, 121 mm (n = 6).

Age and Size at First Seaward Migration:

First seaward migration occurs at Ages I through VI, with the majority of char migrating at Age II, III, or IV. In a sample of 41 out-migrating smolts the average size was 124 mm at Age II, 144 mm at Age III, and 143 mm

Table 6. Age and growth of Kotzebue Sound-Chukchi Sea char based on total otolith age (n = 1,253).

| | Fork Length (mm) at Age– – | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | XIII | XIV | XV | XVI |
| $\bar{x}$ | 49 | 85 | 115 | 227 | 348 | 443 | 515 | 572 | 611 | 642 | 664 | 657 | 611 | 728 | ... | ... | 835 |
| n | 152 | 64 | 41 | 46 | 86 | 172 | 254 | 219 | 138 | 50 | 21 | 6 | 2 | 1 | | | 1 |
| Range | 23–67 | 56–124 | 66–145 | 94–410 | 130–505 | 240–655 | 280–680 | 354–750 | 444–796 | 475–820 | 585–760 | 595–744 | 600–622 | 728 | | | 835 |
| SD | 11.1 | 15.6 | 17.9 | 88.6 | 81.2 | 79.8 | 67.9 | 66.8 | 100.9 | 58.4 | 49.3 | 52.7 | 15.6 | | | | |
| SE | 0.9 | 2.0 | 2.8 | 13.1 | 8.8 | 6.1 | 4.3 | 4.5 | 8.6 | 8.3 | 10.8 | 21.5 | 11.0 | | | | |

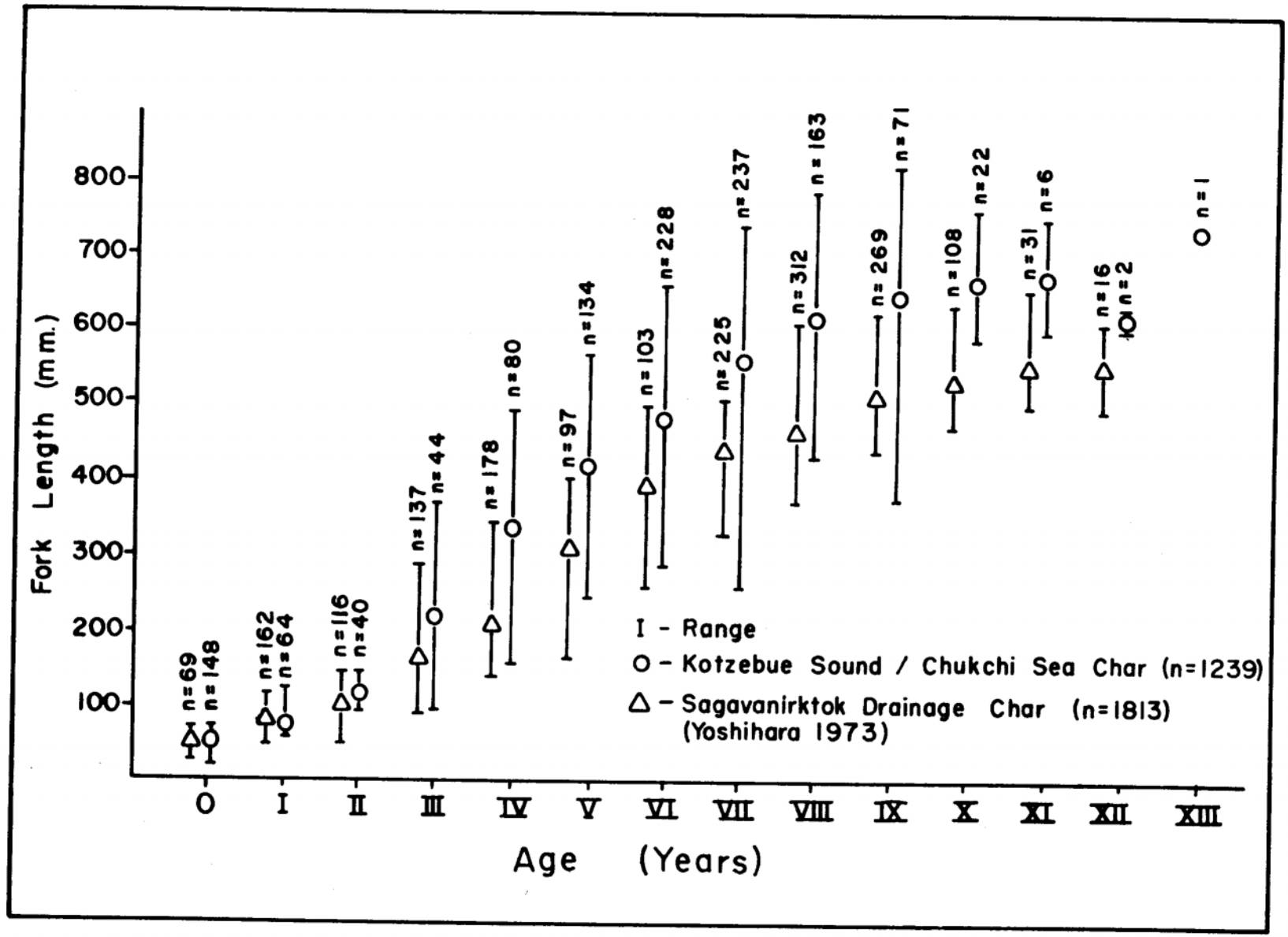


Figure 6. Comparative age and growth of Kotzebue Sound/Chukchi Sea char with Sagavanirktok River char.

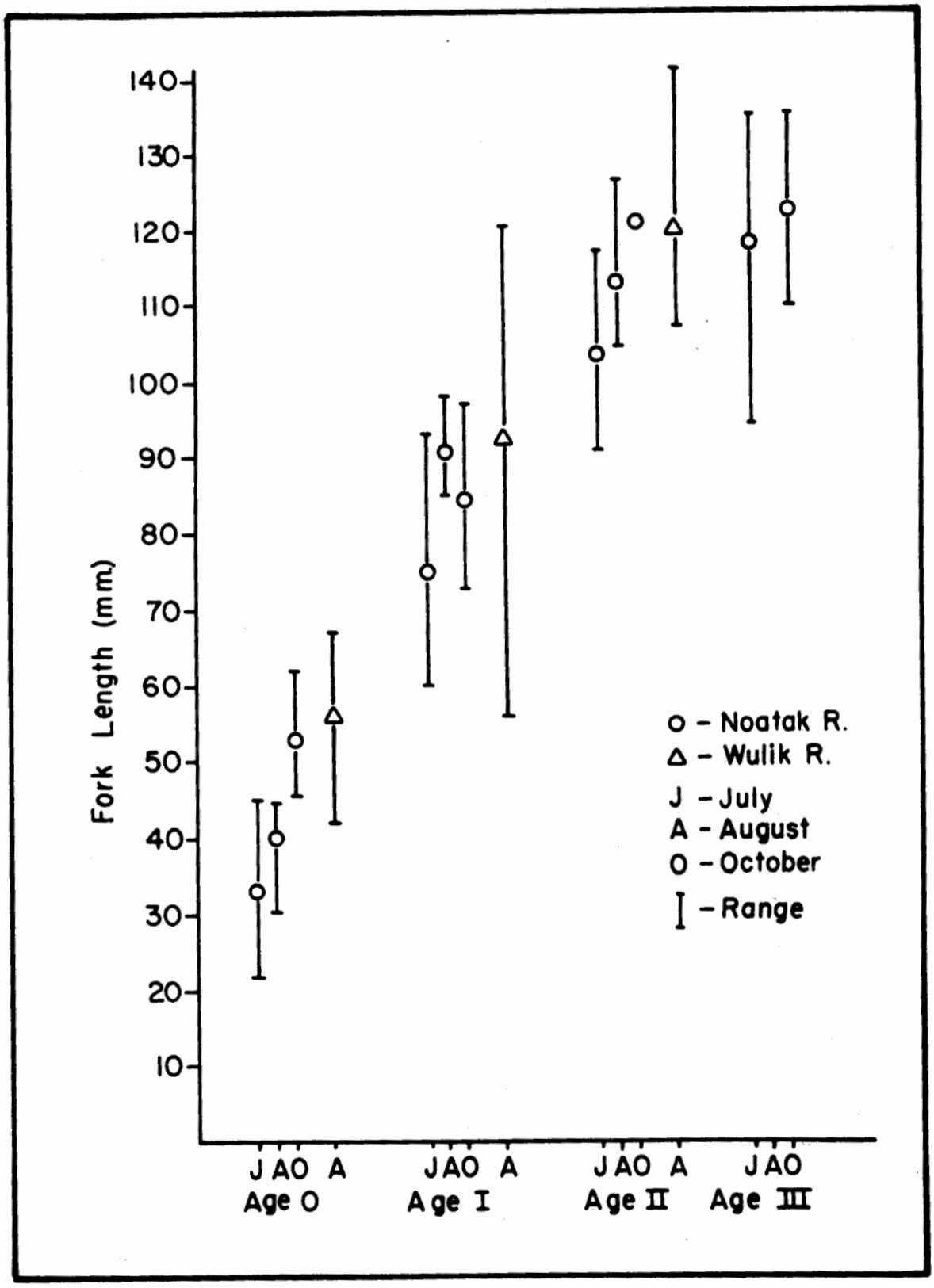


Figure 7. Presmolt growth of rearing char in the Noatak and Wulik Rivers.

at Age IV. Composition of smolts by age class, as determined from otoliths of 785 postsmolt char, was 0.1% Age I, 31.8% Age II, 55.9% Age III, 10.3% Age IV, 1.5% Age V, and 0.3% Age VI (Table 7).

Growth based on years at sea is presented in Table 7. I believe this is a more accurate way to present growth data for char because (1) all feeding after first seaward migration takes place at sea, (2) there is a maximum range of 6 years at smolting, and (3) there is little difference in size at smolting, even though age may vary. Figure 8 compares age and length data on 996 char ranging in age from III to XIII years, based on total otolith age, with 785 fish from the same sample for which age at first seaward migration could be determined. Ages in the second group are given as postsmolt years. This group is displaced 3 years to the right along the horizontal axis to provide a relative comparison because the majority of those aged (55.9%) had migrated to sea at Age III. Standard deviations for the post-smolt group are consistently smaller than the total age sample and a consistent increase in size is found in older fish, as might be expected. Overlap in size of adjacent age classes is still present and is probably due to individual growth variation and individual differences in movement patterns relative to feeding and spawning.

Incremental Growth:

Growth increment as determined from age and length data is compared to growth increment by postsmolt years in Table 8. Incremental growth for 15 tagged fish recovered in subsequent years varied from 7 to 110 mm for one summer feeding season, with a mean annual growth increment of 59.2 mm (Table 9).

Maximum Size and Age:

The largest char captured in this study was an 870-mm male from the Kelly River in 1980. Fish over 800 mm have been captured in 2 of the past 4 years. Winslow (1969) aged an 835-mm char at 16 years and captured a 915-mm male for which no age determination was made. Most of the very large fish encountered in this study were not killed for aging. Only 1% of the spawning population of char is over 740 mm (Table 10).

Size and Age at First Maturity:

The smallest prespawning male char observed was 396 mm in length, taken in the Nimuiktuk River in 1981, and the smallest female was 455 mm from the Kelly River, also in 1981. Over the 4 years of this study, 98 of 1,226 (8%) male prespawning char were under 500 mm in length and 123 of 3,138 (3.9%) females were under 500 mm. These fish probably spent only 3 years at sea and could thus be 4 to 7 years old. The youngest prespawning females aged in this study were 5 years old (n = 16); all except two had spent three postsmolt years at sea. The two exceptions had spent 2 years at sea. Many fish are spawning for the first time at a much larger size; evidence of this is indirect, however, based on length frequency of spawners and a low incidence of tag recovery from second-time spawners (see section on Length Frequency and Reproduction). One tag was recovered from a summer spawner that was tagged as a juvenile at 461 mm and recaptured on spawning grounds at 624 mm after two intervening summer seasons. It is

Table 7. Age and growth of Kotzebue Sound-Chukchi Sea char based on smolt age (n = 785).

| | | Post-smolt Years | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
| Age I smolts | $\bar{x}$ FL | | | | 568 | | | | | |
| | n | | | | 1 | | | | | |
| | range | | | | 568 | | | | | |
| | $S_x$ | | | | | | | | | n = 1 .1% |
| Age II smolts | $\bar{x}$ FL | 255 | 391 | 454 | 548 | 604 | 659 | 694 | | |
| | n | 3 | 22 | 62 | 70 | 64 | 22 | 6 | | |
| | range | 250-266 | 330-455 | 392-544 | 432-655 | 470-702 | 600-750 | 595-796 | | |
| | $S_x$ | 9.24 | 31.83 | 33.94 | 39.22 | 41.80 | 38.32 | 68.48 | | n = 250 31.8% |
| Age III smolts | $\bar{x}$ FL | 282 | 398 | 475 | 556 | 614 | 668 | 679 | 712 | |
| | n | 11 | 34 | 117 | 120 | 102 | 37 | 15 | 3 | |
| | range | 255-309 | 323-461 | 397-578 | 476-646 | 540-740 | 530-820 | 645-760 | 680-744 | |
| | $S_x$ | 20.5 | 30.34 | 38.13 | 37.94 | 57.32 | 60.36 | 36.71 | 32 | n = 439 55.9% |
| Age IV smolts | $\bar{x}$ FL | 251 | 405 | 487 | 554 | 591 | 637 | | | |
| | n | 2 | 7 | 29 | 20 | 18 | 5 | | | |
| | range | 240-262 | 364-490 | 405-590 | 430-655 | 475-665 | 607-723 | | | |
| | $S_x$ | 15.56 | 53.61 | 45.68 | 62.66 | 56.22 | 48.15 | | | n = 81 10.3% |
| Age V smolts | $\bar{x}$ FL | 319 | 380 | 500 | 567 | 585 | 610 | | 728 | |
| | n | 3 | 1 | 3 | 1 | 1 | 2 | | 1 | |
| | range | 280-366 | 380 | 462-542 | 567 | 585 | 595-624 | | 728 | |
| | $S_x$ | 43.55 | | 40.15 | | | 20.51 | | | n = 12 1.5% |

Table 7. (Cont.) Age and growth of Kotzebue Sound_Chukchi Sea char based on smolt age (n = 785).

| | | Postsmolt Years | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
| Age VI smolts | $\bar{x}$ FL | | 449 | | | | 622 | | | |
| | n | | 1 | | | | 1 | | | |
| | range | | 449 | | | | 622 | | | |
| | $S_x$ | | | | | | | | | n = 2 0.3% |
| Combined | $\bar{x}$ FL | 280 | 397 | 471 | 553 | 607 | 660 | 683 | 716 | |
| | n | 19 | 65 | 211 | 212 | 186 | 67 | 21 | 4 | |
| | range | 240-266 | 323-490 | 392-590 | 430-655 | 399-740 | 530-820 | 595-796 | 680-744 | |
| | $S_x$ | 30.144 | 33.807 | 39.594 | 41.014 | 50.304 | 52.643 | 46.457 | 27.325 | |
| | SE | 6.916 | 4.193 | 2.726 | 2.817 | 3.688 | 6.431 | 10.138 | 13.663 | TOTAL: 785 |

Table 8. Incremental growth by total age and by postsmolt years.

| | Age Class Interval | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0-I | I-II | II-III | III-IV | IV-V | V-VI | VI-VII | VII-VIII | VIII-IX | IX-X |
| Growth increment (mm) | 36 | 30 | 112 | 121 | 95 | 72 | 57 | 39 | 31 | 22 |
| Postsmolt interval (years) | | | | 1-2 | 2-3 | 3-4 | 4-5 | 5-6 | 6-7 | 7-8 |
| Growth increment (mm) | | | | 116 | 74 | 82 | 55 | 52 | 23 | 33 |

Table 9. Incremental growth of tagged char.

| Fork Length (mm) | | | |
|---|---|---|---|
| Tagged | Recovered | Growth Increment | # Ocean Seasons |
| 550 | 557 | 7 | 1 |
| 362 | 438 | 76 | 1 |
| 638 | 679 | 41 | 1 |
| 580 | 626 | 46 | 1 |
| 525 | 635 | 110 | 1 |
| 546 | 600 | 54 | 1 |
| 480 | 548 | 68 | 1 |
| 510 | 560 | 50 | 1 |
| 457 | 500 | 43 | 1 |
| 590 | 700 | 110 | 1 |
| 555 | 597 | 42 | 1 |
| 577 | 612 | 35 | 1 |
| 572 | 600 | 28 | 1 |
| 586 | 660 | 74 | 1 |
| 461 | 624 | 163 | 2 |

Table 10. Percent composition of Noatak River spawning char by size, sex and year.

| Fork Length (mm) | 1981 | | | | 1982 | | | | 1983 | | | | 1984 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Male | | Female | | Male | | Female | | Male | | Female | | Male | | Female | |
| | n | % | n | % | n | % | n | % | n | % | n | % | n | % | n | % |
| 390-399 | 1 | 0.1 | | | | | | | | | | | | | | |
| 400-409 | 0 | 0 | | | | | | | | | | | | | | |
| 410-419 | 1 | 0.1 | | | | | | | 1 | 0.1 | | | 1 | 0.1 | | |
| 420-429 | 1 | 0.1 | | | 1 | 0.1 | | | 1 | 0.1 | | | 0 | 0 | | |
| 430-439 | 0 | 0 | | | 1 | 0.1 | | | 1 | 0.1 | | | 0 | 0 | | |
| 440-449 | 2 | 0.2 | | | 0 | 0 | | | 0 | 0 | | | 0 | 0 | | |
| 450-459 | 2 | 0.2 | 2 | 0.2 | 1 | 0.1 | 1 | 0.1 | 1 | 0.1 | | | 3 | 0.3 | 1 | 0.1 |
| 460-469 | 2 | 0.2 | 1 | 0.1 | 6 | 0.5 | 0 | 0 | 1 | 0.1 | | | 1 | 0.1 | 5 | 0.6 |
| 470-479 | 5 | 0.5 | 8 | 0.8 | 2 | 0.2 | 2 | 0.2 | 1 | 0.1 | 1 | 0.1 | 2 | 0.2 | 5 | 0.6 |
| 480-489 | 13 | 1.3 | 25 | 2.6 | 8 | 0.7 | 2 | 0.2 | 1 | 0.1 | 0 | 0 | 4 | 0.5 | 5 | 0.6 |
| 490-499 | 17 | 1.7 | 42 | 4.3 | 5 | 0.4 | 10 | 0.8 | 7 | 0.7 | 3 | 0.3 | 5 | 0.6 | 10 | 1.1 |
| 500-509 | 23 | 2.4 | 68 | 7.0 | 12 | 1.0 | 9 | 0.7 | 3 | 0.3 | 8 | 0.8 | 2 | 0.2 | 13 | 1.5 |
| 510-519 | 25 | 2.6 | 77 | 7.9 | 11 | 0.9 | 23 | 1.9 | 9 | 0.9 | 18 | 1.8 | 1 | 0.1 | 14 | 1.6 |
| 520-529 | 27 | 2.8 | 93 | 9.6 | 16 | 1.3 | 35 | 2.8 | 5 | 0.5 | 35 | 3.5 | 4 | 0.5 | 22 | 2.5 |
| 530-539 | 20 | 2.1 | 76 | 7.8 | 13 | 1.1 | 59 | 4.8 | 7 | 0.7 | 40 | 4.0 | 1 | 0.1 | 43 | 4.9 |
| 540-549 | 25 | 2.6 | 58 | 6.0 | 20 | 1.6 | 89 | 7.2 | 11 | 1.1 | 58 | 5.8 | 8 | 0.9 | 34 | 3.9 |
| 550-559 | 22 | 2.3 | 51 | 5.2 | 26 | 2.1 | 137 | 11.1 | 18 | 1.8 | 71 | 7.1 | 11 | 1.3 | 48 | 5.5 |
| 560-569 | 12 | 1.2 | 35 | 3.6 | 22 | 1.8 | 120 | 9.8 | 18 | 1.8 | 78 | 7.8 | 5 | 0.6 | 71 | 8.1 |
| 570-579 | 5 | 0.5 | 30 | 3.1 | 34 | 2.8 | 100 | 8.1 | 13 | 1.3 | 87 | 8.7 | 9 | 1.0 | 67 | 7.6 |
| 580-589 | 6 | 0.6 | 33 | 3.4 | 29 | 2.4 | 76 | 6.2 | 26 | 2.6 | 91 | 9.1 | 10 | 1.1 | 78 | 8.9 |
| 590-599 | 6 | 0.6 | 20 | 2.1 | 42 | 3.4 | 60 | 4.9 | 21 | 2.1 | 68 | 6.8 | 5 | 0.6 | 79 | 9.0 |
| 600-609 | 8 | 0.8 | 20 | 2.1 | 36 | 2.9 | 31 | 2.5 | 17 | 1.7 | 59 | 5.9 | 13 | 1.5 | 59 | 6.7 |
| 610-619 | 4 | 0.4 | 8 | 0.8 | 26 | 2.1 | 12 | 1.0 | 9 | 0.9 | 32 | 3.2 | 20 | 2.3 | 40 | 4.5 |
| 620-629 | 5 | 0.5 | 7 | 0.7 | 24 | 2.0 | 10 | 0.8 | 12 | 1.2 | 22 | 2.2 | 15 | 1.7 | 26 | 3.0 |
| 630-639 | 5 | 0.5 | 6 | 0.6 | 18 | 1.5 | 7 | 0.6 | 11 | 1.1 | 16 | 1.6 | 14 | 1.6 | 18 | 2.0 |
| 640-649 | 3 | 0.3 | 9 | 0.9 | 7 | 0.6 | 3 | 0.2 | 16 | 1.6 | 12 | 1.2 | 10 | 1.1 | 7 | 0.8 |
| 650-659 | 8 | 0.8 | 4 | 0.4 | 6 | 0.5 | 4 | 0.3 | 8 | 0.8 | 2 | 0.2 | 15 | 1.7 | 3 | 0.3 |
| 660-669 | 7 | 0.7 | 3 | 0.3 | 8 | 0.7 | 1 | 0.1 | 9 | 0.9 | 4 | 0.4 | 7 | 0.8 | 1 | 0.1 |
| 670-679 | 9 | 0.9 | 5 | 0.5 | 5 | 0.4 | 4 | 0.3 | 8 | 0.8 | 0 | 0 | 10 | 1.1 | 1 | 0.1 |
| 680-689 | 3 | 0.3 | 5 | 0.5 | 4 | 0.3 | 1 | 0.1 | 9 | 0.9 | 1 | 0.1 | 11 | 1.3 | 1 | 0.1 |

Table 10. (Cont.) Percent composition of Noatak River spawning char by size, sex and year.

| Fork Length (mm) | 1981 | | | | 1982 | | | | 1983 | | | | 1984 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Male | | Female | | Male | | Female | | Male | | Female | | Male | | Female | |
| | n | % | n | % | n | % | n | % | n | % | n | % | n | % | n | % |
| 690-699 | 1 | 0.1 | 4 | 0.4 | 7 | 0.6 | 6 | 0.5 | 10 | 1.0 | 1 | | 8 | 0.9 | | |
| 700-709 | 7 | 0.7 | 2 | 0.2 | 7 | 0.6 | 1 | 0.1 | 9 | 0.9 | 3 | 0.3 | 5 | 0.6 | | |
| 710-719 | 2 | 0.2 | 0 | 0 | 7 | 0.6 | 1 | 0.1 | 8 | 0.8 | 0 | 0 | 7 | 0.8 | | |
| 720-729 | 2 | 0.2 | 1 | 0.1 | 5 | 0.4 | 1 | 0.1 | 3 | 0.3 | 1 | 0.1 | 4 | 0.5 | | |
| 730-739 | 0 | 0 | | | 12 | 1.0 | 2 | 0.2 | 2 | 0.2 | 0 | 0 | 2 | 0.2 | | |
| 740-749 | 3 | 0.3 | | | 4 | 0.3 | | | 4 | 0.4 | 0 | 0 | 8 | 0.9 | | |
| 750-759 | 1 | 0.1 | | | 5 | 0.4 | | | 1 | 0.1 | 1 | 0.1 | 3 | 0.3 | | |
| 760-769 | 0 | 0 | | | 1 | 0.1 | | | 2 | 0.2 | | | 2 | 0.2 | | |
| 770-779 | 2 | 0.2 | | | 1 | 0.1 | | | 1 | 0.1 | | | 1 | 0.1 | | |
| 780-789 | 2 | 0.2 | | | | | | | 0 | 0 | | | 0 | 0 | | |
| 790-799 | 0 | 0 | | | | | | | 0 | 0 | | | 2 | 0.2 | | |
| 800-809 | 1 | 0.1 | | | | | | | 1 | 0.1 | | | | | | |
| 810-819 | 0 | 0 | | | | | | | | | | | | | | |
| 820-829 | 2 | 0.2 | | | | | | | | | | | | | | |
| Total | 290 | 29 | 693 | 71 | 432 | 35 | 807 | 65 | 285 | 29 | 712 | 71 | 229 | 26 | 651 | 74 |

assumed that this fish was a first-time spawner because it is doubtful that it could have attained this length unless it had spent both summer seasons feeding. It can thus be concluded that age and size at maturity are variable; that char spawn for the first time from 396 to 624 mm in length at 5 to 9 years of age, after having spent 2 to 5 postsmolt years feeding at sea.

Residuals:

Residual char, the nonanadromous male segment of the char population that resides in spawning streams, exhibit much slower growth rates than their anadromous counterparts. Residual char ranged in age from II to VII and in fork length from 125 to 237 mm (n = 15) (Table 11).

Growth is similar to presmolt anadromous char for the first 3 years and the two cannot be distinguished until residuals begin to show signs of sexual maturity, as early as Age II, but usually at Age III.

It is not known what proportion of rearing char become residuals, they were uncommon in samples, but not rare. The fact that most other juveniles that are of the same age classes have already left rearing areas and migrated seaward complicates such a determination. Their presence in the population helps explain the preponderance of females in anadromous spawning populations.

Weight-Length Relationships

The weight of a char at a given length varies over the course of the reproductive cycle and the time of year. Overwintering char fresh from the sea will be relatively heavy for their length, whereas postspawners after having spent up to 20 months in fresh water without feeding will be very light for their length. Table 12 gives weight-length relationships for prespawning char sampled in 1983 from Noatak spawning streams and the Wulik River.

Condition factors were calculated for char in various life history phases from different rivers (Table 13). Prespawning char from the Wulik River showed consistently higher condition factors in all years ($\bar{K}$ = 1.022) than prespawners in Noatak River tributaries ($\bar{K}$ = 0.994) ($t = 5.652$; $p < 0.001$). Female prespawners in all streams exhibited higher condition factors ($\bar{K}$ = 1.004) than did male prespawners ($\bar{K}$ = 0.968). Changes in condition in relation to season, feeding and spawning are apparent. Prespawning char from all areas had a mean condition factor of 0.996. Nonspawning overwintering fish in the Kivalina River in the fall were in better condition (K = 1.053) than postspawners (K = 0.799 for males, K = 0.750 for females), and postspawning char captured in the spring after having wintered in a spent condition were in the worst condition (K=0.715 for males, K = 0.629 for females). Males declined less in condition from spawning and overwintering than did females.

Although the condition difference between Wulik and Noatak River spawners is significant, it is quite small. For example, a 600-mm char from the Wulik would weigh 2,208 g, while one from the Noatak would weigh 2,147 g.

Table 11. Age and growth of residual char.

| Age Class | Fork Length (mm) in Age Class- - II | III | IV | V | VI | VII |
|---|---|---|---|---|---|---|
| Fork Length (mm) in | | | | | | |
| $\bar{x}$ | 125 | 131 | 156 | 204 | 230 | 237 |
| range | 125 | 122-147 | 143-170 | 204 | 195-253 | 237 |
| n | 1 | 5 | 4 | 1 | 3 | 1 |
| SD | | 10.85 | 11.79 | | 30.81 | |

Table 12. Weight-length relationships of prespawning char tagged in 1983.

| Location | Sex | n | Length (mm) | | Weight (g) | | Weight-Length Relationship |
|---|---|---|---|---|---|---|---|
| | | | Mean | Range | Mean | Range | |
| Kelly River | M | 61 | 598 | 419-760 | 2,219 | 650-4,150 | $Log_{10}W = -4.84 + 2.94\ Log_{10}L$ |
| | F | 168 | 574 | 501-709 | 1,941 | 1,200-3,600 | $Log_{10}W = -5.48 + 3.17\ Log_{10}L$ |
| Kugururok River | M | 76 | 616 | 513-800 | 2,390 | 1,250-5,200 | $Log_{10}W = -5.64 + 3.23\ Log_{10}L$ |
| | F | 124 | 579 | 494-705 | 2,021 | 1,100-3,800 | $Log_{10}W = -5.48 + 3.18\ Log_{10}L$ |
| Nimiuktuk River | M | 48 | 599 | 455-713 | 2,175 | 800-3,975 | $Log_{10}W = -6.14 + 3.40\ Log_{10}L$ |
| | F | 154 | 571 | 494-646 | 1,860 | 1,100-2,700 | $Log_{10}W = -5.45 + 3.16\ Log_{10}L$ |
| Wulik River | M | 150 | 617 | 470-820 | 2,459 | 975-6,000 | $Log_{10}W = -5.61 + 3.22\ Log_{10}L$ |
| | F | 224 | 568 | 452-793 | 1,935 | 900-4,950 | $Log_{10}W = -5.10 + 3.04\ Log_{10}L$ |

Table 13. Condition factors (k) of char in various years, seasons and life history phases.

A. Prespawners

| River | 1980 | | 1981 | | 1982 | | 1983 | | All Years | |
|---|---|---|---|---|---|---|---|---|---|---|
| Kelly | n | k | n | k | n | k | n | k | n | k |
| male | 18 | 0.942 | 92 | 0.944 | 119 | 0.998 | 61 | 0.992 | 290 | 0.976 |
| female | 71 | 1.013 | 264 | 1.000 | 189 | 1.026 | 168 | 1.013 | 692 | 1.012 |
| both | 89 | .999 | 356 | .985 | 308 | 1.015 | 229 | 1.007 | 982 | 1.001 |
| Kugururok | n | k | n | k | n | k | n | k | n | k |
| male | - | - | 81 | 0.936 | 185 | 0.953 | 76 | 0.989 | 342 | 0.957 |
| female | - | - | 209 | 0.996 | 316 | 0.990 | 124 | 1.026 | 649 | 0.999 |
| both | - | - | 290 | 0.980 | 501 | 0.976 | 200 | 1.012 | 991 | 0.984 |
| Nimiuktuk | n | k | n | k | n | k | n | k | n | k |
| male | - | - | 111 | 0.979 | 86 | 0.922 | 48 | 0.952 | 245 | 0.954 |
| female | - | - | 229 | 1.017 | 197 | 0.954 | 154 | 0.986 | 580 | 0.987 |
| both | - | - | 340 | 1.005 | 283 | 0.944 | 202 | 0.978 | 825 | 0.977 |
| Wulik | n | k | n | k | n | k | n | k | n | k |
| male | 4 | 1.018 | 6 | 1.036 | - | - | 150 | 0.999 | 160 | 1.001 |
| female | 4 | 1.157 | 15 | 1.086 | - | - | 224 | 1.033 | 243 | 1.037 |
| both | 8 | 1.088 | 21 | 1.059 | - | - | 374 | 1.019 | 403 | 1.022 |

B. Overwintering Nonspawners

| | | n | k |
|---|---|---|---|
| Kivalina River | 1981 and 1982 sexes combined | 407 | 1.054 |

Table 13. (Cont.) Condition factors (k) of char in various years, seasons and life history phases.

C. Spent Char — Kugururok and Wulik-Kivalina Rivers 1979-84

Noatak River

| | n | k |
|---|---|---|
| male | 13 | 0.812 |
| female | 22 | 0.765 |
| both | 35 | 0.783 |

Wulik-Kivalina Rivers

| | n | k |
|---|---|---|
| male | 4 | 0.754 |
| female | 13 | 0.725 |
| both | 17 | 0.732 |

D. Spent char captured in June

Wulik River

| | n | k |
|---|---|---|
| male | 2 | 0.715 |
| female | 5 | 0.617 |
| both | 7 | 0.645 |

Wulik River char are recognized by residents of the area as being fatter and more desirable than char from other rivers (Bob Hawley, Oran Knox, pers. comm.) The fact that Wulik spawners are in better condition than Noatak spawners may be due to one or a combination of factors. Spawning areas in the Wulik are located closer to the sea than Noatak spawning areas, fish therefore expend less energy to reach spawning areas. Wulik River char may feed in a different area during the summer which may be more productive than feeding areas used by many Noatak char. There may also be genetic factors selecting for heavier fish in the Wulik system.

Length Frequency of Spawning Char

Anadromous char spawning in the Noatak system ranged in fork length from 396 to 870 mm, and averaged 567 mm over the 4 years of this study (n = 2,946). Spawners in the Wulik and Kivalina Rivers ranged from 422 to 820 mm, and averaged 588 mm (n = 485). Male spawners in the Noatak averaged 586 mm (n = 918), and females 559 mm (n = 2,028). In the Wulik and Kivalina Rivers, males averaged 619 mm (n = 198) and females 569 mm (n = 285).

The length frequencies of spawners in the Noatak system from 1981 through 1984 are shown in Fig. 9. The modal size of spawners increased from 520-530 mm in 1981 to 580-590 mm in both 1983 and 1984. The increase in size over the course of this study is further substantiated when size groupings which most closely approximate 50% of the spawning population are compared. In 1981, 50.8% of spawners were 500 to 540 mm; in 1982, 53.1% were 540 to 580 mm; in 1983, 49.1% were 550 into 590 mm; and in 1984, 51.9% were 560 to 610 mm.

Both the largest and the smallest anadromous spawners were males, and they made up the majority in larger size groups in all years. In 1981 and 1984 males predominated over 600 mm in length. In 1982 they made up the majority of spawners over 580 mm, and in 1983 they made up the majority over 610 mm (Table 10).

Reproduction

There are two distinct groups of spawners within the Kotzebue Sound-Chukchi Sea char stocks. The majority of char are summer spawners and either most do not go to sea during the year of spawning or, if they have wintered in a river system other than their home stream, move to sea and travel immediately to the river in which they will spawn. Fall spawners compose 10 to 15% of the spawning population and feed at sea during the summer, prior to ascending streams to spawning areas in late August (see section on movements).

Summer Spawning:

Location of Spawning Grounds. Summer spawning areas are located near groundwater sources in side channels and main channels of streams. In the Noatak system spawning occurs in the Eli, Kelly, Kugururok, Kaluktavik and Nimuiktuk Rivers and to a lesser degree in the Anisak, Kugrak and Igning Rivers and several other small tributaries (Figs. 2 and 3). Spawning also

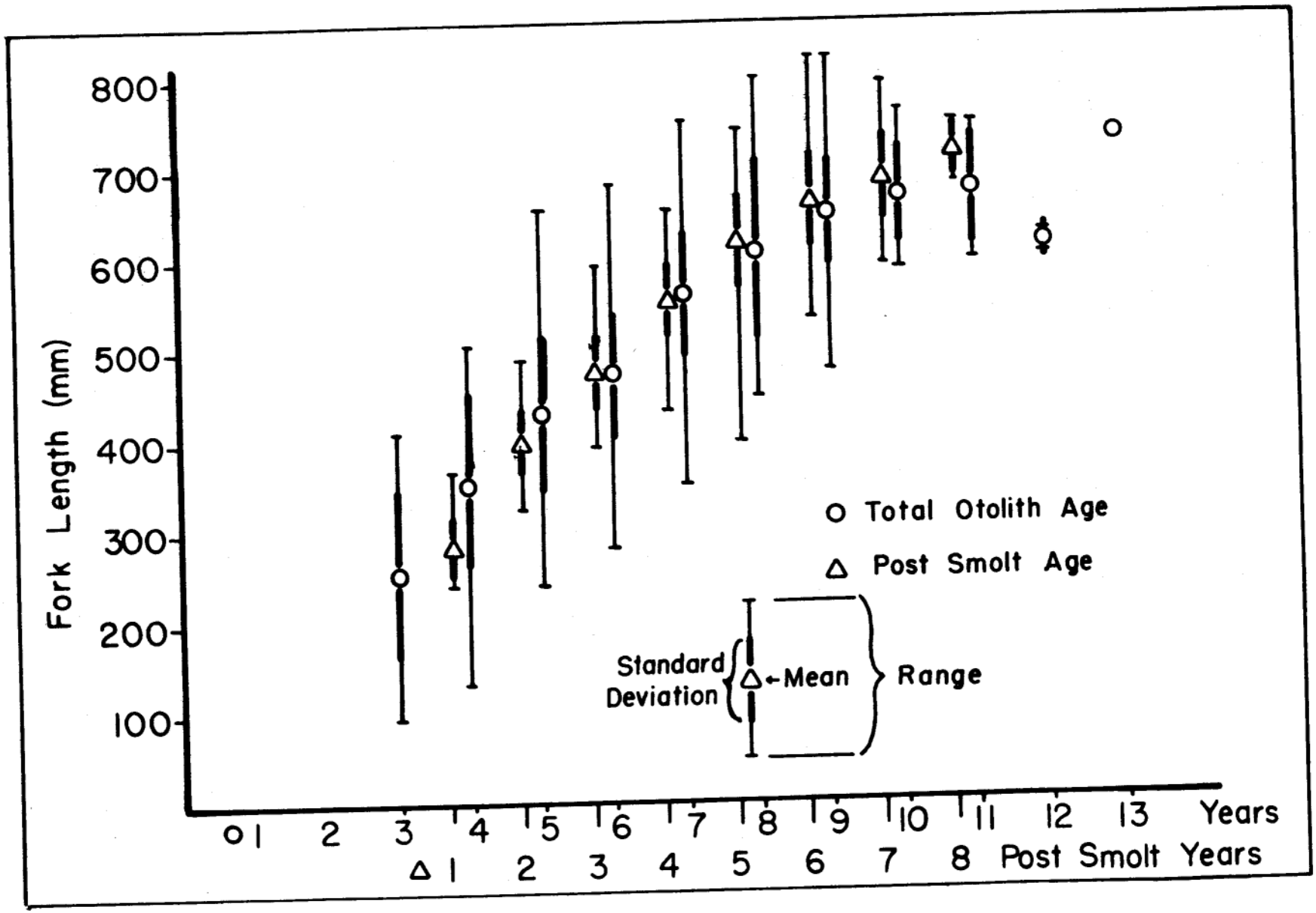


Figure 8. Comparison of age and growth of char based on total otolith age versus post smolt years. The post smolt group is offset three years because most char smolt at Age III. Heavy lines indicate standard deviation, which for post smolt aging are consistently smaller than for the total otolith aging method.

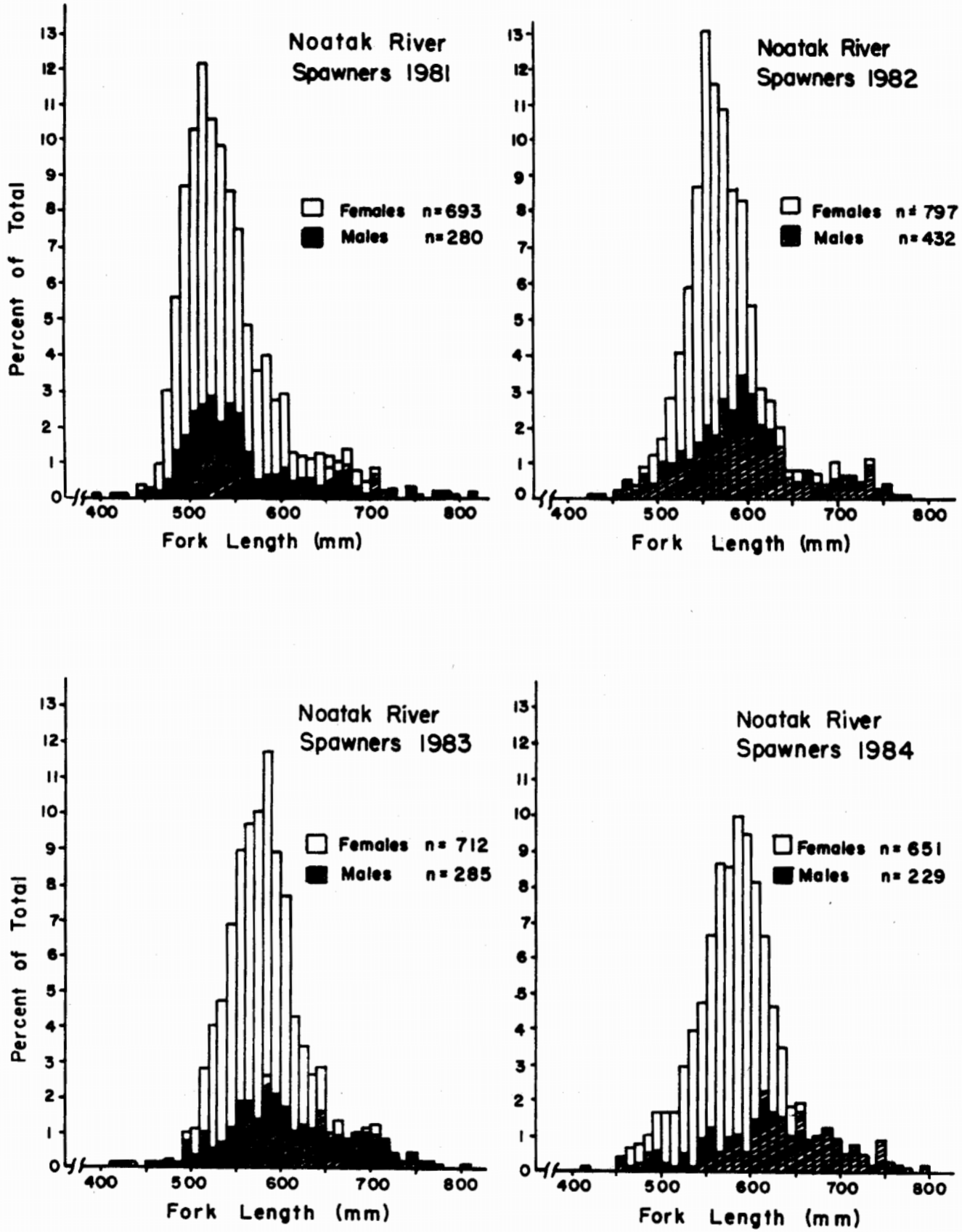


Figure 9. Length distribution of male and female prespawning char sampled on the Noatak River 1981-1984.

occurs in the Wulik River, Kivalina River and several smaller coastal streams.

Surveys from 1982 to 1984 have shown between 214 and 301 char spawning in the Eli River system (Table 14). Most spawning occurs in Ahaliknak Creek and in the Eli River near its confluence with the Ahaliknak Creek. Ahaliknak Creek has many small spring areas throughout most of its length, and char seem to seek out spring water for spawning. Ahaliknak Creek is very small, seldom over 25 ft in width, and spawning takes place in the main channel of the stream. The most intensely used spawning area is near its confluence with the Eli River, where approximately half of the spawning in the Eli system occurs.

A few char spawn in the braided section of the Eli about 12 mi downstream from Ahaliknak Creek, and spawning was observed in Uvgoon Creek for the first time in 1984 (Fig. 10).

The Kelly River system is the second most important spawning stream on the Noatak, supporting between 2,326 and 2,894 spawners annually from 1981 to 1984.

Spring areas are common throughout most of Wrench Creek, No Name Creek, the upper Kelly in the vicinity of Atneerich Creek, and in the Kelly between No Name and Wrench Creeks. There are a few spring areas in the upper reaches of the Avan River as well. Spawning occurs throughout most of the Kelly River system (Fig. 11). Two major spawning concentrations are present on Wrench Creek, one about 12 mi upstream from its mouth, below an aufeis area, and one about 3 mi upstream from its mouth, in a single channel section of the stream. Two other intensively used spawning areas are located on the Kelly River where the spring-fed tributaries, Wrench and No Name Creeks, enter. About 3 mi upstream on No Name Creek is another important spawning area, just downstream of a large groundwater source. The other major spawning concentration is located on the mainstem of the Kelly, just above Atneerich Creek and below another large spring area. Although all of the major concentrations of spawners are associated with groundwater sources, spawning at lower densities takes place along much of the mainstem Kelly and its tributaries. These areas are often near smaller groundwater sources or in areas where larger upstream groundwater sources or tributaries maintain flow throughout the winter. The Avan River has low-density spawning throughout much of its length, most of which occurs in the upper half of spawning distribution.

The Kugururok River is the most important char spawning stream in the Noatak system, with 3,284-4,751 spawners present from 1981 to 1984 (Table 14). The area from about 2 mi below Kagvik Creek and its lower reaches to the lower 2 mi of Nunaviksak Creek is most heavily used (Fig. 12). Like the Kelly River, the Kugururok and its tributaries Kagvik Creek, Nunaviksak Creek and Trail Creek are heavily influenced by groundwater sources over much of their length, and major spawning concentrations are within these areas. Summer spawning for the most part occurs in the main channels of the Kugururok and its tributaries and some spawning takes place well upstream into the mountains, where streams are very small.

The Kaluktavik River is smaller than the Kugururok and supports char

Table 14. Summary of char spawning surveys.

| | 1981 | 1982 | 1983 | 1984 |
|---|---|---|---|---|
| Kelly River mainstem | 882 | 1,079 | 943 | 951 |
| Wrench Creek | 1,005 | 748 | 1,066 | 1,182 |
| No Name Creek | 365 | 158 | 661 | 317[a] |
| Avan River | 364 | 341 | 254 | 168 |
| Total: | 2,589 | 2,326 | 2,894 | 2,618[a] |
| Kugururok mainstem | 1,756 | 2,499 | 884[a] | 2,818 |
| Trib below Trail Creek | - | - | 39 | 30 |
| Trail Creek | 419 | 485 | - | 617 |
| Kagvik Creek | 792 | 620 | 463 | 726 |
| Nunaviksak Creek | 317 | 257 | - | 430 |
| Okatak Creek | - | 115 | - | 130 |
| Total: | 3,284 | 3,986 | 1,386[a] | 4,751 |
| Poktovik Creek | - | - | - | 20 |
| Kaluktavik Creek | - | 549 | - | 584 |
| Nimiuktuk R. mainstem | 202 | 857 | - | 587 |
| Tumit Creek | 853 | 783 | - | 899 |
| Kukukpilak Creek | 361 | 56 | - | 97 |
| Seagull Creek | 606 | 474 | - | 338 |
| Total: | 2,022 | 2,170 | No survey | 1,921 |
| Eli River | - | 237 | 301 | 214 |
| TOTAL: | | 9,268 | | 10,183 |
| Kivalina R. mainstem | 73 | - | 90 | 119 |
| Braided Fork | 382 | 299 | 412 | 286 |
| Grayling Creek | 106 | 146 | 183 | 247 |
| Little River | - | 7 | 10 | - |
| Total: | 561 | 452 | 695 | 652 |
| Wulik R. mainstem | 129 | 184 | 394 | 420 |
| West Fork | - | 133 | 196 | 410 |
| East Fork | - | 73 | 223 | 213 |
| Sheep Creek | 54 | 28 | 123 | 209 |
| Ikalukrok Creek | 89 | - | 201 | 240 |
| Tutak Creek | - | - | 43 | 213[b] |
| Total: | 272 | 418 | 1,180 | 1,705 |

[a] Partial survey.

[b] (Jon Houghton, pers. comm.).

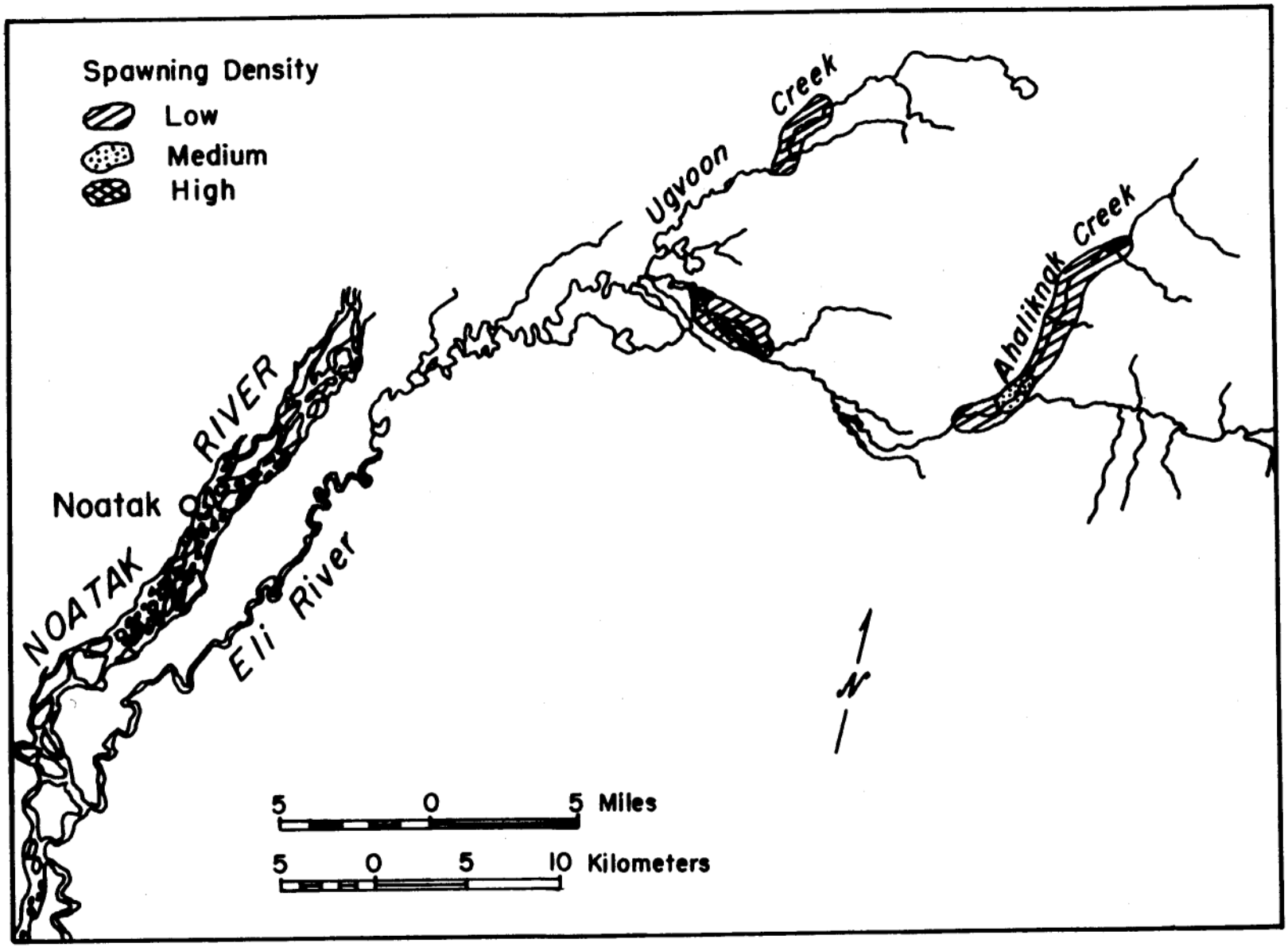


Figure 10. Distribution of spawning char in the Eli River.

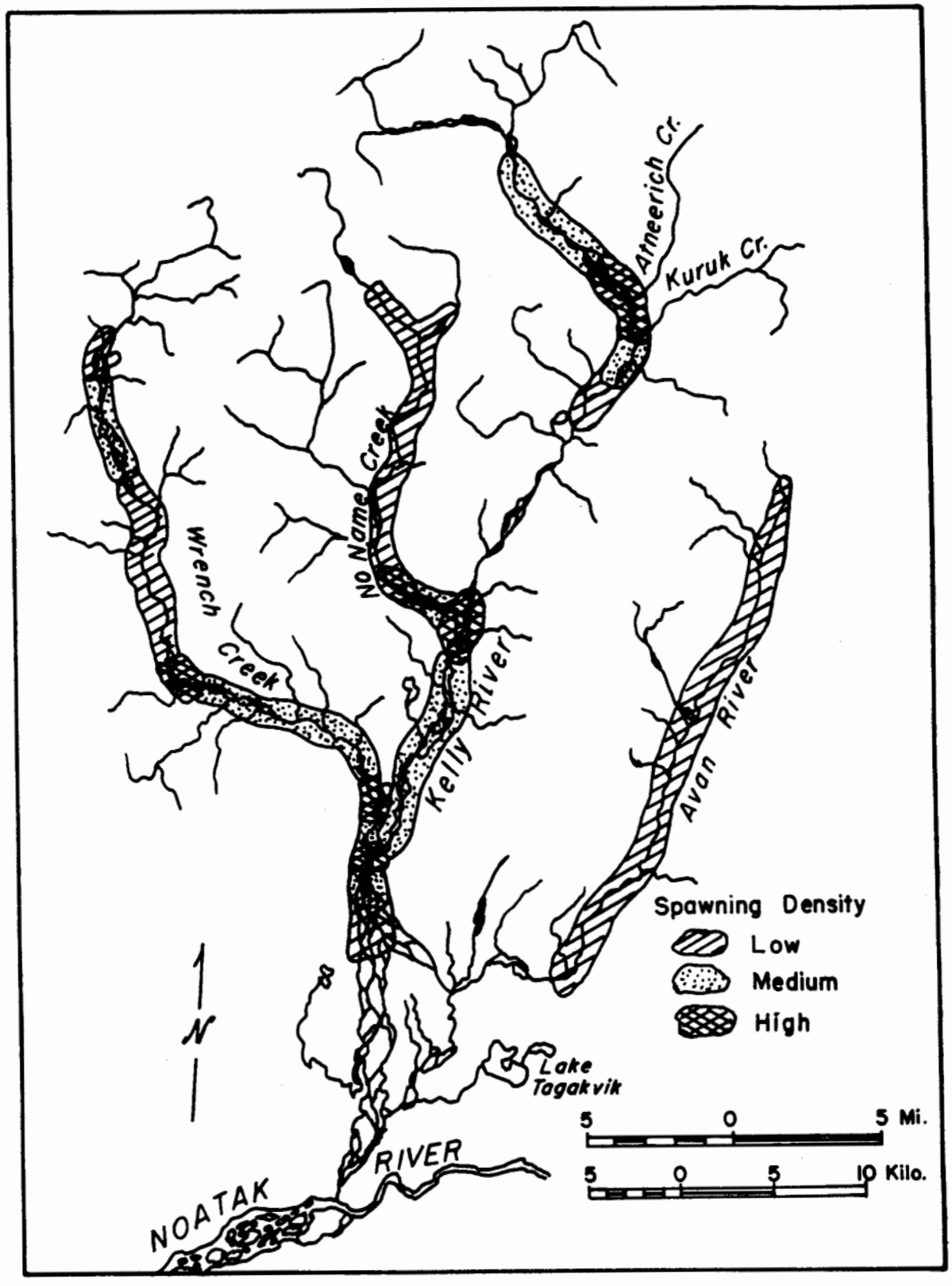


Figure 11. Distribution of spawning char in the Kelly River.

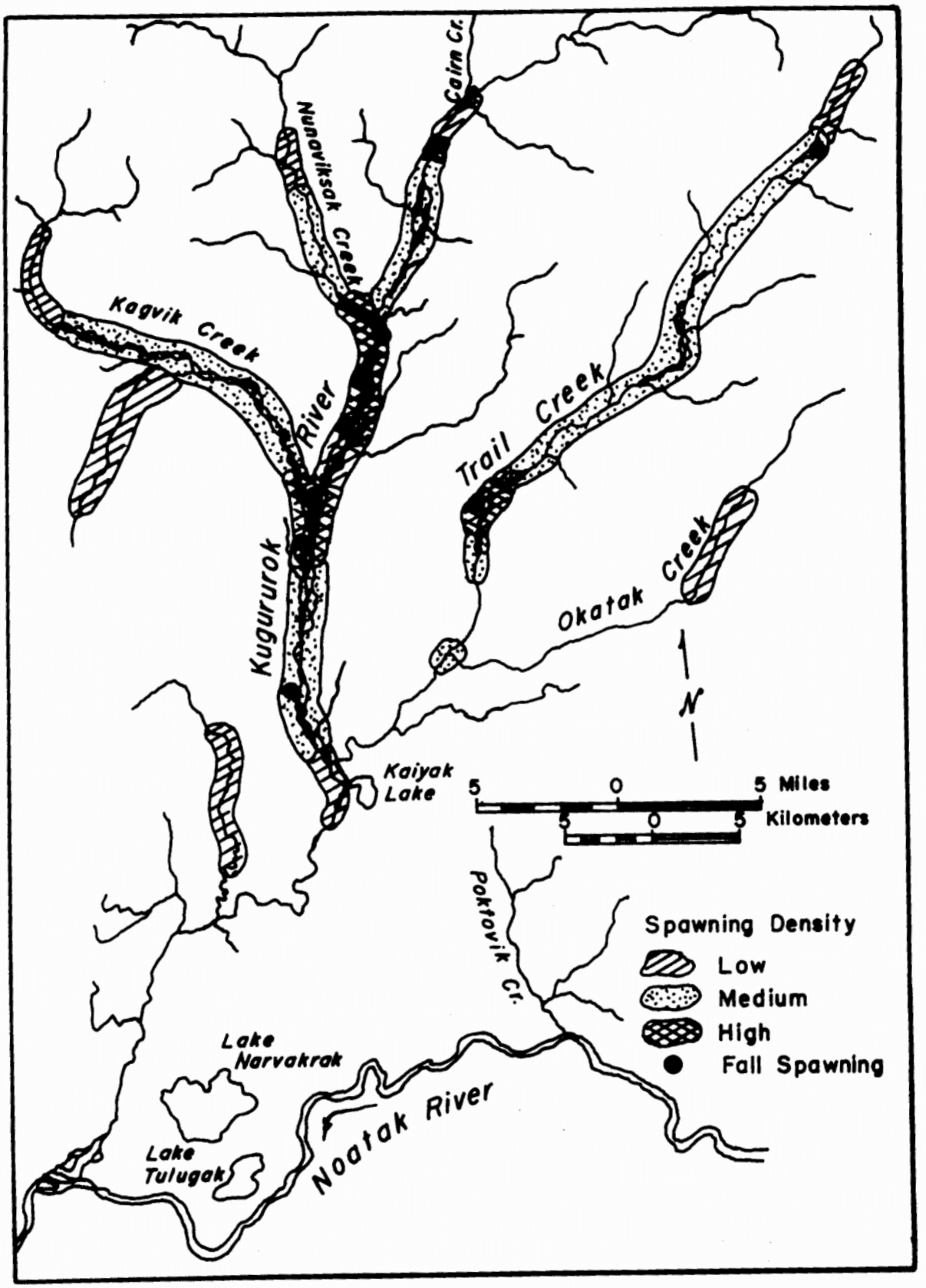


Figure 12. Distribution of spawning char in the Kugururok River.

spawning only in its mainstem from about 2 mi above the confluence of Analak Creek for a distance of about 10 mi upstream (Fig. 13). Two major spawning concentrations occur within this reach, one near the confluence of a small spring-fed tributary in the upper end of the spawning area and one about 2 mi downstream in a braided aufeis area. Approximately 550 summer spawning char use the Kaluktavik annually.

The Nimiuktuk River is the third most important Noatak spawning stream, with around 2,000 char spawning annually from 1981 to 1984. Like other spawning streams, spring-water sources are common along the mainstem of the Nimiuktuk and its tributaries Tumit Creek, Kukukpilak Creek and Seagull Creek. Major spawning concentrations are located near the confluences of these tributaries with the Nimiuktuk and in the Tumit Creek about 12 mi upstream from its mouth (Fig. 14). This 600-ft section of Tumit Creek had between 200 and 300 spawners in it from 1981 to 1983; however, there was a channel change during high water in the spring of 1984 and this concentration no longer existed. Fish that spawned there probably spread to less desirable areas nearby. Spawning occurs mostly in main channels within the range of distribution. During low rainfall years Kukukpilak Creek can become intermittent, with no flow in its lower few miles. This situation existed in August of 1982 when char were observed in spring-fed spawning areas above the flow interruption. Several large aufeis areas, indicating the combination of perennial flow and seasonal stream blockage from freezing, exist on Seagull Creek, Tumit Creek and the lower Nimuiktuk.

The Wulik River drains into the Chukchi Sea near the village of Kivalina 84 mi up the coast from Kotzebue. It is a very important char overwintering stream, but supports less spawning than the three major Noatak spawning streams. During 1983 and 1984, 1,180 and 1,705 char spawned in the Wulik River (Table 14). Spawning occurs over much of the drainage, with the most important areas being an 8-mi section from the forks downstream, Sheep Creek, and the East Fork for about 7 mi downstream of the mouth of Sheep Creek (Fig. 15). Like the Noatak tributaries, most spawning areas are closely associated with spring-water areas and much spawning occurs in the main channels of the streams. Tutak Creek is an exception, in that springs were not readily apparent in aerial surveys of spawning grounds.

The Kivalina River also enters the Chukchi Sea near Kivalina, and drains an area to the north of and roughly parallel with the Wulik River. Counts of char spawning on the Kivalina River have ranged between 452 and 695 over the past 4 years (Table 14). Spawning occurs along a 15-mi stretch of the mainstem and Braided Fork, beginning about 20 mi upstream of the lagoon. Grayling Creek also supports considerable spawning, with major concentrations located about 5 mi upstream from its mouth, in a large spring area. The Braided Fork near Bahkalik and Five Fingered Creek Springs also supports concentrations of spawners (Fig. 16).

Description of Spawning Grounds. Summer spawning takes place in main river channels, smaller spring-influenced side channels and small tributary streams. The common characteristics of these three area types include groundwater influence and gravel size. Springs are common throughout all areas used for spawning. Some are within main river channels, but most are adjacent to main channels within the floodplain of the river in the form of

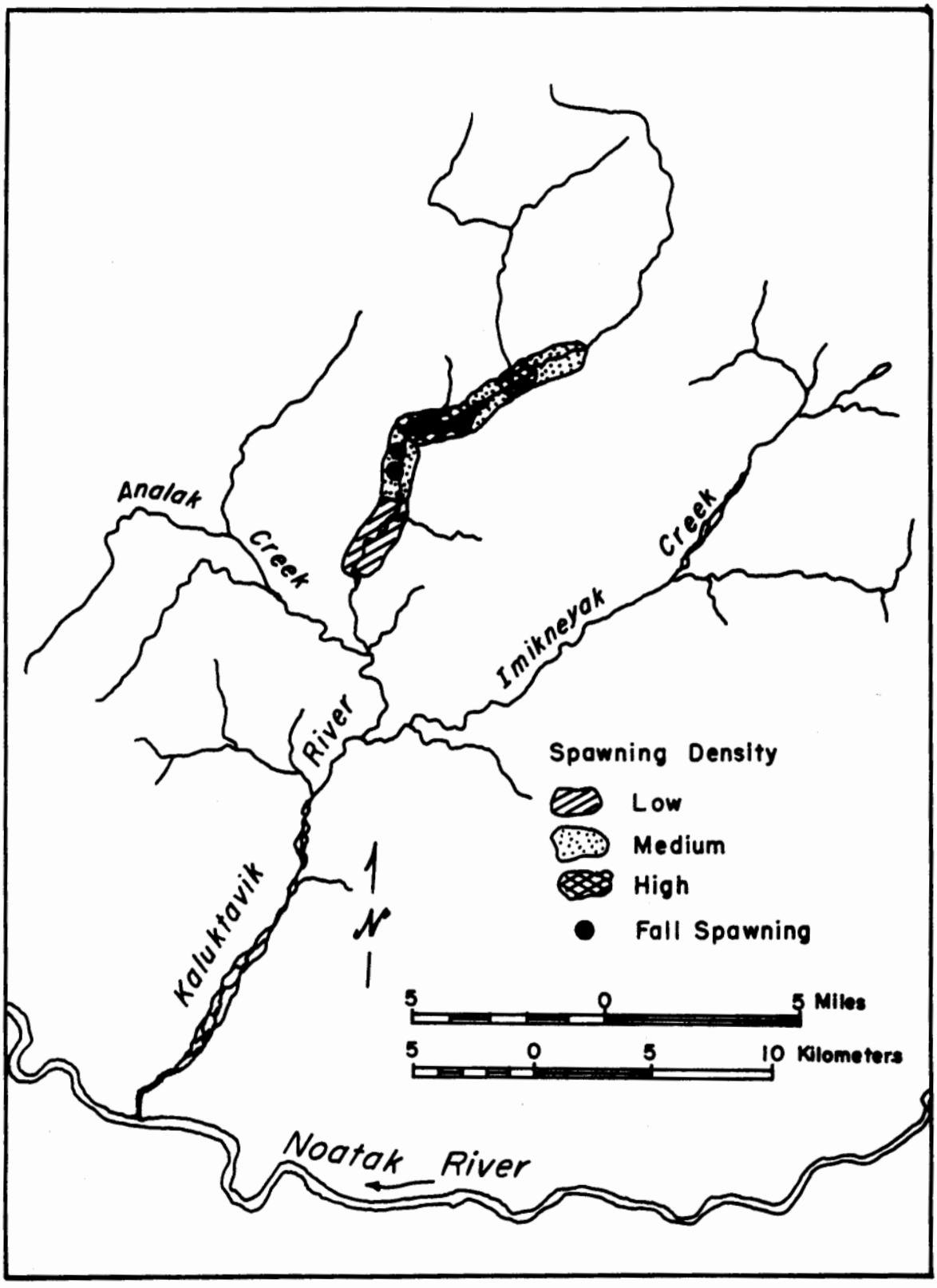


Figure 13. Distribution of spawning char in the Kaluktavik River.

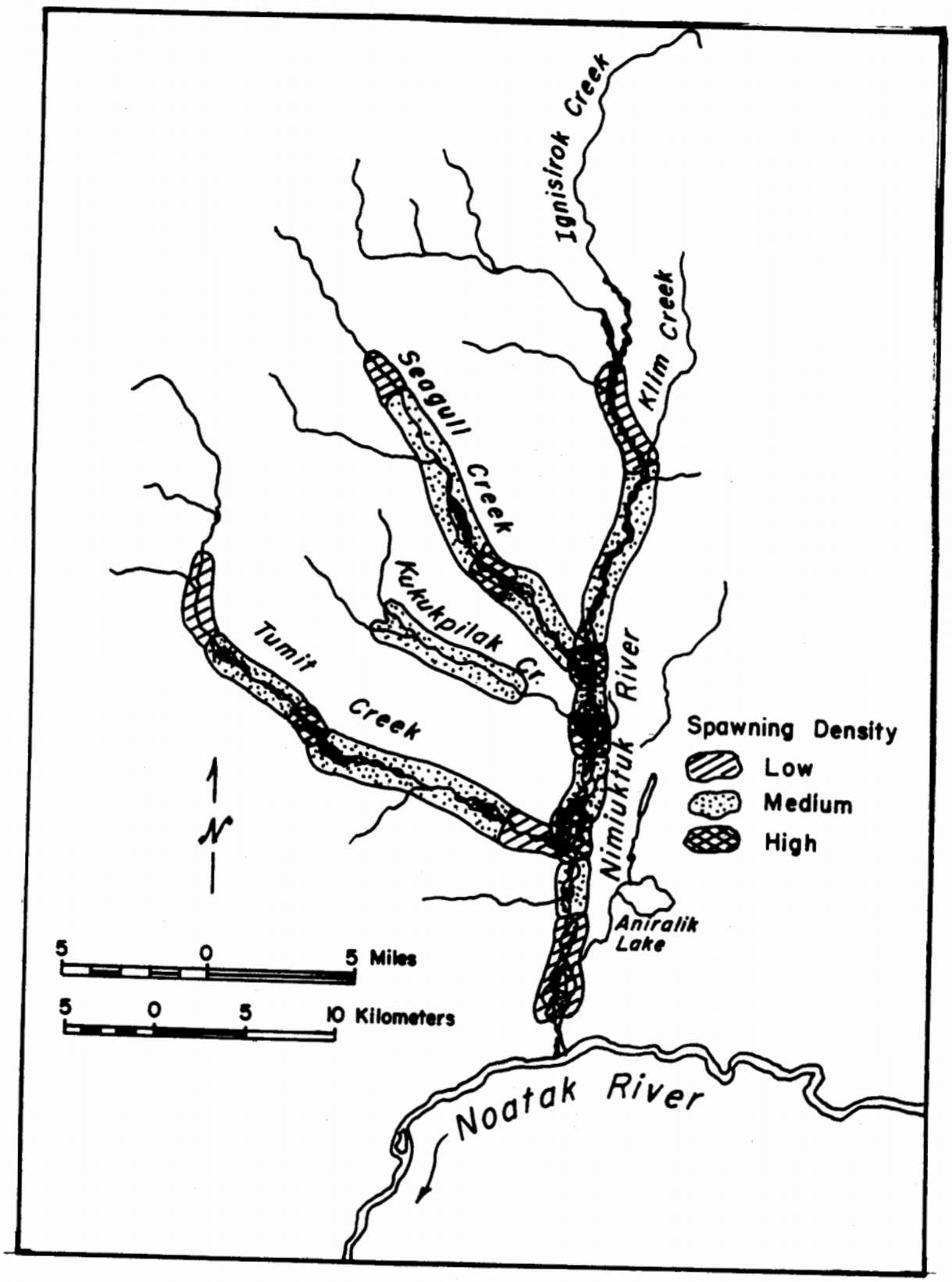


Figure 14. Distribution of spawning char in the Nimiuktuk River.

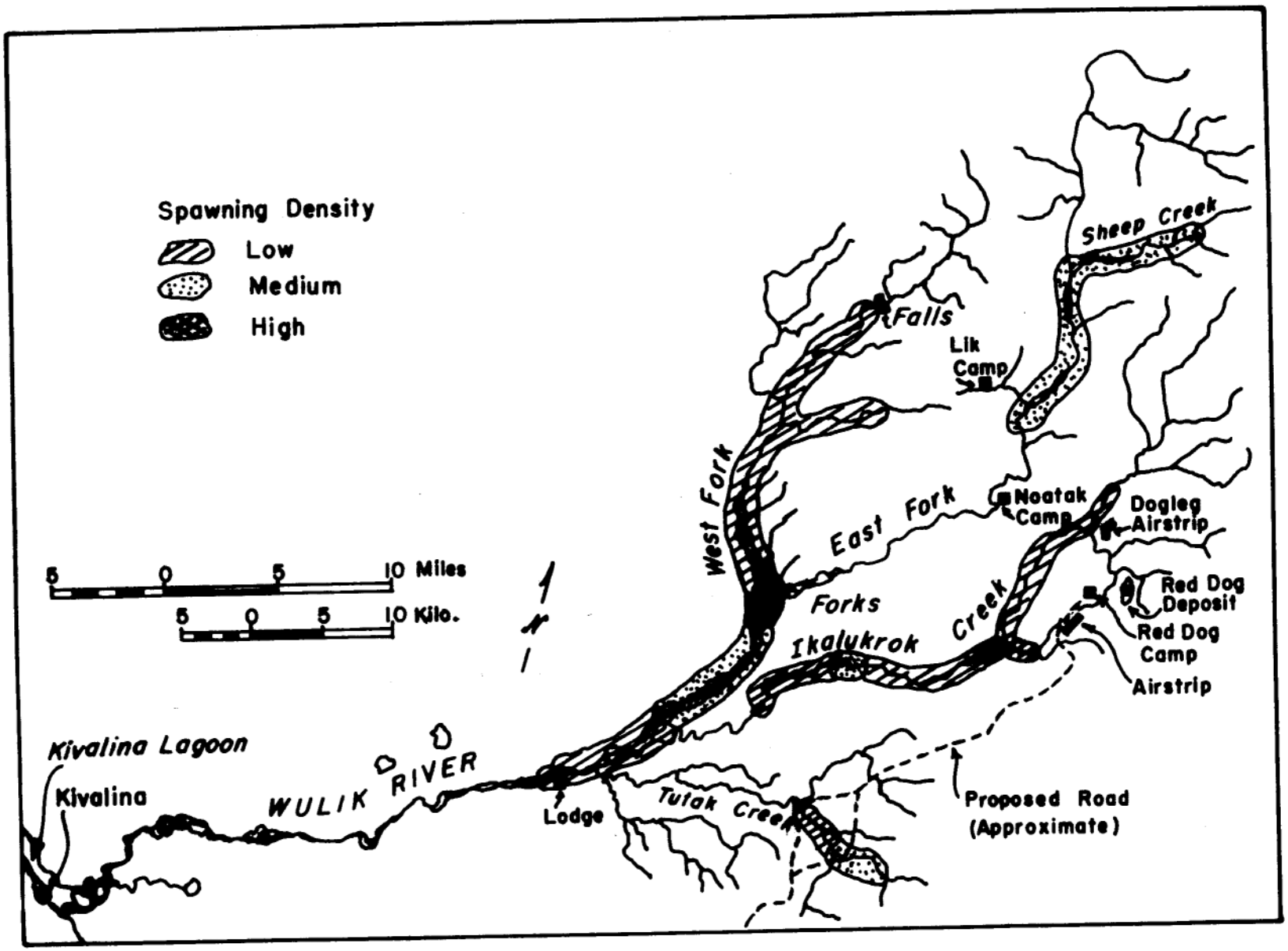


Figure 15. Distribution of spawning char in the Wulik River.

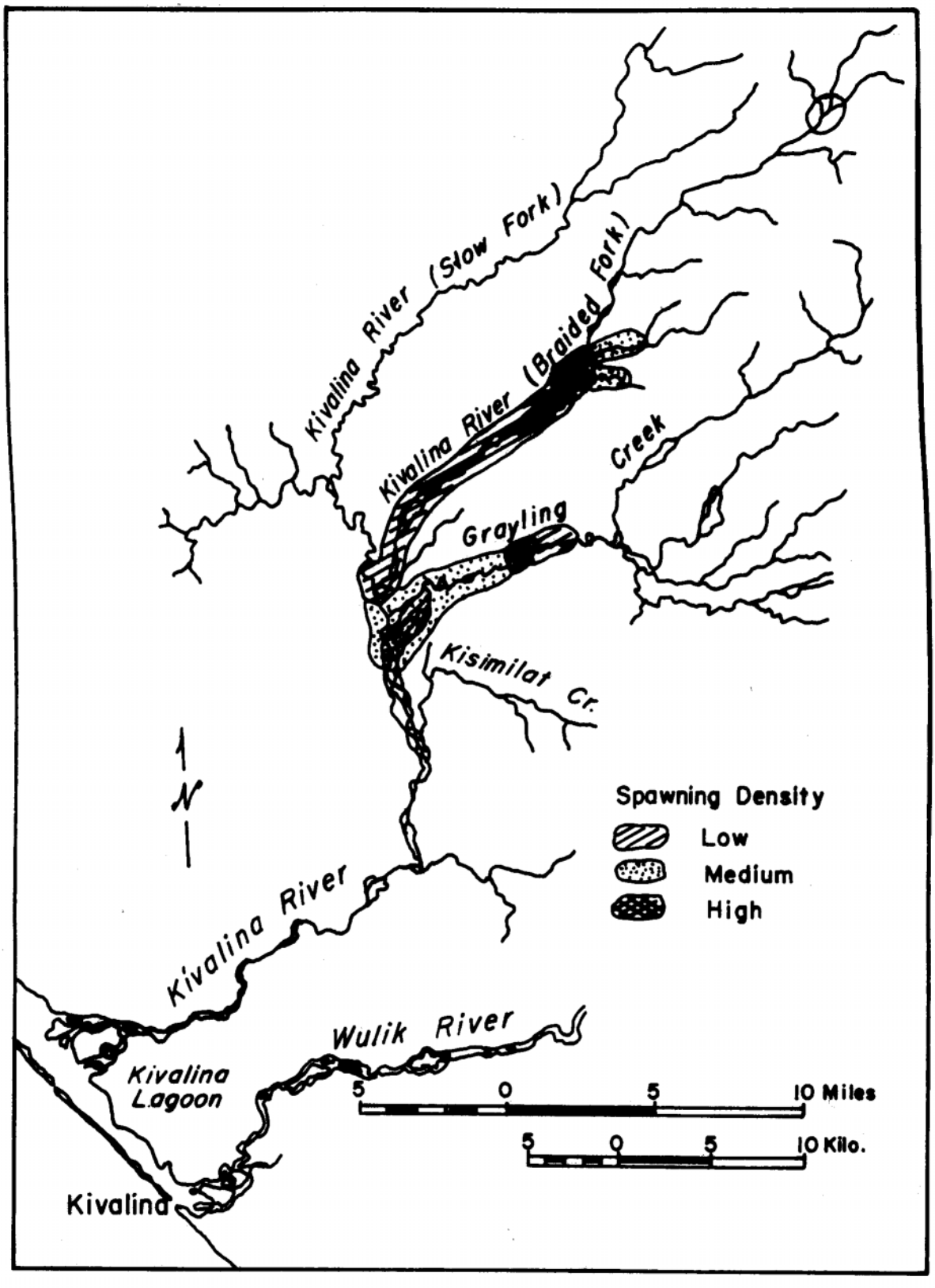


Figure 16. Distribution of spawning char in the Kivalina River.

small channels branching through riparian vegetation. Some of these flow for several hundred yards to over a mile before entering stream channels. Often spring channels have silty bottoms and velocities of less than 1 fps. In these cases spawning is located below the entrance of spring water, within main river channels. The substrate throughout most spawning channels is loose gravel with a composition of approximately 40% sand to 1 in, 40% 1-3 in, and 20% 3-5 in. Current through spawning areas varies from about 1.5 to 3.5 fps. Temperatures in spring areas varied from 4 to 10°C about 2 weeks prior to spawning. Alt (1978) described spawning areas on Grayling Creek on the Kivalina River, dividing the stream into "upper" and "lower" areas. Upper Grayling Creek above a large spring area was 3-5 ft wide, 10-16 in deep, and had a current of 3-4 fps. Redds in this section were in 1-2 ft of water, where bottom composition was 10% sand and silt, 20% fine gravel (3-25 mm diameter), 30% coarse gravel (25-50 mm in diameter) and 10% boulders. Lower Grayling Creek was about 75 ft wide and 1 ft deep, and had a current of 1.5 fps for an average flow on August 25, 1976 of 125 cfs. Redds in lower Grayling Creek were in 0.36-1.52 m of water, with a bottom composition of 10% sand and silt, 20% fine gravel, 50% medium gravel, and 20% coarse gravel. Substrate was uncompacted in all areas. Alt found that redds ranged in size from 10 in x 10 in to 8 ft x 4 ft; the larger redds were in upstream areas. Some of the smaller redds described may have been holding depressions (see next section).

Holding and Timing of Spawning. Some summer spawners are present in the vicinity of spawning grounds during the last week of June, and additional fish continue moving upstream into holding areas through the end of July. Spawners hold in pools and pool margins until spawning commences during the third week of August. Most fish spawn in these holding-spawning areas, but some move from these areas into spring channels, side channels and small tributaries prior to spawning. During the holding period, which can be up to 60 days, summer spawners are spread out within pools in the spawning area. Usually several of the largest males will be at the head of the pool, where water plunges from the upstream riffle. Most of the holding fish, however, are in shallower water along the lateral margins of the pool just above the downstream riffle (Fig. 17). Fish are usually distributed in a fairly even pattern in these areas and remain in the same location for long periods, turning on their sides from time to time to exhibit "flashing" behavior. Fish are very close to the stream bottom and by mid-July small depressions, formed as water is deflected around individual fish, are present at each holding location. The gravel is clean of debris in these depressions and when they were first noted in 1981 it was thought that these were the beginnings of redds. Fish were never observed paired at this time, however, and when spawners were observed paired during aerial surveys near the end of August, many small, unoccupied depressions could also be seen where fish had been holding earlier in the year.

Spawning usually begins around the third week of August. Males running milt were captured on the Kelly River on August 25, 1984, and in Tumit Creek on August 16, 1981. Females with fins abraded from digging were captured on No Name Creek on August 25, 1984, and spent females were caught in the Kugururok River on August 29, 1983. On August 29, 1984, of 15 char captured on the Kugururok River, 2 were spent and 13 had not yet spawned. By September 29, 1982, summer spawning was completed on the Kugururok and Nimiuktuk Rivers. No fish were seen in areas occupied by spawners in late

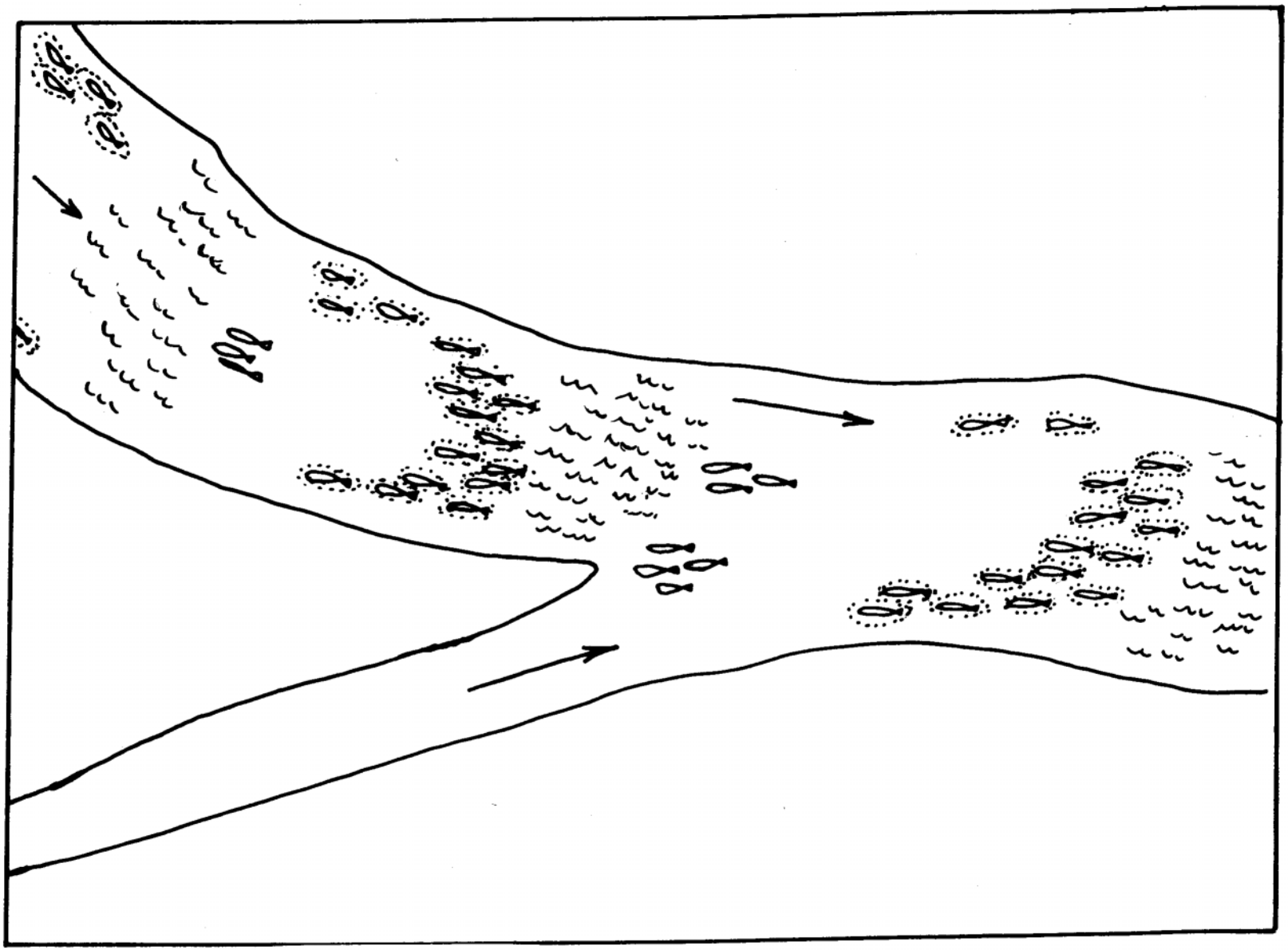

Figure 17. Distribution of prespawning char in a typical holding/spawning area.

August, but large numbers of spent fish were present in the lower 10 mi of the Kugururok River.

Some spawning takes place in July on the Kivalina River in the lower few miles of the Slow Fork (Little River) (Phil Driver, pers. comm.). A limited amount of early spawning also takes place on the Nimuiktuk River, as two prespawners tagged there in early July 1981 were recaptured in late July and early August at the mouth of the Noatak River. I presume these fish had spawned early and were moving to sea.

Egg Development:

The egg diameter of summer spawners on the Noatak River during the third week of August ranged from 3.7 to 4.2 mm and averaged 3.89 mm. The egg diameter of prespawning female char out-migrating from the Wulik River ranged from 2 to 2.7 mm on June 19. Egg diameters of nonspawning char ranged from 1 to 1.5 mm at the same time.

Mean egg diameters of prespawners traveling up the lower Noatak from July 1 through August 4 increased from 2.05 to 3.54 mm. Mean egg diameters of prespawners in Noatak spawning streams increased from 2.4 mm in late June to 3.56 mm by August 4 and to 4.09 mm by August 18 (Table 15).

The normal egg size in subadults and nonspawning adults is 1 to 1.5 mm. Egg size does not vary seasonally or with the size of the fish until the fish approaches a spawning cycle, and even then, egg diameters vary little until the summer of spawning. Seaward-migrating char from the Wulik River showed three groupings by egg size. The first was the normal 1 to 1.5 mm of nonspawning and juvenile char. The second group ranged from 2 to 2.7 mm (most at 2 mm) and were considered to be from prespawners. The third group was from spent fish, having spawned the previous fall. Of spent fish, some had redeveloping eggs of 1 to 1.5 mm and a few had redeveloping eggs slightly larger at 1.75 to 2 mm. This last group may be fall spawners which move to sea each year and may be shown to be consecutive spawners.

Little egg development occurs over the winter. By late June, eggs grow to 2-2.7 mm. Most of this growth probably begins with warming water temperatures in early June, and continues rapidly until spawning in August and September.

Fecundity:

Ova counts from the study area ranged from 3,556 to 10,558 eggs per female. Fish ranged in fork length from 478 to 760 mm and in weight from 1,000 to 3,600 g (Table 16). The number of eggs per millimeter of fork length ranged from 7.44 to 14.70, and averaged 11.04, and the number per gram of body weight ranged from 2.47 to 4.67 and averaged 3.71.

Char from the Kotzebue area are more fecund than char from the North Slope.

The linear regression relating fork length to the number of eggs for this sample is $Y = 24.657X - 7511.762$ where Y is the number of eggs and X is the fork length in millimeter ($r = 0.852$, $p < 0.001$) (Fig. 18). The slope of

Table 15. Egg development[a] in prespawning char.

| | | June 17–June 23 | June 24–June 30 | July 1–July 7 | July 8–July 14 | July 15–July 21 | July 22–July 28 | July 29–Aug. 4 | Aug. 5–Aug. 11 | Aug. 12–Aug. 18 | Aug. 19–Aug. 25 | Aug. 26–Sept. 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wulik River and | $\bar{x}$ | 2.07 | | 2.05 | 2.79 | 3.28 | 3.17 | 3.54 | | | | |
| Upstream Noatak | n | 30 | | 2 | 5 | 8 | 11 | 6 | | | | |
| Migrants | S | 0.18 | | 0.07 | 0.21 | 0.75 | 0.39 | 0.41 | | | | |
| Noatak River and | $\bar{x}$ | 2.4 | 2.67 | | 3.15 | 3.55 | 3.69 | 3.56 | 3.97 | 4.09 | 3.89 | 3.90 |
| Spawning Streams | n | 1 | 3 | | 2 | 13 | 9 | 5 | 3 | 10 | 11 | 2 |
| | s | | 0.42 | | 0.35 | 0.38 | 0.45 | 0.17 | 0.15 | 0.41 | 0.16 | 0 |

[a] Egg diameters in mm.

Table 16. Fecundity of Kotzebue Sound-Chukchi Sea char.

| Location* | Fork Length (mm) | Weight (g) | Number of Eggs | Ova/g body wt. | Ova/mm FL | Summary (25-mm increment) |
|---|---|---|---|---|---|---|
| Eli | 478 | 1,100 | 3,556 | 3.23 | 7.44 | |
| Kug | 480 | 1,000 | 4,012 | 4.01 | 8.36 | 478-497 |
| Kug | 482 | 1,100 | 4,855 | 4.41 | 10.07 | $\bar{x}$ FL = 488 |
| Kug | 487 | 1,060 | 4,200 | 3.96 | 8.62 | SD FL = 7.2 |
| Kug | 492 | 1,150 | 5,304 | 4.61 | 10.78 | n = 8 |
| Nim | 492 | 1,125 | 4,780 | 4.25 | 9.72 | $\bar{x}$ ova = 4,611 |
| Kug | 495 | 1,175 | 6,465 | 5.50 | 13.06 | SD ova = 960 |
| Nim | 497 | 1,175 | 3,717 | 3.16 | 7.48 | |
| Nim | 501 | 1,100 | 3,987 | 3.62 | 7.96 | |
| Kug | 510 | 1,175 | 4,548 | 3.87 | 8.92 | 501-525 |
| Nim | 510 | 1,175 | 4,886 | 4.16 | 9.58 | $\bar{x}$ FL = 515 |
| Kel | 512 | 1,675 | 4,143 | 2.47 | 8.09 | SD FL = 8.1 |
| Kel | 515 | 1,325 | 4,567 | 3.45 | 8.87 | n = 9 |
| Nim | 516 | 1,230 | 4,345 | 3.53 | 8.42 | $\bar{x}$ ova = 4,694 |
| Kug | 523 | 1,375 | 5,515 | 4.01 | 10.54 | SD ova = 507 |
| Kug | 525 | 1,300 | 5,172 | 3.98 | 9.85 | |
| Kug | 525 | 1,500 | 5,082 | 3.39 | 9.68 | |
| Kug | 531 | 1,300 | 5,092 | 3.92 | 9.59 | |
| Kiv | 535 | 1,525 | 5,161 | 3.38 | 9.65 | 531-545 |
| Kel | 537 | 1,750 | 5,916 | 3.38 | 11.02 | $\bar{x}$ FL = 539 |
| Kug | 538 | 1,450 | 5,975 | 4.12 | 11.11 | SD FL = 4.37 |
| Eli | 540 | 1,575 | 5,988 | 3.80 | 11.09 | n = 8 |
| Kel | 541 | 1,450 | 5,789 | 3.99 | 10.70 | $\bar{x}$ ova = 5,703 |
| Nim | 542 | 1,600 | 5,879 | 3.67 | 10.85 | SD ova = 363 |
| Kel | 545 | 1,725 | 5,825 | 3.38 | 10.69 | |
| Kug | 553 | 1,700 | 5,852 | 3.44 | 10.58 | |
| Kug | 560 | 1,625 | 6,451 | 3.97 | 11.52 | 553-575 |
| Kug | 565 | 1,800 | 5,984 | 3.32 | 10.59 | $\bar{x}$ FL = 565 |
| Nim | 565 | 1,925 | 7,000 | 3.64 | 12.39 | SD FL = 7.46 |
| Kel | 567 | 1,900 | 6,675 | 3.51 | 11.77 | n = 7 |
| Nim | 574 | 1,700 | 6,475 | 3.81 | 11.28 | $\bar{x}$ ova = 6,522 |
| Eli | 575 | 1,975 | 7,220 | 3.66 | 12.56 | SD ova = 497 |

Table 16. (Cont.) Fecundity of Kotzebue Sound-Chukchi Sea char.

| Location | Fork Length (mm) | Weight (g) | Number of Eggs | Ova/g body wt. | Ova/mm FL | Summary (25-mm increment) |
|---|---|---|---|---|---|---|
| Nim | 577 | 1,900 | 8,307 | 4.37 | 14.40 | |
| Ik | 581 | 1,850 | 8,538 | 4.62 | 14.70 | 577-600 |
| Kug | 582 | 1,850 | 6,243 | 3.37 | 10.73 | $\bar{x}$ FL = 586 |
| Kug | 585 | 1,875 | 8,758 | 4.67 | 14.97 | SD FL = 6.58 |
| Kug | 586 | 2,150 | 8,029 | 3.73 | 13.70 | n = 9 |
| Kel | 588 | 1,900 | 7,543 | 3.97 | 12.83 | $\bar{x}$ ova = 8,028 |
| Kug | 589 | 2,100 | 7,781 | 3.71 | 13.21 | SD ova = 780 |
| Kug | 590 | 2,350 | 8,436 | 3.59 | 14.30 | |
| Nim | 600 | 1,925 | 8,618 | 4.48 | 14.36 | |
| Kug | 604 | 2,000 | 5,867 | 2.93 | 9.71 | 604-615, $\bar{x}$ FL = 608 |
| Kel | 604 | 2,050 | 6,317 | 3.08 | 10.46 | SD FL = 5.32, n = 4 |
| Kug | 610 | 2,400 | 6,367 | 2.65 | 10.44 | $\bar{x}$ ova = 6,680 |
| Kug | 615 | 2,200 | 8,167 | 3.71 | 13.28 | SD ova = 1,017 |
| Kug | 630 | 2,300 | 7,946 | 3.45 | 12.61 | 630-640, $\bar{x}$ FL = 637 |
| Nim | 640 | 2,500 | 8,182 | 3.27 | 12.78 | SD FL = 5.77, $\bar{x}$ Ox = 7,639 |
| Kug | 640 | 2,200 | 6,788 | 3.09 | 10.61 | SD ova = 746 |
| Nim | 652 | 2,500 | 8,018 | 3.21 | 12.30 | |
| Kug | 760 | 3,600 | 10,558 | 2.93 | 13.89 | |
| $\bar{x}$ | 557 | 1,708 | 6,218 | 3.71 | 11.04 | |
| SD | 55 | 502 | 1,583 | 0.56 | 1.99 | |

* Kug = Kugururok River
Ik = Ikalukrok River
Nim = Nimiuktuk River
Kiv = Kivalina River
Kel = Kelly River

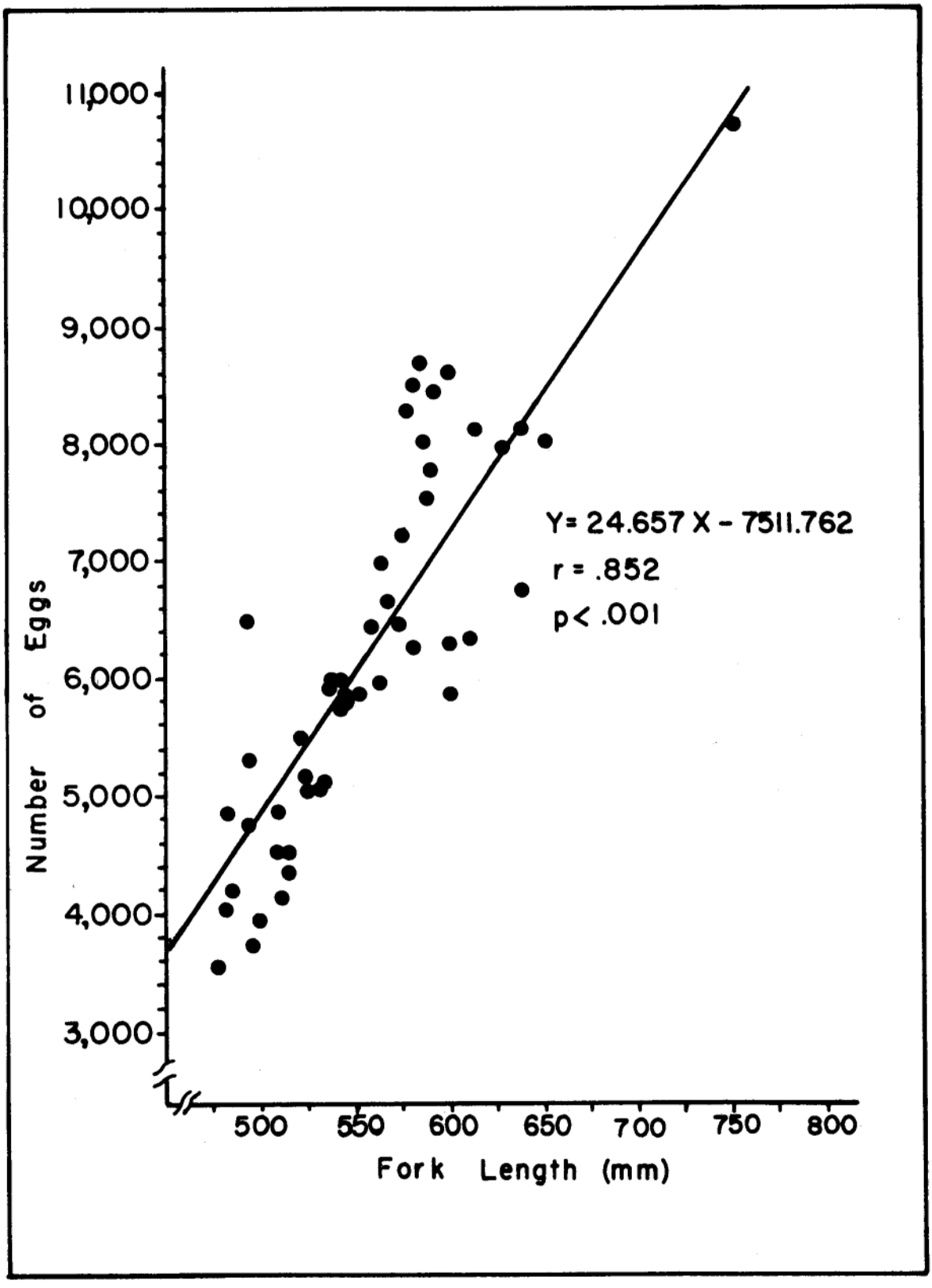


Figure 18. Fecundity of Kotzebue Sound - Chukchi Sea char.

this regression was compared to a similar one for North Slope char from the Sagavanirktok River where Y = 14.90x - 3285.58 (Yoshihara, 1973), and found to be different ($t = 3.6176$ $p < 0.001$).

Sex Ratio of Spawners:

The overall sex ratio for spawning char in the Noatak drainage from 1981 to 1984 ranged from 1 male:1.87 females in 1982 to 1 male:2.84 females in 1984, and averaged 1 male:2.34 females (Table 17). The range by river was greater, with a range of 1 male:1.59 females in the Kelly River in 1982, to 1 male:4.45 females in the Eli River in 1984.

In the Wulik River the sex ratio for 1983 was 1 male:1.50 females.

A skewed sex ratio in spawning populations of char favoring females is not uncommon, and has been documented in other areas. Yoshihara (1973) found a sex ratio of 1 male:3.4 females on spawning grounds in the Ivishak River and Johnson (1980) found a male:female ratio of 1:10 in Willow Creek in 1976 and 1:4 in 1977. Armstrong and Kissner (1969) found that mortality between spawnings was much greater in male Dolly Varden in Hood Bay Creek (61.4% in 1967 and 49.2% in 1968) than in females (4.3% in 1967 and 8.8% in 1968).

The observed sex ratio of spawners may be due to a combination of factors, including differential mortality between spawnings, the presence of residual males and, perhaps, a varying spawning interval between males and females contributing to higher mortality in males. Another factor influencing the sex ratio of spawners on the Noatak River is the presence of the commercial salmon fishery in Kotzebue Sound which intercepts overwintering char during mid-August. This fishery selects large char that are mostly males (see length frequency of spawners).

Fall Spawning:

Locations. Fall spawning occurs in springs and spring-water side channels on the Kugururok, Kaluktavik and Kivalina Rivers (Figs. 12, 13, 16). Fall spawners have also been found moving upstream on the Wulik River, but spawning locations have not been determined. Fall spawning has not been found on the Eli or Nimiuktuk Rivers but has been observed in the upper reaches of Wrench Creek on the Kelly River (P. Driver, pers. comm.). On September 28, 1982, 609 fall spawners were seen on the Kugururok River and 199 were seen on the Kaluktavik River.

Descriptions of Fall Spawning Areas. A fall spawning area on the Kugururok River was surveyed on September 30 and October 1, 1984. Char were actively spawning in a spring channel within the river floodplain about 3 mi below Kagvik Creek. The channel was about 1.5 mi long, but all spawning was confined to the lower 400 yd, just above its confluence with the Kugururok. In this area the channel was 25 to 35 ft wide and had a current of 1.3 fps over a mixed gravel substrate composed of 40% sand to 1 in, 40% 1-3 in, and 20% 3-5 in diameter stones. Water temperatures varied from 2°C in the early morning to 4°C by midafternoon in this spawning channel, while the Kugururok was 1.5°C. Redds were located in areas 12-36 in deep and varied in size from 5 ft x 2.5 ft to 15 ft x 5.5 ft. The upstream one-third of

Table 17. Sex ratios of spawning char.

| | Eli R. | | Kelly R. | | Kugururok R. | | Nimiuktuk R. | | Wulik R. | | Total Noatak | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F | M | F | M | F |
| 1981 | | | 93 | 270 | 83 | 209 | 113 | 228 | | | 280 | 693 |
| | | | 1:2.90 | | 1:2.52 | | 1:2.02 | | | | 1:2.48 | |
| 1982 | 34 | 97 | 121 | 192 | 186 | 319 | 91 | 203 | | | 432 | 807 |
| | 1:2.85 | | 1:1.59 | | 1:1.72 | | 1:2.23 | | | | 1:1.87 | |
| 1983 | | | 78 | 253 | 150 | 291 | 57 | 170 | 149 | 223 | 285 | 714 |
| | | | 1:3.24 | | 1:1.94 | | 1:2.98 | | 1:1.50 | | 1:2.51 | |
| 1984 | 22 | 89 | | | 207 | 564 | | | | | 229 | 651 |
| | 1:4.45 | | | | 1:272 | | | | | | 1:2.84 | |
| Total | 56 | 186 | 292 | 715 | 626 | 1383 | 261 | 601 | 149 | 223 | 1226 | 2865 |
| | 1:3.32 | | 1:2.45 | | 1:2.21 | | 1:2.30 | | 1:1.50 | | 1:2.34 | |

each redd was dug to approximately 6 in below the level of the streambed, the middle section was composed of larger-size gravel deposited from upstream digging and was 4-6 in above the level of the streambed. The downstream extreme of the redd had a small depressed area and a small elevated area of smaller gravel (Fig. 19).

Timing. Fall spawning takes place from mid-September through early October. On September 29, 1982, fall spawning was in progress on the Kugururok and Kaluktavik Rivers. At this time summer spawners had departed spawning areas on the Kugururok and were in the lower 10 mi of the river. On October 5, 1981, fall spawners were observed in the Kugururok River and in Trail Creek, while summer spawning areas were devoid of fish. On September 12, 1979, a single female fall spawner was caught about 20 mi upstream on the Kugururok River. It was silvery in color, had 4-mm eggs and was probably en route to spawning areas about 10 to 20 mi upstream. On October 1, 1984, fall spawners were observed in spawning areas. Most females were already spent, and only one of those handled had yet to spawn. Most males were badly abraded from spawning activities, and males outnumbered females in the spawning area. One large male was observed moving downstream into the Kugururok River and 3 of 8 radio-tagged fish moved downstream within one day; this may have been a result of the tagging. From these observations, coupled with the presence of several abandoned redds, it was deduced that spawning was almost completed at this time. Alt (1978) reported taking three silvery prespawning female char during August 25-28, 1976, 29 mi upstream on the Wulik River. He estimated that these fish would not spawn for another 3 weeks and would thus be considered fall spawners. On August 20, 1981, seven silvery female fall prespawners were captured on the Kivalina River approximately 12 mi upstream from its mouth.

Discussion:

Several questions have developed during our investigations of spawning and relevant movement patterns associated with both summer and fall spawning, and several important aspects of spawning behavior and relationships of spawning groups remain to be addressed by future studies.

The majority of summer spawners do not go to sea during the year of spawning, but remain in fresh water for up to 20 months without feeding during a spawning cycle. This would not seem to be an advantageous survival scheme, but the fact that it is the case is prima facie evidence that it must be in the overall best interest of the population. The influence of uncertain and variable streamflows within tributary streams used for spawning seems a logical explanation for this strategy, but the fact that most summer spawning takes place in the mainstems of streams, where summer flow even during dry years is not a problem, counters this argument.

The fall spawning movement scheme, whereby spawning fish can feed in the ocean during years of spawning, would seem to be the most advantageous to the species, but the number of fish in this category is small when compared to the number of summer spawners.

Although many spawning areas on the Noatak River have been identified, the

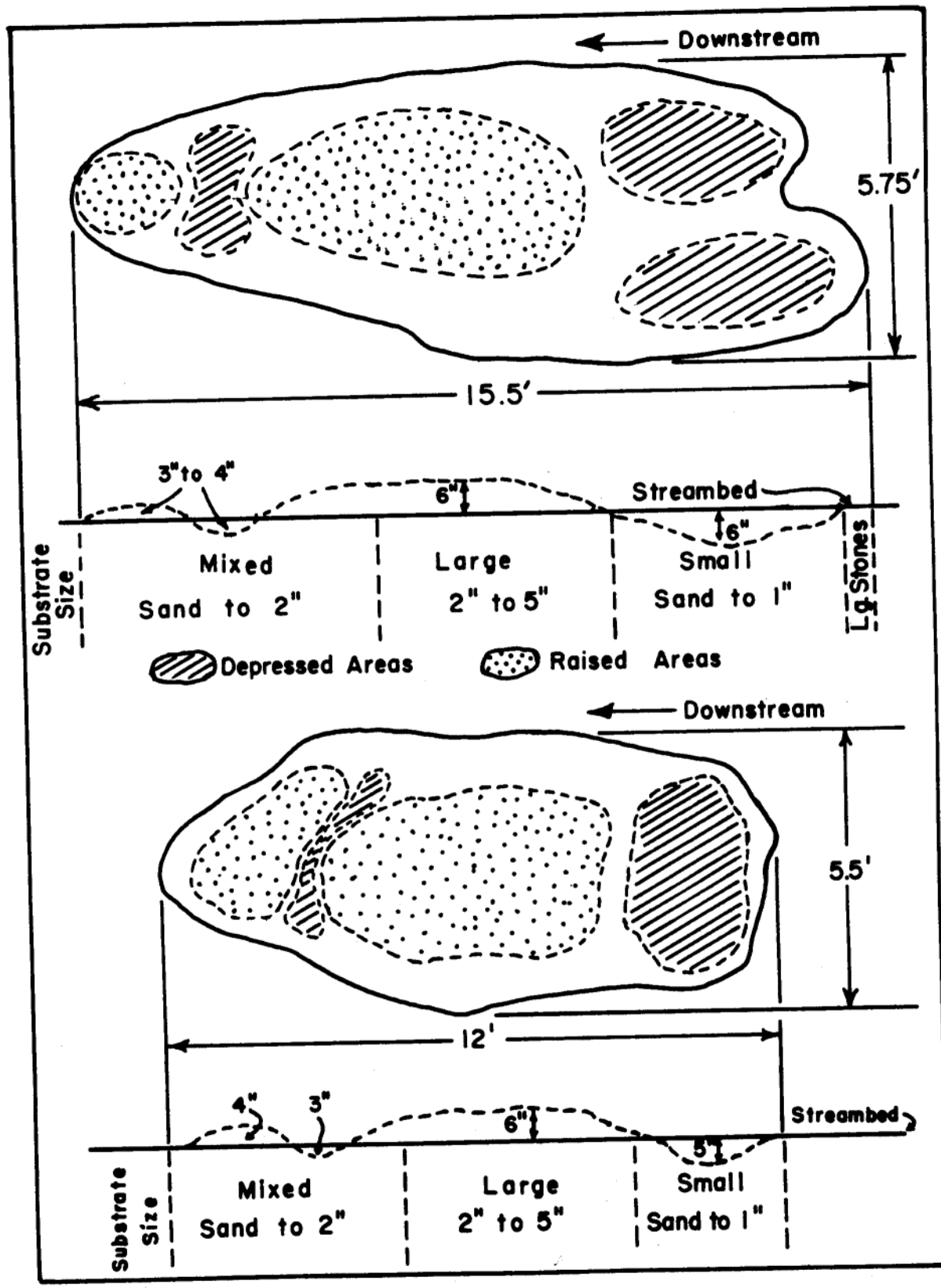


Figure 19. Two typical redds of fall spawning char from the Kugururok River.

main river below the confluence of Kelly River, and the upper mainstem above Kugrak Creek may support spawning. Both areas have many groundwater sources, which is the single common factor that all spawning areas possess. Due to the size of the river, water turbidity, and budgetary constraints, these areas have not been adequately surveyed for the presence of spawning char.

The tag recovery rate of repeat spawners has been very low over the course of this study (n = 7), but all were recovered 2 years after tagging, and all were tagged and recovered in a prespawning condition. It can thus be assumed that alternate-year spawning is the rule and that survival between spawnings may be very low. Another possibility is that the number of spawners in all areas is much greater than indicated by aerial survey. If there is high postspawning mortality, it is not known when this takes place. No dead or dying postspawners have been observed near spawning grounds, and many spent fish have been observed in the lower reaches of spawning streams after spawning. Mortality might take place over the course of the winter after spawning, but each spring large numbers of "skinny trout" migrate out of the Noatak River system (Bob Uhl, pers. comm.). Mortality may take place at sea the following spring, spent fish in poor condition probably being more susceptible to predation by marine mammals.

There has been a notable increase in the length frequency of the spawning population in the Noatak over the past 4 years. The average size of spawners has steadily increased: 548 mm in 1981, 575 mm in 1982, 583 mm in 1983, and 582 mm in 1984.

The increase may be due to a strong age class, some of which entered the spawning population in 1981 for the first time, while others entered the 1982 or 1983 spawning groups at a larger size. Another contributing factor might be the lower-than-average incidental char catch in the Kotzebue Sound commercial salmon fishery over the past 2 years.

Food Habits

Presmolt and residual char live and feed exclusively in fresh water. After moving to sea for the first time at Age II-V, char feed almost exclusively at sea. In northwestern Alaska the marine feeding period is 60 to 90 days per year.

During 1981 and 1982, stomachs of 58 rearing char from the Noatak and Wulik Rivers were examined for food items. Diptera, Ephemeroptera and Plecoptera larvae were the most frequently encountered food organisms in order of occurrence (Table 18). Tricoptera, Diptera (Tipulidae), and Hydracarina were also present, but in low frequency. Fish examined varied in age from I to II and in length from 30 to 127 mm. No correlation between fish size and food item preference was noted, but larger fish often contained larger Plecoptera or Ephemeroptera larvae than did smaller fish. Of 40 fish examined from the Noatak system, 34 (85%) contained Diptera larvae. Of 18 fish examined from the Wulik River, 16 (89%) contained Diptera (chironomid) larvae. Of the 58 stomachs examined, 11 contained only one type of food organism and only one was empty.

Table 18. Frequency of food item occurrence in rearing char.

| River | Diptera | | Ephemeroptera | Plecoptera | Other |
|---|---|---|---|---|---|
| | Chironomidae | Simuliidae | | | |
| Noatak n = 40 | 32 (80%) | 2 (5%) | 11 (28%) | 10 (25%) | 1 Tricoptera<br>1 Tipulidae<br>1 Hydracarina<br>(7.5%) |
| Wulik n = 18 | 12 (67%) | 4 (23%) | 13 (73%) | 3 (17%) | 1 (6%) Empty |
| Total | 44 (76%) | 6 (11%) | 24 (42%) | 13 (23%) | 4 (7%) |

Many postsmolt char were sampled in this study in various life history phases. Most were captured in fresh water and very few had any food items in their stomachs. Spring out-migrating char were sampled at the mouth of the Wulik River. Of 180 char, only 4 had food items in their stomachs: 2 contained amphipods, 1 chironomids, and 1 unidentified plant matter. In contrast, 5 out of 9 char sampled in the sea south of Kivalina in June had been feeding on amphipods, 1 had a stone in its stomach, and 3 stomachs were empty. No spawning anadromous char of 122 taken on the Noatak River over the course of this study contained food items and, of 35 spawners taken from the Wulik and Kivalina Rivers, 1 contained a few insect remains. But 4 residual spawners from the Noatak River spawning areas all had been feeding, 1 on juvenile char, 2 on char eggs, and 1 contained both items.

Fall in-migrating, overwintering fish in Kotzebue Sound and the Noatak River also showed a low incidence of feeding. Only 4 out of 254 had anything in their stomachs, 1 each containing sculpin, shrimp, isopods and caddis fly larvae. Some overwintering char captured at the mouth of the Kugururok River in August 1981 contained salmon eggs (J. P. Jakobson, pers. comm.). Of 19 overwintering char sampled on the Noatak River, 1 contained salmon eggs and 1 a caddis fly. Stomachs of 237 overwintering char from the Wulik and Kivalina Rivers were all empty.

Little study has been done on the ocean feeding of char, but observations by locals indicate that fish are associated with the receding ice edge in early summer and that they feed on small schooling fishes which tend to concentrate in these areas (Bob Uhl, pers. comm.). On June 27, 1983, Joe Dinnocenzo (pers. comm.) observed what he thought to be char feeding on large schools of small fish along the Chukchi sea coast south of Kivalina. Dave Roseneau, a biologist with Renewable Resources Ltd. (pers. comm.), observed and captured char near Cape Thompson in July. He thought that char were feeding on abundant small cod (species unknown) which he observed associated with drifting ice floes.

Overwintering

Locations of Overwintering Areas:

The major overwintering areas for postsmolt migrant char are located on the lower Noatak, lower Wulik and lower Kivalina Rivers (Figs. 2 and 3). Spent summer spawners and nonspawning fall in-migrants winter in the Noatak River from the mouth of the Nimiuktuk River (Ray Hodges, pers. comm.) downstream to the lower canyon about 15 mi from Kotzebue Sound. On April 14, 1982, four char were captured through the ice off the mouth of the Kugururok River. Most spent fall spawners remain in the tributary stream used for spawning during the winter, seeking out groundwater sources, rather than moving downstream into the mainstem of the Noatak River. Partially spent char were observed in a spring area above newly building aufeis on Trail Creek on October 5, 1981. It appeared that there was not enough flow through the aufeis to allow passage out of the spring area. To investigate this possibility, eight radio tags were placed in spent and partially spent fall spawners in a spring area about 1 mi downstream from Kagvik Creek on the Kugururok River on October 1, 1984. By October 26, one male had moved about 1 mi below the tagging location, the three other males were grouped in a spring area about 3 mi further downstream, three females were near a

spring-fed tributary stream 17 mi downstream from the tagging location and one female had left the Kugururok entirely and was about 5 mi below the Kelly river on the mainstem of the Noatak. On November 29, the fish had moved slightly, but their locations had not appreciably changed.

Bendock (1981) found that char radio-tagged in the Anaktuvuk River in September remained in the same vicinity throughout the winter. He also found fish spawning and overwintering in the same general area of the river. Fall-spawning char in the Noatak system are similar to North Slope char in these respects.

Presmolt and residual char probably remain in small spring-fed side channels of Noatak tributary streams throughout the winter.

On the Wulik River, nonspawners and spent summer spawners overwinter from about 5 mi above the mouth of Ikalukrok Creek (Mile 33) downstream to about 6 mi from the lagoon. Houghton and Hilgert (1983) observed several schools of small overwintering char in Ikalukrok Creek, about 30 km from its mouth, in Tutak Creek below its major fork and in Dud Creek. He suggested that these fish, after spending one or two summers feeding at sea, were returning to their natal stream for overwintering.

Char overwinter on the Kivalina River from just above the forks at Mile 27 downstream to approximately 5 mi from the lagoon. Overwintering postsmolts have not been observed in tributaries of the Kivalina.

It is not known if spent fall spawners in the Wulik or Kivalina Rivers remain in spawning areas or move downstream to overwinter in locations used by nonspawners, but spent summer spawners have been captured mixed with overwintering in-migrants from the sea in both rivers.

The critical factor in the selection of overwintering areas is the presence of adequate habitat throughout the lengthy winter season. In the Wulik and Kivalina Rivers, small open-water areas and perennial springs are present intermittently throughout the areas used for overwintering. As winter progresses, some places along these streams freeze to the bottom, which further concentrates fish as winter progresses (Phil Driver, pers. comm.). The lower Noatak from the Kugururok River downstream maintains limited flow throughout the winter (Childers and Kernodle, 1981), affording potential overwintering habitat over a 120-mi length of the river. They also found winter discharge in the lower Nimiuktuk River 77 mi above the Kugururok, which suggests that observations of overwintering char in that area in September are not unfounded.

Overwintering Populations:

Overwintering populations in the Wulik and Kivalina Rivers are made up of mixed stocks of char. Tag recoveries in the Wulik River from the fall subsistence fishery showed the presence of char from the Wulik and Kivalina Rivers, as well as fish which had previously spawned in each of the four major tributaries of the Noatak. Noatak fish have also been recovered overwintering in the Kivalina River. No tag recoveries have been made from Kivalina or Wulik spawners in the Noatak River, but because of the low numbers of fish tagged in these two streams, this does not preclude the

possibility of mixed stocks overwintering in this system. One Wulik River spawner was recovered near Kotzebue in early July of the following year. This fish may have overwintered in the Noatak system.

Aerial counts of overwintering char between 1979 and 1984 have ranged from 30,923 to 113,553 in the Wulik River and from 5,474 to 45,355 in the Kivalina River (Table 19). No counts were done in 1983 due to bad weather, and the 1984 counts are lower than any previous surveys. All surveys were conducted by the same surveyor under good conditions as close to freeze-up as possible. The obvious trend in these counts is downward, but even though the counts are considered minimum numbers of fish present, it is not known if they are representative of the same proportion of the overall char population from year to year. In 1982 residents of Kivalina reported that many char entered the Wulik River under the ice, and would not have been included in the count. The temporal distribution of the fall in-migration varies from year to year, and except for the timing of the first group into the river, no data documenting the duration of the run are available. It is not known how numbers of char overwintering in the Noatak relate to numbers in the Wulik and Kivalina Rivers. Large numbers of overwintering fish have been seen in the Noatak. In 1969, 21,000 were counted in the Noatak and it was noted that they were as abundant there as on the Wulik River. In 1980, Frank Bird (pers. comm.) counted 45,185 char in a partial survey of the Noatak. Groups of overwintering char were also observed in 1982 and 1984 in the area below the Kugururok River, but weather conditions precluded counts. It may be that in years that small numbers of char use the Wulik and Kivalina Rivers, there are more in the Noatak system. The fact that the number of spawners has been increasing over the past 3 years, while counts of overwintering fish have been declining, further clouds the interpretation of survey data.

Char Fisheries and Harvests

Char are harvested in the Kotzebue Sound-Chukchi Sea area in subsistence and sport fisheries. They are also harvested incidentally in the Kotzebue Sound commercial chum salmon fishery.

Subsistence Fisheries:

The major use of Kotzebue Sound-Chukchi Sea char stocks is for subsistence. Residents of Kivalina, Noatak and Kotzebue fish for char at various times and locations. The migratory habits of char cause them to be seasonally abundant in the localities where they are harvested.

Kivalina residents seine during late September in the Wulik and Kivalina Rivers, use hook and line through the ice during the winter, and gill net in the spring and fall in Kivalina Lagoon to capture char for subsistence use. The majority of the harvest occurs in the fall seine fishery.

Fall harvests in Kivalina Village since 1959 have ranged from 12,000 to 49,720 char (Table 20). The September 1984 catch of 12,000 is the lowest harvest recorded, and is coincident with low overwintering counts. It also reflects a lower effort by the people of the village, with only five groups taking part in the fishery, rather than a lower-than-normal catch per effort. Burch (1983) found that in 1982 and 1983, 76% of the Kivalina

Table 19. Aerial survey counts of overwintering char on the Noatak, Wulik and Kivalina Rivers.

| Year | Noatak River | Wulik River | Kivalina River |
|---|---|---|---|
| 1968 | ... | 90,236 | 27,640 |
| 1969 | 21,000 | 297,257 | ... |
| 1976 | ... | 68,300 | 12,600 |
| 1979 | ... | 55,030 | 15,744 |
| 1980 | 45,185 | 113,553 | 39,692 |
| 1981 | ... | 101,826 | 45,355 |
| 1982 | ... | 65,581 | 10,932 |
| 1983 | ... | ... | ... |
| 1984 | ... | 30,923 | 5,474 |

Table 20. Kivalina subsistence char harvests.

| Year | Season | Pounds | Number of char (2.5 lb/char) | Source |
|---|---|---|---|---|
| 1959 | fall | 85,600 | 34,240 | Sarrio & Kessel, 1966 |
| 1960 | fall | 124,300 | 49,720 | Sarrio & Kessel, 1966 |
| 1964/65[1] | year | 84,611 | 33,845 | Burch, 1983 |
| 1965/66[1] | year | 35,218 | 14,087 | Burch, 1983 |
| 1968 | fall | ... | 49,512 | Winslow, 1969 |
| 1969 | spring | ... | 8,402 | Roguski & Winslow, 1970 |
| 1971 | fall | ... | 29,281 | Yoshihara, 1973 |
| 1972 | fall | ... | 35,733 | Yoshihara, 1973 |
| 1979 | fall | ... | 14,600[2] | DeCicco, 1982 |
| 1981 | fall | ... | 15,000-18,000 | DeCicco, 1982 |
| 1982 | fall | ... | 18,438 | Braund & Burnham, 1982 |
| | winter | 4,426 | 1,771 | Burch, 1983 |
| 1982/83[1] | year | 72,352 | 28,900 | Burch, 1983 |
| 1983 | spring | 12,183 | 4,870 | Burch, 1983 |
| 1983 | fall | ... | 16,270 | DeCicco, 1984 |
| 1984 | fall | ... | 12,000 | This study |

[1] Subsistence year June-July.

[2] Original estimate based on 365 tubs at 89 char/tub (Winslow, 1969). This estimate is based on 40 char/tub (DeCicco, present study).

annual char harvest occurred in the fall, 6% in the winter, 17% in the spring and 1% in the summer.

Participating groups in fall seining are made up of members of several households. After fish are seined, they are divided among the participants and stored in willow cribs constructed near the seining site above the high water line. Fish are left to freeze in place for use later in the winter. Most fish taken upriver are stored in this manner, while fish taken on the lower Wulik are often transported to the village.

Noatak villagers seine char in the Noatak River prior to freeze-up in early October and fish through the ice during the winter. The major part of their catch is taken in the winter ice fishery. Some people from Noatak fish in the Wulik during the fall or winter, particularly in years when fishing success on the Noatak is poor. The fall catch at Noatak in 1984 was 1,881 char, based on an estimate of 40 fish per sack. The harvest for the same period in 1981 was 4,920, in 1982 it was 2,403 and in 1983 it was 4,450. The 1981 harvest was originally reported as 12,300 based on an estimate of 100 fish per sack, but has since been reevaluated using 40 fish per sack, with a 2.5-pound average weight per fish.

On September 30, 1981, 15 people were observed fishing through the ice in front of Noatak. Two women fished 5.5 hours each and caught 24 and 26 char, respectively, or approximately five fish per hour. Kotzebue residents also subsistence fish for char on the Noatak River in some years, but no harvest data are available.

People from Kotzebue harvest char in the spring and fall in the vicinity of Sheshalik Spit and near the mouth of the Noatak River. Fish are captured in gill nets as they leave Noatak River wintering areas in June and travel east around Sheshalik Spit and as they enter Kotzebue Sound from the sea in August. No harvest data are available from these fisheries.

Recreational Fishery:

Sport fishing takes place on the Noatak, Wulik and Kivalina Rivers. Four guides fly small numbers of anglers into the area for char fishing. Some Alaskan residents also fly small aircraft into these streams for fishing. Most people doing this are Kotzebue residents. People attracted to the Noatak River as a wilderness float trip make up another recreational user group. Most floaters augment their food supplies by fishing. The char harvest by recreational anglers, as determined by a statewide Sport Fish creel census, has averaged 1,455 annually (Mills, 1982, 1983, 1984) (Table 21).

Guided anglers fish for char on the Kivalina, Wulik, Kelly and Nimiuktuk Rivers and Trail Creek, and Noatak River floaters fish char near the mouths of the Kugrak, Nimiuktuk, Kaluktavik, Kugururok and Kelly Rivers. In 1983, based on information provided by the National Park Service (Gil Hall, pers. comm.), 79% of the estimated 300 river floaters in the middle reaches of the Noatak fished, capturing 328 char, of which 150 were retained. In 1984, an estimated 225 people floated this section of the river and caught 374 char, retaining 164. Other species harvested include grayling, lake trout, chum salmon and northern pike.

Table 21. Recreational harvest of char (Mills, 1982-84).

| | Wulik | Noatak | Other Streams | Total |
|---|---|---|---|---|
| 1981 | ... | 583 | 486 | 1,069 |
| 1982 | 545 | 860 | 126 | 1,531 |
| 1983 | 705 | 557 | 502 | 1,764 |

Commercial Fishery:

There is no commercial char fishery in the Kotzebue Sound-Chukchi Sea area, but char are taken incidentally in the Kotzebue Sound commercial salmon fishery. The disposition of these fish varies. Some are kept for personal use by the fishing families, and some are sold to commercial buyers in Kotzebue when the buyers have markets available. The only records of char harvest available through 1982 are for those fish sold to commercial buyers and, therefore, do not represent the total catches in this fishery. The reported catches from 1966 through 1984 range from 367 in 1967 to 7,746 in 1972 (Table 22).

In 1983 the total catch of char was estimated at 835, of which 190 were sold; and in 1984, 1,090 char were caught, of which 347 were sold. The low incidental catch in the last 2 years was due to two factors. In both years, the fall char movement into Kotzebue Sound, which usually begins around August 10, was about a week late. In addition, the commercial salmon season closed early in both years, due to a weak salmon return in 1983 and a compressed run in 1984. In both years, the majority of the char catch occurred during the last open commercial periods, August 19, 1983, and August 22, 1984. The size of char in this catch ranged from 380 to 760 mm, with a modal 10-mm group at 620 to 630 mm and a sex ratio of 1 male to 1.07 females (Fig. 20). Most of the char caught in this fishery would probably have spawned in the upcoming spawning season. The modal length increment for Noatak spawners during these 2 years was 580-590 mm, with a sex ratio of 1 male to 2.66 females. The commercial catch selects for larger fish, most of which are males, and thus affects the already skewed sex ratio found on the spawning grounds.

Discussion

Spawning and associated movements of char relative to the summer or fall spawning scheme, when taken separately, are quite straightforward. However, when viewed as aspects of areawide population life history, they present a complex pattern of movements, stream residency, and ocean residency as survival adaptations. At almost any time, except during the overwintering period, one cohort of postsmolt fish may be composed of spawners, nonspawners, or maturing fish, some of which may be at sea, on spawning grounds, or en route to spawning grounds, overwintering areas or the sea. The overwintering period exception is a significant one because it includes a 9-month period from mid-September through mid-June during which most of the areawide population is concentrated in three or four major rivers and would be vulnerable to catastrophic events, whether human or natural in origin.

Some winter protection from catastrophic events is afforded by the following: (1) fall spawners overwinter in streams used for spawning rather than in lower river areas, (2) rearing presmolts occupy upstream habitats, (3) individual fish do not overwinter in the same stream each year, and (4) overwintering takes place over widespread areas of lower rivers.

During the course of this study questions relating to aspects of life history have come to light which were beyond the scope of this work but

Table 22. Incidental commercial catches of char, Kotzebue, 1966-84.[1]

| Year | Number of Fish[2] | Pounds[3] | Average Weight |
|---|---|---|---|
| 1966 | 3,325 | 1 | |
| 1967 | 367 | 2,606 | 7.1 |
| 1968 | 3,181[4] | 21,949 | 6.9 |
| 1969 | 1,089[5] | ... | |
| 1970 | 2,095 | ... | |
| 1971 | 3,828 | 23,353 | 6.1 |
| 1972 | 7,746 | 56,545 | 7.3 |
| 1973 | 640[6] | 4,608 | 7.2 |
| 1974 | 2,605 | 20,580 | 7.9 |
| 1975 | ... | ... | |
| 1976 | ... | ... | |
| 1977 | ... | ... | |
| 1978 | 1,229 | 9,094 | 7.4 |
| 1979 | 2,523 | 12,523 | 4.9 |
| 1980 | 3,049[7] | 17,015 | 5.6 |
| 1981 | 3[8] | 16 | |
| 1982 | 3,447[9] | 23,648 | 6.9 |
| 1983 | 835[10] | | |
| 1984 | 1,090 | | 6.1 |

1 1966-1982 data from Dinnocenzo.
2 Reported 7-10-pound average; all numbers are fish sold except for 1983.
3 Some data extrapolated from average weight reported.
4 Includes 269 taken by permit.
5 Includes 179 taken by permit.
6 Includes 234 taken during commercial inconnu fishery.
7 No market for char this year; many more char either used for subsistence or dumped.
8 Limited market; many char either utilized at home or dumped.
9 Total catch 835, of which 190 were sold (this study).
10 Total catch 1,090, of which 347 were sold (avg. wt. 6.06lb) (this study)

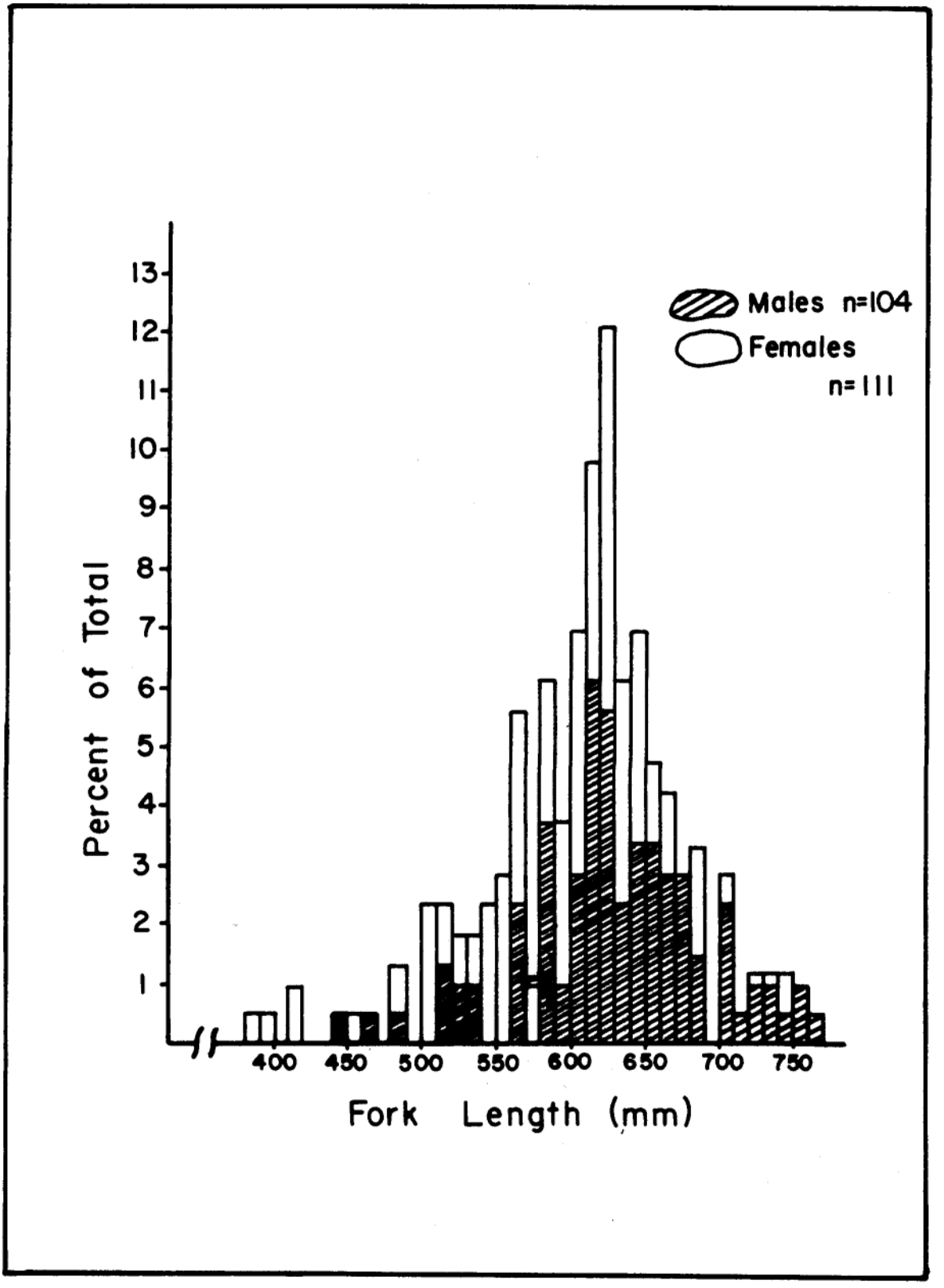


Figure 20. Length frequency of char sampled from the commercial salmon fishery in Kotzebue Sound in 1984.

should be mentioned in hope that future efforts might be directed toward their resolution.

1) Frequency of repeat spawning: The interval between consecutive spawnings is not known for certain. All tag recoveries of repeat spawners have been in the second year after tagging, suggesting an alternate-year cycle. However, the number of tag recoveries of this nature is small (n = 7). The possibility of fish going more than 2 years between spawnings cannot be ruled out. No tag recoveries have been made from spawners in consecutive years and, in conjunction with movement patterns of summer spawners, this suggests that consecutive-year spawning does not occur in the summer-spawning group. Tagging and recovery efforts were not directed at fall spawners, however, and considering that these fish are able to make an annual migration to sea for feeding, the possibility for consecutive spawning exists within this portion of the population.

2) Low incidence of tag recovery and mortality: The low rate of tag recovery in this study, particularly in spawning streams, suggests that fish do not necessarily spawn every other year as mentioned above, that there are many more char in the spawning populations than indicated in aerial survey data, or that there is considerable mortality in adult fish and very few survive to spawn more than once. Johnson (1980) stated that the mortality for mid-sized char in the anadromous Nauyuk Lake stock was low, with a tag recovery rate of over 80%. He could not be so sure about smaller or larger fish because of system interchange. He also stated that predation is insignificant after char have reached a certain size because of the absence of predators other than birds. In the Kotzebue Sound area man is a significant predator, but man's harvests do not reflect a tag recovery rate consistent with low recovery rates on spawning grounds. Marine mammals may be significant predators in the spring, when spent fish in poor condition are leaving streams. Belhuka whales are quite common at this time of year in the vicinity of the migratory path of char, and these whales are capable of taking char (Lloyd Lowry, ADF&G, pers. comm.).

   Mortality may not be from predation but could be a factor of the poor condition of spent fish which must spend the winter after spawning in fresh water. Anadromous char do not usually feed in fresh water, so this additional winter fast further depresses the already poor condition of spent fish. There is no direct evidence of winter mortality in spent fish and, indeed, many survive and are caught in the spring

subsistence fishery at Sheshalik Spit and in Kotzebue Sound. Immediate postspawning mortality has been ruled out. In studies of spawning grounds during and after spawning, no dead fish have been observed. The reasons for the low incidence of tag recovery of spawners and the causes and rates of mortality in adult char remain unknown.

3) Fall spawners as a separate stock: Fall-spawning char probably constitute a genetic stock separate from summer spawners that predominate in the area. A movement pattern distinct from that of summer spawners, and different locations of spawning, lead to this conclusion. Enough data on fall spawners have not been collected to determine if growth rates or juvenile life history patterns are different.

The Kotzebue area is in the throes of a push for economic independence and expansion which has taken the form of pressure to develop the natural resource potential of the area. Two major development thrusts are in the fields of mining and fisheries.

The Red Dog mineral deposit is located in the De Long Mountains in the headwaters of the Ikalukrok River, a major tributary of the Wulik River. The development is supported by local politicians and the Northwest Alaska Native Association (NANA), which has entered into an agreement with Cominco American, a Canadian-based mining company. The State of Alaska may also be directly involved in the development of the mine by financing a $150 million roadway from the proposed port site to the mine.

The mine plans as laid out in the baseline studies prepared by Dames & Moore pose no direct threat to the char resources. The road route crosses one spawning area on Tutak Creek but, when viewed in relation to the possible impacts of an alternate road route which would cross many major spawning streams of both the Wulik and Kivalina Rivers, it is by far the best choice. If water quality standards can be maintained in water discharged into the stream, there should be no significant impacts on char. Possible impacts might result from the direct or indirect influence of the 200 to 300 people who would be employed at the mine in the form of increased fishing on the Wulik and conflicts with local subsistence use of the char.

A major potential problem, however, lies with the port site docking facility. Plans are to use a reinforced surplus oil tanker sunk in the Chukchi Sea near the port site to act as a loading dock and also to serve as a fuel storage facility for the mine and the village of Kivalina. If this facility were broken loose or ruptured by sea ice, it could have disastrous effects on the ecosystem of the nearshore areas, including char migrational routes and feeding areas. I believe that this is the environmentally weakest part of the proposed Red Dog project.

ADF&G will continue to monitor the project during its developmental and production phases.

The Sikukuliaq Springs Salmon Hatchery is located on the Noatak River approximately 39 mi upstream from its mouth. The facility produces chum salmon fry which are released into the river to supplement the commercial salmon fishery in Kotzebue Sound. In 1983, 480,000 fry were released, and in 1984, 1,347,000 were released. It is projected that fry releases will increase to 32 million by 1993 and remain at that level. Adult returns from hatchery releases will begin in 1985 when over 900 are expected, and gradually increase to over 500,000 in 1995. Expected harvests from these returns will range from 700 in 1985 to 400,000 in 1995 (Jan. 26, 1985 memo from Peter Rob to Keith Pratt, Fisheries Rehabilitation, Enhancement, and Development Division, ADF&G).

With additional commercial fishing effort in the form of either extended periods of fishing or an increase in the length of the commercial season, increased interception of char in the fishery can be expected.

The present level of interception is probably detrimental to the char population, and any increase would be unacceptable. A system to minimize the incidental commercial catch of char should be in place before hatchery salmon significantly increase the commercial effort in Kotzebue Sound.

The subsistence fisheries on the Noatak and Wulik Rivers take significant numbers of char each year. In the Noatak River some char are seined in the fall, but the majority of the catch is taken by jigging through the ice during late fall and early spring. Char are immediately taken home and utilized or kept frozen until needed. People fish as they need fish, or often just for recreation, but still take the catch for their own use or give them to friends or relatives.

On the Wulik River most of the subsistence catch takes place in the fall. Char are seined in large numbers and laid out on a gravel bar until partially frozen, then stacked in woven willow cribs and covered with willows. Fish are retrieved from these storage cribs as needed throughout the winter. Just prior to denning, bears often raid these char caches and account for a considerable loss of the catch. If only enough fish were taken for human consumption, and those could be stored at the village or in a manner impervious to bear, the catch could be significantly reduced and still meet the needs of the village.

Future research on char should address the gaps in understanding pointed out earlier in this section. A weir on a Noatak River tributary where both summer and fall spawning occurs, which could be operated for four consecutive open-water periods, could address several questions including residency on spawning grounds, survival between spawnings and interval between spawnings. It would also allow for collection of biological data on fall spawners, including age and growth, run timing, frequency of spawning, and survival, to be compared with the summer spawning population.

Development of the Red Dog Mine should be monitored to ensure that effects on the char populations are minimized.

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Prepared by:

Alfred L. DeCicco
Fishery Biologist

Approved by:

E. Richard Logan, Ph.D., Director
Division of Sport Fish

Louis S. Bandirola, Deputy Director
Division of Sport Fish

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