LIFE HISTORY AND MANAGEMENT OF THE GRAYLING IN INTERIOR ALASKA

A THESIS

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By

Frank J. Wojcik

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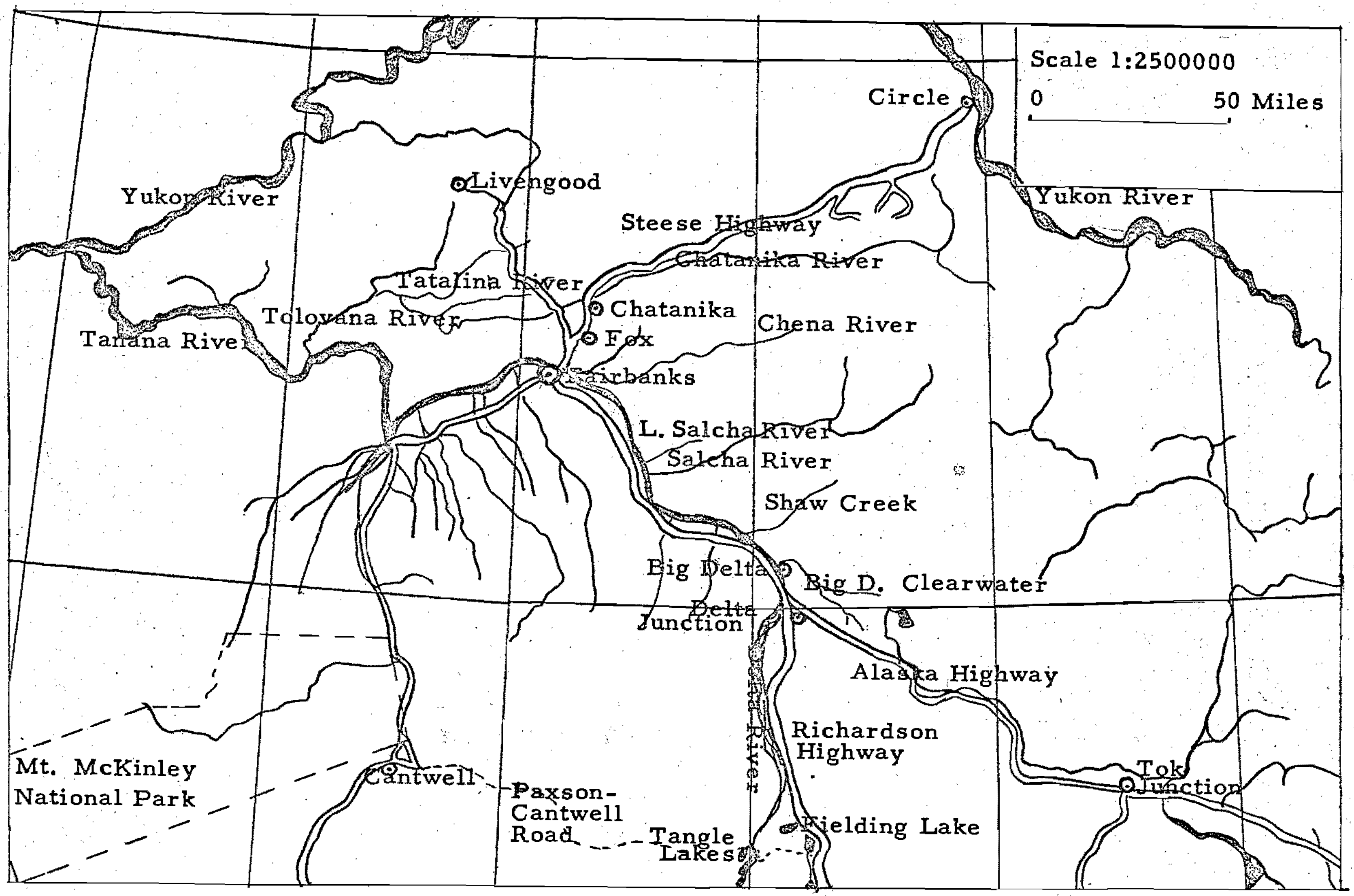

Frontispiece. Map of Fairbanks Area. (Reproduced from U. S. G. S. Map E.)

PREFACE

The Arctic grayling (Thymallus signifer signifer) is interior Alaska's most important sportfish. Yet, despite its importance, little is known of the various phases of its life history or the ecologic factors which affect it.

Life history data which might aid in the management of this species were collected for three years, 1951 through 1953, in the Fairbanks area, with most of the study being concentrated on the Little Salcha, Big Delta Clearwater, and Chatanika rivers. This study was made possible through funds supplied by Federal Aid to Fish Restoration, Alaska Project 550 F-1 R-1 and R-2, through the Alaska Cooperative Wildlife Research Unit at the University of Alaska.

The scientific names of the fish mentioned in this thesis follow Wilimovsky (1954) whenever possible, but Miller (1946) was taken as the source for the Arctic grayling, and Brown (1943) was followed in the case of the Montana and Michigan grayling.

The author wishes to express his appreciation to the many friends and students who assisted in this study, and without whose assistance this thesis could not have been completed. Special mention is due the following persons:

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ABSTRACT

Life History and Management of the Arctic Grayling in Interior Alaska

Field work on the Arctic grayling was conducted from September, 1951, to May, 1953; data on movements, spawning, food habits, sex ratios, and population dynamics were obtained.

Returns on 1,222 tagged grayling varied from 0 to 20 per cent with areas. No returns were obtained from 165 fin-clipped fish. Fish entered the streams in the spring as soon as water started flowing, the dates varying from March 15 to May 9, 1952. Spawning in the Little Salcha River during 1952 is believed to have occurred between June 12 and June 16.

Of 262 grayling checked for maturity, 18.7 per cent were mature in their fourth summer, 45 per cent in their fifth summer, and all by their sixth summer.

Sex ratios obtained for adults varied with areas. The average sex ratio found for all areas was 79 males per 100 females.

The rate of growth was determined for grayling from six areas. The average increment for class V fish varied from 2.7 to 4.6 cm. per year.

Aquatic insects were the main food organisms taken by grayling. Some terrestrial insects, fish, fish eggs and vegetable

matter were also taken.

In view of the findings made in this study, overfishing appears to be the major cause of the decline in the sizes of grayling populations along the highways in the Fairbanks area. A twelve-inch minimum size limit is apparently the best management procedure, although an area closure is advisable for overfished spawning runs.

INTRODUCTION

The Arctic grayling, *Thymallus signifer signifer* (Richardson), is one of the few freshwater sportfish in North America that has not been ravaged by the advancement of civilization. Therefore, a study of this species was started in Alaska while many of the populations were still in their virgin state.

According to Miller (1946), Richardson described the Arctic grayling, *Salmo signifer* (now *Thymallus signifer signifer*), from specimens taken from Great Bear Lake, Northwest Territories, Canada, in 1836. Although this subspecies was probably the first of the North American grayling to be accurately described, it is still one of the least known forms.

The Michigan grayling, *Thymallus s. tricolor* Cope, was described about 1858 from specimens taken from the Lower Peninsula of Michigan; eighty years later it was extinct. Hope was held for the possible existence of *tricolor* in the Otter River in Michigan, but after an intensive survey of that stream in 1937, it was concluded that Michigan grayling had been extirpated (Brown, 1938b). The Montana grayling has since been introduced into some areas in Michigan, but the introductions do not appear to be satisfactory.

The first description of the Montana grayling, *Thymallus s. montanus* Milner, is believed by Henshall to occur in the records of the Lewis and Clark Expedition in 1805 (Brown, 1938b):

> Towards evening we formed a drag of bushes, and in about two hours caught 528 good fish, most of them large trout. Among them we observed for the first time ten or twelve trout of a white or silvery color, except on the back and head, where they are of a bluish cast; in appearance and shape they resemble exactly the speckled trout, except that they are not so large, though the scales are much larger; the flavor is equally good.

Henshall believed that since this expedition had explored the area which encompassed the drainages of the Jefferson, Madison and Gallatin rivers (the original range of the Montana grayling) this subspecies was being described, and not a salmon or trout as had been previously believed.

Distribution of Arctic Grayling

The Arctic grayling is found through much of northwestern Canada; it is known to occur in the drainages of the Mackenzie, Athabaska, Peel, Porcupine and Yukon rivers. Specific locations of occurrence can be found in the works of Miller (1946), Rawson (1950) and Ward (1951).

In Alaska the Arctic grayling occurs in unsilted rivers which drain into the Bering Sea and Arctic Ocean as well as in most streams in the Interior. This species has been collected from, or observed in, drainages of the Chandalar, Colville, Copper, Dennison, Fortymile, Gulkana, Innoko, Kobuk, Maclaren, Porcupine, Tanana, Tolovana and Yukon rivers. It is not native to the streams of

Southeastern Alaska.

Description

The color of grayling changes with age. Adults vary normally from a silvery-blue to a dark blue but a few bright yellow individuals have been observed. The fish have large reddish-purple, irregular-shaped markings which extend from the opercle to the posterior end of the dorsal fin. Spots also occur on the dorsal fin where they are ringed with light blue, or even bronze. The top edge of the dorsal fin is often outlined in bronze, and two bronze streaks occur commonly along the ventral surface of the fish. The paired fins are orange, streaked with light blue.

Newly hatched fry are transparent for a short period of time, and then take on parr-markings. At the early parr stage it is difficult to distinguish between whitefish and grayling, although they can be separated by a fin ray count. Grayling are easily distinguished from the broad-striped juvenile lake trout.

Fingerlings are usually silver, with black spots on their forward half. Faint traces of parr-marks often remain along the dorsal portion of the fish until a fork length of 30 cm. is reached.

The Arctic grayling is a large-scaled, trout-like fish with an unusually large dorsal fin. In adults the weight is distributed slightly forward of the mid-point of the body, with the greatest girth occurring at the front end of the dorsal fin. Thus, the posterior end of the fish is thin and somewhat asymmetrical in appearance. The relationship of head length, eye length and opercle length to fork length remains constant throughout life. The dorsal fin increases in length in relation to fork length with age, but at a decreasing rate (Fig. 1).

The most outstanding physical feature of the Arctic grayling is its large, banner-like dorsal fin, the distal portion of which often extends back as far as the adipose fin. The dorsal fin of a resting fish lies flat against its back, but it is usually extended when the fish is feeding.

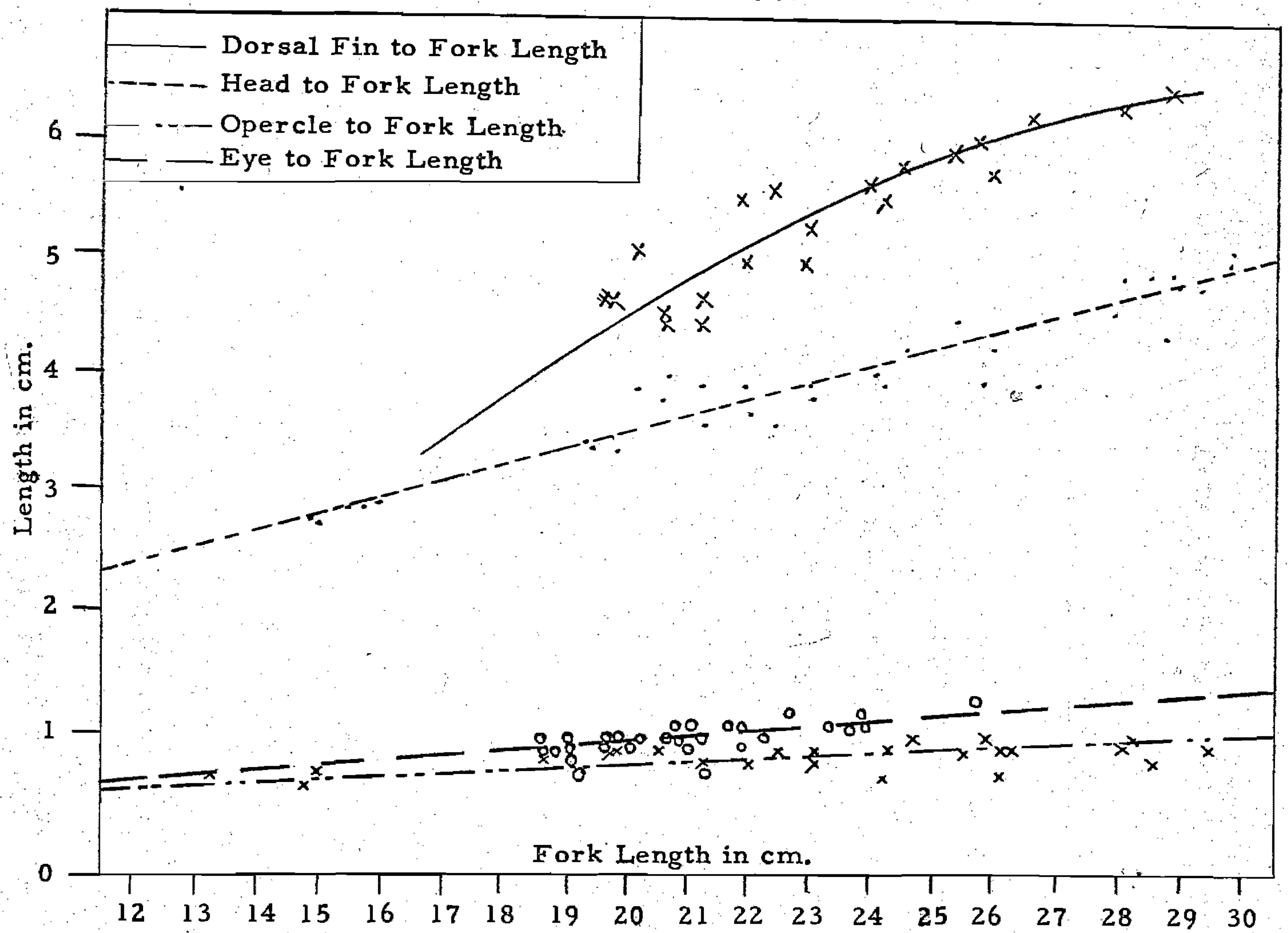
Rawson (1950) found that mature grayling from Wallaston and Reindeer Lakes in Saskatchewan could be sexed by the size and shape of their dorsal fins. He found the dorsal fins of adult males were low in front, high behind, and extended to the adipose fin; the opposite was true for adult females.

In Alaska an attempt was made to sex 152 adult grayling by this external characteristic. Sixty-seven mature grayling, less than 30 cm. fork length, showed no relationship between the dorsal fin and sex; 67 adults, between 30 and 35 cm. fork length, showed a relationship in 66 per cent of the fish, and 18 grayling, over 35 cm. fork length, showed a relationship in 98 per cent of the fish.

The difference in results obtained by Rawson (ibid.) in Canada, and in the present study in Alaska is probably caused by the length

Fig. 1. Body Proportions of Arctic Grayling

from Interior Alaska



of the fish examined. While the Alaskan fish averaged about 32.8 cm. fork length, those in Canada averaged about 40 cm. fork length (Miller, Letter dated May 1, 1952). These data indicate that the size and shape of the dorsal fin varies not only with sex and maturity, but also with the length of the fish. Thus, if fish are to be sexed by this external characteristic, they apparently should be at least 35 cm. in fork length.

Fin rays were counted on 25 fish from three different streams. None of the yellow grayling was included in this count. Although there was some variation with individuals, it was slight. The fin formula is

D-20, P-14, V-10, A-10.[1]

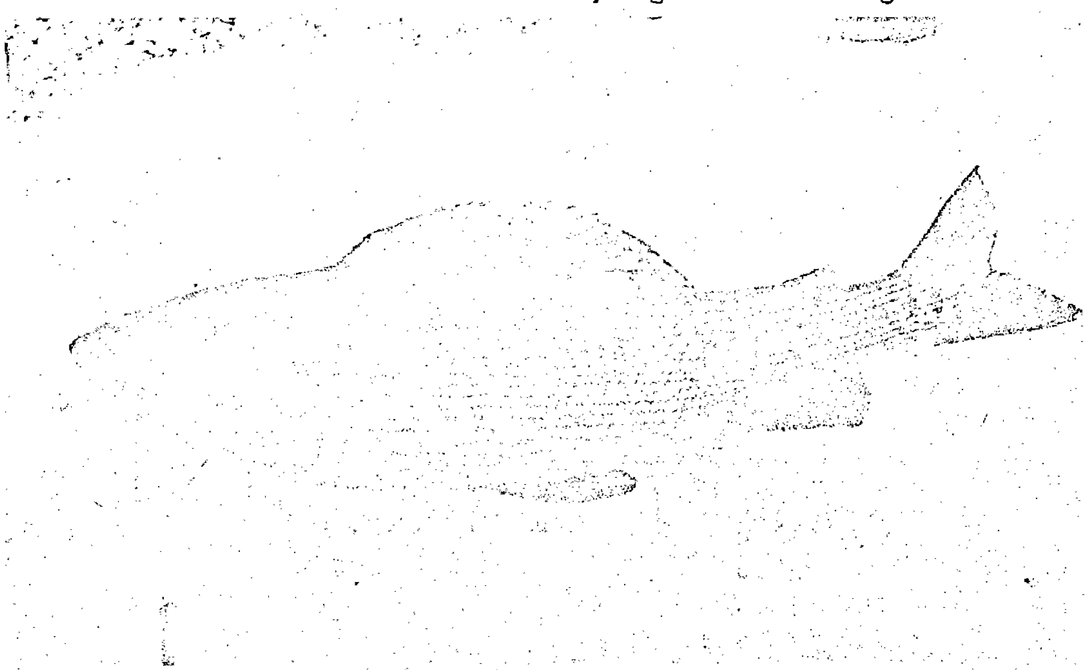
The grayling is highly prized as a sportfish by Alaskans as well as tourists. Oddly enough it is known for the manner in which it takes a fly and not for the fight it puts up. While trout and other fish usually rush for a fly, and in their hurry often throw themselves clear of the water, a large grayling rises to a fly very deliberately, seldom exposing more than its brilliant dorsal fin. Small fish are not so deliberate, often clearing the water on a rise. During periods of low water temperatures, grayling are spirited, but in

1/ The fins are denoted as: D, dorsal; P, pectoral; V, ventral and A, anal.

Fig. 2. Male and Female Adult Grayling from Fielding Lake, Illustrating Differences in the Size of the Dorsal Fin

A Seventeen-Inch Male Grayling from Fielding Lake

A Seventeen-Inch Female Grayling from Fielding Lake



warm water the fish are often sluggish. However, sluggishness with warm water is not a steadfast rule, for during the heat of the summer of 1953, some of the grayling caught by the author fought harder than those taken at any other time; their fight was comparable to that of most trout.

Normally, the grayling exhibit no preference for lures and will take flies, spoons, spinners and plugs readily throughout the season. During the spring and at times when salmon are spawning, grayling also take salmon eggs.

Collection Methods

Most of the grayling examined during the 1952 season were taken with rod and reel by the author. However, fish taken by other fishermen were examined whenever possible. The author constructed several traps, but his inexperience and lack of knowledge of stream conditions and grayling habits made most of them ineffective. One small sample of grayling fry was taken by means of a small seine.

More funds and assistance were available during the 1953 season, and more extensive as well as more representative samples were collected. Traps, rod and reel, seines, gill nets, electric shockers and extensive creel censuses provided material and information.

HABITAT

Although a few fish may spend their entire lives in one stream, the majority of the grayling in interior Alaska require two or more streams. During the late fall most small streams in the Interior freeze to the bottom, and grayling are forced to winter in the large, deep rivers. Because these are heavily laden with silt during the late spring and summer the fish are forced to summer in the small, clear streams. Another type of stream, a nursery stream, may also enter into the habitat requirement of some grayling.

The streams of the Interior have been classified, for the purpose of the present study, into easily recognizable types:

I. Run-off streams

   A. Silted

      1. Silt due to scouring action (silt sporadic)

      2. Silt due to mining (silt sporadic)

   B. Unsilted

II. Spring-fed streams (usually clear)

III. Bog-fed streams (usually stained)

IV. Glacier-fed streams (heavily silted during entire period of flow)

Although the above classification may be overly simplified, it is adequate for this study.

Run-off Streams

A run-off stream is one whose water is supplied chiefly by rain and melting snow and ice. This stream can be either clear or silted depending on the nature of the underlying soil. If it flows through an area of loess and tends to fluctuate, it is usually silty; but if it flows through an area of sand or gravel and does not fluctuate, it is clear.

Silted Run-off Streams

A run-off stream in the Interior is silted either because it scours its bed or because mining has been conducted nearby and silt is washed into it.

Silt Due to Scouring

This type of stream is usually large, fluctuates considerably, and tends to meander. It is often clear in the late fall and winter while its flow is at a minimum, and silted in the spring and summer while its flow is at a maximum. In addition to the silt which this type of river scours from its bed, additional silt is often contributed by smaller glacier-fed streams which empty into it. The Tanana River is characteristic of this type of stream. It rises in the Nutzotin Mountains on the Canadian Border and flows northwest about five hundred miles to the village of Tanana where it empties into the Yukon River.

During the time that the Tanana River runs clear, it has an abundant insect fauna. Numerous insects were observed during the spring of 1953 and fish taken at that time were gorged. This stream was not sampled during the silted stage.

Fish species found in a stream of this type are grayling, Thymallus signifer signifer (Richardson); pike, Esox lucius Linneaus; round whitefish, Coregonus (Prosopium) cylindraceus (Pallas); sucker, Catostomus catostomus (Foerster); and sculpin, Cottus spp. Three species of salmon, king, Oncorhynchus tshawytscha (Walbaum); silver, Oncorhynchus kisutch (Walbaum); and dog, Oncorhynchus keta (Walbaum), are known to use this large waterway enroute to smaller streams in the Interior. Lamprey, Entosphenus spp.; sheefish, Stenodus leucichthys (Pallas); ling cod, Lota lota maculosa (LeSueur); and creek northern chub, Hybopsis plumbea (Agassiz), have been reported from the Tanana, but have not been observed by the author. The creek northern chubs, found commonly in small gravel pits which are inundated periodically, are believed to have been introduced from the Tanana River. Of the stream fish known to occur in the Interior, only the dolly varden, Salvelinus malma (Walbaum), is believed at the present time to be absent from the Tanana.

Silt Due to Mining

Gold mining can prove detrimental to grayling waters. If only a small amount of mining occurs, streams sometimes can support a moderate amount of fishing, but when the operation is large, grayling are forced to leave the streams, and all fishing stops. Many streams, now choked with silt, were at one time fine, clear grayling streams. Since the advent of intensive mining operations, tons of silt "overburden" have been washed into them leaving mud-filled sloughs.

Since mining plays such an important role in the economy of Alaska, it is improbable that anything will be done in the near future to prevent further silting of streams. It is unfortunate that the destruction of valuable streams is allowed to continue, especially since the time required for them to recover, once mining ceases, may prove to be many years. Considerable effort should be made to determine the effects of mining on these streams, especially the time required for streams to return to production of fish.

Unsilted Run-off Streams

These clear streams are characterized by considerable fluctuation in water levels between spring, summer, and fall, with maximum flow occurring soon after the spring breakup. They have warm summer water temperatures, often reaching 65° F. The water is clear or slightly stained, and is usually slightly basic (pH 7.1 to 7.6).

Although several streams of this type have been surveyed (the

Chatanika River and its tributaries, the Salcha River, the Chena River and the West Fork of the Forty-mile River), they are basically so similar that only data from the Chatanika River are presented here.

The width of the Chatanika River, at the bridge on the Steese Highway, varies from a maximum of about 280 feet at the spring breakup, to a minimum, in the fall, of 10 to 20 feet. It rises in a series of low hills about 70 miles northeast of Fairbanks, parallels the Steese Highway between Miles 70 and 28, and then swings away from the highway and flows west about 50 miles to its confluence with the Tolovana River. Below the village of Chatanika (Mile 29), the river becomes a settling basin for the overburden washed down from a mining operation. The resulting mud-filled slough is used by fish as a migration route and possibly as a wintering area.

The Chatanika River has a minimum velocity of 1 foot per second in the fall and a maximum velocity of about 2.8 feet per second in the spring. After the spring maximum, this stream fluctuates less than do others of this type. The hydrogen-ion concentration of this stream varies little throughout the year, pH 7.4 to 7.6.

"Anchor ice" was not observed in the Chatanika River in 1952. Inasmuch as anchor ice was observed forming in other streams of this type during that year, it may form in the Chatanika River at other times. The depth to which ice forms on the Chatanika River appears to be affected more by snow cover and overflow than by temperature. During the winter of 1951-52, a winter with a moderate snow fall, ice in the Chatanika River was frozen to a depth of less than five feet. During the winter of 1952-53, a year of little snow, ice in the Chatanika occurred to a depth of over five feet, and the river was completely frozen, except where it was separated from the bottom by an air space. During the winter of 1953-54, also a year of little snow, a maximum thickness of about seven feet was measured. The unusual amount of ice during 1953-54 was caused by water flowing over it most of the winter.

When the ice starts melting in the spring, it is first "rotted" away by overflow. With an increase in the flow, the ice often breaks away from the bottom in large cakes which frequently jam on riffles becoming, in effect, dams. The action of the ice, and the debris carried by it, scours the bottom, often gouging out pools in one area and filling them in another. This turning over of the stream bed in the spring is believed extremely detrimental to the insect fauna, and this is borne out by the fact that the insect fauna of the Chatanika River is very sparse. At no time did the author collect more than a trace in a square foot of bottom sample. The sample included mayflies, caddisflies, dragonflies, small beetles and midges. Fish species found in this river were grayling, brook lamprey, round whitefish, silver and king salmon fry and king salmon adults.

Spring-fed Streams

There are two types of spring-fed streams in interior Alaska: streams supplied by hot springs and streams supplied by cold springs. Since streams fed by hot springs do not usually support grayling, they were not surveyed in this study.

Cold Spring-fed Streams

Cold spring-fed streams are easily recognizable. Their rate of flow, temperature and hydrogen-ion concentration (pH) remain relatively constant, and the water is crystal clear the year around. The Big Delta Clearwater, the Richardson Clearwater, and the Chena Clearwater are streams which are representative of this type. Only the Big Delta Clearwater is discussed here.

The water temperature of the Big Delta Clearwater varies from freezing to 45° F. The water level varies less than one inch; the rate of flow remains almost constant the year around; and the river never completely freezes over. These conditions point to a nearly ideal environment for grayling as well as for other aquatic life.

The Big Delta Clearwater originates in a small valley at an elevation of 1,200 feet and flows west for about 25 miles to the

Tanana River. The Clearwater has an average width of 175 feet, an average depth of 2.5 feet, an average velocity of 2.0 feet per second, and a flow of 850 cubic feet per second. Its crystal clear water, beautiful scenery, and fine grayling fishing have made it the best-known grayling stream in interior Alaska.

Fish species found to occur in this stream are grayling, round whitefish, suckers, sculpin, and silver salmon (both adults and juveniles).

The same types of insects are found in the Clearwater as are found in other streams in the Interior. The total number of aquatic insects is greater in the Clearwater.

<u>Bog-fed Streams</u>

Bog-fed streams are easily recognized in the late spring and summer by their darkly stained waters. In the spring, when most of the water in these streams comes from melting ice and snow, these streams often run clear for short periods, but when the "snow water" has run off, the water is supplied mainly by muskeg pools and is greenish-brown in color. The temperature of these streams varies widely with the season. The water is slightly acid in the spring and basic in the summer, pH 6.5 to 7.6. Although Shaw Creek and the Little Salcha are both bog-fed streams, the Little Salcha is more typical and data on it are presented here.

The Little Salcha River originates in a series of low hills at an elevation of 1,000 feet. It is 17 miles long, about 30 feet wide, and one foot deep. It is subject to considerable fluctuation, not only at breakup but after every moderate to heavy rain. During the summer of 1952, this stream rose approximately five feet following a rainfall of about one inch. Apparently the areas drained by this stream are incapable of absorbing large quantities of water, and hence the water runs off almost immediately. The pH of this stream during 1952 varied from 6.6 in the early spring to 7.6 by late summer.

During the fall of 1952, this stream began to freeze about October 10 and by mid-winter it was frozen to the bottom. Anchor ice formed in shallow riffles of this stream even before surface ice. The deep freezing which usually occurs during the winter in this stream is probably detrimental to the bottom fauna.

Water in the Little Salcha River started flowing over the ice on May 1, 1952, and April 26, 1953, and channels were soon melted in it. The stream was free of ice on May 15, 1952, and May 16, 1953. Fish inhabiting this river are grayling, sculpin, round whitefish, dog salmon adults and silver salmon fry. One lake trout has been observed, but it is not believed to occur there normally.

The insect fauna of this stream is sparse; bottom samples collected yielded a maximum of 0.1 cc. per square foot of bottom, with mere traces being most common. Stoneflies, mayflies, caddisflies and chironomids were collected.

TAGGING

During the seasons of 1952 and 1953, 1,222 grayling were tagged in interior Alaska to obtain information on movements (Tables 1, 2 and 3). Metal strap tags were used during the 1952 season. These apparently were lost quickly because only one such tag was returned during 1953. Red plastic, Atkinson-type flutter tags, attached by means of a cadmium wire, were used primarily during the 1953 season, and it is hoped that many of these will be returned during the 1954 season.

In addition to the tagging, 165 grayling were "fin clipped" during the 1952 season. Since none of these fish was returned during 1952, fish were not fin clipped during 1953 (Table 1).

It is believed that a very small percentage of the fish taken by rod and reel were lost through handling. Grayling apparently are quite hardy, for even when taken with a gill net, set for 24 hours, observed mortality was less than 25 per cent. Of fish taken in a gill net, whitefish suffered about 95 per cent mortality and lake trout, 60 per cent mortality.

Strap tags attached to the caudal peduncle caused a great deal of sloughing, resulting in a loss of tags and even death to some of the fish. Many of the fish tagged in this manner had large open wounds about the tags when they were recaught, and in several cases the tags were held by so little flesh that they would soon have been lost.

Table 1. RESULTS OF THE 1952 TAGGING OPERATION[a]

Stream	No. of fish tagged	No. of tagged fish killed	Percentage of tags returned
Big Delta Clearwater[b]	31	1	3
Little Salcha River	553	28	5
Pile Driver Slough	47	1	2
Tatalina River	1	0	0
Washington Creek	9	1	11
Total and Average	641	31	5

a/ All tagging was with strap tags.

b/ The one return for this stream, although taken the same year it was tagged, was not reported until the following year.

Table 2. RESULTS OF THE 1953 STRAP-TAGGING OPERATION

Locality	No. of fish tagged	No. of tags returned	Percentage of tags returned	Locality of return	Max. distance traveled (miles)
Big Delta Clearwater	113	8	7	Big Delta Clearwater	10
		1	1	Richardson Clearwater	40 to 60
		1	1	Clear Lake	10 to 20
		1	1	Shaw Creek	30 to 50
Chatanika River	35	2	6	Chatanika River	0
Little Salcha River[a]	23	1	0	Big Salcha River	5
Pile Driver Slough	10	0	0		-
Salcha Slough	7	0	0		-
Fielding Lake	18	0	0		-
Total and Average	206	14	7		

a/ The return was from a fish tagged the previous year.

Table 3. RESULTS OF THE 1953 ATKINSON-TYPE-TAGGING OPERATION

Locality	No. of fish tagged	No. of tags returned	Percentage of tags returned	Locality of return	Max. distance traveled (miles)
Chatanika River[a]	69	20	29	Chatanika River	22
Little Salcha River	2	0	0		-
Pile Driver Slough	4	0	0		-
Tolovana River	10	1	10	Tolovana River	1
Fielding Lake	30	3	10	Fielding Lake	2
Tangle Lakes[b]	260	43	16	Tangle Lakes	5
Total and Average	375	67	18		

a/ Most of these fish were tagged by W. L. Libby, a graduate student at the University of Alaska.

b/ Fish were tagged in three of the interconnected Tangle Lakes.

The highest return obtained with strap tags was 10 per cent. However, since most of the fish were caught shortly after being tagged, the value of these returns is slight.

Two tags which had fallen off fish were found. One of these was found on the river bottom a few days after it was applied. The other was found on a beaver house located in a pond without inlet or outlet.[2] This fish was tagged in the Little Salcha River in 1952 about 40 miles upstream from where it was recovered. An explanation for this unusual movement could be that the fish was weakened by handling, and drifted downstream to a point near the pond. There it was picked up by some animal, brought to the beaver house, and eaten.

The Atkinson-type tag has proven to be the most satisfactory type of tag used on grayling by the author, although it is difficult to attach. It is preferred because it causes the least amount of sloughing and it comes in a variety of easily observed colors. Results obtained in this study indicate that the number of returns is correlated with the ability of the angler to see the mark. This is borne out by the fact that while many tags have been returned, not one fin-clipped fish has been reported. Flutter tags have a

2/ This tag was found by W. L. Libby of the University of Alaska who was studying beaver.

slight disadvantage. They are easily seen in the water and may attract the fishermen to the tagged fish resulting in a source of error. So slight an error, however, is considered insignificant in this study.

At present, fin clipping appears to be an unsatisfactory method of marking fish in Alaska because the mark is too inconspicuous. Further, nothing is known of grayling fin regeneration. Unless qualified men are checking creels, the marks apparently pass unnoticed and the information is lost.

Best results were obtained by the use of a free-swinging, brightly colored tag attached to the fish by a thin wire.

MOVEMENTS

The migratory habits of grayling have been observed and reported by many people. In Alaska migrations are most pronounced in the spring, although movements are not limited to that season.

Gustafson (1948) observed a spring and fall migration of grayling in Sweden. Ward (1951) observed both spring and fall migrations in Alberta. Brown (1938b), Nelson (1953), Rawson (1950) and many others also have reported observing grayling migrations.

Spawning Migration

In Alaska the most spectacular and easily observed movement of grayling occurs in the spring. The spring spawning run has been observed on several streams in the Interior. Some of the observations follow:

Many fishermen from the Fairbanks area are familiar with the large run of grayling which enters Shaw Creek each spring. The run was observed between April 20 and April 23, 1952, and April 12 and April 19, 1953. This run is so timed that the fish are lying at the junction of the Tanana River and Shaw Creek prior to the spring breakup. They enter Shaw Creek as soon as narrow leads are open in the ice. Upon entering, they are often concentrated by ice barriers into small areas where they are extremely vulnerable to fishing, and many are taken.

The first fish was caught at the mouth of Shaw Creek on April 13, 1952, but the main run did not enter until April 20. The peak of the run continued for three days and contained many fish. Anglers continued taking fish after April 23, but most of these fish are believed to have entered Shaw Creek by April 23, and had remained in the vicinity of the river mouth where they were taken. None was observed entering Shaw Creek after April 23.

During the spring of 1953, the first fish was taken at Shaw Creek on March 15. The main run entered about April 12, but an ice jam in the lower reaches of the stream prevented the fish from going upstream and none was taken above the ice jam for seven days. As soon as this impediment melted, fish moved through and were taken upstream.

Traps were set on the Little Salcha River during the springs of 1952 and 1953 to catch spring migrants. The fish were first observed on May 4, 1952, and a trap was set three days later. Although weather conditions made the trap ineffective, it did prove useful as a barrier at which fish could be observed. After they passed the trap, the fish were followed upstream. They moved to a large beaver dam where they were forced to wait for high water. Concentrations of fish remained at the dam until May 13.

Fish were observed entering the Little Salcha River on April

28, 1953, and a trap was set. Although only a few grayling were taken, many were seen. At the time the fish first entered, the stream bed was covered with ice, and the fish entered only during the period from dusk to dawn. After the bottom ice had melted, the fish entered throughout the day. Since nothing in the stream other than the ice appeared to have changed, the difference in the time of day that the fish entered the stream may have been due to variance in amount of protection offered by changes in the color of the stream bottom. When the ice covered the bottom, the fish were easily observed against the light background, and apparently limited their movement to the hours of darkness; but when the ice had left the bottom, and ample cover was available, they moved during the daylight hours as well.

The 1953 run appeared to have subsided on May 1 and was believed over. However, it was later discovered that an ice dam had prevented some of the grayling from entering the Little Salcha River. After the barrier melted, fish again entered. They were seen moving into this stream until May 9, 1953.

Grayling have been reported to enter and spawn in an outlet to Birch Lake. A trap was constructed on this stream during the spring of 1952 by Edward Marvich, Senior Biologist of the Alaska Department of Fisheries. A few grayling were taken, but these were fish which apparently had spawned at another stream and had later entered the Birch Lake outlet.

Fall Migration

Two years of observation on several streams have failed to provide information on the time of the fall downstream migration. It appears that, unlike the concentrated spring run, the fall run is composed of individual fish or small groups which work downstream and are able to move unnoticed.

Permanent Residents

It appears that some grayling do not undergo a seasonal migration but remain in the same stream the year around. Some evidence of such resident fish has been found at the Big Delta Clearwater and at Beaver Creek. Fish are taken from Beaver Creek and the Big Delta Clearwater long before migrations are observed elsewhere.

Attempts made to ascertain whether or not some grayling remain in the Clearwater throughout the winter failed. Fishing was attempted in this stream on December 14, 1953, but cold weather and ice on the edge of the stream made it impossible. The latest date on which grayling were taken there was November 5, 1953. Fish were not observed in any other stream this late in the year, and so it is quite possible that those taken were winter residents. Further, on March 15, 1953, grayling were taken at the

Clearwater, and could be taken at no other stream, but Beaver Creek.

Trappers report that they have been able to take grayling through the ice from the headwaters of small streams all winter long. If these reports are accurate, then some fish are able to winter in deep pools which do not freeze to the bottom. It is not known whether fish which wintered in small streams did so from choice, or whether a quick freeze trapped them.

<u>Winter Movements</u>

The Tanana River is believed to be the wintering area for the fish from most of its small tributaries. This conclusion is borne out by the fact that natives have caught grayling from the Tanana River while fishing through the ice in the winter. Grayling are commonly taken from the Tanana River during the early spring. Further, one angler states that he had been able to catch grayling from the Tanana River in the vicinity of Big Delta during all of the months of the winter of 1952-53, except February, at which time he claims it was too cold to fish.

Fishing in the Tanana River started in 1953 on March 15; only a few fish were taken. On April 3 there was a sudden increase in the number of fish taken and large catches were reported for six days. After April 8, the fishing dropped off altogether. The increase in the catch on April 3 was caused either by fish concentrating in that area or by increased activity on the part of the fish. Since no temperature change was noted, the increase in the catch is believed due to fish moving into and concentrating in the area. This is believed to be the start of the spring migration.

Movements in Response to Water Temperature

With the advent of warm water temperatures, many salmonoid fishes tend to seek the deeper, cold water; however, grayling do not. Observations made in several lakes during periods of unfavorable water temperatures indicate that unlike the lake trout, the grayling escape unfavorable temperatures by moving to cool inlets and not to deep water.

Following are some of the observations upon which these conclusions are based: During a week of warm weather, about July 4, 1953, it was noticed that there was a large concentration of grayling at the mouth of one of the small inlets of Shallow Tangle Lake. The water temperature was 63° F. and the fish displayed discomfort. This lack of well-being was borne out by the unusually high mortality sustained by a group of fish taken from this area for tagging. Ten of the 85 fish taken at this time died before they could be tagged. Similar high mortality was not experienced at any other time.

Another case of grayling seeking cooler stream water to escape warm surface water in a lake occurred in a small pond in the vicinity of the Tangle Lakes. Normally the grayling are well dispersed throughout this pond, but on July 5, 1953, when the surface water temperature was 68° F. many were concentrated at the mouth of a small inlet.

Results obtained with gill nets set at the Tangle Lakes also indicate that the grayling lie in the vicinity of inlets or springs during periods of high water temperatures. Sets made in deep water during periods of warm water took only whitefish and lake trout. Grayling apparently were not forced out of the deep water at this time by a lack of oxygen, because adequate dissolved oxygen was found at all levels--seven parts per million at the bottom of the lake.

Random Movements

For the period of June 1 to July 15, 1952, few grayling were in the lower section of the Little Salcha River. With the entrance of a salmon run into this river on July 16, 1952, many grayling became available. They left the area about two weeks after the last salmon was observed. Whether the grayling entered the Little Salcha River from the Tanana River, or whether the grayling moved downstream to the area in which the salmon were spawning, to feed on salmon eggs, is not known. Similar grayling movements occurred at the Gulkana River during the summer of 1953.

LIFE HISTORY

Breeding Biology

During both the 1952 and 1953 seasons the majority of the mature grayling entered the Little Salcha River between May 1 and May 9; they did not start spawning immediately. Due to the turbid conditions at the time grayling were spawning, the act was not observed; however, approximate spawning dates have been deduced from the condition of the fish taken.

The first ripe grayling was taken at the Little Salcha River on May 13, 1952; no other ripe individuals were taken until June 12, 1952. The last ripe fish was taken on June 16, 1952. From these observations it is concluded that the Little Salcha grayling spawned between May 13 and June 16, the majority between June 12 and June 16, 1952. This relatively short spawning period agrees with the length of the spawning period found by Brown (1938a), who worked with the American grayling in Montana. Nelson (1953) working with the same species in Montana found the spawning dates to run from May 19 to June 6 for Red Rock Creek fish, and May 23 to June 1 for those of Antelope Creek.

Thirty-seven grayling taken at the Little Salcha River during the 1952 season, and 225 taken from several other streams in the Interior during 1953 were checked for sex and maturity. The youngest mature male examined during 1952 was in his fourth summer, and the youngest mature female was in her fifth summer. Of the fish taken during 1952, 3 of 16 grayling were mature in their fourth summer (18.7 per cent), 5 of 11 were mature in their fifth summer (45 per cent), and all were mature in their sixth summer.

Not all grayling taken during 1953 have been aged as yet; however, length frequency data suggest that the fish begin maturing by their fourth summer, and that all are mature by their sixth summer (Fig. 2). The large 1953 sample, unlike the 1952 sample, suggests that both sexes mature at the same age. Somme (1935) working in Norway also found that both sexes matured at the same age.

Ward (1951), working in the Athabaska Drainage of Alberta, Canada, found that nine female grayling, varying in length from 10 to 12.8 inches fork length, produced an average of 3,649 eggs each. The three-day-old, water-hardened eggs had an average diameter of 0.136 inches, and 376 eggs weighed one ounce. Twenty-five thousand three-day-old eggs, or 20,450 five-day-old eggs made a quart.

Data on egg sizes from Alaskan grayling were obtained from one female. The unfertilized eggs of this female measured 10 to the inch.

Ward (ibid.) found that males produced between a drop and a teaspoonful of milt per "stripping". Males could be stripped more than once, and those which gave the most milt on the first stripping also gave the most on subsequent strippings.

Brown (1938a) states that the eggs of the American grayling are adhesive, whereas Rawson (1950) states that the eggs of the Arctic form are non-adhesive. One group of eggs was collected in Alaska during the spring of 1953. Except for a period in which water was absorbed, the eggs did not tend to adhere.

Ward (1951) found that impregnated eggs of the Arctic grayling required 12.5 days at a temperature of 45.5° F. to reach the "eyed stage". They hatched from the eyed stage in 8.9 days at a temperature of 43.0° F. Nelson (1953) estimated the incubation period of the American grayling to be 14 to 19 days, depending upon temperature; Brown (ibid.) estimated the period to be 11 to 22 days. Data obtained on the Arctic grayling indicate that the eggs hatch in 8 to 21 days depending on the water temperature.

Ward (ibid.) obtained two groups of naturally spawned Arctic grayling eggs, one of 46, and the other of 12. Of this total of 58 eggs, 55 (96 per cent) were fertile. The same author fertilized eggs by the "dry method" and obtained 70 to 80 per cent fertility. Henshall (1907), using the "wet method" on eggs of the American grayling, obtained 95 per cent fertility.

Brown (ibid.) states that the mortality of American grayling eggs hatched at the Grebe Lake Hatchery at Yellowstone National

Park normally did not exceed 10 per cent.

The spawning acts of the Arctic and Montana grayling appear to be similar. Brown (1938b), who observed the spawning of the American grayling at a small inlet to Agnes Lake, Montana, described the act. The following description is based on his observations.

Spawning fish concentrated just below a riffle and showed little fear of the observers. A male would move abreast of a female and remain there for a few minutes, then move up to the female until their bodies touched for much of their length. When they pressed against each other the dorsal fin of the male was extended and arched over the female's back. At first, the female moved away but after several approaches by the male, she did not move away but crowded nearer to him. Their bodies were in contact from head to vent and the male's dorsal fin was curved tautly over her back. Immediately after this contact was established, their bodies stiffened and started to vibrate. This motion increased in intensity to a climax in about 10 to 12 seconds. During the latter part of this act their tails formed an acute angle with the bottom, and the vibration stirred up the gravel. In this period of extreme activity, the eggs and milt were released. Some of the gravel adhered to the eggs and they sank to the bottom.

Ward's (1951) description of the spawning act of the Arctic grayling is similar to that of Brown's (1938b), except that Ward mentions seeing small males constantly following the females, but never spawning with them.

Small grayling were observed in the spawning run at Fielding Lake during the spring of 1953. The actual spawning act was not observed, so it is not known if these small fish attempted to spawn.

During the spring of 1952 many small grayling, taken from areas in which grayling were spawning, had damaged tails; tails of spawning adults were not similarly damaged. Only one juvenile, a small female, was killed and examined. Since she could not have attempted to spawn it is possible that she had followed the adult spawners in an attempt to pick up eggs, and her tail may have been damaged by the adults protecting their spawn.

The work of Brown (ibid.), Nelson (1953) and others indicates that grayling spawn at the "tail" of shallow riffles. Nelson (ibid.) was able to find eggs only in the transition areas between riffles and pools. In Alaska, grayling spawning occurred most frequently in shallow backwater areas.

The optimum balance of sexes in a grayling population is not known. Brown (ibid.) found three males to each two females in the spawning run at the outlet of Agnes Lake. The average sex ratio obtained for all waters during 1952 was 79 males per 100 females (Table 4). An unbalanced sex ratio was found at Fielding

Table 4. SEX RATIOS OF GRAYLING FROM INTERIOR ALASKA TAKEN DURING 1952 ON ROD AND REEL

Area	No. of fish	No. of females	No. of males	No. of males per 100 females
Big Delta Clearwater[a]	29	15	14	93
Big Salcha River	5	3	2	66
Chatanika River[a]	8	5	3	60
Little Salcha River	35	17	18	106
Pile Driver Slough[a]	18	10	8	80
Richardson Clearwater[a]	28	17	11	65
Tanana River	43	26	17	104
Washington Creek[a]	7	5	2	40
Clarence Lake	7	3	4	133
Black Lake	7	4	3	75
Total and Average	187	105	82	79

a/ Heavily fished areas.

Lake for the years 1952 and 1953. Similar unbalanced sex ratios were found for most of the heavily fished areas including the Little Salcha River.

Sex ratios at the Tangle Lakes and the Big Delta Clearwater were more nearly balanced. On the basis of these findings, the author has concluded that fish in heavily fished areas develop an unbalanced sex ratio in favor of females, but the fish in areas which receive less pressure have a balanced sex ratio.

A study should be made to determine the age at which the sexes enter the fishery. Should males grow faster and enter a fishery before females do, then in heavily fished areas males would be taken sooner than females and a distorted sex ratio might result. If this does occur, then it may be possible to analyze fishing pressure on a basis of sex ratios. Such an analysis would prove to be a valuable management tool.

Age and Growth

Ages of grayling in this study were determined from the scales. Unfortunately, known-age fish were not available for comparison. The number of winters completed by the fish, as indicated by "annuli" on the scales (age classes), are indicated in Roman numerals in this paper.

Scales to be read were viewed with a hand lens, and all regenerated and damaged ones were eliminated. Selected scales were cleaned with water and mounted dry between two microscope slides. The scales were not read directly as is the usual procedure, but were projected through a photographic enlarger onto a high contrast, photographic projection paper. The paper was then developed and a negative print of the scale, magnified approximately ten times, resulted (Fig. 4). These negative prints were read by the author. Several positive prints were made by the "contact method", using the reverse prints as paper negatives. A sample of the positive prints was sent to Dr. R.B. Miller, Professor of Fisheries at the University of Alberta, who checked the author's aging.

The method of reading scales described here is somewhat laborious, but has the advantage that scales can be easily re-read. In a growth study it has the further advantage that the scale radii can be measured directly on the print.

In a growth study, scales are usually measured from the focus of the scale to each annulus in an anterio-posterior direction. Because grayling scales proved difficult to read along the anterior radius, they were read and measured along the anterio-lateral radius. Miller (1946), working with grayling in Canada, used the same method.

The total scale lengths, magnified ten times, were then measured and plotted against the fork lengths of the fish at the time of capture. The regression so obtained was linear, or nearly so

(Fig. 3), which indicates that the growth of the scale along the anterio-lateral radius varies directly with the fork length of the fish. Miller (1946) obtained similar results for the grayling of Great Bear Lake, Canada. Since the scale radius varies directly with the fork length, the length of the scale at each age was used in the present study to calculate the fork length of the fish at that age.

Information on the length of Little Salcha River grayling, at the time of scale formation, was not obtained, because only one fry was taken there and it still lacked scales. A sample of thirteen fry, in varied stages of scale formation, was taken at the Chatanika River on August 11, 1952. Of the thirteen fry examined, some had scales only along the lateral line, while others varied from no scales to complete coverage. The fry examined indicated that scale formation occurs first along the lateral line and then progresses in a ventral and dorsal direction from the lateral line.

The average fork length of the Chatanika River fry in all stages of scale formation was 4.1 cm., so this value is used by the author as a constant for the fork length of interior Alaska grayling. This constant was substituted into the formula given by Miller (ibid.) to determine the length of the fish at different ages for all grayling.

Fig. 3. Relationship of Scale Width to Fork Length

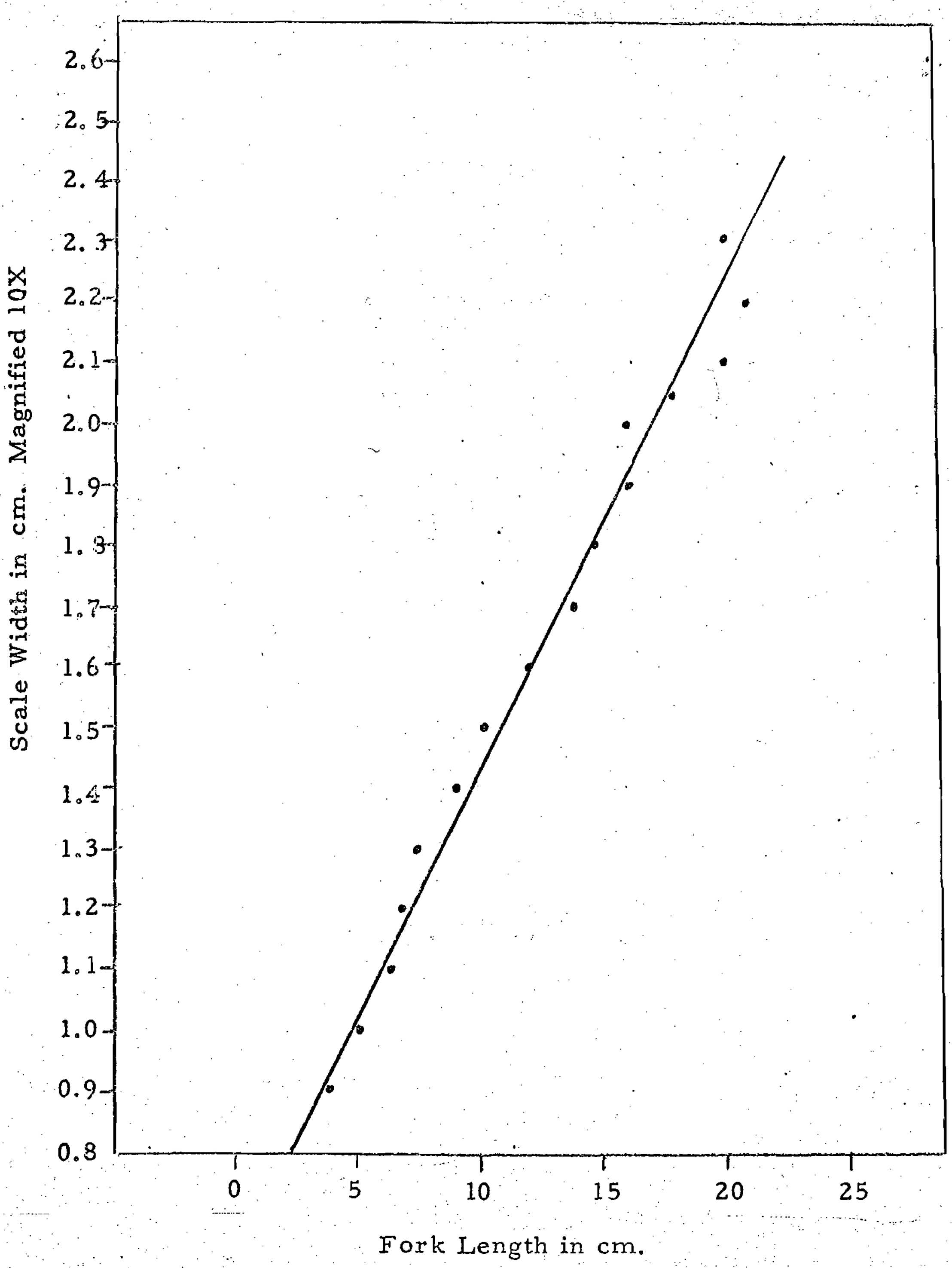
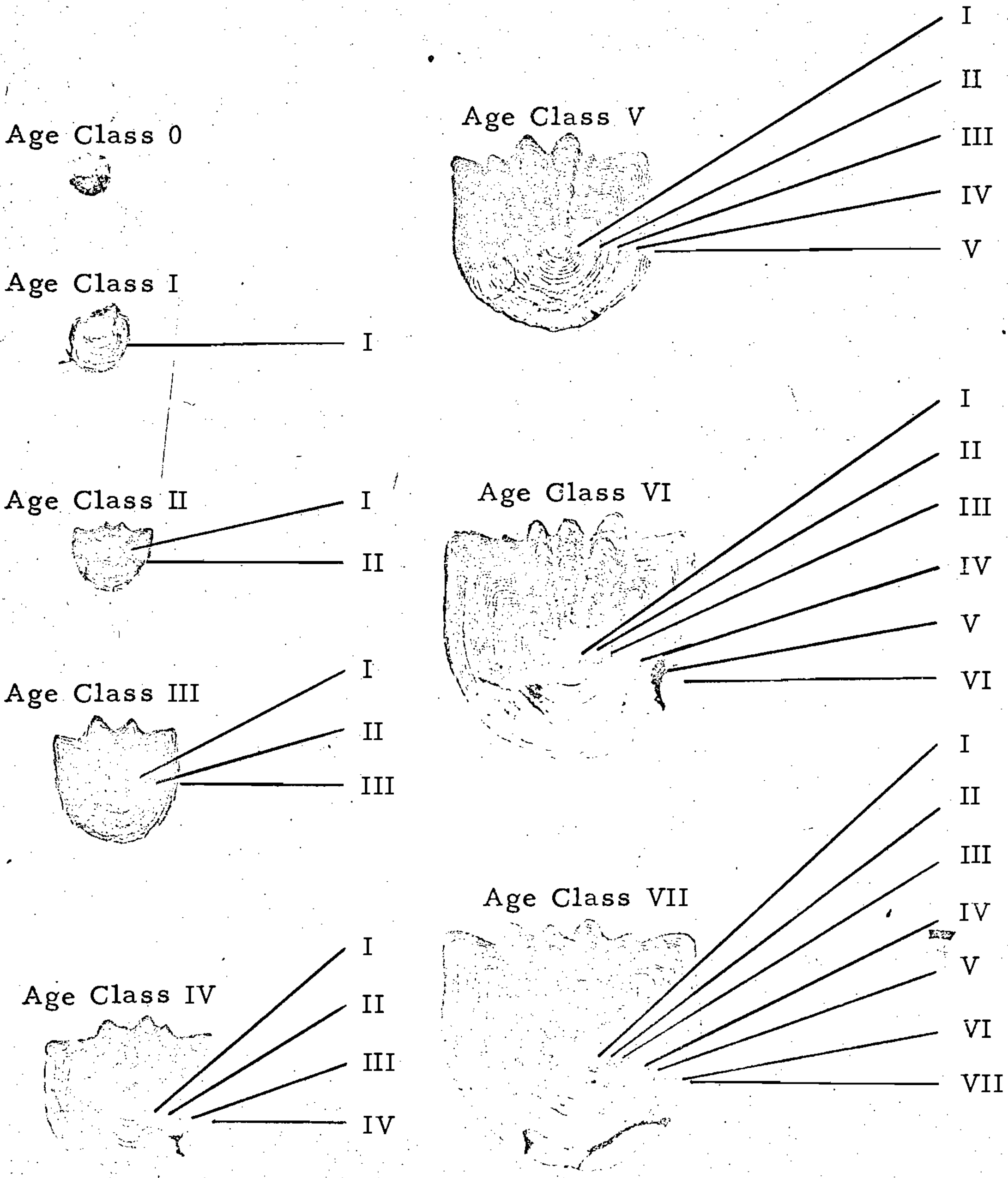


Fig. 4. Scale Photographs Showing the Different Age Classes



$$F.L._x = \left[\frac{R_x}{R_n} \times F.L._n - K \right] + K$$

Where: $F.L._x$ = Fork length at age x

R_x = Scale radius at age x

$F.L._n$ = Fork length at capture

R_n = Scale radius at time of capture

K = Constant for length of fish at time of scale formation.

The importance of the rate of growth of a fish is obvious. The principles applied to the management of any species of fish are dependent upon the speed with which the fish is capable of reaching a catchable size. If a species grows rapidly, it can be harvested intensively; but if it grows slowly, its harvest must be limited or else depletion can occur.

Since many streams examined in this study did not produce fish in an age class older than V, the average annual increment of growth was calculated for fish of all streams for the years I to V. Where older fish also were taken, the average annual increment was calculated for the total age as well. Following are the growths maintained by grayling in interior Alaska.

The rate of growth of the Little Salcha River grayling is about average for the streams in the Interior (Table 5). Age plotted against fork length resulted in a linear growth curve whose slope changed at age class V. The regressions for the growth of the fish from the Little Salcha River are $Y = 4.7x + 4.1$ for the years 0 to V, and $Y = 1.5x + 18.2$ for years V to VII (Fig. 5).

The growth curve for the Big Delta Clearwater grayling is similar to the growth curve of the Little Salcha River, except that the growth curve of the Clearwater fish is more erratic beyond age class V (Fig. 5). The irregular nature of the upper portion of the curve is probably due to the small size of the sample. While the growth added by the Clearwater fish is about the same for the years I to V as was that added for the same period by Little Salcha River fish, the later growth of the Clearwater fish is greater (Table 5).

Although the growth of the Chatanika River grayling is slower than is that of those from the Little Salcha River, the growth curves for both streams are similar in shape. Data are not available for Chatanika River fish older than age class V (Fig. 5).

Washington Creek grayling are the slowest growing of any of the fish checked. The average annual increment is 2.7 cm. for the years I to V (Table 5). Furthermore, a change in the rate of growth of these fish occurs at age class IV (Fig. 5). The reason for this is not known.

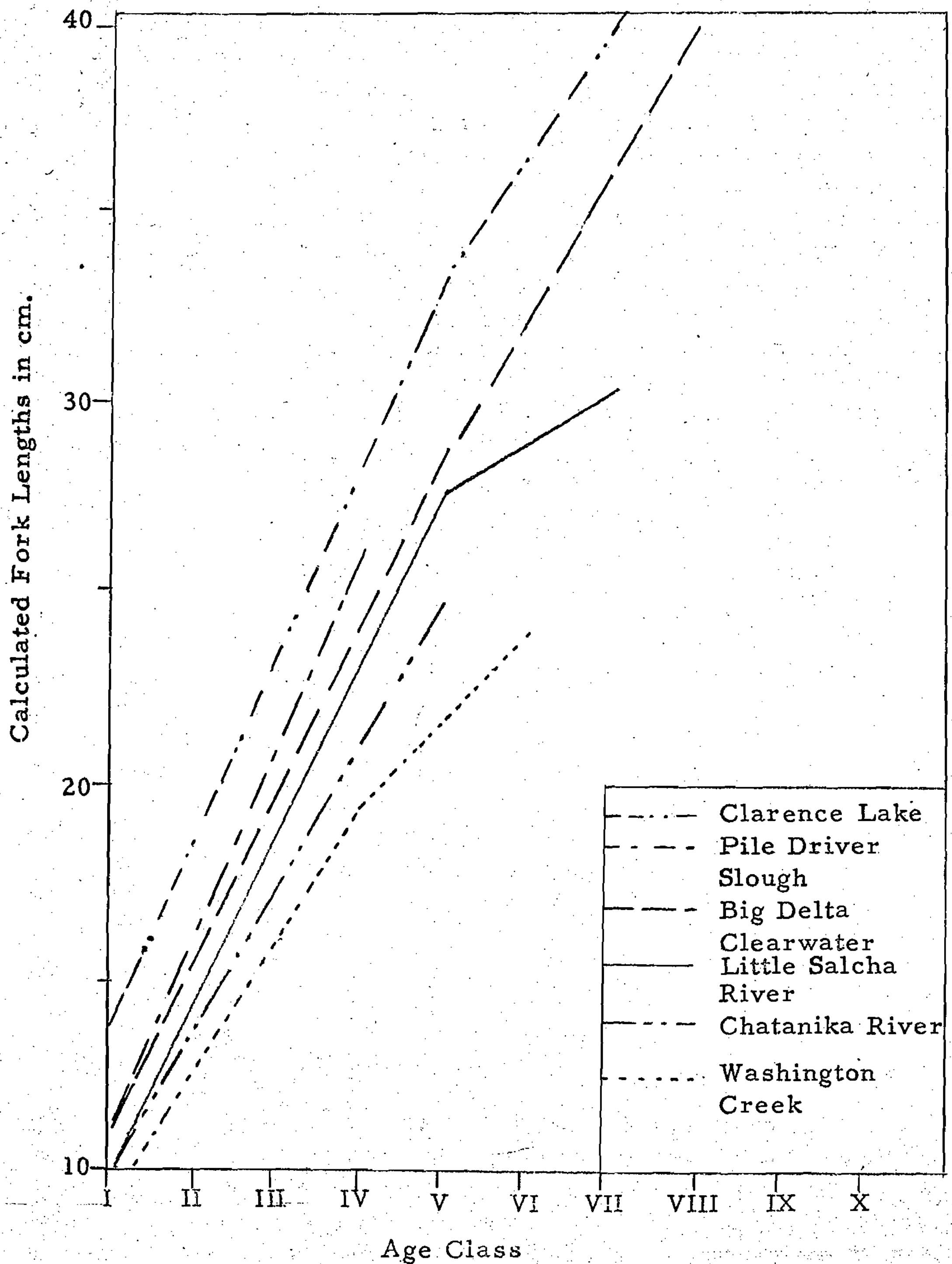
The growth of grayling from several other streams for which only small samples are available appears similar to that of the Little Salcha River (Fig. 5 and Table 5).

Table 5. CALCULATED FORK LENGTH AND ANNUAL RATE OF INCREMENT (IN CM.) FOR GRAYLING FROM INTERIOR ALASKA

	Age									Average	
	0	I	II	III	IV	V	VI	VII	VIII	I - V	V +
(Little Salcha River, 677 fish)											
Fork Length	4.1	9.0	13.5	18.9	23.2	27.4	28.9	30.4	-		
Annual Increment		-	4.5	5.4	4.3	4.2	1.5	1.5	-	4.6	3.8
(Big Delta Clearwater, 66 fish)											
Fork Length	6.6	10.7	15.6	20.4	24.7	28.2	32.1	36.4	42.0		
Annual Increment		-	4.9	4.8	4.3	3.5	3.9	4.3	5.6	4.4	4.5
(Chatanika River, 149 fish)											
Fork Length	4.6	9.4	13.3	17.6	21.2	24.3	-	-	-		
Annual Increment		-	3.9	4.3	3.6	3.1	-	-	-	3.5	-
(Washington Creek, 8 fish)											
Fork Length	7.6	9.5	16.0	19.1	21.2	24.6	-	-	-		
Annual Increment		-	3.2	3.3	2.1	3.4	-	-	-	2.7	-
(Tanana River, 63 fish)											
Fork Length	6.0	10.0	14.9	19.6	23.9	28.0	31.2	34.1	36.6		
Annual Increment		-	4.9	4.7	4.3	4.1	3.2	2.9	2.5	4.5	3.2
(Richardson Clearwater, 30 fish)											
Fork Length	6.4	11.1	15.9	21.0	25.2	28.6	32.4	36.0	37.5		
Annual Increment		-	4.8	5.1	4.2	3.4	3.8	3.6	1.5	4.4	3.8

Fig. 5. Average Calculated Fork Lengths for

Interior Alaskan Grayling



The growth rate of grayling in most streams examined changes at age class V. This is the age at which the majority of the fish checked reach maturity. It is assumed, therefore, that this change in growth is due to maturation.

Scales were obtained from grayling from three lakes in the Interior. These scales proved much easier to read than did the scales from stream fish because the scales are more transparent and the "circuli" and annuli are more distinct in the lake fish. Data were not available for lake grayling fry at the time of scale formation, so the constant found for the Chatanika River grayling, 4.1, is used to calculate the lengths of the lake fish. The results obtained using the constant found for stream fish were checked and the constant appears to be reliable, and its use is believed justified.

A change in the rate of growth of lake grayling at age class V occurred for all but those in Clarence Lake. Figure 5 shows no reduction in the rate of growth of Clarence Lake grayling in the older age classes. The difference in the Clarence Lake growth curve from that of other lakes is undoubtedly due to the small sample on which it is based--seven fish.

There is a marked difference in the total growth of stream and lake fish. Lake fish grow faster initially than do stream fish, and therefore they attain a larger size in the early age classes (Fig. 5).

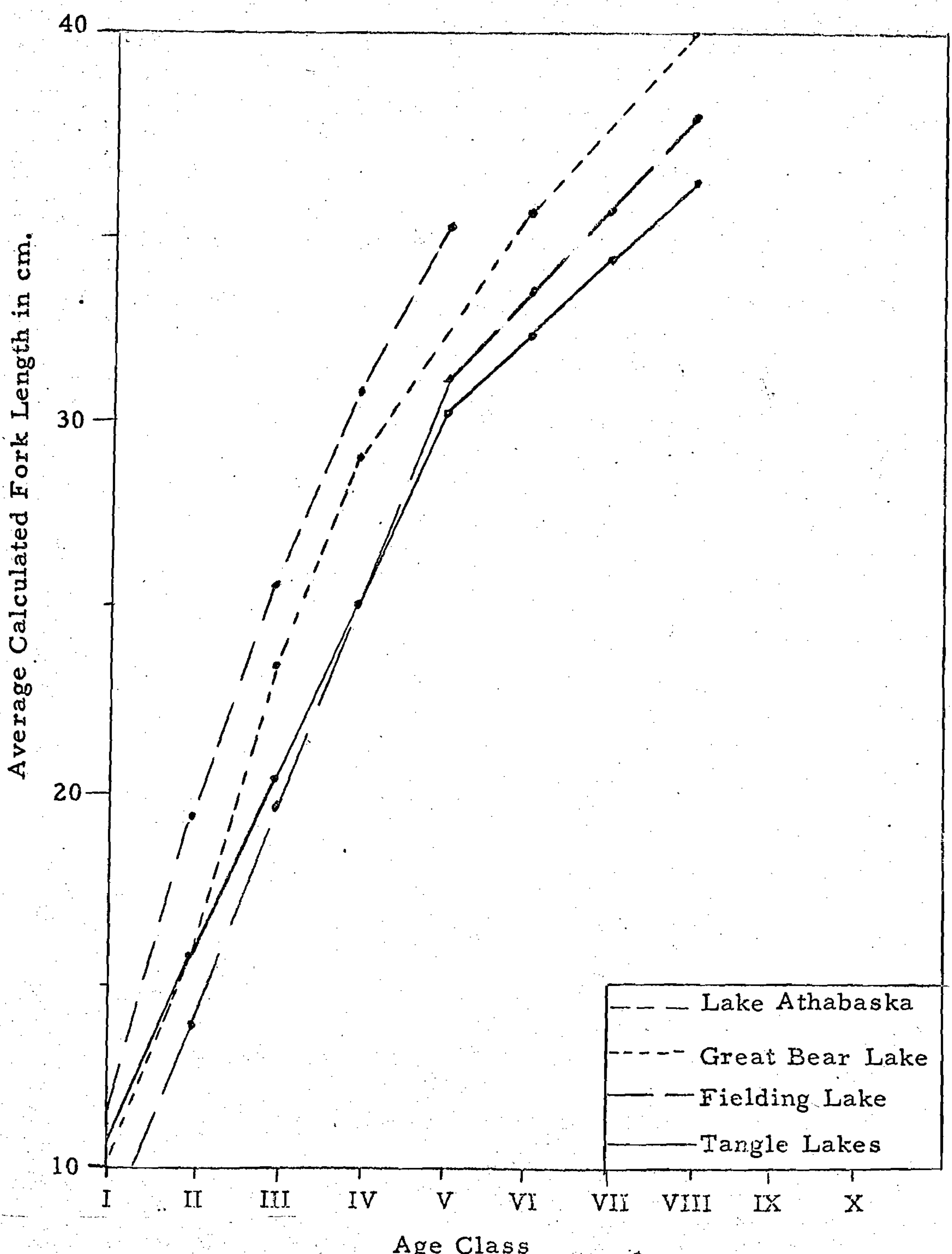
Ward's (1951) work on the grayling in Alberta indicates a decrease in the rate of growth after the second year. The decrease in the rate of increase continues until, by the fifth year, growth practically stops. In comparison, the grayling in Alaska grow rapidly for five years, and continue putting on appreciable growth for two or three more years (Fig. 6). The rate of growth found by Miller (1946) for the grayling from Great Bear and Great Slave lakes is comparable to the growth of Alaskan lake fish.

The rate of growth of the Montana grayling, as found by Brown (1943) and Nelson (1953), appears to decrease with age. The growth of the Montana fish is rapid at first and then slows down quickly. By the end of the fourth year, the annual increment added by the Alaskan form is greater than that added by the Montana form. Genetic as well as environmental factors may be responsible for the difference in growth of these two forms.

It appears that temperature and length of the growing season exert the greatest influence upon the growth of the Arctic grayling in North America. Grayling grow most rapidly in the southern Athabaska Region of Canada, and slowest in the Northwest Territories of Canada, and interior Alaska (Fig. 6).

The rate of growth seems to have a pronounced effect upon maturation and longevity of grayling. The slower the fish grow, the longer they live, and the older they are before they mature.

Fig. 6. Average Calculated Fork Lengths for Lake Grayling from Canada and Alaska



Maturity is reached by the third year in Montana, by the fourth year in Alberta, and by the fifth year in interior Alaska and the Northwest Territories of Canada. Grayling from Ford Creek, Montana, matured at a fork length of about 27 cm.; grayling from Prairie Creek, Alberta, matured at about 27 cm.; and grayling from the Little Salcha River, Alaska, matured at about 27.5 cm.

In regard to longevity, the slower grayling grow, the longer they appear to live. The oldest grayling found by Brown (1938a) was in its seventh summer, while the oldest found in Alaska was in its tenth summer. Miller (1946) found one specimen from Great Bear Lake in its eleventh year. Nelson (1953) found one specimen from Lower Twin Lake, Montana, in its eleventh year. Lower Twin Lake is located at an elevation of 9,100 feet and the unusual longevity of the specimen may have resulted from a slower growth due to the cool waters found at high elevation.

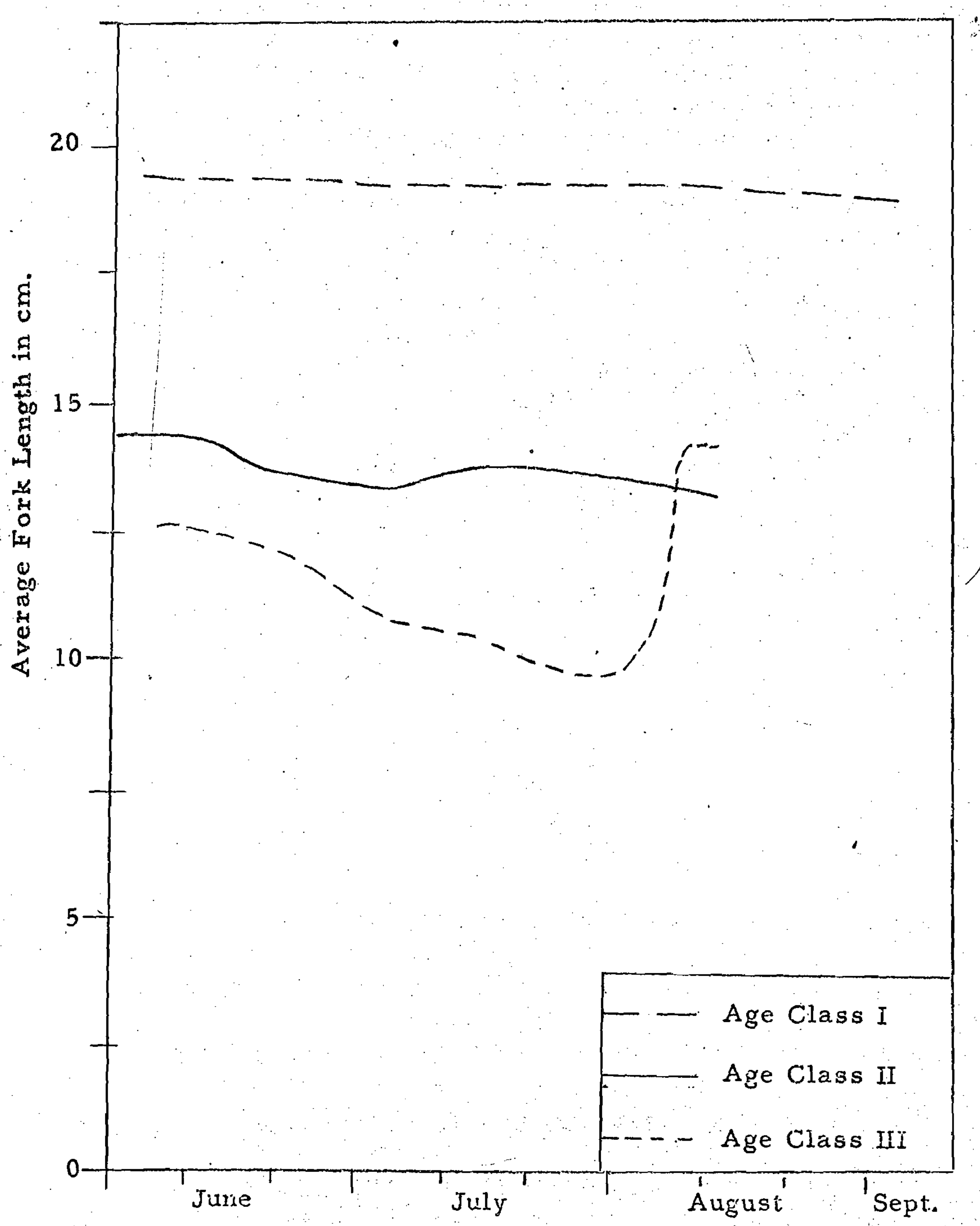
It seems grayling have become adapted to spawning at a certain length, about 27 cm. After this length is attained, and the fish mature, they lose some of their vigor, growth decreases, and mortality increases.

An attempt was made to check the growth of the Little Salcha River grayling at short intervals throughout the season. Because of the size of the samples which were available, the fish were grouped into three day periods, and growth curves were plotted.

The resulting curves were quite irregular, but a trend was apparent. The results indicated a decided decrease in length of the fish as the spring and summer progressed, followed by a sudden increase in length in the fall (Fig. 7). The peculiar growth pattern was probably caused by sampling of different portions of the population of the Little Salcha throughout the year as indicated below.

Plotting of the data for short periods of time did show that the size of the fish which entered the stream differed with the time of year. During the period May 12 to May 16, 1952, only grayling in age classes IV to VI were taken, with age class V predominating. Fish in age class III predominated in the sample of May 17 to May 30, and age class II predominated in the samples for the rest of the season. However, during the fall some fish in age class VI were taken. Since these fish were all taken from the same area, the only plausible explanation for this condition appears to be a differential migration into the Little Salcha River throughout the season. From this it has been concluded that during the spring, large fast-growing fish entered first, and were followed by the small slower growing individuals throughout the summer. The reverse occurred in the fall when the large fish returned to the lower portions of the streams. A similar condition was observed in the Big Delta Clearwater and the Chatanika River.

Fig. 7. Fork Length of Little Salcha Grayling Taken Throughout the Season



FOOD HABITS

Examination of the contents of 278 stomachs taken during 1952 and 1953 indicates that the grayling in Alaskan streams take insects in preference to all other items, although they will take whatever food is available. The stomachs examined contained small quantities of beetles, ants and small wasps, but aquatic insects, both larvae and adults, were predominant. Table 6 presents the results of the stomach analysis.

When they were available, dipterous larvae, especially chironomids, were taken in large numbers; they were often the only food taken. Caddis larvae, which composed the bulk of the food in the early spring, occurred less frequently as the season progressed. Blackfly larvae, although present in many of the stomachs, were never found in large quantities in any one of them. Mayfly larvae were taken the year around, but were of importance only during the late spring and summer; adult forms were uncommon. Stonefly larvae were found in many of the stomachs, but never in large numbers; adults were seldom taken. Corixids were common in the stomachs of early spring fish, but never in large quantities.

Fish eggs were found in grayling stomachs, but their importance even during salmon spawning runs appears to be slight. Many preserved salmon eggs (fish bait) were found in the stomachs of early spring fish taken at the Tanana River and Shaw Creek.

				Aquatic Insects					
Caddis									
Adults	0	0	0	37	0	0	0	27	26
Larvae[a]	54	40	50	50	25	60	67	73	26
Diptera[b]									
Adults	0	20	0	0	8	20	0	9	61
Larvae	65	40	87	37	50	60	0	100	91
Mayflies									
Adults	0	0	0	0	0	20	17	0	1
Larvae	0	20	24	12	8	60	0	100	100
Hemiptera									
Adults	46	40	12	25	8	60	0	18	26
Odonata									
Adults	0	0	0	0	0	0	0	0	0
Larvae	0	0	0	0	0	0	0	0	4
Stoneflies									
Adults	0	0	0	0	0	0	0	0	2
Larvae	2	0	0	37	0	0	0	54	57
				Terrestrial Insects					
Beetles	25	60	50	12	50	60	67	0	83
Hemiptera	0	0	0	0	0	0	0	0	0
Hymenoptera	0	0	0	25	33	0	33	9	70
Thysanoptera	0	0	0	0	0	0	20	0	0
				Other Invertebrates					
Amphipods	0	0	0	0	0	0	0	0	4
Nematodes	2	0	0	12	0	0	0	27	91
Spiders	0	20	0	25	25	20	0	9	30
				Vertebrates					
Fish	1	0	0	0	8	0	17	27	4
Fish Eggs[c]	49	0	0	25	8	20	50	36	4
				Undistinguishable Matter					
Animal[d]	20	60	100	63	83	80	83	83	100
Vegetable	15	20	0	37	17	20	67	64	61
Debris[e]	2	20	0	12	0	0	0	9	0

a/ Although the percentage of stomachs with caddis larvae remained constant throughout the season, the numbers of caddis found in the stomachs decreased as the season progressed.

b/ Primarily chironomids.

c/ Primarily the preserved salmon eggs used by anglers as bait.

d/ Animal matter consisted primarily of insect parts which could not be identified because of their macerated condition.

e/ Primarily sand and gravel.

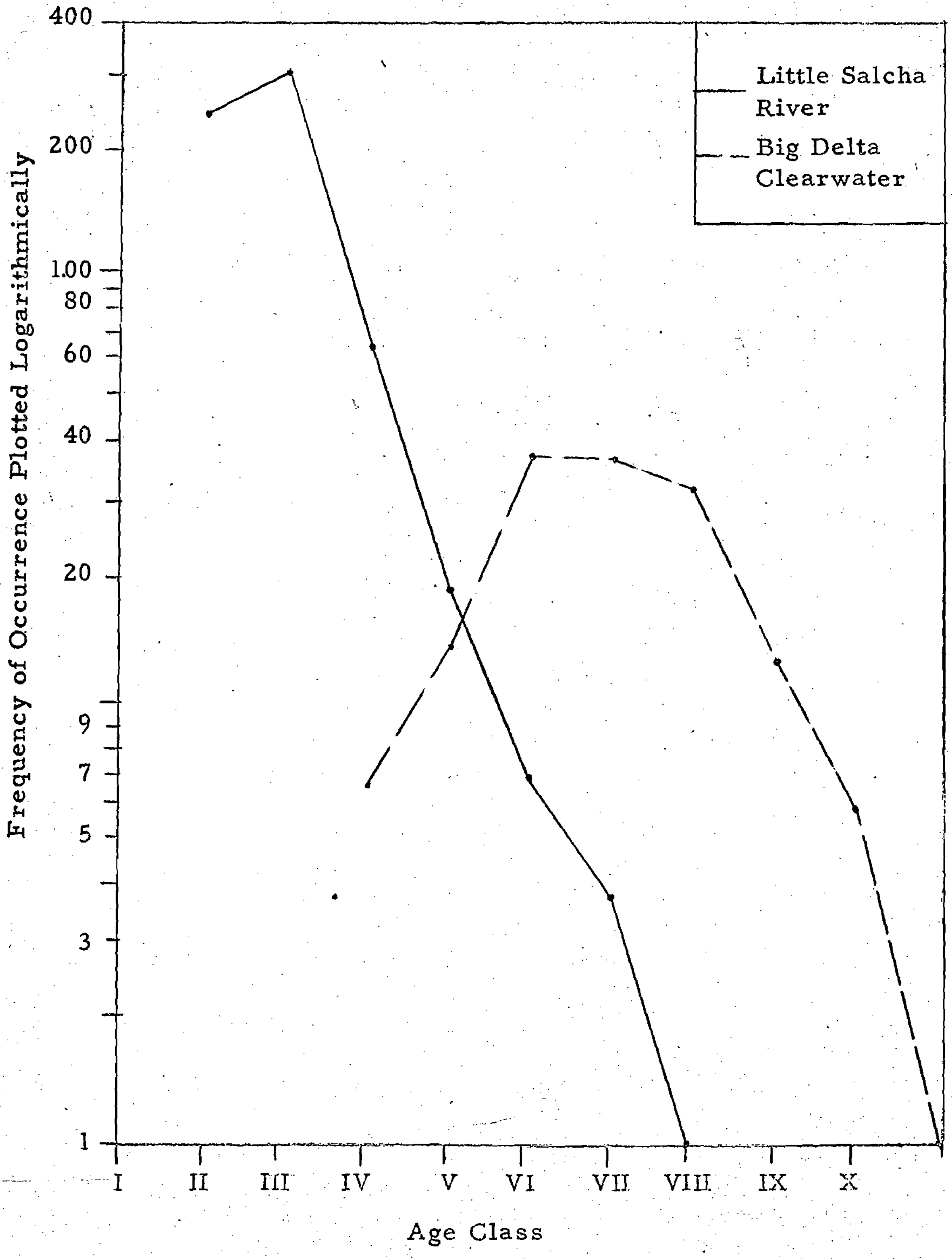
During the salmon run in the Little Salcha River, natural salmon eggs were taken, but only in small numbers. Natural salmon eggs are probably taken in other streams during salmon runs, but stomachs from other areas have not been examined. Traces of small, unidentified fish eggs were found in the stomachs from time to time. Grayling in Alaska seldom feed on fish, although a small percentage of the stomachs examined did contain fish or fish remains.

A considerable amount of vegetable matter was found in the stomachs, and although this may have been taken accidentally, the large quantity present makes it appear otherwise. Several stomachs examined contained corn, rice, barley and small seed, probably discarded by people picnicking near the stream. Other forms of debris such as spruce needles, small sticks, bits of gravel and silt were also common. It appears, from the variety and types of foods taken that the grayling in Alaskan streams are predominantly bottom feeders.

While most fish taken at the Little Salcha River were small (5-10 inches), most fish taken from the Clearwater were large (12-14 inches). Stomachs of the Little Salcha fish contained few organisms, while those from the Big Delta Clearwater fish were often gorged.

Square foot bottom samples taken at the Little Salcha indicate that production of food in this stream is very low. A quantitative sample was not taken at the Clearwater, but organisms were plentiful along the bottom. Apparently, the Clearwater produces more food, and hence is able to sustain a greater population of large fish than is the Little Salcha River (Fig. 8).

Fig. 8. No. Fish of Each Age Class Taken at the Little Salcha and Big Delta Clearwater during 1953



MANAGEMENT

Grayling fishing along the highway systems in interior Alaska is reported by reliable sources to have deteriorated in recent years. It would be foolish to attempt to maintain grayling populations at near-virgin levels in these waters; instead attempts should be made to manage the species for the maximum sustained yield.

While many causes for the decline of grayling in the States have been postulated, overfishing appears to be the primary cause for their decrease in numbers in the Fairbanks area. The slow growth coupled with the added mortality due to overfishing on accessible waters is believed to have reduced the numbers to the point where more are being taken than are being recruited annually. The downward trend of the populations that are easily accessible may prove to be serious since it is not known to what extent, if any, a damaged grayling population will recover. Therefore, action should be taken now to maintain the accessible populations, and to prevent grayling from reaching the low levels reached in the States. To accomplish this, a new set of regulations based on sound biological knowledge is needed.

Measures presently in use to regulate the take of fish are not equally applicable to all species under all conditions, so the following discussion considers each measure as it applies to grayling management in interior Alaska.

Grayling are slow-growing, cold-water fish which require five or six years to mature in the Interior. In the areas along some of the highways in the Fairbanks area, fishing has become sufficiently intense so that few adults are now being taken. If the ratios of adults to juveniles in the populations are as low as the samples obtained indicate, it is doubtful if all of the waters are being adequately "seeded".

Size Limits

Recent studies with salmonoid fishes show that a minimum size limit, set to harvest fish which have just reached maturity, increased the numbers as well as the size of the fish taken. Because the habits of grayling are similar in many respects to those of species on which size limits are being tried, it is felt that a minimum size limit set to include few immature grayling should be tried on a few of the heavily fished waters in the Interior.

Size limits have the same disadvantage with grayling as with any other species. Small fish, which could be taken by anglers, may be lost from the population through natural mortality. Further, additional mortality may be brought about through handling of fish by fishermen. Because of the high rate of returns obtained in the tagging program mentioned in an earlier section of this paper, however, it appears that loss resulting from handling could be kept at a minimum. This conclusion appears even more justified when it is realized that anglers would normally give the released fish less handling than did the author, who not only caught the fish, but also tagged, measured, weighed, and took scale samples from them.

Bag Limits

Bag limits are intended to spread the existing supply of catchable fish among the greatest number of anglers. Many studies have shown that this is true in theory only. Actually, a few skillful anglers take the majority of the fish. Bag limits do produce a desirable psychological effect on anglers when the take of fish must be lowered. This type of restriction gives an angler something to strive for. The average angler is more apt to be satisfied with fewer fish if he is able to simultaneously achieve a goal. Too low a bag limit, however, may discourage anglers from venturing into remote areas, and so increase the pressure on the more accessible areas.

Closures

Areas are frequently closed to fishing to protect fish at a time in their life when they are unusually vulnerable. In Alaska a closure to protect spawning fish appears to have merit in cases where grayling, migrating to their spawning beds, are concentrated into small areas. Alternate year closures, currently in vogue, have been tried with salmonoids, and have not produced the expected results. Closures are most effective in areas in which fishable waters are unlimited. There are few waters accessible to anglers in the Fairbanks area at the present time, and it is felt that the closing of any of these would add pressure to those remaining open. An additional consideration is that when closed areas are re-opened the possibility of improved fishing might draw many anglers, and any gains made during the closed period would be lost.

Recommendations

In conclusion, it is the author's opinion that a minimum size limit is the regulation best suited to the management of the grayling in interior Alaska. The majority of the grayling sampled were mature by the time they reached a total length of 12 inches. Therefore, the size limit should only permit the taking of grayling 12 inches in total length or longer.

In areas where the spawning run is being overfished, a spring closure might also be suitable. The spring closure should run from March 15 to June 15 to eliminate the necessity of setting special regulations for each body of water. It should be emphasized, however, that a general spring closure is not recommended.

The bag limit presently in force--10 fish or 10 pounds and 1 fish, whichever is filled first--appears adequate although with grayling the elimination of the ten pounds and one fish would simplify this regulation.

Pollution

Pollution from both municipal and mining sources may be con- [illegible] to the decline of the grayling in limited areas in the Interior. Some streams which had grayling prior to mining operations no longer do. In fact, many of the streams into which silt is being washed are now running black with the "overburden" washed into them.

Several streams in the Fairbanks area are believed to be polluted, although it is not presently known whether mining wastes, or sewage is the major cause of the pollution. All efforts should be made to eliminate pollution as soon as possible.

Dams

Although dams, both beaver and man-made, can block the run of fish, they are presently of minor importance. Seldom do beaver completely stop a run of grayling. Their dams are usually removed either by high water or other agencies before they do injure a run.

A small, man-made dam on the Chatanika River presently blocks the upper reaches of the river at certain times of the year.

Although this dam may affect the population of this stream, it is of little importance in the overall grayling picture. However, future power developments will no doubt present problems, and legislation which will prevent obstructing fish movements in any water, should be enacted now.

SUMMARY

The grayling is interior Alaska's most important sportfish; ever-ready to rise to a fly, or to take natural bait. In Alaska this species occur in most of the clear lakes and streams north of the Alaska Range, exclusive of the coastal area. Yet, in spite of its wide range and its importance, little is known of its life history and management.

This trout-like fish was first described by Richardson from specimens taken in Great Bear Lake, Canada in 1836. Grayling can be easily separated from trout and whitefish by their unusually large dorsal fin, and large scales. The color of grayling varies with age from a silver with black spots in the juveniles, to a blue-black, or yellow-brown with bright spots in the adults; grayling fry, as trout fry, have parr-markings.

Rawson (1950) found that the sex of adult grayling could be determined by the size and shape of their dorsal fin: The dorsal fin of the male rises slowly, and extends back to the adipose fin, while that of the female rises sharply, and does not extend back to the adipose. This character was found to be reliable only for grayling 35 cm. fork length or longer.

It appears that grayling in the Interior require two or more streams to complete their life history; large rivers to winter in,

and small clear streams in which to spawn and spend the summer. In the area studied, most of the grayling winter in the Tanana River, a time when the waters are running clear, and return to small clear streams during the spring break-up, when the Tanana River becomes silted. Similar movements have been observed in the States, in Canada, and in Norway by various workers.

In Alaska, as well as elsewhere, grayling spawn in a brief period. In the Little Salcha River the grayling apparently spawned between June 12 and June 16, 1952.

Of 262 grayling examined, 18.7 per cent that were in their fourth summer were mature, 45 per cent in their fifth summer were mature, and all were mature by their sixth summer. Both sexes appear to mature at the same age.

Sex ratios obtained vary with waters. The average sex ratio obtained for all areas was 79 males per 100 females. Results obtained indicate that sex ratios of adults favor females in heavily fished waters.

The rate of growth of grayling in Alaska is considerably slower than is the growth of grayling in the States and southern Canada, and is comparable with that in northern Canada. The average annual increment added by age class V ran a high of from 4.6 cm. at the Little Salcha to a low of 2.7 cm. at Washington Creek. There appears to be a decrease in the rate of growth of grayling at age class V, the age of maturity. Further, it appears that longevity is influenced by the rate of growth: The fast-growing grayling from the southern part of their range do not live as long as the slow-growing fish from the northern part of their range.

A total of 1,222 grayling were tagged in the Fairbanks area with three different types of marks during 1952 and 1953. Results obtained indicate that plastic tags attached to the base of the caudal peduncle were most satisfactory, while fin clipping was the least satisfactory method. Anglers were relied upon to report the tags, so the number of returns was strongly influenced by the ability of the angler to see the tag. The bright plastic tags were readily seen and reported, while the metal strap tag, and fin clipped fish which were less easily noticed were reported less frequently.

Examination of 278 stomachs indicate that grayling prefer aquatic insects to all other forms of food. While some ants, beetles, and wasps were taken, the bulk of the food consisted of the immature stages of Diptera (primarily Chironomids), and caddis, mayflies, Hemiptera, and stoneflies. In addition, large quantities of vegetation were taken. It is not known if the plant material was actually selected or taken accidentally.

Grayling populations along the highways in the Fairbanks area have been heavily fished in the last few years, and it appears that overfishing is mainly responsible for the degeneration of fishing in this region. The mortality and growth sustained by grayling make it necessary to limit the take. A minimum size limit set to harvest primarily mature fish is probably the best measure. Since most grayling mature by the time they reach a total length of 12 inches, a regulation set to take only fish over this size would allow many fish to spawn before becoming available to the angler. In areas where the spawning run is being overfished, a spring closure should also be made.

Pollution and dams are presently of limited importance; however, action should now be started to prevent the damaging of fine grayling waters as Alaska develops.

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