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William A. Egan, Governor

Annual Progress Report for

A Life History Study of Sheefish and Whitefish in Alaska

by

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RESEARCH PROJECT SEGMENT

State: Alaska

Project No.: F-9-5 Name: Sport Fish Investigations of Alaska.

Study No.: R-II Study Title: A Life History Study of Sheefish and Whitefish in Alaska.

Period Covered: July 1, 1972 to June 30, 1973.

ABSTRACT

Progress of past sheefish (inconnu), Stenodus leucichthys, transplants into Alaskan lakes are reviewed. Sheefish stocked as 16 cm yearlings in 1969 in Engineer Lake averaged 52 cm in length.

Factors limiting sheefish abundance are discussed and geological and physical factors are hypothesized as main reasons sheefish are only found in certain localities in Alaska. Sheefish are a young species, still in the process of range extension from centers of origin in western and central Siberia.

Saltwater barriers may limit range expansion into the Seward Peninsula area and into upper northwestern Alaska as sheefish seldom enter salt water.

Biological factors are thought to limit abundance rather than distribution.

A three-year study to collect information on movements, age and growth, food habits, and spawning of sheefish in tributaries of the middle Yukon River between Ruby and Ft. Yukon was initiated.

Five hundred sixty-nine sheefish were captured in the middle Yukon River between Ruby and Ft. Yukon, and 296 were tagged. The search for spawning grounds of middle Yukon River sheefish was concentrated in the Nowitna River but no spawning fish were found.

Sheefish taken on the Yukon River at Rampart in September grow faster than Porcupine River sheefish. Growth of Rampart fish is similar to that of sheefish of the lower Yukon population. The Rampart fish are possibly allied with the lower Yukon fish and the Porcupine fish with the upper Yukon sheefish.

Additional information on taxonomy of humpback whitefish, Coregonus pidschian, and distribution of whitefish, Coregonus sp., is presented.

A summary of the taxonomy and ecology of the Bering cisco, C. laurettae, is presented. The spawning migration in the Yukon River is documented. Bering cisco from the Yukon River (Hess Creek) grow faster than Seward Peninsula (Port Clarence - Grantley Harbor) fish, reaching a maximum age of eight years.

BACKGROUND INFORMATION

The life history studies of sheefish and whitefish in Alaska seek to obtain basic information on their life history, ecology and utilization in Alaska. Past years of the sheefish project have provided information on age and growth, food habits, movements, spawning, population dynamics and utilization of sheefish in Selawik-Kobuk drainages, Kuskokwim River system, lower Yukon and Koyukuk rivers, upper Yukon and Minto Flats area. Acclimatization studies have been conducted since 1967 but have met with only limited success. The present sheefish studies are concerned with the population status, movements, age and growth, food habits and location of spawning grounds of sheefish found in middle Yukon River tributaries from Ruby to Fort Yukon. This phase will run from 1971 - 1974.

Whitefish studies have been carried out in conjunction with sheefish studies and general management-type surveys and have dealt mainly with determination of taxonomic status, distribution studies and age and growth studies.

RECOMMENDATIONS

1. Studies on the problems of raising sheefish to fingerling size be intensified.

2. Sheefish tagging studies in the middle Yukon River continue.

3. The search for sheefish spawning grounds be concentrated in Yukon River tributary streams above Rampart.

4. Taxonomic studies of middle Yukon sheefish continue and be expanded to include fish from the lower Yukon River.

5. Whitefish research concentrate on humpback whitefish age and growth studies.

TECHNIQUES USED

Sheefish for the egg takes were captured in the Chatanika River by shocker boat and from the Koyukuk River by gillnet.

Sheefish for the middle Yukon tagging study were collected by monofilament and multifilament gillnets of 2, 2.5 and 3-inch bar mesh and variable mesh nets of .5 - 2.5 inch mesh. Nets ranged from 60-100 feet in length. Nets were checked every 3-4 hours to minimize fish mortality (caused by long exposure at warm water temperatures). Fish captured were tagged with spaghetti tags inserted through the dorsal musculature behind the dorsal fin. A fishwheel at Rampart was rented for tagging sheefish in September. A live box was constructed on the wheel and the box was checked three times a day. Sheefish were tagged with internal anchor tags. Recoveries were made mainly by the tagging crew and also by subsistence fishermen in villages along the middle Yukon. Water samples were analyzed using a Hach Model AL-36-WR kit.

Whitefish for taxonomic and distribution studies were often collected by biologists in other parts of the state. Meristic counts on these fish were made in the lab. Meristic counts of other whitefish were made in the field on the excised first left arch. Bering cisco were captured with graduated mesh gillnets so specimens caught should be representative of the spawning run.

Age and growth data for Bering cisco were analyzed using an IBM 360 computer. The Modified DooLittle Method (Draper and Smith, 1966) was used to compare Bering cisco growth.

FINDINGS

Job R-II-A Sheefish Lake and River Adaptability Study.

Objectives

1. To find a method of rearing sheefish to fingerling size.

2. To determine suitability of new lakes and streams for sheefish.

3. To identify factors which limit sheefish distribution.

Egg Take

Approximately one million sheefish, Stenodus leucichthys, eggs were taken in the upper Koyukuk River near Hughes on September 29 and shipped to the Fire Lake Hatchery. Nearly 80% of the Koyukuk eggs died before the eyeing stage. Hatching began in early January and was completed February 20, 1973. Hatching success of the Koyukuk eggs was 17.6%.

Forty thousand fry were released in Lost Lake near Fairbanks in February; approximately 110,000 were placed in rearing pens in Lost Lake; 10,000 were placed in aquaria at the University of Alaska for feeding experiments; 10,000 were kept in aquaria at the Fire Lake Hatchery.

The fry in the holding pens in Lost Lake were all dead on April 6. At the previous check on March 30, approximately 20 fry were observed swimming in one holding pen and approximately 200 in the other. During the first month, the fry appeared to be healthy and feeding on plankton. There was no noticeable increase in size of the fry during the 45 days they were in the holding pens. The possibility of insufficient water movements to bring food into the holding pen is given as one of the reasons for the 100% mortality.

The fry at the University of Alaska Institute of Water Resources were placed in water temperatures of 5°C and 8°C, and divided into three lots at each temperature and fed frozen brine shrimp, algae, and Oregon mash. Even though the fish were feeding, they slowly died off, until by April 11, only 30 fry remained in an aquaria where Oregon mash was fed. The inconclusive results do not permit one to state that fry survive better on a certain feed or at a certain temperature.

Experimentally-Stocked Lakes

Lost Lake:

Approximately 70,000 eggs were taken from a Chatanika River sheefish on October 1. The eggs were placed in hatching trays in Lost Lake on October 4, 1972. On November 25, observed egg mortality was approximately 20% and by March, 1973, was 70%. On April 6, the last of the eggs had died. None reached the eyeing stage. The hatching trays containing eggs in Lost Lake in 1971 were lost, thus the question as to whether sheefish eggs can hatch in a lake situation remains unanswered.

Engineer Hill Lake:

A 250-foot variable mesh gillnet set overnight in Engineer Hill Lake on August 10, 1972, took approximately 910 lake chubs, *Couesius plumbeus*, and 5 sheefish. The three sheefish autopsied averaged 52.1 cm fork length (range 510-540 mm), and weighed 1.88 kg (range 1.6 - 2.5 kg). Gonads showed some development. The sheefish were from a 1969 introduction of 45 hatchery-reared yearlings (mean length 160 mm).

Four-Mile Lake:

Four sheefish were taken in Four-Mile Lake in August during two net nights of fishing. The fish averaged 466 mm fork length (range 450-482 mm) and weighed 1.3 kg (range 1.2-1.5 kg). These fish were planted as fry in the spring of 1968. The growth of these fish is depressed, suggesting that a fish diet in later years may be necessary for continued rapid growth. Silver salmon, *Oncorhynchus kisutch*, fingerlings were stocked in the lake in August, 1972. They are expected to provide feed for the sheefish and also be available to sport fishermen.

Factors Limiting Sheefish Distribution

The original objective of this study was to determine why sheefish have such a limited distribution in Alaska. It was subsequently decided that it was not feasible to conduct a study of the magnitude required to answer such a complex question. During the previous years of the sheefish project, various observations were made that might shed some light on the problem. Also literature searches, water chemistry data, and spawning ground studies may lend insight. The following discussion represents a summary of these and does not pretend to answer the question of why sheefish have a limited distribution in Alaska.

Physical Factors:

Absence of suitable spawning grounds may be an important factor limiting their distribution. Sheefish have such stringent spawning ground requirements that only a few spawning bars are available in all of Alaska's rivers. In areas where sheefish have been observed spawning in Alaska, water depth and velocity and bottom composition appear to be very important.

Water depth is usually 1.2 - 2.7 meters deep with most spawning observed in water from 1.5 - 1.8 meters in depth. In the Kobuk River spawning grounds, spawning occurred in the relatively swift main current, both where it moved along the cut bank and also in the center of the channel as the current swings to the opposite shore. No spawning was observed on gravel bars on the inside curve of the river where the current was slower than the Kobuk, so spawning occurred in riffle areas of 1.2 - 1.8 meters, or in the main current in the main channel. The Highpower Creek spawning ground had a relatively slow current of two miles per hour.

Observations indicated that nearly all sheefish spawned over a bottom composed of differentially-sized coarse gravel with occasionally a small amount of sand, but no silt present. In a few instances, sheefish were observed spawning over uniformly-sized gravel and over a bottom 50% covered by sand. The swift current keeps the bottom silt-free. It appears that the presence of differentially-sized gravel is a prerequisite to insure lodging of the eggs. If the bottom were of uniformly-sized gravel, the eggs, which are broadcast near the top of the water column, might fail to lodge due to the swift current. They would be carried out into the slow-moving water where there is more silt, thus reducing chances for survival.

The spawning bars on the Chatanika River and Highpower Creek are rated as poor in relation to number of potential spawning sites and character of the sites, while those in the upper Koyukuk and upper Kobuk rivers are rated as excellent, possibly accounting for small sheefish populations in the former and large populations in the latter.

Another limiting factor may be the presence of delta areas for rearing. The area of interconnected lakes and sloughs and slow-moving deep water of the lower rivers are biologically rich and apparently quite important for growth and survival of young sheefish. The fry leave the area of the spawning grounds at spring breakup and travel down to these feeding areas. These extensive delta areas are present in the Minto Flats, Kobuk-Selawik, lower Kuskokwim, lower Koyukuk and Yukon rivers. They are present to a lesser extent in tributary streams of the middle and upper Yukon and Porcupine rivers. The absence of these delta areas may partially explain why sheefish are not in the Noatak River. Some areas in western Alaska, especially the Seward Peninsula, have excellent delta areas and spawning grounds but no sheefish (Golovin Bay, Imuruk Basin).

Another physically limiting factor may be velocity barriers and canyons. Our experiences, which are corroborated by Russian researchers (e.g. Kirilov, 1962), indicate that sheefish will not ascend streams with rapid current and even the slightest falls. They are not the strong swimmers that salmon are.

Water temperature may be another limiting factor. Surface water temperatures, in areas where sheefish feed, range from 22° C in July to 0°C during the winter. Water temperatures in the vicinity of spawning grounds range from a high of 15.5°C during July to 0.5°C at the end of the spawning period.

Chemical Factors:

In this limited study, chemical data was collected in most streams containing sheefish, but in only a few areas where sheefish are not found, it was not feasible.

Table 1 lists the limited chemical data from many of the streams containing sheefish and the Imuruk Basin area, which does not contain them.

Alkalinity and hardness are measures of basic productivity, and low values would probably be a factor limiting abundance rather than distribution. Total alkalinity ranged from 35 to 200 ppm and total hardness from 35 to 390 ppm. The higher hardness values are associated with higher pH values, especially from the Imuruk Basin area.

The values in Table 1 cannot be related to presence or absence of sheefish in various systems. A much more comprehensive chemical study would have to be undertaken before a relation between chemical values and sheefish distribution could be shown. Water chemistry of the micro-habitat of the developing eggs may be a more important limiting factor, but this has not been studied.

Saltwater barriers may limit range expansion into the Seward Peninsula area and from Kotzebue Sound into northwestern Alaska and northern Alaska as sheefish are not taken in salt water.

Biological Factors:

Biological limiting factors may operate to limit sheefish abundance rather than distribution. Generally speaking, sheefish are found in association with lampreys, Lampetra japonica; least cisco, Coregonus sardinella; humpback whitefish, C. pidschian; broad whitefish, C. nasus; northern pike, Esox lucius; suckers, Catostomus catostomus; and burbot, Lota lota. In certain systems, young of salmon - chums, Oncorhynchus keta, kings, O. tshawytscha, and silvers pass through areas where sheefish are feeding and are important in the diet of sheefish (Alt, 1965; 1971). In brackish water situations and lower reaches of rivers, ninespine sticklebacks, Pungitius pungitius, Bering cisco, Coregonus laurettae; starry flounders, Platichthys stellatus; and four-horned sculpins, Myoxocephalus quadricornis, are also found.

Very little is known concerning primary productivity of streams containing sheefish or those streams not containing sheefish. Fry feed on plankton but are

Table 1. Chemical Data From Selected Streams in Alaska.

Area	Date Sampled	Tot. Alk. (ppm)	Tot. Hard. (ppm)	pH	Temp. °C
20 Mile Holitna R.	7-25-71	50	30	6.9	---
90 Mile Holitna R.	7-26-71	80	50	7.0	---
Hoholitna R.	7-27-71	70	50	7.4	---
Highpower Cr. (upper Kuskokwim R. trib.)	9-29-71	110	170	8.0	3.5
Upper North Fork of Kuskokwim R.	9-18-71	70	80	7.0	5.0
Black R. (Porcupine R. trib.)	6-11-71	140	90	---	13.0
90 Mile Porcupine R.	6-14-71	90	100	---	12.5
Birch Cr. Mouth	6-18-71	90	70	7.2	15.5
7 Mile Hodzana R.	6-19-71	80	50	6.9	---
Dall R. Mouth	6-20-71	90	70	6.7	---
Ray R.	6-21-71	70	80	6.9	---
Hess Cr.	6-22-71	90	90	7.3	---
Tozitna R.	5-31-72	50	40	6.8	---
Nowitna R.	6-2-72	60	50	6.9	10.0
Charley R.	7-28-63	30	---	7.5	---
Nation R.	8-8-63	90	---	7.2	---
Tatonduk R.	8-11-63	90	---	8.0	---
Kobuk R. Above Kobuk Village	8-28-71	100	110	7.9	12.5
*Imurk Basin at Agiapuk R. mouth	7-13-71	80	260	7.8	---
*Agiapuk R. - 4 km upstream	7-14-71	150	150	8.0	---
*Lower Kuzitrin R.	7-15-71	90	100	7.8	---
*Upper Imuruk Basin	7-16-71	80	100	7.8	---
*Imuruk Basin at Ptarmigan Point	7-17-71	90	100	8.1	---
*Tuksuk Channel	7-18-71	90	390	9.0	---
Tolovana R.	7-16-72	90	100	7.3	---
Chatanika R.	7-16-72	70	70	7.5	---
Chena R.	10-7-67	50	---	7.5	---
Salcha R.	9-24-63	40	---	7.5	---
*Lost Lake	4-4-71	200	---	---	---
Four-Mile Lake	---	---	---	6.8	---

*Sheefish not present.

feeding actively on crustaceans and insects by the summer of their first year of life. By July and August they also begin feeding on fry of other fish and by the second year of life are almost entirely piscivorous. Sheefish mouth configuration is such that 30 cm is about the maximum length of fish eaten. The biologically rich Imuruk Basin area has an abundant food source for sheefish (Alt, 1971). Sheefish introduced into lakes barren of fish had shown excellent growth during the first four years of life on a diet of insects and freshwater shrimp.

Geological Factors:

Geologically speaking, the sheefish is a young species, still in the process of range extension. Smith (1957) hypothesized that Stenodus leucichthys originated in the rivers of Siberia. Walters (1955) felt that unglaciated Siberian drainages of the Ob, Yenisei, and Lena rivers were reservoirs for many freshwater species including the sheefish. He believed that it spread to Alaska during or after land-bridge times and became distributed via brackish water transfer associated with the melting of the Wisconsin stage of glaciation. The sheefish then probably invaded Canada from Arctic Alaska via the northern coast in the brackish glacial meltwater, or possibly reached the Mackenzie River from the Yukon Valley (Porcupine River) by headwater transfer. If the sheefish reached Arctic Canada via brackish water transfer, it would seem that they would have become established in the Colville River as physical, chemical and biological conditions, as they exist now, appear suitable. Thus, either limiting factors were present in the Colville River 10,000 to 15,000 years ago; the fish which established itself in the Mackenzie came from the North Coast in small numbers and simply bypassed the North Slope rivers, or what seems more likely, they reached the Mackenzie via headwaters transfer in the Porcupine River.

Sheefish probably first became established in Alaska in the Kotzebue Sound area, lower Yukon and lower Kuskokwim areas and extended their range from there. The population in the Koyuk River has probably come from lower Yukon River stocks. The shallow Norton Sound is less saline than the rest of the Bering Sea, especially after breakup, and sheefish are probably able to extend their range along the coast. There are a few sheefish in the Pikmiktalik and Unalakleet rivers and sheefish have been recorded for the first time on the coast near Nome in 1968 and 1970. A sheefish was reportedly taken in the Teller area in 1971 but this was not substantiated. Sheefish from the lower Kuskokwim have been taken in the Eek River south of the mouth of the Kuskokwim, but it is not known if this is a reproducing population. In the Kuskokwim they are taken at the mouths of most tributary streams but probably only enter a few rivers for feeding (Gallic, Johnson, Holitna and Takotna), and Highpower Creek and the middle fork of the Kuskokwim for spawning.

In the Yukon River drainage they have invaded the entire watershed and are found in Teslin Lake, and have been reported in the Muskswa River, a tributary of the Laird River (Clark, Clemens, and Lindsey, 1959). In the upper Yukon River (Circle to the Canadian border) they are found at least in the mouths of all tributary rivers. In the Porcupine they are found as far as 650 km upstream. They are found at least in the mouths of all tributary rivers between the mouth of the Koyukuk and upstream to Ft. Yukon. Some of these streams may serve as spawning grounds but many are feeding and resting areas only. The lower Yukon population feeds in the mainstem of the lower Yukon River and some upstream tributaries, and spawns in the middle Koyukuk River near Hughes and in the Alatna River. Sheefish are not found in the Koyukuk River above Allakaket, possibly because of absence of spawning habitat and shallower and swifter water conditions in this section of the river.

Sheefish range extension can be most clearly documented in the Tanana drainage. Establishment of reproducing population of sheefish in the Minto Flats has occurred very recently. People living near the upper Chatanika River report that no sheefish were present in the upper Chatanika until about 1940. Tagging studies in the Minto Flats in 1967 and 1968 indicate that the Minto Flats is the reservoir for fish extending their range up the Tanana River drainage. One was recovered at Nenana in 1968 and two were recovered in the Chena River at Fairbanks in 1970 and 1972. Invasion of the Chena River by considerable numbers of sheefish (at least ten are taken annually by sport fishermen) began less than 15 years ago (Dale Evans, USFWS, viva voce; Fairbanks News Miner, various years). This population is probably reproducing in the Chena. Sheefish are being taken by both subsistence and sport fishermen in other clear water sloughs near Fairbanks. In 1970 the first sheefish ever recorded in the Salcha River was taken by a sport fisherman. In 1972 a sheefish was taken by a subsistence fisherman in a slough of the Tanana River midway between Delta and Tok.

It would appear that geological and physical factors are most important in limiting sheefish distribution. The chemical factor of saltwater barriers may also be important. With the limited data available it is difficult to ascertain the effects of chemical and biological factors. Chemical and biological factors in association with physical limiting factors, such as spawning ground availability and delta areas, probably act to limit sheefish abundance.

Job R-II-B Movements, Age and Growth, Spawning Ecology, Population Dynamics and Utilization of Sheefish in the Middle Yukon River and Norton Sound Stream.

Objectives

1. To determine movements and population status of sheefish in the section of the Yukon River drainage from the mouth of the Koyukuk upstream to Fort Yukon.
2. To study the spawning ecology of sheefish in the middle Yukon River tributaries.
3. To compile data on age and growth, food habits and population dynamics of middle Yukon River sheefish.
4. To determine sport and subsistence utilization of sheefish in the middle Yukon area.

Middle Yukon Study Area

The middle Yukon River for the purpose of this study is defined as the section of the Yukon above the mouth of the Koyukuk River to Ft. Yukon and including all tributary rivers except the Tanana (Fig. 1). This area is approximately 796 km (494 miles) long. In order to identify various points in the river and to show the distance upstream from the mouth, mileage distances are given in Table 2. Mileage figures for areas not in the study area are included for reference. Preliminary investigations in 1971 indicated that sheefish are present at least in the mouths of all tributary streams.

The middle Yukon study area contains some large tributary streams, eg. Nowitna and Porcupine rivers. Past research (Alt, 1969, 1972, 1973) including taxonomic, tag and recovery, and age and growth studies indicated that sheefish from the lower Yukon River travelled upstream in the Yukon only as far as the mouth of the Koyukuk and spawned in the upper Koyukuk. No tags were recovered in the Yukon above the mouth of the Koyukuk. Based on age and growth and tagging studies, sheefish in the upper Yukon River (Ft. Yukon to Canadian Border) were classed as a separate population which wintered in the main upper Yukon and fed and spawned in the lower reaches of the five tributary rivers in this area. Fish of the Minto Flats area and including the Tanana River from Tanana to Fairbanks are considered to belong to another population, with main spawning grounds in the upper Chatanika River.

At the beginning of the middle Yukon study, all sheefish in the Middle Yukon River were hypothesized as belonging to a single population. Young-of-the-year and yearling sheefish were found 144 km up the Porcupine River in June and it was hypothesized that this river was both a spawning and feeding river for Middle Yukon River fish.

Table 2 Distances From the Mouth of the Yukon River to Various Villages and Mouths of Tributary Streams of the Middle Yukon River.

Location	Km	Miles
Koyukuk River	818	508
Hughes	1,419	881
Galena	853	530
Ruby	936	581
Melozitna River	937	582
Nowitna River	1,002	622
Tozitna River	1,098	689
Tanana	1,119	695
Mouth, Tanana River	1,119	695
*Fairbanks	1,481	920
Texas Creek	1,180	733
Rampart	1,229	763
Hess Creek	1,269	788
Ray River	1,320	820
Dall River	1,356	842
Stevens Village	1,364	847
Hodzana River	1,484	922
Beaver	1,501	932
Birch Creek	1,554	965
Chandalar River	1,575	978
Porcupine River	1,612	1,001
Black River	1,651	1,025
Sheenjek River	1,659	1,031
90-Mile Porcupine	1,757	1,091
Coleen River	1,843	1,145
Old Crow	2,027	1,259
Ft. Yukon	1,614	1,002
*Circle	1,709	1,061
*Charley River	1,810	1,124
*Kandik River	1,828	1,135
*Nation River	1,874	1,164
*Tatonduk River	1,907	1,184
* 70-Mile River	1,923	1,194
*Dawson	2,214	1,375
*Whitehorse	2,810	1,745

* Not in middle Yukon study area but included for reference.

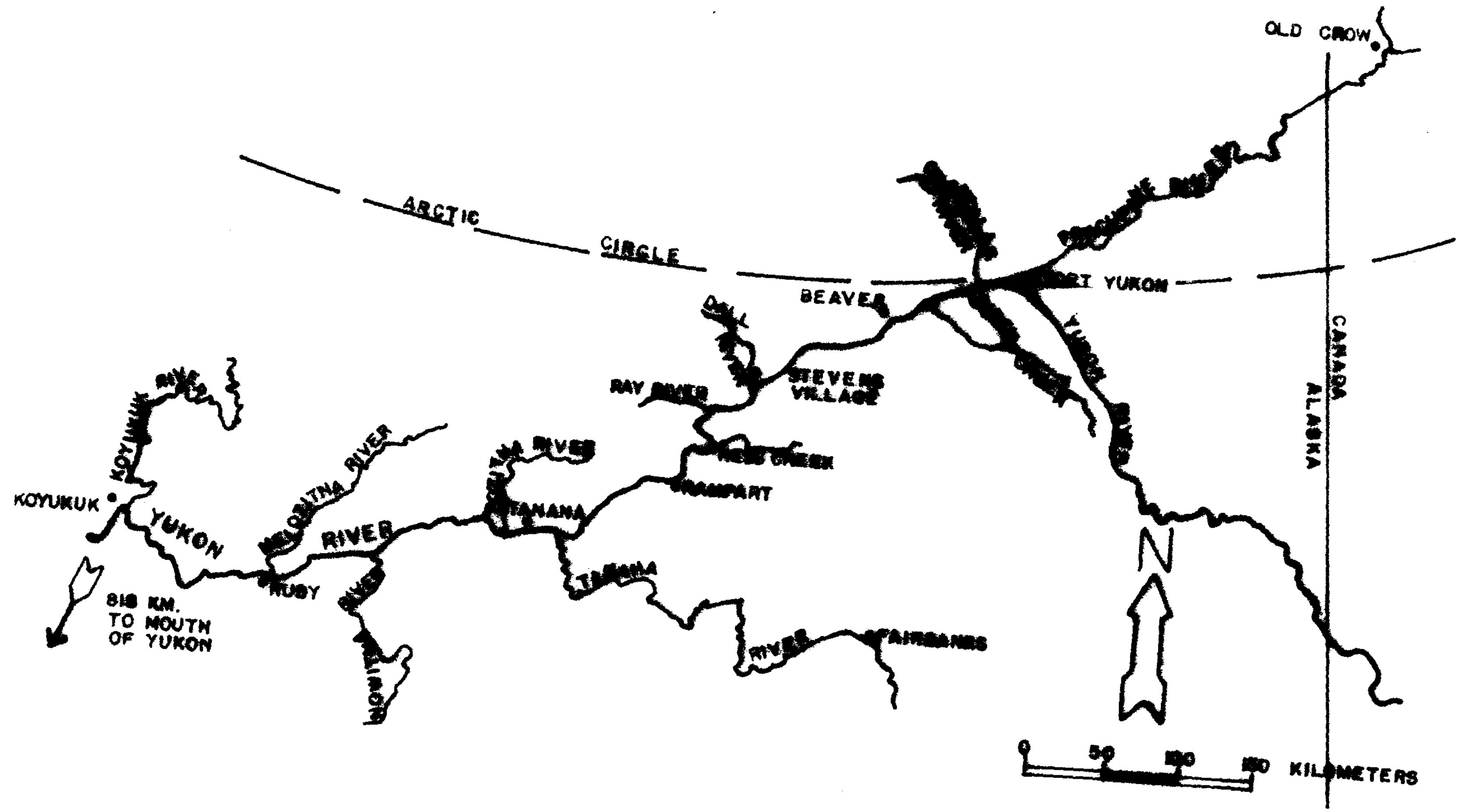

FIGURE 1. Middle Yukon River Study Area.

The main tool used in determining the population status of these fish is a tag and recovery program. Fish were to be tagged at the mouth of all tributary streams, 90 mile Porcupine River and in the Main Yukon at Rampart in September. Since subsistence fishing is declining and little sport fishing occurs, we planned to make most of the recoveries ourselves.

Comparative age and growth studies will be conducted, and samples of sheefish from the upper Yukon, Koyukuk rivers and the Rampart area were collected from electrophoretic protein analyses. Meristic counts of fish taken in all areas will be compared. It is hoped that these various methods employed over a three-year research program will help delineate the population status of sheefish in the Middle Yukon River.

Movements

Table 2 gives distances from the Yukon mouth to various tributary streams and villages in the middle and upper Yukon River. During 1972, sheefish were tagged in tributary rivers of the middle Yukon (Table 3). The sheefish catch per effort was quite high in July but since fish could be captured only in gillnets and many were dead when the nets were checked, the nets were removed at night.

Sheefish abundance at the mouths of various rivers varied considerably with time. Ninety-two sheefish were captured at the mouth of the Nowitna River on June 2 but only 90 were taken in the other eight days of netting. Sheefish movements slowed down in late June but there was no evidence the fish moved up the respective tributary streams. A gillnet set 32 km up Hess Creek in both late June and mid-July took only one sheefish. Hess Creek was floated August 21-23 and no whitefish or sheefish were taken by gillnet or hook and line and none were observed. Most feeding sheefish in the Nowitna River had departed by late September as only eight sheefish were taken during 15 nights of fishing in the lower 370 km of the river. It is too early in the study to determine patterns of movements of sheefish in the middle Yukon River system. The location of spawning grounds of the large numbers of spawners moving past Rampart during September is unknown.

Five of 25 sheefish tagged in 1971 were recaptured in 1972, all in the general location where tagged. Four of the 185 sheefish tagged prior to August 25, 1972, were recaptured the same summer. Two recoveries are significant: one sheefish tagged 145 km up the Porcupine on June 19 was recaptured 6.5 km up the Old Crow River on July 28, and a fish tagged in the Nowitna River June 6 was recaptured at Nulato, 40 km downstream in the Yukon from the mouth of the Koyukuk River on June 10 by a native subsistence fisherman. The latter is the first recorded movement of sheefish past the mouth of the Koyukuk River. It is possible that tagging stress was the cause of this fish moving 224 km downstream. Many of the chum salmon tagged at the Rampart fishwheel in 1962 were recaptured up to 480 km downstream from where tagged (Corps of Engineers, 1964).

Table 3 Sheefish Catch Statistics and Tagging Results, Middle Yukon River, 1972.

Area	Dates	Net Nights	Sheefish Caught	Tagged
Nowitna R.	6/1 - 6/8	64	182	94
	9/19- 9/26	15	8	0
Tozitna R.	9/18	2	2	0
Texas Creek	6/9	2	1	0
Rampart (Yukon R.)	8/29-10/1	Fishwheel	161	111
Hess Creek	6/10-13;6/26-27	56	53	25
	7/8-11;7/20-21	21*	37	17
Ray R.	6/14-16;6/23-25	48	30	7
	7/12-14;7/16-19	24*	25	10
Dall R.	6/22	4	4	1
	7/15	3*	23	15
Porcupine R. mouth	6/17	5	5	3
Porcupine R. (Ward Camp) or 90-Mile	6/18- 6/21	32	38	13
	Totals	276	569	296

*Gill nets not fishing from 1 AM to 9 AM.

Spawning

The search for spawning grounds of middle Yukon River sheefish covered the Nowitna River in 1972. Sixty-seven fish (47 males and 20 females) were examined for maturity in early June. Six males (54-59 cm fork length) were judged to be immature and 41 males (60-80 cm) were potential spawners. Three females (53-60 cm) were immature and 17 (71-80 cm) were potential spawners or nonspawning mature fish (8).

An aerial survey was flown on September 21 from the Nowitna mouth to its junction with Agate Fork 430 km upstream; however no sheefish were observed.

The lower 375 km of the river was surveyed by boat from September 19-26. Gillnets were set at the mouth of the Nowitna River; 10-mile Nowitna River; Sulatna River mouth (70 mile); Big Mud River area, 184, 197 and 200 km upstream; Sulukna River mouth (180 mile); and 368 and 376 km upstream. Only eight fish were taken in this series of gillnet sets and all were immature or non-spawning feeders. The farthest upstream a sheefish was taken was the Sulatna River mouth. Local residents reported taking sheefish at the Sulukna River mouth many years ago.

The Nowitna River has a wide flat river valley with a myriad of sloughs and lakes. A gravel bottom first appears 175 km upstream. The proper conditions of current, depth and gravel composition required for successful spawning were encountered in an area eight km below the Sulukna River mouth and isolated areas 8-32 km above the Sulukna River.

The 1972 evidence indicated no sheefish spawn in the Nowitna River. Possibly it is utilized only as a feeding stream and spawners that are present early in the summer move out and migrate elsewhere; another check will be made in 1973.

A fishwheel was operated at Rampart in the Yukon River from August 26 to October 1. One hundred sixty-one sheefish were taken with the peak of the run occurring in mid-September. All fish examined were in spawning condition. Since sheefish usually have completed spawning by early October, the spawning stream or streams must be fairly close to the Rampart area. Hess Creek (40 km), Ray River (96 km), Dall River (128 km), and the Porcupine River (384 km) above Rampart are the only tributary streams close to Rampart. Hess Creek was floated on August 21-23 but no sheefish were taken. Some of the pool areas 16-32 km up Hess Creek might be suitable for sheefish spawning.

The search for spawning grounds of middle Yukon River sheefish in 1973 will be directed toward these tributary streams, but the possibility that these fish spawn in the main Yukon River in the fall after the water clears up will not be overlooked.

Age and Growth

One hundred-two Porcupine River sheefish collected in August, 1970, and June of 1971 and 1972 were used in an age and growth study. Fish were taken at the mouth of the Porcupine River, the mouth of Black River and Ward Camp and ranged in fork length from 240 to 705 mm. Fork length at the end of each year of life was back calculated (Table 4). Age groups V through VIII were most common. Mesh size of nets used (one graduated mesh and 4 to 6 nets with 2.5 to 3-inch bar mesh) may have resulted in a disproportionate number of larger fish caught.

In addition to the 102 fish used in the study, 10 young-of-the-year sheefish were taken at 90 mile Porcupine in late August when the growing season was nearly completed. These fish averaged 120 mm in length.

Porcupine River sheefish show slower growth than all other Alaskan populations studied except that of the upper Yukon River.

Since many of the Porcupine specimens were tagged, data on maturity are meager. A sample of 29 females and 11 males indicated that females reach sexual maturity between 8 and 10 years of age while males mature between 7 and 9 years.

Rampart Sheefish

The 161 sheefish taken in the Rampart fishwheel in 1972 averaged 758 mm (range 650-910 mm). In comparison 482 sheefish taken in a fishwheel 60 km below Rampart in 1962 also averaged 758 mm (range 595-951). In both years all fish were captured in late August and September and all fish examined were in spawning conditions.

It was possible to age 124 of 1972 samples and ages ranged from V to XIII. Since most of the fish were tagged, little data on sex are available. No females less than age VII were taken and most fish over age XI were probably females.

Back calculated lengths at the end of each year of life of Rampart sheefish are presented in Table 5. The majority of the fish were age classes VII to X.

It became apparent after aging both the Porcupine and Rampart sample that these two groups grew differently. The Porcupine River fish had fairly fast growth up to age V, then slowed down, while the Rampart fish grew slightly faster than the Porcupine fish up to age V, then more rapidly than Porcupine fish the remaining years. Rampart fish also lived longer than Porcupine Fish. It appeared that growth of Rampart fish would closely approximate that of lower Yukon sheefish and growth of Porcupine fish would be similar to that of upper Yukon fish.

Table 4 Mean Back Calculated Length of Each Age Group of Porcupine River Sheefish.

Age at Capture	n	Mean Fork length at end of each year of life in mm										
		L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}	L_{11}
I	2	135										
II	5	139	246									
III	10	142	253	320								
IV	3	148	248	333	378							
V	14	139	227	309	395	454						
VI	11	131	227	296	364	438	492					
VII	14	143	245	319	384	447	503	549				
VIII	21	143	232	288	364	424	476	525	568			
IX	9	153	221	303	368	384	484	532	576	607		
X	9	146	232	298	367	425	475	522	565	604	638	
XI	4	145	249	323	383	431	473	513	558	608	645	674
		Mean length for all age-groups										
	102	142	236	306	375	431	485	530	562	606	640	674

Table 5 Mean Back Calculated Length of Each Age Group of Rampart (Yukon River) Sheefish, 1972.

Age at Capture	n	Mean fork length at end of life in mm L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}	L_{11}	L_{12}	L_{13}
VI	2	159	278	359	427	524	575							
VII	21	154	252	352	440	520	589	655						
VIII	33	161	263	347	420	498	569	636	692					
IX	33	146	234	323	399	472	538	602	666	720				
X	20	152	239	321	389	458	526	584	681	700	748			
XI	10	140	223	299	370	444	510	576	641	709	785	841		
XII	4	115	213	295	352	410	466	530	599	672	731	777	821	
XIII	1	162	257	302	367	481	549	610	659	734	805	859	896	929
		Mean length for all age-groups												
	124	139	245	332	406	481	549	613	672	710	758	825	836	929

Growth curves of lower Yukon, Rampart, Porcupine, and upper Yukon sheefish are drawn in Figure 2 (lower and upper Yukon data from Alt, 1973). Examination of Figure 2 indicates growth of Rampart fish approximates that of lower Yukon River sheefish, but is much faster than growth of Porcupine River and upper Yukon River sheefish; It is difficult to say if the similarity of growth between Porcupine River and upper Yukon River fish indicates they may belong to the same population. This possibility exists. No sheefish have ever been tagged on the upper Yukon River and very few on the Porcupine River. Possibly some of those sheefish caught at the mouths of upper Yukon River tributary streams had actually been spawned in the upper Porcupine River. From this standpoint, the location of the upper Porcupine spawning grounds and the continuation of the tag and recovery program on the Porcupine, as well as reinstating a tag and recovery program on the upper Yukon, appears to have merit.

If the fish passing through Rampart in September are allied with lower Yukon River fish, it seems strange that no tagged fish were recovered upstream of the mouth of the Koyukuk River during tagging studies on the lower Yukon River (1961-69) and upper Koyukuk River (1967-69). After a larger sample is collected from the Nowitna, Ray and Dall rivers, their growth will be compared with these other groups. They might contitute yet another population. Continued tag and recovery efforts, taxonomic and electrophoretic studies should aid in solving the problem.

Utilization of Middle Yukon River Sheefish

Even though sheefish are available at the mouths of middle Yukon River tributaries in June, it is difficult to take them on sport gear until at least July. Water levels and temperatures may be contributive reasons.

The Porcupine and Nowitna rivers appear to be the only tributary streams in which sheefish feed a considerable distance upstream. The remainder of the streams are probably utilized only in the lower few hundred meters.

The Nowitna and Melozitna rivers are the heaviest utilized sheefish sport fishing streams. The Nowitna is fished by many moose hunters in August, and the Melozitna is fished by Ruby and Galena village residents. No data are available on catch. There was no reported sheefish sport fish catch on hook and line in the Nowitna from September 19-27, 1972, the only period Fish and Game personnel were in the area. Many of the feeders had evidently left the river by this time as only eight were taken in 15 net nights of fishing.

The opening of the haul road to the Yukon River will render the Ray and Dall rivers and Hess Creek more accessible to sport fishermen.

There is very little subsistence fishing on sheefish in the middle Yukon. The few taken are incidental to the king and chum salmon subsistence fishery.

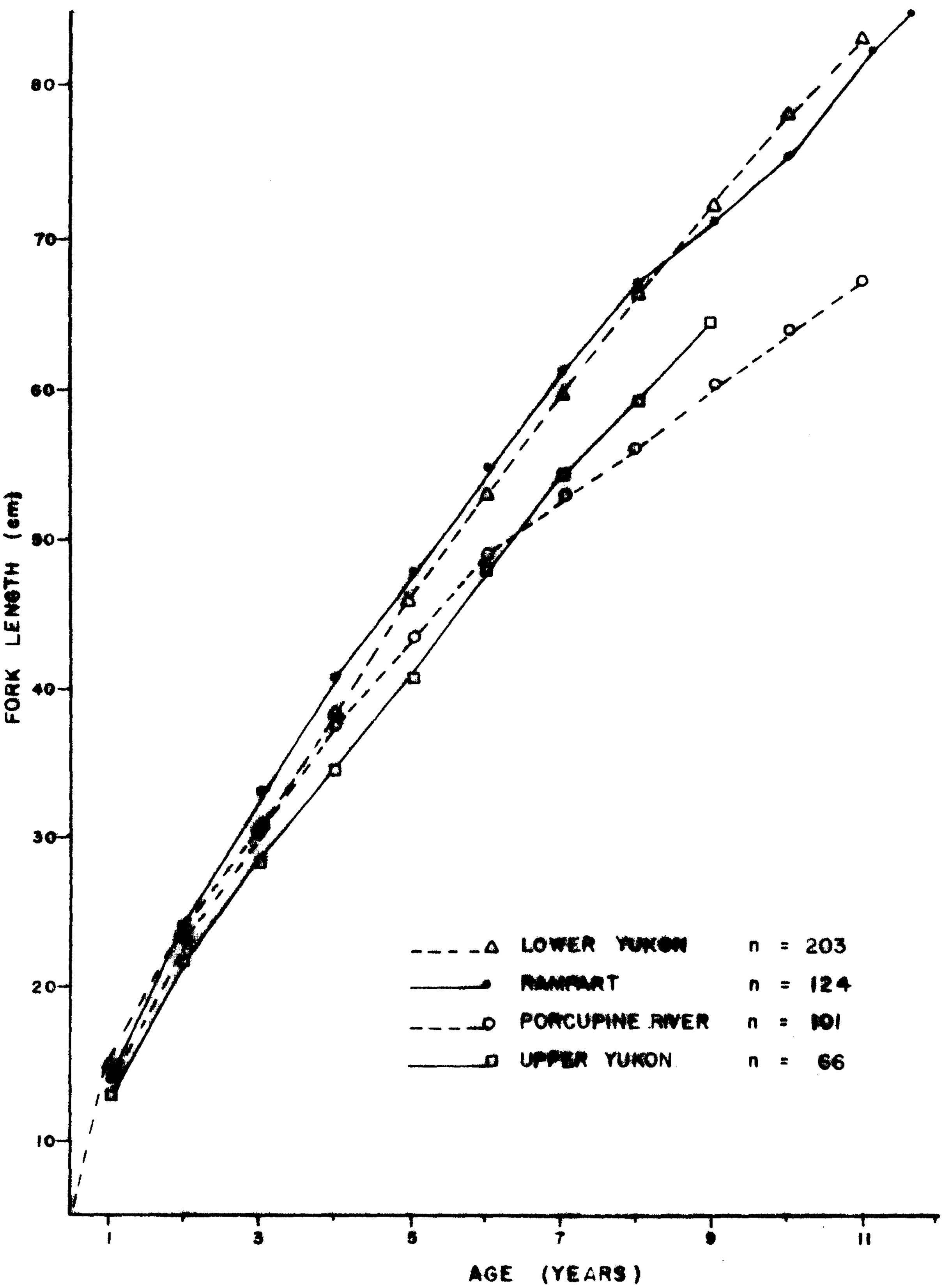

FIGURE 2. Age-Length Relationships for Four Groups of Alaskan Inconnu. Upper and Lower Yukon Data from Alt, 1973.

RAW DATA FOR FIGURE 2

Age-Length Relationships for Yukon River Sheefish.

	n	Mean fork length at end of each year of life in mm												
		L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}	L_{11}	L_{12}	L_{13}
Rampart (Yukon River)	124*	139	245	332	406	481	549	613	672	710	758	825	836	
Lower Yukon	204**	149	238	311	384	459	530	598	668	724	779	837	896	948
Upper Yukon	66	126	215	285	345	406	486	548	594	644				
Porcupine River	102	142	236	306	375	431	485	530	562	606	640	674		

* a single specimen of age 13 was left out

** a single specimen of age 15 was left

Job R-II-C Distribution Movements, Age and Growth, and Taxonomic Status of Whitefish in the Arctic-Yukon-Kuskokwim Area.

Objectives

1. To determine whitefish distribution in the Arctic-Yukon-Kuskokwim area.
2. To determine growth and age at sexual maturity.
3. To determine the taxonomic status of whitefish in the Arctic-Yukon-Kuskokwim drainages and the North Slope.

Whitefish Taxonomy and Distribution

Limited taxonomic data on humpback whitefish, Coregonus pidschian, were collected from the Unalakleet and Slana rivers in 1972:

	Gill Raker Counts			
	n	Range	x	S.D.
Unalakleet R.	5	21-22	21.4	0.5
Slana R. (Copper R. drainage)	3	25	25.0	0.0

Gillnet test netting during 1972 added information to the distribution of whitefish in Alaska (Table 6). In cases where only a short cursory survey was made, some whitefish species present might have been missed or might not have arrived in the system at that time of year.

Summary of Taxonomy and Life History of the Bering Cisco

The Bering cisco, Coregonus laurettae, had always been lumped with the Arctic cisco, C. autumnalis, until McPhail (1966) established C. laurettae as a valid species. It is distributed from the Gulf of Alaska to Oliktok near the Colville River (McPhail and Lindsey, 1970). At present, the Bering cisco is little utilized with the exception of small numbers taken for subsistence use by gillnet and fishwheel in the Yukon and Kuskokwim rivers.

Taxonomy

The Arctic and Bering ciscoes are similar in appearance, both having a terminal mouth and immaculate pectoral and pelvic fins. The Bering cisco has significantly fewer gill raker than the Arctic cisco (Arctic cisco - Colville R. $\bar{x}$=42.1, n=10, Alt and Kogl, 1973; Bering cisco - $\bar{x}$=33.8-36.6, present study).

Gill raker counts of Bering cisco from Bering Sea drainages are presented in Table 7 and range from 18 - 24 on the upper arch and 31 - 40 total count. The highest counts are from the Koyuk River ($\bar{x}$=23.6 on the upper arch) and the lowest counts are from Port Clarence-Grantley Harbor ($\bar{x}$=20.4 on the upper arch).

Table 6 Presence of Whitefish Species in Various Waters of Alaska as Determined by Netting (mainly variable mesh nets).

Area	Date	Method of Sampling	Species Taken*
Kantishna R.	May 31	1 net night	HWF
Nowitna R.	June, Sept.	200 net nights	HWF, BWF, RWF, LCi, BCi
Tozitna R.	Sept. 18	2 net nights	HWF, BWF, LCI
Hess Cr.	June, Aug.	50 net nights	HWF, BWF, LCi BCi
Ray R.	June, July	35 net nights	HWF, BWF, LCi, BCi
Dall R.	June, July	12 net nights	HWF, BWF, LCi, BCi
Porcupine R.	June	30 net nights	HWF, BWF, LCi, BCi
Unalakleet R.	July	hook and line	HWF, BCi
Slana R.	Oct. 12	2 net nights	HWF, RWF
Kobuk R.	July-Sept.	30 net nights beach seine	HWF, BWF, LCi, RWF
Clearwater L. (Tanana)	May	2 gill nets	HWF, RWF
George L.	Aug.	2 net nights	HWF
Volkmar L.	Aug.	2 net nights	HWF, LCi
Healy L.	Aug.	2 net nights	HWF, LCi
Stikine R.	Aug.	2 net nights	RWF

*HWF - humpback whitefish
BWF - broad whitefish
RWF - round whitefish
LCi - least cisco
BCi - Bering cisco

Table 7 Gill Raker Counts of Alaskan Bering Cisco.

Area	n	Total Count Range	X	S.D.	Upper Arch Range	X	S.D.
Port Clarence-Grantley Harbor	21	31-36	33.8	1.50	18-23*	20.4	1.17
Koyuk River	7	34-40	36.6	2.07	21-24	23.6	.97
Yukon River Hess Creek	24	33-37	35.5	1.28	20-24	22.0	.95
Porcupine River	8	33-37	34.4	1.36	21-23	21.6	.72
South Fork of Kuskokwim River	10	33-37	34.6	1.40	20-22	21.4	.69

*n = 18

Movements

Bering cisco are generally more abundant near the coast. During limnological investigations of the Port Clarence-Grantley Harbor and the Imuruk Basin area of the Seward Peninsula in 1971 and 1972, 21 Bering cisco (7 net nights) were taken in Port Clarence and Grantley Harbor where the salinity ranged from 27 to 31 ppt. Only four were taken in the Imuruk Basin area (35 net nights) where salinity was 1 to 4 ppt.

Ten Bering cisco, all potential spawners, were taken in the South Fork of the Kuskokwim River, 840 km up from the mouth, in late July during two net nights of fishing. No cisco were taken in the course of test netting in the area of the Holitna River in June and July nor were any taken during test netting of other upper Kuskokwim tributaries in September. The spawning run was not followed further.

Bering cisco appear at the mouths of middle Yukon River tributary streams quite early in the summer (eg. Porcupine River - June 17, Nowitna River - June 7) and numbers fluctuate widely (Table 8). This is a spawning migration and all fish examined were mature. During June, 1972, when 349 cisco were taken in the lower 500 meters of Hess Creek (40 km above Rampart), an experimental gillnet was set 3.2 km up Hess Creek on June 26, but no Bering cisco were taken. Test netting at the mouths of Hess Creek, Ray River and Dall River July 9-22 took only 12 Bering cisco, and again the net 3.2 km upstream in Hess Creek contained none. Hess Creek was floated August 21-23 and no cisco were noticed in the river. Nets at the mouth of Hess Creek these three nights took only one Bering cisco.

At Rampart a fishwheel operating in the Yukon River from August 25 - October 1 took 180 Bering cisco. The peak of this run was September 4-8 when up to 18 were taken per day. The run stopped abruptly on September 16. Again all fish were potential spawners. Location of spawning grounds still remains a mystery. Some cisco evidently spawn in the Yukon River system upstream of the mouth of the Porcupine River, as a fishwheel at Fort Yukon took four to six mature Bering cisco per day in late August.

The presence of Bering cisco in the lower Porcupine River, 1,400 km up the Yukon River on June 17, suggests overwintering in the middle Yukon area or a very rapid upstream migration.

Age and Growth

Age determinations were made on 97 Hess Creek Bering cisco (56 males - 315-475 mm; 41 females - 335-480 mm) and 17 Port Clarence-Grantley Harbor Bering cisco (10 males - 235-340 mm; 7 females - 235-350 mm). The Hess Creek sample was selected to include fish of all length ranges.

The majority of Hess Creek males were age groups V and VI while females were

Table 8 Results of Bering Cisco Test Netting, Middle Yukon River, 1971 and 1972.

Date	Net Nights	Location	Bering Cisco Caught
6/1-9/72	18	Nowitna River	2
6/10/72	1	Texas Creek	10
6/23/71	1	Minook Creek	10
6/10-14/72	10	Hess Creek	262
6/22/71	2	Hess Creek	65
6/26-27/72	4	Hess Creek	11
8/21-22/72	4	Hess Creek	1
6/14-15/72	4	Ray River	18
6/21/71	2	Ray River	7
6/23/71	2	Ray River	25
6/24/71	2	Ray River	11
6/20/71	2	Dall River	1
6/17/71	2	Porcupine River	3
6/17-23/72	7	Porcupine River	0
			426

age groups V, VI and VII. The Port Clarence-Grantley Harbor fish were mainly immature fish of age III and IV. Two age VII females were captured.

Data were analyzed using the abbreviated Doolittle Method and indicated no significant difference between growth of males and females from Hess Creek ($\alpha > .1$) and Port Clarence-Grantley Harbor ($\alpha > .5$) at the 90% level.

Sexes were combined in the comparison of growth of Hess Creek Bering cisco and Port Clarence-Grantley Harbor fish (Figure 3). Hess Creek fish grow faster than Port Clarence-Grantley Harbor fish (abbreviated Doolittle Method gave $\alpha > .001$).

No comparative Bering cisco age and growth data is available in the literature. Ten mature Bering cisco taken 3 km up the South Fork of the Kuskokwim River in July (320-410 mm) were age III to VII and had length-age relationships similar to Hess Creek cisco. One male was age III, one female was age IV and the remainder were age V or older.

Both male and female cisco from Hess Creek became mature in the fifth year of life (age 4+). Only one male of age VII was taken but five females of age VIII averaged 439 mm. The length frequency distribution of the 339 cisco caught in Hess Creek in 1971 and 1972 indicates that many do not spawn until age V and VI. No indication of retained eggs could be found in Hess Creek fish.

Faster growth of Kuskokwim and Yukon river fish is to be expected because of their longer growing season. Broad whitefish from these areas grew faster than broad whitefish from the Imuruk River Basin-Grantley Harbor area near Teller (Alt, 1973).

Food Habits

All Bering cisco examined from the Yukon and Kuskokwim rivers (June through September) were potential spawners and had empty stomachs, a condition common to many species of whitefish in Alaska.

The limited sample of cisco examined from the Port Clarence-Grantley Harbor and Koyuk River areas were feeding on invertebrates and two cisco were feeding on small cottids.

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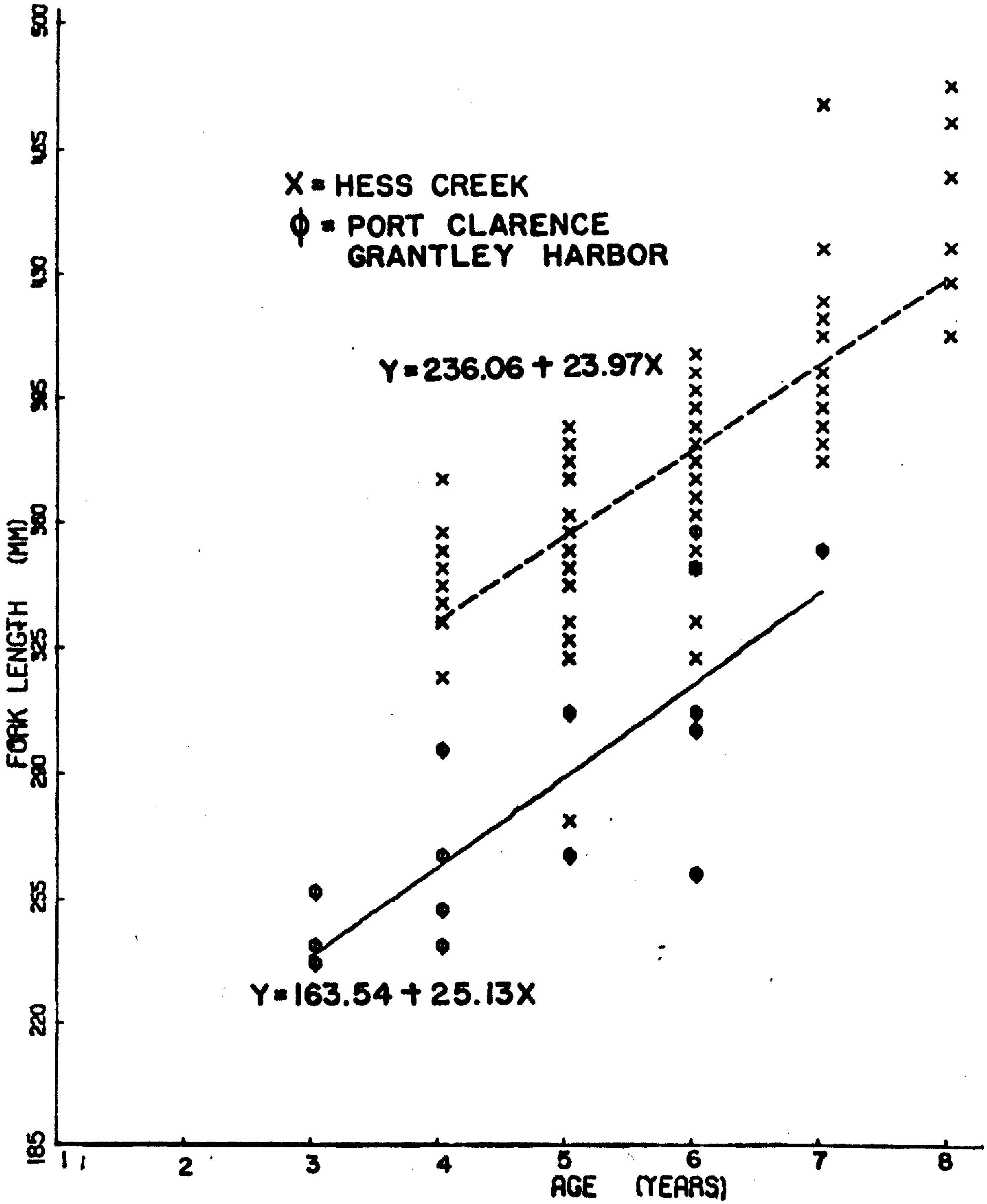

FIGURE 3. Age-Length Relationship Comparisons from Hess Creek, and Port Clarence - Grantley Harbor, 1973.

Table 9 Mean Fork Length at Capture of Bering Cisco from Hess Creek and Port Clarence-Grantley Harbor, Alaska.

Location		Mean fork length in mm and sample size ( ) at each age					
	Age	3	4	5	6	7	8
Hess Creek	♂♂	-	340 (8)	351 (25)	367 (19)	420 (3)	480 (1)
(n = 97)	♀♀	-	352 (4)	363 (8)	384 (12)	400 (12)	439 (5)
	Combined	-	344 (12)	354 (33)	373 (31)	405 (15)	446 (6)
Port Clarence-Grantley Harbor							
(n = 17)	♂♂	243 (3)	258 (2)	285 (2)	305 (3)	-	-
	♀♀	238 (2)	268 (2)	-	325 (2)	350 (1)	-
	Combined	241 (5)	263 (4)	285 (2)	313 (5)	350 (1)	-

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