STATE OF ALASKA

Jay S. Hammond, Governor

Annual Performance Report for

A LIFE HISTORY STUDY OF SHEEFISH AND WHITEFISH IN ALASKA

by

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ALASKA DEPARTMENT OF FISH AND GAME
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RESEARCH PROJECT SEGMENT

State: ALASKA Name: Sport Fish Investigations of Alaska

Project No.: F-9-13

Study No.: R-II Study Title: A LIFE HISTORY STUDY OF SHEEFISH AND WHITEFISH IN ALASKA

Job No.: R-II-A & R-II-B

Cooperator: Kenneth T. Alt

Period Covered: July 1, 1980 to June 30, 1981

ABSTRACT

Sheefish stocked during past years under the sheefish lake and river adaptability study continue to show good survival and generally excellent growth. Fish stocked in Eielson Cooling Pond in 1977 were spawning in 1980 at Age III. A few fish of the original 1968 and 1969 plants into Four Mile Lake still survived but three of 11 fish captured in June 1980 were spawned and hatched in the lake. Sheefish stocked in Island Lake had reached 264 millimeters fork length at Age I. Four lakes and ponds were surveyed and will be monitored after they have been stocked with sheefish when fry and fingerlings are available.

A comparative age and growth study of Holitna River sheefish indicated little difference in growth rate and age composition from 1967-1971 to 1978-1980. More small size and a few more large size fish were present in the 1978-80 sample. The Hoholitna River was surveyed in an effort to determine if sheefish spawned in this system. Eight sheefish were captured but none were prespawners. A second spawning ground of Kuskokwim River sheefish was located about 40 miles up Big River in early October. This glacial stream had cleared considerably by early October and fish were distributed in spawning areas. Spawning fish, especially females, were larger than sheefish of the Highpower Creek spawning grounds. A summary of the status of the Kuskokwim River sheefish population is given and indicates a stable population over the last 13 years. A synthesis of the population status and movements of the sheefish of the lower Yukon River is presented. Most sheefish belong to the anadromous lower Yukon River population which spawn up the Koyukuk River and in the Middle Yukon River above Rampart. Local populations are present in the Nowitna, Porcupine, Tanana and upper Yukon Rivers and probably the Innoko River.

BACKGROUND

The emphasis of the sheefish project the past few years has been mainly on the Yukon River and Kotzebue area together with the Sheefish Lake and River Adaptability Study.

Experimental stocking of sheefish in waters of interior Alaska has been proceeding on a sporadic basis since 1968. The greatest problems have been in securing ripe fish for the egg takes and problems with the hatchery in rearing fry to the fingerling stage. A new hatchery was to be built at Clear in 1979 but construction was not begun until 1980. The hatchery at Anchorage was shut down in 1979, so no sheefish were available for stocking in 1980. Emphasis the past 2 years has been in evaluating success of past plants and surveying new waters for future experimentation.

Sheefish life history work in the Yukon River has centered on the question of discreteness of populations in the lower and middle Yukon River. The movements, run timing and range of the anadromous lower Yukon River population has been fairly well elucidated. During the present report period additional information on the sheefish of the Andreafsky, Melozitna and Tozitna Rivers was gathered. A large population of sheefish was located in the Innoko River in June of 1979, but other than collecting information on the possible range of sheefish in the huge Innoko system from residents of McGrath, Aniak, Sleetmute, Holy Cross, Ruby and Galena during 1979 and 1980, no further on-the-ground research will be conducted on this system until 1981.

Major Kuskokwim River sheefish research had been conducted between 1967 and 1971, with only limited utilization-type studies being conducted between 1971-1978. In 1978 a 3-year study was begun to compare the population structure of sheefish in the Holitna River from 1967-1971 and 1978-1980. Data collected in 1978 and 1979 were combined with data collected in 1980 for the comparison. Searches for spawning grounds of the single population of Kuskokwim sheefish had covered a large part of the Kuskokwim River during the early years of the study (Aniak, Holitna, Middle Fork, Takotna, North Fork and Swift (McKinley) Fork Rivers and Highpower Creek). Spawning sheefish were located in only one area - Highpower Creek (Alt, 1972). In subsequent years information gained through test netting and discussions with residents of various areas of the Kuskokwim River led the author to believe that sheefish of the Kuskokwim River population could be spawning in additional areas. Efforts in 1980 were centered on the Hoholitna River and on a glacial stream, Big River, in the upper Kuskokwim River. Results of the Kuskokwim studies are presented in this report, as well as a summary of the status of the Kuskokwim River population. Future sheefish work in the immediate future need only be concerned with angler and subsistence utilization.

TECHNIQUES USED

Sheefish were captured by hook and line and gill nets of 5, 5½ and 6-inch bar mesh and standard graduated mesh gill nets of 125 foot length.

Standard length, weight and age data were collected in the field and many of the hook and line-caught fish were released. Scales of sheefish were cleaned, mounted between glass slides and read on an Eberbach projector. For the Holitna River age and growth comparative study, the 1978-80 length at capture was used in age computations. The 1967-1971 data had been back-calculated to length at annulus formation for each age. Thus, fish captured in 1978-1980 have an apparent larger size for each age than fish of the 1967-71 sample simply because they have put on marginal growth (plus growth) since annulus formation of from 10 to 40% of a year's growth.

Spawning ground surveys on Big River were conducted from a base camp using a wheel plane for reaching camp and a 12 foot inflatable raft with a 4hp motor to navigate the river. Aerial surveys proved unsuccessful because of the slight turbidity still present in the glacial Big River. Gill nets were set in all available eddies and sloughs of the 5-mile stretch of the river surveyed. Hook and line fishing was attempted in all sections of the Big River study area but sheefish were captured only in the upper part of the study area, which probably corresponds to the upper area of spawning. Ovaries were collected only from two large females which had died, and egg counts should not be considered mean counts for all spawning females of the Big River spawning segment. Egg numbers were determined gravimetrically by determining the weight of 2,000 eggs and comparing this with the weight of all eggs in the two ovaries.

Common and scientific names and abbreviations of fish mentioned in this report are listed in Table 1.

RECOMMENDATIONS

Research

1. It is recommended that all sheefish research activities be concentrated on a 2-year life history study of sheefish of the Innoko River.

2. Sheefish Lake and River adaptability study emphasis should shift to stocking fingerlings in lakes and ponds containing forage fish.

Management

1. Monitoring of trends in patterns of utilization should continue.

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

OBJECTIVES

1. To interim-rear sheefish to fingerling size and to stock various lakes and streams in interior Alaska.

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

Common Name	Scientific Name and Author	Abbreviation
Arctic char	Salvelinus alpinus (Linnaeus)	AC
Arctic grayling	Thymallus arcticus (Pallas)	GR
Arctic lamprey	Lampetra japonica (Martens)	AL
Broad whitefish	Coregonus nasus (Pallas)	BWF
Burbot	Lota lota (Linnaeus)	BB
Chinook salmon	Oncorhynchus tshawytscha (Walbaum)	KS
Coho salmon	Oncorhynchus kisutch (Walbaum)	SS
Chum salmon	Oncorhynchus keta (Walbaum)	CS
Humpback whitefish	Coregonus pidschian (Gmelin)	HWF
Inconnu (sheefish)	Stenodus leucichthys (Güldenstadt)	SF
Lake chub	Couesius plumbeus (Agassiz)	LC
Least cisco	Coregonus sardinella Valenciennes	LCI
Longnose sucker	Catostomus catostomus (Forster)	LNS
Northern pike	Esox lucius Linnaeus	NP
Rainbow trout	Salmo gairdneri Richardson	RT
Round whitefish	Prosopium cylindraceum (Pallas)	RWF
Slimy sculpin	Cottus cognatus Richardson	SSC

2. To evaluate success of past sheefish plants.

3. To survey new waters for experimentation with stocking.

FINDINGS

1980 Egg Takes

On October 1, 385,000 sheefish eggs were taken at Hughes on the Koyukuk River. An egg take was attempted at Big River (Kuskokwim River) but eggs were not ripe and fish had not yet begun to spawn on October 3 when research was terminated. Eggs were hatched in temporary facilities in the Radar Dome Building at Clear Air Force Station. They were transferred to the hatchery building in late December. Hatching was completed by January 20, 1981. Hatching success was 53%.

1980 Sheefish Stocking

No fish were stocked in 1980 since no eggs had been taken in 1979. An attempt was made in July to capture sheefish fingerlings from the mouth of the Nowitna River by seine and transport them by airplane to Silver Fox Pit located on the Richardson Highway 54 miles from Fairbanks. Despite extensive seining in the lower 10 miles of the Nowitna, where sheefish were taken by seine and net in July of 1978, no sheefish were captured in 1980. Over 2,000 pike and whitefish were captured.

Sixty-six fingerling whitefish (Coregonus sp.) were held overnight in pens then placed in a 15 gal plastic container, supplied with oxygen and transported by air to Birch Lake, near Fairbanks. After being held overnight in Birch Lake, all were disposed of. Only one fish had died as a result of the transport. Thus the secondary objective of testing the feasibility of transporting fingerlings by air was achieved.

Evaluation of Past Plants

Island Lake:

A 125 ft variable mesh gill net and a 25' 1/2 in mesh gill net were set overnight in Island Lake on Ft. Greely on August 1. Twenty sheefish were captured and nine were released. Fish ranged in length from 233 to 278 mm (x = 264 mm) and in weight from 160 to 240 g (x = 191 g). The fish had grown considerably from October 10, 1979 when they averaged 192 mm fork length. Growth and survival have been excellent. In October of 1979 only 10 fish were caught in an overnight set. Fish were feeding mainly on scuds (Gammarus sp.) but also on mayflies and diptera larvae.

Surface dissolved oxygen readings from Island Lake during both February and March were quite low (2-2.5 ppm) and it was felt that fish might experience considerable winterkill. This probably was not the case as no dead fish were observed in May after breakup and the high gill net catches in August indicated high population levels.

Four Mile Lake:

A variable mesh sinker gill net set in Four Mile Lake on June 1 took seven sheefish and six rainbow trout. A variable mesh floater gill net took only rainbow trout and on June 2 a sinker gill net, set from 10 a.m. to 10 p.m. in 15 feet of water, took four sheefish and four rainbow trout. No sheefish were caught on hook and line. Evidently sheefish were in deeper water this year than in previous years when they were on the surface. No sheefish were captured by gill nets in 1979 because net size (5½ in mesh) was probably too large.

The sheefish population in Four Mile Lake is now increasing instead of decreasing, as successful reproduction is an established fact. Of the 11 fish captured in 1980, three had been spawned and hatched in the lake.

Fish captured ranged in size from 358-700 mm ($\bar{x}$ = 505 mm) and 570-3,410 g ($\bar{x}$ = 1,760 g). Eight fish (FL 457-700 mm) were of the original 1969 plant and Age XI. Because of extreme slow growth the past 3 years, the last 2-3 annuli were either very difficult to ascertain or completely absent. Of these eight fish, all except the largest (700 mm and 3.5 kg) were in poor condition. Three had badly deformed backs and appeared to be missing three to five vertebrae in the caudal region. The 700 mm fish was a prespawning female, three other females were non-consecutive spawners and contained retained eggs from previous spawnings, and the four males were all mature. Two of the eight fish contained an insect each in the stomach, but all others had not been feeding. Thus fish of the original plants, while still present in some numbers, are in poor condition either from old age or severe competition from rainbow trout and now also from younger sheefish.

The three sheefish hatched in the lake included an Age II - 358 mm fish and two Age III fish (370 and 382 mm). The fish captured in 1979 was Age III, thus successful spawning has been documented in Four Mile Lake in the fall of 1975, 1976 and 1977 with fish hatching out in 1976, 1977 and 1978.

The Age II and III fish were feeding on a tiny freshwater shrimp and insects.

Walden Pond:

Only two sheefish were taken in an overnight sinker gill net set in Walden Pond. They included a 513 mm long 1.7 kg prespawning male and 514 mm 1.8 kg immature female. Both fish were Age III and had been stocked from Eielson Cooling Pond in 1977 and 1978. The fish had averaged 489 mm in length and 1.25 kg in 1979. Fish were feeding on freshwater shrimp, beetles and insects. Hook and line fishing was unsuccessful in 1979, possibly because of the small number of fish in the lake and the fact that fish are probably on the bottom.

Eielson Cooling Pond:

In 1980, 39 sheefish were captured in nine net nights of fishing with variable mesh gill nets in early April and five were captured in 16 net

nights of fishing in mid October. The April sample included two yearling sheefish (265 mm) that had been stocked in March of 1979. The larger fish ranged from 460-504 mm ($\bar{x}$ = 484 mm). Weights ranged from 960 to 1,250 g. All males examined and one of the five females examined were judged to be potential spawners.

Eight humpback whitefish were also captured in Eielson Pond in April. This was totally unexpected since no humpback whitefish had been captured during extensive netting the past 2 years and there is no evidence of them having been introduced from the hatchery. The cooling pond is completely isolated from local rivers, thus the fish didn't come in during high water. They ranged in size from 340 to 380 mm ($\bar{x}$ = 365) and in weight from 620 to 910 g. All females were immature, while all males were mature. Water temperature April 2 was 13.5°C; October 15 water temperature was 7.0°C.

Only five sheefish and three humpback whitefish were taken in 16 net nights of fishing in mid October 1980. All were Age III. Fish were 526-562 mm ($\bar{x}$ = 542 mm) and 1.33 to 1.65 kg ($\bar{x}$ = 1.50 kg). Males were running milt and only one female (534 mm and 1.65 kg) was ripe. Egg diameter was 2.4 mm and the fish contained 41,000 eggs. This is the first ripe Age III female sheefish reported in Alaska. Age at first spawning for wild populations of sheefish is seldom less than Age VII (Alt, 1973). Reasons for lowered age at maturity for females is not known but could be related to initial rapid growth and warmer water temperature. Two of the humpback whitefish caught were Age II. Slow growth the first year of life indicates that these fish entered the pond in 1978.

South Greely Pond:

During two net nights of fishing in late July, 38 sheefish were taken in South Greely Pond on Ft. Greely Reservation. These fish were from a February 1977 plant of 10,000 fry. Netting conducted during 1977 and 1978 took no sheefish and it was assumed all had died. The discovery of the apparent high survival of these fish will force us to reassess our philosophy of stocking newly-hatched fry under the ice. North Greely Pond, which had physical and chemical characteristics similar to South Greely Pond, had been stocked at the same time, but no fish had been recovered in 1977, 1978 or in 1980. South Greely Pond fish ranged from 432 to 468 mm in ($\bar{x}$ = 444) in length, weight ranged from 780 to 980 g ($\bar{x}$ = 856 g). All fish were immature. Fish were eating diptera larvae, mayfly nymphs and tiny shrimp.

Grayling Lake:

Only one sheefish was captured from Grayling Lake on Eielson A.F.B. during one net night of fishing in July 1980. This Age VII fish was 515 mm and weighed 1,446 g. Five fish had been captured in 1979. Grayling Lake was not stocked by the Department of Fish and Game and it is not known how the sheefish entered the lake.

Survey of New Waters:

In 1980 four lakes or ponds were surveyed for possible future sheefish introduction.

Silver Fox Pit, located 54 mi from Fairbanks on the Richardson Highway, is a 2.5 acre pond. March dissolved oxygen readings were 4.5 ppm. Silver Fox Pit contains lake chubs and will be stocked with sheefish fingerlings.

Weigh Station Ponds:

North and South Weigh Station Ponds are located 5 mi from Fairbanks on the Richardson Highway. Both ponds are 2 acres. North Pond is 32 feet deep and had a surface dissolved oxygen reading of 6.0 ppm on March 20. South Weigh Station Pond is 30 feet deep and had a surface dissolved oxygen reading of 5.0 on March 20. Both ponds contain lake chubs, so both will be stocked with fingerlings.

Gull Lake:

Gull Lake is a 16 acre lake on the Ft. Greely Reservation. It is located to the north of "J" Lake on the Meadows Road. It is 21 feet deep and had a March dissolved oxygen reading of 5 ppm. The lake is barren and will be stocked with sheefish fry.

R-II-B Movements, Abundance, Population Dynamics, and Spawning Ecology of Sheefish and Whitefish in Interior and Arctic Alaska.

OBJECTIVES

1. To synthesize data relative to population status of sheefish from middle and lower Yukon River.

2. To compare population structure of Holitna River sheefish (1967-1971 vs. 1978-1980).

3. To search for spawning grounds of Kuskokwim River sheefish.

4. To collect data on sheefish utilization from selected areas of Alaska.

FINDINGS

Holitna River Comparative - Age and Growth Study
1967-1971 vs. 1978-1980

Age and growth data were analyzed from 139 sheefish collected from various areas of the Holitna River, including 32 fish from 1978, 35 fish from 1979 and 72 fish from 1980 (Table 2). All fish were captured by anglers on hook and line and nearly all fish were released, so it was impossible to separate the sexes for analysis. Fish captured during the 3-year study ranged in length from 440 to 1,000 mm, in weight from 0.45 to 12.5 kg, and in age from 3 to 14 years. In the combined sample, fish of Ages VI and VII predominated, but fish from Ages III to IX were well represented. Based on a

Table 2. Holitna River sheefish age, length, weight data 1978-1980.

		Age											
		III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
						1978 n=32							
Length mm	$\bar{x}$	460	610	608	670	714	775	800	953				
	n	1	3	13	8	4	1	1	1				
	Range	460	555-690	500-720	600-750	625-795	775	800	953				
Weight kg	$\bar{x}$	1.25	2.82	2.75	3.97	4.46	5.45	6.36	7.95				
	n	1	3	13	8	4	1	1	1				
	Range	1.25	1.82-3.86	1.70-4.00	2.72-6.14	2.87-6.82	5.45	6.36	7.95				
						1979 n=35							
Length mm	$\bar{x}$			535	638	731	756	794	838	850	888	963	1000
	n			1	7	8	9	5	1	1	1	1	1
	Range			535	625-663	713-750	688-788	638-875	838	850	888	963	1000
Weight kg	$\bar{x}$			2.16	3.13	4.43	5.10	6.00	6.81	7.96	10.45	11.82	12.50
	n			1	7	8	9	5	1	1	1	1	1
	Range			2.16	2.38-3.64	3.07-5.00	4.43-5.90	4.20-7.39	6.81	7.96	10.45	11.82	12.50
						1980 n=72							
Length mm	$\bar{x}$	487	508	568	632	666	759	780	855		945		
	n	11	10	14	21	5	7	2	1		1		
	Range	440-580	445-560	520-615	580-715	640-700	720-860	740-820	855		945		
Weight kg	$\bar{x}$	1.14	1.32	2.13	2.86	3.59	5.24	5.57	7.27		9.77		
	n	11	10	14	21	5	7	2	1		1		
	Range	0.45-2.27	0.80-1.70	1.25-2.73	2.04-3.75	3.18-4.55	4.20-6.36	4.55-6.47	7.27		9.77		

small number of these fish autopsied and data from spawning grounds on Big River and Highpower Creek, it is estimated that nearly all fish older than Age IX are females. Past studies have shown that although males and females have similar growth rates, females live longer than males and thus attain a larger maximum size.

Before comparing data of the present study with 1967-71 data it is necessary to discuss sheefish capture locations for all years. Sheefish found in the Holitna River in June and July are nearly all feeding fish and include prespawning fish, immature fish, and non-spawning mature fish. The sheefish seem to segregate in various areas of the Holitna and Hoholitna Rivers by size and by state of maturity. The major areas of concentration are shown in Figure 1.

Holitna River Mouth:

Large concentrations of large size fish are found here but they arrive late (late June-July). These fish are the largest of all Holitna sheefish. Fish include prespawners, non-spawners and a few immature fish. The fish are found deep and are often difficult to capture on hook and line. The prespawning fish are often resting in this area before proceeding further up the Kuskokwim River to spawn. The non-spawning fish as well as a few of the prespawning fish are feeding mainly on lampreys and whitefish. Few fish remain in this area after early August.

One Mile Islands:

Generally the first sheefish to arrive at Holitna feeding grounds are small, immature fish that are found in various areas above the islands, 1 mi upstream in the Holitna River. They are present from early June to early July and are often observed feeding on chum salmon fry on the surface of the water. Fish seldom exceed 4.5 kg (10 lbs) and few mature fish are found.

Six Mile Holitna:

During sheefish research from 1976 to present this area has only been used the past few years by feeding sheefish. The fish are similar in size to those found at One Mile and most are surface feeding on chum salmon fry. They generally are present from mid-June to early July, depending on the duration of the salmon outmigration.

Cutbank or Twenty Mile Holitna:

This has been the major feeding area of Holitna River sheefish during our research from 1967 to 1980. Although a few fish may arrive as early as late May and feed on outmigrating king and coho salmon smolts, the majority arrive in late June and July when the chum salmon fry outmigration is at its peak. At this time large numbers can be taken on hook and line. The fish in this area run larger than those at One Mile or Six Mile and include a few prespawners, but are mainly immature and non-spawning fish. Most

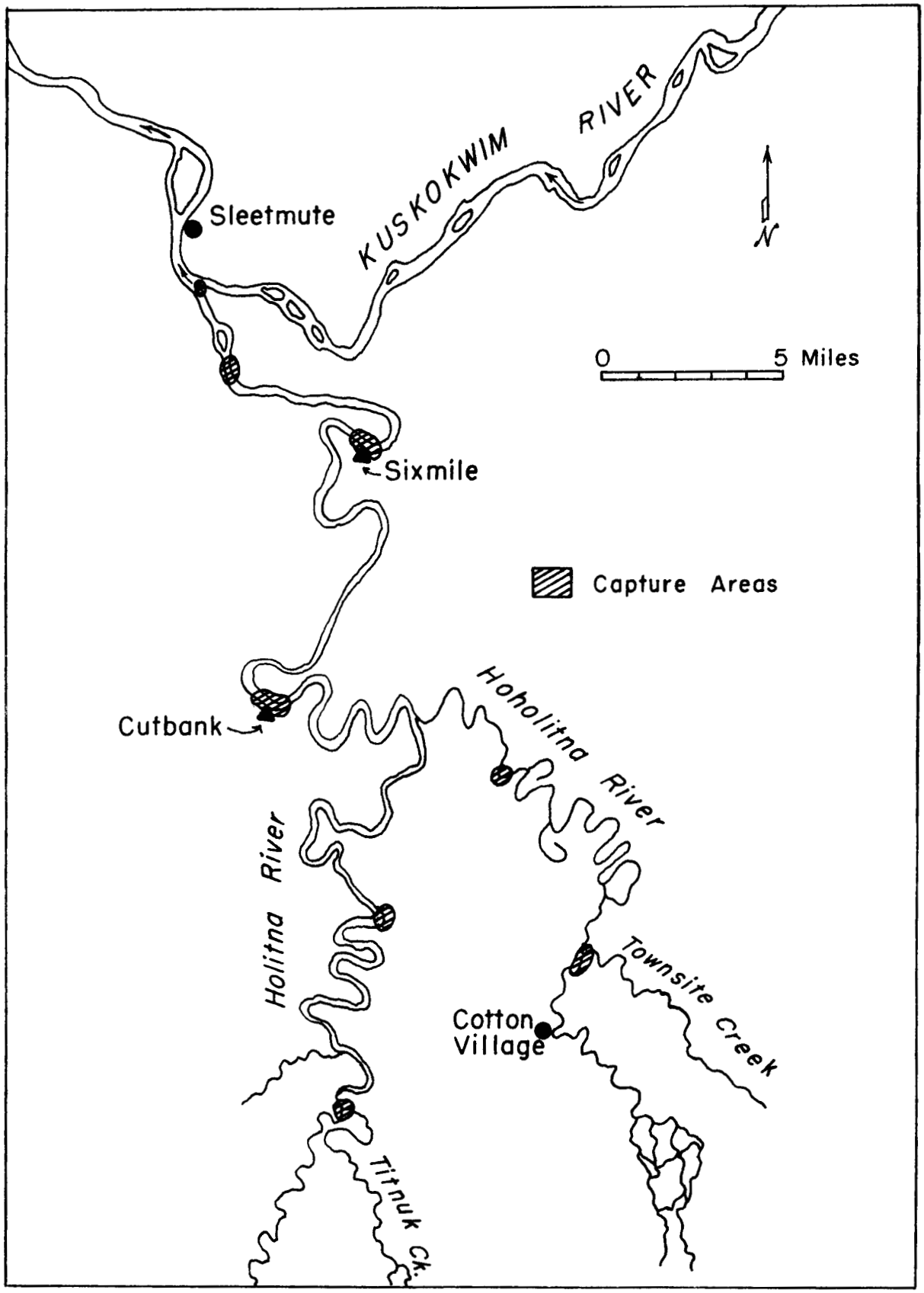

Fig. 1. Sheefish feeding and resting areas Holitna and Hoholitna Rivers.

fish here are 7-10 years old. Some of the large, older sheefish found at the mouth usually do not migrate up this far. Fish are normally gone from this area by late July. If water levels are high, as in 1980, or if the chum salmon outmigration is of short duration, the fish may be present for only a short time or not at all.

Forty Mile Holitna:

A few sheefish are generally found in this area in July. They are of the same size and maturity as fish found at Cutbank, but in addition to feeding on the surface on salmon, they feed deeper in the water column on lampreys. Two immature fish were captured here on September 26, 1968, but generally most fish are gone well before then.

Titnuk Creek:

Located about 55 mi up the Holitna River, Titnuk Creek generally has a few sheefish in the deep hole at the mouth. They are generally small (less than 4 kg), immature fish and are feeding deep on lampreys and whitefish. Fish are usually present only in July.

Hoholitna River:

The fifth bend, located about 6 mi up the Hoholitna River, generally has a few sheefish present in July and early August. The fish are generally large but most appear to be non-spawners. The fish are found in a deep hole where they feed on lampreys if they feed at all.

Townsite Creek:

Townsite Creek is located about 30 mi up the Hoholitna River. Eight sheefish were caught on hook and line in close proximity to the mouth of Townsite Creek in mid-September 1980. The fish included immature fish and non-spawning mature fish of 1-6 kg. Fish were deep and feeding on lampreys and whitefish. Date of arrival of these fish is not known.

In 1978 most sheefish were captured in the area of the Islands, with smaller numbers captured at the mouth of the Holitna, Cutbank and 40 Mile.

Small sheefish remained in the area longer because of a slow outmigration of chum salmon fry. This explains the predominance of fish of Age V-VII in the sample. In 1979 the smaller sheefish were not present among the Islands or at Six Mile and very few were present at the Cutbank. Thus most fish were captured at the mouth of the Holitna and large fish predominated. This sample was caught in mid July. The largest sheefish caught in 14 years of research on the Holitna were captured in 1979. In 1980 water levels were extremely high all summer and sheefish never did occupy the traditional feeding area at Cutbank. Most fish were captured at the Islands and at Six Mile. This explains the predominance of 3 to 6-year-old fish in the sample. The large number of 6-year-old fish also indicates a good 1974 year class of sheefish.

The sheefish used for the 1973 age and growth study were captured for a tagging study between 1967 and 1971 (Alt, 1973). The majority of fish were taken at the Cutbank and were intermediate size fish of Age VI-X. Smaller numbers were taken at 40 Mile, Titnuk Creek, Holitna mouth and Fifth Bend Hoholitna River. Thus while the data shows a shift in age composition toward the younger fish, I feel the data is biased because of sampling location, and had the entire 1978-1980 sample come from the Cutbank, I feel that age composition would be similar (Table 3). My personal observations over the 13 years are that there are more smaller size feeding fish in the lower Holitna the past 3 years. This could indicate a population increase or simply that more fish are migrating up from the lower Kuskokwim River for feeding. The large number of 6-year-old fish found in 1980 should benefit the spawning population the next 4-6 years. The presence of a large number of age classes in the spawning population (7 for males and 7-8 for females) is encouraging and indicates that the subsistence fishery is not capturing all of the large sheefish in the lower Kuskokwim population.

Growth rate comparisons of the two samples would seem to indicate faster growth for the 1978-80 sample. Ages of fish from the 1967-71 sample were back-calculated, thus the length for each age is length at annulus formation for each year; i.e., May 20-June 1. Length for each age of the 1978-80 sample is length at capture in late June or July, thus 20-50% of the current year's growth had occurred by time of capture. If this difference is taken into account then it could be said that growth rate has remained fairly similar.

Alt (1973) reported age at maturity for sheefish of the Kuskokwim River population at 6-8 years for males and 7-9 years for females. Data from the Big River spawning grounds in 1980 suggest that it is age 4-8 for males and 6-9 for females. In fish a lowered age at first maturity is a compensatory mechanism in response to increased exploitation. This could be the present case but rather I feel that the larger sample of fish from the spawning ground in 1980 is the reason.

I feel cautiously optimistic about the current population status of the sheefish of the Holitna River and feel that the Holitna River segment of the Kuskokwim River sheefish population have remained stable from 1967-1980.

Hoholitna Spawning Ground Survey

The Hoholitna River, from its junction with the Holitna River upstream to 3 mi above Little Diamond, was surveyed by boat from September 14-18 (Fig. 1). This is approximately 40 miles up from the mouth of the Hoholitna and 70 mi up from the Holitna mouth at Sleetmute. The lower 30 mi of the Hoholitna, below Townsite Creek, are quite meandering. The river is fairly slow moving and the bottom is mud and sand. The first gravel appears across from Townsite Creek. Gravel bottom was found intermittently with a mud bottom up to Little Diamond. The stream from Townsite Creek upstream is less meandering, has a less defined channel, and swifter current (approximately 2.8 fps). The entire river is heavily timbered.

Table 3. Comparative sheefish age, length, weight data Holitna River 1967-1971 vs. 1978-1980.

		Age											
		III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
						1967-1971 n=187							
Length mm	$\bar{x}$	417	496	563	622	676	729	777	810	847	936	971	
	n	2	3	5	13	37	50	40	21	11	4	1	
						1978-1980 n=139							
Length mm	$\bar{x}$	484	532	587	642	707	758	791	882	850	917	963	1000
	n	12	13	28	36	17	17	8	3	1	2	1	1
	Range	440-580	445-690	500-720	580-750	625-795	688-860	638-875	838-953	850	888-977	963	1000
Weight kg	$\bar{x}$	1.15	1.66	2.41	3.16	4.19	5.18	5.94	7.34	7.96	10.11	11.82	12.50
	n	12	13	28	36	17	17	8	3	1	2	1	1
	Range	0.45-2.27	0.80-3.86	1.25-4.00	2.04-6.14	2.87-6.82	4.20-6.36	4.20-7.39	6.81-7.95	7.96	9.77-10.45	11.82	12.50

Areas that might contain suitable spawning gravel are limited, but the region near Townsite Creek and the region 7 mi above Townsite Creek are the most promising. Water level was rising daily during the survey because of heavy rains, but the water was still quite clear. Water temperature was 9°C during the survey. Graduated mesh gill nets were set in various sloughs, eddies and areas of slow current from Townsite Creek to 8 mi upstream. In eight net nights of fishing, no sheefish were captured, but chum and coho salmon, Arctic char, round whitefish, humpback whitefish, broad whitefish, least cisco, pike, suckers, burbot and grayling were caught (Table 4). Considerable hook and line fishing was done from Townsite Creek upstream to beyond Little Diamond but sheefish were captured only in the Hoholitna River at the mouth of Townsite Creek and 100 yards upstream. They were found in mainly deep water at the edge of the main current. Eight fish were captured, but numerous other fish were lost. Gill nets set in the same area failed to take sheefish. Fish captured included both immature fish and mature non-consecutive spawners. None of the fish captured would spawn in the current fall and thus the conclusion is that no sheefish spawn in the Hoholitna River. Fish ranged in length from 465-790 mm and 1.1 kg to 6.4 kg in weight. Fish were Age IV to XII. Three females 720-750 mm and Age VII and VIII had all spawned in previous years, thus minimum age at maturity of Kuskokwim River female sheefish is VI rather than VII as indicated by Alt (1973). A 790 mm female (Age XII) was in very poor condition, had a slow growth rate the past 3 years and probably would not live to spawn again. This is about the maximum age for Kuskokwim River sheefish. Only three of the fish examined were feeding. Sheefish ate whitefish fingerlings, sculpins, suckers and lampreys.

Residents of Sleetmute reported taking about one sheefish every other net night in salmon nets in the lower Holitna River. Fish examined were non-spawners and are part of the feeding population that is migrating down to the Kuskokwim River for overwintering.

Big River Spawning Ground Survey

Big River arises from the 9,345 foot high Revelation Mountains of the Alaska Range and flows due north for approximately 130 mi before emptying into the Kuskokwim River at 62° 58' N. lat. and 155° 02' long. The source of Big River, including the North Fork and Lyman Fork, is in glaciers and the river carries a heavy load of suspended glacial silt from June to early October when the glaciers stop melting. Only small unnamed tributaries enter Big River from the headwaters to near the mouth. The Middle Fork of the Kuskokwim River enters Big River 6 mi from its mouth and Blackwater Creek enters 5 mi from the mouth.

Big River is heavily timbered over most of its course with spruce, cottonwood and birch, the dominant species. The lower 40 mi meanders considerably and has a muddy bank. Current speed was not measured but is considerably slower than in the upper reaches. The river is braided from below Lone Mountain up to the headwaters. Glacial silt and sand have been deposited on some of the bars in the upper river and these deposits are more abundant in the lower river. Most of the glacial flow remains in suspension and is transported to the Kuskokwim River. Very few sloughs are present, even in the lower river. Water level is dependent on glacial

Table 4. Gill net catches in the Hoholitna River September 14-18, 1980. No sheefish were captured by gill net, but eight were captured adjacent to net sites near Townsite Creek on hook and line.

Location	Net Nights	Species Captured									
		AC	CS	SS	HWF	BWF	LCI	RWF	GR	NP	LNS
7 mi above Townsite Cr.	2	2	1	13	1	10	4		2	4	11
5 mi above Townsite Cr.	1		1	4	1	1		1	3	2	1
3 mi above Townsite Cr.	1		1	2	1	2			3	4	
2 mi above Townsite Cr.	1			1		1			2	2	
Townsite Creek	3		1	7	1	2	4		5	9	1

runoff, and level is usually highest in midsummer. A period of warm, rainy weather in mid-September 1980, following an earlier snowfall, resulted in flood conditions on Big River that altered some of the stream channels. Water levels had just gone down to normal by September 29 and only dropped 2 in during the 5 days we were on the river.

In 1971 three prespawning sheefish (two males and one female) were taken in gill nets set 3 mi up Big River on July 23. Subsistence fishermen further downstream on the Kuskokwim at McGrath were catching up to one prespawning sheefish a day at this time, but many of these fish were probably migrating up to Highpower Creek. Area residents also mentioned observing sheefish rolling on the surface of the water at the mouth of Big River in early September. Movement of spawners into Big River occurs at least from late July until early September. Spawning grounds are approximately 40 mi up Big River so fish probably arrive on the spawning grounds from early August through early October.

Spawning Ground Locations:

Big River sheefish spawn over at least a 2 mi stretch of Big River approximately 40-42 mi upstream (south) of the mouth. This area is west and slightly north of Lone Mountain. The spawning area is immediately upstream of the last large meandering bend of Big River. In addition to less meandering, the river has a faster current, more gravel bars, a more open course, and generally is more shallow.

Of the 3 mi of river surveyed by raft, it appears that the best spawning areas are 2 to 2.5 mi above the big bend of Big River. This area has a clean swept gravel bottom, a current of 4.4 fps and depth of 3 to 6 ft (Fig. 2). A school teacher from Nikolai had seen sheefish spawning here on October 6, 1975. Slush ice was running at that time. I feel that some spawning also occurs in the area of our camp.

Big River is the only known glacial stream in Alaska where sheefish spawn. It was thought that glacial silt would cover the bottom. However, in areas where sheefish spawn (i.e. fast current), the bottom was hard-packed gravel and completely swept clear of glacial silt. Water would probably clear up slightly more, but the author was unable to detect any silt that had settled out of a bucket of Big River water left overnight on October 3. An area resident mentioned that water level in Big River stayed quite high all winter and that this area was frozen-over all winter. He mentioned that many other glacial streams of the upper Kuskokwim had very low flow during winter.

In the study area there were very few good holding areas for sheefish, thus no large concentrations were found. Rather, sheefish were holding in many areas with probably small concentrations in each. There are numerous areas where downed timber and log jams create small eddies. Where these are associated with deep water, favorable resting areas are created. Nets set in these areas always captured sheefish (Table 5). A 25' net set at area "I" took six sheefish overnight. Large, deep eddies were probably the next most important holding areas, although it may be possible that sheefish

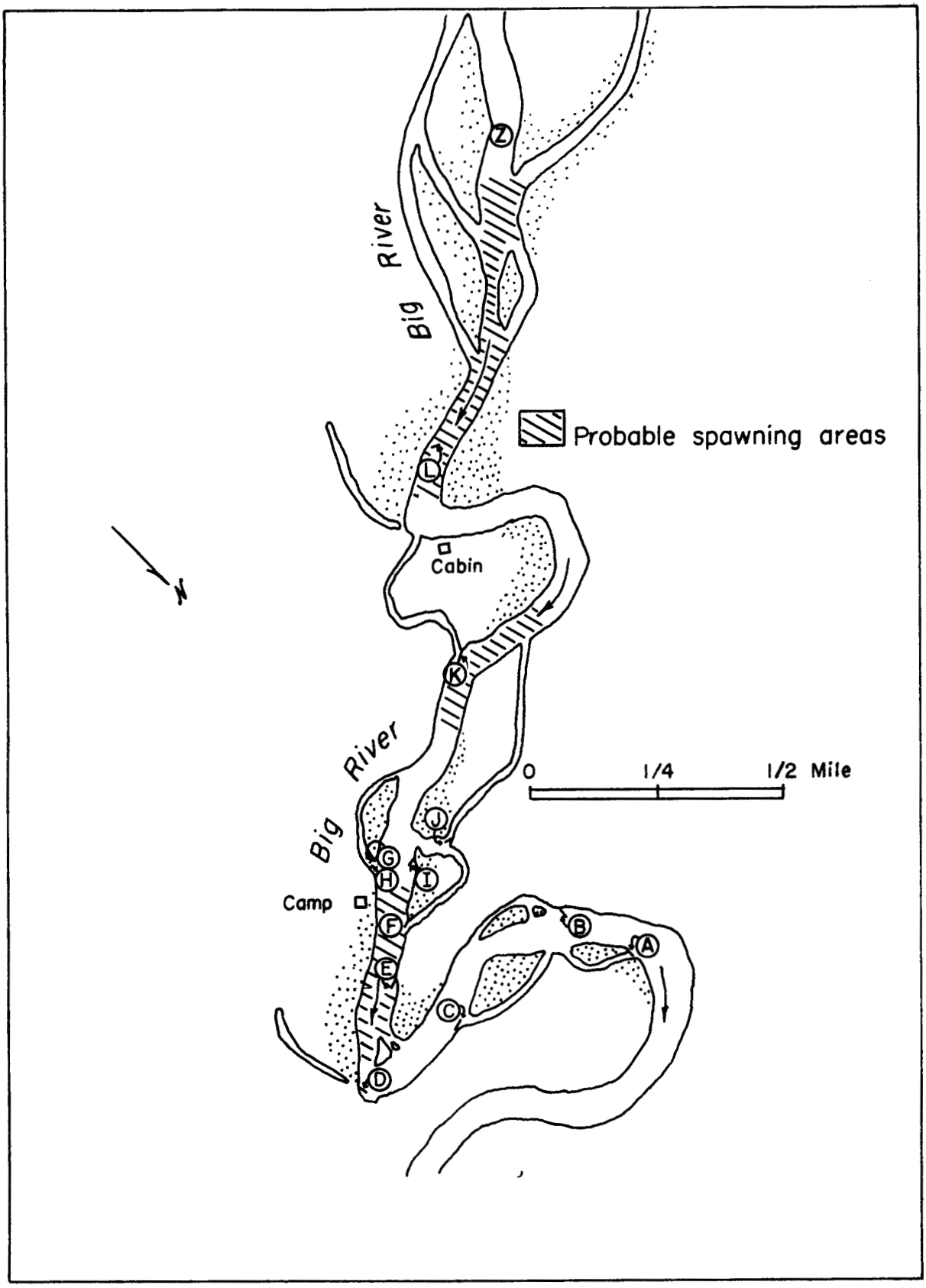

Fig. 2. Big River netting and spawning areas. A-L = netting areas, Z = hook and line capture.

Table 5. Gill net catches Big River September 29-October 3, 1980. Net location numbers correspond with numbers on Fig 2. Nets C & B were variable mesh, nets at B, D & K were 60' nets of 5 1/2" bar mesh and other nets were 25' 5 1/2" nets.

Net Location	Net Nights	Species								
		SS	CS	SF	HWF	RWF	LCI	GR	NP	LNS
A	1				5					
B	1				1					
C	2		1	1	30		58		1	
D	2	1	3	12	2					
E	2			4	6					
F	1				4					
G	1			1	27	1	4	29	1	1
H	1			1	1					
I	2			8	1					
J	1				2					
K	1			7	1					
L	1				1					
Total	16	1	4	34	81	1	62	29	2	1

caught here were still moving upstream. A 60' net set at "K" took nine sheefish overnight. Nets set in calm water sloughs took few sheefish and these are probably not major holding areas. The other type of holding area is located in moderate current in the main channel where the main current is deflected from a gravel point. No eddy is created but favorable resting areas are found in water of 2 to 5-foot depths. Very few of these areas were located and they are impossible to net. One such holding area was located at "Z" and probably contained large numbers of sheefish. Seven were captured by hook and line in 30 minutes of fishing on October 2 and numerous other fish were lost. All fish caught were males but none were running milt. This is probably the major holding area for sheefish spawning in the long run below the capture location.

Physical Aspects of Spawning Area:

During the September 29-October 3 trip water temperature ranged from a high of 3°C to a low of 2°C. Air temperature ranged from 8° to -4°C. Colder temperatures in the mountains had probably caused the glaciers to stop melting. The water cleared considerably during the 5-day trip and by October 3 it was possible to see gravel through 1 ft of water. The river was generally in a single channel with occasionally interspersed gravel bars. The river was 150-250 ft wide and water depth along some of the cut banks exceeded 6 ft. In likely sheefish spawning areas water depth was 2 to 5 ft deep.

In front of camp, in an area where sheefish would probably spawn, velocity was 4.4 fps. In an adjacent area velocity was 3.3 fps. Velocity was calculated at 4.3 fps in a probable spawning area 2 mi above camp. Bottom substrate was hard gravel of varying sizes, but generally composed of 5% sand, 15% gravel less than 1/2 in, 30% gravel 1/2 in to 1 in and 50% course gravel and rocks.

Big River spawning grounds could be rated as far superior to spawning grounds on Highpower Creek and much more extensive. The author feels that considerably more sheefish spawn in Big River than in Highpower Creek (Alt, 1972).

Biological Aspects of Spawning Fish:

Sixteen net nights of fishing with gill nets, from September 29 to October 3, took 34 sheefish. Angling with rod and reel was attempted throughout the study area but was successful only at location "Z" (Fig. 2) where seven fish, all males, were captured. Their size range was the same as for net-captured fish.

Capture of sheefish was affected by net placement. Nets set in areas with current became clogged with leaves and debris and caught no sheefish (Location A. B, F, and L in Fig. 2). Nets set in large eddies and short 25-ft nets set behind downed trees such as sites "E" and "I" took most of the sheefish captured.

The 34 sheefish captured included six females and 28 males. Females averaged 895 mm FL (range 780-1,033 mm) and 9.27 kg (range 5.3-12 kg). Males averaged 715 mm FL (range 560-860 mm) and 4.05 kg (range 2.0 to 6.3 kg). The Big River females were considerably larger than females on the spawning grounds of Highpower Creek (895 mm vs. 810 mm) and the largest female taken at Highpower Creek was 7.8 kg (Alt, 1972). Highpower Creek males were slightly larger than Big River males (730 mm vs. 715 mm). The 12 kg female probably represents the maximum size reached by Kuskokwim River sheefish and in examining over 1,000 sheefish from 1967 to the present, I have observed only two fish larger.

Age, Growth and Fecundity:

Ages of thirty-two sheefish ranged from IV to XII with the majority being Ages VII and VIII (Table 6). All fish were mature. The fish of the younger age groups were all males and no males older than Age X were found. The six females included two Age VIII fish, one each of Age IX and XI and two of Age XII. The prespawning Age IV males represent the youngest age at spawning of Alaskan sheefish. Growth of Big River sheefish is similar to that of Kuskokwim River sheefish, which is to be expected since they belong to the same population (Alt, 1973).

Egg counts were made from two of the larger females from Big River. A 1,033 mm, 11.9 kg fish contained 286,840 eggs or 27.4% of body weight. A 968 mm 11.1 kg fish contained 248,800 eggs or 25% of body weight. These are the largest size females spawning in the Kuskokwim system, thus most spawning females would have considerably fewer eggs. Big River females averaged more eggs per pound of body weight than fish of other Alaskan populations (Geiger, 1969; Alt, 1978) where eggs made up about 20% of body weight.

Summary of Life History of Sheefish of the Kuskokwim River

Sheefish in the Kuskokwim River constitute a single population. They are considered anadromous, but only part of the population reaches brackish water for overwintering. Tagging studies from 1967-1971 delineated major migration patterns (Alt, 1977). No local populations have been discovered in the Kuskokwim River that are similar to local populations in the Yukon River. The general yearly pattern of activity of Kuskokwim River sheefish is a slow upstream movement of fish (mainly prespawners) under the ice in April and May from overwintering areas in the lower reaches of the Kuskokwim River. By late May the vanguard of the current year's spawning population is near Aniak and considerable numbers are caught in chinook salmon nets. The non-spawning population (which includes immature and non-spawning fish) also migrates upstream, but later and not as far as the spawning fish. The feeding fish are widely distributed in lakes and sloughs of the lower Kuskokwim River and the Holitna River, with smaller concentrations along the Kuskokwim River and its tributaries (Fig. 3). The Holitna River is a major feeding area and sheefish arrive there in early June with smaller fish arriving first. Few non-spawning feeding individuals migrate further upstream in the Kuskokwim River than the Stony River area. Some of the earlier migrants spend some time feeding in the lower 20

Table 6. Population structure of Big River sheefish spawning population. Fork length in mm.

	Age at Capture								
	IV	V	VI	VII	VIII	IX	X	XI	XII
Mean	614	633	673	757	790	780	860	940	1000
	n=4	n=3	n=4	n=8	n=8	n=1	n=1	n=1	n=2
Range	560-646	606-648	652-708	655-820	746-870	780	860	940	968-1033

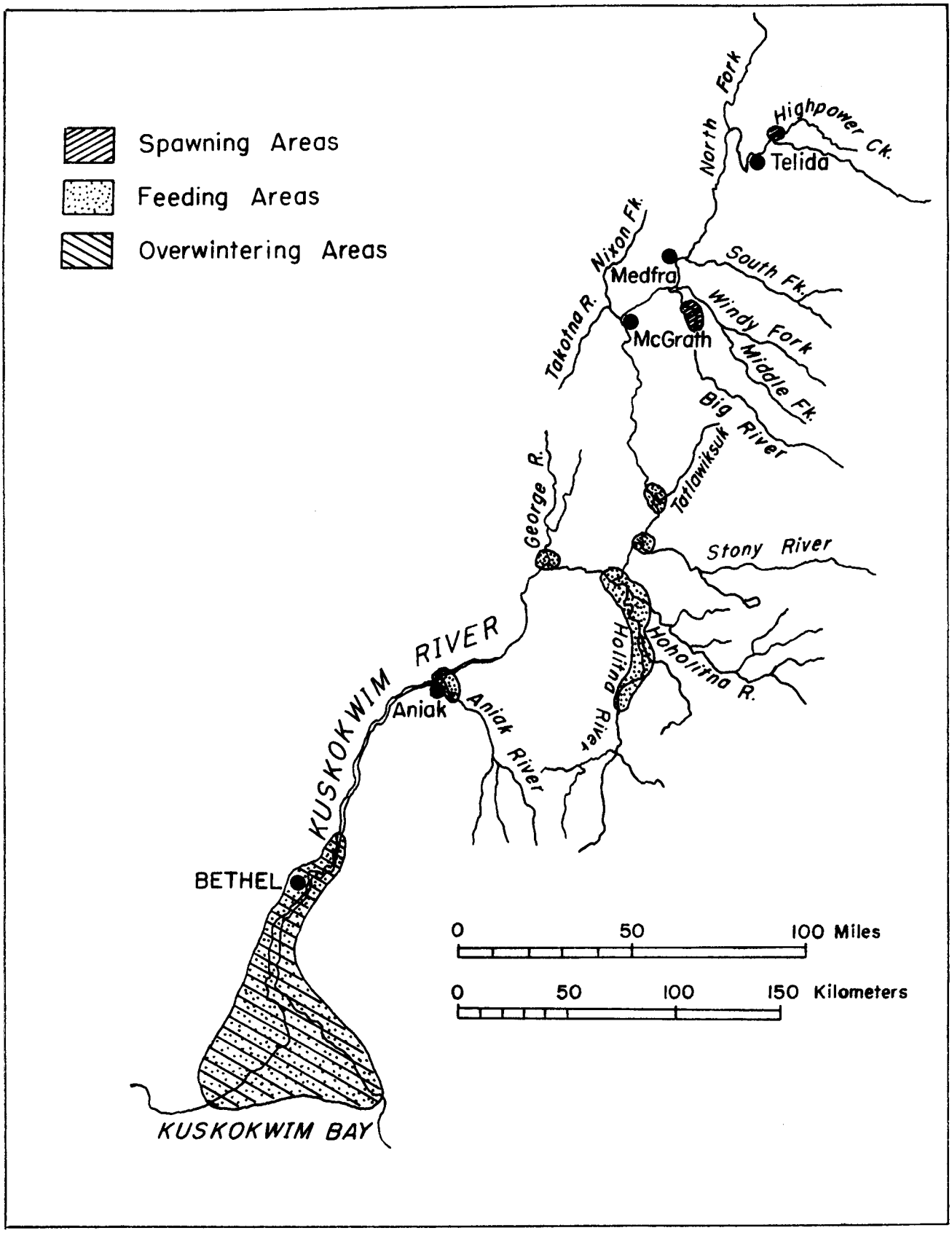

Fig. 3. Location of important spawning, feeding and overwintering areas of Kuskokwim River sheefish.

mi of the Holitna River and probably other tributary mouths such as the Aniak and Tatlawiksuk River. The spawning run past Aniak is quite protracted. In late May 1975 and on June 16, 1980 I caught many prespawners and one nonspawner feeding at the mouth of the Aniak River, thus spawners are probably coming up past Aniak throughout June. In July and August feeding prespawners move out of the Holitna River and migrate toward spawning grounds. Feeding ceases in July, and the prespawners taken in McGrath in July and August all have empty stomachs. The spawning population begins to reach the mouth of Big River in late July and August and probably arrives in the vicinity of the spawning grounds in August and September. The portion of the population spawning in Highpower Creek has a greater distance to travel and does not reach Telida until early September. They are in the vicinity of the spawning grounds by late September. By late August and early September feeding fish in the Holitna River and other tributary streams are migrating slowly downstream toward overwintering grounds. A few feeding fish are still up the Holitna and Hoholitna Rivers as late as early October and it is likely that a few individuals overwinter in the deep holes of the upper and middle Kuskokwim River. Spawning occurs in Highpower Creek and Big River in early October. These are probably the only two spawning grounds in the Kuskokwim system. Spent fish then migrate downstream to overwintering areas and reach the Bethel area and Kuskokwim Bay in December and January. Sheefish are non-consecutive spawners and the majority of females spawn once every 2 years and possibly once every 3 years for older fish. Fry leave with the spring floods and probably migrate to the lower Kuskokwim River for rearing. No Age 0, I or II sheefish have been captured in the Kuskokwim.

Management Implications:

Historically and presently the greatest use of sheefish on the Kuskokwim River has been for subsistence. Some fish are taken with under-ice net sets and some others are captured during the upstream migration. With the proliferation of the commercial fishery on the lower Kuskokwim River in the past 10 years, considerably more sheefish have been caught incidental to salmon. The subsistence use of chinook salmon nets (8' stretch mesh) prior to the chinook salmon commercial season has cropped many of the large prespawning females from the population before they reach the spawning grounds. Because sheefish have a protracted upstream migration they are vulnerable for a long period of time. Area residents have complained that Telida people are severely depleting the spawning population in lower Highpower Creek. We have no actual figures on subsistence harvest since 1971. Sport fishing pressure on the Holitna River has increased only slightly from 1971 (Alt, 1972). Guided fishermen now account for most of the man days of fishing, followed by local residents. The most recent trend is a decrease in effort directed toward sheefish as sport fishing preference is now for the chinook salmon. We have no exact figures on the size of the Kuskokwim River sheefish population but it is quite small. Results of the population dynamics study on the Holitna River are encouraging in that large numbers of small sheefish as well as some very large sheefish have been observed in the past few years. Large (over 25 lbs) spawning females have been able to reach the spawning grounds at Big River but the skewed sex ratio (6 females to 27 males) may indicate that

subsistence fishing is taking an inordinate number of females. Age structure of the spawning population includes six to seven age classes of males and only three to four age classes of females. The presence of seven age classes of males and the young age at which they are recruited into the spawning population is a healthy sign. In contrast, the small number of age classes of females and the late age at maturity suggests that the population could be in jeopardy. Under no circumstances should a commercial fishery be allowed.

Synthesis of Sheefish Movements in Lower and Middle Yukon River

Summaries of tag recovery information for lower Yukon and Koyukuk River sheefish were published by Alt (1977) and summaries of middle Yukon River tagging studies conducted from 1972-1975 were published by Alt (1976). The few tag recoveries generally support the original hypothesis that the lower Yukon River population contains fish overwintering in the lower Yukon River and traveling up the Yukon River above Rampart and to the Koyukuk River to spawn. Sixteen recoveries of fish tagged in 1974 at Marshall (lower Yukon River) or Rampart (middle Yukon) were made in various areas of the lower Yukon River between January and July 1976-1978. Eight additional recoveries of fish tagged at the mouth of the Nowitna River from 1972 to 1974 were made between 1976 and 1979. All were made in the same location as tagged. No fish tagged at Marshall or at Rampart have ever been recaptured at the Nowitna River mouth. In 1974, two sheefish tagged at the Nowitna River mouth had been recovered at Tanana and Rampart. This indicates that there is some slight intermingling of the local Nowitna population and the anadromous lower Yukon River population.

Test netting and hook and line fishing in the lower 40 mi of the Andreafsky River from 10-14 June took no sheefish. Residents of St. Marys indicate that occasionally a few sheefish enter the lower Andreafsky River, but sheefish apparently do not use the river for spawning. An early spring upstream migration of sheefish occurs in the main Yukon near St. Marys during breakup and before the chinook salmon run. The migration is composed mainly of spawners and is of short duration. A few stragglers are moving upstream with the chinook salmon and four of these (prespawners up to 10 kg) were examined from the lower Yukon River. They were in excellent condition. Test nets in various areas of the lower Yukon during June were averaging from 0.25 to 1.0 sheefish per net night. These fish were mainly prespawners. Evidently, after the main upstream spring migration, a few fish still remain in the lower river and travel upstream slowly as summer progresses. Also many lakes and sloughs in the lower river contain summer populations of immature and non-consecutive spawning sheefish. The heaviest fishing pressure on sheefish for subsistence use occurs under the ice in November and December. Fish captured are mainly immature or non-spawners, indicating that spent fish have not yet returned from spawning grounds up the Koyukuk River and in the area above Rampart. The spent fish evidently reach the lower Yukon and the ocean under the ice in January or later. Drew Crawford (ADF&G, Commercial Fish Division, Emmonak) said that major late winter and spring movements in from the ocean are in the lower mouth (Sheldon Point) and the upper or North mouth (Kotlik).

The Melozitna River was floated from July 21 to 23 from Hot Springs Creek to the mouth (≅ 55 miles). No sheefish were found above the Melozitna Canyon and it is unlikely that sheefish would be able to surmount the rapids. Gravel and current above the canyon did not appear suitable for sheefish spawning. Approximately 1 mi below Grayling Creek (8 mi up from the mouth), sheefish were hooked on rod and reel but could not be landed. They were resting in a deep hole at the edge of the current and the six fish that were hooked all appeared to be in the 3-6 kg range and were assumed to be prespawners. A number of other sheefish were hooked in the area 3-5 mi upstream but none were landed. Most of the sheefish at the Melozitna mouth had left and only a single 4 kg prespawning male was taken by hook and line. In 1979 sheefish were observed in the lower Melozitna on June 19 but none were captured.

On June 27, 1979 numerous sheefish were hooked at the Melozitna mouth but only an Age XII 100 cm 11.34 kg prespawning female and a 72 cm 1.82 kg prespawning male were captured. Thus it appears that all sheefish found at the mouth of the Melozitna in June and July are prespawners. It is not known if they spawn in the lower 8 mi of the Melozitna or simply use it for a resting area before migrating further up the Yukon River to spawn. There appeared to be some suitable spawning gravel in the area 6-8 mi up the Melozitna River. The author feels that the Melozitna fish are part of the lower Yukon River population which have migrated up from the lower Yukon River and reach the Melozitna in late June-early July. They do not feed in the Melozitna but merely rest there before migrating further up the Yukon River to spawn. At the time they are not considered a local population as are the Nowitna or Innoko sheefish.

Two prespawning sheefish were captured at the mouth of the Tozitna River (6 mi below Tanana) in late June 1980. The fish had empty stomachs. No survey work has been conducted on the upper Tozitna but it does not appear to be a suitable spawning stream. The author feels that these fish will also migrate further up the Yukon River to spawn and can be considered part of the anadromous Lower Yukon population.

Data collected in the middle Yukon River survey in 1979 and 1980, work done previously (Alt, 1973, 1975, 1977, 1978, 1979, 1980) tend to substantiate earlier opinions of the population status of lower and middle Yukon River sheefish. That is, that there is a population of anadromous sheefish comprised of large numbers of individuals as well as smaller locally occurring populations within the range of the anadromous population. The anadromous population is called the Lower Yukon population. Overwintering and rearing grounds are in the lower Yukon River, feeding areas are in the lower and middle Yukon River and spawning areas are located in the upper Koyukuk and Alatna Rivers and in the Yukon River somewhere above Rampart. A segment of this population may spawn in the Melozitna River. Local spawning populations exist in the Nowitna, Porcupine, and Tanana Rivers and probably also in the Innoko River. During summer and fall (until freeze-up) immature sheefish are found scattered throughout the lower and middle Yukon River. These feeders are generally found in slack water areas of the main Yukon and in mouths of tributary rivers. Their relationship with local populations and the lower Yukon population is not fully understood,

but presently I feel they are feeding members of the lower Yukon River population.

Research will be conducted in the Innoko River in 1981 and 1982 to further clarify the population status of these sheefish. Future work also needs to be initiated to verify population status of the Melozitna fish and to locate spawning grounds of the anadromous segment spawning upstream of Rampart.

Sheefish Utilization

Holitna River:

Because of extremely high water levels all summer, sport fishing pressure was quite light. Guided fishermen still make up the bulk of the fishing public, with local residents the next most numerous group. From June 25 to July 1 in 15 man-days of fishing, 60 sheefish were caught on hook and line, of which fewer than 10 were killed. Through conversation with guides and local residents it appeared that the total kill during 1980 was less than 100 fish.

Subsistence fishermen were getting about one sheefish per day in their salmon nets set at the mouth of the Holitna and in the lower Holitna River.

Kobuk River

Local residents of upper Kobuk River villages reported large numbers of airplane anglers from Fairbanks and Anchorage fishing for sheefish. No estimate of total number of airplanes or anglers was given. In late August one airplane (two people) and two parties of kayakers (12 people) were observed on the river.

Sheefish subsistence data are being collected by the Subsistence Section of the Department of Fish and Game. Subsistence utilization appears to have remained stable during past years.

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