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STATE OF ALASKA

Jay S. Hammond, Governor

Annual Report of Performance for

INVENTORY AND CATALOGING OF ARCTIC AREA WATERS

by

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RESEARCH PROJECT SEGMENT

State: Alaska Name: Sport Fish Investigations of Alaska.

Project No.: F-9-7

Study No.: G-I Study Title: INVENTORY AND CATALOGING

Job No.: G-I-I Job Title: Inventory and Cataloging of Arctic Area Waters

Period Covered: July 1, 1974 to June 30, 1975

ABSTRACT

Final results of a four year Arctic char, Salvelinus alpinus, tagging study initiated in 1971 in the Sagavanirktok River drainage are presented.

A brief study found tagging and handling mortality to be 6.7%. A total of 5,759 Arctic char was tagged in 1971 and 1972. During 1972-1974, recovery efforts captured 12,297 adult char in the Sagavanirktok River drainage, of which 464 (3.8%) had previously been tagged. In addition, 32 tagged char were recovered in the Sagavanirktok Delta, Colville and Canning rivers, and along the Beaufort Sea coast between Barrow and Barter Island. The tagging study indicates that reproductive homing of Arctic char is highly specific.

The sex ratio of adult char was found to be imbalanced with a disproportionately high number of females in the anadromous population. Most char are nonconsecutive spawners, although a small number spawn in consecutive years. A large proportion of nonconsecutive spawners probably spawn in alternate years.

A large aggregation of nonspawning char in the Ivishak River system was composed of char from all spawning grounds in the Sagavanirktok River system and may represent the entire mature, nonspawning segment of the Sagavanirktok River char population.

Tagged char captured along the Beaufort Sea coast indicate that Sagavanirktok River char feed near shore between Barrow and Barter Island.

Tag recoveries indicate that interdrainage exchange of Arctic char occurs, but it is infrequent.

Mean length of char collected in the Sagavanirktok River drainage has increased annually. Data indicate that this increase is due to a shift

in age structure of the populations caused by a lack of three consecutive year classes.

The mean annual growth increment of 365 tagged char was 26.3 mm. Age and length data are presented for Arctic grayling, Thymallus arcticus, captured in various North Slope drainages. Similar data are also presented for round whitefish, Prosopium cylindraceum, captured in the Ivishak River system.

An overwintering study of fish in the Sagavanirktok River drainage was initiated.

The Kongakut River, a large stream in the Arctic National Wildlife Range, was surveyed the last week of August. Char spawners and grayling were abundant throughout the drainage. Considerable sport fish potential exists but use to date is nonexistent.

A traditional Eskimo winter fishery on the Hulahula River was monitored for a week in late April. Char and grayling were captured.

Monitoring and technical advisory function were carried out during initial construction phases of the Trans-Alaska Oil Pipeline.

RECOMMENDATIONS

1. Conduct a fish overwintering habitat survey and attempt to observe and capture Arctic char in the Sagavanirktok River drainage.

2. Determine the status of the adult char in the lower Echooka River in late May and early June.

3. Survey the Kuparuk River headwaters and conduct population estimates, and an age and growth study on Arctic grayling in this river.

4. Monitor the sport fishery for Arctic char in the Prudhoe Bay area.

5. Continue annual aerial index counts of char in the Sagavanirktok drainage and initiate an aerial survey of char in the Canning River drainage.

6. Monitor near shore fish movements in the Beaufort Sea between Harrison Bay and Flaxman Island.

OBJECTIVES

1. Continue enumeration of char populations in the Sagavanirktok River system and at the same time complete spawning migration aspects of char life history.

2. Begin overwintering life history aspects for char in the Sagavanirktok River system.

3. Continue assessment of the existing and potential fishery waters on the North Slope, especially those adjacent to the proposed Trans-Alaska Oil Pipeline, haul road, oil drilling sites, and those adjacent to the proposed Arctic Gas pipeline, including important waters of the Arctic National Wildlife Range.

4. Determine present utilization of sport and subsistence fisheries of the North Slope and Brooks Range waters.

5. Monitor and evaluate development projects involving water use and their effects on North Slope waters.

TECHNIQUES USED

Fish populations were sampled with 125' x 6' (38.1 x 1.8 m) graduated mesh gill nets of 1/2-2 1/2 inch (1.3-6.3 cm) square mesh.

Fish up to 2,610 g were weighed to the nearest gram on a triple beam balance. Larger fish were weighed on a Hansen 895 spring scale. Fork lengths were measured to the nearest mm.

Sex and state of maturity of sampled fish were determined by examination of gonads. Maturity was based on size, color, and consistency of gonads, and egg diameter.

Maturity and sex of live char were determined by sexual dimorphic characteristics. In some cases immature fish were impossible to separate from mature but nonconsecutive spawners.

Maturity categories are:

Potential spawner - will spawn in the year of capture.
Nonspawner - adult, nonconsecutive spawners; some large immatures which could not be separated.
Immature - juvenile, determined by gonadal examination.

Otoliths were used for age determination of char, as described by Heiser (1966), except that xylene was used as the wetting agent. Scales were used to determine age of all other fish.

All meristic measurements were taken according to Hubbs and Lagler (1958). Fish were tagged with spaghetti tags and Floy internal anchor tags.

Aerial counts of adult char in the Sagavanirktok River system were made from a 206B Jet Ranger helicopter. Tagged char were recaptured with bag seines, gill nets, tangle nets, rifle, and hook and line.

INTRODUCTION

Fish studies were necessitated by proposed construction of the 789 (1,348 km) mile long Trans-Alaska oil pipeline from Prudhoe Bay to Valdez. On the Arctic North Slope the pipeline parallels the west bank of the Sagavanirktok River for more than 140 miles (225 km), crossing many tributaries, and presents considerable potential for adversely affecting fish populations along the route. Thus in 1971 a four year life history study of Arctic char in the Sagavanirktok River system was begun. Concurrently, a general assessment of fisheries in the region (Fig. 1) was conducted. The initial two years of the project were completed by Yoshihara (1972, 1973). The third year of study was reported by Furniss (1974) and this report marks the completion of four years of the char life history study.

Much of this project concerns fisheries and fisheries related work on the North Slope. By cooperating with other agencies, including the oil companies involved, much more work was accomplished than might have otherwise been done. Accordingly, this material is presented as a separate report, entitled Prudhoe Bay Study.

During the last two years of the study, spawning aspects of char life history were emphasized. Char spawning areas in the Sagavanirktok River drainage were first identified by McCart et al. (1972) and Yoshihara (1973). It was found that Arctic char spawning grounds within the Sagavanirktok River system are restricted to spring areas within the foothills of the Brooks Mountain Range. Large aufeis areas (extremely thick ice created by spring water overflow) are generally located immediately downstream.

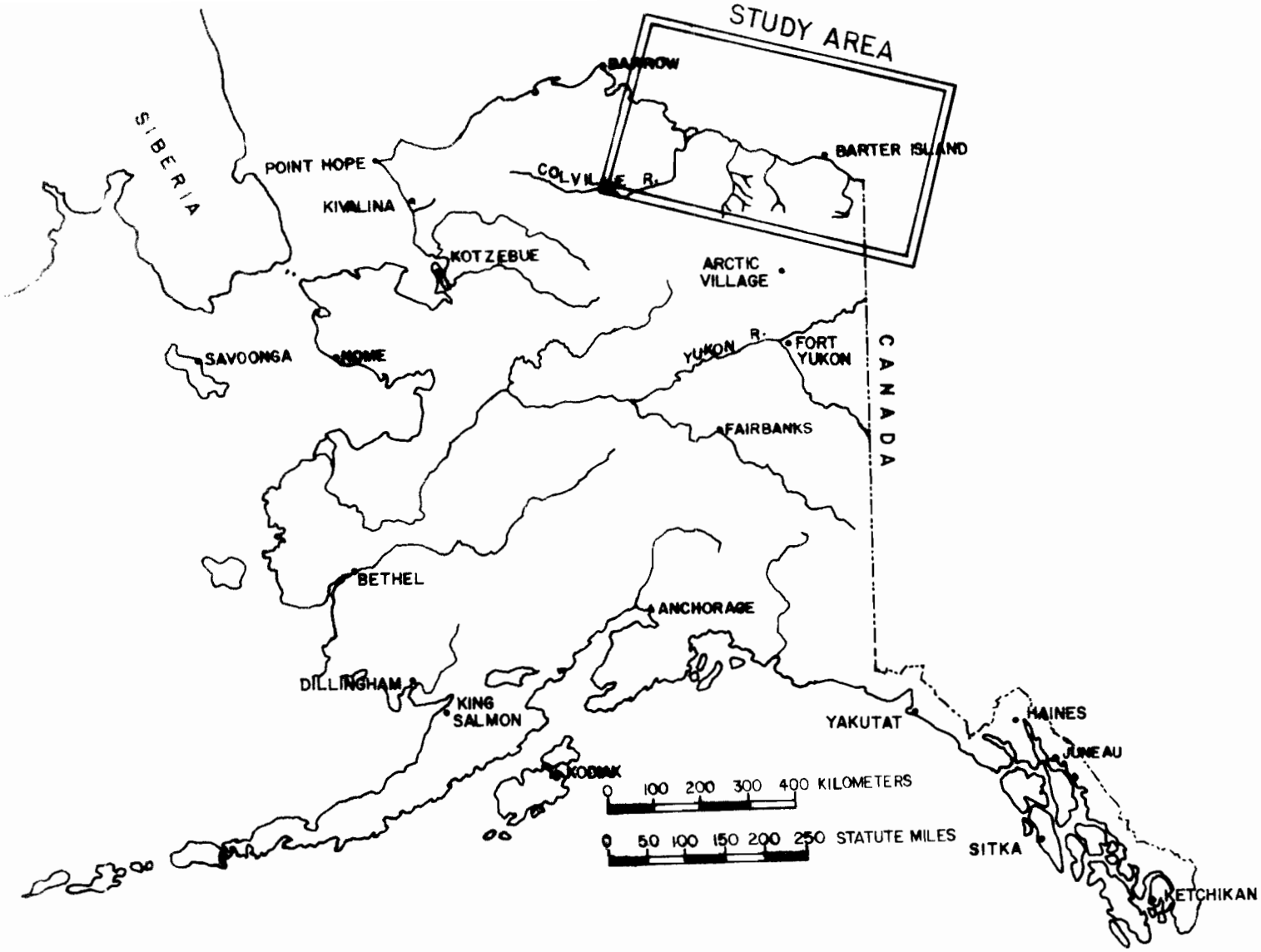

Figure 1. Map of Alaska Showing North Slope Study Area.

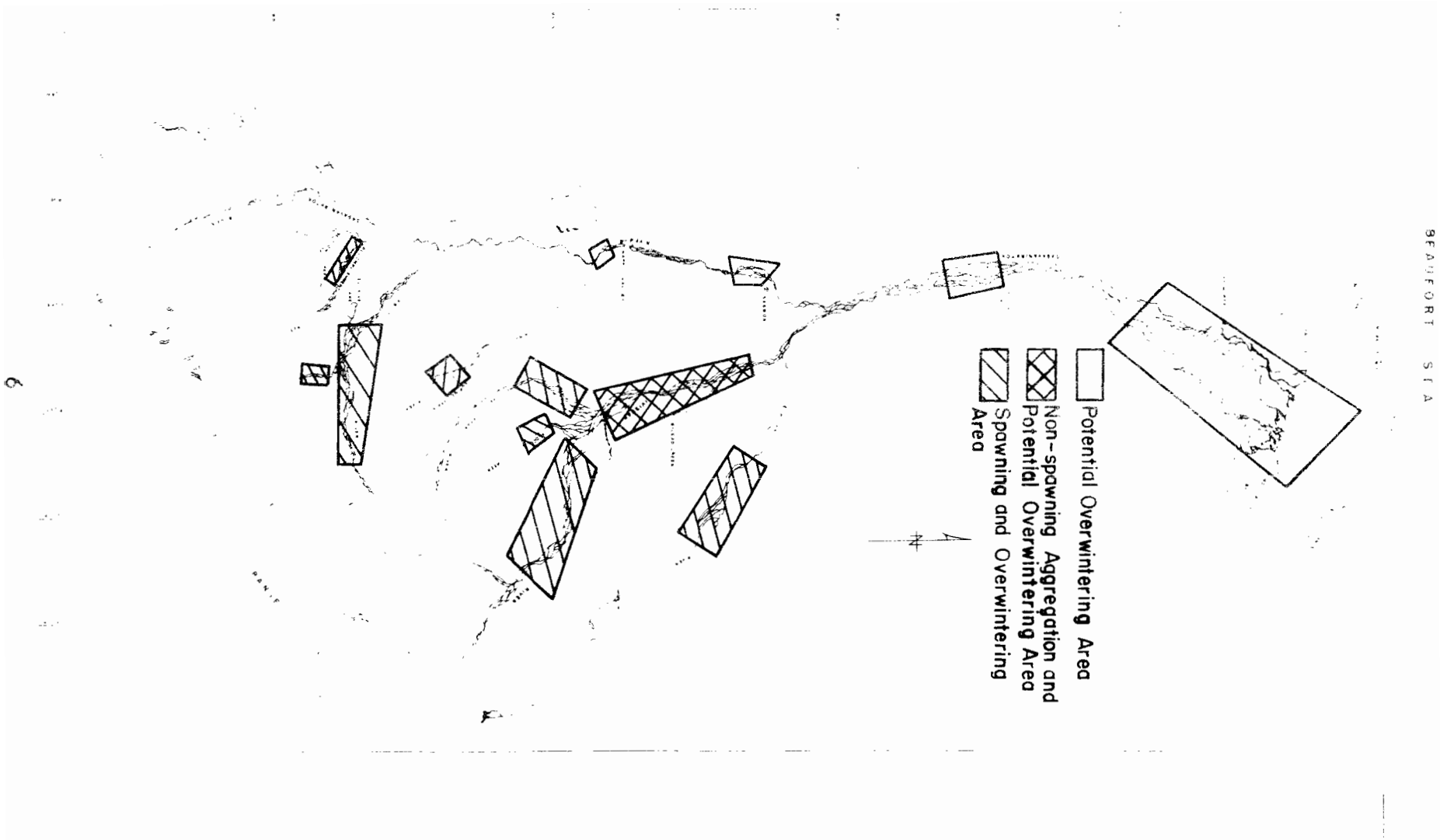

Figure 2. Major Arctic Char Spawning Grounds, Area of Non-spawning Aggregation and Potential Overwintering Areas in the Sagavanirktok River Drainage.

Summer water temperatures in the springs range from 2.8 to 9.2°C (Childers et al., 1973). The winter temperature sometimes drops to slightly below 0°C but no icing occurs, thus assuring survival of ova and alevins.

Major Arctic char spawning grounds in the Sagavanirktok River system are located adjacent to springs at Echooka River, Ivishak River, Saviukviayak River, Flood Creek, Lupine River, Ribdon River, and Accomplishment Creek (Fig. 2). Since 1971 char have consistently utilized the same spawning locations and appear to be using all suitable areas within the Sagavanirktok River system.

Surveys of other drainages indicate that suitable spawning habitat is extremely limited in all char producing drainages of the North Slope.

As a part of the char life history study in the Sagavanirktok River system, a study of tagged char was begun in 1971. The study encompassed the area from Barrow to Barter Island (Fig. 3) but work was concentrated in the Sagavanirktok River drainage.

The objectives of the tagging study were:

1) Determine the specificity of homing to spawning areas.

2) Determine the spawning frequency of Arctic char.

3) Determine homogeneity of the Ivishak River nonspawning char aggregation.

4) Determine migration patterns and extent of feeding migration along the Beaufort Sea coast.

5) Determine extent of interdrainage exchange of anadromous char on the North Slope.

6) Assess yearly growth increment of the char population and evaluate the validity of growth increment measurements from tagged char.

In addition, data concerning size, sex ratio, timing, length of spawning season, and age structure were gathered to support data previously gathered by Yoshihara (1972, 1973).

The first phase of the char tagging study consisted of tagging 5,759 Arctic char in 1971 and 1972 (Yoshihara, 1972, 1973). A total of 4,807 char was tagged in the eastern tributaries of the Sagavanirktok River. The remainder were tagged principally in the Sagavanirktok River delta. No tagging was done after 1972.

A tag recovery program was conducted in 1972, 1973, and 1974 as the second phase of the project. Tag recoveries in 1972 were made while specimens were collected for tagging. Forty-seven char tagged in 1971 were recovered (40 in the Sagavanirktok system) in 1972. Tag recovery operations in 1973 and 1974 were conducted during September, primarily at known spawning and nonspawning concentrations of char in the eastern tributaries of the Sagavanirktok River system (Fig. 2). Tag recoveries were also made along the Beaufort Sea coast by sport, subsistence, and commercial fishermen and by biologists conducting other fish studies.

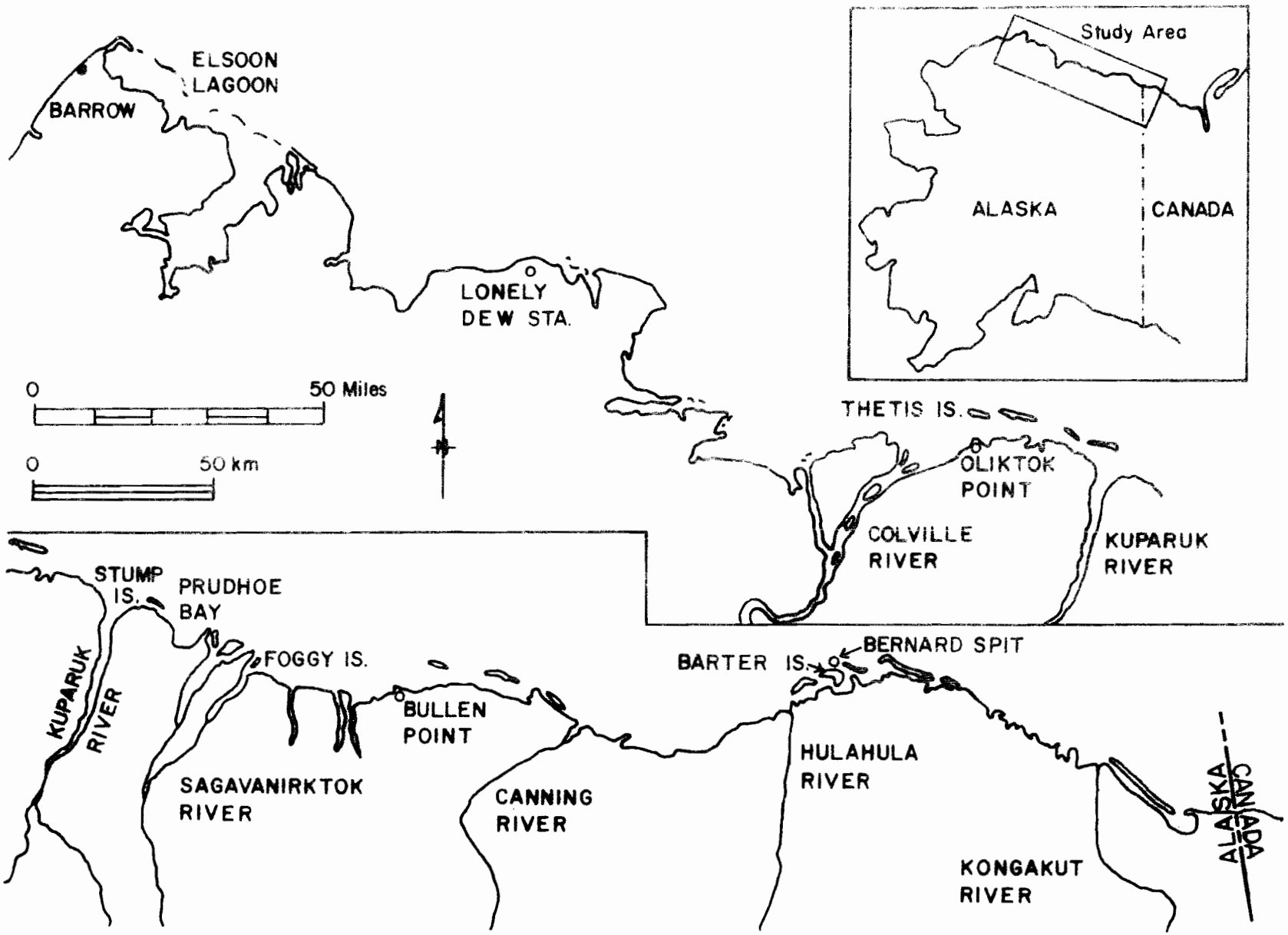

Figure 3. Beaufort Sea Coastline in Area of Study from Point Barrow to Canadian Border.

During the three year tag recovery program, a total of 12,297 adult Arctic char was captured in tributaries of the Sagavanirktok River. Of these, 464 (3.8%) had been previously tagged (Table 1). In addition, 32 tagged char were recovered in the Sagavanirktok delta, Colville and Canning rivers, and along the Beaufort Sea coast between Barrow and Barter Island. Of the 496 total tag recoveries made, 474 were usable in some aspect of final analysis.

The best spawning frequency data were collected from Accomplishment Creek in 1972-1974. A minimum of 40% of the char population was tagged there in 1971 and 1972. The shallow and limited nature of the Accomplishment Creek spawning area facilitates char recovery. Probably 40-80% of the entire spawning population (estimated maximum of 1,000 fish) was sampled each of the three years of recovery effort.

In addition, char tagging and recovery in the Lupine River also provided substantial data. Some data were obtained from other spawning grounds, but conclusions are less detailed.

The location of potential fish overwintering areas and the degree these areas are utilized by fish has become an important factor in the proper management of the fishery resource now that haul road and pipeline construction has begun to alter the hydraulics of Arctic rivers.

Fish overwintering areas in the Sagavanirktok River drainage are extremely limited since much of the river is frozen to the bottom during the winter. The river averages less than 6 feet in depth, while winter ice has been found to be as deep as 9 feet. It has long been recognized that little knowledge exists about the overwintering of Arctic fishes. Identification of potential sites and verification in the winter that these sites have the physical properties to support fish throughout the winter was begun in September 1974.

FINDINGS

Arctic Char Aerial Index Counts

Annual aerial index counts of Arctic char in the Sagavanirktok River system were conducted between September 10-23, 1974. Weather conditions were good to excellent. Counts were made when the water was clear and wind was minimal.

Index counts made in 1974 are similar to those made in previous years (Table 2), indicating that the char numbers and distribution are stable.

Table [illegible] Number of char captured, tagged and recaptured in the Ivishak River system from 1971 to 1974.

	Total Tagged		1972		1973		1974	
	1971	1972	Untagged Captures	Tagged Recaptures*	Untagged Captures	Tagged Recaptures*	Untagged Captures	Tagged Recaptures*
Accomplishment Cr	462	375	383	12	787**	92	336	80
Lupine River	614	111	164	2	612**	84	140	16
Ivishak River Main Stream (nonspawner)	1,033	1,992	2,569	22	2,961	71	2,026	38
Spawning grounds above Flood Creek	0	0	?	1	125	2	288	14
Echooka River	0	128	133	0	458**	6	383	10
Flood Creek	0	0	0	0	79	0	24	0
Saviukviayak River	0	0	0	0	45	0	225	11
Ribdon River	0	92	93	3	42	0	0	0
Total	2,109	2,698	3,342	40	5,109	255	3,422	169

* Some tag recaptures were not used in final analysis because the tags were illegible.
** Includes about 100-150 char that were captured twice.

Table 2. Comparative Aerial Counts of Char in the Sagavanirktok River Systems from 1971 to 1974.

Location	1971	1972	1973*	1974*
Accomplishment Creek	178	322	512	505
Ribdon River-Main Stem	400	467	123	240
-South Fork	49	276	1,183	1,330
Lupine River	Few	...	318	260
Saviukviayak River	321	378	264	650
Flood Creek	350	508	512	370
Echooka River	1,137	1,688	1,883	2,160
Ivishak River				
Echooka to Flood Creek**	12,470	11,937	8,992	11,000
Upstream From Flood Creek	1,488	...	1,017	2,140***

* These counts are average figures for counts by two observers.
** Approximately 95% nonspawners
*** Approximately 40% nonspawners.

Arctic Char Tagging Studies

Tagging and Handling Mortality:

A test of mortality caused by tagging and handling was conducted September 17-20, 1974. Fifteen nonspawning char (5 males, 10 females) ranging in size from 397-648 mm were captured by bag seine in the Ivishak River, measured, tagged with spaghetti tags, and placed in a 8' x 6' x 4' (2.4 x 1.8 x 1.2 m) holding pen of 1/4" (0.64 cm) nylon netting. Each fish was held out of the water for about 45-60 seconds. The pen was located in a quiet backwater with little current. Water temperature was 7°C. After 15 hours of holding, one female char had died. No further mortality occurred during the 72 hour holding period. The remaining 14 fish released alive appeared normal and healthy.

Mortality due to tagging and handling was 6.7%. The sample size is small but the test indicates that under similar conditions tagging and handling mortality of char probably ranges from 5 to 10%.

A test was made to evaluate mortality associated with opercular bone removal which could be an alternative aging method.

Another 15 char (5 males, 10 females) ranging in size from 403 to 619 mm were handled identically to fish in the previous experiment, except that their left opercular and sub-opercular bones were removed by scissor cuts. After 15 hours of holding, five females and one male had died. No subsequent mortality occurred during the 72 hour holding period. The over-all mortality of handling, tagging, and removing the opercular bone was 40%.

Specificity of Homing to Spawning Areas:

The tagging study indicates that reproductive homing of Arctic char is highly specific. Of 306 tagged char recovered on the Sagavanirktok River drainage spawning grounds, 255 had been tagged and recaptured at the same spawning location, 50 were nonspawners or enroute to spawning grounds when tagged, and only one char was known to have spawned in two different tributaries (Table 5). The only char that did not home back to the location where it had initially spawned was tagged in Accomplishment Creek in 1972 and recovered in a spawned out condition near Gilead Creek in the Ivishak River in 1974. Probably it had spawned somewhere upstream of the recovery location.

Similarly, Armstrong (1974) has found that anadromous Dolly Varden exhibit a high degree of reproductive homing in southeast Alaska.

Sex Composition of Spawners:

The sex composition of spawning char in the Sagavanirktok River system is imbalanced with a disproportionately large number of females in the anadromous population (Table 4).

Table 5. Number and Original Tagging Location of Tagged Char Spawners Recovered at Spawning Grounds in the Sagavanirktok River System, 1972 to 1974.

Recovery Location	Year(s)	Original Tagging Location	Number
Accomplishment Creek	1972-1974	Accomplishment Creek	171
		Ivishak River nonspawning area	6
		Beaufort Sea (Foggy Is, Pt Barrow, Prudhoe Bay)	3
Ribdon River	1972	Ivishak River nonspawning area	2
		Beaufort Sea (Foggy Island)	1

Table 3. (cont.) Number and Original Tagging Location of Tagged Char Spawners Recovered at Spawning Grounds in the Sagavanirktok River System, 1972 to 1974.

Recovery Location	Year(s)	Original Tagging Location	Number
Lupine River	1972-1974	Lupine River	84
		Ivishak nonspawning area	14
		Prudhoe Bay	1
Savinkviayak River	1974	Ivishak River nonspawning area	11
Ivishak River Spawning Ground	1972-1974	Ivishak River nonspawning area	10
		Lupine River uptrap(nonspawner)	1
		Sagavanirktok River Delta (DS-4)	1
		Accomplishment Creek (spawner)	1

Spawning Frequency of Arctic Char:

The tagging study confirmed that char spawn both consecutively and nonconsecutively in the Sagavanirktok River system. The data substantiate the earlier belief (Yoshihara, 1973) that most char spawn in nonconsecutive years. Spawning frequency could be determined in 384 of 438 tagged char recaptures examined (Table 5). Of those for which spawning frequency was determined, 365 (95.1%) were nonconsecutive spawners. Two hundred-thirty three (63.8%) of the nonconsecutive spawners were alternate year spawners. Only 19 of the 384 (4.9%) char recaptures (for which spawning frequency was determined) were confirmed consecutive spawners.

Nonconsecutive Spawning:

In 1973 about 700 spawning char (approximately 70% of the entire population) were captured in Accomplishment Creek. Eighty-eight readable tags were recovered, of which 85 were classed as nonconsecutive spawners.

Results of the 1974 tag recaptures at Accomplishment Creek were similar to results of 1973. Of 416 char captured in 1974, (about 50% of the spawning population) 80 had been previously tagged. Seventy-five of the 80 tagged char were classed as nonconsecutive spawners (Table 6).

Eighty-one of 83 tag recoveries in Lupine River springs during 1973 were classed as nonconsecutive spawners.

Table 4. Sex Composition, Spawning Condition, and Length Data for Char from the Sagavanirktok River System, September 1974
Number in parentheses is percentage of total.

Location	Date		Sample Number	Sex Composition		Spawning Condition					Length	
				Male	Female	SO	R	GR	NS	IM	Range	Mean
Accomplishment Cr	Sept 21	untagged	238	59(25)	179(75)	117(49)	107(45)	10 (4)	1(0.4)	3(1)	311-726	55
		tagged	80	11(14)	69(86)	46(58)	32(40)	1 (1)	1 (1)	0	488-645	556
Ivishak Spawning Ground	Sept 20	untagged	188*	41(22)	147(78)	15(14)	69(64)	24(22)	0	0	448-773	544
		tagged	14	5(36)	9(64)	1 (7)	9(64)	4(29)	0	0	486-663	547
Ivishak River Main Stem	Sept 17	untagged	1,888**	715(38)	1,173(62)	2(0.1)	16(0.9)	4(0.2)	1,854(99)	0	326-663	522
		tagged	38	13(34)	25(66)	1 (3)	0	0	37(97)	0	453-651	548
Echooka River	Sept 18	untagged	231***	65(28)	166(72)	3 (2)	84(45)	98(53)	0	0	470-687	545
		tagged	10	3(30)	7(70)	0	8(80)	2(20)	0	0	509-650	570
Lupine Springs	Sept 13	untagged	140	35(25)	105(75)	15(11)	45(32)	80(57)	0	0	450-710	553
		tagged	16	2(13)	14(87)	7(44)	3(19)	6(38)	0	0	500-640	542
Saviukviayak River	Sept 15	untagged	199	47(24)	152(76)	...	...	...	3 (2)	5(3)	...	...
		tagged	11****	3(27)	8(73)	0	9(82)	2(18)	0	0	518-624	563

SO - spawned out
R - ripe
GR - green
NS - nonspawner
IM - immature

*n = 108 for length and spawning condition
**n = 132 for length; spawning condition is given for 22 of 34 spawners collected in the area.
***n = 185 for length
****n = 9 for length data

Table 3. Spawning frequency of Arctic Char in the Sagavanirktok River Drainage as determined by Tag Recoveries. Numbers in parentheses are percent of total recoveries for the listed year. Spawning frequency was unknown in an additional 19 males and 55 female char collected.

Locations	Recapture Year	Spawning Frequency of Tagged Recaptures*												Total	
		Consecutive**				Nonconsecutive Spawning: Alternate Year				Nonconsecutive Spawning: Undetermined Freq.					
		♂	%	♀	%	♂	%	♀	%	♂	%	♀	%	♂	♀
Accomplishment Cr	1972	0		7	(58)	...	...	...	...	1	(8)	3	(25)	1	10
	1973	1	(1)	2	(2)	13	(15)	69	(78)	0		3	(3)	14	74
	1974	...	...	...	...	7	(9)	66	(83)	1	(1)	1	(1)	8	67
Ribdon River	1972	0		0		...	...	...	...	2	(66)	0		2	0
Lupine River	1972	0		1	(50)	...	...	...	...	1	(50)	0		1	1
	1973	0		2	(2)	16	(19)	53	(64)	5	(6)	7	(8)	21	62
	1974	...	...	...	...	0		6	(43)	0		1	(7)	0	7
Ivishak River Spawning Ground	1972	0		0		0		0		0		1	(100)	0	1
	1973	0		1	(50)	0		0		0		0		0	1
	1974	...	...	...	...	0		0		0		0		0	0
Echooka Springs	1973	0		3	(50)	0		0		2	(33)	1	(17)	2	4
	1974	...	...	...	...	0		3	(30)	2	(20)	2	(20)	2	5
Ivishak River (nonspawning area)	1972	0		0		0		0		5	(23)	6	(27)	5	6
	1973	0		2	(3)	0		0		16	(27)	42	(70)	16	44
	1974	0		0		0		0		7		23		7	23
Total		1		18		36		197		42		90		79	305

* Includes only fish determined to be mature or those which could not be determined as mature but which are greater than 400 mm fork length.

** Sampling method nearly eliminated the opportunity to capture consecutive spawners in 1974 - see text under "consecutive spawners".

Tag recoveries from the Ivishak River nonspawning aggregation further reinforced the findings of spawning ground recoveries. Of 117 recaptures, 99 were classed as nonconsecutive spawners (Table 5).

The percentages of total tags recovered by year of tagging and year of recapture (Table 7), also indicate that alternate year spawning occurs more frequently than consecutive spawning.

Of 462 char tagged in Accomplishment Creek in 1971, 82 (17.8%) were recaptured there in 1973, and all appeared to be alternate year spawners. Of 81 nonconsecutive spawners captured at Lupine Creek in 1973, 69 (85.2%) were probably alternate year spawners.

Seventy-two of 75 nonconsecutive spawners captured at Accomplishment Creek during 1974 appear to be alternate year spawners. These 72 captures represent 19.2% of the total char tagged in Accomplishment Creek in 1972.

The study could not determine what percentage of the nonconsecutive spawners spawned at infrequent intervals, but the 1974 recovery of spawners tagged in 1971 was low. Natural mortality may have been an important factor.

Consecutive Spawning:

Tag recoveries indicate that a small percentage of char spawn consecutively. Because of the design of the study, relative magnitude of consecutive spawning could only be determined from the recaptures made in 1972 and 1973.

Nineteen of 384 (4.9%) of total tag recoveries were identified as consecutive spawners in 1972 and 1973 (Table 5). Seventeen of these were captured on the various spawning grounds and two were captured passing through the Ivishak nonspawning area on their way to a spring area upstream.

Of 462 spawning char tagged at Accomplishment Creek in 1971, 7 (1.5%) were recovered as spawners in 1972. Three (0.8%) of 375 spawners tagged in 1972 were recovered as spawners in 1973.

At Lupine River springs one of 614 (0.2%) char tagged in 1971 was recovered in 1972 as a consecutive spawner. Two of 111 (1.8%) spawners tagged in 1972 were recovered in 1973 as consecutive spawners. At Echooka Springs three of 128 (2.3%) spawning char tagged in 1972 were recaptured as spawners in 1973.

Table 6. Spawning Frequency of Char Captured at Spawning Areas, Sagavanirktok Drainage, 1972 to 1974.

Location	Recapture Year	Spawning Frequency of Tagged Recaptures: Consecutive Years	Non-Consecutive Years	Unknown	Total
Accomplishment Creek	1972	7	4	1	12
	1973	3	85	0	88
	1974	0*	75	5	80
Ribdon River	1972	0	2	1	3
Lupine River	1972	1	1	0	2
	1973	2	81	0	83
	1974	0*	7	7	14
Saviukviayak River	1974	0	0	11	11
Ivishak River Spawning Ground	1972-1974	1	1	10	12
Echooka Springs	1973	3	3	0	6
	1974	0	7	3	10
Total		17	266	38	321

* Study design virtually eliminated opportunity for capture of consecutive spawners. See explanation in section on "Consecutive Spawning".

Table 7. Percent of the Char Tagged on Spawning Grounds in Accomplishment Creek and the Lupine River That Were Recaptured in the Same Location and in Spawning Condition.

Location	Year of Tagging	Number of Char Tagged	Percent of tag recoveries percent tagged char recaptured: 1972	1973	1974
Accomplishment Creek	1971	462	1.5(7)	17,8(82)	0.7 (3)
	1972	375		0.8 (3)	19.2(72)
Lupine River	1971	614	0.2(1)	11.2(69)	1.0 (6)
	1972	111		1.8 (2)	5.4 (6)

Homogeneity of Ivishak River Nonspawning Char Aggregation:

An aggregation in excess of 12,000 adult char in a nonspawning condition has been observed annually since 1971 in the main stem of the Ivishak River from the mouth of Flood Creek to the mouth of the Echooka River. It has been hypothesized that this aggregation overwinters in the Ivishak River and represents the nonspawning segment of the char population in the Sagavanirktok River drainage. Tag recoveries in 1972-1974 indicated that the Ivishak nonspawning aggregation is comprised of fish which spawn at all known spawning grounds in the system (Table 3; Table 8).

It is not known whether this aggregation represents the entire population of nonspawning char in the Sagavanirktok drainage; however, no other such aggregations have been observed.

Char Feeding Migration Along the Beaufort Sea Coast:

From late May to mid-September anadromous char migrate east and west from the Sagavanirktok River along the Beaufort Sea coast. During this time they feed heavily upon marine invertebrates, other fish, and insects.

Twenty-six tag recoveries (Table 9) made along the Beaufort Sea coast indicate that char from the Sagavanirktok River utilize the near shore areas between Point Barrow and Barter Island (Fig. 3).

Table 8. Number and Original Tagging Location of Tagged Char Nonspawners Recovered in the Main Stem of the Ivishak River System, 1972 to 1974.

Original Tagging Location	Number
Ivishak River nonspawning area	83
Accomplishment Creek	17
Foggy Island	5
Sagavanirktok River Delta (DS-4)	5
Ivishak spawning area	3
Lupine Springs	3
Echooka Springs	2
Prudhoe Bay	1
Canning River - Marsh Fork @ CS-10	1

Table 9. Date and Location of Recapture for Char Tagged in the Sagavanirktok River Drainage and Recaptured in the Beaufort Sea, 1972 to 1974.

Date Recaptured	Location Recaptured	Number of Char
June 26	Foggy Island	1
July 8, 26	Stump Island	2
August	Oliktok Point	9
July 15 to August 29	Thetis Island	3
August 17	Lonely Dew Station	1
July 26 to August 12	Prudhoe Bay	2
August 12, 15	Elson Lagoon (Point Barrow)	2
July 3, 13, Aug 4	Bullen Point	5
August 15	Bernard Spit (Barter Island)	1

Inter-System Exchange of Anadromous North Slope Char:

Tag recoveries indicate that inter-drainage exchange of Arctic char occurs, but it is infrequent. During 1972 and 1973 a fisheries research team, Aquatic Environments Ltd., conducted a fish study in the river drainages east of the Sagavanirktok River, principally the Kavik, Canning, and Firth rivers (McCart, 1974a). All three are utilized by anadromous char. They captured a large number of char in the Canning and Firth rivers and some in the Kavik River. This provided an excellent opportunity for recapture of any char which had been tagged in the Sagavanirktok River drainage and had migrated into another drainage to the east. They recovered only one char that had been tagged in the Sagavanirktok drainage. This fish, a female of undetermined sexual condition, had been tagged in the main stem of the Ivishak River in 1971 and was recaptured as a spawner September 15, 1972, in the Marsh Fork of the Canning River.

During 1972, Aquatic Environments Ltd. tagged approximately 345 anadromous char in the Canning River and 641 in the Firth River just east of the Alaskan border. In addition, they tagged about 290 char in the Canning River in 1973. Our tag recovery effort in 1972-1974 netted 11,873 untagged and 464 tagged anadromous Arctic char (Table 1), of which only one had been tagged outside the Sagavanirktok drainage. This one, a male, had spawned in the Marsh Fork of the Canning River in 1973 and was captured as a nonspawner in the Ivishak River in September, 1974. Glova and McCart (1974) report that two tagged char from the Firth River were recaptured, one each in the Canning and Kongakut rivers in Alaska. Neither of these two fish were spawners.

One char tagged in the Ivishak River in 1972 was recaptured July 30, 1973 in the Colville River near the village of Nuiqsut, approximately 15 miles upriver from the mouth. Another tagged char was captured at about the same location and time but the tag was lost. Both fish had been eaten by the time researchers arrived to obtain information from the Eskimos, thus nothing is known about their condition. However, it is likely that both char had moved into the river delta to feed, rather than stay for the winter, since there are few anadromous char in the Colville drainage (Kogl, 1971).

If inter-drainage exchange of char occurred frequently, more tagged char would have been recovered by the two groups of researchers. These data indicate that there is a high degree of homing accuracy in char. It should be noted that none of the inter-drainage recoveries had spawned in one drainage and then another. This may indicate that char are more specific in homing to spawning areas than nonspawning areas or a few spawn in one major system and then move as nonspawners to another.

Sex, Spawning Condition, and Length of Sagavanirktok River Char:

Sex composition and spawning condition (Table 4) of char captured in the Sagavanirktok River system in September, 1974, were similar to those captured in 1971 and 1972 (Yoshihara, 1972, 1973). A comparison of char length data collected at Prudhoe Bay, Ivishak River, (nonspawning aggregation), Lupine River springs, and Accomplishment Creek spawning area shows that mean length of char in the Sagavanirktok River system has annually increased (Table 10). This phenomenon was first observed in 1972 by Yoshihara (1973) and again at Accomplishment Creek in 1973 by Furniss (1974). Data indicate that this increase in mean length is due to a shift in age structure of the population, as shown in Table 11. The percentage between the two dark lines includes 73-89% of the population sampled and the three most frequent ages recorded. Each year between 1971 and 1974 there has been a one year shift of these most frequent age classes. This age structure shift is probably due to a lack of recruitment of younger age classes.

The age structure of Arctic char collected at Prudhoe Bay in the summer of 1974 (Table 11) is similar to that of Accomplishment Creek. This similarity strengthens the validity of the Accomplishment Creek observations and indicates that the situation is probably typical for all North Slope char populations, since the Prudhoe sample consisted of mixed stocks from all North Slope drainages.

These data indicate that in 1974 the ages VII, VIII, and IX char were missing. These char would have been hatched in the spring of 1965, 1966, and 1967. Ages III-IV char were strongly represented in the 1974 sample of Prudhoe Bay, indicating that the age and length structure shift is probably limited to char hatched in 1965-1967, and this phenomenon will probably not continue. The cause of mortality is not known; however, the widespread nature of the phenomenon inidcates it is likely a natural factor which affected all Sagavanirktok drainage char populations. Weather conditions would be a likely cause.

Table 10. Length Comparison of Arctic Char Greater Than 200 mm Collected From 1971 to 1974, Sagavanirktok River Drainage and Prudhoe Bay, Alaska.

Location	Year	Sample Size	Fork Length	
			Mean	Range
Prudhoe Bay	1971	1,153	437.9	200-660
	1972	131	499.4	410-650
	1973	0	0	0
	1974	175	458.0	136-679
Ivishak River (nonspawners)	1971	1,154	450.3	230-680
	1972	2,557	484.8	210-710
	1973	71*	509.0	357-604
	1974	170	527.5	326-663
Lupine River**	1971	693	500.4	200-720
	1972	114	511.9	380-670
	1973	84*	543.0	467-667
	1974	156	551.7	450-710
Accomplishment Creek	1971	274	501.9	260-620
	1972	392	516.5	360-700
	1973	355	541.4	430-690
	1974	318	551.4	311-728

* Sample comprised of tagged fish only.
** Sample excludes immature fish.

Growth of Tagged Char:

The mean annual growth of 365 tagged char from the North Slope was 26.3 mm (Table 12). The minimum time interval between measurements was set at six months to allow each fish at least one growing season between measurements.

Since the growth increment was calculated from char greater than 400 mm, it represents mature fish, mostly 7 years of age or older.

It is not known if the tagging process reduced growth of these char. Indirect evidence indicates that the effect was negligible. A comparison of mean length of tagged and untagged char from various locations (Table 4) shows that in all but one case the tagged char were slightly larger than untagged char.

Table 11. Comparative Age Structure as a Percentage of the Entire Sample of Char Spawners at Accomplishment Creek and Prudhoe Bay. Number in parentheses is sample size. The ages between the dark lines in each column encompass 73-89% of the sample.

Age Class	Accomplishment Creek 1971	1972	1973*	1974**	Prudhoe Bay 1974
V	2.8 (2)	0	0	0	***
VI	5.6 (4)	0	0	0	***
VII	18.3 (13)	0	0	4.0 (1)	11.9 (5)
VIII	22.5 (16)	20.0 (3)	2.6 (2)	0	0
IX	40.9 (29)	6.7 (1)	22.4 (17)	8.0 (2)	4.8 (2)
X	9.9 (7)	33.3 (5)	44.7 (34)	28.0 (7)	54.8 (23)
XI	0	13.3 (2)	20.0 (17)	20.0 (5)	14.3 (6)
XII	0	6.7 (1)	3.0 (2)	36.0 (9)	14.4 (6)
XIII	0	6.7 (1)	4.0 (3)	4.0 (1)	0
XIV	0	13.3 (2)	0	0	0
XV	0	0	1.0 (1)	0	0

* Includes only tagged recaptures
** Random sample of 30 fish from 300 char collected; 5 otoliths were unreadable.
*** Age Class V and VI were excluded from sample so that only mature fish would be included.

Table 12. Monthly and Annual Growth Increment of Tagged Char Greater Than 400 mm From the North Slope, 1972 to 1974. Minimum interval between measurements was six months.

Location	n	Growth Increment (mm) Monthly Mean	Monthly Range	Annual Mean
Accomplishment Creek	122	1.86	0.58-3.92	22.3
Ribdon River	3	2.28	1.43-3.33	27.4
Lupine River	95	1.76	0.56-3.46	21.1
Ivishak River Spawning Area	12	2.10	0.83-3.56	25.2
Saviukviayak River	7	2.42	1.52-3.67	29.0
Echooka River	13	2.94	1.50-5.67	35.3
Miscellaneous returns	7	1.43	0.25-4.82	17.2
Ivishak River (nonspawning char)	106	2.75	0.67-9.25	33.0
All Tag Returns Combined	365	2.19	0.25-9.25	26.3

Discussion of Arctic Char Findings

Aerial Index Counts:

These counts are only an index to relative abundance of char. The counts will vary somewhat each year due to differences in observers, skill of pilots, observation conditions, natural changes in river configuration, timing, and fish behavior. Therefore, these counts should be used over a moderate time period to show trends. Minor fluctuations in counts should be regarded as normal products of the technique. Also, it should be obvious that in an index count similar to this, not all fish are counted. We estimate that the index counts represent 50-90% of the actual char population in the areas counted.

Sex Ratio of Spawners:

The imbalanced sex ratio with a high proportion of females in the anadromous spawning population in the Sagavanirktok River drainage has been noted by other researchers. Yoshihara (1972, 1973) found an overall male:female ratio of 1:2.9 to 1:4.1 in the Sagavanirktok River system. He stated that the most reliable sex ratio was 1:3.4 obtained from gill net catches in the Ivishak River.

A sex ratio of 1:3 for Sagavanirktok River anadromous char was found by McCart et al. (1972). Similar sex ratios were found in the Sagavanirktok system in 1973 (Furniss, 1974). Three potential explanations exist: 1) a portion of the anadromous males fail to smolt, remaining as residents or "residuals", 2) greater postspawning mortality occurs in anadromous males; 3) anadromous males require more years of rest between each spawning than females. Some observations have been made which relate to each of these possible reasons but the extent to which each accounts for the imbalance remains unclear. It is likely that all three factors contribute.

Significantly more females than males have been noted among anadromous char of the Firth River in Canada. Glova and McCart (1974) attributed this imbalance to the fact that some males mature without having undertaken a seaward migration. These 'residual' males have been noted in abundance within the Sagavanirktok drainage (McCart et al., 1972).

Armstrong (1974) found that male anadromous Dolly Varden in southeast Alaska suffered much higher spawning mortality than females. In the Sagavanirktok River system only 5% of consecutive spawning char and 15.5% of alternate year spawning char which had been tagged and recovered at spawning areas were males (Table 5). Since the overall sex ratio for anadromous char in the Sagavanirktok River is normally around 25% males, these data may indicate that spawning is more physically strenuous for males and postspawning mortality in males is greater than in females.

However, this is not entirely clear since 32% of nonconsecutive spawners of undetermined spawning frequency were males (Table 5). This may mean that males require more years of rest between each spawning than females. There seems to be some merit in this hypothesis. In 1974, the Ivishak River non-spawning aggregation of char was composed of 38% males (Table 4), which is an unusually high percentage of males, when compared to the spawning populations. These data indicate that male char spawn less frequently than females.

The implications of unbalanced sex ratios as described for Arctic char are important to successful management of the species. Reproductive success of char harvested on the spawning ground will be reduced through the disproportionate reduction of females (assuming the methods used are unselective for sex), since females are numerically more abundant. Females return to spawn in subsequent years in greater frequency than males, compounding the disproportionate removal of females over a several year period. In addition, McCart et al. (1972) found that mature spawning females in the Sagavanirktok River system are more susceptible to capture by angling than are males.

These three factors indicate that differential mortality of the sexes may seriously reduce char production where and when a sport fishery concentrates on a spawning area. Some spawning populations within the Sagavanirktok system number less than 1,000 fish. It is doubtful these can support much sport fishing pressure.

Spawning Frequency of Arctic Char:

The tagging study found that char spawn both consecutively and nonconsecutively, but 95% of the char were nonconsecutive spawners. Approximately 64% of the nonconsecutive spawners appeared to spawn in alternate years.

Since none of the char that appeared to be alternate year spawners were actually captured during the year in which they presumably were nonspawners, it is not positively known whether or not they spawned that year. However, using the data from 1973 Accomplishment Creek recaptures, it can be inferred that the char designated as alternate year spawners were indeed nonspawners in the preceeding year. Evidence indicating this includes: 1) no retained eggs were found in any of the 69 females recaptured at Accomplishment Creek in 1973; 2) char that spawned at Accomplishment Creek in 1971 were not abundant there in 1972 (only 1.5% of the 1971 spawners were recovered in Accomplishment Creek in 1972)(Table 1).

Assuming natural mortality of tagged and untagged char was the same, and that they were recaptured in the same proportion, the tag data from Accomplishment Creek and Lupine River indicate that from 11.2 to 19.2% of the spawning population will return to spawn at the same location two years later.

The opportunity to recover consecutive spawners in 1974 was considerably reduced, as 1973 tag recoveries were killed and autopsied, thus eliminating the chance of recapturing tags captured in the 1973 recovery work. However, this was not important since it was determined that the comparative magnitude of consecutive spawners in the population should be obtained in the first two years after tagging to reduce the loss of tagged fish in subsequent years due to natural mortality.

Size Increase and Age Structure Shift of Anadromous Spawners:

The char length increase and age structure shift observed in the Sagavanirktok drainage has probably reduced char production slightly. An even greater reduction in spawner numbers should occur during the next three years as the old spawners die.

The magnitude of this reduction will depend upon the rate at which the old spawners die, the rate at which recruitment of younger fish to the spawning population occurs, and the natural compensation due to better survival of the younger age classes. It is likely that aerial index counts in the Sagavanirktok system will be lower than in previous years. The situation should be monitored closely.

Overwintering Study of Fish in the Sagavanirktok River Drainage

In addition to spring areas (Fig. 2) six other possible major overwintering areas within the Sagavanirktok River drainage were located during a September aerial survey (Fig. 4). Before freezing, water depth of these locations ranged from 1.8 to 3.6 m (6-12 ft). Preliminary drilling at Franklin Bluffs and Sagwon Bluff found pools under 1.5-2.8 m (5-9 ft) of ice. Water depths have varied from 25 to 325 cm (10-128 in). Water temperatures have varied from -0.2° to 0.5°C. Dissolved oxygen has ranged from 1.6 to 4.8 ppm.

Aerial surveys in open water spring areas at all known spawning locations indicate that rearing juvenile char are abundant at all these locations. Six adult spawning char were observed in Echooka Spring but none were observed in the other springs. Minnow traps set at these locations have captured large numbers of juvenile anadromous and residual male char and one slimy sculpin, Cottus cognatus.

Grayling Captured on the North Slope

Thirteen grayling were captured in the Lupine River incidental to char recovery work in September (Table 13).

Thirty-seven grayling were captured in the Ivishak River system, mainly the Saviukviayak River (Table 14).

Table 13. Age and Length of 13 Grayling Collected in Lupine River Springs, September 13, 1974.

Age Class	Number	Length (mm) Range	Mean
IV	1	...	342
V	3	264-345	317
VI	4	310-370	351
VII	2	320-393	357
VIII	2	340-400	370
IX	1	...	336

Table 14. Age and Length of 37 Grayling Collected in the Ivishak River System, September 15, 1974.

Age Class	Number	Length (mm) Range	Mean
V	3	243-272	258
VI	28	270-336	297
VII	4	300-393	342
VIII	1	...	370
XI	1	...	406

Round Whitefish Captured in the Ivishak River System

Seventy-five round whitefish were collected in the Ivishak River system, Table 15.

Table 15. Age and Length of Round Whitefish Collected in the Ivishak River System (Saviukviayak River, Echooka River, Ivishak River), September 15, 1974.

Age Class	Number	Length (mm) Range	Mean
VI	1		299
VII	3	297-340	321
VIII	2	335-347	341
IX	22	323-388	347
X	21	351-400	377
XI	18	357-410	389
XII	7	397-445	421
XIII	0	...	...
XIV	1	...	435

Kongakut River Survey

The Kongakut River, easternmost and largest river entirely within the Arctic National Wildlife Range, was surveyed August 22-28, 1974.

The survey crew was flown 75 miles upstream, where they began floating down a 40 mile segment of the river lying within the Brooks Mountain Range. The river in the surveyed segment is typical of mountain streams described by McCart (1974b). Numerous springs exist which char were actively utilizing for spawning. Spawning char were abundant throughout the survey area. Many char were observed spawning in holes 1.84.6 m - (615 ft) deep, which is the first observation on the North Slope of char spawning in a nonspring area.

Char captured by angling ranged in length from 350 to 740 mm. Maximum weight was 3.2 kg (7 lb). The Kongakut River char population is slightly larger in maximum length and weight than fish in other systems on the North Slope. Nearly all char captured were anadromous. No concentration of nonspawning char was located.

Large numbers of juvenile char were observed in small tributaries, some of which were flowing underground near their mouth and thus connected to the Kongakut River only during high run-off periods.

Grayling ranging in size from 200 to 450 mm were captured in abundance by angling.

Water temperature ranged from 5° to 7°C. Water chemistry included: pH 6.0, free acidity 0, total acidity 11.5 ppm, phenolphthalein alkalinity 0, hardness 120 ppm.

The Kongakut River system is located in a pristine mountain setting of great aesthetic value. The sport fishery for char and grayling is of exceptional quality, but to date utilization of the fishery resource has been nonexistent.

Hulahula River Winter Subsistence Fishery

The winter subsistence fishery at the Hulahula River was monitored April 25-29, 1974. Subsistence fishing at the Hulahula River is traditional with Kaktovik villagers. Three major use sites exist. The upper hole (3rd hole) is approximately 25-30 miles upstream of the confluence of the Hulahula and Old Man Creek. The second hole is located one mile above Old Man Creek and receives the majority of use. The first fish hole is about 25 miles downstream of hole 2.

During the survey only one family, consisting of four individuals, was continually utilizing the fishery at hole 2. On weekends a few Kaktovik villagers drove snow machines out to participate in the fishery. Since most of the Kaktovik villagers now work at the local D.E.W. site, fishing intensity has dropped at the Hulahula over the past few years. In addition, a definite shift of fishing to Schrader and Peters lakes has occurred.

Two open water areas existed at hole 2. Water temperature at those locations was 0°C. Maximum water depth was 0.6 m (2 ft). Velocity appeared to be 0.15 m/sec (1-2 ft/sec). Air temperature ranged from -13.5° to -35.5°C (+5° to -30°F). Jigging with small, bright lures was done through 0.6-1.2 m (2-4 ft) of ice. Four days of fishing by four individuals (about 25 hr) produced 18 char ranging in size from 122 to 331 mm, and two small grayling (205 mm).

An additional 16 char taken by villagers prior to the survey ranged in size from 138 to 570 mm. Most of the char ranged from 200 to 300 mm and were rearing char of the anadromous form. Two residual male char (called "old man" fish by Eskimos) and four adult anadromous char were caught.

Monitoring and Technical Advisory Function Related to Arctic Oil Development

From the inception of the Trans-Alaska Pipeline haul road construction in December of 1973 until mid-June 1974, when the Fish and Game monitoring team was put in the field, the Arctic District fishery biologist assumed all monitoring and advisory functions along the haul road north of the Brooks Range. This work included evaluation of gravel, fuel storage, waste disposal, and water use sites along the route and recommendations concerning locations, time of use, and minimization of detrimental impact. These recommendations were incorporated into state permit authorizations for these activities. Field inspection was conducted to insure that permit criteria were met.

Evaluation of stream crossing type, location, and timing was an important aspect of this job.

This work was conducted in close cooperation with field engineers and construction workers to minimize the impact of haul road construction on the aquatic environment and fish populations.

A substantial effort has continued toward assisting the Joint Fish and Wildlife Advisory Team which has been established to monitor the construction of the Trans-Alaska Oil Pipeline. This assistance has consisted of technical advisory function concerning knowledge of the fishery resource in the pipeline corridor and study of fish overwintering sites in the Sagavanirktok River system to evaluate their importance and the potential alteration of these sites by construction activities.

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PRUDHOE BAY STUDY

ABSTRACT

Fish sampling and tagging was done at eight netting stations in Prudhoe Bay during July 25-30 and August 10-13, 1974. A total of 897 fish comprising eight species was netted. Least cisco, Coregonus sardinella, was the most abundant species; Arctic char, Salvelinus alpinus, was the second most abundant. Catch per hour of fishing was greater at inshore nets. Least cisco, Arctic char, fourhorn sculpin, Myoxocephalus quadricornis, Arctic flounder, Liopsetta glacialis, broad whitefish, C. nasus, and humpback whitefish, C. pidschian, were caught predominately at inshore locations. Arctic grayling, Thymallus arcticus, were caught only near the mouth of the Sagavanirktok River, where salinity was low.

Length, weight, and sex for all autopsied fish are presented.

Arctic cisco were captured more frequently at offshore sites. The net site at the proposed dock was the only inshore net to catch a large number of Arctic cisco.

A total of 302 fish was tagged and released alive but none were recaptured during the study. Movement data were obtained from the direction fish were moving when captured.

Amphipods, isopods, mysids, and insects were found to be the major food items in fish stomach samples.

RECOMMENDATIONS

Road accessible recreational fishing is highly popular in the Prudhoe Bay area. This fishing pressure is expected to increase substantially as development in the area occurs. The new dock facility provides increased sport fishing access to an important char feeding and migration area, and the vulnerability of char to anglers is considerably increased by the dock facility. Thus, it is recommended that fishing pressure in the Prudhoe Bay area be monitored to determine the extent of this pressure and effect on Arctic char.

INTRODUCTION

Increased activity in the estuarine environment of Prudhoe Bay, resulting from haul road construction and development of the oil field, and principally as a result of the proposed construction of a 4,000-5,000 foot long earth-filled dock facility at the northwest corner of Prudhoe Bay, prompted a cooperative study of the estuarine fisheries resources of that area by the Alaska Department of Fish and Game and Atlantic Richfield Company.

Fisheries knowledge of the Prudhoe Bay area is minimal, although the Alaska Department of Fish and Game, Sport Fish Division, has conducted fish sampling and tagging operations there in 1971 and 1972 (Yoshihara, 1972 and 1973). The study was conducted between July 25-30 and August 10-13, 1974.

OBJECTIVES

1. Determine the distribution, relative abundance, size, species composition, feeding habits, sexual condition, and growth rates of Beaufort Sea fishes in the vicinity of Prudhoe Bay.

2. Determine the migration patterns and timing of fishes in the vicinity of the dock.

TECHNIQUES USED

Eight netting stations were established (Fig. 1). Two of these sites (net 1 - Sagavanirktok River mouth and net 5 - Stump Island) were abandoned after the initial two nights of the study. The net at site 2 was fished adjacent to Heald Point on two nights. After the second night, only three of the six prime net sites (2, 3, 4, 6, 7, 8) selected for continuous fishing were fished on a given day. A schedule was established so that each site was fished, but only on alternate days. By limiting the total nets fishing to three per day, each could be checked twice daily to minimize capture mortality.

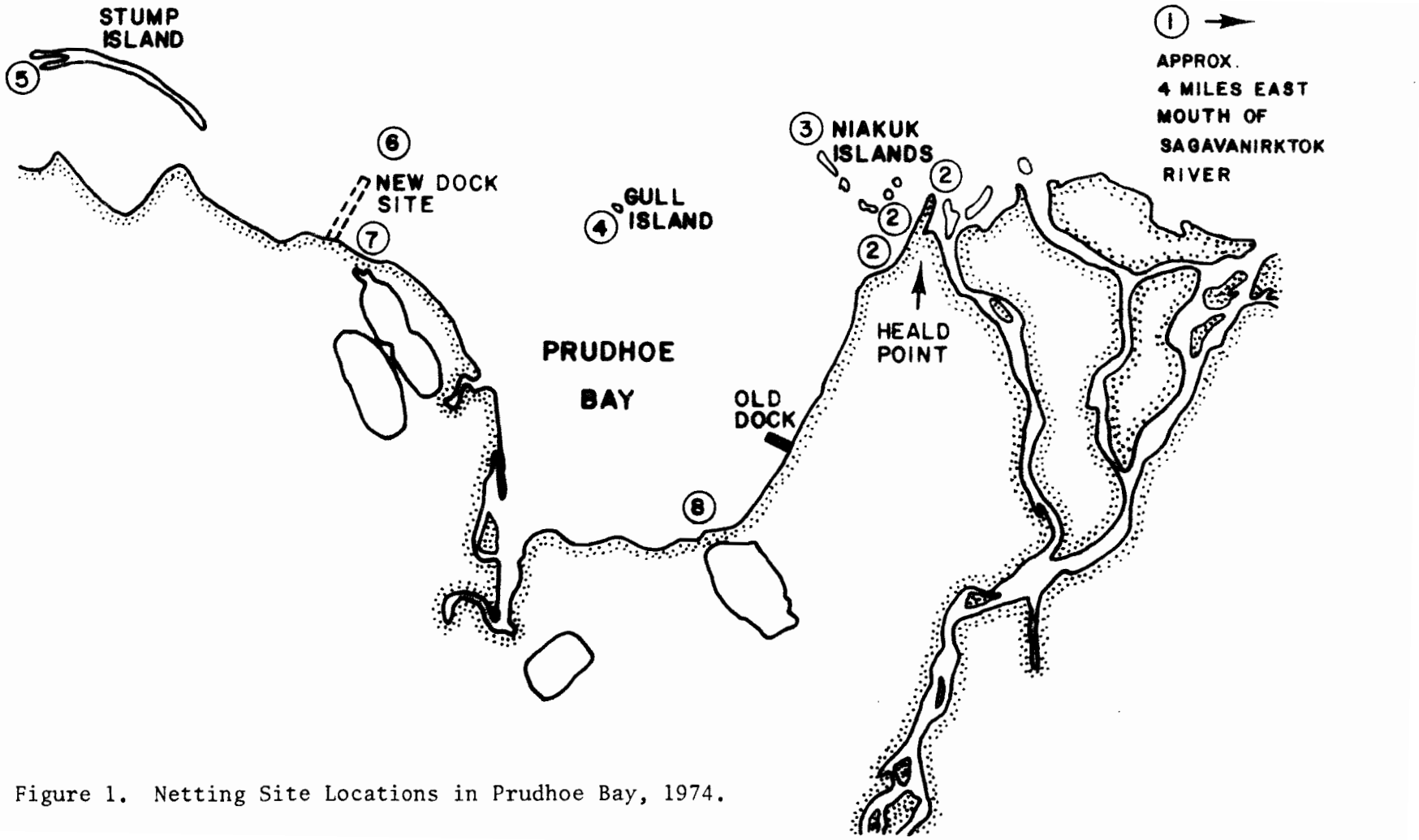

Figure 1. Netting Site Locations in Prudhoe Bay, 1974.

Transportation was by pontoon-equipped helicopter, though a rubber raft was used to reach the offshore net at the site of the proposed dock.

Most of the live fish were tagged and released. Most of the dead fish were frozen and returned to the laboratory for examination.

Sex and stage of maturity were determined by examination of gonads in all species except char. In the latter case sex was determined by sexual dimorphic characteristics. Stage of maturity was based on size, color, and consistency of gonads and egg diameter. In some cases immature fish were impossible to separate from mature but nonconsecutive spawners.

Maturity categories are:

Potential spawner - will spawn in the year of capture.
Nonspawner - Adult, nonconsecutive spawners and some large immatures which could not be separated.
Immature - a juvenile, determined by gonadal examination.

Egg numbers were determined by the volumetric subsampling techniques described by Lagler (1956).

Otoliths were used for age determination of char and flounder as described by Heiser (1966), except that xylene was used as the wetting agent. Scales were used to determine age of all other fish.

Fish were tagged with spaghetti tags and Floy internal anchor tags.

FINDINGS

A total of 897 fish comprising eight species was netted during the study (Table 1). Least cisco, Coregonus sardinella, was the most abundant species; Arctic char, Salvelinus alpinus, was the second most abundant.

Catch per hour of fishing was greater at inshore nets (1, 2, 7, 8) than at offshore nets fished at Prudhoe Bay. Least cisco, Arctic char, fourhorn sculpin, Myoxocephalus quadricornis, Arctic flounder, Liopsetta glacialis, broad whitefish, Coregonus nasus, and humpback whitefish, Coregonus pidschian, were caught predominantly at inshore locations. Arctic grayling, Thymallus arcticus, were caught only near the mouth of the Sagavanirktok River.

Length, weight, and sex for all autopsied fish are presented in Table 2. Arctic cisco were captured more frequently at offshore sites. Net site 7, at the new dock site, was the only inshore net to catch a large number of Arctic cisco. The catch of Arctic cisco at site 7 was 0.4 cisco per hour, which equalled the best catch rates at offshore sites.

Table 1. Fish Caught, By Location and Species, During Study at Prudhoe Bay, Alaska July 25 t August 13, 1974. The number of fish tagged is indicated in parentheses.

Net Location	Total Hours Fished	Net Nights	Total Catch*								All Species
			LCI	AC	ACI	FHS	BWF	HWF	AFL	GR	
#1 Mouth of Sagavanirktok R.	46	2	51(12)	18 (4)	9 (7)	15 (6)	8 (5)	0	1(1)	1	103
#2 S. Niakuk Island & Heald Pt.	114	6	23 (3)	27 (6)	7	57(10)	13 (3)	1(1)	1	4(1)	133
#3 N. Niakuk Is.	117	5	18 (4)	10 (3)	8 (3)	17 (1)	6 (3)	2(2)	1	0	62
#4 Gull Island	131	7	34(15)	11 (3)	48(21)	15	1 (1)	0	0	0	109
#5 Stump Island	58	2	2	27 (7)	14 (7)	1 (1)	0	0	0	0	44
#6 1/2 Mi. Offshore Arco New Dock Site	78	3	3	5 (2)	18 (2)	4	0	0	0	0	30
#7 Shoreline at New Dock Site	123	6	122(42)	52(22)	50(17)	21 (1)	32(25)	22(18)	2	0	301
#8 1 Mi West of Arco's Old Dock Site	71	3	25 (8)	45(21)	3 (1)	24 (4)	12 (6)	6 (3)	0	0	115
	738	34	278(84)	195(68)	157(58)	154(23)	72(43)	31(24)	5(1)	5(1)	897

* LCI - Least cisco AC - Arctic char ACI - Arctic cisco FHS - Fourhorn sculpin
BWF - Broad whitefish HWF - Humpback whitefish AFL - Arctic flounder GR - Grayling

Table 2. Length, Weight, and Sex of Fish Samples from Prudhoe Bay, 1974.

Species*	Length (mm)			Weight (gms)			Sex		
	n	$\bar{x}$	Range	n	$\bar{x}$	Range	♂	♀	IM**
AC	175	458	136-679	90	962	25-2,800	47	80	17
LCI	246	310	104-365	140	295	14-507	44	105	1
ACI	139	321	195-437	67	365	161-782	53	11	1
FHS	136	157	22-275	33	48	5-255			
BWF	68	419	132-561	14	856	486-2,033	11	5	0
HWF	29	416	380-460	2	1,075	846-1,305			
APL	5	210	195-233						
GR	5	217	123-255	3	167	121-192	1	2	0

*AC - Arctic char
ACI - Arctic cisco
BWF - Broad whitefish
APL - Arctic flounder
LCI - Least cisco
FHS - Fourhorn sculpin
HWF - Humpback whitefish
GR - Grayling

**IM - Immature

Movements:

A total of 302 fish was tagged during the study (Table 1). It was hoped that movements could be recorded through subsequent recapture of the tagged fish; however, none were recovered in the study nets. Six tags were eventually recovered in August and September at locations outside the study area. Three tagged Arctic char were recaptured at the Ivishak River, Accomplishment Creek, and Lupine River during September. Two of these char were spawners. Three broad whitefish tagged at net site 7 on July 28 and 30 moved west approximately 35 miles and were recaptured sometime between August 1 and September 1 by a subsistence fisherman at Oliktok Point.

In addition to tagging, movement data were gathered by recording the direction fish were moving when they entered the net (Table 3). The sample of 367 fish in Table 3 for which movement data were collected represents 41% of the total fish collected at Prudhoe Bay. The sample size is a result of two factors. First, at the beginning of the study movement data were to be gathered by tag and recapture methods only, thus the direction fish were moving when caught in the net was not recorded during the first 3 days of the study. Secondly, the sample includes only those fish for which direction of movement could be positively determined.

The majority of least cisco, Arctic char, Arctic cisco, broad whitefish, and humpback whitefish movements were from west to east when both sampling dates were combined. However, in looking at movements of these species by separate sampling dates, except for Arctic cisco, most movement the first week (July) was opposite to the majority of the mid-August movement. The difference may be a result of fish movement away from overwintering sites into new feeding areas during the first sampling week. By August 10 when the second sample was made, they had reversed their direction to begin the return to wintering areas. Mann (1974) reported that brackish water least cisco appear to disperse westward from the Mackenzie Delta area along the North Slope in spring and summer and return to the Delta by late August.

Large numbers of Arctic char were observed migrating very close to shore in extremely shallow water.

Table 3. Direction of Movement of 367 Fish Captured at Prudhoe Bay.

	n		Percentage Moving Each Direction			
			July 26-30		August 10-12	
Species*	Week 1	Week 2	E-W**	W-E	E-W	W-E
LCI	55	84	25	75	64	36
AC	18	76	61	39	32	68
ACI	34	38	24	76	37	63
BWF	23	21	17	83	81	19
HWF	13	5	23	77	80	20

*LCI - Least cisco
ACI - Arctic cisco
HWF - Humpback whitefish
AC - Arctic char
BWF - Broad whitefish

**Fish were moving from east to west when captured.

Age, Length, Weight, Sex. and Maturity of Samples

Age, length, weight, sex, and maturity data by age class of Arctic char, least cisco, and Arctic cisco are presented in Table 4, 5, and 6. Of particular note are the few Arctic char in age classes VII, VIII, and IX. The reason for the lack of these age classes is unknown at this time.

The presence of age III and IV Arctic char and absence of younger fish in the sample gives further support for age of III and IV at smolting as reported for this species by Yoshihara (1973).

Most of the least cisco ranged in age from VI to XI with only a single fish above and below these ages. Autopsy showed potential spawners in all age classes from VI to XII.

Arctic cisco ranged in age from IV to X. Over 87% of all Arctic cisco sampled were age VI and VII. Fish less than age VIII appeared to be immature, therefore most Arctic cisco utilizing Prudhoe Bay in July and August are immature. Over 85% of these cisco were males. In a sample from the Beaufort Sea coast in Alaska, Craig and Mann (1974) found that 91% of age IV-VII Arctic cisco were immatures.

Food Habits:

The occurrences of food items in the stomachs of least cisco, Arctic char, Arctic cisco, fourhorn sculpin and broad whitefish are presented in Tables 7, 8, 9, 10, and 11. Amphipods, isopods, mysids, and insects are major food items. Insects were more important as food in the first sampling period than in the second. Malacostracans occurred in a high percentage of stomachs containing food during the second week, although total occurrences were less than in the first week.

Two grayling stomachs contained amphipods, isopods, and fish remains.

Two Arctic flounder stomachs contained amphipods, isopods, and mysids.

Most fish remains were impossible to identify; however, two species, Arctic cod, Boreogadus saida, and sandlance, Ammodytes hexapterus, were identified from several Arctic char stomachs. These occurrences are notable since they represent two additional species in the Prudhoe Bay area that were not captured by net sampling. It is probably that these two species were in deeper waters outside the study area and were picked up by char moving from deep water to inshore.

The large amphipods are probably suborder Gammaridea. The isopods were mostly Saduria entomon. A cumacean, Diastylia spp., was identified. The identifiable polychaetes were Eteone longa.

Table 4. Age, Length, Weight, Sex, Egg Diameter, and Maturity of Arctic Char From Prudhoe Bay, 19[illegible]

Age	n	Length (mm) Range	Length (mm) Mean	Weight (gm) Range	Weight (gm) Mean	Sex ♂	Sex ♀	Egg Dia. (mm) Range	Egg Dia. (mm) Mean	Maturity Potential Spawner	Maturity Non-Spawner	Maturity IM*
III	3	136-155	148	23-80	26					0	0	3
IV	11	154-265	194	26-173	71					0	0	11
V	10	331-393	360	319-510	416	1	9	1.0-1.5	1.25	0	0	10
VI	10	346-410	380	370-766	519	4	6	1.0-2.0	1.5	0	0	10**
VII	5	401-460	431	589-991	829	2	3	2.5-2.8	2.7	4	1	0
VIII	0											
IX	2	465-510	488	1,120-1,155	1,137	1	1		2.3	1	1	0
X	23	450-538	503	828-1,838	1,341	4	19	1.4-3.3	2.5	19	4	0
XI	6	535-549	541	1,454-2,022	1,614	2	4	1.5-3.5	2.8	4	2	0
XII	6	503-620	563	1,213-2,666	1,946	4	2	2.4-2.5	2.5	6	0	0

*IM - Immature
**A small percentage of these could have been ripening for spawning in September.

Table 5. Age, Length, Weight, Sex, and Maturity of Least Cisco from Prudhoe Bay, 1974.

Age	n	Length (mm) Range	Length (mm) Mean	Weight (gm) Range	Weight (gm) Mean	Sex ♂	Sex ♀	Maturity: Potential Spawner	Maturity: Non-Spawner*	Maturity: Immature
I	1		104		14			0	0	1
VI	11**	243-308	270	143-280	210	3	6	2	7	0
VII	20	258-318	280	149-369	233	11	9	5	15	0
VIII	39	198-338	297	189-380	278	15	24	12	27	0
IX	35	280-345	310	200-470	314	8	27	17	18	0
X	23	277-349	325	213-476	362	3	20	12	11	0
XI	7	305-354	333	287-496	393	0	7	4	3	0
XII	1		320		386	0	1	1	0	0

*May include some immature fish.
**n = 9 for weight, sex, maturity data.

Table 6. Age, Length, Weight, Sex, and Maturity of Arctic Cisco From Prudhoe Bay, 1974.

		Length (mm)		Weight (gm)		Sex		Maturity		
Age	n	Range	Mean	Range	Mean	♂	♀	Potential Spawner	Non-Spawner	Immature
IV	1		195		161			0	0	1
V	1		300		280	1	0	0	1	0
VI	47	281-334	310	239-426	337	43	4	0		47*
VII	15	305-350	326	283-531	397	12	3	0		15*
VIII	6	322-398	357	337-782		2	3	2	3	0
IX	0									
X	1		305							

*May include some mature nonspawners.

Table 7. Occurrences of Food Items in Stomachs of Least Cisco, Prudhoe Bay, July and August, 1974. One of 37 (2.7%) stomachs were empty in July. Sixteen of 33 (48.5%) stomachs were empty in August.

Food Items	Stomachs Containing Food Items			
	July 25-30		August 10-13	
	Number	Percent	Number	Percent
Malacostraca				
Amphipoda	11	31	10	59
Isopoda	13	36	11	65
Mysidacea	4	11	0	0
Insecta				
Diptera adults	28	78	2	12
Diptera larvae	1	3		
Culicidae adults	1	3		
Culicidae larvae	1	3		
Trichoptera	2	6		
Plecoptera	1	3		
Hymenoptera	1	3		
Unidentified	5	14		
Fish Eggs	1	3	1	6
Detritus	2	6		
Unknown	0	0	1	0

Table 8. Occurrence of Food Items in Stomachs of Arctic Char, Prudhoe Bay, July and August, 1974. Seven of 35 (20%) stomachs were empty in July. Seven of 17 (41%) were empty in August.

Food Items	Stomachs Containing Food Items			
	July 25-30		August 10-13	
	Number	Percent	Number	Percent
Malacostraca				
Amphipoda	10	36	7	70
Isopoda	13	46	4	40
Mysidacea	4	14	5	50
Insects				
Diptera adults	10	36		
Coleoptera adults	1	4		
Unidentified	2	7		
Fish Remains	11	39	3	30
Fish Eggs	2	7		
Unidentified Plant Tissue	3	11		

Table 9. Occurrence of Food Items in Stomachs of Arctic Cisco, Prudhoe Bay, July and August, 1974. Nine of 31 (29%) stomachs were empty in July. Five of 22 (22.7%) stomachs were empty in August.

Food Items	Stomachs Containing Food Items			
	July 25-30		August 10-13	
	Number	Percent	Number	Percent
Malacostraca				
Amphipoda	4	18	7	41
Isopoda	7	32	11	65
Mysidacea	9	41	14	82
Cumacea	0	0	1	6
Ostracoda	0	0	3	18
Insecta				
Diptera adults	10	45	0	0
Culicidae adults	1	5	0	0
Plecoptera adult	0	0	1	6
Unidentified	2	9	0	0
Fish Remains	1	5	0	0
Polychaetes	0	0	2	12
Detritus	5	23	7	41

Table 10. Occurrence of Food Items in Stomachs of Fourhorn Sculpin, Prudhoe Bay, July, 1974. Two of 10 stomachs were empty.

Food Items	Stomachs Containing Food Items July 25-30	
	Number	Percent
Malacostraca		
Amphipoda	1	13
Isopoda	7	88
Fish Remains	1	13
Detritus	2	25

Table 11. Occurrence of Food Items in Stomachs of Broad Whitefish, Prudhoe Bay, July and August, 1974. Seven of 12 (58%) stomachs were empty in July. One of 2 stomachs was empty in August.

Food Items	Stomachs Containing Food Items			
	July 25-30		August 10-13	
	Number	Percent	Number	Percent
Malacostraca				
Amphipoda	4	80	1	100
Isopoda	1	20		
Pelecypoda	1	20		
Insecta				
Diptera adults	1	20		
Diptera larvae	1	20		

CONCLUSIONS

This study indicates that Prudhoe Bay is a feeding area and migratory path for Arctic char, least cisco, Arctic cisco, broad whitefish, and humpback whitefish. Fourhorn sculpin and Arctic flounder are resident to the area.

The proposed dock site at the west end of Prudhoe Bay is located at the most productive sampling site (net 7). It is likely that the dock will disturb an important feeding and migration area of char, cisco, and whitefish. The degree of this disturbance is unpredictable.

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