Environment Canada Environnement Canada

Fisheries and Marine Service
Service des pêches et des sciences de la mer

Northern Yukon Fisheries Studies, 1971 - 1974. Volume 1

Compiled and edited by L.W. Steigenberger
M.S. Elson R.T. DeLury

PAC/T - 75 - 19

Northern Operations Branch
Pacific Region

NORTHERN YUKON FISHERIES STUDIES, 1971 - 1974. VOLUME 1

Compiled and Edited

by

L. W. STEIGENBERGER

M. S. ELSON

R. T. DeLURY

Northern Operations Branch

Fisheries and Marine Service

Department of the Environment

for the

Environmental-Social Program

Northern Pipelines

January 31, 1975

Environmental-Social Committee
Northern Pipelines,
Task Force on Northern Oil Development

The data for this report were obtained as a result of investigations carried out under the Environmental-Social Program, Northern Pipelines, of the Task Force on Northern Oil Development, Government of Canada. While the studies and investigations were initiated to provide information necessary for the assessment of pipeline proposals, the knowledge gained is equally useful in planning and assessing highways and other development projects.

CONTENTS

FOREWORD

The probability of construction of oil and gas pipelines across Canadian territory increased with the discovery of substantial oil reserves at Prudhoe Bay in Alaska in June, 1968. Two pipeline routes were proposed through the northern Yukon Territory, one on the coastal plain of the Beaufort Sea and one through the interior approximately 120 miles south of the coast. The proposals raised important national questions, including the potential environmental impact on aquatic resources along the pipeline routes. Fisheries Service initiated a programme in 1971 to measure the productivity levels of aquatic ecosystems in the vicinity of northern Yukon pipeline routes, and studies were continued through 1974 to collect further information on specific sensitive areas. The basic objectives of all programmes were:

(a) to inventory the fish stocks qualitatively and quantitatively;

(b) to inventory characteristics of the aquatic environment relevant to the fishery resources;

(c) to identify factors in connection with pipeline construction or operation which could result in environmental changes detrimental to the fishery resource; and

(d) to recommend measures to prevent degradation of the environment during pipeline construction or operation.

The data presented in the reports in this volume were obtained from investigations funded for the most part by the Environmental-Social Program, Northern Pipelines, of the Task Force on Northern Oil Development. Divisional funds of the Fisheries Service, Pacific Region, were utilized for segments of the studies conducted in the Fishing Branch River. Although the investigations were primarily concerned with the assessment of potential environmental degradation by pipeline construction, the results obtained are useful in providing preliminary information for the assessment of impact by highway or mining construction, recreational or commercial fisheries and other northern development projects.

The results of the preliminary inventory programme conducted in 1971 have been published [1]. Surveys conducted since then have been concentrated on the southern alternative pipeline route to avoid duplication of effort with industrial fishery research on the coastal route [2].

The reports in Chapter I provide preliminary information on winter conditions of northern Yukon rivers. Subjective evaluations are made on the capacities of these rivers to support fish life in the winter. Some physical and chemical parameters were collected and compared with those from other rivers. Chapters II, III and IV provide detailed information on anadromous and stream resident fish populations utilizing specific areas of streams near the proposed southern pipeline route. These areas are usually associated with groundwater sources, which are recognized as substantial contributors to the capacity of northern rivers to provide spawning, rearing and overwintering habitat for fish. Chapter V presents an evaluation of historical and present day exploitation of fish stocks in the northern Yukon Territory. Chapter VI provides a detailed appraisal of the chemistry of two groundwater sources near the proposed southern pipeline route.

The information contained in these reports is intended to provide a preliminary appraisal of sensitive aquatic areas in the northern Yukon Territory, to identify problems which require additional research, and to aid in the formulation of baseline parameters for industrial activity in the North.

---

1. Bryan, J. E. 1973. The influence of pipeline development on freshwater fishery resources in northern Yukon Territory. Aspects of research conducted in 1971 and 1972. Environmental-Social Committee, Northern Pipelines, Task Force on Northern Oil Development. Report No. 73-6. 63 p.

2. McCart, P. 1974. Fisheries research associated with proposed gas pipeline routes in Alaska, Yukon and Northwest Territories. Canadian Arctic Gas Study Limited, Biological Report Series (Vol. 15 (1). 183 p., 15 maps.

C H A P T E R I (a)

PRELIMINARY INFORMATION ON THE WINTER CLASSIFICATION OF THE RIVERS IN THE NORTHERN YUKON, THEIR PHYSICAL AND CHEMICAL CHARACTERISTICS AND THE FISH STATISTICS OF THE VARIOUS WATER BODIES EXAMINED DURING THE FIRST YUKON PIPELINE WINTER SURVEY, MARCH, 1972

by

L. W. STEIGENBERGER

for the

Environmental-Social Program

Northern Pipelines

Acknowledgements

This study was carried out for the Environmental-Social Program, Northern Pipelines, of the Task Force on Northern Oil Development, Government of Canada.

The author wishes to express his appreciation to those people who assisted in the collection of data and preparation of the manuscript.

W. J. Schouwenburg made arrangements for analysis of water samples in the Cypress Creek Laboratory. J. E. Bryan and R. Kendal provided willing and able assistance in the collection of field data. J. E. Bryan and C. E. Walker helped in planning and administering the study. R. T. DeLury reviewed the manuscript.

1. Abstract

This report provides preliminary information on the winter classification of the rivers of the northern Yukon Territory. The winter condition of the rivers was evaluated according to seven categories: open water; overflow ice; overflow water; snow and ice cover; meandering and shallow; deep holes; and intermittent (flows intermittently).

Initial data on some of the physical and chemical parameters of the aquatic environment were collected. Oxygen concentration varied with ice thickness and distance from groundwater sources. The T.D.S. (total dissolved solids) values were usually higher than those reported during the summer. Of the areas sampled, fish were found only in the open water areas in the Fishing Branch River and reported in Joe Creek, a tributary of the Firth River (P. McCart, 1972, pers. comm.). The methods and conditions of the study are evaluated and recommendations for future summer and winter research are proposed.

Table of Contents

Page

List of Figures

List of Tables

List of Plates

List of Appendices

2. Introduction

Several companies and governmental agencies are undertaking ecological and technical research for the development of the natural gas and oil reserves of Alaska, the northern Yukon and the Mackenzie Delta. Correct technology and proper management could minimize the damage to the productive capacity of the aquatic resources of the area.

During July and August, 1971, the first field studies by the Fisheries Service were undertaken. The preliminary summer baselines for fish stocks, and recommendations for pipeline construction were published (Bryan et al, 1971). This first winter survey (March 16-26, 1972) was intended to provide preliminary information about the winter aquatic resources and the winter fish habitats in that section of the northern Yukon that may be affected by pipeline development.

This report is intended to provide initial information for delineating potentially critical geographic areas within the study area. Once the potentially critical areas have been determined, future study can be initiated during summer research programmes. Moreover, the problems and experiences will contribute to the design of the forthcoming winter survey (1972-73).

Included in the report is the explanation of the river classification system used during the survey, the geographic locations of some of the documented and potential overwintering areas within the northern Yukon, and the results of some preliminary field work (water chemistry and fisheries resource).

3. Materials and Methods

The winter survey included flying the study area to observe winter conditions. All of the rivers observed were subjectively classified and mapped.

Observations were made from a De Havilland Beaver DHC-2 aircraft at usually less than 1000 feet. Areas of special interest, such as open water, were observed from 50-200 feet. On one occasion a trackmaster (military personnel carrier) was employed to sample Fish Creek near Komakuk Beach. While investigating the river systems of the Beaufort drainage, Komakuk Beach Dewline Station was the airbase. For the rivers in the Porcupine drainage, Old Crow was the airbase. An attempt to sample easily accessible areas near Old Crow by foot proved difficult.

At some locations in the study area attempts were made to collect baseline information on the chemical and physical nature of the winter environment and some conceptions of the winter fisheries.

Discharge was calculated from a transact depth related to velocity (V = t X 0.85 where, t = time required for an object on the surface to travel 100 feet) (Clay, 1961: 261). Field oxygen concentrations and pH were determined with a Hach Kit (Model Ox-2-P). In addition, temperature (^{o}C) and the depth of snow, ice and water were recorded. Water samples were collected and frozen. The Fisheries Service Laboratory at Cypress Creek analyzed the collected water samples for pH, total phosphate, phosphate, nitrate, T.D.S., and alkalinity.

In addition to water sampling, attempts were made to gill-net, seine, angle and visually observe fish in open water and under ice. Only two areas were sampled using gill nets or seines. On one occasion a helicopter provided transportation to the south arm of the Fishing Branch River. Samples were collected using a 24-foot by 4-foot by ¼-inch stretch mesh beach seine (area 3,000 sq. ft., depth 4-6 inches). On another occasion three gill nets (3/4, 2½, and 3½ inch stretch mesh) were set overnight in the open water of the Firth River. In ice covered areas hand lines were used with bait or flashers.

3.1 Winter Classification of the Rivers in the Study Area

The rivers within the study area were subjectively classified into seven categories. Each river classified in this manner has specific characteristics. The applied name and the characteristics of the observed rivers are listed below. Representative photographs are included after the descriptions of the classification system.

3.1.1 Open Water (Plates 1 and 2)

Open water is an area of a river or creek that is free of ice during the winter. Open water areas are presumably areas with groundwater discharges of sufficient volume and temperature to remain free-flowing even at air temperatures well below freezing.

3.1.2 Overflow Ice (Plates 3 and 4)

Overflow ice is an area of ice build-up (resembling summer aufeis) resulting from a repetitive overflow and freezing of a stream or groundwater source. Peripheral and protected cross-cutting channels are frequently associated with overflow ice. A potential protected overwintering environment may be provided in the peripheral and cross-cutting channels and the water flow may provide the necessary discharge to maintain fish populations in deep holes under ice downstream of the overflow ice.

3.1.3 Overflow Water (Plate 5)

Overflow water is the presence of water on ice. Observations indicate this is associated with several situations including overflow ice, detectable winter flow in a water course, and groundwater sources. The overflow water appears to freeze and is most likely the site of summer aufeis. Overflow water on ice is probably not a habitat for overwintering fish. Note that overflow water on river channel ice in the spring is entirely different. In the spring, fish may respond differently to overflow water in a thawing environment.

3.1.4 Snow and Ice Cover (Plate 6)

Snow and ice cover is a highly probable overwintering area, as judged subjectively from the topography. This is a general category used to denote areas where the criteria for overwintering are probable but no other distinguishing features such as open water are evident. Large rivers, such as the Old Crow River, would fall into this classification.

3.1.5 Meandering and Shallow (Plate 7)

Meandering and shallow is an area where there appears to exist a low probability of habitat for overwintering fish populations. This is a characteristic of smaller tributaries or some of the headwaters of major rivers. Large, apparently shallow meanders, and suspected or observed gravel bars typify these areas. Undetected deep holes in these areas may, however, provide overwintering sites for fish.

3.1.6 Deep Holes (Plate 8)

Deep holes describe an area where holes are evident or suggested by geographical features. There is a reason to suspect these localities as possible overwintering areas for some fish populations (assuming water depth as a criteria for overwintering). These areas are usually associated with detectable riffles and/or cutbanks found near directional changes of the water course.

3.1.7 Intermittent (Plates 9 and 10)

Intermittent describes an area in which there are no apparent overwintering sites (based on potential water depth). These areas are typically observed as steep banked frozen runoff streams and would appear devoid of water suitable for overwintering.

Plate 1. Open water (south fork of Fishing Branch River).

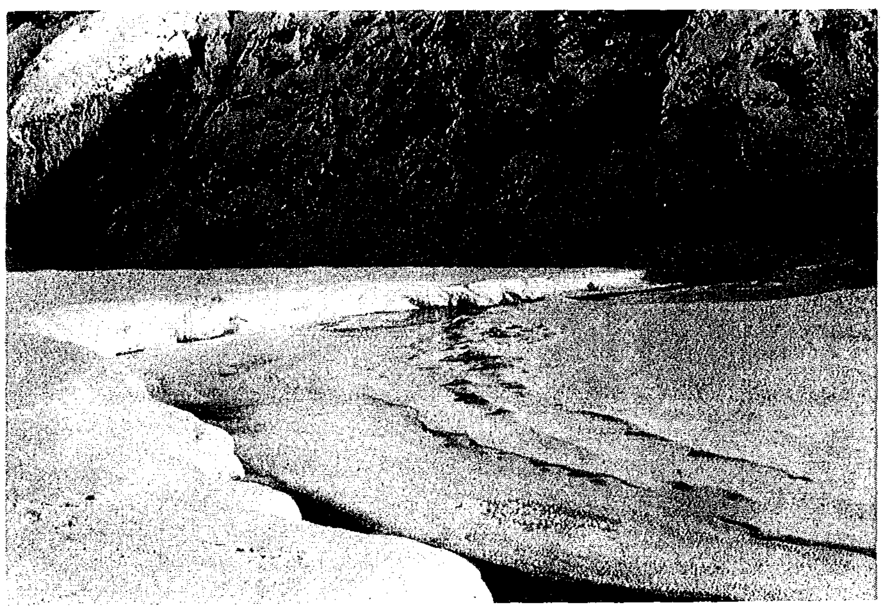


Plate 2. Open water (headwaters of the Firth River).

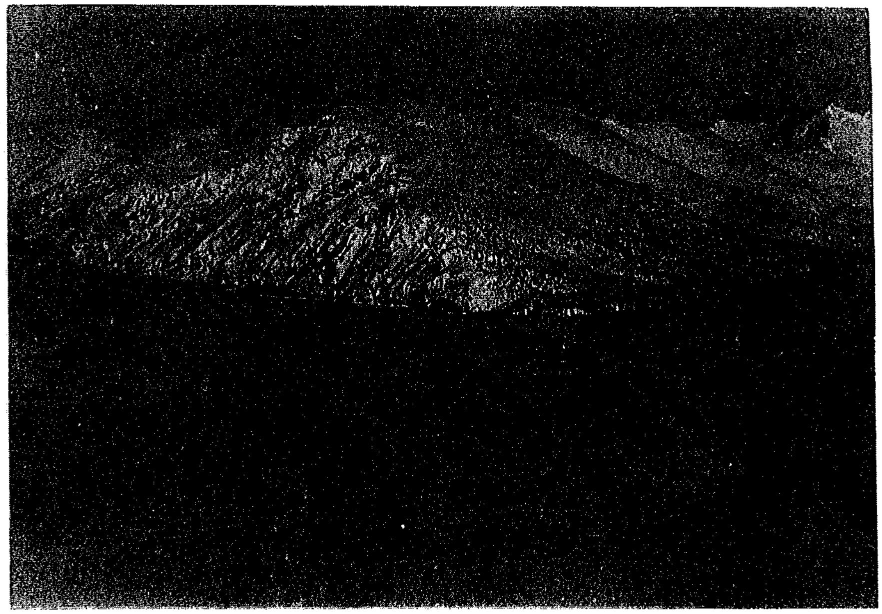


Plate 3. Overflow ice (headwaters of the Firth River).

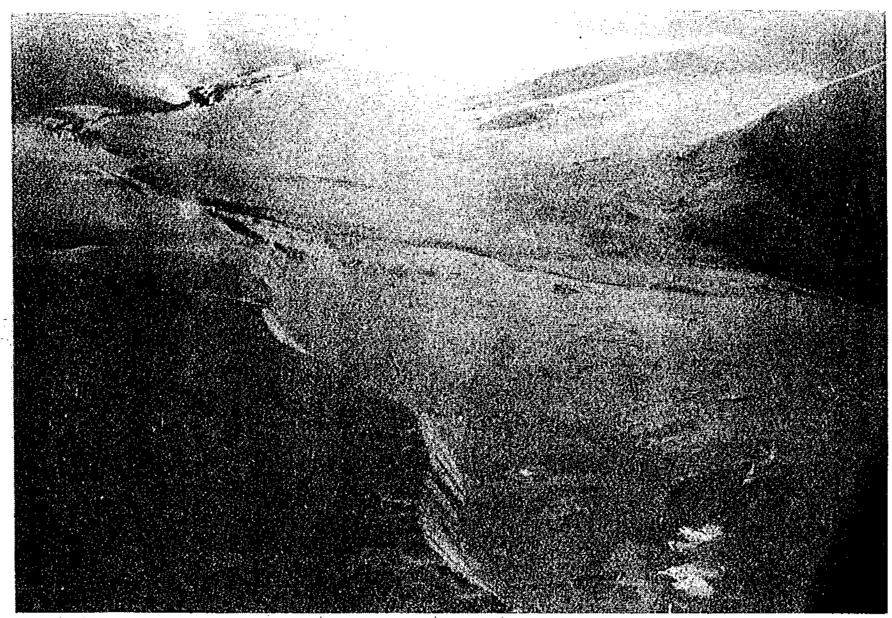


Plate 4. Overflow ice (headwaters of the Babbage River).

Plate 5. Overflow water (on the Firth River overflow ice).

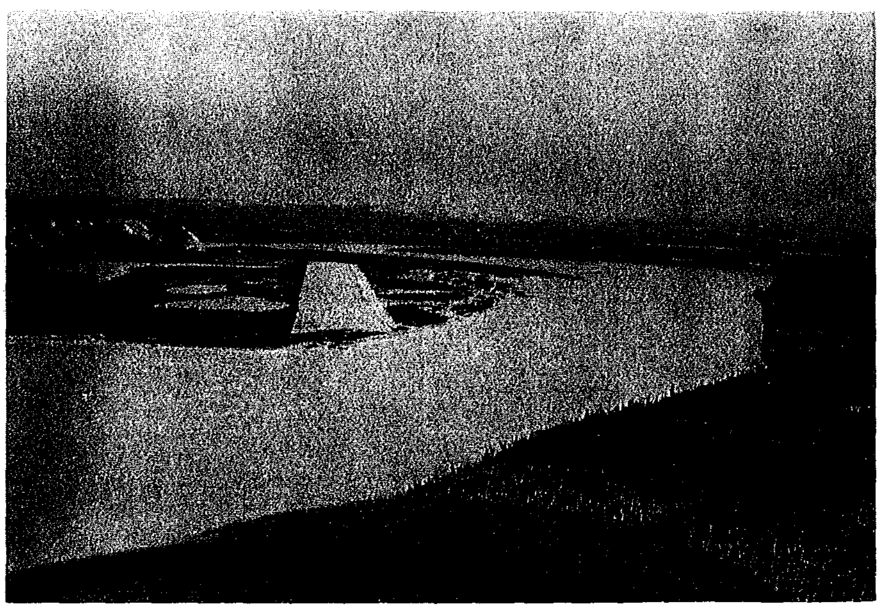


Plate 6. Snow and ice cover (on the Porcupine River near Old Crow).

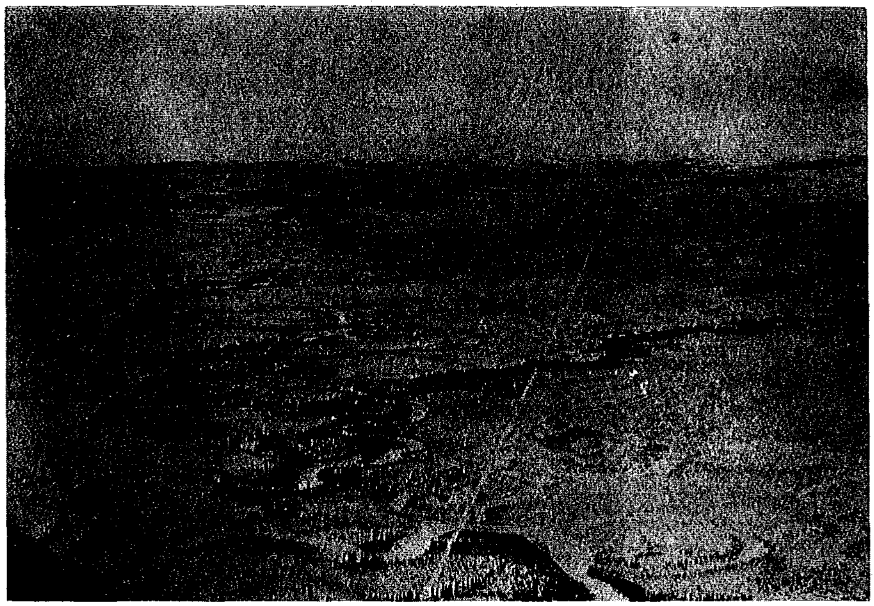


Plate 7. Meandering and shallow (Johnson Creek).

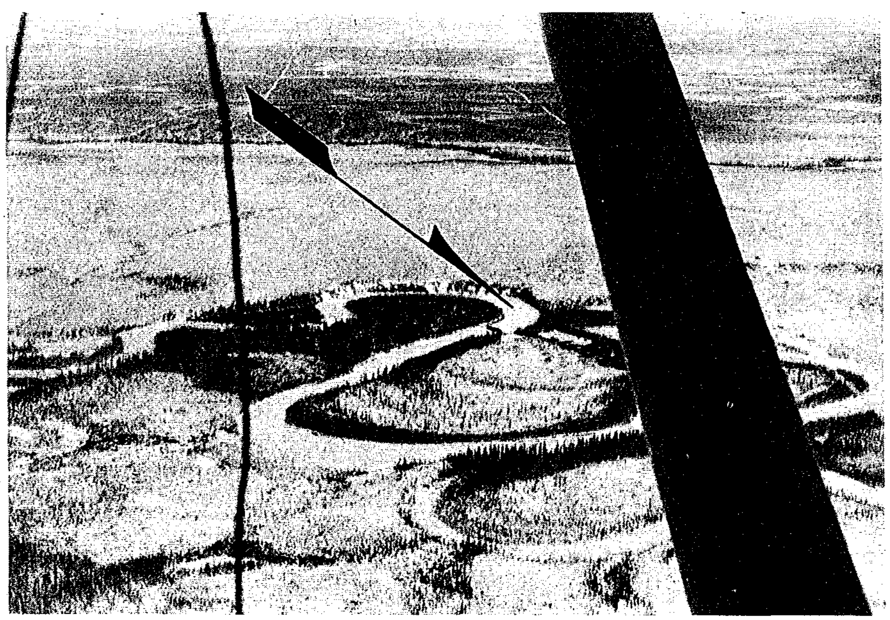


Plate 8. Deep holes (good possibility of deep hole under snow and ice cover downstream of riffle).

Plate 9. Intermittent (intermittent tributary of the Porcupine River near Old Crow).

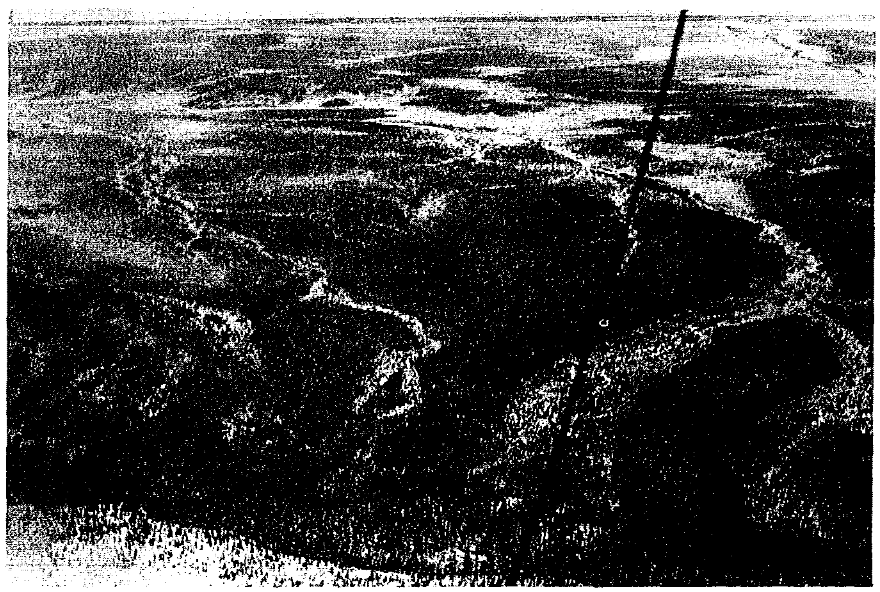


Plate 10. Intermittent (typical tributaries of headwater streams).

4. Results

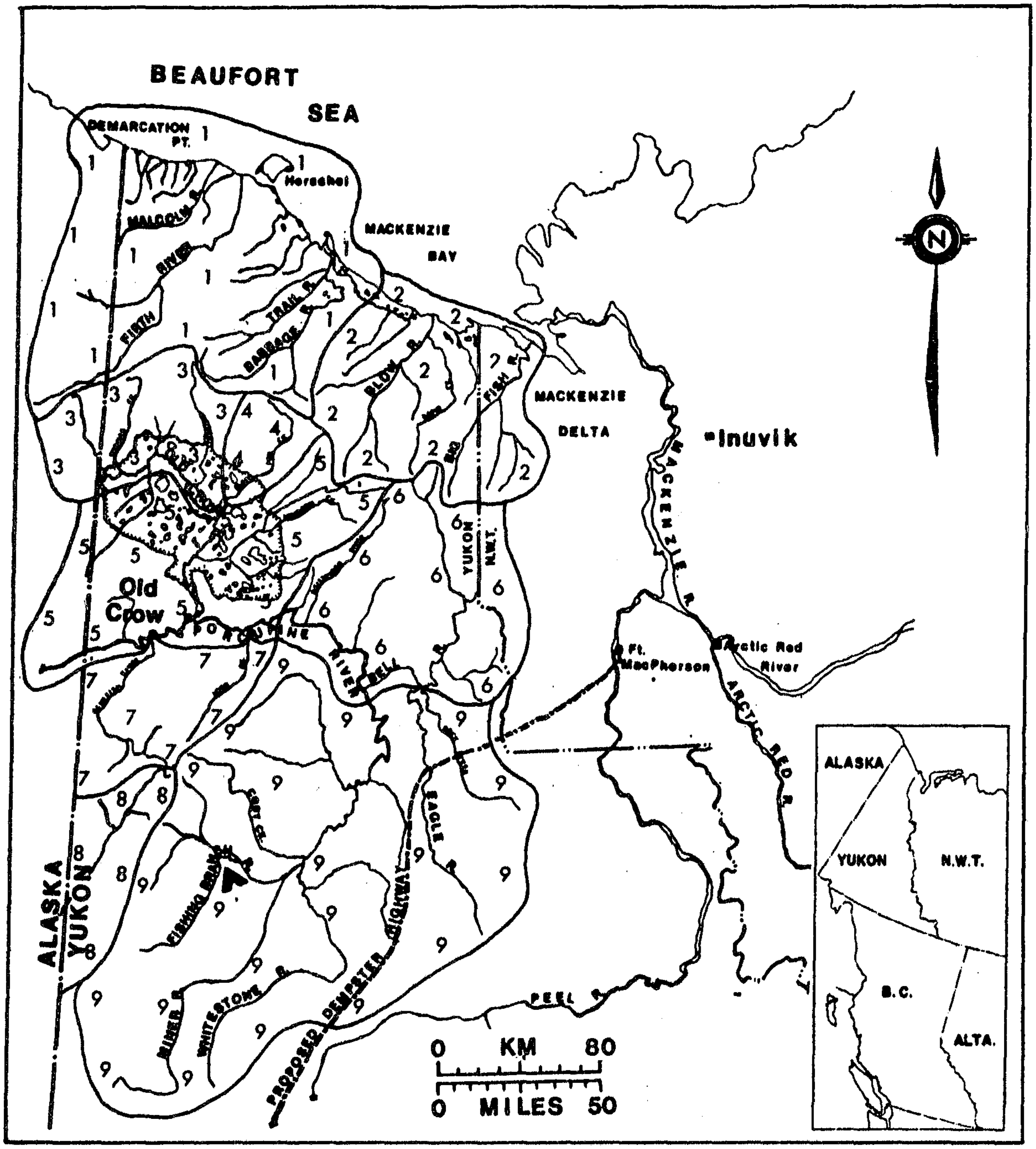
The results are presented in four sections. General comments, the rivers of the north slope drainage (Beaufort Sea), the rivers of the southern drainage (interior), and information on water chemistry and fish within the study area. Figure 1 illustrates the division of the study area into nine arbitrary regions. Figure 2 shows the locations of the biologically important areas referenced in the text of the report.

4.1 General Comments on the Winter Classification of Rivers

There are in the north and south drainages specific locations that on first observation appear potentially important for fish stocks during the critical winter months. In temperatures well below freezing, the open water areas remain ice free and these areas may provide the environment for overwintering of eggs, juveniles and adults. These areas are biologically important.

In most cases, overflow ice and overflow water areas appear to provide additional potential overwintering areas as a result of their frequent association with groundwater sources, or peripheral or cross-cutting streams. Alternatively, overflow ice often forms as a result of ice partially or completely blocking a river channel. This may hinder movement and limit sections of a fish population to specific regions within a stream or river. During extreme winter conditions a partial winter kill may result. It was not possible to drill holes in overflow ice areas to determine their true significance and as a result the above is speculative.

The only other general category to be considered is snow and ice cover. Thin ice and no detectable current were observed in the Bell River under a snow depth of 50 cm. This is in contrast to greater ice depth in lakes with the same snow cover. Ice thickness also appears to increase in windblown rivers of the southern drainages and perhaps those of northern drainage. Water quality measurements along with sampling is necessary to delineate these areas as critical overwintering habitats for fish and invertebrates.



Northern Drainages
1 Babbage and West
2 East of the Babbage

Southern Drainages
3 South of the Firth
4 South of the Babbage
5 Of Old Crow Flats and Old Crow Range
6 West and Central Richardson Mts.
7 Northern Keele Range
8 Southwestern Keele Range
9 Southeastern Keele Range and Northern Ogilvie Mts.

Figure 1. Principal drainage systems of the northern Yukon Territory depicting the areas surveyed during the winter survey (March, 1972).

4.2 Rivers of the Northern Drainage

4.2.1 Rivers from the Babbage River and West (Figures 1 (Region 1) and 2)

The Babbage River and rivers to the west appear potentially more productive for overwintering of fish populations than those to the east. The presence of open water on Fish Creek (Location 1, Figure 2), Firth River (Location 2, Figure 2), Joe Creek (Location 3, Figure 2) (McCart, 1972, pers. comm.), Babbage River (Location 4, Figure 2), and Fish Hole Creek (Location 5, Figure 2) increase the possibility of overwintering sites for fish. Overflow ice, overflow water and deep holes on the Malcolm River, Fish Creek and side tributaries of the Firth River and Babbage River may provide additonal groundwater discharges or water of sufficient depth to provide overwintering environments for fish.

4.2.2 Rivers East of the Babbage River (Figures 1 (Region 2) and 2)

The rivers east of the Babbage River are subjectively different. Deep and Running River appear meandering and shallow on their lower reaches. The upper reaches are snow and ice covered, and appear intermittent with high ice content relative to available water. This is in contrast to snow and ice covered areas of the southern drainages where there still exists under snow and ice deep enough water to overwinter fish.

At the junctions of Anker and Purkis Creeks with the Blow River and upstream on Purkis Creek there appears to be overflow water and deep holes of sufficient depth and area to provide possible overwintering habitat. Fitton Creek appears intermittent. The upper sections of the Blow River surveyed appear to be meandering and shallow and basically a poor overwintering habitat.

Farther east, the headwaters of the Rapid River and the streams and creeks surveyed on the northern extremities of the Richardson Mountains appear intermittent, meandering and shallow. The rivers in this area had the least amount of water of all the rivers surveyed. There exists, however, the possibility of undetected holes of major importance on the lower reaches of some of the larger rivers.

Big Fish River (lower reaches) for the most part is similar to Rapid River except for some areas of slope instability and erosion. This type of environment may be

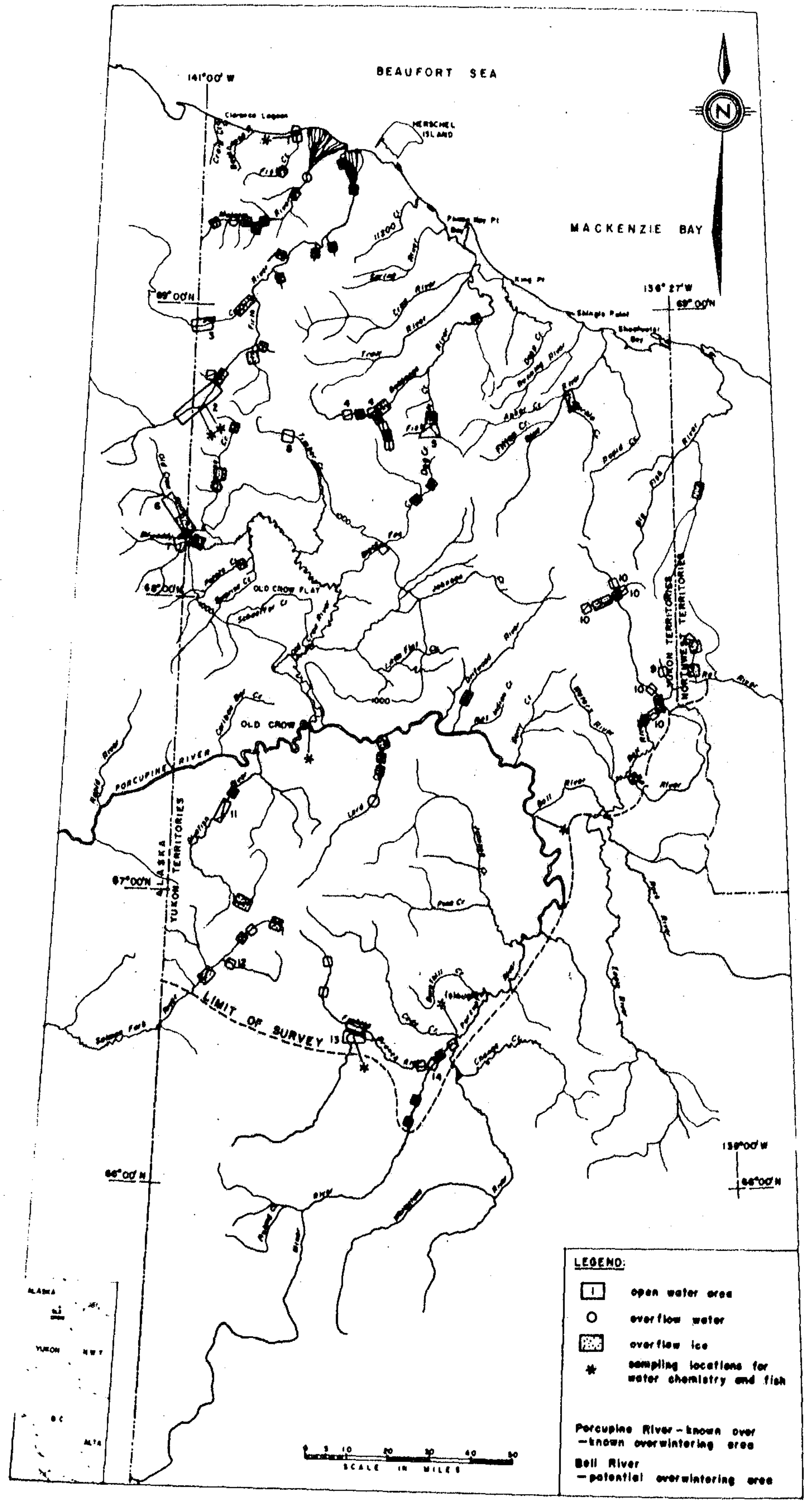


Figure 2. Locations of open water, overflow water and ice areas noted during the first winter survey for the northern Yukon (March, 1972).

a major threat to any possible overwintering fish populations. The lower reaches of the Little Fish River (N.W.T.) north of the two major branches have a high probability of deep water sufficient to overwinter fish populations. This section of the river may be of prime importance.

4.3 Rivers of the Southern Drainage

The rivers of the southern drainage were arbitrarily subdivided into seven groups.

4.3.1 Drainages South of the Firth River (Figures 1 (Region 3) and 2)

The Old Crow River (Location 6, Figure 2), Bilwaddy Creek (Location 7, Figure 2), and Timber Creek (Location 8, Figure 2) all have open water. Thomas Creek contained overflow ice and water and there is a very high probability of undetected open water. The confluence of these rivers in the upper reaches of the Old Crow River along with lower reaches of Potato Creek (tributary of the Old Crow River) are snow and ice covered with sections of overflow water or thin ice. It appears that these associated areas may be potential overwintering sites.

4.3.2 Drainages South of the Babbage River (Figures 1 (Region 4) and 2)

In direct contrast to the rivers draining south near the headwaters of the Firth River, the upper reaches of Dog Creek and Black Fox Creek of the Babbage River, appear intermittent. There may exist undetected holes and water of sufficient depth to overwinter fish in the lower reaches of these two rivers.

4.3.3 Drainages of Old Crow Flats and Old Crow Range (Figures 1 (Region 5) and 2)

For the most part, many of the drainages of the Old Crow Flats are comparable to the upper reaches of Rapid Creek in the eastern North Slope. The streams are deep-gorged and apparently completely frozen affording only suitable habitat during breakup or spring, summer and early fall. Two examples are Little Flat Creek and Schaeffer Creek. The remainder of the Rivers of Old Crow Flats meander, appear shallow, and were snow covered during March, 1972. The presence of undetected deep water in rivers or lakes may be of prime importance for overwintering fish.

Caribou Bar Creek and some additional smaller streams drain the southern slopes of the Old Crow Range. Caribou Bar Creek drains south directly into the Porcupine River. It is shallow and meanders for most of its length and appears intermittent in the upper reaches. Again, there may be deep water as yet undetected which may be important for the various life stages of fish and invertebrate populations in areas nearer the Porcupine River. The mainstem Porcupine River is snow and ice covered and is undoubtedly an important overwintering area.

4.3.4 Drainages of the West and Central Richardson Mountains (Figures 1 (Region 6) and 2)

In this area the Little Bell River (Location 9, Figure 2) and Bell River (Location 10, Figure 2) contain open water, overflow water and overflow ice in their upper reaches. Much of the lower sections of the rivers are snow and ice covered with many of the side tributaries appearing intermittent. The mainstem of the Bell River having thin ice and deep snow cover may be of prime ecological importance for overwintering of fish populations. Snow depth may provide an insulation layer to prevent excessive ice thickness evident in windblown areas. Overflow ice was evident in the lower reaches of the Rat River. Berry Creek and Rat Indian Creek farther west appear intermittent except for a snow covered, meandering section of stream very close to the Porcupine River. The mainstem of the Driftwood River possessed overflow ice midstream. This may indicate a groundwater source.

4.3.5 Drainages of the Northern Keele Range (Figures 1 (Region 7) and 2)

The Bluefish River, David Lord Creek and the streams associated with the flats south of Old Crow are included in this grouping. The upper reaches of the Bluefish except for one sighting of overflow ice appear intermittent and are probably only active in the spring or early summer and fall. Open water, overflow water and overflow ice were recorded in the lower reaches of the Bluefish River (Location 11, Figure 2) near the Porcupine River. Unsupported evidence from residents of Old Crow suggest the open water area of the Blue fish River as a prime overwintering area for grayling.

At two locations on David Lord Creek, overflow ice and overflow water were evident. The area downstream of the overflow water may have the potential to support overwintering fish populations in undetected holes of deep water.

Like the smaller streams of the Old Crow Flats, the streams of the flats south of Old Crow and the smaller tributaries of the Porcupine River apparently fail to provide suitable habitat for overwintering for fish populations. The mainstem has good potential to overwinter fish populations. In all these areas, it should be pointed out that the true significance of the lakes is still unknown and further studies are required.

4.3.6 Drainages of the Southwestern Keele Range (Figures 1 (Region 8) and 2)

The only river inspected in this region was the upper limits of the Salmon Fork River (Location 12, Figure 2). Open water, overflow ice and overflow water were recorded on the section of the river surveyed. Consultation with Alaskan Fish and Game personnel revealed that an Indian salmon fisheries exists at Chalkyitschk and that the spawning area for the salmon may be located in the open water observed in the Salmon Fork River.

4.3.7 Drainages of the Southeastern Keele Range and the Northern Ogilvie Mountains (Figures 1 (Region 9) and 2)

This area contains the vast drainages of the upper Porcupine River. Time restrictions prevented a survey of the upper limits of the Miner and Whitestone Rivers on the northern slope of the Ogilvie Mountains. A fairly comprehensive survey was completed on the river draining the southern Keele Range. Johnson, Pine, Burnhill and Cody Creeks contained little or no detectable overflow water. For the most part, these creeks were snow and ice covered, intermittent, and shallow and meandering. The upper limits of all these streams were intermittent (along with many of the tributaries), however, the lower limits (especially Johnson Creek and Cody Creek) were meandering with ice and snow cover (average depth snow 50 cm). The lower regions of these streams appear important and may contain potential overwintering areas. Snow cover may mask deep water of significant importance.

Both branches of the Fishing Branch River (Location 13, Figure 2) contained large stretches of overflow ice and overflow water. The lower limits were essentially snow covered with occasional sections of overflow ice and open water of shallow depth. The lower limits of the Miner River (Location 14, Figure 2) contained some open water and overflow ice. The mouth of the Whitestone River was snow and ice covered. The mainstem Porcupine River downstream of Whitestone River has good potential to overwinter fish populations.

4.4 Some Physical and Chemical Characteristics of the Winter Environment and the Fish Statistics for the Winter Survey during March, 1972

The winter survey was designed to provide initial information on the physical and chemical parameters of the aquatic environment and the characteristics and distribution of fish populations (by visual observation or fishing). The acquisition of data during the winter survey was extremely difficult. The constraints of weather and fixed-wing aircraft limited the amount of sampling.

4.4.1 Information on the Physical and Chemical Characteristics of the Winter Environment

The data (Table I) reveal variability in oxygen concentration, discharge, ice thickness, T.D.S. and temperature. Sections of open water analyzed from the Firth River and the south fork of the Fishing Branch River contained 11 ppm of dissolved oxygen. Duplicate samples of water analyzed from the groundwater springs on the Firth River and Fish Creek contained 6 ppm and 5 ppm respectively. Within a few hundred yards the water samples of the Firth River contained 11 ppm. These high concentrations of oxygen appear to be a characteristic of a system in which there was a detectable current or flowing open water. In the Bell River having snow and ice cover and no detectable current, the concentration of oxygen was 4 ppm. Thus, based on oxygen concentration, the snow and ice covered rivers and lakes have only marginal habitat for the overwintering of most fish. This, however, may not be entirely true as percolation through small riffles or within areas of pools may be sufficient to produce overwintering habitats. The lower oxygen concentrations (4-6 ppm) may be adequate for fish exposed to colder temperatures and decreased activity.

TABLE I THE PHYSICAL AND CHEMICAL CHARACTERISTICS AND THE FISH STATISTICS OF THE VARIOUS WATER BODIES EXAMINED DURING THE YUKON PIPELINE WINTER SURVEY, MARCH 1972

STUDY AREA	FIELD ANALYZED DATA								LABORATORY ANALYZED DATA						
	DISCHARGE (CFS)	TEMPERATURE °C	O_2 CONC. (mg/1)	FIELD pH	DEPTH SNOW (cm)	DEPTH ICE (cm)	DEPTH WATER (cm)	FISHING METHOD	CATCH	LABORATORY pH	TOTAL PHOSPHATE mg/1	PHOSPHATE mg/1	NITRATE mg/1	T.D.S. mg/1	ALKALINITY mg/1
BELL RIVER (Snow and Ice)	-	-0.6	4	8.5	46	20	26	Line	0	6.90	.02	.02	.20	221	86.25
LAKE (BELL R.) (Snow and Ice)	-	0.0	1	7.5	47	70	207	Line	0	6.42	0.034	.02	.20	70	9.20
PORCUPINE R. (Snow and Ice)	-	-0.6	7	-	0	143	443	Line	0	7.43	.02	.02	.20	236	175.95
SLOUGH (Cody Cr.) (Snow and Ice)	-	0.0	1	7.0	46	62	192	Line	0	6.40	0.168	0.09	0.24	250	88.55
FISHING BRANCH (Open Water)	400	1.7	11	8.5	-	-	30	Seine	150* 27**	7.29	.02	.02	.20	226	133.40
FIRTH RIVER (Spring)	-	0.0	6	7.5	-	-	20	G.Net (Line)	0	7.39	.02	.02	.20	148	120.15
FIRTH RIVER (Open Water)	32	0.0	11	7.5	-	-	50	G.Net (Line)	0	6.87	.02	.02	.20	111	86.25
FISH CREEK (Spring)	-	0.0	5	8.0	30	20	18	-	-	7.24	.02	.02	.20	253	129.95

NOTE: Sampling site locations in Appendix - * coho salmon, ** juvenile grayling

The winter T.D.S. value in the Bell, Porcupine, Fishing Branch, Firth Rivers and Fish Creek are higher than summer values (Bryan et al, 1971). This is probably a result of a decrease in total volume of rivers and streams with a resulting increase in the proportion of the available water coming from mineralized groundwater sources. The total phosphate, phosphate and nitrate values are comparable to the summer values. The only notable exception is an increase in phosphates above the detection levels in a lake on the Bell River and a slough near Cody Creek. The low oxygen concentration in these two examples could be sufficient to inhibit fish and some life forms and the increase in phosphates may be the result of the build-up of breakdown products.

Of additional interest is the increase in water temperature of the Fishing Branch River. This factor may greatly influence overwintering success of eggs, juveniles and adult fish.

4.4.2 Information on the Overwintering of Fish

At each of the sites sampled different fishing methods were attempted. In all cases (Table I, Fishing Methods), whether the river or stream was open water or snow and ice covered, visual observations (use of hand lines and flashers to attract fish) were recorded. Gill nets and seines were used when deemed feasible. No fish were caught in an overnight set of 3 gill nets in the open water of the Firth River. Seining was not carried out in the Firth River. On the other hand, in the south fork of the Fishing Branch River, a 24-foot seine haul (area of haul 3,000 square feet with an average depth of approximately 4-6 inches) caught 150 coho and 27 grayling (age classes 1-2 years).

5. Discussion

The ability to measure the actual or potential fishery resource by the general classification of one or more of its important parameters is limited at best.

This winter survey can establish two types of evidence. The first and most conclusive is the areas where fish cannot overwinter (e.g., intermittent streams, frozen to the bottom); second, those areas where fish might overwinter. A definitive priority of these areas is hard to establish without sampling (fish and water quality). It might be fair to assume that groundwater areas are the first priority and perhaps deep pools in lakes and rivers that have an acceptable water quality are second.

Although seven categories were used to classify the river habitat they are not mutually exclusive. Often different classifications are interrelated. For example, open water, overflow ice and overflow water appear to be associated with springs and groundwater sources. The snow and ice cover concealing deep lakes or even deep water areas in rivers emphasize the weakness of the classification system.

5.1 Open Water and Interrelated Areas

Open water areas were discovered in rivers of both the north and south drainages. Three gill nets in the headwaters of the Firth River failed to locate overwintering fish, however McCart (1972, unpublished data) apparently found overwintering char in the open water areas of Joe Creek, a major tributary of the Firth River. The char were associated with areas classified as open water and overflow ice conditions. The char were located upstream close to the Alaskan border and beyond. Residents of the north slope (Eskimos and Indians) and the older Indian residents of Old Crow in previous years fished the open water areas in the headwaters of the Firth River and Fish Hole Creek, a tributary of the Babbage River.

Other residents of Old Crow in the past had also fished for adult grayling in the open water of the Bluefish River. Spawning chum salmon were observed in the south fork of the Fishing Branch River in the fall, and during the winter survey this area was an open water area. A seine haul yielded 150 coho salmon (1-2 years old) and 27 juvenile grayling. All of this information supports a hypothesis that the open water areas provide a critical and unique environment for the overwintering of various species and life stages (eggs, juveniles and adults) of some northern fishes. Moreover, since these areas are limited in distribution specific research is required to investigate species composition and distribution, species frequency distribution, population estimates and the timing of species utilization.

An additional open water area occurred in the headwaters of the Salmon Fork River. Being adjacent and in a similar environment to the Fishing Branch River, it was postulated that the open water area could support a salmon population. Alaskan Fish and Game personnel agree with this hypothesis noting that sections of the Salmon Fork River may be the spawning grounds for the subsidiary salmon fisheries at Chalkyitsik. Thus, it should be emphasized that some open water areas are important for overwintering fish populations and research should be completed to determine the true significance of "<u>all</u>" the designated open water areas.

5.2 Snow and Ice Cover and Deep Holes

It can be hypothesized that fish populations may overwinter in two different areas. First, in deep water beneath the ice within the same stream they occupied during the summer. This would involve localized migrations. Second, the fish may overwinter in the mainstream of larger rivers or open water areas. This may involve migrations of considerable distances. There is no reason to suppose that all species and size classes of fish utilize similar refuges during the winter. Further research in the winter months will be required to answer these questions. Only then will the significance of deep holes, open water areas, main river channels and lakes be determined.

From the winter survey it can be concluded that some tributaries, lakes and larger rivers with an adequate winter discharge and/or an acceptable dissolved oxygen level should have overwintering capabilities even under snow and ice cover. The mainstem Porcupine River is a known overwintering area and the deeper sections of the Bell River have the potential to be an overwintering area.

5.3 The Interrelationship of the Physical and Chemical Properties of the Winter Environment

As noted, oxygen concentration in the open water areas was close to saturation (11 ppm). However, in the Bell and Porcupine Rivers under snow and ice conditions the oxygen concentration was 4 ppm and 7 ppm respectively. In lakes the oxygen concentration was only 1 ppm. Thus, within the winter classification of streams the physical and chemical characteristics may limit distribution of overwintering fishes and thus the critical habitats for fish populations.

5.4 Problems Encountered in the Winter Survey

Generally, the problems were associated with equipment and procedures for the technical collection of data. Listed in point form the problems were:

5.4.1 Locating water in the streams.

5.4.2 The advantage of using power saws and power augers below 20°F is questionable. The effort for handling, maintaining and operating power equipment in thin ice situations (<25 cm) is greater than the effort of using hand equipment (ice chisels and hand augers). The efforts appear equitable at depths up to 6 feet.

5.4.3 The performance of hand augers on new or snow covered ice (rivers of the southern drainages) was satisfactory. In overflow ice situations and generally the drainages in the north, the ice was extremely hard and satisfactory performance was impossible.

5.4.4 In dealing with parameters related to water chemistry at cold temperatures (down to 30°F),

(1) the chemicals in the Hach Kits freeze and dissolved materials come out of solution;
(2) the oxygen samples freeze before being able to add the Hack chemicals;
(3) in shallow water, the water may be under pressure. Drilling may release trapped air (oxygenating the water) or disrupt the bottom sediment (introducing excess sediment to the water column);
(4) the water freezes on the bulb of the max.-min. thermometers which may give a misleading temperature reading.

5.4.5 Problems with Sampling Fish in Cold Temperatures:

(1) that of setting fishing gear through the ice;
(2) the icing and freezing of gill nets in open water;
(3) the impossible task of visual observation of fish through holes in the ice;
(4) floating ice in open water areas posing danger to equipment and personnel.

5.5 Future Research Requirements

Even after completing the winter survey it is difficult to delineate all the locations for overwintering fish. The collected data only suggest the species distribution and size class utilization of the open water because of the small sample sizes. The true significance of all the other classified areas in the study area is still unknown. It is possible to postulate that open water areas in other localities may be important but extensive research is required to test this hypothesis. Moreover, overflow ice and water areas near the groundwater sources may also be important; however, investigations in the open water in the headwaters of the Firth River failed to locate fish even though it is supposedly an important overwintering area. More than likely, the sampling techniques (fishing, visual and gill nets) were inadequate. On consideration of these factors it becomes evident that there are a large number of unanswered questions. Specific research must be designed to expand the present knowledge of species distribution, winter migrations, species utilization for all life stages, as well as the interrelationship of the physical and chemical parameters of the winter environment to the designated classifications of the study area.

5.6 Relevant Pipeline Concerns

The pipeline, if constructed on a route adjacent to Old Crow, will place certain demands on the local environment. The long term and short term effects of river crossings on the Bell River, the Old Crow River and the Driftwood River will be felt. Indirectly, construction may affect the Porcupine River, tributaries of the Porcupine River, and the lakes of the Old Crow Flats.

The long and short term effects of construction may take the form of siltation, water utilization and the utilization of all the other available resources. The pipeline guidelines and construction standards will consider the aquatic resources including fish populations, pollution standards and water utilization, but the following factors should be emphasized.

It may be necessary to predetermine the availability of water in lakes and streams to prevent over-utilization. This would require the monitoring of volumes and discharges for each system being considered.

It is possible that winter discharge in open water areas and the volume in deep holes are critical, in the Bell River and Driftwood River, for the maintenance of adult or juvenile populations of fish. In addition, the timing of construction should be regulated to avoid seasonal migrations and spawning of fishes. In the rivers containing open water, overflow water or groundwater sources that may be critical overwintering habitat, construction may be prohibited in sections of the rivers.

The utilization of resources for construction materials will also affect fish populations. Areas adjacent to groundwater sources may be on the short term affected by timing and duration of gravel removal and in the long term, by bedload movement within the stream and the rate of gravel recruitment to areas where gravel removal has taken place.

6. Conclusions

During the winter survey, the area was subjectively classified and some of the physical and chemical characteristics of the winter environment were collected. It is evident that open water and the interrelated overflow ice and groundwater source are important areas for overwintering, rearing, migration sites and spawning of fish populations. The aquatic chemical and physical conditions may also affect overwintering of fish.

It is evident that restrictions on pipeline construction and maintenance should be imposed in areas deemed important to the fisheries. Open water areas have been indicated as one of these resources. Many additional areas to date have not been located or described.

Resources useful to both pipelines and fisheries should come under similar restrictions. Water, either from open water or under ice, and gravel, either from stream beds or stream banks, are two resources to be considered. Not only should the location be considered but the timing of construction should not conflict with the critical life history periods of the fish. Two such periods are migration and spawning for all species concerned (DeLury, 1972, pers. comm.).

In addition, future winter research and seasonal classification of the river systems is required to find supporting evidence for the degree of importance of rivers, streams and lakes. Considering these factors, the data necessary to formulate regulations for the utilization and management of resources can be collected.

7. References

Bryan, J. E., C. E. Walker, R. E. Kendel, and M. S. Elson. 1971. The influence of pipeline development on freshwater aquatic ecology in northern Yukon Territory. Progress report on research conducted in 1971. Report for the Fisheries Service, Department of Environment, Vancouver, B. C.

Clay, C. H. 1961. Design of fishways and other fish facilities. Department of Fisheries of Canada, Ottawa. 301 p.

Appendix Table 1. Latitude and longitude of sampling locations within the northern Yukon Territory (Winter Survey, March, 1972).

Water Body	Location
Bell River	Lat. 67°17'N, Long. 137°47'W
Lake	Lat. 67°20'N, Long. 137°15'W
Porcupine River	Lat. 67°34'N, Long. 139°49'W
Slough	Lat. 66°33'N, Long. 138°20'W
Fishing Branch River	Lat. 66°32'N, Long. 139°21'W
Firth River (spring)	Lat. 68°41'N, Long. 140°50'W
Firth River (open water)	Lat. 68°41'N, Long. 140°50'W
Fish Creek	Lat. 69°36'N, Long. 140°07'W

C H A P T E R I (b)

ADDITIONAL AERIAL SURVEY INFORMATION
OF SOME OF THE RIVERS IN THE NORTHERN YUKON
APRIL, 1973

by

G. J. BIRCH

for the

Environmental-Social Program

Northern Pipelines

Acknowledgements

The author acknowledges the assistance of R. T. DeLury, who provided an impetus, and A. Gibson and C. E. Walker for their administrative assistance. The invaluable field assistance of P. Nukon and L. Charlie is also appreciated. L. W. Steigenberger reviewed the manuscript. J. Fisher deserves special acknowledgement for his share of the responsibility for the field work.

1. Abstract

This survey was undertaken on April 11-16, 1973 to complete a spring aerial survey of the study area in the northern Yukon (Steigenberger, 1972). Rivers in the Richardson Mountains were of primary concern, namely Waters, Rat, Rock, Whitestone and Eagle Rivers. Some areas previously surveyed were repeated. Open water areas are of prime importance for overwintering of fish populations. The Old Crow River headwaters, Fishing Branch River and Firth River (including some tributaries) should have maximum protection during northern development.

Table of Contents

List of Figures

List of Plates

2. Introduction

In March, 1972 the Fisheries Service embarked on its first aerial classification of the winter habitat of the northern Yukon Rivers (Steigenberger, 1972). It was hoped that this survey would indicate some definite overwintering areas for fish.

The aerial classification of the study area was completed in April, 1973 as part of a broader winter sampling programme.

The primary area of reconnaissance lay in the Richardson Mountains and included the Waters, Rat, Rock and Eagle Rivers, as well as an upstream portion of the Whitestone River. While involved in other studies additional surveys were conducted along the rivers classified previously (Steigenberger, 1972). These included the Black Fox, Firth, Joe, Bluefish Rivers and Lord Creek, as well as the headwaters of the Old Crow River (Figures 1 and 2). The survey was conducted on April 11, 13, and 16, 1973.

3. Results

3.1 Eastern Porcupine Drainage

The area of primary concern lay along the tributaries of the Bell River and upper Porcupine River (Figures 1 and 2). All rivers appeared to be in the preliminary stages of break-up and as such the value of this information is uncertain. No large open water areas were sighted. The Rock, Eagle and Whitestone Rivers showed numerous open water patches located along the edges of gravel bars (Plate 1). Many of these areas are associated with overflow areas downstream (Plate 2) and many were surrounded by fresh animal tracks indicating substantial wildlife utilization. The Waters River showed a few open water patches (Plate 3) with a couple of overflow areas downstream. On the Rat River substantial overflow ice and water areas associated with the more braided sections of the river (Plate 4) and small open water patches were observed. This latter sighting probably occurs throughout the winter and is not a result of break-up.

While conducting the survey, numerous tributaries in this area were observed. All, including Chance Creek, a tributary of the Whitestone River, were covered with snow and ice and are probably frozen solid or are intermittent (Plates 5 and 6).

Seismic and winter road crossing sites were sighted (Plates 7, 8 and 9) in several instances.

3.2 Central Porcupine Drainage

The Bluefish, Lord and Driftwood Rivers were observed previously but, for various reasons, were surveyed anew (Figures 1 and 2). The Bluefish River is unusual in the changed locations of open water areas (for reference see Steigenberger, 1972), but its extensive open water, and overflow water and ice areas should indicate a substantial overwintering site. Preliminary sampling in October, 1972 showed that such is not the case. On Lord Creek and the Driftwood River, overflow water and ice areas, and open water patches were sighted. These appear to be recurring conditions and suggest further investigation of these rivers.

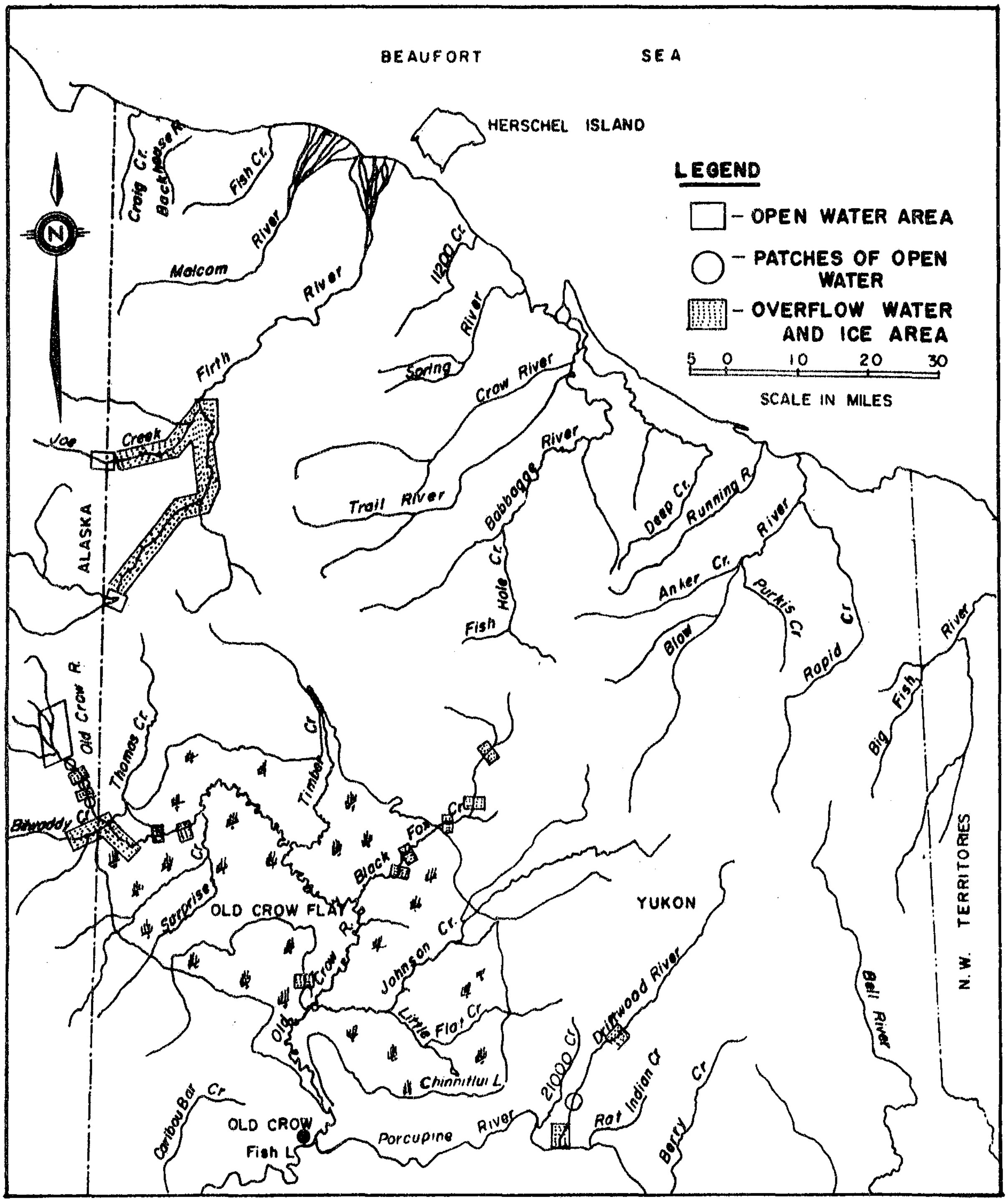


FIGURE 1: OPEN WATER AND OVERFLOW WATER AND ICE AREAS AS SIGHTED DURING A LIMITED AREAL SURVEY APRIL 1973

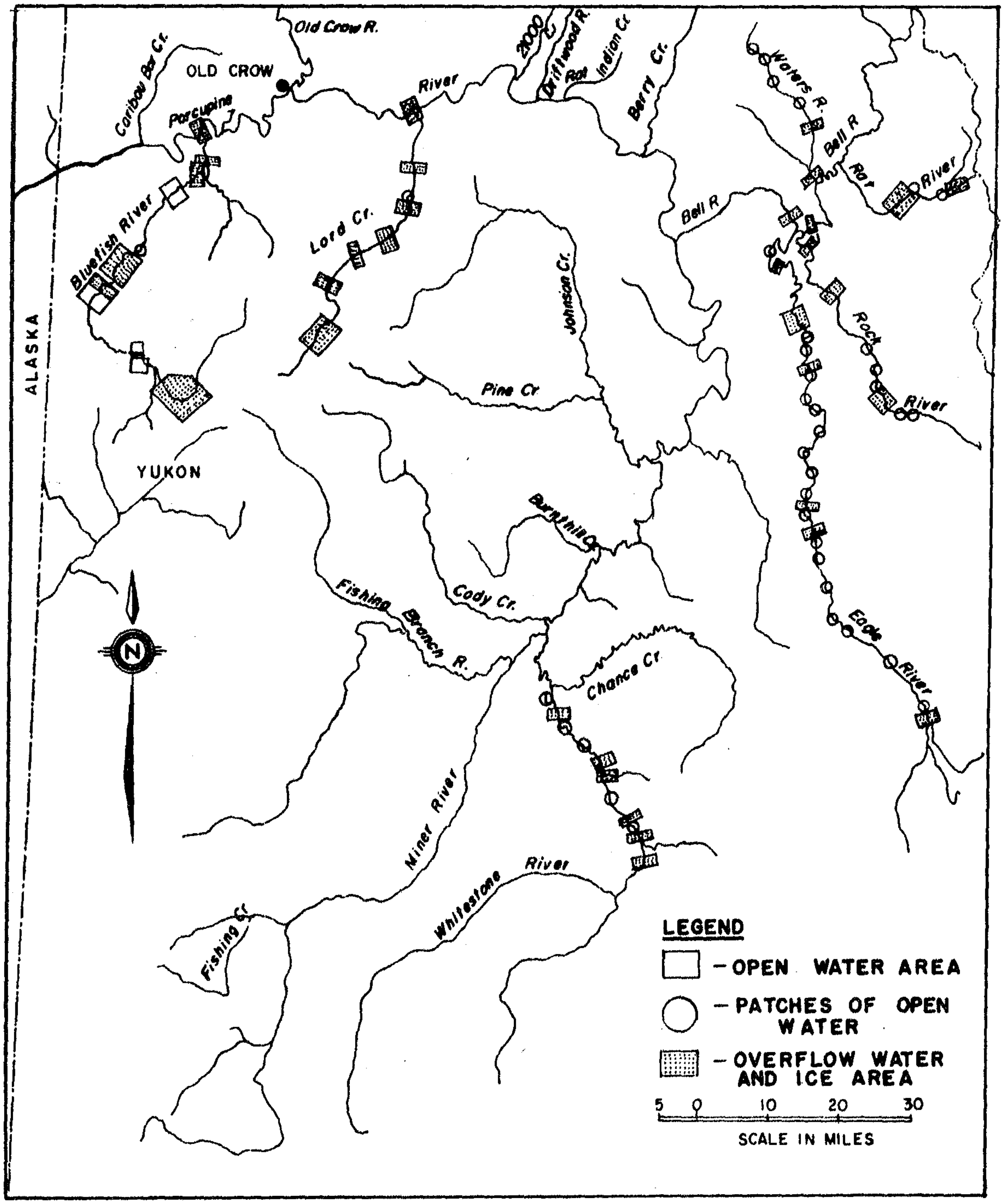


FIGURE 2: OPEN WATER, AND OVERFLOW ICE AND WATER AREAS AS SIGHTED DURING A LIMITED AREAL SURVEY, APRIL 1973

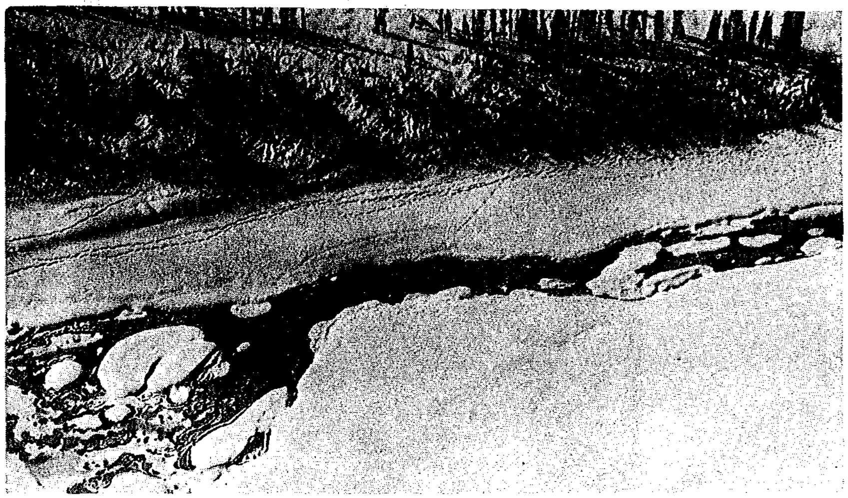


PLATE 1 - Open water patch on the Eagle River
April 1973.

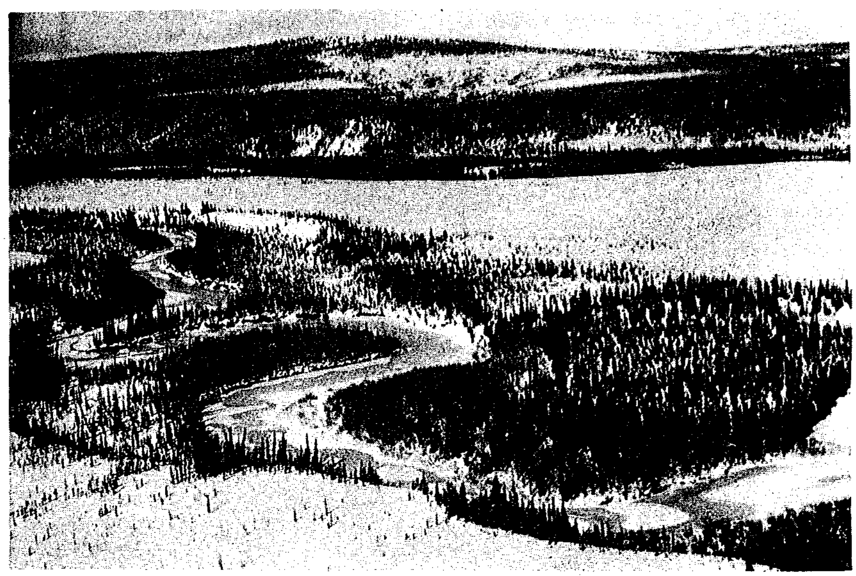


PLATE 2 - Overflow water, headwaters of Rock
River April 1973.

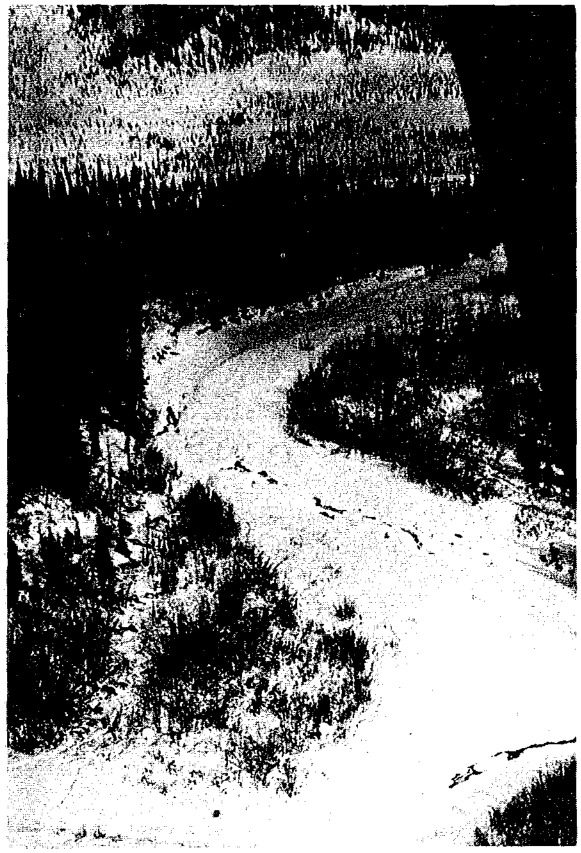


PLATE 3 - Open water patch on the Waters River April 1973.

PLATE 4 - Overflow ice and water, braided section of the Rat River April 1973.

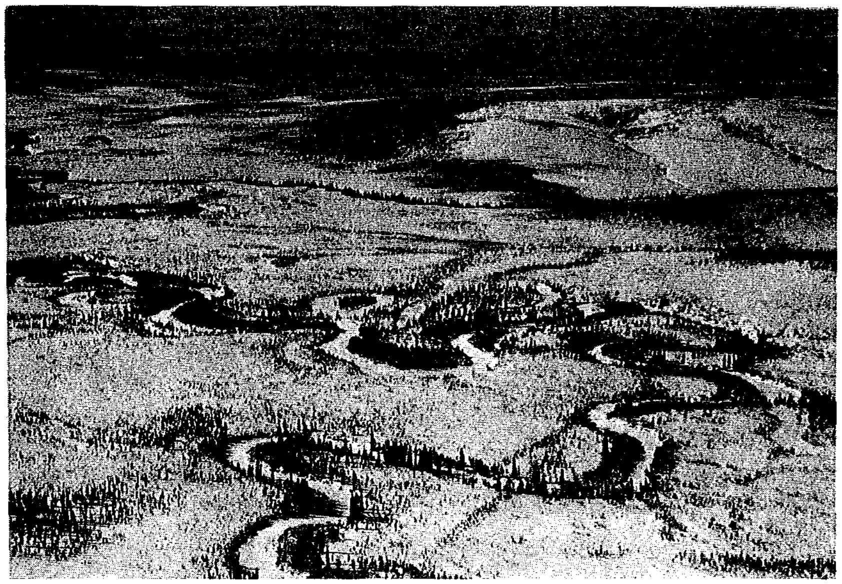


PLATE 5 - Ice and snow cover on streams in the Richardson Mountain Range April 1973.

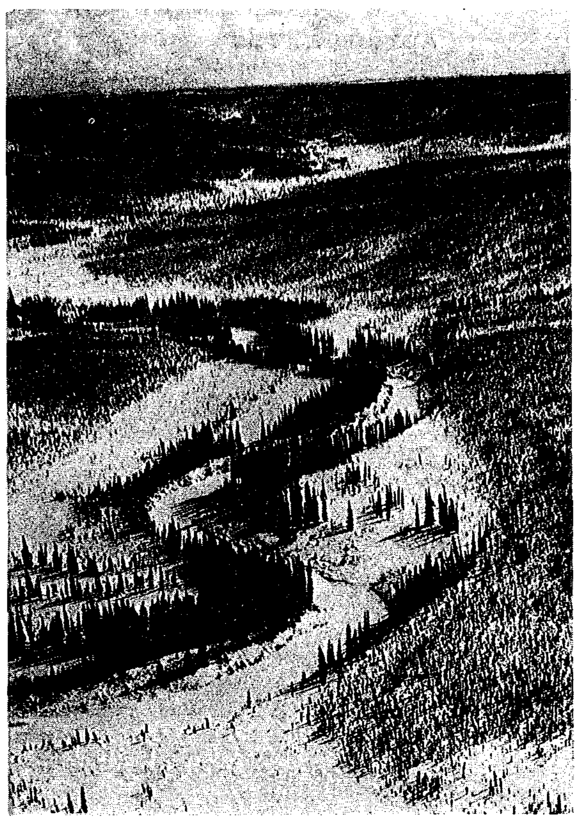


PLATE 6 - Snow and ice cover on Chance Creek, a tributary of the Whitestone River April 1973.

PLATE 7 - Overflow water downstream of a winter road crossing on the Eagle River April 1973.

PLATE 8 - A winter road crossing on the Eagle River April 1973.

3.3 Old Crow Flats

The lower limits of Schaeffer Creek and Black Fox Creek were also surveyed (Figure 1). Other than areas of overflow ice and water that may be the initial effects of break-up, no indication of open overwintering areas were observed.

3.4 Firth River

The Firth River and Joe Creek (Plate 10) were surveyed, and their consistently located groundwater areas resighted (Figure 1). Substantial overflow ice and water were observed downstream of these localities.

3.5 Old Crow River Headwaters

The reported groundwater area on the Old Crow River was mapped. It is located in Alaska along the western fringe of Ammerman Mountain. Oddly enough, no large grayling concentrations were sighted. These may be found associated with the considerable ice cover and overflow areas downstream, extending all the way into Canada (Plate 11).

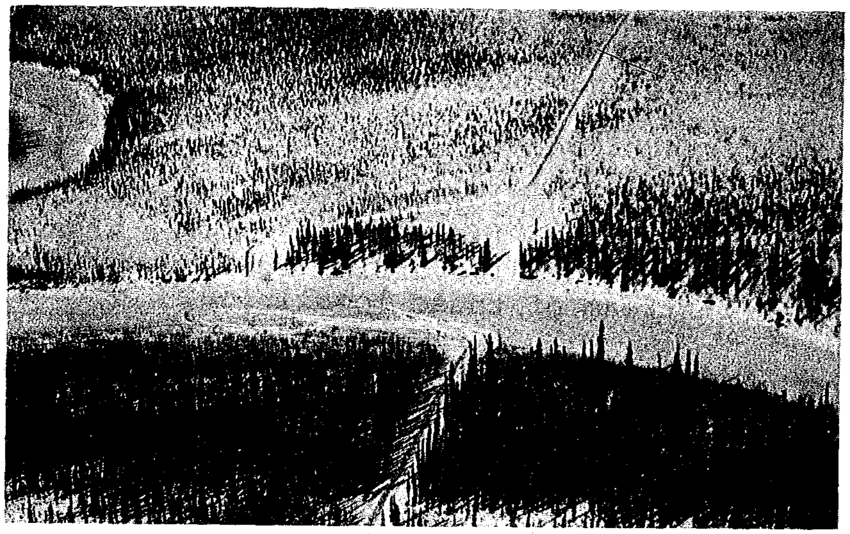


PLATE 9 - A winter crossing of the Rock River April 1973.

PLATE 10 - Open water below a groundwater source on Joe Creek, a tributary of the Firth River April 1973.

PLATE 11 - Overflow water in the Old Crow River headwaters near the Yukon - Alaska border.

4. Discussion and Recommendations

Time limitations made it impossible to sample any of the sighted open water areas. Little is known in the way of fish utilization of many of the sites, and until more data are collected they must be considered as highly probable overwintering areas and afforded protection from pipeline associated disturbance. Even if not directly utilized by fishes, the possibility of these winter water sources contributing to downstream habitability cannot be overlooked. The Old Crow River headwaters, Fishing Branch River, and Firth River (including some tributaries) should have complete protection according to their known utilization.

5. References

Steigenberger, L. W. MS 1972. Preliminary information on the winter classification of the rivers in the northern Yukon, their physical and chemical characteristics, and the fish statistics of the various water bodies examined during the first Yukon pipeline winter survey, March, 1972. Fisheries Service, Department of the Environment, Vancouver, B. C.

C H A P T E R I I

ENUMERATION OF SPAWNING CHUM SALMON (*ONCORHYNCHUS KETA*) IN THE FISHING BRANCH RIVER IN 1971, 1972, 1973 AND 1974

by

M. S. ELSON

Northern Operations Branch

Fisheries and Marine Service

Department of the Environment

for the

Environmental-Social Program

Northern Pipelines

Acknowledgement

Funds for the study of the Fishing Branch River were supplied in 1971 and 1974 by the Environmental-Social Program, Northern Pipelines, Task Force on Northern Oil Development. Regular divisional funds were utilized in 1972 and 1973.

Thanks are due the Fisheries Service staff of the Whitehorse office for support of the field operations and to R. Kendel and O. Sweitzer for assistance in 1971 surveys. P. Ryan provided valuable expertise in the 1972 aerial photography surveys. Able technical assistance was supplied by E. Smyth, D. Desjardins, W. Moses, R. Howe, C. W. Brandt, P. Bruce, H. Algotsson and D. Yates in the field operations.

L. W. Steigenberger reviewed the manuscript. The project was administered by A. Gibson and C. E. Walker.

1. Abstract

A ten mile long spring-fed section of the south fork of the Fishing Branch River (Lat. 66°27'N, Long. 138°32'W) in northern Yukon Territory is a major overwintering open water area. Large numbers of chum salmon (Oncorhynchus keta) spawn in September and October in the ice-free area. Much smaller spawning populations of chinook salmon (O. tshawytscha) and coho salmon (O. kisutch) utilize the spawning grounds earlier (July to August) and later (October to November) respectively than the chum salmon. The population of chinook salmon in any year probably does not exceed twenty-five fish. The population of coho salmon in peak years may approach 300 fish. Three species of non-anadromous fish have been identified in the south fork of the Fishing Branch River. These are Arctic grayling (Thymallus arcticus), round whitefish (Prosopium cylindraceum) and slimy sculpin (Cottus cognatus). Other species may be present seasonally.

The chum salmon spawning population was estimated in 1971, 1972, 1973 and 1974 by employing several methods of enumeration including aerial surveys, mark and recapture programmes, and (most efficiently) a counting fence in the last three years of the study. The population estimates for each year of the study were:

1971	115,000 chum salmon
1972	35,125 chum salmon
1973	15,989 chum salmon
1974	31,525 chum salmon

The sex ratio of 22,000 chum salmon was very close to 1:1. Males are larger than females. Males form a greater proportion of the migration from September 1 to 20; females outnumber males from October 1 to 20. The fecundity is approximately 2500 eggs per female. Most of the chum salmon are four years old. Age composition, sex ratios, fecundity, size and spawning ground preference of Fishing Branch River chum salmon are very similar to characteristics of summer chum salmon of the Amur River in U.S.S.R.

A mark and recovery programme was conducted in 1973 to estimate the populations of Arctic grayling (Thymallus arcticus) and round whitefish (Prosopium cylindraceum) in the south fork of the Fishing Branch River. The grayling population was estimated to be approximately 9000 fish. The round whitefish population is believed to be less than 200. Arctic grayling prey on both the eggs and fry of chum salmon, but the extent of predation and its effect on the salmon stocks is not known.

Table of Contents

List of Figures

List of Tables

List of Plates

2. Introduction

The Fishing Branch River is one of the headwater streams of the Porcupine River in northern Yukon Territory. It drains via the Porcupine and Yukon Rivers into the Bering Sea in Alaska, a distance of approximately 1,600 miles. The major chum salmon spawning area is confined to approximately 9 miles of the south fork of the Fishing Branch River (Figure 1), and straddles the Arctic Circle at 66° 30'N latitude. More northerly spawning streams are known on the Arctic coast of the U.S.S.R. and in Alaskan tributaries of the Porcupine River, notably the Sheenjek and Colleen Rivers, but it is not known whether these populations approach the magnitude of the Fishing Branch River runs.

On the spawning grounds, discharge of sub-permafrost groundwater from springs provides the major source of sustained flow in late summer, fall and winter. Water temperatures are relatively constant throughout the year at the areas of discharge, and the discharge area of the river remains free of ice all year. The river is clear and swift, meandering in nature with alternating riffles and pools and large exposed gravel bars formed on the inside of each bend. The outsides of the bends frequently exhibit undercutting and slumping of the banks. The maximum depth is about 8 feet in pools below riffles and the bed is of medium to large cobble with finer gravel forming the bars. Side channels of the river are slow-moving, brownish in colour with loose, fine granular sediment over medium-sized cobble. Devonian limestone and shales are exposed in sections of the upper spawning grounds. Muskeg often extends to the river bank and supports good stands of black and white spruce, unidentified fir, willow, larch and minor amounts of birch. Stream discharges on September 16 and September 22, 1972 were approximately 2000 cfs and 800 cfs respectively, reflecting substantial fluctuations caused by fall rains. Water temperatures at the areas of groundwater discharge range from 1°C to 30°C during the fall salmon spawning period.

Wildlife is abundant in the area, particularly during the months of September and October when certain carnivorous species are attracted by the readily available supply of fish as a food source. Grizzly bear, timber wolves, pine marten, and bald and golden eagles have been observed feeding on dead chum slamon. Mink, fox, wolverine and

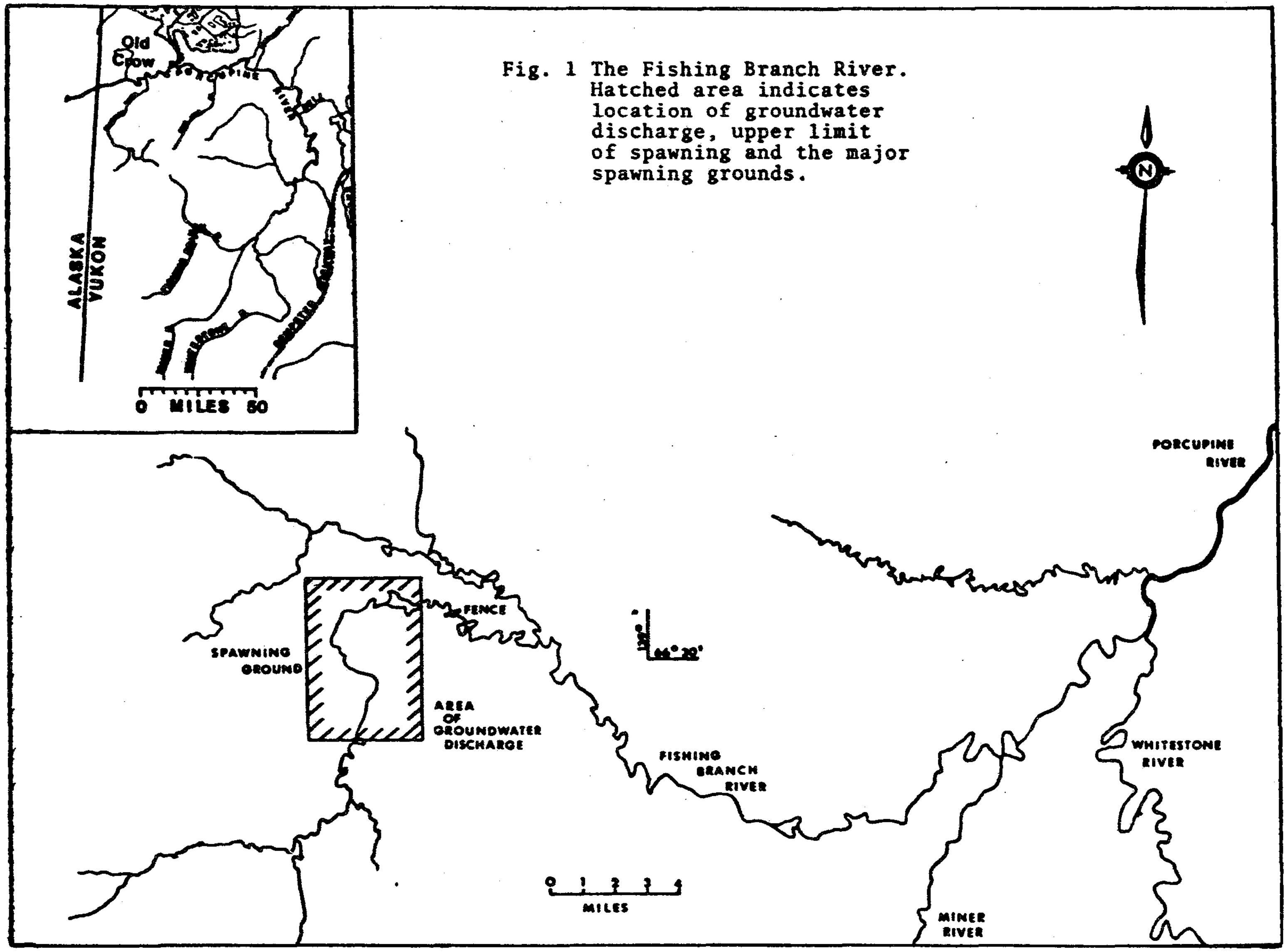


Fig. 1 The Fishing Branch River. Hatched area indicates location of groundwater discharge, upper limit of spawning and the major spawning grounds.

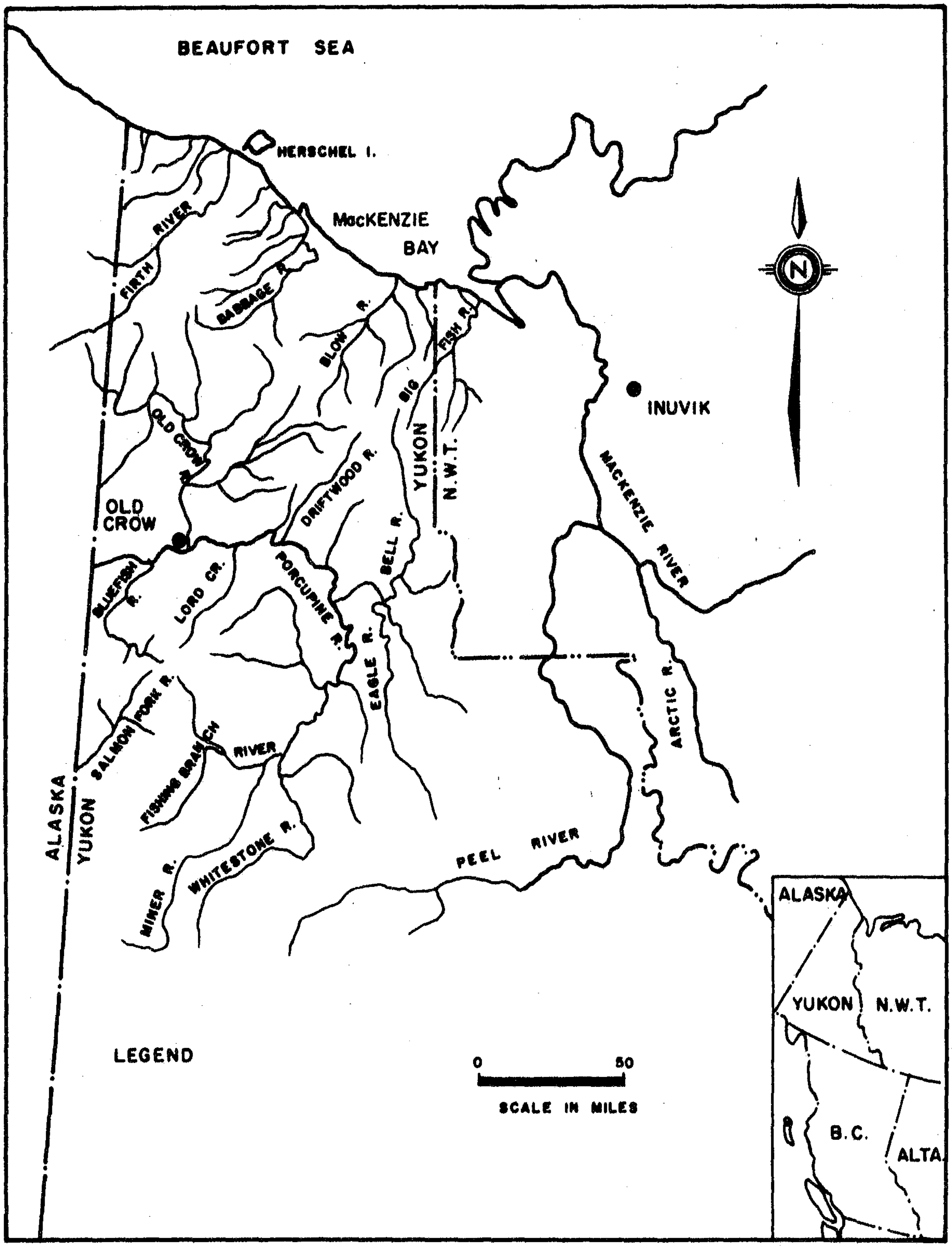


Figure 1(a) General locality map of the northern Yukon Territory.

common mergansers are present and possibly prey on the spawning fish. Fish species in the south fork of the Fishing Branch include chum salmon (Oncorhyncus keta), Arctic grayling (Thymallus arcticus), round whitefish (Prosopium cylindraceum), coho salmon (Oncorhyncus kisutch), chinook salmon (Oncorhyncus tshawytscha) and slimy sculpin (Cottus cognatus). Other species may be present seasonally, since pike (Esox lucius), humpback whitefish (Coregonus clupeaformis), and broad whitefish (Coregonus nasus) have been captured farther downstream in the Fishing Branch near its confluence with the Miner River. The location of the spawning grounds had long been known by Loucheaux Indians from the village of Old Crow on the Porcupine River approximately 220 miles downstream. Chum salmon en route to the spawning grounds form a significant part of the catch in the domestic fishery conducted at Old Crow. Estimates range from 5,000-10,000 pieces annually for the period 1962-1972, and the catch may have been higher previously because of heavier reliance on local food sources. Information received from the natives of Old Crow prompted the first biological investigation of the salmon spawning grounds in 1971 in conjunction with investigations of fish resources on and adjacent to proposed northern pipeline routes. Initial attempts at quantification of the chum salmon spawning population in the Fishing Branch River were made by aerial surveys in September and October of 1971. More accurate population estimates were made in 1972, 1973 and 1974 by means of a counting fence. Table I indicates population estimates for all years and the methods of enumeration. An experiment was conducted in 1972 to test the efficacy of photoenumeration, and mark and recovery programmes were employed in 1972 and 1973 in conjunction with the fence count. Observations and activities of fish species other than salmon were noted throughout the projects, and a mark and recovery programme was conducted to estimate the population of Arctic grayling.

This report summarizes the techniques employed and the results obtained during four years of enumeration of chum salmon populations in the Fishing Branch River (1971-1974). It provides additional information and supersedes an earlier technical report (Elson, M., 1973) on 1971 and 1972 work and an earlier manuscript report (Elson, M., 1973) on 1973 work.

Table I. Total chum salmon population by year as determined by all methods of enumeration.

Year	Enumeration Method	Population
1971	Aerial Surveys	115,000
1972	Mark and Recovery) Aerial Surveys) Counting Fence)	35,125
1973	Counting Fence	15,989
1974	Counting Fence	31,525

3. Methods (General Presentation)

The report is divided into four sections, one for each year of the four-year project. The methods employed in data collection are presented in subsections preceding the results and discussion for each year of the study.

4. Results and Discussion (General Presentation)

Results for each method of enumeration for each year are presented in the corresponding subdivision for that year. The results are discussed, compared and contrasted with results from other years of the project.

3.1 Methods 1971

3.1.1 Aerial Surveys

Helicopter-supported surveys were conducted in September and October, 1971, over the Fishing Branch River spawning grounds. The first survey was conducted in the period September 22-29 and the second from October 12-14. A further one-day inspection of the river was made in early December. In all surveys, estimates were made by at least two observers from a helicopter, one observer seated in the front of the aircraft and one in the rear. Airspeed of the machine was kept to a minimum safe limit, the average being about 20 mph. The optimum altitude for observing large numbers of spawning fish was found to be about 200 feet above the stream. In areas of dense concentration where it was not possible to count individual fish, the method of enumeration was to estimate the number of units of 100 fish. Polaroid glasses were worn to eliminate glare. In the first two surveys, aerial estimates were made from the junction of the Miner and Whitestone Rivers to the upper limit of spawning in the south fork of the Fishing Branch. In conjunction with the aerial surveys, a downstream drift enumeration was conducted from a rubber boat on September 25 in the areas of heaviest spawning.

In efforts to locate undocumented spawning grounds for chum salmon in other streams in the area, aerial surveys were conducted in late September and early October by fixed-wing and helicopter aircraft in some years. These surveys were prompted by the capture of a male chum salmon in the Bell River in September 1971. The fish was caught in a gill net approximately 30 miles above the confluence of the Bell and Porcupine Rivers.

All surveys were made on tributary streams of the Porcupine River, and included the north fork of the Fishing Branch, the Bell River, Cody Creek, the Miner River and the Whitestone River in 1971 (Figure 1(a)).

3.1.2 Old Crow Sampling

Scales, otoliths, lengths, weight, fecundity and sex samples were collected from segments of the chum salmon population migrating past Old Crow in the Porcupine River in the fall of 1971. These fish were collected in the gill-netting programme conducted by the Yukon Pipeline Survey. It is assumed that most of the salmon were migrating upstream to the Fishing Branch River spawning grounds, and the data are therefore included in this report.

4.1 Results and Discussion 1971

4.1.1 Aerial Surveys

Table II shows the 1971 chum salmon population estimates as indicated by aerial and rubber boat surveys. Visibility was good in all aerial surveys, but difficulties were experienced with glare in conducting the drift enumeration from the rubber boat. The population estimate obtained from the rubber boat is believed to be poor.

No live chum salmon were seen in the December 6 aerial survey, but 6 live coho salmon were observed on the spawning grounds.

In 1971, the highest estimate of population by aerial survey was 115,000 chum salmon. Bevan (1961) stated variability among observers of ±50%. Assuming this degree of variability, the actual population was in the range of 115,000 ±50% on October 12, 1971. Any estimate made at one time does not correctly estimate the total number of spawners utilizing a particular stream because of continuing recruitment to and mortality of segments of the population. Information on longevity of individual spawners combined with more frequent observations would provide a more accurate assessment of total population. More information is required on turnover rates in the Fishing Branch River before such a method of total assessment of population could be implemented.

No chum salmon were located in any of the aerial surveys conducted on other tributary streams in the area (Figure 1(a)). Visibility was often partially obscured by ice cover and/or silty water, especially in the lower reaches of the Bell River. Also, due to logistical limitations imposed by time and fuel constraints, the entire lengths of these rivers were not surveyed, observations being made mainly in those sections of the rivers having suitable spawning gravels. For these reasons, the possibility of minor spawning in some of these streams should not be discarded, but it is improbable that significant numbers of chum salmon will be found in Cody Creek, the Bell River, Miner River, Whitestone River or north fork of the Fishing Branch River.

4.1.2 Old Crow Sampling

Length-frequency relationships of male and female chum salmon captured at Old Crow in 1971 are shown in Figure 2. Information on age, sex and fecundity of fish sampled in 1971 is presented and discussed in relation to corresponding information from other years in the appropriate sections for those years. Table III gives statistical data on mean fork lengths for samples of chum salmon for each year of the study, and Table IV shows mean fork lengths of different age classes by sex for each year. The data illustrate that the mean fork lengths of males is consistently larger than females for each year of the study. In addition, older fish (age 5 as opposed to age 4) are consistently larger than younger fish.

Table II. Population estimates of chum salmon in 1971, 1972 and 1974 as indicated by aerial and rubber boat surveys.

Year	Date	Type of Survey	Live	Dead	Total
1971	Sept 25	Rubber boat	52,000		52,000
	Sept 29	Aerial	90,000	2,000	92,000
	Oct 12	Aerial	85,000	30,000	115,000
	Dec 6	Aerial	0 (6 coho)		
1972	Sept 9	Aerial	1,500		1,500
	Sept 14	Aerial	7,000		7,000
	Sept 22	Aerial	11,600		11,600
1974	Nov 19	Aerial	5,000	800	5,800

Table III(a). Statistical data on mean fork lengths of various sized samples by year of male chum salmon from the Fishing Branch River. 1971 sample from Old Crow.

Year	Sample Size	Mean Fork Length (mm)	Variance	Standard Deviation	Standard Error
1971	275	639.0	1010.2	31.8	1.92
1972	226	691.3	1120.1	33.5	2.23
1973	272	685.3	1406.8	37.5	2.27
1974	62	634.6	2890.4	53.8	6.83

(b). Statistical data on mean fork lengths of various sized samples by year of female chum salmon from the Fishing Branch River. The 1971 sample is from Old Crow.

Year	Sample Size	Mean Fork Length (mm)	Variance	Standard Deviation	Standard Error
1971	48	609.6	1188.5	34.5	4.98
1972	435	643.3	793.4	28.2	1.35
1973	345	638.9	1012.8	31.8	1.71
1974	57	598.9	2145.4	46.3	6.14

Table IV(a). Statistical data on mean fork lengths by age class of male chum salmon from Old Crow and the Fishing Branch River. Sample includes some fish from each year (1971, 1972, 1973, 1974).

Age	Mean Fork Length (mm)	Standard Deviation	Sample Size
4	635.9	36.9	204
5	673.9	41.3	65

(b). Statistical data on mean fork lengths by age class of female chum salmon from Old Crow and the Fishing Branch River. Sample includes some fish from each year (1971, 1972, 1973, 1974).

Age	Mean Fork Length (mm)	Standard Deviation	Sample Size
4	607.7	38.8	129
5	652.4	23.5	53

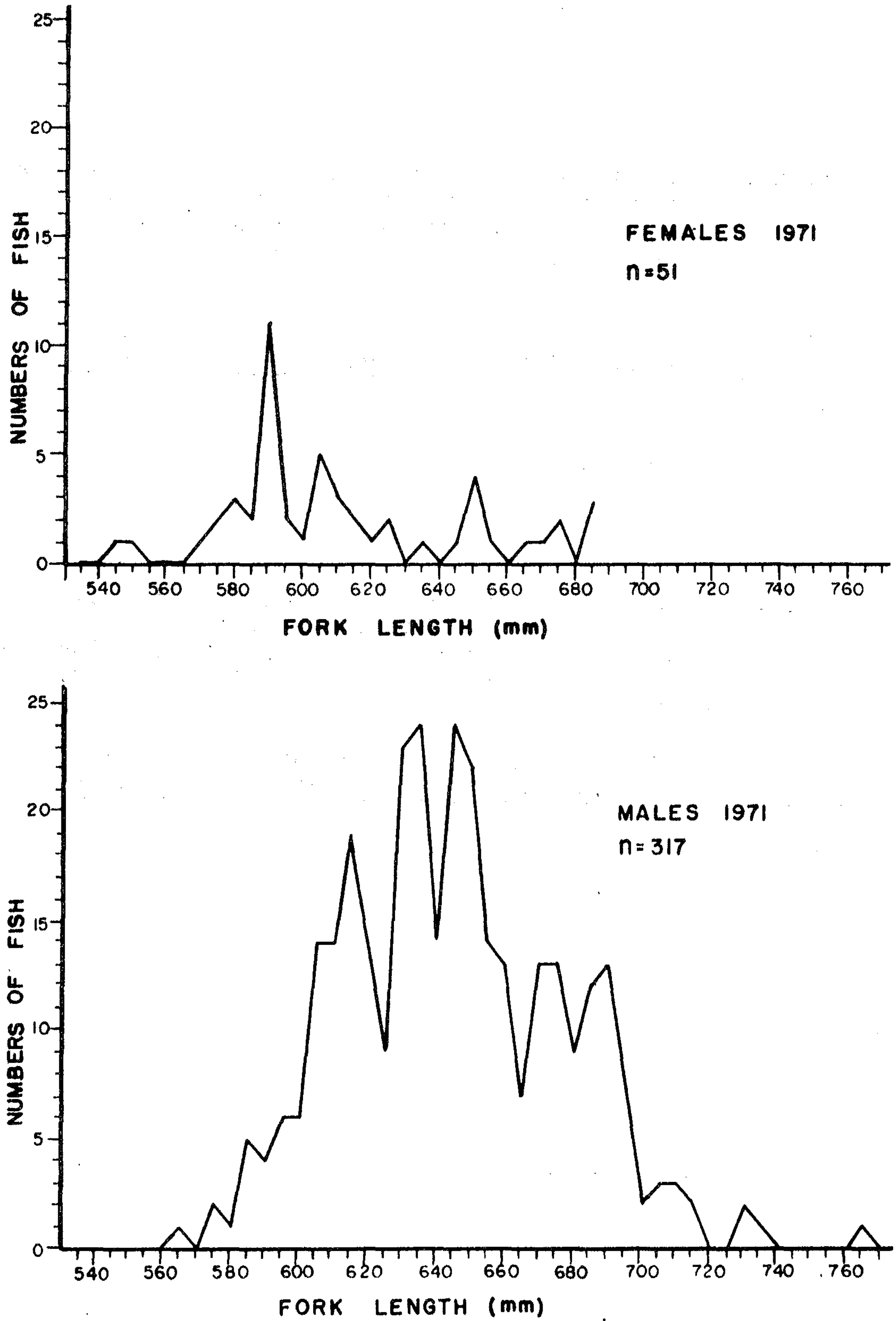


FIGURE 2: LENGTH-FREQUENCY DISTRIBUTION OF CHUM SALMON CAPTURED AT OLD CROW IN 1971.

3.2 Methods 1972

3.2.1 Counting Fence

In 1972, a counting fence was selected as the best means of obtaining a more accurate population estimate of the spawning salmon. A fence site was established on the south fork of the Fishing Branch River approximately 20 miles upstream from its confluence with the Miner River. Selection of the site was determined by suitable physical dimensions of the river and by knowledge of the downstream limits of extensive spawning as determined by the previous year's aerial surveys. The river at the enumeration point was 250 ft. wide, with an average depth of 2.5 ft. and a velocity of 3.5 fps. on September 4, 1972.

Unusually high water levels caused by heavy rains and debris prevented immediate construction of the fence, but it was installed on September 13th. However, high water conditions necessitated its removal after 16 hours of operation to prevent loss of the entire structure. By September 22nd, water levels had receded to a point at which reconstruction of the fence was possible. The fence remained operational to October 21st, and was manned for an average of 13 hours per day. Hours of counting were reduced when numbers of fish ascending the river decreased. Twenty-four hour counts were made on September 27th and 28th, to determine diel periodicity. The gate was closed at all times when the fence was unmanned. No attempt was made to determine fish sex during counting.

Supporting structures for the fence were constructed as follows: Tripods of 2" X 4" lumber in 6 ft. lengths were spaced across the river at 9-10 ft. intervals. Approximately 400 lbs. of rock in sandbags was placed on the top of each tripod to hold it in place against the current. Each tripod was braced with 2" X 4" crosspieces between all three pairs of legs. Plates 1 and 2 illustrate the structural components of these tripods.

Ten-foot lengths of five-eighth-inch concrete reinforcing bar were attached to the forward legs of adjacent tripods approximately 4 in. above the river bottom. Ten-foot lengths of pole were attached to the forward legs of adjacent tripods approximately 2 ft. above the water level. Two types of metal panel provided the grid barrier of the fence. One type, 4' X 4' with aluminum rods at 2 in. centres, presented less water resistance and was used in deeper parts of the river, while 4' X 8' welded wire mesh in 2 in. squares was used in shallower water. These panels

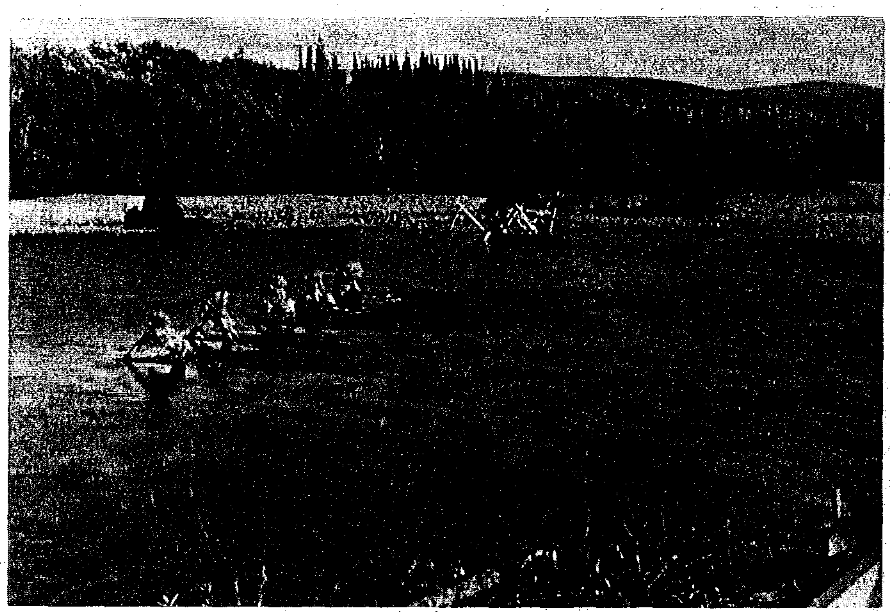


Plate 1. First stage in construction of the counting fence, September 7, 1973.

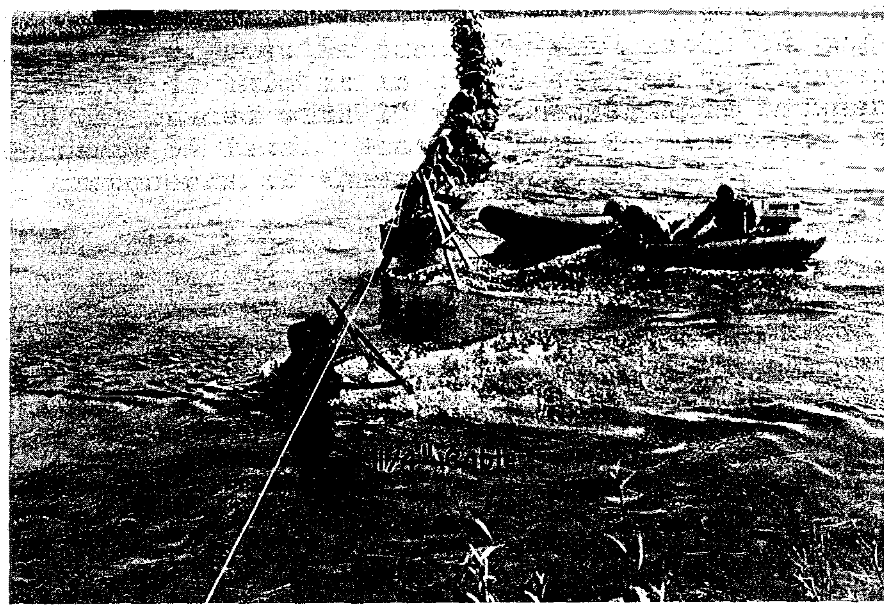


Plate 2. Placing tripods for the counting fence September 9, 1973. The supporting cable is indicated.

were wired to the pole stringers and reinforcing bar to form a continuous barrier across the river. One 4' X 4' panel in the deepest channel 20 ft. from the west bank was removable, and served as the gate to allow passage of fish. A section of white muslin was submerged immediately in front of the gate. This provided a suitably light background against which fish could be easily counted. The area at the opening was illuminated by two 100 Watt flood lamps suspended 2 ft. above the water surface. Electric power was provided by a 3000 Watt Kohler electric generator which also provided lighting for the camp. Plate 3 shows the completed fence in 1972.

3.2.2 Tagging Programme

To provide information on stream residence, tags were applied to a part of the population in 1972. Six hundred and fifty salmon were tagged in the period September 16-21 with various coloured 7/8 in. Petersen disc tags. Additional buffer discs were not applied. Tagging was done at various points above the fence site but within 2 miles of the structure. An additional 200 chum salmon were tagged on the spawning grounds on October 7 and October 10. The fish were captured in an 80' X 9' seine net set from shore with an inflatable boat powered by a 9.5 h.p. outboard motor.

Fork lengths (tip of snout to fork of tail) and sex were recorded from 650 fish and 100 scale samples were taken for age determination during the tagging operation. Sex was recorded for all dead salmon found on the fence, and additional fork lengths taken from some of these.

It was not possible to do daily dead recoveries because of distances involved from the fence site to areas of major spawning and dying. Dead fish recoveries were made on each of ten days in the period October 7-20 and tagged to untagged ratios established.

In addition to localized tagging done in the vicinity of the counting fence, one thousand salmon were tagged at Ramparts on the Yukon River through an arrangement made with the Alaska Department of Fish and Game to obtain information on migration of chum salmon in the Upper Yukon River system. Tagging was done from August 26 to October 1, 1972, approximately 800 miles downstream from the Fishing Branch spawning grounds. The times of passage through the fence were noted for some of these fish but in only one case was a tagged fish captured and the tag number identified.

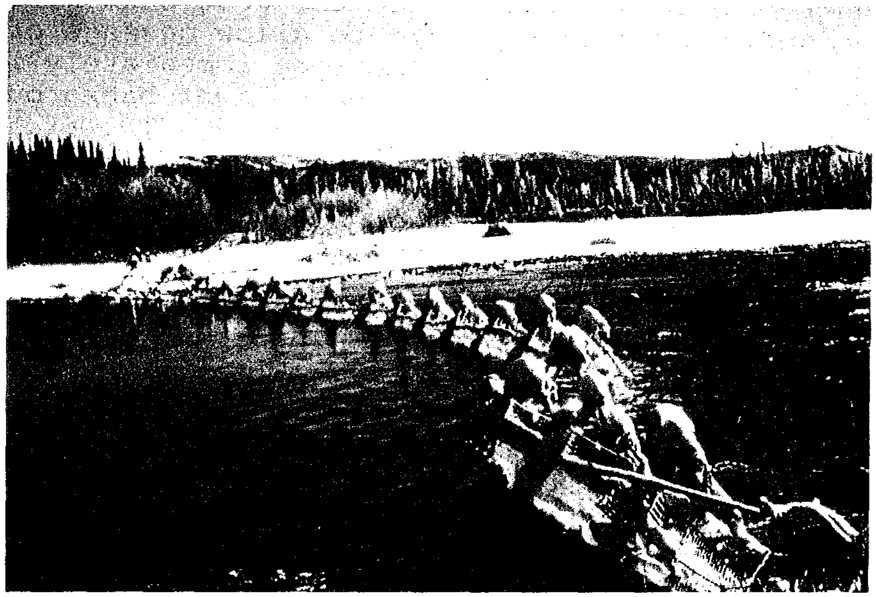


Plate 3. Completed counting fence in early October, 1972.

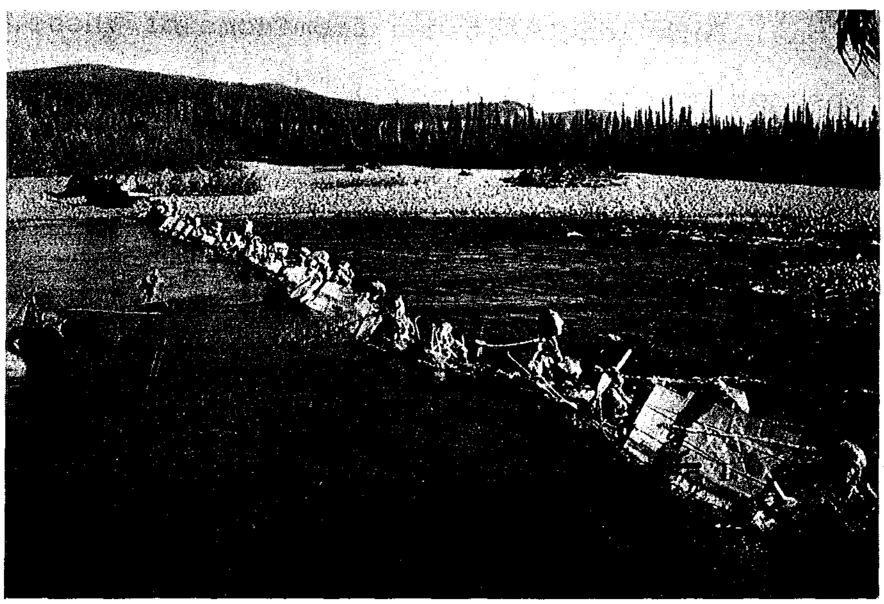


Plate 4. Completed counting fence in 1973. The holding pen and grid panels are indicated.

3.2.3 Aerial Photography

An experiment was conducted in 1972 to investigate the possibility of utilizing aerial photographs as a means of estimating spawning population magnitude.

A 35-mm Shackman Autocamera Mark 3 was utilized in the aerial photography survey. It was mounted on the inside of the bubble of a helicopter in such a position that photographs were taken at an angle of 20° from the vertical when the aircraft was in normal flying attitude. This slight deviation from the vertical was adopted so that visual observations could be made at the same time as photographs were being taken. The spawning grounds were photographed from the upper limit of spawning to the fence site from a planned altitude of 200 ft. with an airspeed of approxaimtely 40 miles per hour. Individual photographs were taken with a frequency to theoretically provide a continuous sequence with a 15% overlap between successive frames.

3.2.4 Aerial Surveys

Aerial surveys (by helicopter) were conducted over the Fishing Branch River spawning grounds on three occasions in September. Because of heavy silt load in the water caused by heavy rains, visibility was very poor in the September 9 and September 14 surveys. Visibility was good in the September 22 survey.

Survey flights were made in late September over the Salmon Fork River and the north fork of the Fishing Branch River in efforts to locate undocumented chum salmon spawning grounds. Visibility was good.

4.2 Results and Discussion 1972

4.2.1 Counting Fence

The total fence count in 1972 was 17,190 chum salmon.

Table V lists the fence counts by date for the three successive years 1972, 1973 and 1974. This information is presented graphically in Figure 6 as percentages of the run present on the spawning grounds by date in the three successive years. A discussion of this information is presented in section 4.4.1, where it more properly lends itself to comparison.

Table VI lists hourly totals of two successive 24-hour counts made in September 1972. No definite patterns of migration in relation to time of day are evident.

One chinook salmon was seen at the fence site in 1972. Approximately 100 round whitefish were observed passing upstream through the fence in mid-October, possibly on a spawning migration.

4.2.2 Tagging Programme

In 1972 tag recovery ratios indicated a chum salmon population of 17,935 already on the spawning grounds prior to installation of the fence on September 22. The aerial estimate made at this time was 11,600. Several sources of error are inherent in a mark and recovery programme. Population estimates based on tagging exhibit significant positive bias due to tag loss. For example, Vernon et al (1964) reported a positive bias of 25% for male pink salmon and 11% for females as compared to fence counts. Lister and Harvey (1969) showed that the addition of accessory buffer discs to the tag reduced loss by 50%. Additional buffer discs were not applied in the Fishing Branch study. It is probable that tag loss combined with incomplete recovery of available tags resulted in an appreciable positive bias in the population estimate as calculated from tagging results, but the tagging estimate is probably more accurate than the aerial estimate.

It is assumed that the majority of dead recovered were fish occupying the river prior to initiation of the fence count. The limited information gathered suggests that stream residence for fish in the early part of the run is approximately one month. If, as in southern streams, turnover rates (length of life) decrease for the latter part of the run, it is possible that some of the dead recovered had already been counted through the fence. This would result in an unknown negative bias in the population estimate based on tag recoveries. Since it is believed that the population estimate based on tag recoveries is more accurate than the aerial estimate of 11,600, the tagging estimate of 17,935 chum salmon is used as the actual population.

The total chum salmon population in the Fishing Branch River in 1972 is taken to be 17,190 (fence count) + 17,935 (tagging estimate) = 35,125. This total would be increased by an unknown number of fish arriving on the spawning grounds after removal of the fence on October 21.

Table V. Daily and cumulative counts of chum salmon through the Fishing Branch River counting fence in 1972, 1973 and 1974.

	1972		1973		1974	
Date	Daily Count	Cumulative Count	Daily Count	Cumulative Count	Daily Count	Cumulative Count
Sept 5					0	0
6		Note:			15	15
7		Cumulative			17	32
8		count on			30	62
9		Oct. 21			69	131
10		includes	83	83	217	348
11		estimate of	93	176	384	732
12		17,935 chum	345	521	1477	2209
13		salmon as	1036	1557	1389	3598
14		determined	625	2182	2896	6494
15		from tagging	704	2886	3529	10023
16		plus fence	1197	4083	3742	13765
17		counts from	1054	5137	3388	17153
18		Sept 22.	758	5895	2369	19522
19			689	6584	1953	21475
20			720	7304	2325	23800
21			579	7883	1642	25442
22	32*	17967	548	8431	1017	26459
23	1101	19068	781	9212	1044	27503
24	896	19964	852	10064	621	28124
25	980	20944	533	10597	583	28707
26	1002	21946	503	11100	388	29095
27	1396	23342	536	11636	234	29329
28	1192	24534	847	12483	291	29620
29	1135	25669	594	13077	164	29784
30	988	26657	567	13644	166	29950
Oct 1	690	27347	437	14081	220	30170
2	637	27984	493	14574	92	30262
3	437	28421	323	14897	123	30385
4	239	28660	301	15198	88	30473
5	261	28921	174	15372	31	30504
6	121	29042	115	15487	30	30534
7	156	29198	149	15636	20	30554
8	262	29460	69	15705	26	30580
9	200	29660	69	15774	5	30585
10	129	29789	46	15820	14	30599
11	270	30059	32	15852	70	30669
12	998	31057	41	15893	85	30754
13	1331	32388	27	15920	17	30771
14	638	33026	28	15948	81	30852
15	426	33452	12	15960	35	30887
16	545	33997	10	15970	124	31011
17	309	34306	8	15978	344	31355
18	190	34496	6	15984	170	31525
19	377	34873	0	15984		
20	132	35005	3	15987		
21	120	35125	2	15989		
Total		35125		15989		31525

*1/2 hour count

Table VI. Numbers of chum salmon per hour passing through the Fishing Branch River counting fence during two consecutive twenty-four hour periods in 1972.

Time Period	Count Sept. 27	Sept. 28
0000-0100	59	53
0100-0200	56	43
0200-0300	63	38
0300-0400	55	63
0400-0500	50	68
0500-0600	32	44
0600-0700	60	48
0700-0800	46	54
0800-0900	50	60
0900-1000	34	44
1000-1100	26	38
1100-1200	20	58
1200-1300	24	38
1300-1400	31	54
1400-1500	37	50
1500-1600	63	53
1600-1700	43	59
1700-1800	60	70
1800-1900	109	46
1900-2000	66	47
2000-2100	61	53
2100-2200	68	37
2200-2300	64	45
2300-2400	49	29
Total	1396	1192

Table VII indicates the average stream residence of a sample of chum salmon tagged near the fence site in 1972. All of these fish were tagged in the period September 16-21 en route to the spawning grounds.

Table VII. Average length of life from tagging to recovery of a sample of chum salmon tagged near the fence site in 1972.

No. of Tagged Fish Recovered	Tagging Period	Average Length of Life from Tagging to Recovery	Range in Days from Tagging to Recovery
39	Sept 16-21	30.5 days	28-32

Nine chum salmon tagged at Ramparts in Alaska were observed passing through the fence. One of these tags was recovered at the fence on October 13. It had been tagged on August 29 and had averaged approximately 20 miles per day en route to the spawning grounds.

Figure 3 shows length-frequency distribution of a sample of male and female chum salmon in the Fishing Branch River in 1972.

4.2.3 Aerial Photography

Fish could not be identified in any of the photographs obtained in the aerial photography programme conducted on the Fishing Branch River in 1972. The most important contributing factors to the unfavourable results were:

(1) The use of a camera with mechanical deficiencies including an unsuitable lens, inadequate light-meter and an insufficiently fast shutter speed.

(2) Differences in shaded and sunlit areas of the stream surface resulted in contrast extremes which were beyond the range of latitude of the film.

(3) Poor colour contrast existed between the chum salmon and their background.

Aerial methods of recording sizes of population of sockeye salmon on spawning grounds in western Alaska have been highly developed (Eicher, 1953). Successful results in streams in Alaska have been achieved mainly because of the sharp contrast between the colour of spawning sockeye and the stream bed.

In the Fishing Branch River, the use of a more sophisticated camera would solve most of the mechanical difficulties associated with the experiment, such as shutter speed and lens length. The use of a spotmeter might improve the light problems and different flying procedures could alleviate problems associated with glare and shadow. However, given solutions to all the mechanical difficulties encountered, the probability of success in developing photoenumeration as a viable technique on the Fishing Branch River is low because of the insoluble problem of altering contrasts between the chum salmon and their background.

4.2.4 Aerial Surveys

No chum salmon were located by aerial survey flights on the Salmon Fork River and the north fork of the Fishing Branch River. The presence of undocumented salmon spawning populations in areas of the rivers surveyed is highly unlikely.

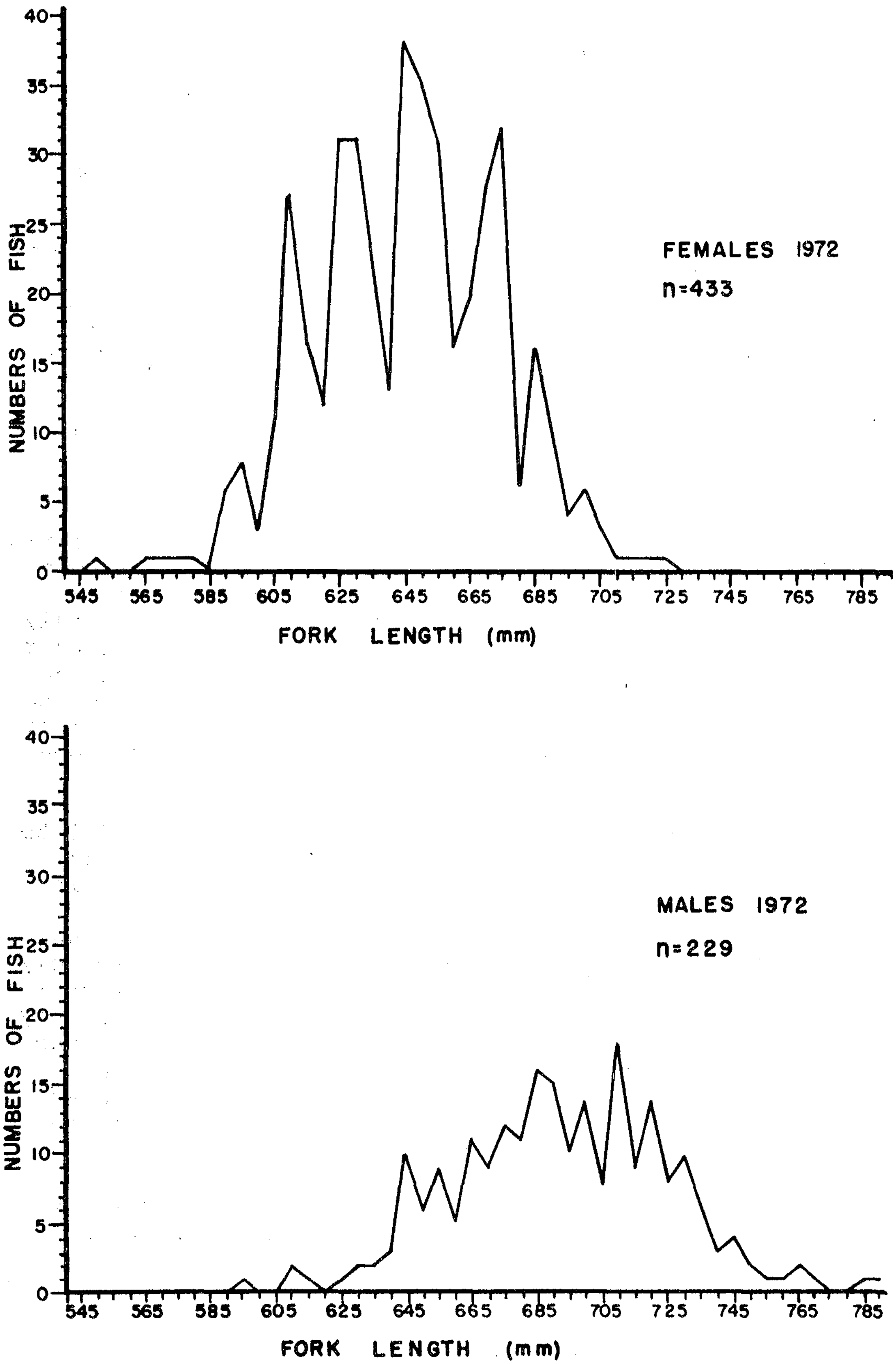


FIGURE 3: LENGTH-FREQUENCY DISTRIBUTION OF CHUM SALMON FROM THE FISHING BRANCH RIVER IN 1972.

3.3 Methods 1973

3.3.1 Counting Fence

The counting fence, with some structural refinements, was re-installed in September 1973.

The camp was established on September 1 via helicopter from the Dempster Highway. A Parcoll housing unit was erected which provided more comfortable living conditions than were available the previous year. Supply trips were made by helicopter from Inuvik on September 30 and October 10. Radio contact was sporadically available through CN Tel Inuvik. The counting fence was operative from September 8 to October 22, the first total count was made on September 10, and camp was abandoned on October 24.

To combat problems in construction and maintenance of the fence associated with high water levels and heavy debris load of the river, innovations were made in design of some supporting structures of the fence. Most importantly, a 1/4 inch cable was stretched across the river approximately 4 ft. above the water level and anchored to trees on either side (Plate 2). All fence components were attached to the stretched cable with lengths of rope. This device provided a sturdier structure and enabled an earlier installation of the fence (September 8) than was possible in 1972 (September 22).

A holding pen (20' X 20' square) was incorporated into the fence for part of the run (Plate 4). Purpose of the pen was to temporarily capture tagged fish from Alaska in order to identify tag numbers. Most of the total chum salmon population in 1973 was counted through the holding pen. Fish were released from the holding pen approximately once every hour, but more frequently when large concentrations were present. Most of the fish sampled for fecundity were captured in the holding pen and tagging was also done by removing fish from the pen. The pen operated on the principle that upstream migrating salmon had unrestricted access into the pen via a 12 inch opening but once in the pen were unable to locate an exit.

Approximately 5000 chum salmon were identified as to sex during passage through the counting fence.

3.3.2 Tagging

The Alaskan chum salmon tagging programme was continued. Seven hundred and seventy-seven chum salmon were tagged with 1/2 inch diameter red Petersen disc tags at Ramparts on the Yukon River through an arrangement made with the Alaska Department of Fish and Game. Tagging was done approximately 800 miles downstream from the Fishing Branch River counting fence. Times of passage through the counting fence were noted for some of these fish.

To obtain further information on stream residence of chum salmon in the Fishing Branch River, four hundred and ninety-two fish were tagged with 3/4 inch Petersen disc tags in different colour sequences. Four hundred and fifty-eight of these salmon were tagged in the holding pen at two-day intervals from September 14 to October 2. The remainder were tagged above the fence site but were all recent arrivals in the river. Plates 5 and 6 show a typical tagging location and a tagged male chum salmon, respectively. Upstream recoveries of dead chum were made from a rubber boat over approximately 3 miles of the river at two-day intervals from September 28 to October 21. Fork lengths (tip of snout to fork of tail) were recorded from 626 salmon and scales from 128 fish were used in age determination.

3.3.3 Fecundity

To provide preliminary information on fry production by chum salmon in the Fishing Branch River, egg counts were made of 39 female chums killed at the fence site. The fish were captured by hand in the holding pen and killed by a sharp blow on the head. Total egg number for each fish was determined by a weight proportion method in which the total number of eggs per fish is related to the number of eggs in an aliquot, the weight of the aliquot and the total weight of the ovaries. Ninety-three dead female chums recovered at the fence site were examined for egg retention.

3.3.4 Other Species

A mark and recovery programme was conducted to provide information on life biology aspects of the other species in the river, notably Arctic grayling. A discussion of this work is presented by separate report (Bruce, 1974).

Plate 5. The Fishing Branch River upstream of fence site in early September, 1973.

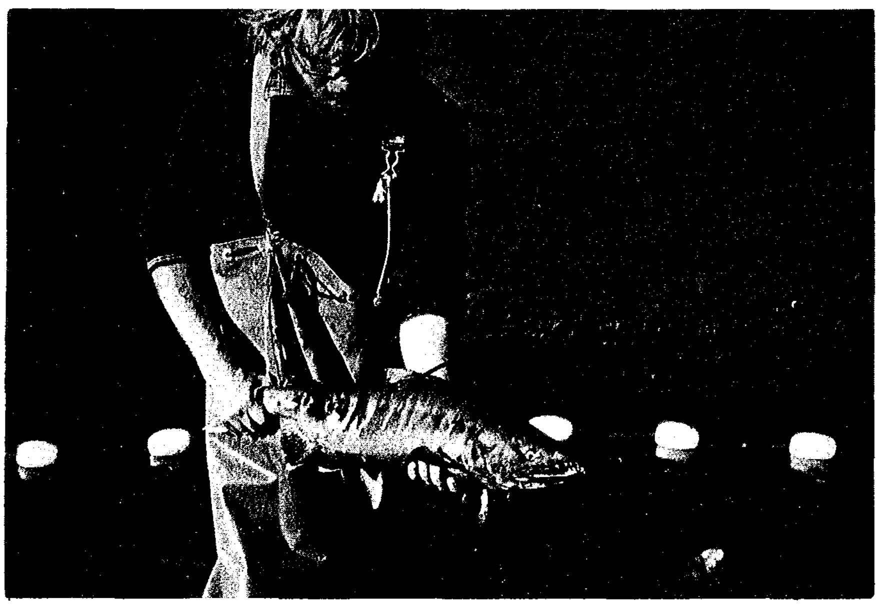


Plate 6. A newly tagged male chum salmon in the Fishing Branch River, September, 1973.

4.3 Results and Discussion 1973

4.3.1 Counting Fence

The fence count of 15,989 chum salmon is taken to be the total population in 1973. Table V lists the fence counts by date. Figure 6 represents graphically the accumulative percentage of the population present by date. Figure 4 illustrates length-frequency distribution of a sample of chum salmon taken at the fence site during the tagging operation.

4.3.2 Tagging

Table VIII lists the length of time from tagging to recovery of 7 chum salmon tagged at the Fishing Branch River fence site in 1973. The average length of life is 21 days (range 14 to 27 days), compared with an average of 30.5 days (range 28 to 32 days) in 1972. However, the sample size is small (7 of 492), and may not be representative. Table IX lists tagging and recovery data of chum salmon tagged at Ramparts in Alaska and recovered at Old Crow and at the Fishing Branch River counting fence in 1973. It took on an average 25 days (range 21 to 37 days) for the salmon to travel the 600 miles (approximate) from Ramparts to Old Crow, and on the average the fish travelled 24 miles per day. Only two Alaskan tagged fish were recovered at the Fishing Branch River counting fence. One took 34 days to cover the 800 miles (24 miles per day) and the other required 41 days (20 miles per day).

It was observed at the Fishing Branch River counting fence that tagging resulted in disruption of normal migrational behaviour of the chum salmon. Some fish tagged at the fence were so weakened by the operation that they were unable to proceed upstream and were released on the downstream side of the fence. Most of these fish eventually returned through the fence, but some were delayed for several days, presumably due to weakness caused by the tagging operation.

4.3.3 Fecundity

Average fecundity of 39 female chum salmon sampled in 1973 was 2,513 eggs per fish. The 95% confidence interval of the sample mean gives a low and high egg count of 1672 and 3353 respectively.

The range in egg number from 21 chum salmon sampled in 1971 at Old Crow was 1658-3200, and the average egg number per female was 2360. V. K. Soldatov (in Berg, 1948) reports that in the Amur River summer chum* of U.S.S.R. "the fecundity is 2008-2978 eggs, average 2,515". Average egg retention at the Fishing Branch River was 81 eggs per fish, but 71 of 93 fish examined retained less than 10 eggs per fish. The average number of eggs available for deposition per female chum salmon = 2513 - 81 = 2432. No information exists for egg to fry survival rates in the Fishing Branch River.

4.3.4 Other Species

Three chinook salmon were observed at the fence site in 1973. All went downstream through the fence in early September and presumably all had finished spawning. Six coho salmon were counted through the fence from October 15 to October 20. It is believed that these coho are the earlier arrivals of a small population which spawns in the south fork of the Fishing Branch River.

Predation by grayling on both eggs and fry of chum salmon has been documented in the Fishing Branch River. Bruce, 1974, found chum salmon eggs in four of twenty-five Arctic grayling stomachs examined from the Fishing Branch River spawning grounds in 1973. Four of twenty-two grayling stomachs examined on May 18, 1972 contained evidence of chum salmon fry. Further study is necessary to determine the effects of predation by grayling on the total chum salmon stocks. Bruce, 1974, estimated the 1973 Arctic grayling population at approximately 9000 fish.

---

*Note: The Russians distinguished between summer and autumn chums. Autumn chums enter the rivers later, are older and much larger (mean female fork length 720 mm; mean male fork length 750 mm), and have higher fecundity (average 3860 eggs). On the basis of size, age and fecundity, Fishing Branch River chums more closely resemble the summer chums of the U.S.S.R.

Table VIII. Length of time from tagging to recovery of seven chum salmon tagged near the fence site in 1973.

Recovery Date	Interval from Tagging to Recovery	
Oct. 8	21 days	Average = 21 days
Oct. 9	27 days	
Oct. 13	23 days	
Oct. 16	17 days	
Oct. 17	14 days	
Oct. 17	25 days	
Sept. 19	1 day	(Killed by bear)

Table IX. Tagging and recovery data of a sample of chum salmon tagged at Ramparts in Alaska and recovered in the vicinity of Old Crow and at the Fishing Branch River in 1973.

Tagging Date	Recovery Date	Days from Tagging to Recovery	Recovery Location
Aug. 28	Sept. 18	22	Old Crow
Aug. 29	Sept. 18	21	" "
Aug. 29	Sept. 18	21	" "
Aug. 29	Sept. 20	23	" "
Aug. 31	Sept. 21	22	" "
Sept. 1	Sept. 25	24	" "
Aug. 28	Sept. 27	31	" "
Sept. 1	Sept. 27	26	" "
Aug. 27	Sept. 28	32	" "
Sept. 3	Sept. 28	26	" "
Sept. 3	Sept. 29	27	" "
Sept. 8	Sept. 29	22	" "
Aug. 27	Oct. 2	37	" "
Aug. 31	Sept. 24	25	" "
Aug. 28	Sept. 18	22	" "
Aug. 31	Oct. 3	34	Fishing Branch
Aug. 31	Oct. 10	41	Fishing Branch

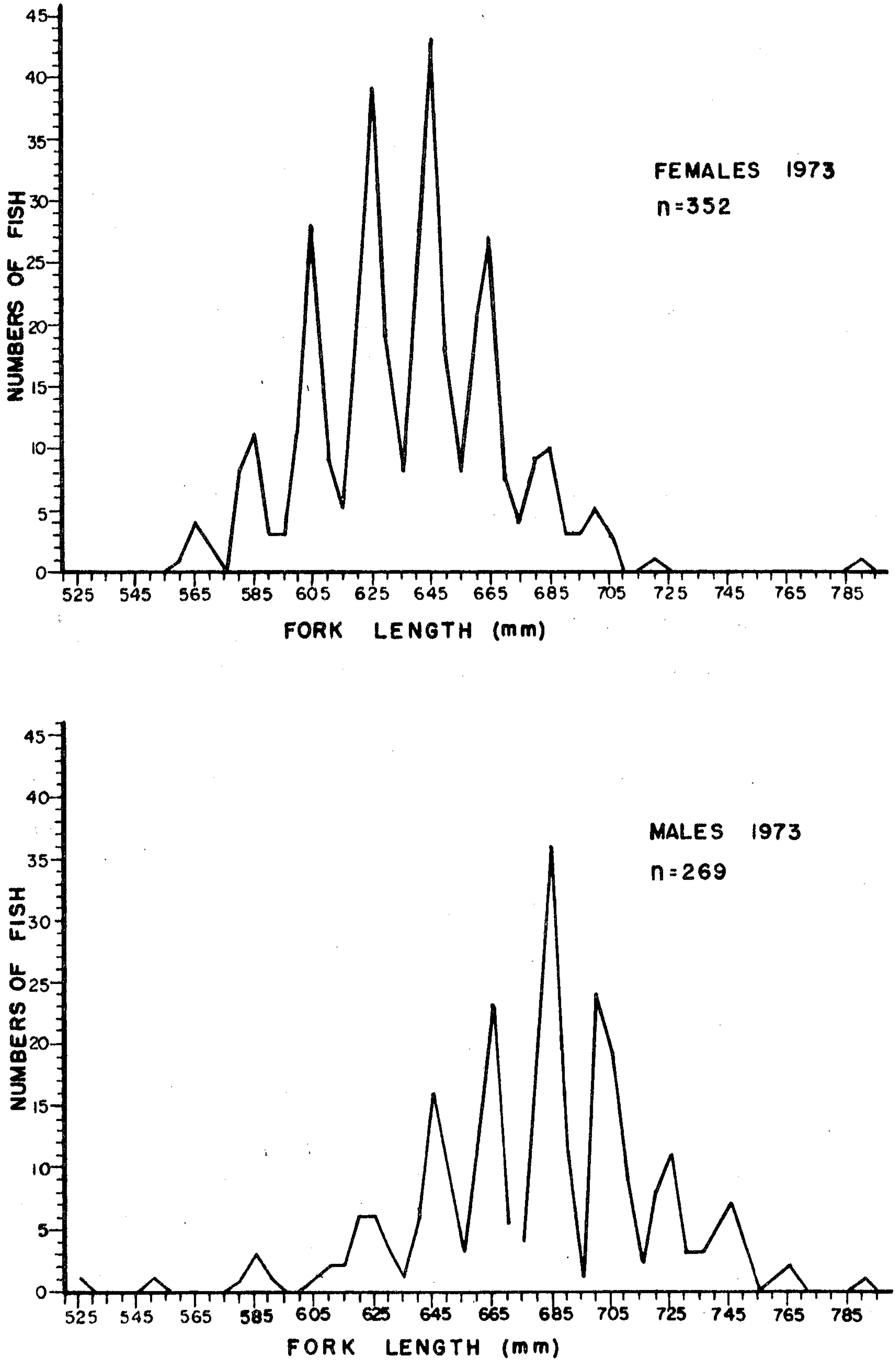


FIGURE 4: LENGTH-FREQUENCY DISTRIBUTION OF CHUM SALMON FROM THE FISHING BRANCH RIVER IN 1973.

3.4 Methods 1974

3.4.1 Counting Fence

Camp was established in the same location as in the previous two years on September 2. Water levels were unusually low and the fence was installed without difficulty on September 4. It is believed that no chum salmon were present on the spawning grounds at this time. The fence was manned continually till October 18 at which time it was removed from the river and camp was abandoned. Approximately one-half of the total chum salmon population was identified as to sex.

3.4.2 Tagging

Nineteen chum salmon were tagged with Floy tags at Old Crow on September 7. No tags were applied at the counting fence or at Ramparts in Alaska.

3.4.3 Aerial Survey

A one-day inspection of the spawning grounds was made from a helicopter on November 19 in an effort to establish the population of coho salmon spawning in the Fishing Branch River. Chum salmon were also enumerated in this survey.

A survey flight was conducted over approximately 60 miles of the Bell River on September 14. Silty water prevented good visibility in the downstream 30 miles of the survey, but conditions were good in the upper 30 miles.

4.4 Results and Discussion 1974

4.4.1 Counting Fence

The total fence count in 1974 was 31,525 chum salmon. This figure is tabled and represented graphically in Table V and Figure 6 respectively. Figure 5 indicates length-frequency distribution of a sample of chum salmon taken in the Fishing Branch River.

Of 90 dead chum salmon recovered after drifting onto the fence from September 10 to October 5, 61 or 67% were males. This disproportionate ratio favouring males probably reflects their earlier arrival in the river and consequent earlier death. The same sorts of ratios of sex-composition of dead were evident in 1972 and 1973.

A discussion is included in this section of the fence counts for all years. Inspection of Figure 6 and Table V shows that in 1973 and 1974 over 90% of the total chum salmon population was on the spawning grounds by October 2. In these two years the fence count is believed to have begun before significant numbers of fish arrived on the Fishing Branch River spawning grounds. Also in these two years, only 1% of the total estimated population was on the spawning grounds by September 10. Therefore, over 90% of the total run occurred in the corresponding three-week period from September 10 to October 2.

In 1972, difficulties connected with high water levels prevented installation of the fence until September 22. On this date it was subsequently estimated from tag recoveries that 17,935 chum salmon were on the spawning grounds. This number plus the fence count shows that 80% of the total run was on the spawning grounds by October 2. In future years, operation of the counting fence could be restricted to the last three weeks of September. An incomplete but significant enumeration of the total population would still be obtained.

Potential sources of error in the fence counts include the possibility of undetected openings in the fence and human error in counting. Contributions to error from these sources are believed to be small.

4.4.2 Tagging

In 1974, four chum salmon tagged at Old Crow on September 7 were recovered at the Fishing Branch River counting fence. Three of the tagged fish arrived at the counting fence on September 22 and the other arrived on September 26. The distance from Old Crow to the counting fence is approximately 220 miles, so the first three fish averaged 15½ miles per day, and the fish recovered September 26 averaged 10½ miles per day. The tagging operation may have caused weakness influencing the speed of migration.

It is possible that significant mainstem spawning occurs in the Porcupine River between Old Crow and the Fishing Branch River spawning grounds. Some supporting evidence for this hypothesis exists in the disproportion of tag recoveries at the two locations in 1973. Of seven hundred and seventy-seven tags applied at Ramparts in Alaska, fifteen were recovered in the Old Crow domestic gill net fishery while only two were recovered at the Fishing Branch River counting fence. This information is presented in the following table:

Location	No. of Tags Recovered	No. of Fish
Old Crow	15	Approx. 5,800 (domestic harvest)
Fishing Branch	2	Approx. 16,000 (fence count)

This disparity in numbers of tags recovered indicates that a significant number of chum salmon passing Old Crow failed to reach the Fishing Branch River spawning grounds and probably spawned at some intervening point in the Porcupine River.

The 1974 tagging experiment at Old Crow failed to provide substantial evidence that mainstem spawning occurs. Nineteen chum salmon were tagged with Floy tags after being caught in gill nets near Old Crow. Only four of these fish were recovered at the Fishing Branch River counting fence, which would indicate that some spawning occurred at intermediate points, but it is believed that stresses caused by the tagging operation accounted for high mortality in the tagged fish. Five of the nineteen salmon tagged were recovered dead at the tagging site, and probably some of the remainder were extremely weak at the time of release.

4.4.3 Aerial Survey

Approximately 5000 chum salmon were observed in the November 19, 1974 helicopter survey. This survey was conducted 32 days after removal of the fence, which exceeds the average stream residence as established in 1972 (30.5 days from tagging to recovery). It can be inferred that the majority of the 5000 chums observed on November 19 (Table II) arrived on the Fishing Branch River spawning grounds after removal of the fence. Thus the total population in 1974 is increased by some order of magnitude and is larger than the fence count of 31,525. Since small numbers of chum salmon were still passing through the fence at the times of its removal in 1972 and 1973, the total populations in these years are larger by some unknown amount than the actual fence counts.

No chum salmon were located in the survey flight of the Bell River.

4.4.4 Sex-Composition

A total of 22,005 chum salmon were identified as to sex during transit through the counting fence in 1973 and 1974 (Table X). In 1973, of 5096 fish sexed, 47.6% were male and 52.4% were female while in 1974 of 16,909 fish sexed, 52% were male and 48% were female. In both years males outnumbered females during the first 3 weeks of the run (Figure 7). Of the total of 22,005 fish sexed, 51% were male and 49% female; a ratio of 1:1. Of 10,000 specimens of chum salmon identified in the Amur River of U.S.S.R., Soldatov reports a sex ratio of 46.5% male and 53.5% female. These fish spawn "in the mountain streams, near springs", a situation which seems very similar to conditions obtaining in the Fishing Branch River. The apparent ratio of 6 male: 1 female of the sample taken at Old Crow in the 1971 gill-netting programme is almost certainly an artifact caused by the susceptibility to capture of males because of their hooked snout and pronounced dentition.

4.4.5 Age-Composition

Four-year-old fish predominate in the samples for all years except 1972 (Table XI). Only two three-year-old fish were present in the total of all samples for all years. It is not understood why five-year-old fish should predominate in the 1972 run, or whether in this year the high percentage of five-year-old fish in the sample is an artifact resulting from capture procedures (unlikely) or sampling period. If the sample ratio of 3:1 favouring five-year-old fish over four-year-old fish is an accurate reflection of the total 1972 population, this large proportion of five-year-olds may be the result of heavy recruitment from the 1967 brood year. It is logical to assume that the 1967 population was of the same order of magnitude as the 1971 population (approximately 115,000). Assuming further that the 1968 and 1972 populations were roughly equivalent (approximately 35,000), four-year-old fish in the 1972 population would be recruited from this smaller population, hence the high proportion of five-year-old fish in 1972. The disproportion may, however, be due to biological factors such as high mortality during incubation, or to marine mortality, of the four-year-old stock.

Of 1,886 Amur River summer chum salmon reported by I. I. Kuznetsov (in Berg, 1948) in the years 1927 through 1933, the following average percentages by year class resulted:

Age in years	3	4	5	6
Percentage	14.8	76.2	8.5	0.5

Of 454 Fishing Branch River chum salmon in the years 1971-1974, the following average percentage by year class resulted:

Age in years	3	4	5
Percentage	0.44	73.6	26.0

(Note: Ageing techniques are not described in the Russian literature, and may differ substantially from those used in the Fishing Branch River study.)

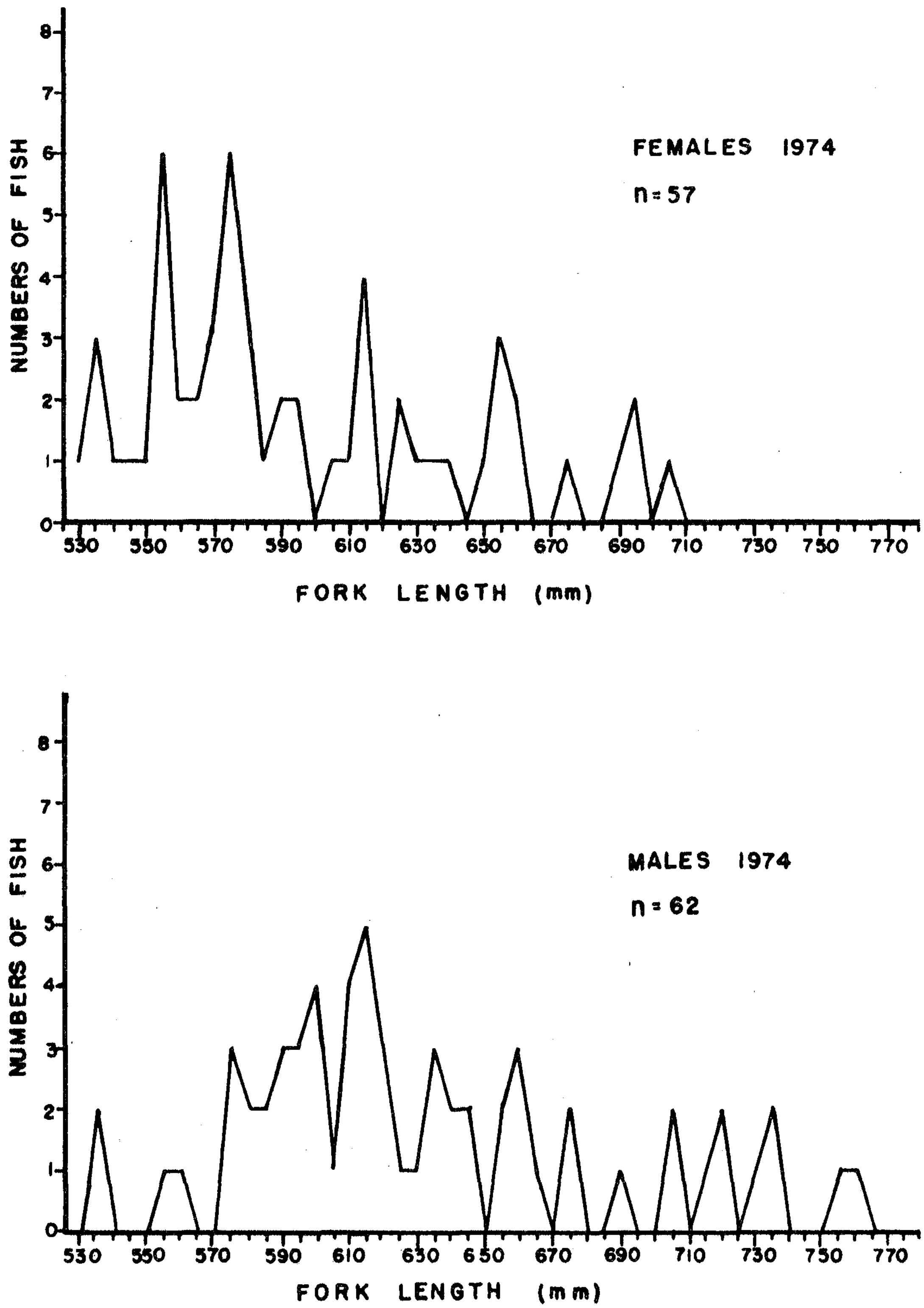


FIGURE 5: LENGTH-FREQUENCY DISTRIBUTION OF CHUM SALMON FROM THE FISHING BRANCH RIVER IN 1974.

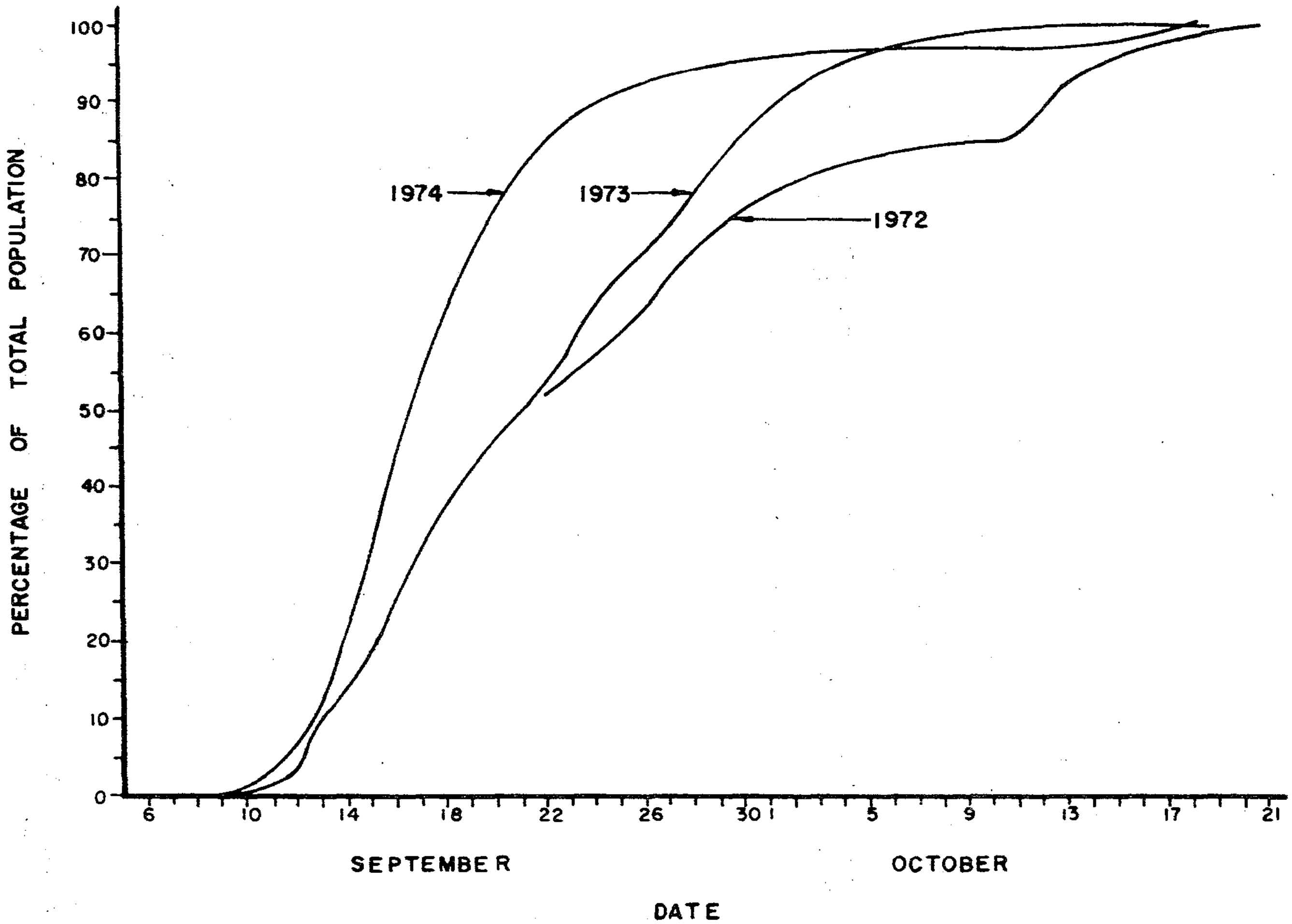
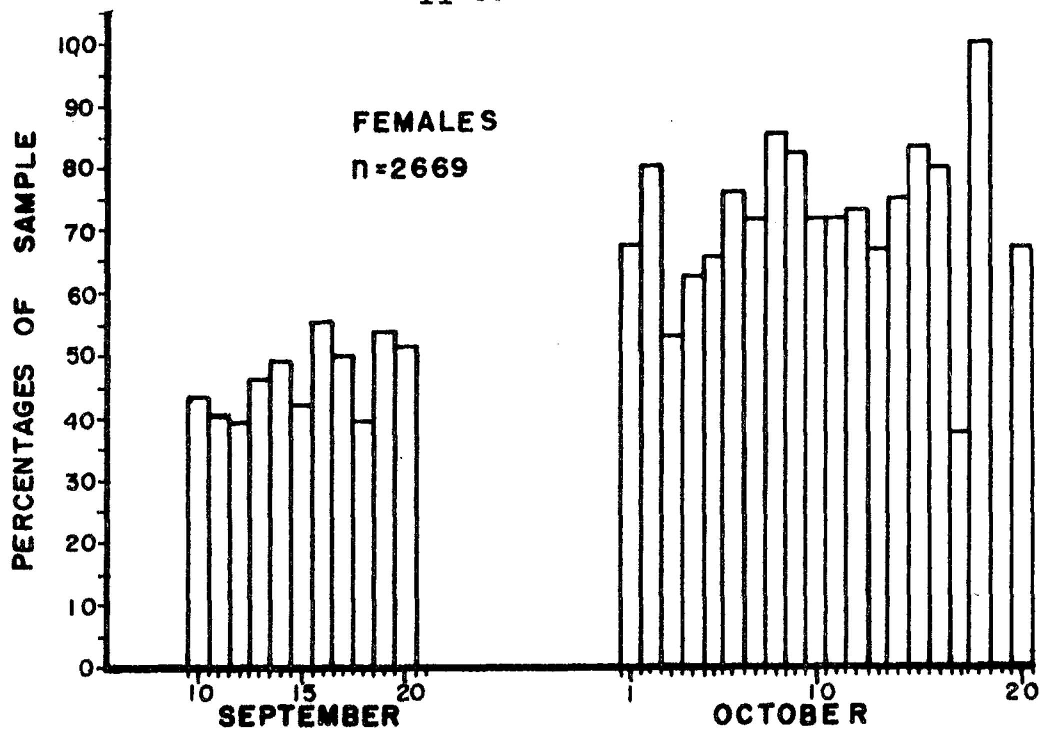


FIGURE 6: PERCENTAGE OF TOTAL CHUM SALMON POPULATION PRESENT ON THE SPAWNING GROUNDS BY DATE IN 1972, 1973 AND 1974.

Table X. Sex-composition of samples of the chum salmon run by date taken in 1973 and 1974 at the counting fence.

	1973				1974			
Date	No. Sexed	Male	Female	Daily Count	No. Sexed	Male	Female	Daily Count
Sept 6					14	5	9	15
7					17	9	8	17
8					28	16	12	30
9					69	39	30	69
10	73	41	32	83	-	-	-	217
11	93	55	38	93	219	147	72	384
12	345	208	137	345	446	283	163	1477
13	585	313	272	1036	322	192	130	1389
14	421	217	204	625	1701	1016	685	2896
15	523	301	222	704	1254	738	516	3529
16	1020	453	567	1197	1912	982	930	3742
17	615	306	309	1054	1291	635	656	3388
18	174	105	69	758	1771	891	880	2369
19	286	131	155	689	1611	827	784	1953
20	159	77	82	720	2028	979	1049	2325
21					1341	638	703	1642
22					654	304	350	1017
23					813	408	405	1044
24					421	212	209	621
25					398	201	197	583
26					219	112	107	388
27					99	44	45	234
28					121	58	63	291
29								164
30					41	18	23	166
Oct 1	59	19	40	437	87	41	46	220
2	108	21	87	493				92
3	66	31	35	323	63	34	29	123
4	40	15	25	301	32	19	13	88
5	79	27	52	174				
6	50	12	38	115				
7	49	14	35	149				
8	69	10	59	69				
9	69	12	57	69				
10	46	13	33	46				
11	32	9	23	32				
12	41	11	30	41				
13	27	9	18	27				
14	28	7	21	28				
15	12	2	10	12				
16	10	2	8	10				
17	8	5	3	8				
18	6	0	6	6				
19	0	0	0	0				
20	3	1	2	3				
Totals	5096	2427	2669	9647	16,909	8795	8114	30,473
Percentages		47.6%	52.4%			52%	48%	



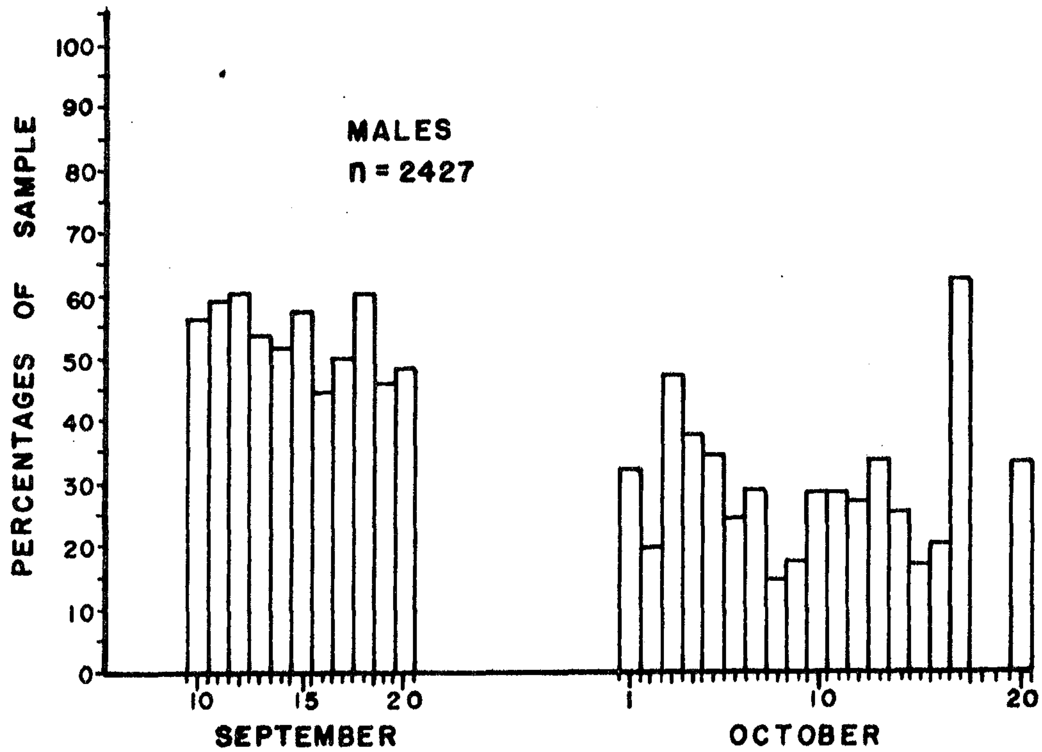


FIGURE 7: PERCENTAGE SEX-COMPOSITION BY DATE OF SAMPLES OF CHUM SALMON AT THE FISHING BRANCH COUNTING FENCE IN 1973.

Table XI. Age-composition of samples of the chum salmon population for all years. The 1971 sample is from Old Crow, the others from the Fishing Branch River.

Year	Sample Size	Age 3	%age	Age 4	%age	Age 5	%age
1971	203			174	(85.7)	29	(14.3)
1972	88			20	(23.3)	66	(76.7)
1973	51			50	(98.0)	1	(2.0)
1974	113	2	(1.7)	89	(78.8)	22	(19.5)

5. Conclusions

(1) The installation of a counting fence on the Fishing Branch River provides the most accurate measurement of the size of the chum salmon population. The peak year occurs once every four years, and in the peak year of 1971 the population was approximately 115,000 fish. The successive counts in 1972, 1973 and 1974 were approximately 35,000, 16,000 and 31,500 chum salmon respectively. Very small populations of chinook salmon (<25) and coho salmon (<250) also spawn in the south fork of the Fishing Branch River. Large numbers of Arctic grayling are present all year, and round whitefish may spawn in the river.

The mean lengths and length-frequency distributions of male chum salmon for all years is consistently larger than those for females. Older fish of both sexes are consistently larger than younger fish. Comparison of data on age, fecundity, size and spawning ground preference of the Fishing Branch River chums indicate strong similarity to summer chum salmon of the U.S.S.R. Amur River.

(2) Aerial surveys and mark and recapture programmes provide only limited and inaccurate estimates of the population. More information on turnover rates (stream residence) combined with more frequent observation would improve the accuracy of the aerial estimates. The quality of results of a mark and recovery programme could be improved by intense efforts in recovery of tags. At present, logistical constraints limit the expenditure of such effort.

(3) The use of aerial photography as a method of enumerating the chum salmon population in the Fishing Branch River is not efficient.

(4) Information deficiencies are evident in several sectors of the study. The most important deficient areas and suggested procedures to fill these gaps in knowledge include:

a) Mainstem spawning

To provide information on the extent of mainstem chum salmon spawning in the Porcupine River, an intensive tagging and recovery programme should be initiated on the Porcupine River segment of the Yukon River chum salmon population. Suggested mechanisms of this programme include the application of tags to several thousands of chum salmon at each of Fort Yukon (confluence of Porcupine and Yukon Rivers) and the village of Old Crow. The fish should be captured and tagged using methods which result in minimum stresses, since protracted or complicated tagging operations very probably result in disruptions of the natural migrational behaviour of the fish. The Old Crow domestic gill net fishery would constitute an effective recovery point for fish tagged downstream at Fort Yukon, and the Fishing Branch River counting fence would be the corresponding recovery point for fish tagged in the vicinity of Old Crow. Comparison of populations based on tag recoveries at Old Crow and at the Fishing Branch River counting fence would provide indications of proportionate diminution of the total chum salmon population between Fort Yukon and the Porcupine River headwaters. This programme could be most efficiently accomplished as a joint effort between American and Canadian fisheries organizations.

Helicopter-supported surveys should be conducted on the mainstem Porcupine River before freeze-up in late September in efforts to locate chum salmon spawning areas upstream of Old Crow. Because of impaired visibility caused by heavy silt load of the Porcupine River, it is unlikely that these surveys would be effective in providing accurate assessment of population, but would be of value in locating evidence of spawning activity in the form of redds. Where spawning activity was noted, follow-up ground surveys could be conducted to estimate the population.

b) Undocumented chum salmon spawning grounds in the Canadian section of the Porcupine River drainage might be located by intensive helicopter supported aerial surveys of all tributaries in the period September 15-30. In conjunction with the aerial surveys, gillnetting in tributary streams within 10-20 miles of their confluence with the Porcupine River might capture migrating chum salmon.

c) The magnitude of the chinook and coho salmon populations could be determined by an earlier installation and later removal of the Fishing Branch River counting fence. Available parameters on the life history stages of both chinook and coho salmon are well below levels necessary for adequate management of the stocks.

d) Extension of the period of operation of the Fishing Branch River counting fence and tagging programme into the month of November would provide additional information on stream residence and turnover of the chum salmon population.

e) Information is lacking on the incubation period of chum salmon eggs, thermal unit requirements to hatching, time and rate of emergence of alevins, and the duration of stream residence prior to migration of the fry in the Fishing Branch River. This sort of information may differ considerably from that in more southern rivers. A programme conducted in the period March 15-May 15 should provide preliminary information concerning some of these problems.

(5) Assuming a good return from the large spawning population in 1971 (115,000), it is expected that the 1975 chum salmon population in the Fishing Branch River will be in excess of 100,000 spawners.

References

Berg, L. S., 1948. Freshwater fishes of the U.S.S.R. and adjacent countries. Vol. 1, Israel Program for Scientific Translations. Jerusalem, 1962.

Bevan, D. E., 1961. Variability in aerial counts of spawning salmon. Jour. Fish. Res. Bd. Can. 18 (3): 337-348 Illus.

Bruce, P. G., MS 1974. A preliminary study of fish species other than salmon found in the Fishing Branch River, Yukon Territory, during September, 1973. Fisheries Service, Department of the Environment, Vancouver, B.C.

Eicher, G. J., Jr., 1953. Aerial methods of assessing red salmon populations in Western Alaska. Jour. Wildlife Management 17 (4): 521-527 Illus.

Elson, M., 1973. Enumeration of Spawning Chum Salmon in the Fishing Branch River in 1971 and 1972. Technical Report 1973 - 5, Canada, Department of the Environment, Fisheries and Marine Service, Pacific Region.

Elson, M., MS 1973. Fishing Branch Studies - 1973. Fisheries Service, Department of the Environment, Vancouver, B.C.

Lister, D. B. and R. A. L. Harvey, 1969. Loss of Petersen disc tags from spawning chum salmon (Oncorhynchus keta). The Canadian Fish Culturist No. 40, February, 1969.

Vernon, E. H., A. S. Hourston, and G. S. Holland, 1964. The migration and exploitation of pink salmon runs in and adjacent to the Fraser River Convention area in 1959. Internat. Pacific Salmon Fish. Comm., Bull. 15, 296 p.

C H A P T E R   I I I

ASSESSMENT OF CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*) STOCKS IN THE UPPER PORCUPINE RIVER DRAINAGE IN NORTHERN YUKON TERRITORY

by

L. W. STEIGENBERGER

M. S. ELSON

R. T. DELURY

Northern Operations Branch

Fisheries and Marine Service

Department of the Environment

for the

Environmental-Social Program

Northern Pipelines

Acknowledgement

The data for this report was obtained from investigations carried out under the Environmental-Social Programme of the Task Force on Northern Oil Development. Additional financial assistance was provided from the regular operating budget of Fisheries and Marine Service.

The authors are grateful for assistance during the field work to J. Bryan, G. J. Birch, J. Fisher, W. Moses, P. Nukon, D. Brock, D. Kato, and members of the field party at the Fishing Branch River counting fence.

The project was administered by A. Gibson and C. E. Walker. In addition, C. E. Walker provided constructive critisms and reviewed the first drafts of the report.

1. Abstract

Chinook Salmon spawn in August in the Old Crow River, the Miner River and the Fishing Branch River, all of which are tributary streams of the Porcupine River in northern Yukon Territory. The spawning grounds are usually in open-water areas of the streams. The majority of spawning fish are four years old. The major spawning grounds are in the Miner River. The Miner River population was estimated at more than 30 fish in 1972 and more than 89 fish in 1974. The fish were enumerated by aerial surveys. The peak of spawning is from August 1-14. Chinook salmon are valued for human consumption in the domestic fishery conducted at Old Crow. The Fishing Branch River chinook salmon stocks are estimated at less than 25 fish annually. Information is minimal on the Old Crow River chinook salmon stocks, and the spawning grounds are still unknown. The spawning grounds must be protected at all times of the year from proposed pipeline activity.

Table of Contents

List of Figures

List of Tables

2. Introduction

The presence of chinook salmon in the Porcupine River drainage has been known by natives of the village of Old Crow (Figure 1) for generations. Chinooks are one of the most prized species captured in the domestic gill net fishery conducted at Old Crow in the summer and fall.

From discussions with Indians from Old Crow, it was discovered that chinook salmon spawn in the headwaters of the Porcupine and Old Crow Rivers. In the Porcupine River headwaters, spawning was said to be localized in the Miner River but there were unconfirmed reports that spawning also occurred in the Whitestone, Fishing Branch, Bluefish and Salmon Fork Rivers. In the headwaters of the Old Crow River, chinooks reportedly utilized Thomas and Timber Creeks for spawning (Figure 1).

During a winter survey conducted in 1972, ice-free open-water areas were found in the Old Crow River, Timber and Bilwaddy Creeks, and overflow ice was found in Thomas Creek (Steigenberger, 1972). Coho salmon and chum salmon are known to prefer ice-free areas of streams as spawning areas (Berg, 1948; Elson, 1973) in the Arctic environment. Ice-free open-water areas as determined by winter surveys were therefore selected as prime target areas for the location of spawning chinook salmon.

The data presented in this report was collected during ecological surveys of proposed pipeline routes within the northern Yukon Territory (1971-1974).

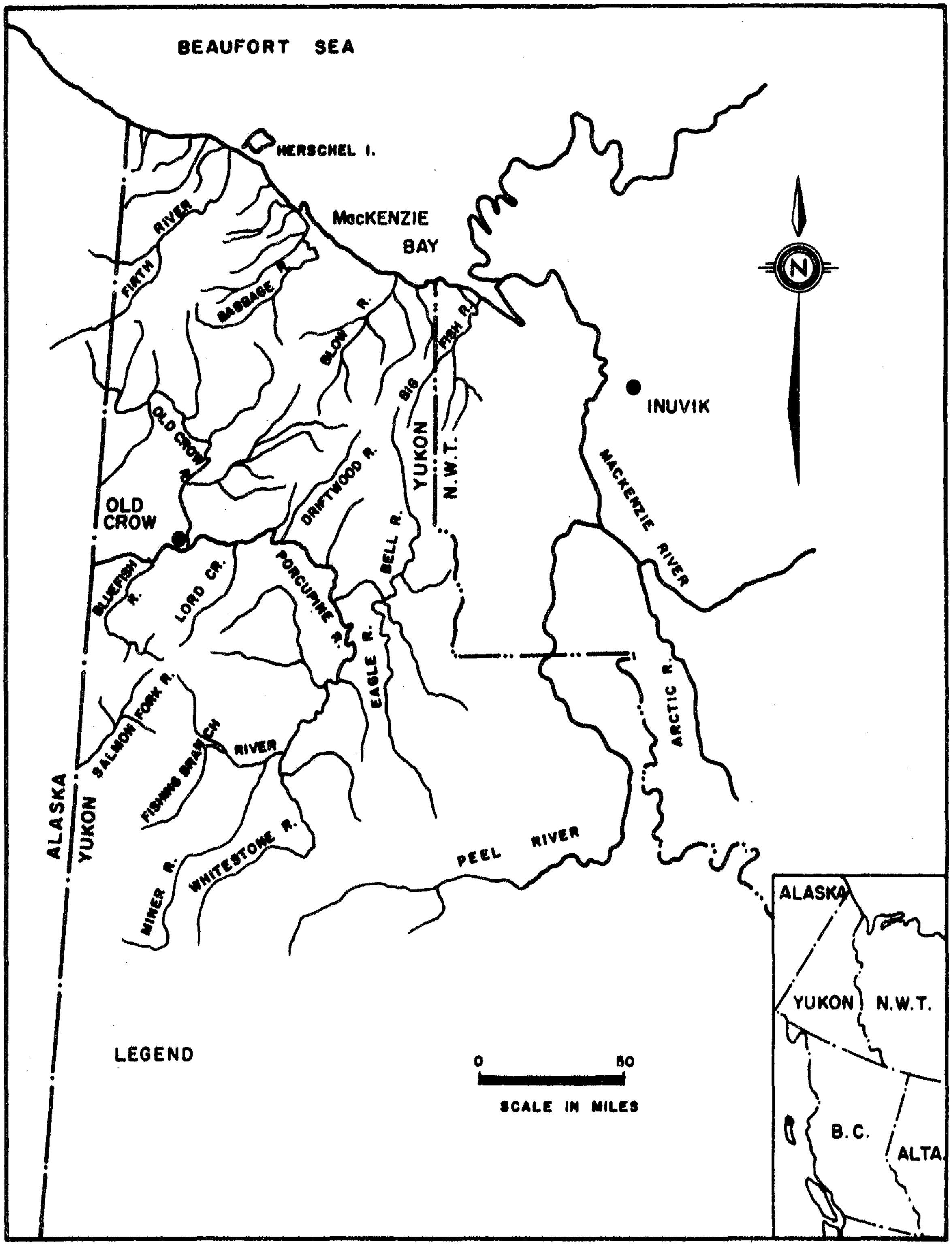


Figure 1. Location map of the upper Porcupine River drainage.

3. Materials and Methods

3.1 1971 Programme

A total of 18 gill net stations were sampled in the Porcupine and Old Crow Rivers near Old Crow in the summer of 1971. Not all stations were sampled at the same time. Most stations consisted of panel gill nets with sections of different mesh sizes from 1.5 in. to 5.5 in. stretch measure. Main objectives of the 1971 gill-netting programme were to determine species composition and relative abundance of fishes in the Porcupine River. Emphasis was not placed on the capture of particular species.

A continuous synoptic survey was carried out on both proposed pipeline routes from July 22 to September 9. The village of Old Crow served as the logistical base for the survey of the proposed southern route. Most fish captured in the synoptic surveys were taken in a seine net with dimensions 6 ft. X 90 ft. X 1/2 in. mesh size.

In September, October, and December, aerial surveys were conducted to locate and count spawning salmon (particularly chum salmon) in the headwaters of the Porcupine River drainage.

3.2 1972 Programme

The timing of migration of chinook salmon in the Porcupine River near Old Crow was measured by the continuation of the 1971 gill-netting programme. A graded series of 6 gill nets (50 ft. long) measuring 1 inch to 6 inches stretched mesh were set for a 24-hour period once each week from early May to September. Gill net stations were located in the lower six miles of the Old Crow River and in the Porcupine River upstream and downstream of Old Crow. To determine the timing of migration of chinooks close to the reported Miner River spawning grounds, two gill-netting stations were established in the Miner River one and two miles respectively upstream of its confluence with the Fishing Branch River. Each station consisted of three 50 ft. gill nets each having 1½, 3, and 5 in. stretched mesh. The nets at each station were set for 24-hour periods on June 18, June 30, and August 26.

At infrequent intervals, a census was conducted of resident fishermen at Old Crow to estimate their catch of chinook salmon.

Aerial reconnaissance surveys were utilized in attempts to locate chinook salmon spawning grounds and to determine general distribution and abundance of the spawning fish. The Old Crow River headwaters were surveyed for chinook salmon on July 29, August 6, and August 19 using a De Havilland Beaver DHC-2 aircraft. The normal flight route was from the village of Old Crow to the junction of the Old Crow River and Thomas Creek; upstream on the Old Crow River and Bilwaddy Creek into Alaska, immediately south of Yankee Ridge; overland to the mouth of Thomas Creek and upstream to the headwaters; overland to the headwaters of Timber Creek, and downstream to the Old Crow Flats.

The Porcupine River headwaters were surveyed using the Beaver aircraft on four occasions: July 18, July 25, August 9, and August 23. In addition, on August 12, a Bell G-2 helicopter was used to sample the north and south forks of the Fishing Branch River and the Miner River. The normal flight route was from Old Crow to the Bluefish River and upstream to the headwaters; overland to the headwaters of the Salmon Fork River and downstream to Lat. 66°45'N; east on the tributary of the Salmon Fork River to the headwaters of the north fork of the Fishing Branch River; downstream to the junction of the north and south forks of the Fishing Branch River; upstream, on the south fork, to the groundwater source south of Bear Cave Mountain; downstream to the junction of the Fishing Branch and Miner Rivers; upstream on the Miner River to either Mt. Dewdney (July 18, July 25), or Fishing Creek (August 9, August 12, August 23); usually downstream over areas of spotted fish to the confluence of the Miner and Fishing Branch Rivers; and downstream of the confluence inspecting most sections of the Miner River to the Whitestone River.

Ten chinooks caught near Old Crow on July 26 were measured for length (tip of snout to fork of tail) identified to sex, weighed, and a scale removed for age determination.

The quality of spawning grounds was measured by criteria developed previously by Fisheries Service personnel.

A counting fence (Figure 2) was established on the south fork of the Fishing Branch River primarily to count migrating chum salmon (Elson, 1973). Other species were enumerated incidentally to the chum salmon count.

3.3 1973 Programme

No aerial surveys were conducted with the primary objective of locating chinook salmon spawning grounds or enumerating the Miner River population. During aerial surveys designed to locate undocumented chum salmon spawning grounds (Elson, 1973), observations were made on suitable chinook spawning habitat.

Records were kept of the catch of chinook salmon in the domestic gill net fishery conducted in the Porcupine River near the village of Old Crow.

The Fishing Branch River counting fence was reconstructed and manned from September 10 to October 20.

3.4 1974 Programme

In 1974, aerial enumerations of chinook salmon were conducted on the Miner River on August 2 and on August 9. On both occasions the area of the river surveyed was from the mouth of Fishing Creek (Lat. 65°55'N, Long. 139°24'W) to the mouth of the Whitestone River (Lat. 66°30'N, Long. 138°24'W). In addition, a cursory examination was made on August 9 of a 20-mile section of the river upstream of the mouth of Fishing Creek. On both dates, water levels and water clarity in the mainstem of the Miner River were ideal for the aerial enumeration of salmon. The August 2 survey was conducted from a Cessna 185 fixed-wing aircraft and the August 9 survey from a Bell 206 B helicopter. Airspeeds of the aircraft were kept to minimum safe limits and elevations above water level varied from 100-300 ft. in order to take best advantages of varying conditions of light and shadow, river depth and river width. Two observers kept separate counts of the fish on both occasions. Separate counts were made of live and dead fish. No samples were collected because of time and fuel limitations and because of the limited availability of recoverable dead salmon.

Records were kept of the catch of chinook salmon in the domestic gill net fishery conducted in the Porcupine River near the village of Old Crow.

The Fishing Branch River counting fence was again in operation from September 6 to October 18.

4. Results

4.1 1971 Programme

Seven male chinook salmon were captured in the vicinity of Old Crow in 1971 by the Fisheries Service gill-netting programme in the Porcupine River. The fish were captured in the period July 26 to August 27. Range in fork length was from 570 mm to 840 mm. The fact that only males were captured is believed to be an artifact caused by net selectivity towards males because of their hooked snout and pronounced dentition.

One juvenile chinook salmon was captured on September 5 by beach seining in the Miner River approximately 8 miles above its confluence with the Fishing Branch River. This fish measured 78 mm in fork length and is believed to have been in its second year of life in fresh water. Its capture provided evidence in support of local information that chinook salmon spawn and rear in the Miner River.

Aerial surveys of the Fishing Branch River, and the Miner, Whitestone and Bell Rivers, with the primary objective of locating chum salmon spawning grounds failed to locate spawning chinook salmon. These surveys were conducted in September, October and December, well past the peak spawning period of chinook salmon.

4.2 1972 Programme

Table I indicates the catch of chinook salmon at or near Old Crow in 1972. The Fisheries Service gill-netting programme collected only 6 chinooks while 81 chinook salmon were taken in the domestic fishery. Only two chinooks were captured in the Old Crow River.

Table II lists the sex, age, length and weight of ten chinook salmon captured in the Porcupine River near Old Crow in 1972. The ratio of 9 male:1 female probably does not reflect the true ratio of the entire population. The high proportion of males probably reflects gill net selectivity in favour of males. Although four-year-old fish predominate in the sample, a much larger sample size is necessary to accurately establish age-composition of the chinook population.

Table I. Catch of chinook salmon at or near Old Crow, summer, 1972 (from the subsistence fishery and gill net programme).

Date	Fish Caught Downstream of Old Crow	Fish Caught at Old Crow	Fish Caught Upstream of Old Crow	Fish Caught in the Old Crow River
July 1-15	11(0)	0(0)	0(0)	0(0)
July 15-31	39(2)	1(0)	0(0)	0(0)
Aug 1-15	0(0)	2(0)	14(0)	1(1)
Aug 15-31	13(2)	1(0)	0(0)	0(0)
Sept 1-12	0(1)	0(0)	0(0)	0(0)

Subtotal 82(6)

Total 87

where,

n = number caught in subsistence fishery (subject to error)

(n) = number caught in gill net programme

Table II. The sex, age, length and weight data of 10 chinook collected near Old Crow, summer, 1972.

Sample Number	Age	Length (mm)	Weight (gm)	Sex
1	6_2	10200	10260	F
2	5_2	817	2528	M
3	5_2	778	4839	M
4	4_2	645	2744	M
5	4_2	584	2058	M
6	4_2	586	1790	M
7	R	550	1768	M
8	4_2	492	1002	M
9	4_2	571	1990	M
10	*4_2	565	1554	M

where,

*4_2 = age after Gilbert, (1922)

F = female

M = male

R = regenerated scale

Spawning chinook salmon were found only in the Miner River in any of the aerial surveys conducted in 1972. However, two migrant fish were caught in the Old Crow River suggesting spawning may occur there. Also the capture of advanced sexually mature fish in the Porcupine River in late August indicates spawning may occur in the mainstem.

In the Miner River, chinooks were first observed on July 18. The first visible redds and the peak of the run as indicated by the aerial survey occurred on August 12. No chinooks were captured in the Miner River gill net sets (Table III).

Table III. Counts of chinook salmon in the Miner River in 1972.

Date	Method	No. Alive	No. Dead	Total	Redds
*June 18	GN	0	0	0	Absent
*June 30	GN	0	0	0	Absent
July 18	Beaver Aircraft	2	0	2	Absent
July 25	Beaver Aircraft	3	1	4	Absent
**Aug 9	Beaver Aircraft	-	-	-	-
***Aug 12	H	27	3	30	Present
Aug 23	Beaver Aircraft	8	1	9	Present
*Aug 26	GN	0	0	0	Absent
			Total	45	

GN * sampled using gill nets

** excessive turbidity decreased visibility

H *** enumerated from helicopter

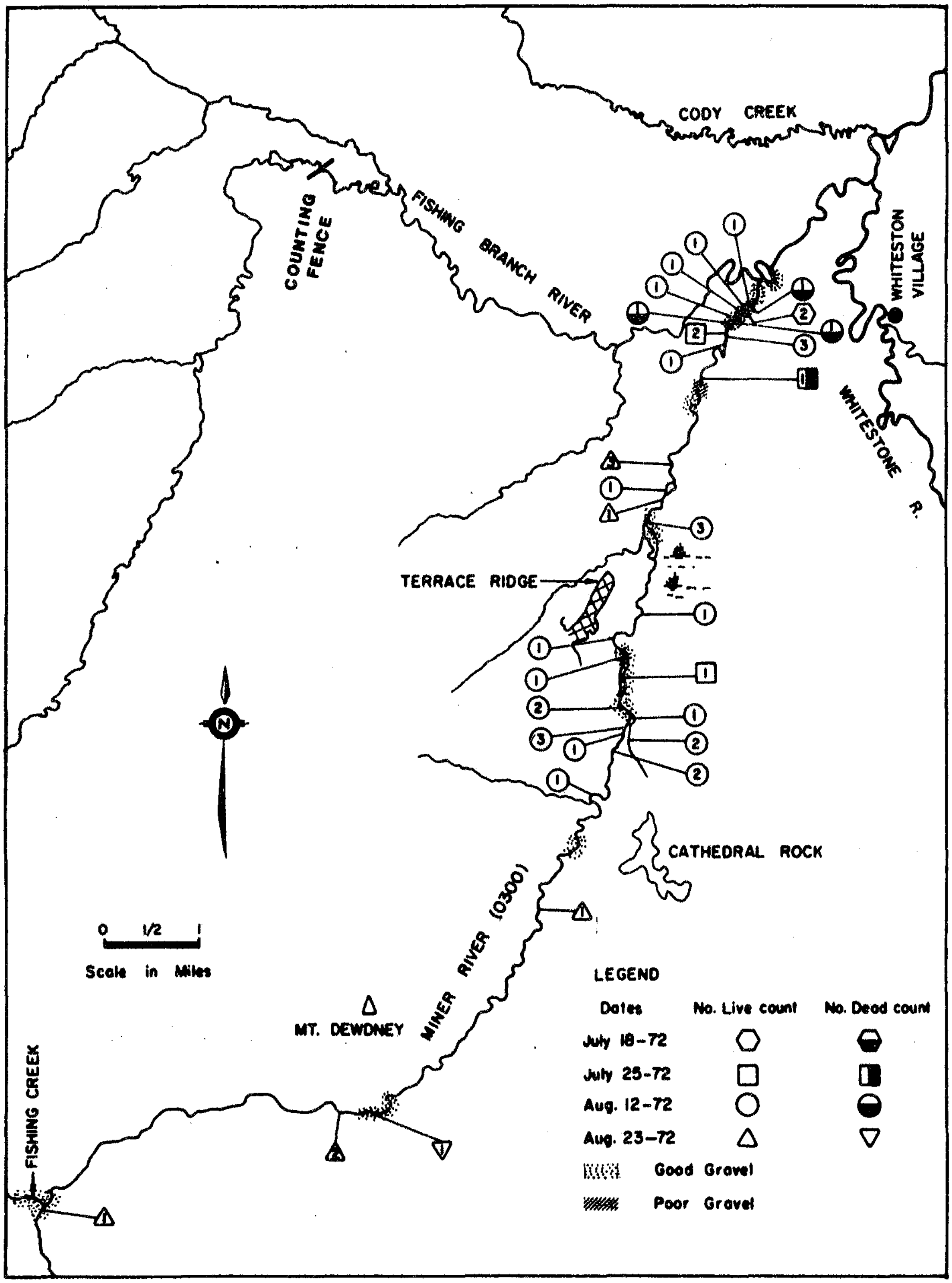


Figure 2. Distribution of chinook salmon in the Miner River in 1972.

The highest individual count of chinook salmon was 30 on August 12 (Figure 2). The salmon were distributed in two main groups, (a) from ½ mile to 1½ miles above the confluence of the Miner and Fishing Branch Rivers, and (b) from 7 to 11 miles above the confluence of the Miner and Fishing Branch Rivers. On August 23, chinooks were distributed as far upstream as Fishing Creek, but the total number was less.

The distribution of spawning chinooks for the most part occurred in areas subjectively classified as good gravel. The areas downstream of Cathedral Rocks, south of Mt. Dewdney and at the junction of Fishing Creek and the Miner River were sited as good gravel areas and potential spawning habitat.

The spawning gravel was sixty percent coarse (2 in. to 10 in. diameter) and forty percent fine (1/8 in. to 2 in. diameter). The poor gravel areas contained a higher percentage of fine gravel and silt.

One female chinook salmon was observed going downstream through the counting fence on the south fork of the Fishing Branch River on September 23. The fish was not captured.

4.3 1973 Programme

Fisheries Service estimates based on interviews of local Old Crow fishermen indicated a chinook salmon catch of <20 in the Old Crow domestic fishery in 1973. Stager (1973) estimated the chinook salmon catch in 1973 as 13 fish based on similar interviews. No samples were taken from the domestic fishery.

Limited gill-netting conducted by Fisheries Service personnel resulted in the capture of one male chinook on September 13 in the lower part of the Old Crow River. The fish was 85 cm. long and weighed 5908 grams.

Aerial enumerations were not conducted on the Miner River chinook spawning grounds in 1973.

Two chinook salmon were observed going downstream in early September through the counting fence on the south fork of the Fishing Branch River. These fish were not captured.

4.4 1974 Programme

A total of 88 chinook salmon were observed in the August 2 survey, of which 77 were alive. All live fish were seen on redds. The distribution of these fish is shown in Figure 3. Grizzly bears were observed feeding on dead salmon.

A total of 89 chinook salmon were observed in the August 9 survey, of which only 30 were alive. Numerous bald and golden eagles (approximately 15) were observed along the river, presumably attracted by the dead salmon. In the August 9 survey, chinook salmon (both live and dead) were distributed only from Cathedral Rocks to the confluence of the Miner River and the Fishing Branch River.

The results obtained in the August 9 helicopter survey are believed to be the most accurate. The precision of aerial enumeration of salmon from a fixed-wing aircraft suffers from the limited ability of such aircraft to easily follow all meanders of a tortuous stream like the Miner River. The aircraft must make repeated time- and fuel-consuming circles to negotiate all the bends of the river. In the August 2 survey fuel limitations precluded circling back, so that some bends in the river were only partially surveyed. Visibility and maneuverability are far superior from a helicopter, and all meanders of the river were adequately surveyed in the August 9 flight.

The highest total number of spawning chinook salmon seen on one day in 1974 = 89 plus numbers removed by the predators plus numbers not seen from the aircraft. A conservative estimate is 100 fish. An appraisal of the precision of this estimate is presented in the discussion section.

Two chinook salmon were observed going downstream in early September through the counting fence on the south fork of the Fishing Branch River.

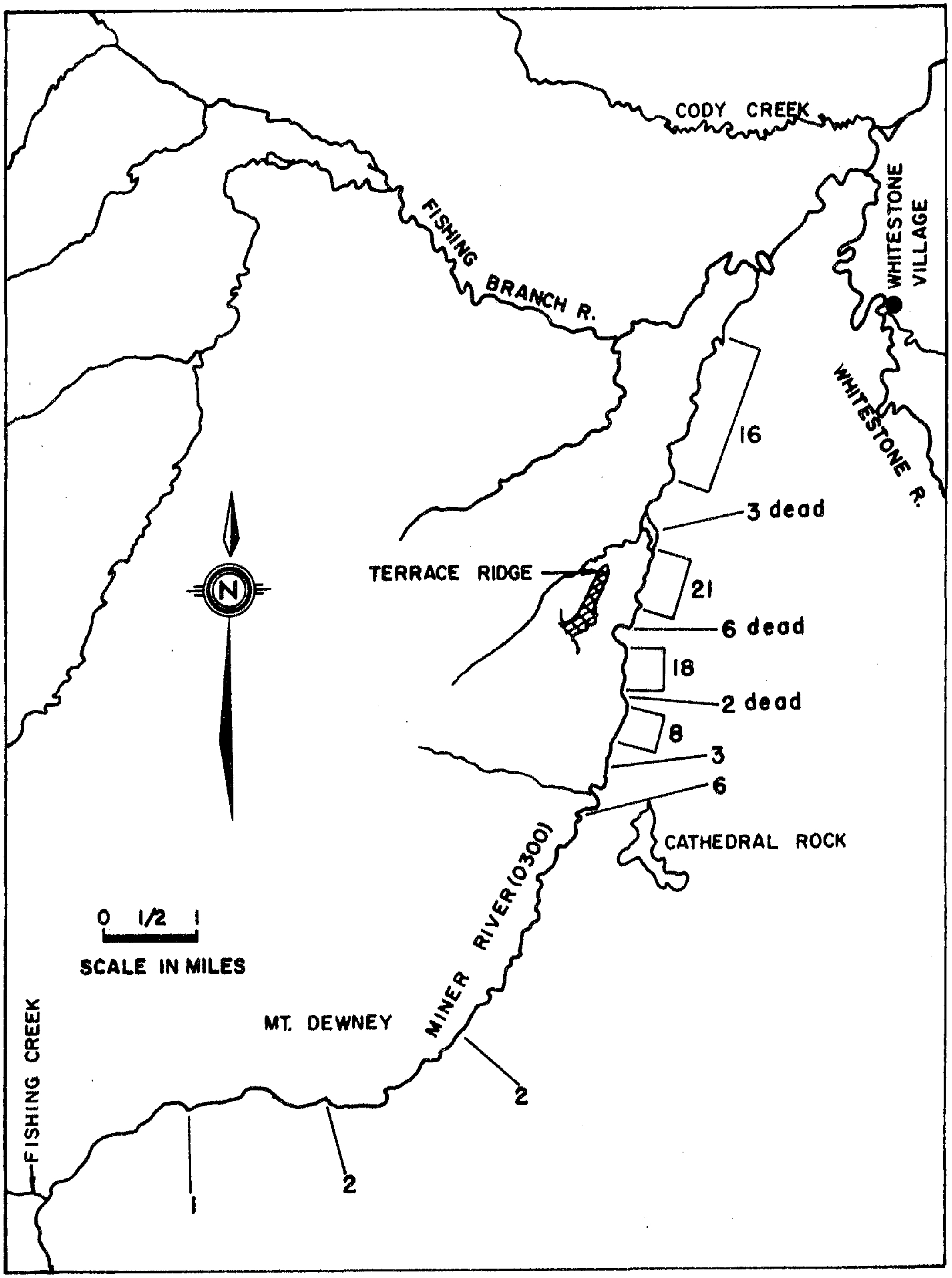


Figure 3. Distribution of chinook salmon in the Miner River on August 2, 1974.

5. Discussion and Conclusions

5.1 Open-Water Areas

In 1972, chinook salmon were captured or observed in the Old Crow River, the Miner River and the Fishing Branch River, all of which are tributary streams of the Porcupine River. Open-water areas exist in the headwaters of all these tributaries. Chinook salmon spawned in the Miner and Fishing Branch Rivers' open-water areas but not in ice-free areas of the Old Crow River headwaters or Timber Creek. Local information suggests that the open-water areas of the Old Crow River headwaters serve as spawning grounds for chinook salmon in some years. The capture of sexually mature chinook salmon in the lower reaches of the Old Crow River reinforces the evidence that chinooks spawn somewhere in the system. The information collected to date indicates that the presence of open-water areas in streams of the upper Porcupine River drainage may constitute a preferred habitat but not always a necessary condition for the spawning of chinook salmon. Until the question is satisfactorily resolved, all open-water areas should be treated as areas of aquatic sensitivity, and afforded maximum protection.

Small numbers of chinook salmon utilized the open-water areas of the Fishing Branch River for spawning in each of 1972, 1973 and 1974.

In the Miner River, a combination of stream characteristics may influence spawning site selection. The area near the mouth had good gravel conditions and was an open-water area during the 1972 winter survey. In addition, the few fish downstream of the Terrace Ridge tributary were sighted in a winter overflow water area that was observed during the 1972 winter survey. These areas may be a ground water source (Steigenberger, 1972). Unlike other streams of the Miner River, the Terrace Ridge tributary continued to flow throughout the summer. This may be associated with summer aufeis or ground water sources in the headwaters.

5.2 Population Estimates

Small numbers of chinook salmon were seen in early September at the Fishing Branch River counting fence in each of 1972, 1973 and 1974. The counting fence, designed primarily to enumerate chum salmon, is not constructed till early September to coincide with the spawning migration of these fish. It is possible that larger numbers of chinook salmon spawn in the south fork of the Fishing Branch River before installation of the counting fence. Earlier construction of the fence (approximately August 15) would provide more accurate counts of the Fishing Branch River chinook salmon population. The population is estimated at less than 25 chinook salmon annually.

The highest estimate of the Miner River chinook salmon population in 1972 was 30 fish (August 12) and the highest estimate made in 1974 was 89 fish (August 9). Because of excellent conditions for aerial enumeration on both dates, these estimates are believed to be subject to errors of less than ±10%. However, enumerations made at any one time do not correctly estimate the total number of spawning salmon utilizing a particular stream because of continuing recruitment to and mortality of segments of the population. If accurate information is available regarding stream residence of the fish, and if this information is combined with the results of enumeration conducted at constant intervals, a much more accurate estimate of total spawning population may be obtained. Accurate information is not available on stream residence of chinook salmon in the Miner River. The 1972 chinook salmon population in the Miner River was at least 30 fish and the 1974 population was at least 89 fish.

5.3 Migration Timing and Peak Spawning Period

The limited information available on adult chinook salmon in the Fishing Branch River indicates that they spawn later than chinook salmon in the Miner River.

The peak of spawning of chinook salmon in the Miner River may be inferred from the highest individual estimates made in each of 1972 (30 fish on August 12) and 1974 (89 fish on August 9). A much higher proportion of dead chinook salmon were observed in the August 9, 1974 survey than in the August 2, 1974 survey, indicating that the peak spawning period in 1974 was in the time period August 1-August 9. In 1972, 27 of 30 chinook salmon were alive on the Miner River spawning grounds on August 12, indicating a peak spawning period from August 10-14.

In 1972, the peak of abundance of migrating chinook salmon in the Porcupine River near Old Crow occurred on approximately July 15, based on catches in the domestic gill net fishery. Since the peak spawning period of chinook salmon in the Miner River was assumed to be from August 10-14, the average migration time from Old Crow to the Miner River spawning grounds was approximately one month. It is believed that gill-netting conducted in June, 1972 in the Miner River was of no use in contributing to information on the migration of chinooks in the Porcupine system. Similarly, aerial surveys conducted in September, October and December, 1971, had little chance of locating chinook salmon. These programmes were conducted earlier and later respectively than the period of stream residence of chinook salmon in the Miner River.

5.4 Information Deficiencies

The levels of knowledge on the biology of chinook salmon in the Porcupine River drainage are well below those necessary for adequate management of the stocks. Information deficiencies exist in areas of timing of migration in the Porcupine and Miner Rivers, in the magnitude of chinook stocks in the Fishing Branch and Old Crow Rivers, and in the general biology of the eggs and juvenile stages of the fish.

Information on migration timing to the Miner River and stream residence of chinook salmon on the spawning grounds could be obtained by mark and recovery programmes conducted at Old Crow and at the confluence of the Miner and Fishing Branch Rivers and recovery of dead chinooks on the Miner River spawning grounds would determine stream residence of the fish.

Magnitude of chinook salmon stocks in the Old Crow River and in the Fishing Branch River could be determined by aerial surveys and by an earlier installation of the Fishing Branch River counting fence respectively.

Information on timing of incubation of chinook salmon eggs, thermal requirements to hatching, time of emergence of the fry, duration of stream residence of fry and juveniles, and times of migration of juveniles could be determined by ground surveys conducted in the spring and summer.

5.5 Pipeline Concerns

Some techniques of pipeline construction could be detrimental to chinook salmon stocks in the Porcupine River drainage. Gravel removal from the mainstem Porcupine River must be timed to avoid interference with the migration of adult and juvenile chinooks. No pipeline associated activity should be allowed on documented chinook spawning grounds at any time of the year. Potential chinook spawning habitat, including all open-water areas, should be afforded protection from pipeline activity.

6. References

Berg, L. S. 1948. Freshwater fishes of the U.S.S.R. and adjacent countries. Vol. 1. Akad. Nauk S.S.S.R. Zool. Inst. (Translated from Russian by Israel Program for Scientific Translation OTS 61-31218, Jerusalem, 1962. 504 p.)

Elson, M. S. 1973. Enumeration of spawning chum salmon in the Fishing Branch River in 1971 and 1972. Canada Dept. Envir., Fish. Mar. Serv., Pacific Region. Technical Report 1973-5. 20 p.

Elson, M. S. Ms 1973. Fishing Branch Studies - 1973. Memorandum Report.

Gilbert, C. H. 1922. The salmon of the Yukon River. Bulletin of the Bureau of Fisheries. No. 38: 317-332.

Stager, J. K. 1974. Old Crow, Y. T., and the proposed Arctic Gas Pipeline. Evironmental-Social Committee, Northern Pipelines, Task Force on Northern Oil Development. Unpublished Report.

Steigenberger, L. W. 1972. Preliminary information on the winter classification and mapping of the rivers in the northern Yukon, the physical and chemical characteristics and the fish statistics of the various water bodies examined during the first Yukon Pipeline Winter Survey, March, 1972. Environmental-Social Committee, Northern Pipelines, Task Force on Northern Oil Development. Unpublished Report.

C H A P T E R I V

A PRELIMINARY STUDY OF FISH SPECIES OTHER THAN SALMON FOUND IN THE FISHING BRANCH RIVER, YUKON TERRITORY IN SEPTEMBER, 1973

by

P. G. BRUCE

for the

Environmental-Social Program

Northern Pipelines

Acknowledgement

Funds for this project were provided by the Environmental-Social Programme, Northern Pipelines, of the Task Force on Northern Oil Development, Government of Canada.

Appreciation is extended for the efforts of M. S. Elson, E. E. Smyth and C. W. Brandt for assistance in the collection of field data. G. T. Birch analyzed the stomach contents and Y. Yole read the otoliths and scales for ageing. Dr. D. Gallup analyzed the water samples.

M. S. Elson and L. W. Steigenberger edited the manuscript. A. Gibson and C. E. Walker provided planning and administrative assistance.

1. Abstract

A ten-mile long spring-fed section of the south fork of the Fishing Branch River in northern Yukon Territory remains free of ice all year. This section of the river is considered a sensitive aquatic habitat for chum salmon (Oncorhynchus keta), chinook salmon (O. tshawytscha), coho salmon (O. kisutch), Arctic grayling (Thymallus arcticus), round whitefish (Prosopium cylindraceum), and slimy sculpin (Cottus cognatus). The three species of anadromous Pacific salmon spawn in the ice-free areas of the Fishing Branch River. Apart from chum salmon, Arctic grayling are the most abundant fish species in the river. The grayling population was estimated at 8889 fish (range at 95% confidence: 6186 to 15,790) by means of a mark and recapture programme conducted in September, 1973. The population of round whitefish was estimated at less than 100 fish. The chum salmon spawning population was approximately 16,000 fish in 1973.

Water chemistry of the Fishing Branch River is of a high quality for the support of fish life. Age determination of grayling by means of scales gives values approximately one year less than age determination from otoliths. The mean scale age of grayling was 5.6 years and the mean otolith age was 6.6 years. The maximum age was 9 years. Growth rates slow at about 7 years of age. The majority of the grayling found were over 300 mm in fork length, very few were less than 250 mm. Length-weight relationships in grayling were similar to those in other northern areas. Sex ratios of grayling were close to 1:1; fecundity may be lower than in other northern areas. The diet of grayling was varied, but based chiefly on aquatic forms such as Chironomidae larvae. Predation by grayling on eggs and fry of chum salmon has been documented, and an upstream migration of grayling was observed coincidental with the upstream migration of chum salmon to their spawning grounds.

Table of Contents

Page

List of Figures

List of Tables

2. Introduction

The Fishing Branch River is one of the headwater tributaries of the Porcupine River in northern Yukon Territory. Approximately 9 miles of the south fork of the Fishing Branch River remains free of ice all winter. This section of the river is utilized as a spawning grounds by three species of Pacific salmon: chum salmon (Oncorhynchus keta), chinook salmon (Onchorhynchus tshawytscha) and coho salmon (O. kisutch). During a project conducted to enumerate the chum salmon in September and October of 1972, large numbers of Arctic grayling (Thymallus arcticus) and smaller numbers of round whitefish (Prosopium cylindraceum) and slimy sculpin (Cottus cognatus) were observed in the open water, spring-fed section of the river. In the fall of 1973 a mark and recovery programme was carried out to study aspects of the life biology of fish species in the system other than salmon. The programme was in conjunction with an enumeration of the chum salmon spawning population conducted by Elson (1973, MS 1973), and as part of a general study by the Yukon Pipeline Study Group of groundwater sources associated with winter open water areas.

The area of study extended approximately 4 miles upstream of the base camp and fish fence (Lat. 66°31'N, Long. 139°12'W), along the north side of Bear Cave Mountain, and within the winter open water area (Figure 1).

"Middle Devonian limestones (and some shale) of the Bear Rock or Hume Formation are exposed on the west side of the river and on Bear Cave Mountain" (van Everdingen, 1972). Muskeg often extends to the river bank and supports black and white spruce, unidentified fir, willow, larch and birch. The main chum salmon spawning channel (station 50) is within a fine mature stand of white spruce.

The river is clear and swift with much of its discharge from groundwater sources, especially during the fall and winter. It is meandering in nature with alternating riffles and pools and large exposed gravel bars formed on the inside of each bend. The outsides of the bends frequently exhibit undercutting and slumping of the banks. The maximum depth is about 8 feet in large pools, and the bed is of medium to large cobble with finer gravel forming the gravel bars. Side channels of the river are much slower, brownish in colour with loose, fine granular sediment over medium-sized cobble. The maximum width of the river during September, 1973 was approximately 250 feet.

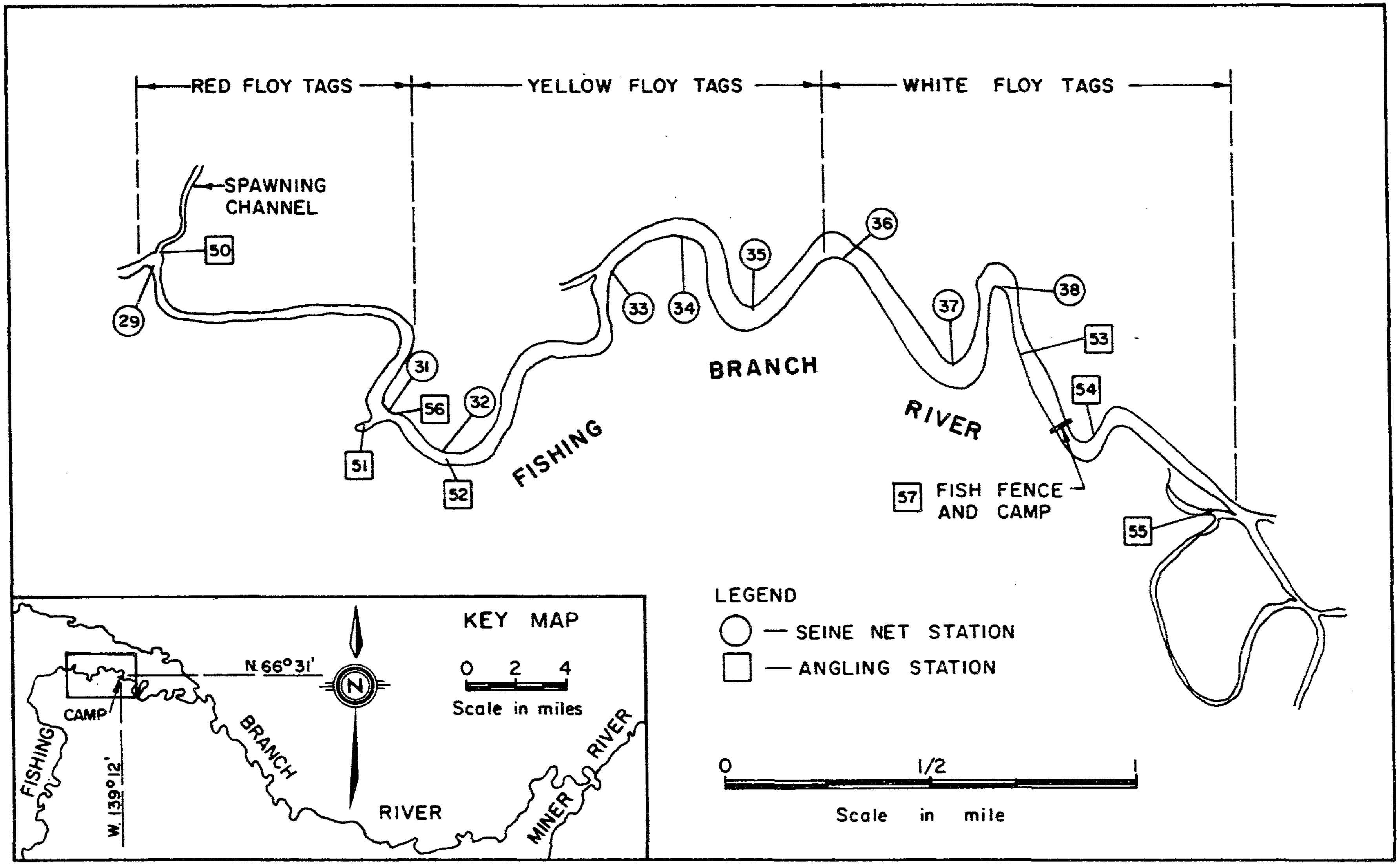


FIGURE 1. Map of study area on the Fishing Branch River, Northern Yukon Territory, showing seining and angling stations, and indicating the areas in which coloured tags were applied.

3. Methods

3.1 Water Chemistry

Water samples were collected from three sites in the study area. These were stations 50, 31 and 36. Chemical analysis was conducted in the field by means of Hach kits for the following criteria: oxygen (model OX-2P), pH (model 17 N), alkalinity (model AL-AP) and carbon dioxide (model CA-23). To measure conductance a Beckman RA-2A conductivity meter was used. Detailed water chemistry was completed by Dr. D. Gallup, University of Alberta, Edmonton.

3.2 Biological Sampling

The criteria used in visual sexual identification of grayling was after Bishop, 1971. If the dorsal fin extended past the adipose fin the fish was considered a male.

A total of 784 grayling were measured for fork length. A sub-sample of 127 grayling had scales removed for ageing. From this sub-sample, 31 grayling were killed. This sample was comprised of 10 fish from the 350-399 mm, and 300-349 mm length classes, and 11 fish from the 240-299 mm length class. The following data were collected from each fish in the dissection sample: fork length (mm), weight (g), scales and otoliths for comparative ageing, sex, sexual maturity, gonadal volume (g or mls), egg diameter (mm), and stomach volumes and contents. Two round whitefish were dissected and one found dead on the fence was examined.

Scales used for ageing fish were taken from the left side, midway between the lateral line and the origin of the dorsal fin. Scales were kept in scale envelopes and otoliths were preserved in a solution of thymol and glycerin. It was possible to age only 112 grayling scales of the 127 taken, and 30 of the 31 in the dissected sample. This means that the comparative age data between scales and otoliths is based on 30 of the 31 dissected fish.

Both gonads from each fish were measured by total weight or by total volumetric displacement and the stage of maturity was assessed by the standard criteria used by the Pipeline Study Group, defined as follows:

Class 2 - gonads differentiated but not well developed (immature)

Class 3 - gonads differentiated and developing but fish incapable of spawning in the coming season (immature)

Class 4 - dormant (mature)

Class 5 - fish capable of spawning in the coming season (mature).

Mean fecundity was determined by relating aliquot counts to total ovary weight or volume. Egg diameter was determined as the mean from the total length of ten aligned eggs.

A total of 27 grayling and 3 round whitefish stomachs were collected from the dissection sample and preserved in 10% formalin solution, for detailed examination of their contents in the Vancouver laboratory.

3.3 Tagging

The study area was divided into three areas, and fish were tagged with different coloured tags in each section. The tags were sub-cutaneous plastic Floy tags, numbered and brightly coloured to aid in visual sightings. The fish in the upper area were tagged with red tags. Yellow tags were used in the central area and white tags in the downstream area (Figure 1). Effort was concentrated on the capture and tagging of Arctic grayling, since, after chum salmon, this was by far the most abundant species.

Each gravel bar was seined with a net of dimensions 80 ft X 9 ft x ½ inch with a 20 ft X 8 ft X ¼ inch bunt. Stations were seined by wading or by using a rubber boat powered with either a 9 hp outboard or a 25 hp jet outboard motor. The net was drawn into the shore, leaving enough of it in the water to prevent injury of the fish. When chum salmon were captured their hyper-activity often resulted in the loss of grayling from the seine haul. Fish were extricated by hand, the fork length measured, a visual identification of the sex made, a tag injected and the fish released.

Angling was found to be an effective means of capturing fish where it was impossible to seine. A "Mepps" lure size 0, with a single hook was very successful and did little damage to the fish.

The tags were injected with a tagging gun below the dorsal fin on the left side from September 9-17, and thereafter on the right side. The fish was then observed after release to see if mortalities occurred.

3.4 Tag Recovery

To obtain an estimate of the population of grayling within the study area, data were collected from a tag and recovery programme. These data were used in the Schumacher-Eschmeyer modification of the Schnabel census technique.

Movements were detected by recovering previously tagged fish by seining and by 2 visual techniques. Grayling movements upstream or downstream were observed at the fish fence in the course of salmon enumeration. Also, at stations 29, 50 and 51, where the water was undisturbed and clear, visual observation of tag colours was feasible.

4. Results and Discussion

4.1 Water Chemistry

The results are presented in Table I, in addition to data collected by previous workers. Bryan (1973) collected data at station 31 and van Everdingen (1972) had sample sites upstream of the study area. A preliminary discussion of the characteristics of the river and the groundwater has been presented in a manuscript report by van Everdingen (1972).

The results of water sample analysis indicate that the habitat is highly suitable for the maintenance of fish populations within the study area. Turbidity is low, dissolved oxygen content is high, and nutrient levels and heavy ion concentrations appear adequate for primary productivity.

The groundwater discharge, through a combination of temperature and flow rate, maintains the open water area during the winter. The water temperature on September 12, 1973, was 5°C, and had dropped to 3°C by September 28. The 1973-74 winter conditions had been characterized elsewhere in the Porcupine drainage by considerable ice formation and little snow cover, yet the study area was still open and flowing on March 20, 1974, and had remained open all winter.

Table I. Results of chemical analysis of water samples collected from the Fishing Branch River. Field results are in parentheses.

		Bryan Sept 1, 1972	van Everdingen July 21, 1972		Sept 2, 1973 Station 31	Sept 24, 1973 Station 36	Sept 25, 1973 Station 50	Mar 20, 1974 Station 29
			Ponds	Springs				
Temperature (°C):	Air °C	-	-	-	-	2.5	2.5	
	Water °C	5	16.2	5.3	4	3.5	3.5	
Colour....................		-	-	-	-	25.0	-	11
DO_2	(mg/l).........	-	9.0	6.4	(12)	(13)	(8)	
Free CO_2	(mg/l).........	-	-	-	(10-15)	(10-15)	(10-15)	
H_2S	(mg/l).........	-	-	-	-	-	-	-
pH	....	8.5	7.8	7.6	7.92(8.5)	7.8(8.5)	7.63(8.5)	6.87
Alkalinity	(mg/l $CaCO_3$):							
	Phenol-phthalein	-	-	-	-	-	-	-
	Total....	154	-	-	110.7(154.8)	111.2(154.8)	109.6(172)	69.0
Hardness	(mg/l $CaCO_3$):							
	Calcium..	-	-	-	94	92	84	63
	Total....	-	-	-	132	128	128	160
T.D.S.	(mg/l).........	161	-	-	164.6	188.4	146.0	186.8
F.D.S.	(mg/l).........	-	-	-	146.9	160.1	134.8	103.05
Turbidity	(mg/l) suspended material.	-	-	-	17.7	28.3	11.2	10.5
Conductance	(micromhos)....	-	138	316	260(224)	260(216)	260(176)	177.5
Nitrate - N	(mg/l).........	-	-	-	0.05	0.04	0.06	0.17
Orthophos-phate	(mg/l).........	-	0.011	0.011	0.06	0.07	0.10	0.10
Sulfate	(mg/l).........	-	3.6	17.9	15.0	17.0	13.0	14.0
Chloride	(mg/l).........	-	0.6	3.8	3.06	3.30	7.07	4.71
Silica	(mg/l).........	-	2.2	2.5	2.30	2.25	2.50	2.05
Iron	(mg/l).........	-	0.5	0.1	0.02	0.02	0.05	0.02

4.2 Biological Sampling

4.2.1 Age Determination

From the dissected sample of 31 grayling only 30 fish had both scales and otoliths suitable for ageing to permit comparison of the ageing techniques.

The ages found by the two techniques appeared to differ for individual fish. An attempt was made to determine which of the ageing techniques was more accurate, as discussed below.

The following summarized age data from the sub-sample of 30 fish, determined by scale age and otolith age, was found.

	n	$\bar{x}$ age (yrs)	Standard Deviation	S.E.	Min.	Max.
Scale Age	30	5.600	1.221	.223	3.00	9.00
Otolith Age	30	6.667	1.295	.237	4.00	9.00

The two techniques were tested for significant differences by means of the paired t test ($H_0 : D = 0$; $H_1 : D>0$) which gave t = 4.147 (p = 0.05, d.f. = 29, one tailed test). This result means that the mean ages found by both ageing techniques are significantly different.

To determine the compatibility of the two ageing techniques a bivariate analysis by linear regression was performed on scale age against otolith age. However, the regression results had a low r value (r = 0.741517), invalidating further analysis. The low r value was probably a reflection of too small a sample size (n = 30). A higher level of correlation would be expected with a larger sample.

Bryan (1973) found that the scale age of coastal Arctic grayling was always less than or equal to the otolith age. By inspection it appears that the relationship between scale and otolith ages for grayling on the Yukon coast is different from that of grayling in the Fishing Branch River.

de Bruyn et al (1973) have found that scales may give unreliable ages for grayling on the Yukon north slope, and consider otolith ageing to be the more accurate technique. However, Hatfield et al (1972) found good correlation between scale and otolith ages in grayling from the Mackenzie River system.

Three juvenile grayling from the study area were aged by both techniques. Both scale and otolith ageing techniques found that two of the fish were 1^+ years of age and that one fish was 2 years of age. Incompatibility between ageing techniques occurred in the dissection sample (n = 30) where ages ranged from 3 to 9 years of age, and a significant difference of approximately one year was found. In this sample of aged fish the slopes of regression lines of fork length and age, by scales and by otoliths, were nearly parallel and separated by approximately one year. By inspection of the regression lines it appears that otolith age is closer to true age, and that scale readings give ages approximately one year less than otolith ages.

It was not possible to determine the primary source of discrepancy between the ageing techniques. Ageing by both techniques was carried out by qualified personnel using a standardized technique of counting annuli on scales and otoliths. The scales from the study area in the Fishing Branch River were noticeably easier to read than grayling scales from elsewhere in the Porcupine River drainage.

"Plus growth" does not appear to be a potential source of accountable difference as it was not recorded during ageing, and occurs on both scales and otoliths.

Another possible source of difference is in the time required from hatching (and assumed otolith development), to the laying down of scales. However, the juvenile grayling that were aged by both techniques gave the same results at ages one and two years. Yet discrepancy occurred between scales and otolith ages in fish of three and four years of age. It appears likely that at least some of the accountable difference between ageing techniques occurs between the ages of one and four years of age.

de Bruyn et al (1973) attribute the discrepancy between scale and otolith readings to the formation of a "dense edge" on older scales that tends to obscure annuli.

It would appear that the most practical way of studying the differences in ageing techniques is by working with grayling of known age.

Scale age was the primary ageing technique utilized by the Fisheries Service Pipeline Study Group and for consistency the results of this ageing technique are used in the discussion of age and growth in this study. However, in comparison with the results of other studies, it should be remembered that scale age in the Fishing Branch River study underestimates the age by otoliths of grayling by approximately one year, and that a discrepancy between scale and otolith ages in grayling has been noted by other researchers.

4.2.2 Scale Age and Fork Length Relationships in Grayling

Scale age and fork lengths of 112 grayling were used to determine the relationship between age and growth. The mean fork lengths at a given age were computed and the percentage frequency of fish in each age class calculated as shown in Table II. From this data a growth curve was plotted (Figure 2).

The minimum age of grayling in the sample was 3 years, and the maximum was 9 years which was greater than the maximum age of 8 years reported by McCart et al (1973) in the Firth River on the Yukon north slope. As shown in Table II, age 5 fish had the greatest percentage occurrence, followed by age 6, then by age 7 fish. An examination of length frequency distribution by age class shows considerable overlap in these aforementioned age classes, and indicates that growth rate slows by age 7 (Figure 2).

Three juvenile grayling were aged and no difference was found between scale and otolith age. Two fish were found to be 1^+ years of age and measured 113 and 101 mm. The remaining fish was 2^+ years old and measured 134 mm long.

An equation of growth, developed from the linear regression of scale age on fork length from the sample of 112 grayling, was determined as follows:

$$y = ax + b$$

$$\ell n \text{ fork length} = \text{slope (scale age)} + (y - \text{intercept})$$

Table II. The scale age, mean fork length ± one standard deviation at the 95% confidence interval, the minimum and maximum length for the confidence interval and the percentage frequency of each age class from 112 grayling (*Thymallus arcticus*) collected from the Fishing Branch River, September, 1973.

Scale age	Sample size	Mean length ± one standard deviation	Minimum		Maximum	Percentage frequency
3	2	276.5 ± 19.1	257.4	-	295.6	1.8
4	8	287.6 ± 28.7	258.9	-	316.3	7.1
5	36	318.5 ± 22.8	295.7	-	341.3	32.1
6	34	336.6 ± 19.6	317.0	-	356.2	30.4
7	24	354.8 ± 18.4	336.4	-	373.2	21.4
8	7	351.3 ± 20.7	330.6	-	372.0	6.3
9	1	360.0 -	-		-	
	Σ 112					100.0

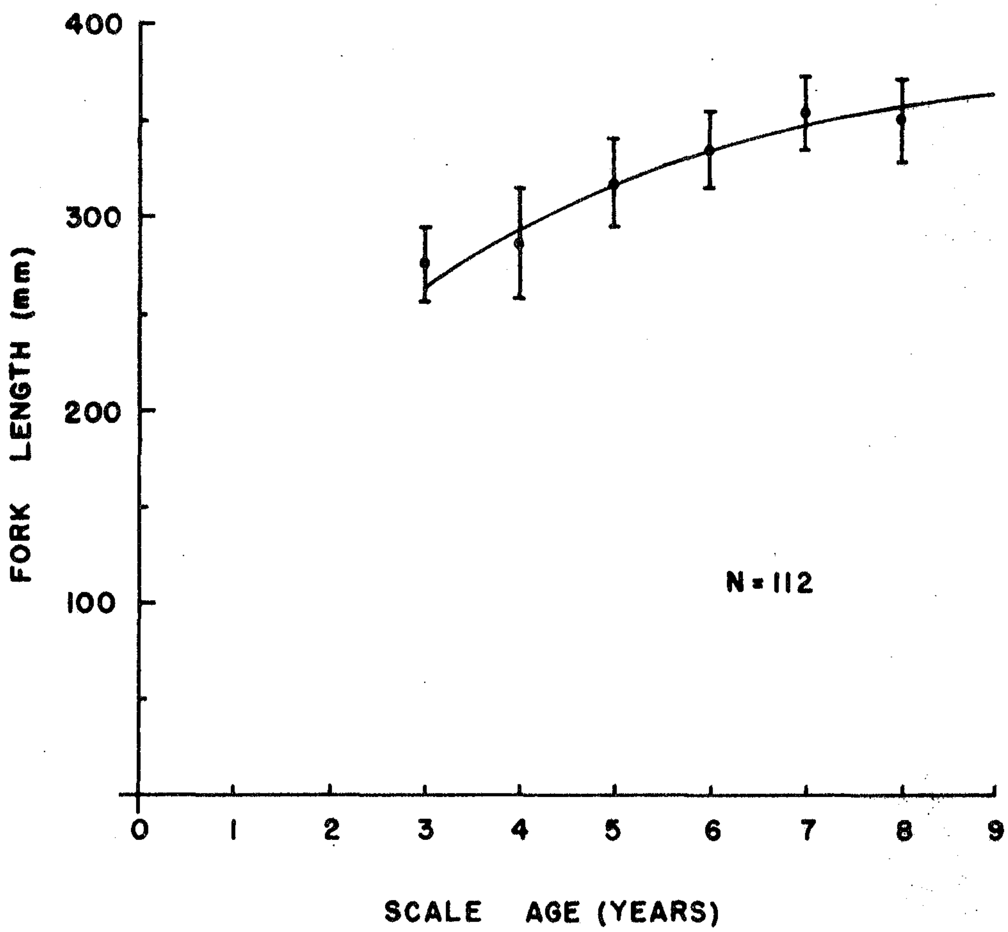


FIGURE 2. Age-length relationship for Arctic grayling from the Fishing Branch River, September 1973. (Vertical bars indicate standard deviation about mean fork length).

The formula found was,

$$\ell n \text{ fork length} = 0.0515 \text{ (scale age)} + 5.4989$$

where,

n = 112

S.E. = 0.0060

r = 0.6317

Slope limits = 0.0396 to 0.0634 at 95% confidence limits

Range in ages = 3-9 years

This equation was compared to one derived by G. Birch (pers. comm.) for the growth rate of grayling caught in the vicinity of Old Crow during October, 1972.

The formula found was,

$$\ell n \text{ fork length} = 0.09195 \text{ (scale age)} + 5.4014$$

where,

n = 157

S.E. = 0.0085

r = 0.6687

Slope limits = 0.0746 to 0.1083 at 95% confidence

Range in ages = 2-7 years

As there was no overlap of slope limits, there is a significant difference between the slopes, or rate of growth of grayling in the two areas which means that grayling in the Fishing Branch River grow at a significantly slower rate than do grayling in the Old Crow area. This, however, may be a reflection of age composition of the populations or the fact that samples of fish collected from the vicinity of Old Crow were primarily downstream migrants from the productive lakes of the Old Crow Flats.

The underestimation of actual age by the scale age of fish in the study area results in a growth rate equalling or exceeding that found by Hatfield et al (1972) in the

Mackenzie River grayling. However, Hatfield had found good compatibility of scale and otolith ages. When the otolith age of fish from the study area in the Fishing Branch River is used to compare growth rates, it is found that the grayling at Norman Wells (n = 60) and Arctic Red River (n = 27) have a greater growth rate.

Bryan (1973), who had also noted the incompatibility of scale age and otolith age, determined a growth rate by scale age for interior grayling (vicinity of Old Crow) of the Porcupine River drainage (n = 31) that was greater than the growth rate found by scale age of the Fishing Branch River population. The growth rate of Fishing Branch River grayling was greater than that found by Bryan (1973) for Yukon coastal grayling (n = 123).

Growth rates of interior Alaska grayling (n = 1300) computed by Reed (1964) are compatible with the growth rate of fish in the study areas, except that Alaska fish grow more in their 7th and 8th year.

Growth rate of grayling from the study area as determined by scale age exceeded the growth rate of Yukon coastal grayling (n = 124, n = 118, n = 142), determined from otolith age by de Bruyn et al (1973). The growth rates are reasonably compatible if otolith age of the Fishing Branch River grayling is used.

As de Bruyn et al (1973) note, the relationship of growth rates may be an artifact of the scale method of ageing used by other researchers as found by McCart et al (1972).

4.2.3 Length-Frequency Distribution in Grayling

A length-frequency histogram was prepared from the fork lengths of 784 fish (Figure 3). Intervals of 10 mm were used (0.0-9.9, 10.0-19.9, etc.).

The general configuration of the histogram was basically similar and smoother than the length-frequency histogram from a sample of 127 fish, indicating that a sample of 127 fish is roughly representative of the population of grayling from the Fishing Branch River.

Fork lengths in the sample of 784 fish ranged from the 220.0 to 229.9 mm interval to the 420.0 to 429.9 mm interval. In addition, 24 grayling were collected that were considered as young of the year and juveniles. The fork lengths

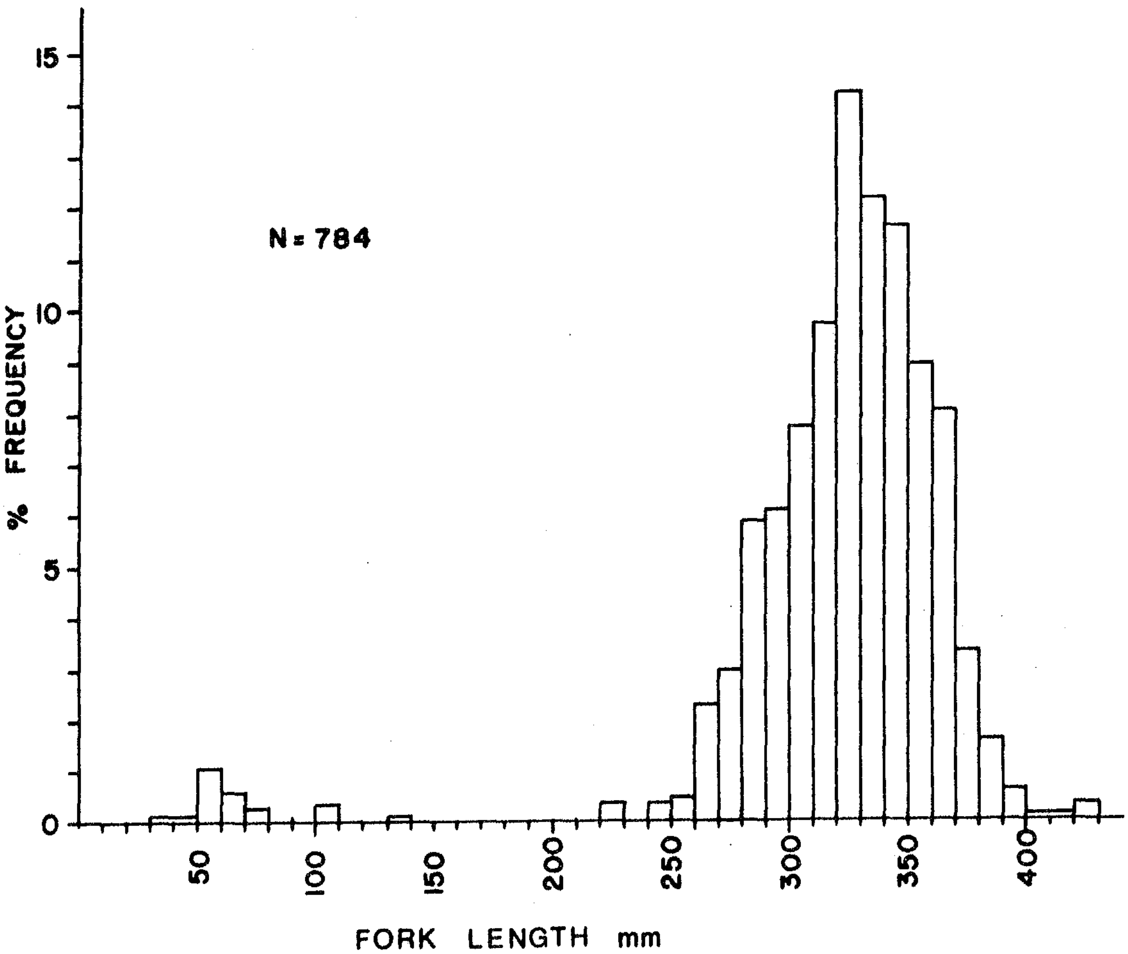


FIGURE 3. Length-frequency distribution of Artic grayling from the Fishing River, September, 1973

of these fish ranged from the 30.0 to 39.9 mm interval to the 130.0 to 139.9 mm interval, with the greatest percentage frequency occurring at 50 to 60 mm.

It was noted that very few fish were caught in the smaller length intervals up to the 220.0 to 229.9 mm interval, and the sample size up to this interval was considered inadequate for analysis.

From Figure 3 it appears that very few fish of less than 250 mm are present in the study area during September. Grayling of fork lengths between 320 and 329 mm were the most abundant, with a percentage occurrence of 14.2%. As the fish were captured by intensive repetitive seining it is probable that the population structure indicated is accurate and that the absence of small fish is not merely a product of sampling technique.

The maximum length recorded in September, 1973 was in the 420-429 mm range. The maximum fork length of grayling found in the study area on May 18, 1972 was 389 mm.

4.2.4 Length-Weight Relationships in Grayling

The natural logarithmic values of weight and fork length of a sample of 31 grayling were calculated. A linear regression was then performed of ℓn weight (y-axis) against ℓn length (x-axis).

The relationship of weight to length of grayling in the Fishing Branch River study area was expressed in the following form:

$$\ell n\ W = a + b\ (\ell n\ L)$$

where,

a = y intercept

b = slope

W = weight (grams)

L = fork length (mm)

all expressed by natural logarithms. The resulting formula was:

$$\ell n\ W = 11.5658 + 3.0059\ (\ell n\ L)$$

$$n = 31$$

$$S.E. = 0.1249$$

$$M = 0.9759$$

The length-weight relationship of grayling from the Fishing Branch River does not appear to be significantly different from the relationship found by Bryan et al (1973) for North Slope grayling and for interior grayling in the Porcupine drainage, or that found by Hatfield et al (1972) in the Mackenzie River Valley.

4.2.5 Sex Ratios, Maturity and Fecundity of Grayling

Visual sexing of grayling in the Fishing Branch River was not successful. Bishop (1971) found 92% accuracy by visual sexing on a sample of 308 judgments on fish 400 mm or longer. On a sample of 19 fish collected from the Fishing Branch River area, accuracy was only 68% using the same technique. This result is probably due to the fact that none of the fish equalled or exceeded 400 mm in length, and that the sample size was small. The data was consequently not considered for analysis.

Table III shows the percentage of males and females and the percentage of mature fish of each sex in the sample. Table IV indicates the percentage of mature fish by sex and size range. Tables V and VI show the gonadal development of female and male grayling respectively, in the dissection sample.

From Table III there was a ratio of 1.21 male to one female in the sample, which is not apparently different from the expected 1:1 ratio. Only 35.5% of the males and 42.9% of the females were considered mature enough to take part in the next spawning period.

Generally the gonads of both sexes were reduced in size and difficulty was experienced in assigning maturity classes to the specimens, particularly in immature fish (maturity class 3).

Table III. Sex and maturity percentages of *Thymallus arcticus* sampled.

Sex	% occurrence in sample n = 31	% of mature fish of each sex in sample
male	54.8% (n = 17)	35.3%
female	45.2% (n = 14)	42.9%

Table IV. % maturity by size range and sex of *Thymallus arcticus* sampled.

	% mature fish of each sex in range				
Fork length range (mm)	Male	Sample size	Female	Sample size	Total % mature fish in size range
240 - 299	0	4	0	7	0 (n = 11)
300 - 349	57.1%	7	66.7%	3	60% (n = 10)
350 - 399	33.3%	6	75.0%	4	50% (n = 10)

Table IV shows the percentage of mature fish of either sex found within each of the length classes. No fish under 300 mm were found to be mature. From 300-349 mm in length, 57.1% of the males and 66.7% of the females were mature, whereas from 350-399 mm in length, only 33.3% of the males and 75.0% of the females were mature. The larger length classes of males would be expected to have the greater percentage of mature fish. This discrepancy is probably due to too small a sample size.

It appears that the percentage of mature grayling in each of the length classes is higher, and that maturity occurs at a shorter fork length in grayling from the Beaufort drainage and other areas of the Porcupine drainage (vicinity of Old Crow), as found by Bryan et al (1973), than in grayling from the Fishing Branch River.

Tables V and VI show the mean values and ranges of gonadal data for female and male grayling respectively for each of the maturity classes. The mean fork lengths of fish in each maturity class were greater for males than for females. Reed (1964) showed that mature males appear to grow more than females in Alaska.

The average number of eggs per mature female (n = 3, fork lengths = 322, 360 and 360 mm) was 4,112 undeveloped eggs. Three female grayling (fork lengths = 310, 330 and 354 mm) sampled on May 18, 1972, at station 29 had a total egg number of 1,233 to 3,512 eggs ($\bar{x}$ = 2262). Bishop (1971) found an average fecundity of 9,670 eggs in grayling from Great Slave Lake, and Rawson (1950, in Bishop, 1971) determined a range of 4000 to 7000 eggs per female. de Bruyn (1973) found a mean fecundity of 8,967.8 eggs (range of 4,077 to 14,429 eggs) from grayling on the Yukon north slope.

Although the dissected sample sizes of females from the Fishing Branch River is very small, there is an indication that the fecundity of grayling in this area is lower than that reported for grayling in other northern areas. There is also a possibility of error in the volumetric computation of total egg number due to variability in egg size, although efforts were made to take representative aliquots.

The mean egg diameter of 1.6 mm from the study area is comparable with the mean egg diameter of 1.7 mm determined by de Bruyn (1973) for north slope grayling during September.

Table V. Gonadal data of female *Thymallus arcticus*. (R = Range)

Maturity	Fork length (mm)	Gonadal volume (mls or gms)	Egg diameter (mm)	Egg number	Sample size
				n = 3	
5	$\bar{x}$ = 339.5	$\bar{x}$ = 19.91	$\bar{x}$ = 1.6	$\bar{x}$ = 4112	6
	R = 316-360	R = 11.6-26.7	R = 1.5-1.7	R = 3240-4910	
3	$\bar{x}$ = 329.0	$\bar{x}$ = 14.5	$\bar{x}$ = 1.53	-	2
	R = 286-355	R = 4.0-23.4	R = 1.4-1.6		
2	$\bar{x}$ = 268.8	$\bar{x}$ = 1.52	-	-	6
	R = 240-289	R = <0.5-3.0			
				TOTAL =	14

Table VI. Gonadal data of male *Thymallus arcticus*. (R = Range).

Maturity	Fork Length (mm)	Gonadal Volume (mls or gms)	Sample Size
5	$\bar{x}$ = 350.7	$\bar{x}$ = 4.83	6
	R = 328-383	R = 2.5-9.5	
3	$\bar{x}$ = 346.3	$\bar{x}$ = 3.07	7
	R = 300-383	R = 0.5-4.5	
2	$\bar{x}$ = 276.5	$\bar{x}$ = 0.5	4
	R = 263-290	R = <0.5-0.5	
		TOTAL =	17

The otolith age of mature grayling varied from 6 to 9 years in females, and between 7 and 8 years in males. There were fish of both sexes in these age ranges that were considered immature, although these may have been misclassified due to the difficulty of defining the upper limits of class 3 maturity.

It is probable that female grayling spawn each year as no immature category fish showed evidence of previous spawning; however, more data are required.

In comparison with gonadal data of grayling from other areas, grayling in the study area of the Fishing Branch River appear to mature at a later age, have a lower fecundity, and show a less advanced development of the gonads in September. These features may be related to characteristics of the winter open water habitat.

Only two Prosopium cylindraceum were dissected, both of which were female and of class 5 maturity. One female was 8 years of age (otolith age) with a gonadal volume of 108.6 mls, a fecundity of 7085 eggs with a mean egg diameter of 2.6 mm. The second fish was 10 years of age (by otolith), with a gonadal volume of 53.2 mls, fecundity of 4,423 eggs with an egg diameter of 2.3 mm. It was interesting to find that the 8-year-old fish was larger (fork length 420 mm) than the 10-year-old fish (384 mm), and had a greater fecundity. It appears likely that spawning of this species would occur in the study area as they are fall spawners. However, there appeared to be only a very small population present during September, probably numbering less than 100 fish in the study area of the Fishing Branch River. More data on this species are required.

4.2.6 Food Habits

An analysis was made of the stomach contents of 27 grayling (240 to 383 mm in fork length) and 3 round whitefish caught in the study area during September, 1973. Twenty-five of the grayling (93%) and 2 of the round whitefish (67%) stomachs examined contained food. The results of the analysis are summarized in Table VII where the food items found are listed and the relative percentage of occurrence of these items and the percentage of stomachs containing each food item are shown.

Table VII : ANALYSIS OF STOMACH CONTENTS FROM FISH IN THE FISHING BRANCH RIVER, SEPT. 1973.

STOMACH CONTENTS	*Thymallus arcticus* Stomachs examined = 27 Stomachs with food = 25 (93%)		*Prosopium cylindraceum* Stomachs examined = 3 Stomachs with food = 2 (67%)
	Rel. % of occurrence of items, n = 115 occurrences	% of stomachs containing each of the following items, n = 25 stomachs	Rel. % occurrence of items, n = 7 occurrences
Chironomidae larvae	14.7	68	14.3
Hydracarina	10.3	48	
Terrestrial Insects	9.5	44	
Trichoptera larvae	7.8	36	28.6
Ephemeroptera	2.6	12	14.3
Corixidae	4.3	20	
Plecoptera	6.0	28	
Diptera	3.5	16	
Coleoptera	1.7	8	
Amphipoda	0.9	4	
Hemiptera	0.9	4	
Empididae	1.7	8	
Culicidae	0.9	4	
Simuliidae	0.9	4	
Unidentified Aquatic Insects	5.2	24	14.3
O. Keta eggs	3.5	16	
O. Keta scales	1.7	8	
T. arcticus scales	0.9	4	
Small mammals	0.9	4	
Nematodes	7.8	36	
Digested matter	2.6	12	
Debris	12.1	56	28.6
	≃ 100 %		≃ 100 %

In the round whitefish the most frequently occurring food item was Trichoptera larvae (28.6%), followed by Chironomidae larvae (14.3%), Ephemeroptera (14.3%), and unidentified aquatic insects (14.3%). The stomachs also contained a large quantity of very fine gravel.

The diet of grayling showed a diverse range of food items. Chironomidae larvae occurred with the greatest relative percentage frequency (14.7%) and were found in 68% of the stomachs. Other abundant invertebrate food items included Hydracarina, terrestrial insects, Trichoptera larvae, and Plecoptera, which had relative percentage occurrences of 10.3, 9.5, 7.8 and 6.0 percent respectively. The percentage occurrence of terrestrial insects was noticeably lower than that previously observed in the area by Bryan (1972) and do not appear to be as important an item in the diet as noted by Hatfield et al (1972) in the Mackenzie River. This relationship may be due to the time of year of the study.

Nematodes occurred in 36% of the stomachs examined and were the only parasite found in grayling, either in the flesh or the digestive tract.

Unusual food items in grayling stomachs included a small rodent, probably a mouse, in one stomach, and one stomach that was full of grayling scales. Chum salmon scales and eggs occurred in 8% and 16% respectively of the grayling stomachs examined.

Chum salmon were beginning to spawn towards the end of September and grayling were observed on the spawning channel, hovering downstream of salmon engaged in redd construction. When the salmon were digging in the redd, grayling were observed to dart into the cloud of disturbed material, presumably to feed. This may account for the presence of O. keta scales and eggs in the stomachs of the examined grayling. Reed (1964) noted that grayling "apparently feed on whatever is available to them".

Unfortunately the study was terminated before the majority of the chum salmon spawned. Random samples of grayling taken at the counting fence indicated a higher percentage of occurrence of O. keta eggs in the stomachs of grayling than noted during the study. This indicated that predation by grayling on O. keta eggs may be significant. Whether the grayling become specific predators of salmon eggs is unknown, but it does appear likely that as opportunistic feeders grayling would take advantage of this food source. This is supported by the movement of grayling "following" the salmon into the spawning channel area.

A sample of 22 grayling captured at station 29 on May 18, 1972 showed that 18% of the stomachs examined contained chum salmon alevins. Predation by grayling on both eggs and alevins of chum salmon may be a significant factor affecting chum salmon stocks in the Fishing Branch River.

An invertebrate sample was taken from the spawning channel by collecting the cloud of material raised by disturbing the bed. Chironomid larvae, Coleoptera, Pelycepoda, nematodes and debris were present.

As the study area is in an area of open water during the winter, food items for grayling, particularly terrestrial insect forms, may be more abundant there later in the year than in areas that would normally be ice covered.

4.3 Population Estimate of Grayling by Tag and Recovery

An estimate of the population of grayling in the Fishing Branch River study area above the counting fence (4 miles of river) was made by means of the Schumacher-Eschmeyer modification of the Schnabel multiple census technique as applied to a tag and recovery programme. Although there was a slight recruitment as 81 grayling were observed to move upstream through the fence, the conditions required for this census technique were considered satisfied, and each day's total captures and recaptures were considered as one sample. A total of 725 grayling were tagged with Floy tags. The data was arranged as described by Ricker (1958), and the results are presented in Table VIII.

The tags used in the study were found to be very satisfactory. No mortalities or serious ill effects due to the tagging operation were noticed, no loss of tags appeared to occur, and the tag colours were conspicuous.

The notations found in Table VIII, as used in the population estimate technique, are explained as follows:

Mt = the total marked fish at large at the start of the t^{th} day
ΣMt = the total number of fish marked
Ct = the total sample taken on day t
Rt = the number of recaptures in the sample Ct

ΣRt = the total number of recaptures
m = the number of samples (days in this case)
N = the population present through the experiment

The Schumacher-Exchmeyer formula for the evaluation of N is used in the reciprocal form as a more symmetrical distribution of confidence limits can be calculated for 1/N from the standard error using t-values. The limits are then inverted to give the confidence range for N (Ricker, 1958).

The formula for calculating the population N is as follows:

$$N = \frac{\Sigma(CtMt^2)}{\Sigma(MtRt)}$$

$$= 8,889$$

and

$$1/N = 0.00011250$$

The standard error was calculated by:

$$s^2 = \frac{\Sigma(R^2t/Ct) - (\Sigma MtRt)^2/\Sigma CtM^2t}{m - 1}$$

$$s = 0.3434$$

The standard error of 1/N was calculated by:

$$s_{\frac{1}{N}} = \frac{s}{\Sigma CtM^2t} = 0.000022557$$

The 95% confidence range for 1/N at t = 2.179, d.f. = 12, was ±0.000022557 (2.179) = ±0.00004915.

The confidence limits for 1/N are therefore:

$$1/N = 0.0001125 \pm 0.00004915$$

The reciprocal values were then computed to determine the confidence limits about N, which gave a population estimate of:

Table VIII Computations for Schumacher - Eschmeyer estimate for the Arctic grayling population in the study area on the Fishing Branch River, September 1973, from marked and recaptured fish by seining and angling.

Date (Sept) (1973)	Number caught C_t	Recaptures R_t	Number marked less removals	Marked fish at large M_t	$C_t M_t$	$M_t R_t$	$C_t M_t^2$	R_t^2/C_t
9	38	0	34	0	0	0	0	0
11	76	1	62	34	2,584	34	87,856	0.0132
12	127	7	64	96	12,192	672	1,170,432	0.3858
13	146	9	132	160	23,360	1,440	3,737,600	0.5548
14	151	12	137	292	44,092	3,504	12,874,864	0.9536
15	33	-	29	429	14,157	-	6,073,353	-
16	57	1	55	458	26,106	458	11,956,548	0.0175
17	83	2	78	513	42,579	1,026	21,843,027	0.0482
18	3	-	3	591	1,773	-	1,047,843	-
19	41	6	35	594	24,354	3,564	14,466,276	0.8780
20	107	6	96	629	67,303	3,774	42,333,587	0.3365
24	156	11	-	725	113,100	7,975	81,997,500	0.7756
25	65	5	-	725	47,125	3,625	34,165,625	0.3846
	Σ 1083	Σ 60	Σ 725		Σ 418,725	Σ 26,072	Σ 231,754,511	Σ 4.3478

N = 8,889 with a range of 6,186 to 15,790 fish at 95% confidence.

This estimate appears to be within the expected order of magnitude for the population in the Fishing Branch River study area.

The study area is approximately 4 miles long resulting in an average density of about 2,200 fish per mile. This result is similar to the grayling population estimates found by Tack (1972) on the Chena River, Alaska.

An aerial census of the headwaters of the Old Crow River in October, 1973 was approximately 20,000 grayling over 10 miles of river or an approximate density of 2,000 grayling per mile, which is a similar density estimate to that computed in the Fishing Branch River.

Visual observations of the grayling population made from aerial surveys by helicopter (primarily conducted to estimate the chum salmon spawning population) indicate a higher grayling population than indicated by the statistical methods used in this report. However, population estimates obtained by aerial survey are subject to large errors. Accuracy is dependent upon several factors including experience of the observers, water clarity and depth, and contrasts in colour between the fish and the bottom composition of the stream. A combination of these factors is believed to have reduced the accuracy of the aerial estimate of grayling population in the Fishing Branch River. This estimate was approximately 30,000 fish for the 4-mile section of the river.

4.4 Movements and Behaviour

There is evidence to suggest that an upstream movement of grayling occurs during September. On September 9, 1973, there were approximately 60 grayling at the spawning channel (Figure 1, station 50). The population of grayling at the mouth of the channel and in the vicinity of station 29 was small in relation to that found later in the study. By September 24, 1973, the population of grayling within the spawning channel was approximately 400 fish. The largest proportion of the fish observed were of the larger length classes but a noticeable increase of fish of approximately 250 mm in length was observed. Such numbers of the smaller size class grayling had not previously been observed at station 50.

There was a noticeable increase in yellow and white tags in the vicinity of stations 50, 31 and 51, during the latter part of the study. There was no appearance of red tags from the upper tagging area in the two lower tagging areas except for the occasional appearance of red tags at station 51, which was probably due to fish weakened by tagging upstream drifting downstream to recover.

The third piece of data to substantiate an upstream movement of grayling was collected at the salmon enumeration fence where 101 grayling were observed of which 80.2% were moving upstream. By comparison, no distinct upstream movement of round whitefish was noted as only 45.5% of the fish observed were moving upstream. A total of 11 were observed at the fence.

The degree of utilization of the study area by grayling as a spawning area is difficult to assess as spawning has not actually been observed.

Very few fry were captured in September, 1973. The apparent lack of fry in the study area may be due to emigration of fry or due to the inability to effectively fish parts of the river where fry might be.

No grayling were observed at stations 29 or 50 on March 20, 1974, but concentrations of grayling were observed downstream of station 31. Spawning had not yet appeared to occur. The total number of grayling present in the study area was not estimated but appeared to be much less than that observed in September, 1973.

Mature, ripe grayling were caught at station 29 on May 18, 1972, indicating that spawning probably occurs there, but had not yet taken place as no fry were captured. A large number of chum salmon alevins were captured at this time.

Concentrations of juvenile and some grayling fry were observed on June 15 and 20, 1972 in the lower reaches of the Fishing Branch River towards its confluence with the Miner River. It appears that this area is an important rearing area.

Grayling fry were captured July 21, 1972, upstream of station 29 (Bryan, 1973), indicating that spawning had occurred by this date.

The data indicates that there is an upstream movement of grayling within the study area in the fall which is probably related to the spawning migration of chum salmon and the subsequent addition of eggs to the diet of grayling. Concentrations of grayling on the chum salmon spawning grounds observed at station 29 on May 18, 1972 are probably associated with predation on the emerging chum salmon alevins and/or the spring spawning behavior of the grayling.

The seasonal upstream movement of other species of fish in the Fishing Branch River should also be noted. Two adult chinook salmon and nine adult coho salmon were observed at the counting fence. A population of less than 100 round whitefish was observed immediately upstream of the fence site. Spawning activity was observed by Elson (pers. comm.) in the fall of 1972, but was not observed in 1973. This is the largest reported population of round whitefish in the northern Yukon Territory.

5. Conclusions

During September, 1973 a preliminary study was made of fish species other than chum salmon present in the headwaters of the Fishing Branch River, northern Yukon. The study area is in a perennial open water region due to groundwater sources, and the study was conducted to add to existing knowledge of open water areas.

The main conclusions of the study are as follows:

1. The most abundant fish species present in the Fishing Branch River headwaters during September other than chum salmon is the Arctic grayling. Small numbers of slimy sculpin, several coho salmon (adult and juveniles), and low numbers of adult chinook salmon are also present.

2. The chemical characteristics of the Fishing Branch River are highly suitable for supporting fish populations.

3. There is a discrepancy between techniques of ageing grayling by scales and otoliths. Otolith age may be a closer estimate of actual age than scales, which give values approximately one year less than otolith age.

4. The mean scale age of the grayling population sample was 5.6 years, and mean otolith age was 6.6 years. Juvenile grayling and young of the year were noticeably few in number.

   The maximum age found for grayling in the study area was 9 years, with an apparent slowing down in the growth rate at about 7 years of age. An equation of growth rate was derived from scale age and fork length relationships.

5. The growth rate of grayling in the study area is less than that found in other areas of the Porcupine drainage, but equal to or greater than the growth rate of grayling on the north slope of the Yukon.

6. The majority of the grayling found were greater than 300 mm in fork length. Fish of fork lengths between 320 and 329 mm were the most abundant and very few fish of less than 250 mm were caught.

   The length-weight relationship of grayling in the Fishing Branch River is similar to that documented from other northern areas.

7. The ratio of male to female grayling in the study area was close to 1:1. It appears that grayling in the area mature at a later age, and have less developed gonads in September than grayling in other documented areas. Although sample

sizes were small there is an indication that the fecundity of female grayling in the Fishing Branch River may be lower than that reported for other areas.

Some data of round whitefish fecundity was collected.

8. The diet of grayling was found to be varied and based chiefly on aquatic forms such as Chironomidae larvae. There is an indication that predation on chum salmon eggs contributes significantly to the late fall diet and that predation on chum salmon alevins may be significant in the spring.

9. A population estimate of 8,889 grayling (range at 95% confidence: 6,186 to 15,790 fish), was determined by a tag and recovery programme, and supports the previous indication of a high density grayling population in the area at this time of year. An aerial estimate of the same area suggests that the population may even be substantially larger.

10. A localized upstream movement of grayling was observed that was coincidental with the upstream movement of chum salmon (O. keta) to their major spawning grounds. It is probable that the movement of grayling is in response to the spawning activities of the salmon and the availability of salmon eggs as a food source.

11. It is known that the Fishing Branch River supports a large population of grayling in the fall, and possibly at other times of the year as well. Grayling, chum salmon, and round whitefish all spawn in the study area. There is evidence that grayling, slimy sculpins, and juvenile coho salmon overwinter in the area but the presence of additional overwintering species is unrecorded.

12. In an area so seemingly well suited as a grayling habitat, it is difficult to explain the slower growth rate and possibly lower fecundity of the population when compared to other grayling populations that have been studied. As habitat quality and food appear to be highly adequate, perhaps this phenomenon may be related to the high population density.

6. Recommendations

One of the major needs for further research to reach a better understanding of the life-cycle of fish species in open water headwater areas is that of seasonal movements. The extent and timing of migrations of fry, juveniles and adults are largely unknown.

As there are now a large number of tagged fish present in the headwaters of the Fishing Branch River, an effort should be made to determine their movements and growth rates during future seasons.

Additional study is also warranted by the fact that grayling prey on the eggs and alevins of the only documented spawning stock of chum salmon in the northern Yukon.

Although this project will not contribute directly to an impact assessment of proposed pipeline development in the region, it is recommended that all perennial open water areas be considered as critical areas in the life cycle of the fish species involved and that no construction within them should be permitted.

Furthermore, it is recommended that the study be continued to more fully understand the life cycle of the most ubiquitous fish species of the northern Yukon, the Arctic grayling, in terms of future management plans for the fishery resource.

7. References

Bishop, F. G. 1971. Observations on spawning habits and fecundity of the Arctic grayling. Progressive Fish-Culturist. 33: 12-19.

Bryan, J. E., C. E. Walker, R. E. Kendel, M. S. Elson. 1973. Freshwater aquatic ecology in northern Yukon Territory 1971. Environmenta-Social Committee, Northern Pipelines, Task Force on Northern Oil Development. Report No. 73 - 21. 64 p.

Bryan, J. E. 1973. The influence of pipeline development on freshwater fishery resources in northern Yukon Territory. Aspects of research conducted in 1971 and 1972. Environmental-Social Committee, Northern Pipelines, Task Force on Northern Oil Development. Report No. 73 - 6. 63 p.

de Bruyn, M. and P. McCart. 1973. Life history of grayling (Thymallus arcticus) in Beaufort Sea drainages in the Yukon Territory. A report prepared by Aquatic Environments Limited for Northern Engineering Services Limited. 35 p.

Elson, M. S. 1973. Enumeration of spawning chum salmon in the Fishing Branch River in 1971 and 1972. Canada Department of the Environment, Fisheries Marine Service, Pacific Region. Technical Report 1973 - 5. 20 p.

Elson, M. S. MS 1973. Fishing Branch Studies - 1973. Department of the Environment, Fisheries Service, Vancouver, B. C.

Hatfield, C. T., J. N. Stein, M. R. Falk, and C. S. Jessop.

1972. Fish resources on the Mackenzie River Valley. Interim report 1, Volume 1. Fisheries Service, Department of the Environment, Winnipeg, Manitoba.

McCart, P., P. Craig, and H. Bain. 1972. Report on fisheries investigations in the Sagavanirktok River and neighbouring drainages. Report to Alyeska Pipeline Service Company. 87 p.

Reed, R. J. 1964. Life history and migration patterns of Arctic grayling, Thymallus arcticus (Pallas), Tanana River drainage of Alaska. Alaska Dept. of Fish and Game, Research Report No. 2, 30 p.

Ricker, W. E. 1958. Handbook of computations for biological statistics of fish populations. Fish. Res. Bd. Canada Bull. 119, 300 p.

Tack, S. L. 1972. Distribution, abundance and natural history of the Arctic grayling in the Tanana River drainage. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress 1971-1972, Project F-9-4, Vol. 13, Study R-1, 36 p.

van Everdingen, R. O. MS 1972. Groundwater contribution to rivers of the Porcupine drainage basin, Yukon Territory. Department of the Environment, Water Management Service, Calgary, Alberta.

CHAPTER V

ASPECTS OF THE HISTORICAL AND PRESENT DAY FISHERIES EXPLOITATION IN THE NORTHERN YUKON TERRITORY

by

R. T. DeLURY

L. W. STEIGENBERGER

M. S. ELSON

Northern Operations Branch

Fisheries Service, Pacific Region

Department of the Environment

for the

Environmental-Social Program

Northern Pipelines

Acknowledgements

Support for the study was provided by the Environmental-Social Programme, Northern Pipelines, of the Task Force on Northern Oil Development, Government of Canada.

We would like to thank G. J. Birch, P. G. Bruce, J. Fisher and the residents of the northern Yukon who patiently provided the information and insights for this report. A special thanks to P. Nukon, P. Lord, C. P. Charlie and L. Charlie of Old Crow and R. MacKenzie of Herschel Island who provided additional data. R. Morlan provided information and some of the plates of the historical aspects of the domestic fishery in the vicinity of Old Crow. J. McNiven from the DIAND Library in Ottawa gave permission to publish a portion of a report by R. D. Currie, 1964 on some aspects of the North Slope fishery in the vicinity of Herschel Island. S. W. Horall, historian for the R.C.M.P. in Ottawa, provided the plate of Herschel Island. The graphic illustration was provided by the kindness of L. Borleske, who also typed the manuscript. We appreciate the help of all those associated with the project who provided information, criticism and technical support. The administrative assistance of A. Gibson and C. E. Walker of the Fisheries Service, Vancouver, is also gratefully acknowledged.

1. Abstract

Salient aspects of the historical and present day fisheries exploitation in the northern Yukon Territory are featured and serve as a basis for future management recommendations. The domestic subsistence fishery is the most significant portion of the exploitation today, but recreational and commercial utilizations are also discussed. Faunal and ethnic differences logically divide the study area into two parts, the Porcupine River drainage and the North Slope drainage.

The aboriginal exploitation in the Porcupine River drainage was by small nomadic groups of the Kutchin or Loucheaux Indian tribes. Their fishing technology included highly efficient fish traps, usually situated in small tributary streams, fish spears and bone fish hooks for lake or winter fishing.

Between 1850 and 1900, white traders introduced gill nets and improved materials for fish traps, spears and hooks. It is postulated that gill nets increased the exploitation of the chum salmon and spring migrations of others species. The nomadic life style gradually ceased and since 1960 most of the Kutchin reside in Old Crow and fish in the immediate vicinity with gill nets exclusively.

The present day fisheries studies (1971 to 1974) estimated the annual domestic harvest in Old Crow at between 9,000 and 20,000 fish to supply approximately 250 natives and 200 dogs. The chum salmon represent a large portion of the annual catch. In 1973 they constituted 85% by weight of the total harvest of 54,866 pounds. Most of the chum are caught in the first two weeks in September and constitute between 8% of the chum run in large run years (1971) to 29% in low run years (1973). The largest proportion of the chum salmon harvested are males. The species composition, catch effort and catch per unit effort all vary seasonally and yearly. In general, the natives exploit the fish migrations in spring and fall. Chum salmon comprise the largest part of the fall catches, but other species are important at other times of the year. The species in order of catch frequency are chum salmon, broad whitefish, humpback whitefish, inconnu, suckers, burbot[1], least cisco, pike, coho and chinook salmon. The annual catch is influenced by two variables which are not independent, namely fish abundance and fishing effort. The effort is influenced by availability of nets, social needs for fish and economic alternatives. Recreational fishing by non-residents is

[1]Also referred to as loche by natives in Yukon Territory

restricted to grayling in a few areas. There is very limited sport fishing by the natives. No commercial fishery has existed in the Porcupine River drainage of the Yukon.

The population on the North Slope has dwindled from about 3,000 at the turn of the century when the bowhead whaling industry was thriving, to about 1-3 families. The presence of a broader food base, in particular the marine mammals, results in a low domestic harvest of fish today relative to fish abundance. In the years 1971 to 1974 the catches were estimated at between 1000 and 2750 fish, weighing between 1350 and 4550 pounds. The catch consists of Arctic char used primarily for human consumption, and Arctic cisco, least cisco, broad whitefish and inconnu for dog food. The recreational demand for Arctic char is relatively high. In 1973 about 100 char (5-6 pounds) were caught in July and August at Komakuk Beach. The harvest of Arctic char from the larger population in the Firth River is unknown.

In 1965 the Menzie Fish Company harvested between 11,804 and 16,084 pounds of Arctic char from the vicinity of Herschel Island. In 1966 they harvested between 222 and 1200 pounds of Arctic char. Economic limitations and over-exploitation are presented as possible reasons for cessation of the commercial venture.

In general the present day utilization of fish resources is less than in the past. As development of the north increases, so will the conflicts with the users of the fish resource. Management oriented fisheries research is essential for all species of fish to maintain the population sizes and productivity. Native catches of chum salmon in the Porcupine River drainage and Arctic char catches in the North Slope drainages, in particular, should be monitored. The management of these species should give priority to the subsistence fishery demands and the stocks maintained at levels that, at least, would support a subsistence exploitation at historic levels. For that reason commercial fisheries in either area would be detrimental. Regulation of recreational fishing activities is needed to protect the Arctic char stocks and their habitat in critical overwintering areas on the North Slope. Artificial propagation or enhancement is not considered feasible and is a poor substitute for maintaining the quality of the indigenous fish stocks.

Table of Contents

List of Figures

List of Tables

List of Plates

List of Appendices

2. Introduction

It is intended to present a meaningful perspective on the past and present extent and significance of the domestic fisheries in the northern Yukon Territory. Comments on future utilization and management recommendations for the fishery resources are based on present day studies (1971 through 1974) and limited information available on historical harvests.

The study area was divided into two regions:

a) the Porcupine River drainage with a logistical base at the village of Old Crow (Lat. 67°35'N, Long. 139°50'W) at the confluence of the Porcupine and Old Crow Rivers, and
b) the drainages of all rivers flowing into the Yukon section of the Beaufort Sea, with logistical bases at Herschel Island, Komakuk Beach and Shingle Point.

Faunal and ethnic differences between the two regions both past and present were considered sufficient to warrant the separation. Although the peoples of the two areas were usually isolated, they did trade and cohabit occasionally in an area along the northern extremity of the Old Crow flats.

The population in the village of Old Crow during the study period was approximately 250 people, but was subject to seasonal fluctuation dependent on the degree of involvement of the people in the traditional pursuits of hunting, trapping, and fishing, and employment opportunities outside the village. The life style of the residents was altered to some extent during the brief study period. These changes were induced by the increased exposure to scientists, oil exploration personnel and government representatives. Opportunity for seasonal employment with some of these groups resulted in some diminution of fishing effort. The demand for fish for dog food has declined steadily with the gradual introduction of the snowmobile. The addition of scheduled air services to Old Crow after 1960 has increased the availability of manufactured goods and processed foodstuffs to partially replace natural products, but the costs of these commercial commodities have been prohibitive in some cases. Nevertheless, fish still fulfills a significant proportion of the food requirements of the natives of Old Crow, which, to a large degree, is for the dwindling dog population (approximately 200).

The historical aspects of the fishery resources of the Porcupine River drainage must perforce rely on limited information. Some documentation exists in the records of early explorers, missionaries, naturalists and, more recently, a few anthropologists. However, these only date back to the middle of the 19th century. Archaeological relics of aboriginal fishing techniques such as wooden fish traps are not durable, and smaller stone artifacts used in these fisheries such as fish hooks and spears are rare. Some documentation of fishing historic techniques exists in the native folklore, but this is often marred by embellishment, exaggeration, and inaccuracies regarding historical timing, species composition and numbers of fish captured.

The same general comments regarding the historical exploitation of fish stocks of the Porcupine River drainage apply to those of the North Slope. Documentation is rare and incomplete. The human population of the north coast has diminished rapidly from the turn of the century when 3000 people inhabited Herschel Island alone. About one-half of these were whalers engaged in the bowhead whaling industry who overwintered on Herschel Island. Probably less than 200 native people now visit the north Yukon coast, and less than 20 are permanent residents. Most of the natives who seasonally visit the north slope of the Yukon are permanent residents of Aklavik or Tuktoyaktuk, and conduct seasonal hunting or fishing expeditions (usually in summer) along the coast. The importance of fish stocks to the North Slope people is somewhat different from that of the Old Crow people. In addition to the caribou, fish and fur-bearing mammals of the Porcupine River drainage, the Eskimos have an array of marine mammals to harvest. These likely surpass the importance of fish to these people. From one to three native families on Herschel Island rely annually on the fish and mammal resources of the north coast. In general, fishing with gill nets is limited to coastal bays, estuaries and a few lakes close to the coast. Sometimes the headwaters of the Babbage and Firth Rivers are fished. Arctic char is mainly fished for human consumption and least cisco, Arctic cisco, broad whitefish and inconnu are harvested primarily for dog food. A short lived commercial fishing venture was conducted during 1965 and 1966 in the vicinity of Herschel Island. There has been an increased recreational demand for Arctic char by personnel associated with D.E.W. line stations and research parties working in the area.

Aspects of the historic and present day domestic fishery in the Porcupine River and along the coast of the northern Yukon will be presented in this report.

3. Methods

3.1 Historical

Most of the information was gathered from interviewing the residents in Old Crow during the study period 1971 to 1974. Support, or the lack of it, was sought in the social science literature. No attempt was made to include topics from the literature not discussed with the Old Crow people.

There was not the opportunity of personal interview of the residents to the same extent in the North Slope area. A brief history of this area was quoted from Currie (1964).

3.2 Present Day

Two general approaches were used to assess the demand on the fish resource by the natives of the northern Yukon.

3.2.1 Surveys of the Resident Fishermen

a) Interviews with native fisherman at the end of the major fishing season requested total catch numbers for each species. When possible, similar interviews were made during the active fishing season.

b) In 1974 catch books were distributed to seven fishermen in Old Crow and two on the North Slope. Daily catches for each species were to be recorded.

3.2.2 A creel census programme collected information as the nets were lifted or shortly thereafter. The information included numbers, species composition, size and number of nets and duration of fishing effort.

4. Results

4.1 Historical Fisheries

4.1.1 Historical Aspects of the Fishery in the Porcupine River Drainage

Before the white man's invasion in the mid 19th century, the native people in the area we now call the northern Yukon Territory had cajoled a precarious living from the land for some 50,000 years. Without sophisticated technology, their life styles were shaped by the confines of the harsh environment. It was expedient for the natives of the Porcupine

River drainage to live in small nomadic groups as they relied heavily upon migrating caribou and fish for their protein requirements. Despite the natives' mobility they were vulnerable to population and behavioural variations of their quarry.

In years when the numbers of caribou were low the natives placed a heavier reliance on migrating fish stocks. Just as the migrating caribou were herded and dispatched with spears or arrows, so the fish were trapped during seasonal migrations in late summer and fall. Most of the early fishing technology was developed for these fish migrations.

Weirs or traps of various descriptions and complexity were the most productive means of taking fish. These traps and associated camps were constructed in early summer, and their use continued through autumn even after ice began to form in the streams (Figure 1). The traps were usually placed on small streams where the water was shallow enough to permit building weirs across the river, yet sufficiently strong to drive the fish into the traps.

Since these fish traps were operated for a period of weeks or months by small family groups there were important social implications.

> "Both the construction and the operation of such traps were communal activities, and fish camps of several families were established to carry them out. Balikci (1963b: 18) reports:
>
> > 'Before the construction work started, the men assembled to discuss the exact location of the trap, and the distribution of tasks. Usually over 100 stakes were required for such a weir, and sometime (sic) two sluices were constructed. The fish was shared among all the participants, and the size of each family was taken into consideration. The catch was placed in special wooden caches, about 10 feet long and 3 feet wide, lying on the ground. There was no fish trap superintendent: construction work, actual fishing and sharing were done through common agreement. Considerable amount of fish, up to 2000 fish in a single night, were taken in this manner.'
>
> "I have been told that the fish traps were owned, much as were the caribou surrounds, by a wealthy man

FIGURE I. Artist's conception of an historic Kutchin fishing camp showing aboriginal willow fish trap, high caches, ground cache and willow bundle.

> who organized the labor for their construction and "ran" the camp associated with their operation, but this is not mentioned by Balikci or Osgood." (Morlan, 1973).

The locations of some of these traps are shown in Figure 2. Appendix Table I contains relevant information on the numerically identified sites on Figure 2. Information is compiled from Morlan (1973, 1972a and b), from Stager (1973), and from interviews with Old Crow natives by Fisheries Service personnel. With only limited information available from archaeological excavation, the time periods of the use of these traps is uncertain. It is likely that most of the best locations were repeatedly occupied by many generations. The locations fished since the turn of the century are perhaps more likely to be within the memory of the Old Crow people, and so are perhaps over represented in our presentation. It is perhaps a similar bias that led Osgood (1936) to write "The trapping places are only on the small tributary streams of the Porcupine River". Many other fish trap locations have been reported, such as the headwaters of the Old Crow River, the mouth of the Old Crow River, Old Crow flats, the Rat River, and others (Figure 2).

Fish traps varied in size and sophistication. Traps could range from simple log barricades to highly developed catching devices (Figure 3). The trap on the Old Crow River represented the zenith of trap technology. It contained four or five collecting baskets and a large woven barricade. Of course this required a great deal of manpower to construct and operate.

Perhaps a more typical fish trap was that partially excavated by the Archaeological Survey of Canada (Morlan, 1972b). This trap (Plate 1) was situated on a small river in the Old Crow flats (Figure 2 and Appendix Table I).

Osgood (1936) describes two types of traps (Figure 4).

> "The salmon trap was designed to intercept the upstream run of the salmon and consisted of a shallow V-shaped weir and a willow pole trap. The weir spanned the stream with the point of V upstream, and the trap was positioned just below one end of the weir along the bank; the fish would move back and forth along the front of the weir and were eventually guided to the trap."

In our interviews the Old Crow people never referred to a salmon trap. There was a large salmon fishery in the headwaters of the Porcupine River by the people from Johnson

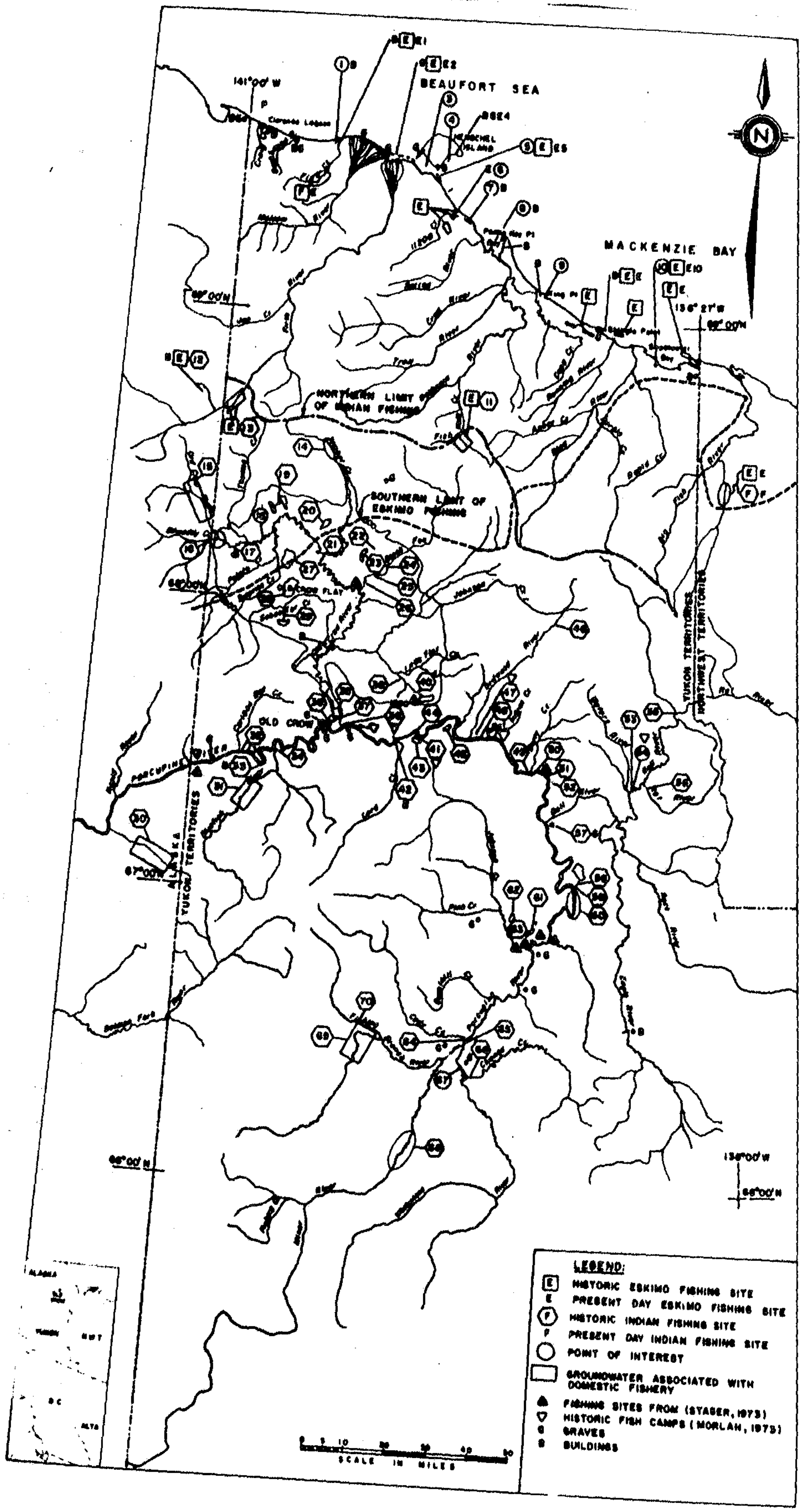


Figure 2. Map of historic and boundaries of present day fishing locations in the Northern Yukon Territory.

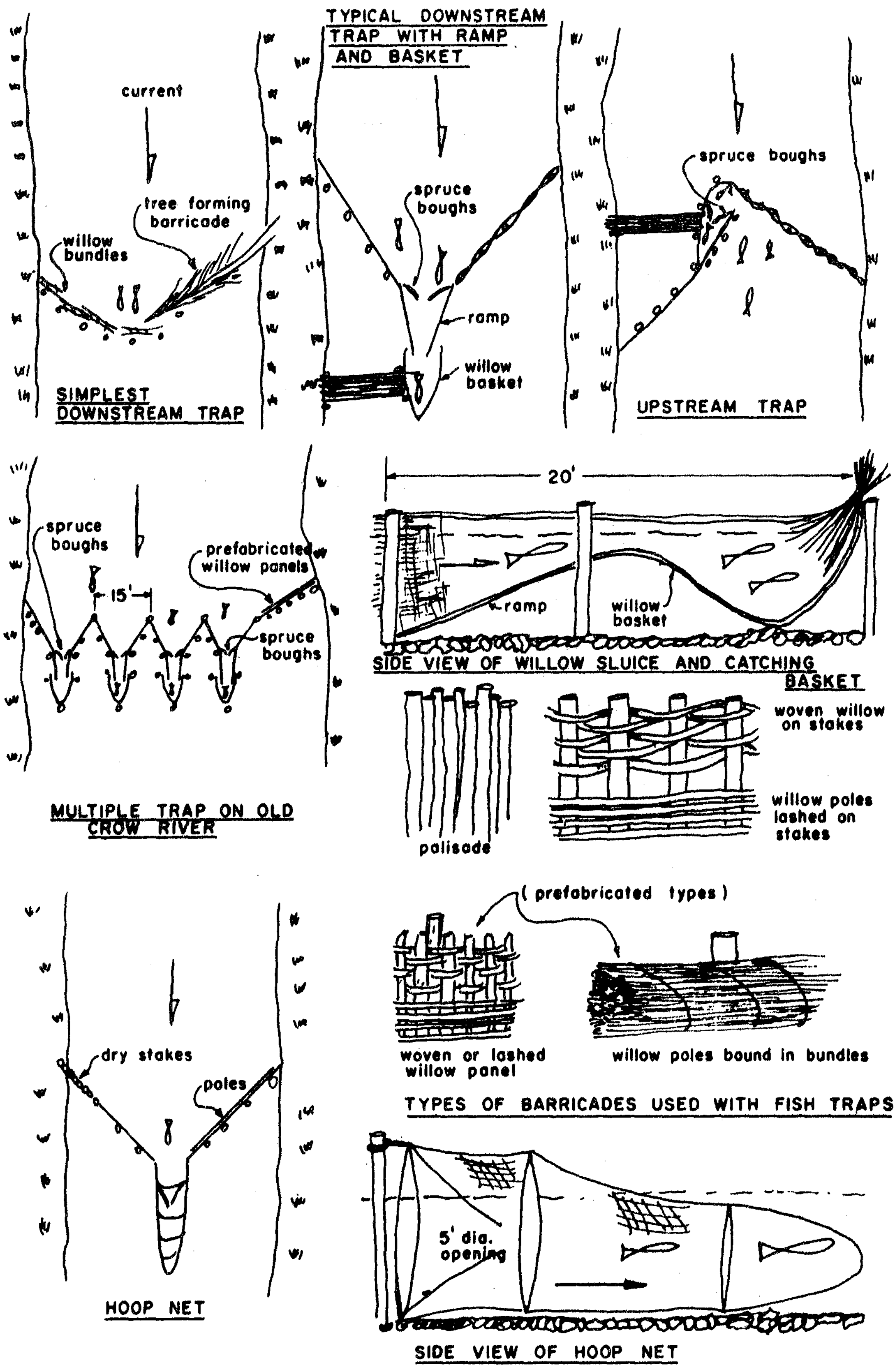


FIGURE 3. The designs of some of the typical fish trap as described by the residents of Old Crow.

PLATE 1. Remains of a restored historic fish trap in the Old Crow flats, NMC Neg. No. 71-4473. (Morlan, 1972b).

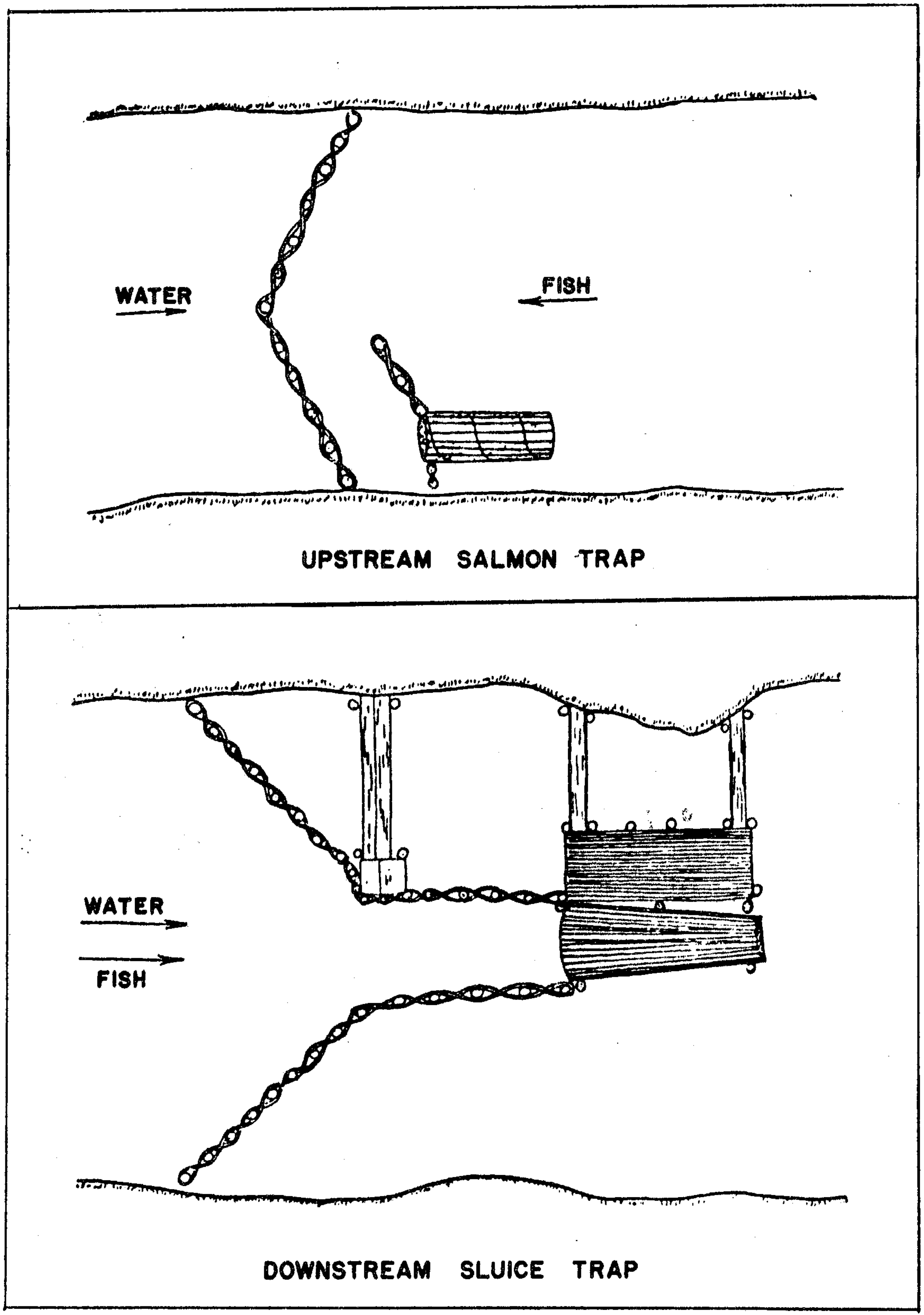


FIGURE 4. An upstream salmon trap and downstream sluice trap after Osgood (1936).

Village and Whitestone Village during the 1920's and 1930's, but these were all fished with gill nets. There are reports that salmon were caught on the spawning grounds in the Fishing Branch and Miner Rivers, but there is no indication that a trap was used. It would appear that other aboriginal techniques such as spearing or gaffing could be adequate for a harvest without the effort of building a trap. This does not, however, preclude the existence of such a trap at some time. The establishment of the existence of an aboriginal salmon trap is not a trivial point. If they did not use such a device, it is probable that not until after contact with the white man and gill nets did the Kutchin Indians establish a significant salmon fishery. Today the salmon represents the largest component of the domestic harvest. If the natives used a salmon trap, then likely salmon would have been high in priority in prehistoric times as well.

A similar trap design was described as used in the headwaters of the Old Crow River (Figure 2, Location 16) around the turn of the century. It was the only example of an upstream trap reported. It was operated in the fall to capture mainly grayling migrating upstream to overwinter. It seemed to be common knowledge in Old Crow that fish (mainly grayling) above a certain point in the Old Crow River (Figure 2, Location 18) migrated upstream to overwinter and those below migrated downstream, probably into the Porcupine River. It was also mentioned that a few chinook salmon were caught in this trap. There is no documented present day salmon run in that area, but there seems sufficient evidence to assume at least a small run in the past. This could be Osgood's salmon trap. If it were, then it could mean the salmon caught were incidental to other fish and the larger Porcupine River salmon run was not exploited. Our reluctance to accept the theory of a weir type salmon trap on the Porcupine River is in part based on the size of the river. The Old Crow River trap was reputed to be a large, formidable undertaking, but even this would be small relative to such a trap on the Porcupine.

The second trap (Figure 3) is described by Osgood (1936) as follows:

> "The sluice trap. . . was used for a month or two in the late summer and was designed to catch pike, grayling, suckers, and other fish as they swam downstream. A V-shaped weir, with the point of the V downstream, spanned the stream but had an opening in the center which permitted entrance into the

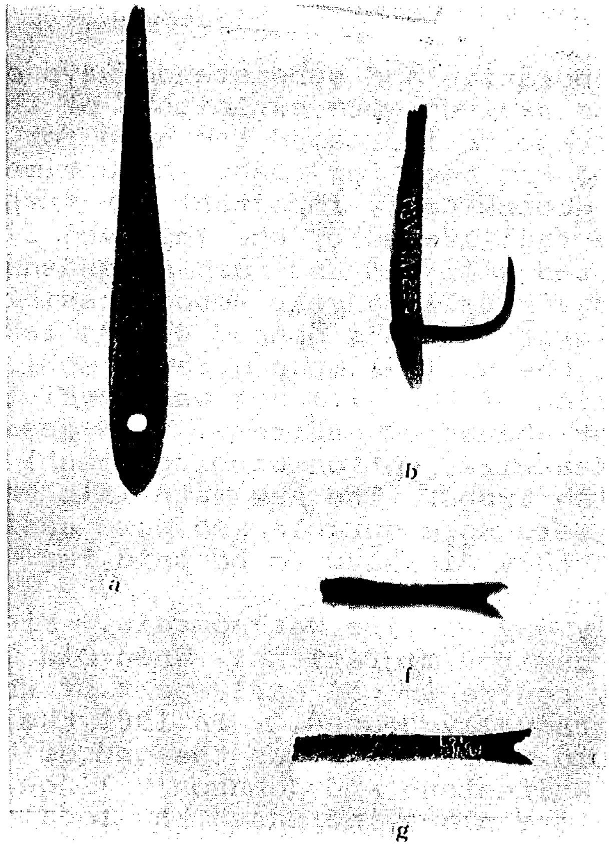
"sluice" which was closed on the lower end by a U-shaped willow pole basket trap; when fish filled the sluice its entrace was closed off, and the fish were driven into the trap and lifted from the weir with a dipnet to a platform built out from the bank. Most of the fish were trapped at night."

Historically, the fish traps likely supplied most of the fish for the needs of the people. The presence of artifacts (Plates 2 and 3) suggest that alternate technologies were developed to provide fish at times or in places where fish traps were impractical. Spears, either a three-point leister or toggle-head bone spear, composite bone and antler hooks, all could have been used for fishing under the ice in rivers or lakes. One resident of Old Crow mentioned they used to spear whitefish and jackfish in a lake near Johnson Village by placing split poles on the bottom under a hole in the ice to silhouette the fish. The fishermen would crouch under a blanket over the hole with a spear. A fish lure (Plate 3) dangled through the hole might well have been used to attract the fish.

There seems to be some disagreement as to the existence of an aboriginal gill net. Osgood (1936) reports the use of a gill net among the Kutchin; these were made of willow bark or fine caribou babiche. Murray, on the other hand, in a letter to his supervisor in Fort Simpson in 1848, wrote "They [the Indians] spend the summer principally in fishing and make a supply of dried trout [chum salmon] and whitefish for the winter. The small rivers and narrow parts of the lakes are barred with stakes and large willow baskets and placed to entrap the fish, sometimes immense hauls are made; they never use nets and know nothing about them." (Elson, 1973, MS). The extensive use of the purported aboriginal gill net seems doubtful. It would be a highly costly and fragile device compared to the other techniques at their disposal.

White man in the first half of the 19th century brought many changes to the life style of the natives. Traders introduced modern technology and different economic and social values to the people. Much has been made of the social effect of firearms on the native life style. Just as important is the coincident introduction of gill nets, fish hooks, snare wire, and steel traps. The aboriginal way of life was irrevocably changed.

Just as the rifle superseded the communal caribou corral, so the gill net replaced the communal fish trap. Fur trapping was no longer for clothing requirements but for trade. Individualism, competition and entrepreneurship replaced



a,b - compound fish hooks
f,g - fish lures

PLATE 2.- Fishing artifacts from the historic and late prehistoric periods, NMC Neg. No. J-20748 -4 (Morlan, 1973).

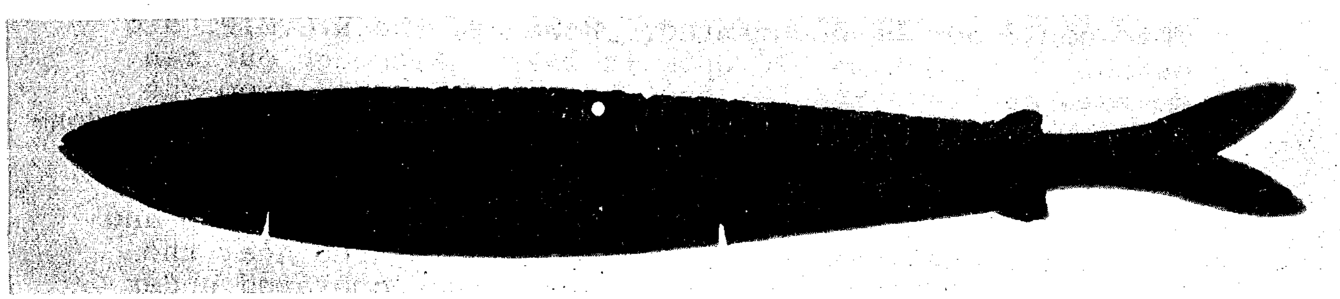


PLATE 3. Late prehistoric period fish lure carved out of bone, NMC Neg. No. J-20748-6 (Morlan, 1973).

communal, cooperative and subsistence ways of life. For the first time the natives were exploiters of the land's natural resources. Trapping increased the need for dogs and more dogs increased the need for fish. At a time when the Old Crow flats became economically important for furs, existence on the flats was facilitated by the improved fishing technology. The manufactured gill net and hook extended the opportunity of fishing to virtually a year round possibility, including the spring migrations, and opened up the lakes to fishing. This afforded the natives much greater mobility. Although the introduction of the gill net was revolutionary, the weir method was not abandoned entirely. New designs and materials such as chicken wire, cotton webbing (mesh) improved the aboriginal fish traps. The new materials that replaced the natural ones were more durable and were easier to install and maintain, but they did have to be paid for.

The early way of life was nomadic. Fishing filled the time between caribou migrations. When Old Crow began to be the community centre in the early part of the century this way of life gradually ceased. In 1961 the Government opened a school in Old Crow. This was the end of the small communities such as Whitestone and Johnson Village. The concentration of natives in one place increased the local demands for fish in the vicinity of Old Crow. Gill nets have supplied this demand around Old Crow in recent history. One fish trap was reported to be operated briefly in 1957 or 1958 on Lord Creek. Thousands of grayling were taken in one night.

There is conflicting evidence on the date of abandonment of the legendary fish trap on the Old Crow River. Our discussions revealed the late 1940's as the termination point. However, Balikci (1963) reports that the last traps were seen along the Old Crow River in the 1920's. It was reported that fish trapping was abandoned at the "request" of the R.C.M.P. This could not be documented. However, the R.C.M.P. did establish a post in Old Crow in 1928. Although our own sources are favoured the best that can be said from the available information is this historic fish trap was abandoned between the 1920's and 1940's.

> "We have sought in vain for signs of a trap and associated camp said to have been located near the mouth of Old Crow River where it was operated under the leadership of the great chief, Zzhe Gitlit, around the turn of the century [from page 15] (V. Leechman, 1954: 13; C. P. Charlie, personal communication in 1970)[see page 14, above]; river

ice and water erosion may have erased the entire record." (Morlan, 1973).

To aid the understanding of the chronological order of historical events in the Porcupine River drainage a summary has been presented in Appendix Table II (from Morlan, 1973).

4.1.2 Historical Aspects of the North Slope Drainages

A concise history of the recent development of the north coast of the Yukon Territory has been extracted from Currie (1964). Although it does not deal specifically with the fisheries exploitation, it does provide background information for assessing the present day use of the fisheries resources.

"In 1826, when Franklin explored the coast of the Yukon Territory, he found many Eskimo camps scattered along the beaches between the mouth of the Mackenzie River, and Demarcation Point. (Today the latter marks the boundary between Canada and the State of Alaska.) The people of the region were hunters living off seal, whale, fish and caribou, according to the season. Trading was limited to an occasional exchange of goods with the Indians who claimed the country to the south, and other Eskimos who were their neighbours to the west.

"Franklin has recorded that 'Herschel Island was much frequented by the Eskimo as it abounded with caribou and its surrounding waters afforded plenty of fish'. But, in 1889, the first of the Whalers, the 'Grampus', arrived and put an abrupt end to the Eskimo's traditional way of life.

"The baleen of the bowhead whale was the reason for her coming. This product was in great demand in world markets, fetching as much as $5.00 a pound. For six weeks each season, bowheads were plentiful in the Beaufort Sea, and the success of the 'Grampus' prompted many more ships to come into the area. They fished from six weeks to two months and then wintered at Pauline Cove on Herschel Island. These ships, fast in the ice for as many as eight months of the year, housed 1,500 idle whaling men. During the winter months, the whalers strove to combat boredom by every kind of revelry that they could promote. Eskimos from the whole coast from Barter Island, Alaska, in the west to Cape Bathurst in the east, came to Herschel Island. Many were employed as hunters the year round and supplied the whaling fleet with fresh meat. Men and women alike joined in the uproarious winter life of Herschel Island. The following extract from an R.C.M. Police Quarterly, April 1942, gives an idea of the impact the whalers had on the traditional life of the Eskimos.

> "'Of the 2,000 Eskimos who roamed the Arctic coast from Barter Island to Cape Bathurst when the pioneering 'Grampus' first pounded her way to Herschel Island, only about 400 remained when the first detachment of the Northwest Mounted Police stepped ashore on August 7, 1903. Liquor, syphilis, measles and other diseases contracted from white men had taken their toll. In the interim, the depleted population had been augmented to some extent by a migration of Alaskan Eskimos.'

"In the early 1900's, the price of baleen began to drop, and by 1906, it had fallen from $5.00 to 40 cents a pound. By 1910, the great baleen bonanza which had netted the fleet 14 million dollars during the boom years was over and with the exception of two or three whaling captains who converted their ships into floating fur trading posts, the whaling ships left the Beaufort Sea and never returned.

"Fortunately for the Eskimos, who by this time had come to depend on manufactured goods, a rising market for the fur of the white fox provided a new economic base. The ex-whalers and other freelancing traders in the region were soon joined by the Hudson's Bay Company which established a post at Herschel Island in 1915. During the following decade, fur trading posts opened the remaining 'virgin' lands of the western Arctic, and many Eskimos left Herschel Island to trap along the coast towards Cape Bathurst and beyond.

"Herschel Island declined further when the Hudson's Bay post at Pauline Cove was closed. The settlement received its death-blow in 1938 when the Company selected Tuktoyaktuk to replace Herschel Island as its transportation center. The once thriving port decayed, and the bulk of its population drifted away.

"As time went on, the price of fox dropped from an all time high in the 1920's of $80.00 a skin to an all time low in the 1940's of $3.00 to $4.00 a skin. Trading posts closed in many places, and the Eskimos who had traded at these posts moved inland to be near the muskrat trapping grounds and trading posts of the Delta.

"In the early 1950's, the construction of the DEW Line stations along the Yukon and Northwest Territories coasts attracted Eskimos into the site areas and many found employment. After the main construction was over, a few obtained permanent jobs at the completed sites, but the great majority were laid off. The construction boom at Inuvik attracted many into that area. Others settled in Aklavik, and in both places they enjoyed a new kind of community life.

"After the construction boom ended, unemployment increased steadily. Today in the main population centers, many once independent hunters are no longer able to make a living. At the same time, the Yukon coast in uninhabited and unexploited." (Currie, 1964).

An example of the level of historical exploitation is presented in Plate 4.

4.2 Aspects of the Present Day Fishery in the Northern Yukon Territory

4.2.1 Present Day Fishery in the Porcupine River Drainage

The results for the present day domestic fishery in the Porcupine River drainage will be presented in three sections. First is a generalized seasonal fishing cycle. Generalizations presented on fish species composition, fishing locations, time periods of fishing and methods of fish utilizations were compiled from data collected in 1972 and 1973. Second is a presentation of a summary of total estimated harvests for the years 1971-1974. Additional specific information on the number of fish and the effort expended during 1972 to harvest the resident and salmon populations is included. Third is a detailed analysis of the 1973 creel data illustrating the seasonal relationships between the total numbers and weights of fish harvested, the numbers and weights of each species harvested, and the catches by unit effort of fishing time. An analysis of the 1973 chum salmon harvests as a proportion of the Fishing Branch River spawning run is provided.

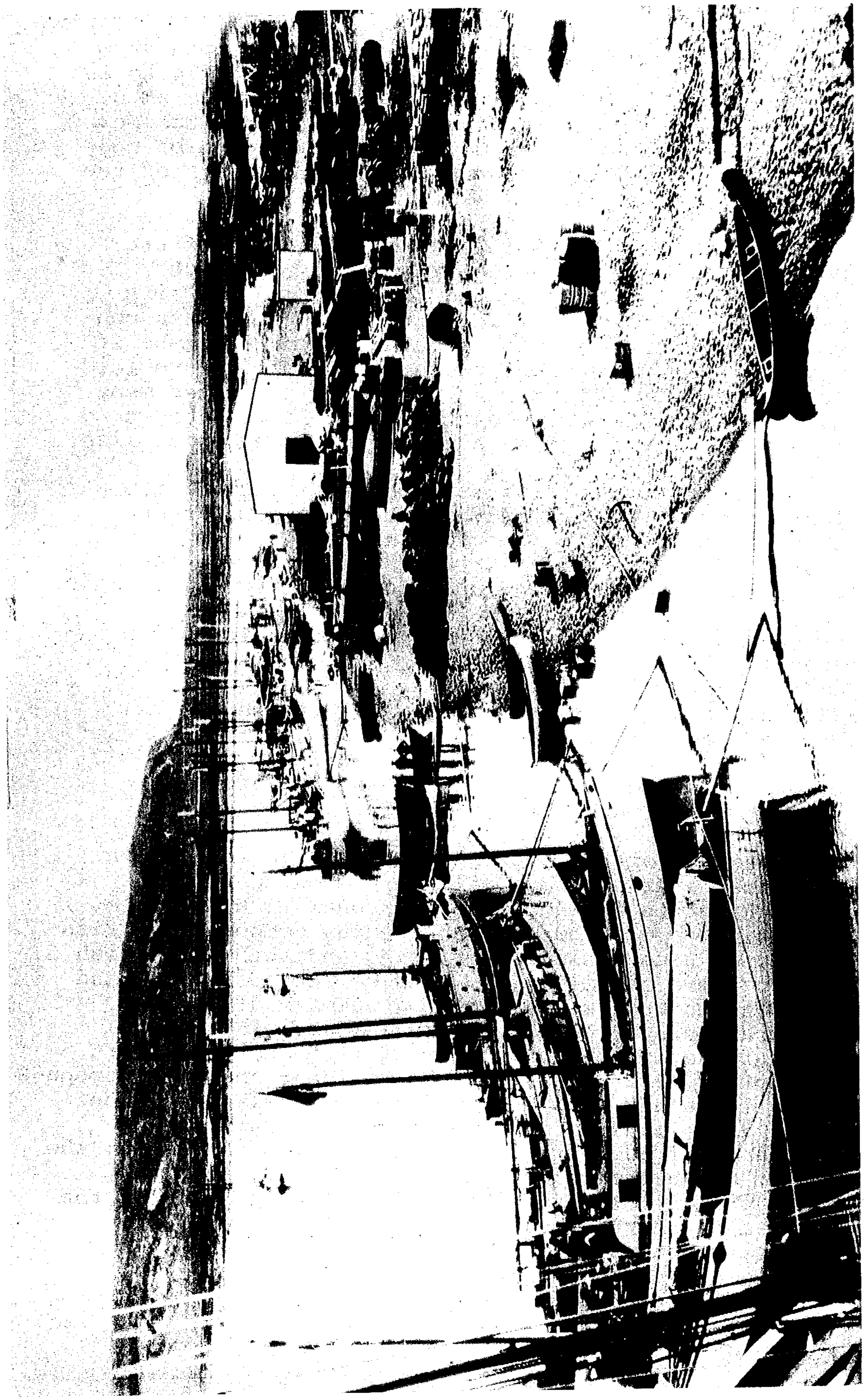


PLATE 4. Pauline Cove as it looked in the early 1900,s.

a) The generalized seasonal fishing cycle.

Fishing commences with the onset of warm spring weather when ice free pools form along the margins of the Porcupine River. Locations 11 and 12 (Figure 5 and Table I) appear to be traditional pre-breakup fishing areas. In 1972 one resident caught approximately 400 whitefish, mainly least cisco and large broad whitefish, at location 12, in a two-week period. In 1973, during the same period, another fisherman caught mainly grayling, suckers and broad whitefish, and lower numbers of pike, burbot, humpback whitefish and least cisco. It was suggested that the fish aggregate in pools and backwaters prior to dispersal to lakes and headwater areas of the Porcupine River after breakup.

During breakup fishing is restricted to open backwater areas for short periods of time. The nets must be tended to avoid damage or loss by floating ice. The catches per unit effort are usually high as the water is turbid and the fish are likely concentrated. After a peak of high water associated with spring breakup in early June some of the stream outlets are fished. The outlet of Fish Lake yielded cisco and broad whitefish in all likelihood migrating out of the lake (Bryan, 1973). The mouths of creeks become good areas for fishing, being out of the fast river currents. During the same period locations 3, 9, 12 and 25 were fished. Most of the nets were fished within a few miles of Old Crow. The species were predominantly whitefish, grayling and small numbers of burbot, pike and suckers. The catch and subsequent fishing effort tended to decrease sharply around the beginning of July. The natives felt the cause of reduced catch was from net avoidance by the fish as a result of decreased water turbidity. It is theorized that the fish had dispersed upstream from localized overwintering or staging areas. During July fishing was usually sporadic. The effort appeared to be concentrated downstream of Old Crow at locations 3 and 6. Fishing was mainly for chinook salmon, which start to run early in July and peak in mid July. The catch of chinook salmon is low, usually less than 100, although they are prized fish. In August, additional nets were set at locations 7 and 8 to catch the first of the chum salmon migrating to the Fishing Branch River. This fishing pattern persisted until the running chum salmon increased in early September. The fishing sites for chum appeared to be traditional. The residents of Old Crow fished mainly downstream of the town. Most of the chum salmon were caught at locations 4, 7, 8 and 25. The annual catch of chum salmon is estimated between 5,000 to 15,000. A rough estimate

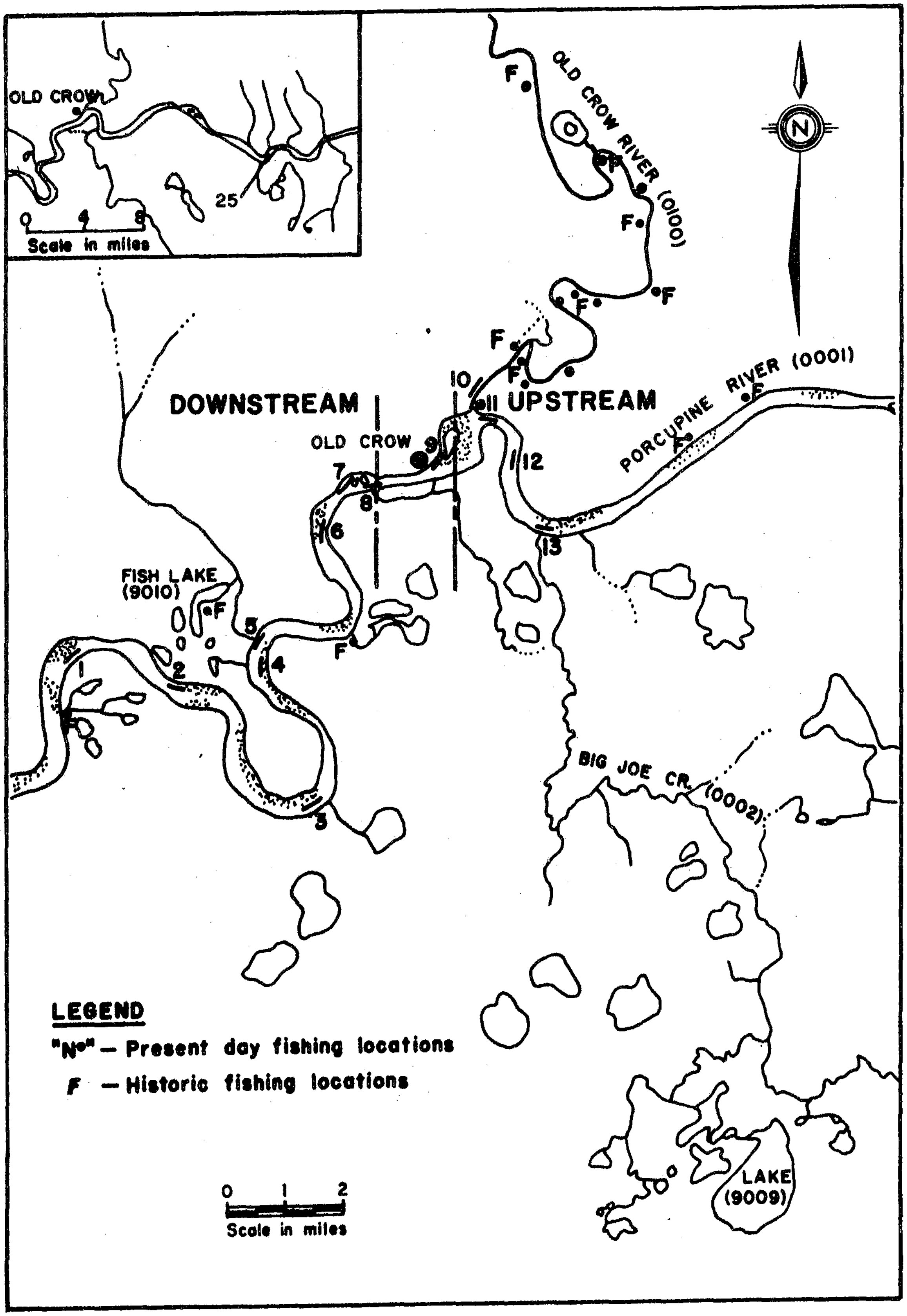


FIGURE 5. Present day domestic fishing locations in the vicinity of Old Crow. Some additional historic fishing sites are also noted.

TABLE I. The fishing locations, approximate time period, site descriptions and major species caught in the present day domestic fishery near Old Crow.

Fishing Location (Figure 5)	Approximate Time Period	Description	Major species
1.	September to freeze-up	- Police camp, traditional R.C.M.P. and local gillnet site (not fished in 1972)	Chum salmon
2.	August to freeze-up - under ice	- New fish camp (1972)	Chum salmon * whitefish
3.	June through August	- Traditional fish camp for resident and anadromous species (chinook salmon peak mid-July)	Chinook salmon Chum salmon * whitefish grayling
4.	Late August to freeze-up	- 6 Mile Camp. Traditional fish camp with drying racks	Chum salmon * whitefish
5.	Late May to mid-June	- Downstream migration from Fish Lake	least cisco broad whitefish
6.	Early July to freeze-up	- Checked periodically from Old Crow. Resident and Anadromous species	* whitefish Chinook salmon Chum salmon
7-8.	mid-June through September	- Resident fishes	* whitefish grayling
		- Anadromous species (fall at (8))	Chum salmon
9.	Early June to July	- Checked daily - gillnets in mouth of slough at high water	* whitefish grayling
	July to August	- Resident fish	suckers whitefish
	September until freeze-up	- Anadromous fish	Chum salmon
10.	Early September to freeze-up in late October	- Downstream migration (Old Crow River)	* whitefish grayling suckers
11.	Spring, early September to freeze-up	- Resident fish	* whitefish grayling burbot
		- Anadromous fish	Chum salmon
	After freeze-up	- Jigging or long or set lines with bait	burbot
		- Gillnets under ice	Chum salmon * whitefish Coho salmon
12.	Early May and break-up	- Gillnetting of fishes before dispersal (edge water)	* whitefish grayling
13.	Mid-June through September	- Gillnetting (not 1972)	grayling * whitefish
		- Recreational fishing	grayling
14.	After freeze-up	- Gillnetting during winter	* whitefish grayling
25.	Early July to October	- Goose camp gillnetting	Chum salmon * whitefish grayling

where,
* whitefishes = least cisco, broad whitefish, humpback whitefish and inconnu.

(From Steigenberger et al, 1972)

of human consumption of chums might be as high as 10% of the total catch depending on the availability of alternate preferred food such as caribou. Chum salmon caught from the end of October to November are the ones usually eaten. At that time the low ambient temperature assures minimum spoilage. The coho salmon which run in late October and November are greatly prized as a food fish. Before freeze-up, the natives also fished the Old Crow River (Location 10) for other species of fish. The utilization of the rich fish stocks migrating from the lakes and rivers of the Old Crow flats has been traditional. The catch was composed of grayling, humpback and broad whitefish, least cisco, suckers, inconnu, pike and a few burbot. The annual catch from the Old Crow River is usually between 1,000 and 5,000 fish.

Following freezeup, fishing is often resumed on the Porcupine River at locations 2, 3, 7, 8, 9, 10 and 11. The catch is composed of chum salmon, whitefish, grayling, burbot and suckers. In November a few coho, usually less than 200, are caught. By the end of November, after the coho run, little gill-netting is done in the river. Ice fishing for burbot, with set lines or by jigging, was done at location 11 during the winter. Ice conditions and severe weather restrict this fishing to November and December, March and April. The burbot is considered a delicacy by the natives and is important nutritionally by virtue of its unique vitamin content of the liver.

Winter fishing on some of the lakes such as Fish and Cadzow Lakes is done in conjunction with trapping activities. Fish Lake supports an overwintering population of cisco and broad whitefish and perhaps other species. Natives report catches of whitefish and pike in Cadzow Lake, although the existence of an overwintering stock could not be confirmed.

There is one native living a subsistence life style typical of some 50-60 years ago at location 25 (Figure 5). The need for fish is relatively great and consequently his fishing effort is proportional. He fishes most of the open water season of the year, and is very dependent on the chum salmon run in the fall. In 1974 his catch was 1400 chum salmon, perhaps the largest of the Old Crow natives. A summary of the fishing locations, the approximate time period, site descriptions and the major species caught is presented (Table 1).

The fish harvested in the Old Crow domestic fishery are preserved and utilized in approximately the traditional manner. Fish are often consumed fresh in the spring and throughout the summer. Fish are usually boiled. The visceral fat and roe of whitefish are eaten raw and considered a delicacy. The fat from the whitefish species is sometimes rendered down. If more fish are caught than can be eaten immediately, they are usually smoked and dried. Chinook and chum salmon caught during the warm weather are often smoked. The process of smoking appears to be used as much to keep the flies away from the meat as it is for preservation. It is convenient that the largest fish catches (chum salmon) occur when the fish can be frozen or at least air-dried without spoiling. This greatly reduces the handling time for the natives. At that time the chum salmon are often beheaded, split longitudinally, eviscerated and hung on racks to freeze or dry. The heads and viscera are usually left in a pile on the ground to freeze and are used for dog food. The eggs are collected and smoked for human consumption (Plate 5). The amount of preparation depends greatly on the individual. Some individuals merely hang the whole fish to freeze and dry. There is minimal preparation for fish used for dog food, however, fish are sometimes boiled before being fed to the dogs.

Traditionally the natives have stored the fish in "high caches" or "ground caches" (Plates 6, 7, 8, 9). The high cache is used before freezeup and for human food at any time. The ground cache is only used for dog food fish after freezeup. In constrast with the historic log ground caches the present ones are merely a pile of fish on the ground.

b) Estimated total domestic harvest in Old Crow, 1971-1974.

A summary of the total domestic harvest with a best estimate as to range in harvest for the years 1971-1974 is presented in Table II. The range of the estimate has been included to provide some measure of the accuracy for each estimate. A more detailed summary of the domestic harvest in Old Crow for 1971-1973 appears in Appendix Table III.

PLATE 5. A small catch hanging to freeze in a fish camp. The plastic garbage bag is full of smoked fish roe.

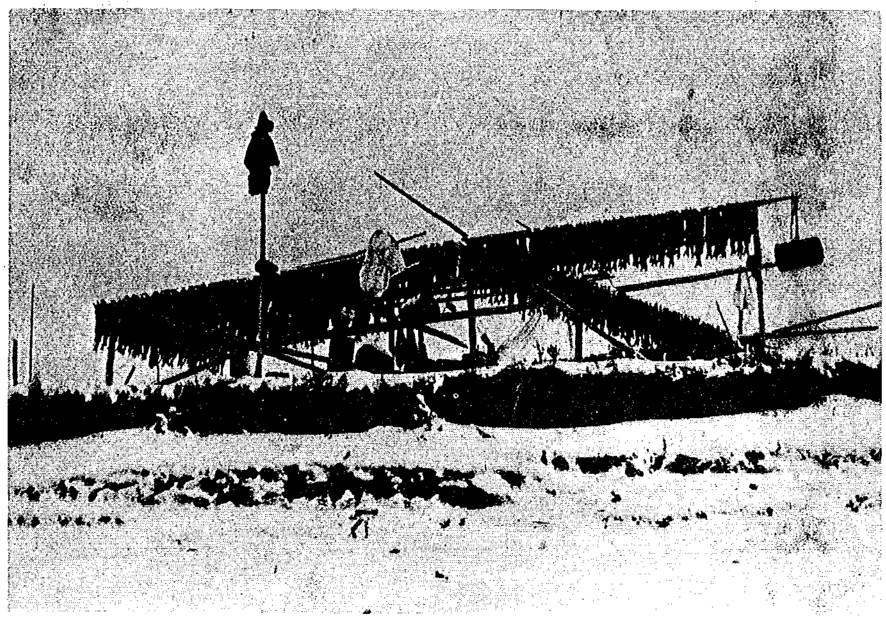


PLATE 6. High cache of chum salmon at a permanent camp on the Porcupine River.

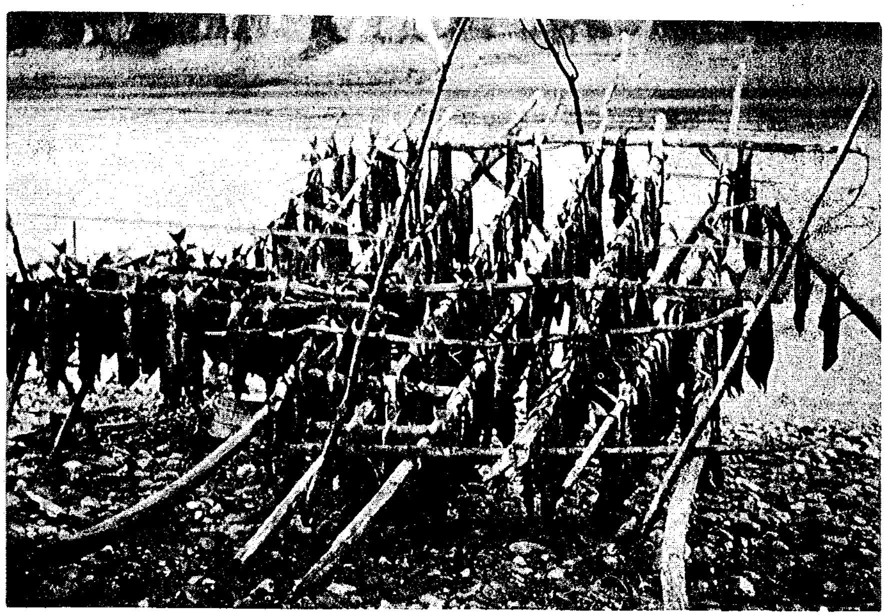


PLATE 7. Chum salmon on drying rocks at a temporary fish camp on the Porcupine River.

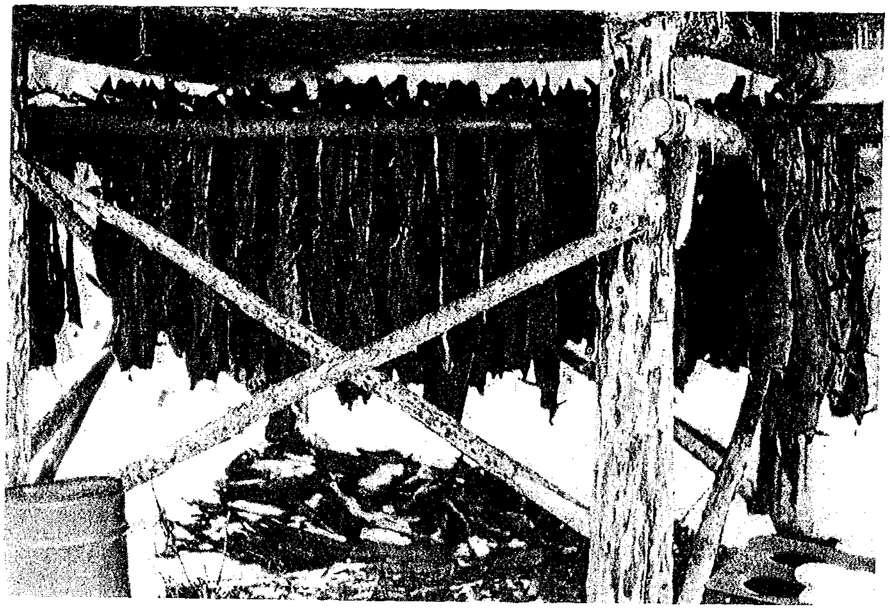


PLATE 8. Details of one method of drying chum salmon in high cache.

PLATE 9. Present day ground cache for dog food fish.

Table II. Summary of the estimates of the total harvest for the Old Crow fishery (1971-1974).

Year	Chum Salmon	Other Species*	Total
1971	10,000 (10,000-15,000)	3,000 (3,000-5,000)	13,000 (13,000-20,000)
1972	4,570 (4,000-6,000)	4,855 (4,000-5,000)	9,425 (8,000-11,000)
1973	6,200 (5,000-7,000)	4,553 (4,000-5,000)	10,753 (9,000-12,000)
1974	7,000 (6,000-8,000)	-	-

where,

( ) estimated range limits of actual harvest

* other fish included in harvest - broad and humpback whitefish, suckers, least cisco, pike, grayling, burbot, coho and chinook salmon

Some additional detailed information for 1972 and 1973 is included in the following pages.

In 1972 the domestic fishery was evaluated on a more qualitative basis. The approximate catch numbers were described according to species and general seasons of the year (Table III). The fishing locations and effort on a weekly basis from early March to late September during 1972 for the domestic fishery in Old Crow are presented in Table IV. Additional information on the fishing location, approximate catch, number of nets and the fishing time for the 1972 fall harvest of chum salmon is presented in Table V.

Table VI presents the numbers of each fish species caught, and the fishing effort recorded in the creel census at Old Crow, 1973.

Table III. Estimated total numbers of fish caught in the 1972 domestic fishery for each season and general location in the vicinity of Old Crow. Species are listed in order of abundance.

Time Period	Species	Estimated Catch
Before breakup:		
Spring (marginal pools)	least cisco, broad whitefish, whitefishes	≃400
Spring (mouth of creeks)	least cisco, whitefishes, grayling	<250
After breakup:		
Spring, summer and fall (Porcupine River)	all species suckers, least cisco, grayling, humpback whitefish, broad whitefish, pike, inconnu	<3,000
Summer	chinook salmon	81
Summer and fall	chum salmon	4,568
Fall (Porcupine River)	coho salmon	<25
Fall (Old Crow River)	whitefishes, grayling, suckers, burbot, pike	≃1,000
Fall and early spring (jigging)	burbot	<100
		<9,424

(from Steigenberger et al, 1972)

Table IV. The number of gill nets fished in the vicinity of Old Crow from May 6 to September 24, 1972.

Dates		Upstream of Old Crow	Near Old Crow	Downstream of Old Crow
May	6 - 12			
	13 - 19			
	20 - 26	1		
	27 -			
June	2			
	3 - 9			* 1 - 3
	10 - 16	3	2	* 1 - 3
	17 - 23	* 3	* 2	* 1 - 3
	24 - 30	* 3	* 2	* 1 - 3
July	1 - 7	0	4 - 5	0
	8 - 14	0	5	5
	15 - 21	2	3	5
	22 - 28	2	4	8
	29 -			
Aug.	4	1	* 3	* 2
	5 - 11	1	* 3	* 2
	12 - 18	1	2	3
	19 - 25	1	0	2
	26 -			
Sept.	1	1	0	* 2
	2 - 8	1 (1-6)	3	3
	9 - 15	1 (1-6)	5	6
	16 - 22	1 (1-6)	4	4
	23 - 29	1 (1-6)	2	1

n - Number of gill nets observed

* n - Reported number of gill nets

(1-6) - Range of number of gill nets in the Old Crow River

(from Steigenberger *et al*, 1972)

Table V. The approximate catch of chum salmon and fishing effort for each fishing location (Figure 5) in the vicinity of Old Crow, 1972.

Fishing Location (Figure 5)	Approximate Catch (Chum)	Number of Nets	Dimensions of Nets	Fishing Time (Days)
2	8	2	-	Lost
2	80	1	-	-
4	40	-	-	7
4	160	2	3½" x 30'	7
4	100	1	3½" x 30'	14
4	300	-	-	-
4	200	2	-	14
4	400	2	3½" x 30'	14
7	100	1		4
7	480	-	-	9
7	100	1	6" x 50'	1
7	600	1	3½" x 30'	14
8	800	1	-	30
8	600	1	3½" x 30'	38
25	600	2	3½" x 50'	56
TOTAL	4,568			

(from Steigenberger et al, 1972)

TABLE VI. The numbers of each fish species harvested and the fishing effort for intervals recorded in the Old Crow creel census, 1973.

Date	Grayling	Chum Salmon	Chinook Salmon	Coho Salmon	Sucker	Pike	Broad Whitefish	Humpback Whitefish	Inconnu	Least Cisco	Burbot	Number of Nets	Total Fishing Time (Hours)	Number of Fishermen
Apr. 20-27	20	0	0	0	3	0	7	8	0	0	6	4	264	1
May 1-10	25	0	0	0	17	3	13	0	0	4	7	5	552	1
May 11-16	(Breakup)													
May 17-31	37	0	0	0	139	3	195	181	25	151	4	26	408	3
June 1-15	12	0	0	0	118	65	186	197	140	190	43	52	657	8
June 15-26	7	0	0	0	6	47	10	27	36	6	3	20	858	3
July 1-15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
July 24-27	0	0	0	0	19	0	13	13	4	2	4	3	22	2
Aug. 1-15	1	68	1	0	2	1	10	7	5	0	0	76	96	4
Aug. 16-31	1	258	0	0	92	26	63	67	46	0	13	59	1344	7
Sept. 1-15	0	743			2	0	39	26	12	0	1	49	1176	5
Sept. 16-31	2	824	0	0	0	6	12	5	4	0	4	62	1923	8
Oct. 1-4	0	17	0	2	0	0	0	0	0	0	0	8	192	1
Oct. 5-30	(Freezeup)													
Oct. 31	2	2	0	6	0	0	2	0	2	0	2	4	240	3
Nov. 1-8	15	15	0	31	10	0	15	13	14	8	10	21	696	6
Totals	122	1927	1	39	408	151	565	544	288	361	97	-	8428	18*

where,

* the total number of different fishermen contributing to creel census data.

c) Detailed analyses of 1973 creel census data

Quantitative analysis of the domestic harvest is limited to 1973 data as the most detailed information was collected in that year. Any conclusions from these analyses are intended to apply to a typical fishing season rather than just to 1973.

The creel census data (Table VI) underestimated the actual harvest. The creel census was more representative of the actual catches before June 26. After this date, the highest proportion of the yearly harvest, composed mainly of chum salmon, is obtained. The creel census data reported 1,927 chum salmon caught, whereas estimates of total chum salmon harvests from all methods indicated about 6,200 (Table II). Therefore the creel census reported 31% of the total chum harvest. For all other species combined the creel census reported 59% of the total harvest for those species. There is no indication of the relative accuracy of creel census data for individual species other than chum salmon. Using these percentages the creel census catch numbers were adjusted. No adjustment was made on the effort and the catch per unit effort calculations.

Figure 6 shows the estimated numbers (adjusted) and the calculated weights for half-month intervals. The calculated weights were the product of the number of each fish species caught and the mean calculated weight for each species (Appendix Table IV). The mean weight was derived by first assigning a mean fork length for each species from the 1972 length-frequency data from gill net catches and then applying the mean fork length to the weight-length regression equations from Bryan (1973). Late August and September is the peak harvest period from the standpoint of fish numbers and total weight.

The presence of chum salmon in the catch was responsible for the peak. A comparison of catch numbers and total weight for each species (Figure 7) demonstrates the importance of chum salmon in the total harvest. Figure 8 presents the seasonal fishing effort and the catch per unit effort in the 1973 Old Crow domestic fishery. The effort recorded in the first two weeks of September was much lower than the actual effort. The greatest fishing effort is during the first two weeks of September when the chum salmon run is at its peak. The catch per unit effort shows a higher success rate in the first period of September than in the latter. The average catch per unit effort for all species of fish was calculated to be 2.34 lbs of fish/net/hour during 1973.

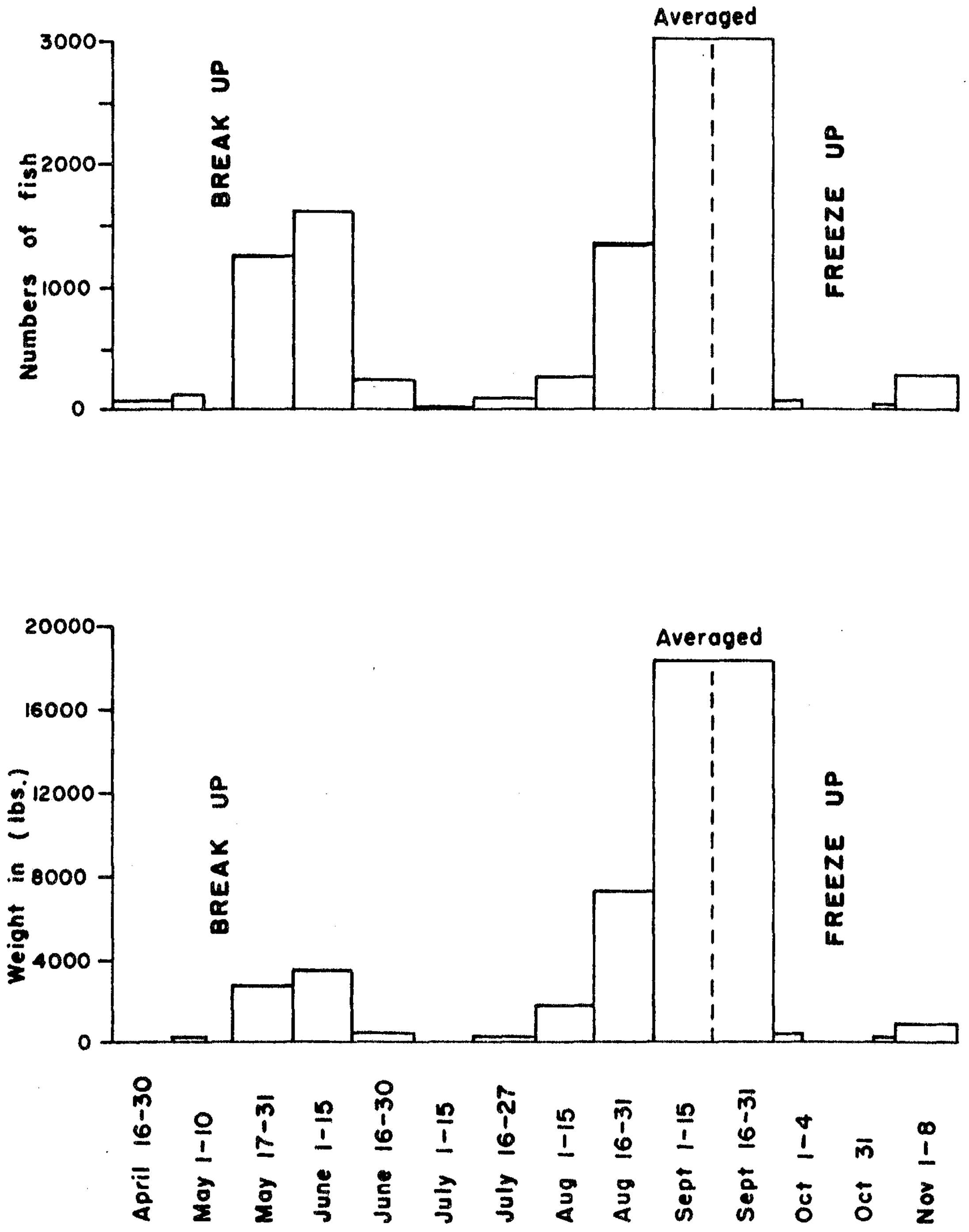


FIGURE 6 The estimated numbers and calculated weights of fish for half month intervals in the Old Crow domestic fishery, 1973.

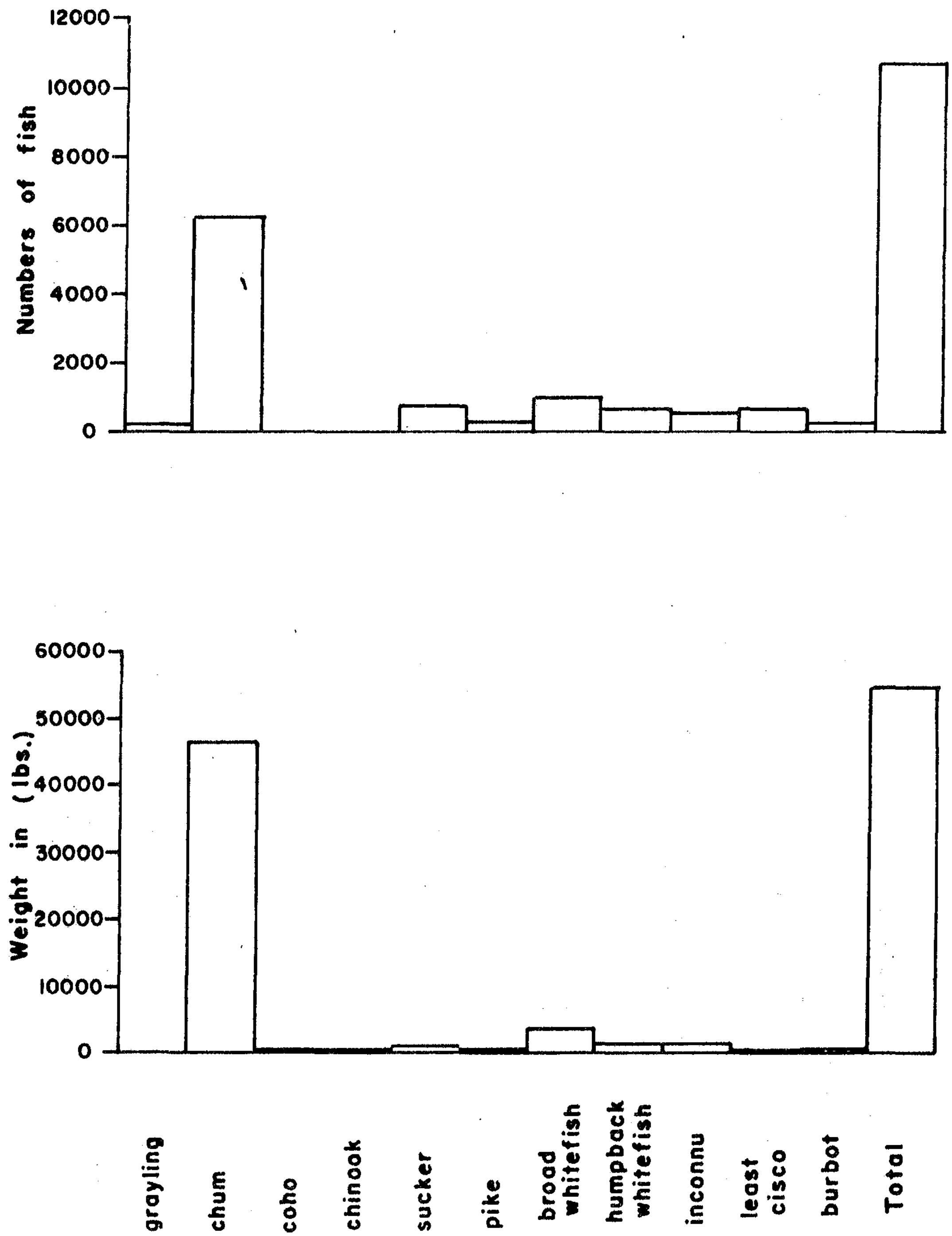


FIGURE 7 The estimated numbers and calculated weights for each species of fish from the Old Crow domestic fishery, 1973.

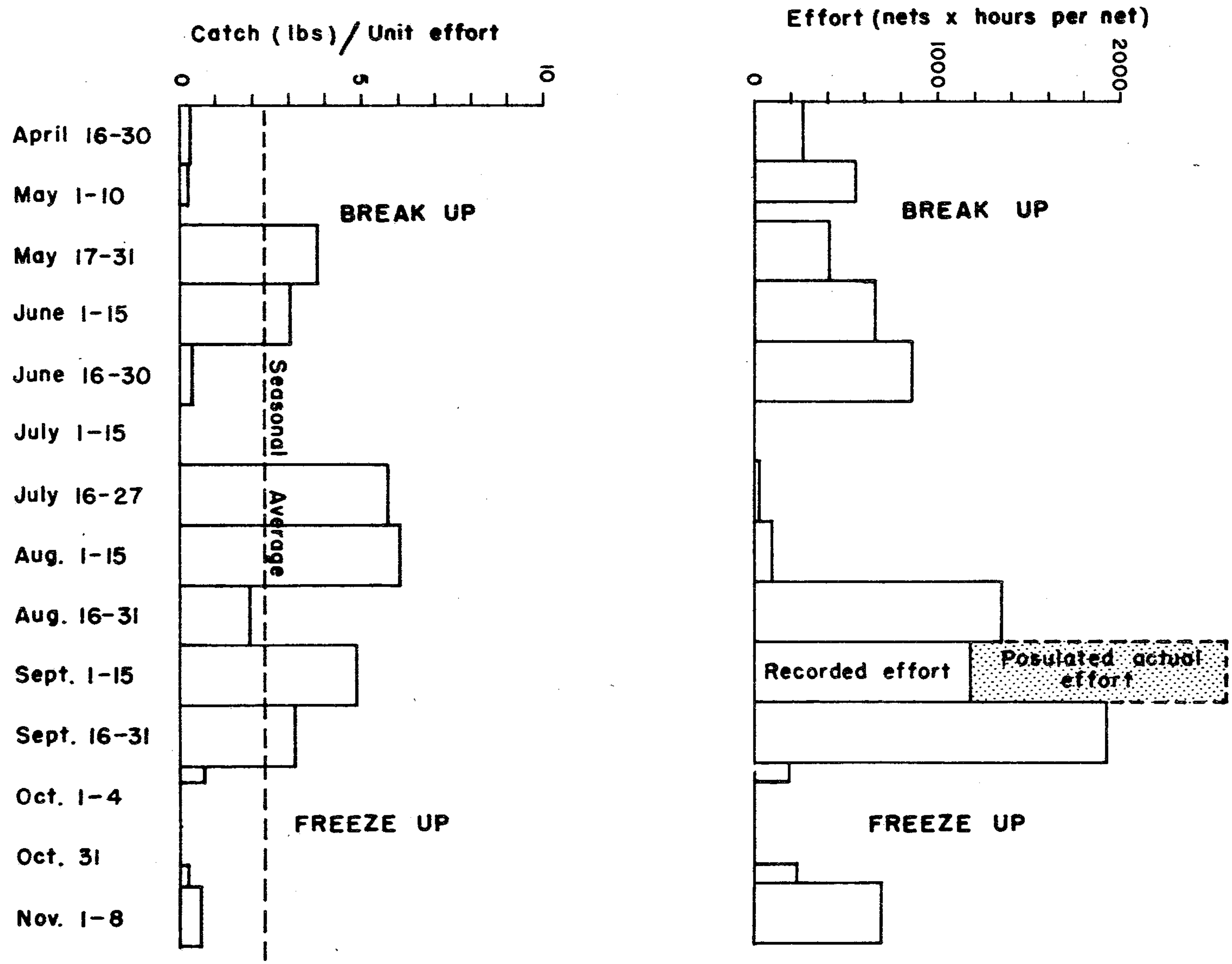


FIGURE 8 The seasonal fishing effort and calculated catch per unit effort reported in the creel census for Old Crow domestic fishery, 1973.

The proportion of the Fishing Branch River chum salmon population harvested in the Old Crow domestic fishery is summarized in Table VII.

Table VII. The proportion of chum salmon harvested at Old Crow from the estimated Fishing Branch River spawning runs, 1971-1974.

Year	Estimated spawning population at Fishing Branch River (Elson, 1975)	Estimated harvest at Old Crow (Table II)	% of run harvested
1971	115,000	10,000-15,000	8-11.5%
1972	35,000	4,000-6,000	10-14.6%
1973	15,989	5,000-7,000	23.8-29.1%
1974	31,525	6,000-8,000	15.9-20.2%

The proportion of chum salmon harvested varies from 8% in the peak year (1971) to 30% in the lowest year (1973). The catch numbers do not appear to reflect merely the abundance of fish.

4.2.2 Present Day Fisheries on the Yukon North Coast

Domestic fisheries conducted in the period 1971 through 1973 on the northern coast of the Yukon Territory were concentrated in the three main areas, Thetis Bay on Herschel Island, Komakuk Beach and Shingle Point. Traditional Eskimo fishing locations also exist off spits and in lagoons near the mouths of the Malcolm and Firth Rivers. When catches are poor, as they were in 1973, fishing effort is transferred to these normally less important areas such as Nunaluk Spit, Catton Point and Ptarmigan Bay. The fishery is confined to the months of July, August and early September. Arctic char is the most prized species for human consumption, whereas Arctic and least cisco and whitefish are preferred for dog food. Data on annual fish harvests by Eskimos was collected in 1971, 1972 and 1973 from the three main fishing areas, and Appendix Table V summarizes the information. Table VIII indicates a minimum weight estimate of the catch for all years.

The fishery from Shingle Point to Shoalwater Bay is centred on migrating fish and localized concentrations of fish believed to be from the Mackenzie River delta. Fishing is often incidental to the hunting of caribou and marine mammals. The catch consists of Arctic cisco, whitefish and smaller numbers of inconnu and Arctic char. The subsistence fishery in this area served the needs of only five people.

The catch at Herschel Island served approximately 10-12 persons and 35 dogs, and consisted of Arctic char for human consumption and Arctic ciscoes for dog food. The number of Arctic char caught in 1971 totalled 300 which was considered below average. In 1972 fishing was terminated in late August as an ample catch of 1000 Arctic char and greater than 1500 ciscoes had been made, but in 1973 the catch of 203 Arctic char from 3 fishing sites near Herschel Island was considered poor. Hunter (1957) stated that "At least eight species of anadromous and freshwater fishes, common to lakes and rivers of the adjacent mainland are caught during the summer in the low salinity waters surrounding the island". These included "whitefish, humpback whitefish, inconnu, least cisco, Arctic char, flounder, smelt, marine sculpin and cod".

The peak of the catch presently occurs between the last week in July and the third week in August. The present day harvest is probably low relative to the abundance of fish (R. Mackenzie, pers. comm.). There was a large variability in the number of Arctic char harvested near Herschel Island in each of the three years of data collection. This variation is probably a reflection of migrational behaviour patterns and not a reflection of the abundance (McCart, 1973, pers. comm.).

Commercial fishing was attempted in the vicinity of Herschel Island and in the Mackenzie delta in 1965 and 1966. Arctic char and whitefish were caught in gill nets, and catch figures are presented in Table IX. The project was discontinued after two years of operation, but the reasons for discontinuation are not known. The capture of approximately 15,000 pounds of Arctic char in 1965 is believed to have been an over-harvest in terms of current estimates of the population.

The recreational use of fisheries resources on the Yukon coast of the Beaufort Sea is low. Arctic char are much prized as a sport fish because of their excellent fighting qualities and palatability. Limited angling was reported in Thetis Bay on Herschel Island and on the spit near the mouth of Fish Creek at Komakuk Beach. At Fish Creek the recreational harvest was taken from the first week in July to late August by personnel employed at the D.E.W. line station. Approximately 100 Arctic char weighing about 5 pounds were harvested for a fishing effort of from 160-200 hours. Arctic char are heavily fished on the Firth River spawning grounds by research personnel operating in the area. This critical spawning population should be protected from potential over-harvest on the spawning grounds where the fish are very susceptible to capture.

Table VIII. Summary of estimated catch numbers and weights (in pounds) from the domestic fishery on the North Slope of the Yukon, 1971-1973.

Year	Arctic char	Whitefish	Total
1971	500 (1,250)	1,000 (1,000)	1,500 (2,250)
1972	1,200 (3,000)	1,550 (1,550)	2,750 (4,550)
1973	508 (1,270)	561 (1,511)	1,069 (2,781)

where,

( ) is the weight in pounds

Table IX. Reported catches (in pounds) from the Beaufort Sea by the Menzie Fish Co.

Year	Herschel Island	Mackenzie Delta	Source (Fisheries Service)
1965	11,804*	19,930**	Yellowknife
1965	16,084*	19,930**	Winnipeg
1966	222*	63,998**	Yellowknife
1966	1,200*	54,000** 2,000*	Winnipeg

where,

* Arctic char
**whitefish

5. Discussion

The discussion is limited to the present day fishery within the northern Yukon Territory. General factors influencing the native harvest and an evaluation of the sampling methods are discussed. Information relative to the present day fisheries in the vicinity of Old Crow and the north coast of the Yukon is evaluated.

5.1 Factors Influencing the Seasonal Domestic Harvest

The domestic use of the fisheries resources in the Porcupine River is centred in the vicinity of Old Crow. On the north slope the fishery centres around Herschel Island and Shingle Point. In general, the fishing locations near Old Crow and on the north slope are related to the life cycles of various species of fish. The natives, from experience, maximize the fishing effort on fish migrations and local concentrations at different times of the year. Fishing intensity is greatest during the spring and fall.

The reliability and significance of the estimates of the domestic harvests are influenced by many factors, some obvious, some more subtle. Two distinct functions are involved. One is the harvest and the effort expended in that pursuit, and the other is the sampling and the evaluation by scientists. Each has its biases through motivational and causal relationships.

The harvest is dependent on several factors. First is the abundance (availability) of the fishes, which is variable in both place and time (seasonally and yearly). Second is the effort expended by the fisherman, which depends on fish abundance, availability of fish nets, social needs, and economic alternatives.

The people in the northern Yukon depend entirely on commercially manufactured nets and web, usually of the cotton variety. The first nylon nets came into Old Crow around 1960. In 1972 few people had nets and none were available for purchasing, thus the fishing effort was much less than required. Therefore, the native fishing effort is influenced by the capriciousness of our production and transportation systems.

Empirically, the social need for food is that quantity required to maintain the natives in their existing life style. Since the natives depend on more than one food source, the need for fish would vary with the supply of alternatives such as caribou and marine mammals. In general, the need for fish also varies seasonally and yearly.

In the past a great proportion of the fish went to feed the dogs which were critical for the trapping activities in the communities. Trapping represented the largest cash income to the inhabitants. Alternatives to both dogs and trapping have developed recently. Therefore it is important when assessing the absolute catch numbers to understand the socio-economic changes that have taken place in the northern Yukon during the years 1971-1974. Thus one must look at the uses of the fish to determine the feasibility and importance of alternatives.

Until recently there were few alternatives to the historic food gathering processes for the natives resident in the north Yukon. During the study period there were economic and social alternatives created. It is probably correct to state that for the duration of the field studies the natives in Old Crow were not fishing at a "typical" level, that is, a level that would support them were the recent economic alternatives not available. During the 1971-1972 field season most of the sampled fish were given to the residents of Old Crow. During 1972 this represented approximately 2000 fish, and in all likelihood influenced the native fishing effort to some degree. After the influence of the pipeline studies has passed one may again see the natives more dependent on the fisheries resource.

5.2 Discussion of Sampling Methods

Each of the sampling methods used to estimate the harvest has particular advantages and shortcomings. The interview, fisherman records (catch books) and creel census methods are each discussed in turn.

The interview method was used to estimate harvest in all years of the study (1971-1974). In 1971 it was the only method used. It was used exclusively by Stager (1973) in Old Crow (Appendix Table VI).

Results from interviews should be viewed with reservation, especially if conducted by those not familiar with both the fishes and the natives. This technique has the advantage of obtaining the maximum amount of information from the minimum expenditure of effort, and is useful for general trends such as comparisons of catches for a few years. It is probably the best method for determining relative chum salmon catches, which are probably the most important for the community of Old Crow. However, it has several drawbacks if one is interested in obtaining absolute numbers. First, some individuals only tell you what they think you want to hear or what they want you to believe. Second, most fishermen do not count the fish unless there is some particular reason to do so. It was found that if the natives catch a large number (over 200), the estimates tend to be high. The converse is true as well; low catches are usually underestimated.

Catch books were used in Old Crow only in 1974. Seven reliable people who regularly fished were selected. Little information was forthcoming. The appeal of this method is the prospect of detailed information similar to the creel census approach without the expenditure of time and manpower. The inherent flaw of this approach is that one is expecting the fisherman to have a technical knowledge and interest to enter his daily catches and other fishing information. This is seldom borne out in practice. It has many of the same drawbacks as the interview method without the advantages of personal contact.

The creel census method was employed with different intensities and successes for the years 1972, 1973, 1974. The advantage of this technique is that it yields the most detailed information on the catch and the effort. Its disadvantages are numerous. It requires a great deal of time on the part of the interviewer. Since the number of fishermen was small and the fishing effort inconsistent, it was difficult to assess the efficiency of sampling. One tends to sample the individuals who fished the most or those who fished in predictable locations. In 1973 the census was more efficient in the spring than in the fall. During the fall chum salmon run when the fishing effort and the catch per unit effort were high, the creel census was least efficient. This was a personnel problem, not an inherent problem with the technique. In 1973 the creel census (Table VI) showed a higher catch of chum salmon in the latter part of September than in the first. This is a reflection of more sampling in late September. In reality, more effort and larger catches were sustained in the first part of September.

Although the harvest estimates are based on data obtained from three methods, it became obvious at an early date that the assessment of the native harvest was more than a mere numerical manipulation of data from interviews or creel census. The Fisheries personnel who were in Old Crow for a number of years gained an understanding of both the residents and the fishery. It was this experience that facilitated an evaluation of the techniques and produced what we consider reasonable estimates.

5.3 Aspects of the Present Day Fisheries of the Porcupine River Drainage

a) Review of the yearly catches (1971-1974)

During 1971, 10,000 chum salmon and 3,000 fish of other species were estimated to be harvested in the Old Crow fishery. The chum salmon run was estimated to be 115,000 and fishing effort was believed to be relatively high. Despite large catches the harvest was the lowest percentage (8-11.5%) of the spawning run for the years 1971-1974 (Table IV). The estimates of the 1971 chum salmon harvest are likely less than the actual catch. The actual catch probably ranges between 10,000-15,000 chum salmon and between 3,000-5,000 of other species (Table II).

In 1972 the creel census was initiated. However, it operated effectively only from May to the end of August. The chum catches were evaluated almost entirely by interviews in October. The estimate of 4,570 chum salmon is likely low. The estimates of other species are probably representative (Table II). In 1972 the lowest catch of chum salmon was found during the study years. Even though the catch was a higher proportion of the run (10-14.6%) than in 1971, the harvest was not as large as the 1973 catch that exploited a lower abundance of chum (Table VII). The low catch was attributed to a shortage of fish nets in Old Crow, and perhaps other social or economic factors not associated with fish abundance.

The creel census and interview methods were probably more extensive in 1973. The estimates (Table II) are likely within 10% of the actual catches. It is interesting to compare these catch estimates with those of Stager (1973), who used the interview method exclusively (Table X). Although there is, in some cases, a great disparity in numbers for some species, others are indeed close. Stager's estimate of total chum salmon harvest is within 11% of our estimate. Stager's catch estimates for all other species is within 9% of our estimates. Stager's total catch number is 98% of ours, but Stager's total weight estimate is only 54% of ours. If our weight calculations are applied to Stager's chum numbers alone, the resulting figure is 33% higher than Stager's value for the total catch. We feel that Stager underestimated his total catch weight by approximately one-half. Both researchers interviewed 22 fishermen.

TABLE X. Comparative summary of the harvest estimates (number and weight) for each species in the Old Crow domestic fishery, 1973 (from Fisheries Service, 1973 and Stager, 1973).

from Fisheries Service, 1973.

	Grayling	Chum Salmon	Chinook Salmon	Coho Salmon	Sucker	Pike	Broad Whitefish	Humpback Whitefish	Inconnu	Least Cisco	Burbot	Total
Number	207*	6,200*	2*	66*	693*	256*	960*	924*	489*	613*	164*	10,574*
Wt. (lbs)	178	45,260	10	264	970	410	4,416	1,349	1,350	331	328	54,866 lbs

from Stager, 1973.

	Grayling	Chum Salmon	Chinook Salmon	Coho Salmon	Sucker	Pike	Broad Whitefish	Humpback Whitefish	Inconnu	Least Cisco	Burbot	Total
Number	1,100	5,580	13	0	851	647	......562.......		498	870	323	10,444
Wt. (lbs)	-	-	-	-	-	-	-	-	-	-	-	30,005 lbs

where,
* the numbers from creel census (Table VI) were adjusted since the creel census data represented 31% of total chum salmon harvest and 59% of the total catch of other species.

In 1973 the chum salmon catches were higher than in 1972, but a higher proportion of the run (24-29%) had to be exploited. This was probably the result of increased fishing effort on the lowest spawning population for chum salmon observed (Table VII).

In 1974 the catch books were distributed to fishermen. The results were disappointing. The estimates in Table II were compiled by a resident of Old Crow interviewing approximately 20 fishermen. The chum salmon catches were higher than 1973 and a lower proportion (15.9-20.2%) of the run was harvested. No information is available on the harvest of the other species.

b) Discussion of 1973 detailed creel census estimates

It has been mentioned that the creel census data represented about 31% of the total chum salmon catch and 59% of the total catch for the other species. It should be noted that in Figures 6 and 7 the catch numbers were adjusted by the factors of 3.2 (reciprocal of 31%) for chum salmon, and 1.7 (reciprocal of 59%) for all other species. The weight calculations were made on the adjusted catch numbers. Although these adjustments were made for each time period, there is every likelihood that most of the discrepancy between creel census data (Table VI) and total estimates (Table II) occurred in the latter part of the season (September). Due to a sampling bias in the creel census the harvests in April, May, June and August are more representative than in July, September and October.

Some of the shortcomings in collection of data are reflected in the magnitude of the catch numbers and therefore calculated weights for particular times of the year (Figure 6). Generally, there are the two peaks, the first after breakup in the spring, and the second during the chum salmon run in the fall. The last part of August and the month of September are the peak harvest periods in Old Crow. About 63% of the numbers and 75% of the poundage of fish are caught in that time period. The percentages might even be higher if the creel sampling had been more extensive in the fall. The low harvest from June 16 to July 27 is not representative of the actual harvest.

In 1973 the chum salmon represented 58% of the catch numbers and 85% of the catch weight for the year (Figure 7). These were harvested in the fall. However, one should not overlook the importance of other species. For example, the whitefish in the spring fishery are important as a food supply when the winter's provisions are usually exhausted. Fish become a critical source of protein at any time of the year in the event of shortages of alternate food supplies.

The seasonal distribution of fishing effort (Figure 8) is not entirely representative for the fishing season. The lack of effort shown from the middle of June to the end of July likely represents a sampling deficiency. Gill net sampling has shown that fish are available during this time period. The recorded effort in the first part of September is lower than in the latter part of September. This is incorrect. There is more effort and a higher catch per unit effort in the first two weeks of September as the chum salmon run is at its peak.

In general it may be stated that there are two periods of concentrated fishing effort, in the spring after breakup, and the fall, before freezeup. The fall harvest represents the greatest effort. Even though the fall effort is large, there is still a notable fishing effort spread over the rest of the season (Figure 8). The postulated effort in early September (Figure 8) depicts the possible disparity between spring and fall fishing efforts. No quantitative comparisons can be made.

When the catch (in pounds) per unit effort from the creel census is compared for each half month period, the chum salmon catch/unit effort is only about 50% higher than the spring catch/unit effort (Figure 8). This perhaps indicates the potential value of the spring fishery, which, to a large degree, is not realized. The seasonal distribution of catch per unit effort is probably an accurate reflection of relative availability of fish. There are two peak periods of high catch/unit effort: the first, after breakup when the water is turbid and the fish are likely concentrated; the second, before freezeup when the chum salmon are migrating upstream. The plot of catch per unit effort (Figure 8) shows an even higher peak for end of July and first of August. This anomaly is due to either incorrect information or a particularly successful fishing strategy, and is believed not to be a reflection of fish abundance.

c) Recreational fishery in the vicinity of Old Crow

There has been in the past a very limited recreational fishery around Old Crow. Some research personnel, a few tourists and natives fished primarily for grayling. The mouth of Big Joe Creek and Lord Creek were regularly fished by sportsmen in the years 1971-1973. Apparently, when trophy fish dwindled in Lord Creek during 1973, the headwaters of the Old Crow River on the border of Alaska were utilized. This location was discovered to be a highly productive grayling area in 1972. The population size approaches 20,000 grayling. No data are available on the recreational harvest or the fishing effort in the vicinity of Old Crow.

5.4 Aspects of the Present Day Fishery of the North Slope Drainages

a) Domestic harvest

The subsistence population in the area is low (less than 20). The relatively small harvest does not reflect the abundance of fish, rather the utilization of a broader food base, in particular, the marine mammals. Despite the relative high abundance of fish, inclement weather or behavioural variations in the Arctic char can result in less than adequate harvests (Appendix Table V, for the harvest during 1973). The potential value of the fish resource would probably only be realized in the event of a failure of alternative food sources.

b) Commercial fishery

The reasons for the failure of the commercial fishing enterprise may provide some useful insights for future management. Although the economic considerations may have been the principal limiting factor, it is possible that the fish populations could not support commercial exploitation. Currie (1964) proposed a 2,000 pound Arctic char quota for the Beaufort Sea in the vicinity of Herschel Island. The Menzie Fish Company harvested 6 to 8 times that quota in 1965. The 1966 catches were small, indeed less than the quota, possibly as a result of over exploitation in 1965 (Table IX).

c) Recreational fishery on the North Slope

We have little data on which to base an evaluation of the sport fishery in this area. It seems likely that any development on the north coast will increase the sport utilization of the Arctic char. Unless high fishing efforts during spawning or in critical areas such as overwintering and open water areas were experienced it is unlikely that the sport fishing would affect the Arctic char populations directly. However, indirect effects of access should not be ruled out as having a deleterious effect on the Arctic char.

5.5 One Aspect of Social and Economic Evaluation of the Domestic Fishery within the Northern Yukon

In the final analysis the question of the economic or social evaluation of the domestic harvest is likely entering into field beyond our terms of reference. The economist or sociologist is supposedly better equipped to deal with such considerations; however, a few reflections on the relative value of the fisheries resource from our point of view may be beneficial.

It appears to be a standard technique to assign a dollar value to a resource for the purposes of economic or social evaluation. Gemini North Ltd. (1974) applied the following values to the Old Crow domestic fishery:

> "30¢ lb. for whitefish, jackfish, trout, inconnu, pikeral [walleye], 75¢ lb. for spring salmon and 50¢ lb. for chum salmon".

These values may have some relevance to a commercial fishery but not to a subsistence fishery. If fish keep an individual from starvation or even hunger then the fish assume a unit of value not found in any monetary system. To obtain a meaningful value for the fish, the costs of substitutes might be applied (50¢ lb for commercial dog food and $3-$4 lb for commercial meat). However, this implies that work for a wage must be substituted for fishing. If this were the case, then for the sake of equality a man must have the same wage-power as fish-power. In 1973 the average catch per unit effort was 2.34 lbs/hour/net. Therefore, to achieve equality a man would have to have a net wage of approximately $7.00/hour. Since gill nets can be fished continually and the wage earning job is limited to 40 hours/week, the relative value of the fishery resource, on a weekly basis, is greatly increased. These analyses are not intended to replace the expertise of the social scientists but merely to point out an obvious folly of being too remote from the theatre of consequence.

6. Conclusions

6.1 Present Day Fishery in the Porcupine River Drainage

The annual catch in Old Crow is influenced by many variables: fish abundance, availability of fishing gear, social needs, economic alternatives. It was felt the best approach to catch estimates was a combination of creel census and survey by personal interview. During the study years, 1971-1974, the annual catches were thought to be between 9,000 and 20,000 fish. In 1973 the catch weight was estimated at 54,866 pounds from 10,574 fish. The abundance of chum salmon had the greatest influence on the annual harvest. The highest abundance for chum salmon was in 1971 and the lowest in 1973. In years of peak abundance the Old Crow residents harvest between 10,000-15,000 chum salmon, while in years of lesser abundance, between 4,000-6,000. In 1973 the chum salmon represented 58% of total catch numbers and 85% of total weight. The residents harvest between 8% in peak run years and 29% in low run years of the chum salmon run. Most of the chum salmon are harvested in the first two weeks of September and the harvest is primarily composed of male fish. Despite the large harvest in the fall of chum salmon, other species are important at other times of the year. In order of importance they are: broad whitefish, humpback whitefish, inconnu, suckers, burbot, least cisco, pike, coho and chinook.

Large catches of fish after breakup provide an opportunity for food at a potentially critical period. It appears that the residents of Old Crow generally concentrate the fishing efforts at times of fish migrations and local concentrations at different times of the year. The fish are available at all times of the year and so provide a potential food source in the event of the failure of alternatives such as caribou. There exists a small sport fishery for grayling by tourists and research personnel. At the present levels the effects on fish population are probably negligible.

6.2 Present Day Fishery of the North Slope Drainages

In the years 1971-1973 the domestic harvest was estimated at between 1,000 and 2,750 fish weighing between 1,350 and 4,550 pounds. The catch is considered low relative to the abundance of fish stocks and the estimates are probably not an accurate reflection of the utilization of the resource. Nevertheless, inadequate harvests of Arctic char occur as a result of inclement weather or variation in fish behaviour.

Special fishing effort is directed at Arctic char for human consumption and ciscoes and other whitefish for dog feed. Often fishing is incidental to other activities such as hunting and whaling. The fishing locations are traditional and the fishing effort is usually restricted to late summer and fall.

There is no commerical fishery operating at present in the northern Yukon. In 1965 the Menzie Fish Company harvested between 11,804 and 16,084 pounds of Arctic char and between 222 and 1,200 pounds of Arctic char in 1966 from the Beaufort Sea in the vicinity of Herschel Island. The commercial fishery was not continued. There is some likelihood the fish stocks could not support a commerical harvest.

Sport fishing is for Arctic char, at the mouth and estuaries of the major spawning rivers (Fish Creek and Firth River), and in the headwater areas of the Firth and Babbage Rivers. In 1973 approximately 100 Arctic char (5-6 pounds) were caught in 160-200 hours of fishing at Komakuk Beach, near the mouth of Fish Creek, in July and August. No estimates of the recreational harvest in other areas are available.

7. Recommendations for Future Fisheries Management

Effective fisheries management within the northern Yukon Territory requires an accurate prediction of the future utilization of the fisheries resource. At the present time there is no apparent conflict between domestic and recreational fisheries, nor is there any commercial fishery in the Porcupine River drainage or the drainages of the North Slope of the Yukon Territory. Future demands might possibly result in conflicts of interest between users in both of these areas.

In Old Crow, there appears to be a trend of a diminishing native dependence and harvest of the fish resource (Appendix Table VII, from Stager, 1973). This is due in part to lower native populations, lesser demands for dog food, and a lessening dependence on indigenous foods. Apparently this also applies to the North Slope of the Yukon. The continuance of a diminishing native harvest might result in proposals for increasing the alternate utilizations of the fisheries resources. Any such requests should be scrutinized carefully. Until adequate information on the species concerned is available, the present levels of exploitation should not be exceeded to any large degree. For the foreseeable future, as long as there is a subsistence fishery, it should have priority in the utilization of the fishery resource. "Not only does subsistence fishing provide the Yukon's native people with a supply of food but it also provides the Indians with an opportunity to maintain the traditional Indian life style. Although total participants in subsistence fishing will likely decline in the future, a significant number of Indians will continue to derive important psychological and economic benefits from this fishery for many years to come." Moreover "...many Indians consider their fishery to be almost a sacred ancestral right" (Boland, 1973). Ancestral right does not imply the lack of management. In fact, it is recommended that the domestic fishery be accurately monitored and even regulated in some cases. Species composition and catch per unit effort monitoring for each season will supply valuable baseline information for long term management of the entire fishery resource. In contrast with the past, the natives today harvest fish with efficient gear from a relatively small area. Therefore the possibility of overexploitation by the domestic fishery may be a recent phenomenon. Regulation of the domestic harvest might be necessary to avoid overexploitation and degradation of the fish stocks. For example, the harvest of chum salmon during 1973 near Old Crow exploited 30% of the small spawning population. On the North Slope, in the Big Fish River (N.W.T.), the harvest of Arctic char was greater that 50% of the population (Stein et al, 1973).

It appears that in the past the domestic harvest has been proportional to the needs of the natives. Until recently the domestic catch is believed to have been relatively constant. Therefore, the future subsistence requirement from the fishery resource should be considered, for management purposes, at least as large as peak harvest in the past, which is more than is being harvested at the present time. The conditions for larger subsistence demand in the future are not difficult to envisage and indeed may be occurring in the community of Old Crow at the present time.

Careful considerations should be given before embarking on commercial ventures within the northern Yukon. There are insufficient data at the present time of the life history stages and population dynamics of any one species to consider the development of commercial or large scale recreational fisheries. As effective management is based on an adequate knowledge of the basic parameters involved, and since the present knowledge is minimal, it seems safer to be conservative with regard to multiple utilization until more management oriented research has been completed and evaluated.

At present, it appears that there is no room for additional harvest of chum salmon and Arctic char, especially at commercially viable levels.

As the development of the north increases, there will be an increasing demand for recreational fishing, especially for Arctic char. There will be a need for regulation, in particular, regulations protecting sensitive areas such as overwintering, spawning and groundwater areas, to avoid over exploitation and habitat degradation. Similar regulations with regard to critical areas should also apply to the domestic fishery.

Production of fish by artificial propagation, as a remedial measure, does not appear feasible at present due to the lack of knowledge of suitable techniques dealing with the species concerned, and the problems imposed by remoteness and climate. In our view the emphasis should be on the maintenance and management of the quality of the indigenous fish stocks.

8. References

Balikci, A., 1963. Vunta Kutchin Social change Northern Co-ordination and Research Center No. 63-3 Ottawa.

Bryan, J. E., 1973. Freshwater Aquatic Ecology in Northern Yukon Territory 1971. Environmental-Social Committee, Northern Pipelines Task Force on Northern Oil Development Report. No. 73-21.

Boland, J. P., 1973. The Yukon Fishery Resource. Its Existing Role and Its Future Potential. Economics Unit, Northern Operations Branch Fisheries and Marine Service, Pacific Region. Department of the Environment NOB/Econ 1-73.

Currie, R. D., MS. 1964. The Yukon Territory Littoral. An Economic Development Program Industrial Division, Department of Northern Affairs and National Resources, Ottawa.

Elson, M. S., MS. 1973. The Historical Exploitation of the Yukon Fish Stocks. Department of the Environment Fisheries Service, Vancouver, B.C.

Elson, M. S., 1975. Enumeration of spawning chum salmon (*Oncorhynchus keta*) in the Fishing Branch River in 1971, 1972, 1973 and 1974. Environmental-Social Committee, Northern Pipelines, Task Force on Northern Oil Development , Northern Yukon Fisheries Studies 1971 - 1974, Volume 1, Chapter 2 (In press).

Gemini North Ltd., 1974. Social and economic impact of proposed arctic gas pipeline in Northern Canada. Book 3. Canadian Arctic Gas Pipeline Limited, Toronto, Ontario.

Hunter, J. G., 1957. Fishery resources survey of the western arctic. Fisheries Research Board, Arctic Biological Station, Ste. Anne de Bellevue, Quebec.

Morlan, R. E., 1972a. The Cadzow Lake Site (MjVi-1). A Multicomponent Historic Kutchin Camp. Archaeological Survey of Canada. Mercury Series, Paper 3.

Morlan, R. E., 1973. The later prehistory of the middle Porcupine Drainage, Northern Yukon Territory. Archaeological Survey of Canada. Mercury Series, Paper 11.

Osgood, C., 1936. Contribution to the Ethnography of the Kutchin. Yale University Publications in Anthropology, Volume 14.

Stager,J. K., 1973. Old Crow, Y.T., and the proposed Arctic Gas Pipeline. Environmental-Social Committee, Northern Pipelines, Task Force on Northern Oil Development (unpublished report).

Steigenberger, L. W., R. T. DeLury, G. J. Birch, and J. Fisher, MS. 1972. An assessment of the domestic fishery at Old Crow, Yukon Territory, 1972. Department of the Environment, Fisheries Service, Vancouver, B.C. (unpublished report).

Steigenberger, L. W., G. J. Birch, P. G. Bruce, and R. A. Robertson, 1974. Northern Yukon Freshwater Fisheries Studies, 1973. Environmental-Social Committee Northern Pipelines, Task Force on Northern Oil Development. Report No. 74-20.

Stein, J. N., C. S. Jessop, T. R. Porter, and K. T. J. Chang-Kue, 1973. An evaluation of the fish resources of the Mackenzie River Valley as related to pipeline development. Volume 1. Department of the Environment, Fisheries Service, Winnipeg, Manitoba. 121 p.

Welsh, A. N., 1970. Community pattern and settlement pattern in the development of Old Crow village, Yukon Territory. Western Canadian Journal of Anthropology, Vol. 2, no. 1, pp. 17-30. Edmonton. (In Appendix Table I, p61).

Appendix Table I. Annotated list of historic and present day fishing locations in the northern Yukon Territory from Figure 2.

1	Komakuk Beach.
2	Nanuluk Spit.
3	Commercial fishing location used by Menzie Fish Co. 1965, 1966.
4	Thetis Bay.
5	Catton Point.
6	Fish camp used by Menzie Fish Co.
7	Fish camp used by Menzie Fish Co.
8	Fish camp used by Menzie Fish Co.
9	Fish camp used by Menzie Fish Co. and historic residence (D. Gordon, pers. comm.).
10	Shoalwater Bay traditional Eskimo fish camp used by Menzie Fish Co.
11	Groundwater overwintering area for Arctic char on Fish Hole Creek. A meeting place for Indians and Eskimos. The most recent Old Crow resident to use this area was J. Kendi whose fish camp was traditionally on the Black Fox River. It was reported that P. Tizya, P. Moses and J. Kendi visited the Fish Hole from 1926 to 1930, and the R.C.M.P. visited from 1928-1932 (J.Kendi, pers. comm.).
12	Historic camp for both Eskimos and Indians in the early 1900's. Liza Ben occupied this camp in 1911 (P. Lord, pers. comm.).
13	Groundwater overwintering area for Arctic char on the Firth River. Apparently the Indians from Old Crow and the Eskimos from the coast would meet here as late as 1920's or 1930's.
14	Timber Creek, reported overwintering of Arctic grayling.
15	Groundwater area. Over 20,000 Arctic grayling overwinter here annually. Liza Ben fished this area in early 1900's.
16	J. Netro fished an upstream trap here in 1907 to 1911.
17	Charlie (pers. comm.) described this trap location "which they call Kie Koo mean birch bark fish trap. This fish trap was all kind of fish is one of good trap". We were told this trap was used by Netro, Linklater and Bruce families in early 1900's, In 1907 there were few fish and they lost their dogs. They caught grayling, whitefish, pike, suckers, loche and a few salmon.
18	Dividing point between upstream and downstream grayling migration for overwintering in Old Crow River. In addition, the fish trap location for P. Norberg (1910-1911).

19 "They call this fish trap Choo tsun Koo. It also all kind of fish in it but Losche is lots in the creek." (C. P. Charlie, pers. comm.).

20 Husky Lake fished before 1930 for whitefish probably winter fishery.

21 Willow Lake was mentioned as supporting overwintering fish.

22 C. P. Charlie, 1973 (pers. comm.) stated that this trap was called "Chil-do gwo Koo". "Koo" meaning that someone was running for the last time. Both C. P. Charlie and L. Charlie had visited this trap location. Likely this is the same historic camp that Morlan investigated (NbVk-1 (68°12'N, 139°31'W)). He found evidence of historic occupation up to 1930 (Morlan, 1972b).

23 David Lord Lake.

24 C. P. Charlie, 1973 (pers. comm.) stated that this trap was called "Koo nut tri keviei". This trap caught many fish however they were mostly grayling. C. P. Charlie and L. Charlie visited the area but only the Old Camp was visible.

25 Peterson's fish camp used 1927 to 1940. This was the first reported use of the hoop net which caught mostly big fish unlike the aboriginal traps that caught all sizes. J. Kendi (pers. comm.) now has a camp near Peterson's old camp. He first fished there in the 1930's - lots of fish, ground cache 10' × 10' × 5'. He reports catches of greater than 12,000 grayling in years 1950 - 1959. Also round whitefish and inconnu. Pike were caught in a nearby lake.

26 Historic fish trap location. M. Tizya (P. Lord, pers. comm.) fished there in 1918 - had a ground cache 5' × 5' × 4'.

27 Whitefish Lake.

28 Thomas Boys Lake "Guill you chou" lake. Irish McCauly fish camp operated in the early 1930's.

29 "Is same is this other fish trap this one they call chin chul Koo fish trap. The old Don Fredson was make fish trap **there** one time he tell me that best fish trap I ever see. He say Lazarus (L. Charlie) know this place." (C. P. Charlie, pers. comm.). This is likely the same camp Morlan (1973) mentions as MlVm-1.

30 An historic Old Crow native fishery has existed on the Salmon Trout River. There is groundwater source used by salmon and other species (Big Joe Kaye, pers. comm.).

31 This groundwater source historically was used for a winter grayling fishery. The grayling were supposedly a different colour in the river and hence the name "Bluefish" was applied to the river. We could not substantiate that significant numbers of grayling overwinter in the Bluefish River.

32 Caribou Bar Creek. Liza Ben 1911. Big Ben Kassie operated fish trap in creek mouth 1926-1927.

33 Historic fishing location (gill nets). A cabin built by P. Frost is closeby (MiVn-1, Morlan,1973).

34 Historic fishing trap site. Here was one of the first applications of chicken wire replacing the woven willow in the fish traps.

35 Old Joe Tizya fish camp.

36 "Klo cut". The early community centre. Excavations by the archaeological survey of Canada MjVl-1, MjVk-2, MjVk-3 (Morlan, 1973).

37 Location of the legendary Old Crow fish trap operated under the leadership of the chief, Zzhe Gitlit, around the turn of the century, and by chief P. Moses until at least the 1920's. This trap exploited the large downstream fish migrations from the Old Crow flats. Most of the fish were caught at night. It was generally fished from the middle of August until after freezeup. The large whitefish (broad and humpback) were the first through, grayling and suckers around the end of September, ciscoes by the thousands in September. Eighteen to twenty families fished this trap. The ground cache was reported to be 20' x 20' x 3 logs high.

38 Historic fishing and caribou lookout.

39 Very old fish trap location on Little Flat Creek. The exact location is unknown.

40 Fish trap near Chinnitlui Lake was last used in 1944. (P. Lord, pers. comm.).

41 Historic camp at outlet of Cadzow Lake on Porcupine River. Morlan (1972a) investigated this site (MjVi-1). It appears characteristic that fish migrate out of Cadzow Lake in the fall when the high water of the Porcupine River opens the outlet stream.

42 Cabin (P. Lord). In 1932 he caught 3-4 tons of grayling. The last fish trap on Lord Creek was fished in 1957 or 1958 when thousands of grayling were captured in two nights of fishing. Downstream migration of grayling from Lord Creek finished by mid-September. Trap fished in 1957-1958 because of poor salmon run in Porcupine River.

43 There was, at least once, a winter camp on the island in the middle of Cadzow Lake (P. Lord, pers. comm.) in the 1940's or 1950's. Whitefish and pike were gill-netted under the ice.

44 Old cabin of D. Cadzow and P. Lord's wife's grandfather (P. Lord, pers. comm.).

45 Old fish lake for grayling and whitefish (P. Lord, pers. comm.).

46 Legendary fish trap location (unsupported).

47 P. Josie camp (1930's).

48 R. C. M. P. camp (1957) used during dog team patrols of the headwaters of Porcupine River drainage.

49,50, 51 Trapping cabin of D. Lord and residence of M. Tizya during the 1920's and 1930's. The people seemed at that time to move between Old Ramparts (Alaska) and LaPierre House setting up temporary fishing and trapping camps along the banks of the Porcupine River.

52 "Salmon cache". This was a traditional fish camp in the early 1900's. People from Johnson Village, LaPierre House, Whitestone Village and Old Rampart's fished this location prior to start of trapping season. Fall upstream dispersal of people from summer fish camps and trading near Old Crow.

53 There was a fish trap operated on a creek flowing out of a lake behind LaPierre House. This probably supplied some of the fish to the Hudson's Bay Company settlement. Later, older natives stayed here year round.

54 LaPierre House - historic trading location and settlement.

55 Old fish trap location used prior to 1900 (C. P. Charlie, pers. comm.).

56 "This fish trap use by my grandfather. My father said mostly grayling. He say lot of fish there. They call ZZeh Kwut tsul kwinnjik. That mean LaPierre House Creek." (C. P. Charlie, pers. comm.). This trap was reported operating through the 1800's and into the early 1900's. One report stated the trap was made out of birch bark and willows in a style much like our present day trap or hoopnet.

57 Old camp and graves (unknown).

58 "This fish trap they call it Chi hil li Koo. Also this lake Whitefish Lake. They call hil li Vun. This first trap used by Head of Porcupine People." (C. P. Charlie, pers. comm.).

59 Trap used in later times by the natives of Johnson Village (L. Charlie, pers. comm.).

60 This area is called the Porcupine Lakes. It is a broad straight stretch where the water moves more slowly and grows lush vegetation. In the 1920's to 1940's this was used for gill-netting chum salmon by people from Johnson Village. Important area even today for hunting of beaver in the spring.

61,62 Lake where winter spearing for big broad whitefish took place during the occupation of Johnson Village.

63 Johnson Creek Village fish trap was a highly sophisticated willow basket type. They caught in order of frequency suckers, grayling, pike, cisco, burbot, and a few round whitefish and broad whitefish. Probably operated from late 1920's to 1940's.

64 Bill Cody lived here, ran a smaller fish trap than the people of Johnson Village. Fish for dog food to enable fur trapping.

65 In 1938, 5,500 dog (chum) salmon were caught in nets. In 1948, four fishermen caught 300/day in gill nets. In 1948 most people left Whitestone Village for Old Crow. A few people returned to Fishing Branch River to fish for dog food in late 1940's and early 1950's (D. Nukon, pers. comm.).

66 "In 1936 poor salmon run for Whitestone Village so people try trap in this location"- caught mostly suckers, round whitefish, pike and burbot. "Approximately 600 fish." (D. Nukon, pers. comm.). Note that numbers given by older fishermen are often misleading.

67 Approximate location of Whitestone Village. Near mouth of river is an old log windlass (winch) used to haul long boats (barges for freight) up on shore for winter.

68 The people report three distinct areas of salmon spawning. This area was the known spawning area for chinook salmon. Some other species of fish were also harvested here during summer.

69 The known chum spawning area. During hard times dead fish were removed and used as dog food.

70 Coho salmon spawning area. We have since learned that at the present time at least coho salmon do not spawn on the north fork of Fishing Branch River. The degree of segregation is not as legent states.

Appendix Table II. A summary of the early history of the Porcupine River drainage (from Morlan, 1973).

"While this list is not complete, it provides a basic framework for understanding the chronology of Kutchin culture change under the influence of white immigrants. Petitot specifically states that Kutchin (Loucheux) Indians visited Forts Good Hope, MacPherson, LaPierre House and Yukon (Savoie 1971: 98-99).

1789 - Alexander MacKenzie (1801) explored to the mouth of the Mackenzie River and became the 'first European that we can be reasonably sure saw members of the Kutchin nation' (Osgood 1936b: 17).

1804 - Fort Good Hope was established by the Northwest Company as its most northerly post at 66°16'N. lat. (Slobodin 1962: 19). Following the amalgamation of Northwest and the Hudson's Bay Company in 1821, the post was moved north to the Lower Ramparts of the Mackenzie (67°21'N. lat.) in 1823 in a bid for the delta trade, and its present location (ca. 66° 30'N. lat.) was established in 1836 (Slobodin 1962: 19; Usher 1971: 73).

1826 - Sir John Franklin's (1828) expedition brought trade to the delta Eskimo and was 'violently resented' by 'Mountain Indians' thought by Slobodin (1962: 16) to have been Crow River or Porcupine River Kutchin.

1835-1845 Parties in search of Franklin journeyed several times on the lower Mackenzie and again contacted Kutchin in the southern end of Mackenzie delta and on the lower Peel River (Simpson 1843; Richardson 1851; Hooper 1853).

1839 - John Bell explored Peel River (Isbister 1845) and, in 1840, established Fort MacPherson for the Hudson's Bay Company on the lower part of the Peel. For details of its history and recent posts in the area, see Usher (1971: 83-94).

1844 - Bell extended his explorations down the Porcupine to its mouth at the Yukon River (Murray 1910: 2). The early history of LaPierre House is still uncertain in my own research to date. It was 'built originally as an outpost of Fort MacPherson, and, after the establishment of Fort Yukon, used in connection with the shipment of supplies and furs to and from the Yukon' (Murray 1910: 27, footnote 2). Its original location is also uncertain, but it must have been comfortably established by 1847 when Murray took his wife there to live for a year while he descended the Porcupine River (Murray 1910: 1-2, 26-28). The post was moved in 1851 (Hudson's Bay Company Archives Folio B. 200/b/29) and again around 1868 when the buildings were dismantled and floated down Bell River to their final location just above the mouth of Waters River (Hudson's Bay Company Archives Folio B. 200/b/36; McConnell 1891: 121D). The Hudson's Bay Company abandoned LaPierre House in 1891 (MacFarlane 1908: 273), but an independent trader named Jackson ran a small store there in the mid-1930's and attracted several Kutchin families to the area (Morlan, 1970, field notes).

1847 - Alexander Hunter Murray descended the Porcupine to its mouth and there established Fort Yukon, the westernmost post of the Hudson's Bay Company. Knowing that he was in Russian territory, Murray (1910: 95) anticipated resistance from representatives of the Russian American Trading Company. This resistance never came, however, and Murray established successful and active trade with Indians from several regions. In his journal he left valuable descriptions and drawings of Kutchin and other Indians.

1850 - Robert Campbell, another Canadian trader, journeyed down the Yukon River to Fort Yukon from his newly established post, Fort Selkirk, at the junction of the Lewes and Pelly Rivers. Soon thereafter Fort Selkirk was destroyed by 'jealous Tlingit..., and until the Klondyke Gold Rush of 1898 this upper Yukon country was virtually sealed off by a Tlingit blockade which successfully prevented whites from entering the area or Athabascans from leaving it' (McClellan 1964: 5).

1860's Two other traders (Hardisty 1867; Jones 1867) and the first missionary to enter the Porcupine region (Kirkby 1865) left brief descriptions of the Kutchin. Missionary zeal increased steadily among both Anglicans and Catholics working at both Fort MacPherson and Fort Yukon. Archdeacon Robert McDonald was especially influential as a result of a syllabic system by which he translated the Bible and the Prayer Book for the Kutchin. Native catechists were trained throughout the northern Yukon and were very potent missionizing influences.

1867 - William Healy Dall (1870: 102-115) visited Fort Yukon and described many interesting contacts with Kutchin and other Indians. His excellent descriptions of the aboriginal inhabitants of northwestern North America have provided the basis for subsequent classifications of Athabaskan speakers (Dall 1870, 1877). The purchase of Alaska by the United States carried with it a ban upon all encroachments by the Hudson's Bay Company (v. Dall 1870: 371-372), and a veritable eviction notice was served to the officers of Fort Yukon (Dawson 1889: 140B; International Boundary Commission 1918: 213). The post was then moved three times - to Howling Dog and Old Rampart - before a satisfactory location was found in 1890 at New Rampart House (Davidson 1903: 113; International Boundary Commission 1918: 227), just east of the 141st meridian, but this final location proved economically unfeasible and was abandoned in 1894.

1890's Trading with whalers wintering over at Herschel Island increased after the Hudson's Bay Company left New Rampart House.

1904 - Dan Cadzow, a private trader, descended the Porcupine to New Rampart House and opened a new trading post. He attracted widespread Indian and even Eskimo trade (Cadzow 1904-1912), and his services were enjoyed by the boundary survey parties in 1911 (International Boundary Commission 1918: 99, 227). A smallpox epidemic ravaged New Rampart House, and, by 1912, many families had left the area, some of them moving upstream to the mouth of Old Crow River. John Tizya, a Vunta Kutchin, had built a cabin there in 1906, and a new village began to take shape, particularly after a pair of white trappers (Shultz and Johnson) provided the location with a store. This was the beginning of Old Crow." (Morlan, 1973)

Other stores have flourished at Whitestone Village, Johnson Village and LaPierre House. Gradually native houses were built at Old Crow especially after the church moved there from New Ramparts in 1926. The R.C.M.P. built their barracks in 1928 (Welsh, 1970). The government added both a nursing station and a school in 1961.

Appendix Table III. (From Steigenberger *et al*, 1974)

ESTIMATES OF THE DOMESTIC HARVEST NEAR OLD CROW IN THE YUKON TERRITORY FOR 1971, 1972 AND 1973

POPULATION ESTIMATE OF APPROXIMATELY 250 RESIDENTS and 200 DOGS

Year	Location	Subsistence Population	Number of dogs	Fishing Method	Number of Nets	Fishing Time	Number of Fish Caught	Composition of catch	Assessment of catch
1971	Porcupine River Old Crow River	≈ 150	≈ 120	gillnet	-	Spring-Fall	≈ 13,000	Chum salmon ≈ 10,000 *Other species ≈ 3,000	Excellent Average
						TOTAL CATCH	≈ 13,000		
1972	Porcupine River	≈ 10	≈ 10	gillnet	1-6	Early May	≈ 650	Whitefish	Average
1972	Porcupine and Old Crow River	≈ 100	≈ 100	gillnet	1-18	May-Oct	≈ 3,000	*Other species	Average
1972	Porcupine River	≈ 100	≈ 100	gillnet	1-18	July-mid-Sept	81	Chinook salmon	Good
1972	Porcupine River	≈ 250	≈ 200	gillnet	1-18	Late Aug-Nov	≈ 4,570	Chum salmon	Average
1972	Porcupine River	≈ 250	≈ 200	gillnet	1-18	Oct-Nov	≈ 25	Coho salmon	Below average
1972	Old Crow River	≈ 30	≈ 20	gillnet	1-6	Sept-Nov	≈ 1,000	*Other species	Average
1972	Porcupine River	≈ 30	≈ 20	handlines	1-6	Nov-Dec	≈ 100	Burbot	Average
						TOTAL CATCH	≈ 9,425		
1973	Porcupine River	≈ 10	≈ 10	gillnet	1-2	Apr 20-May 10	117	*Other species	Average
1973	Porcupine River	≈ 15	≈ 10	gillnet	2-3	May 17-June 1	744	*Other species	Above average
1973	Porcupine River	≈ 50	≈ 30	gillnet	10-11	June	1,122	*Other species	Average
1973	Porcupine River	≈ 50	≈ 30	gillnet	4-8	July-Aug 12	≈ 1,120	*Other species ≈ 1,000 Chinook salmon $<$ 20 Chum salmon $<$ 100	Average Below average Average
1973	Porcupine River	≈ 50	≈ 30	gillnet	10	Aug 13-Sept	601	*Other species 320 Chum salmon 281	Average Average
1973	Porcupine River	≈ 250	≈ 200	gillnet	10-28	Sept-Oct 5	≈ 6,720	*Other species ≈ 900 Chum salmon ≈ 5,800 Coho salmon ≈ 20	Average Above average Above average
1973	Porcupine River	≈ 280	≈ 50	gillnet	[illegible]-16	Oct 31-Nov 8	$>$ 420	*Other species $>$ 200 Chum salmon $<$ 20 Coho salmon $>$ 200	Average Average Above average
1973	Old Crow River	0	0	-	0	Sept-Nov	0		
1973	Porcupine River	≈ 30	≈ 20	handlines	18	Nov 3-13	≈ 150	Burbot	Above average
						TOTAL CATCH	$>$ 10,948		

* Other species = grayling, sucker, pike, broad and humpback whitefish, inconnu, least cisco and burbot.

Appendix Table IV. The mean fork length and calculated weight of fish species common in the Old Crow domestic fishery. The mean fork lengths were determined from the length-frequency distribution in the 1972 gill net data. The weight-length relation is from Bryan (1973).

Scientific Name	Common Name	Fork Length (mm)	Mean Wt. (lbs)
Thymallus arcticus (Pallas)	Arctic grayling	330	0.86
Salveninus alpinus (Linnaeus)	Arctic char	-	2.5*
Oncorhynchus keta (Walbaum)	chum salmon	670	7.3
Catastomus catastomus (Forster)	longnose sucker	390	1.4
Esox lucius (Linnaeus)	northern pike	450	1.6
Coregonus nasus (Pallas)	broad whitefish	500	4.6
Coregonus clupeaformis (Mitchell)	humpback whitefish	440	1.46
Stenodus leucichthys nelma (Pallas)	inconnu	500	2.76
Coregonus sardinella (Valenciennes)	least cisco	270	0.54
Prosopium cylindraceum (Pallas)	round whitefish	-	-
Oncorhyncus tshawytscha (Walbaum)	chinook salmon	620	5.04
Coregonus autumnalis (Pallas)	Arctic cisco	-	1*
Lota lota (Linnaeus)	burbot	600	2*
Oncorhynchus kisutch (Walbaum)	coho salmon	580	4*

*Assigned weights - no weight-length regressions available.

Appendix Table V. (From Steigenberger et al, 1974)

ESTIMATES OF THE DOMESTIC HARVEST ON THE NORTH SLOPE OF THE YUKON TERRITORY FOR 1971, 1972 AND 1973

Year	Location	Subsistence Population	Number of Dogs	Fishing Method	Number of Nets	Fishing Time	Number of Fish Caught	Composition of Catch	Assessment of Catch
1971	Herschel Island	≈ 10	≈ 20	gillnet	2	mid-July-mid-Sept	≈ 1300	Arctic char ≈ 300 ciscoes ≈ 1000	Below average Average
1971	Komakuk Beach Dewline Station	≈ 4	1	gillnet	1	mid-Aug-Sept	≈ 200	Arctic char	Average
1971	Shingle Point	no data	-	-	-	-	-	-	-
						TOTAL CATCH	≈ 1500		
1972	Herschel Island	≈ 12	≈ 25	gillnet	2	Aug-Sept	> 2500	Arctic char ≈ 1000 Ciscoes > 1500	Good
1972	Komakuk Beach Dewline Station	4	0	gillnet	1	mid-Aug-Sept	≈ 250	Arctic char ≈ 200 Ciscoes ≈ 50	Average
1972	Shingle Point	no data	-	-	-	-	-	-	-
						TOTAL CATCH	≈ 2750		
1973	Herschel Island	12	32	gillnet	2	mid-Aug	≈ 80	Arctic char ≈ 30 Ciscoes ≈ 50	Poor
1973	Nanaluk Spit	12	32	gillnet	1	1 day late Aug	1	Arctic char	Poor
1973	Nanaluk Spit	12	32	sweep net	1-3	½ day late Aug	99	Arctic char	Poor
1973	Catton Point	12	32	sweep net	3	½ day late Aug	84	Arctic char 78 Ciscoes 6	Poor
1973	Komakuk Beach Dewline Station	4	0	gillnet	1	Aug 15-Sept	≈ 230	Arctic char ≈ 200 Ciscoes ≈ 30	Average
1973	Shingle Point	≈ 30	5	gillnet	1	July-Aug 21	Daily food	requirements	Average
1973	Shingle Point	5	0	gillnet	1	July-Aug 15	≈ 275	Ciscoe Broad whitefish	Average
1973	Shingle Point	5	0	gillnet	1-3	July 15-Sept	≈ 300	Ciscoe Arctic char Inconnu	Average
						TOTAL CATCH	> 1069		

Appendix Table VI. Fish catch Old Crow (from Stager, 1973).

Hunter/Trapper Family No.	(Chum) Dog Salmon	(Chinook) King Salmon	Grayling	Hump (sic) Whitefish	Little White-fish	Jack Fish	Losch	Sucker	Inconnu	Estimated Weight in pounds
1	200		20	75	20	25	30		50	1300
2			240			4				480
4	500			50	50	20	50	100	30	2600
5							8			15
6	1500	6	25	25	100	35	10	150	25	3715
8	400									1600
9	100		150	70		40			25	1000
10	350	7	15	110		50			32	1885
11			30	10	300	20	20	15	70	770
12	50			20		15			30	385
13	40									160
14	60			10	60	20		60	25	580
15	300		110	17	14	200	90	350	70	3025
16	150		20	7	11				3	675
17	300			30	30		20		20	1400
18	500		300		100	50		100		3000
19	165		10	25	80	80			16	1025
20	15		10	3	25	8	15	6	2	175
21	300		50	50	50	30	40	20	30	2035
23	50		10	10		10	10			325
24	100									500
26	200		60	30	30	20	20	30	30	1460
27	300		50	20		20	10	20	40	1895
Total Fishing Families = 22	5580	13	1100	562	870	647	323	851	498	30005

Appendix Table VII. Old Crow Fisheries 1961-1973 (from Stager, 1973).

Type	1967	1968	1969	1970	1971	1972	1973
Chinook	43	38	27	8	-	81	13
Chum	11,768	10,000	3,377	620	10,000	4,570	5,780
Coho	-	261	34	-	-	25	-
Whitefish	1,124	2,550	734	195	-	650	870
Other*	2,001	2,451	657	368	3,000	4,100	4,232
Totals	14,936	15,300	4,829	1,191	13,000	9,426	10,895

*Others - grayling, sucker, jackfish, hump whitefish, losch, inconnu.

Source: 1967-1970 Bissett and Meldrum, 1973: 37.

1971-1972 Steigenberger *et al*, December 1973: 42.

1973 Field data.

C H A P T E R   V I

GROUNDWATER CONTRIBUTION TO RIVERS OF THE PORCUPINE DRAINAGE BASIN, YUKON TERRITORY

by

R. O. VAN EVERDINGEN

Hydrology Research Division

Inland Waters Directorate

Environment Canada

Calgary, Alberta

for the

Fisheries and Marine Service

Department of the Environment

October, 1972

and

Environmental-Social Program

Northern Pipelines

Acknowledgements

The costs incurred for collection of the data included in this report were, in part, provided by the Environmental-Social Program, Northern Pipelines, of the Task Force on Northern Oil Development, Government of Canada.

The author wishes to express his appreciation to the staff of the Fisheries Service, Vancouver, who assisted during the course of the study. J. A. Banner of the Hydrology Research Division also deserves a special note of thanks.

1. Abstract

Discharge of groundwater contributes a significant portion of the flow in Bluefish River during the summer and fall, and almost all of the late summer, fall and winter flow in the South Fishing Branch of Porcupine River below Bear Cave Mountain. Total-dissolved-solids concentrations in the groundwater discharge are low, ranging from about 200 to about 350 mg/l, with Ca and HCO_3 as main constituents. Actual source of the groundwater has not yet been investigated. Perennial open water maintained by the groundwater discharge in the south fork of the Fishing Branch River provides an important spawning and overwintering area for chum and coho salmon.

Melting of permafrost, exposed along outside banks of meanders on Old Crow River, contributes water, dissolved solids (1000 to 1500 mg/l, main constituents Ca and SO_4), and suspended solids to streamflow. Impact on water quality in the river is not known as no survey of the magnitude of the phenomenon has been made.

Table of Contents

List of Figures

List of Tables

List of Appendices

2. Introduction

At the request of the Pacific Regional Office, Fisheries Service, Vancouver, a short reconnaissance study of groundwater contribution to the Bluefish River, Fishing Branch River and Old Crow River of the Porcupine River was carried out by R. O. van Everdingen and J. A. Banner, Hydrology Research Division, Inland Waters Directorate, Calgary. Transportation in the field, by helicopter and float equipped, fixed-wing aircraft, was arranged by J. E. Bryan, in charge of the Fisheries operation based in Old Crow, Yukon Territory.

2.1 Contributions to Streamflow in Rivers in Permafrost Areas

In general, four different sources may contribute water to streamflow in rivers in permafrost areas. Differences in chemical and physical character between waters from the various sources, as well as variations in the rates of contribution with the seasons, often make it possible to identify these sources. Where large lakes are present in a drainage basin, however, the storage, mixing, and delay in runoff may make identification of the sources extremely difficult. Although quantitative data are scarce for the area of interest at present, a qualitative assessment is still attempted here.

1. Runoff from taiga and tundra, generated by rainfall and snowmelt. Water temperature may range from just over 0°C to 20°C or more. Dissolved mineral content is low (<100 ppm). Organic content is often high, giving a yellowish or brownish colour to the water. Major contribution from this source is restricted to the snowmelt period and longer periods of rainfall.

2. Shallow groundwater, derived from the active layer or from unfrozen zones between the active layer and the permafrost. The temperature at discharge is usually less than 10°C. Dissolved mineral content is most often in the range between 100 and 500 ppm. The water is clear and normally colourless, unless it has picked up organic compounds. Discharge from this source generally ceases in early winter and resumes in the spring.

3. Subpermafrost groundwater, discharged into a river through unfrozen zones below the river channel. The temperature at discharge is relatively low (4-6°C), and constant throughout the year. Discharge rates may fluctuate with the season, depending on the size of the feeding reservoir, and on the sensitivity of the discharge outlets to encroachment of frost. The latter depends in turn on water temperature and discharge rate. Discharge may thus decrease and even stop later in the winter. If the discharge is continuous, appreciable stretches of river may be maintained free of ice through the winter; the discharge may also contribute to the growth of aufeis deposits (icings) downstream from the discharge area. The dissolved mineral content can range from low to extremely high values (150 to as much as 100,000 ppm). Organic content is usually absent, and the water is clear and colourless.

4. Melting permafrost, exposed in eroding banks along the outside of river meanders, and in so-called "thermokarst" areas. This source contributes relatively small quantities of water to streamflow, during late spring, summer and early fall. Melting may start shortly before break-up and will probably stop again shortly before freeze-up. The initial temperature of the water from this source is very low (<1°C). The dissolved mineral content may be high and, in addition, the water may carry a large proportion of suspended solids if the mineral matrix of the permafrost is fine-grained and the ice content large. The organic content is usually small.

Major areas of perennial discharge of subpermafrost water, represented in winter by stretches of open water of varying magnitude, may be important as overwintering and spawning areas for various anadromous fish species, e.g. chum and coho salmon, and Arctic char. Characteristics of such discharge areas, which are of importance in this respect, include the following:

a. Groundwater temperature - should be high enough in conjunction with the prevailing discharge rate to maintain a sizable open water reach throughout the winter. It should also be within the tolerance range of fish.

b. Dissolved oxygen content - may be very low at discharge, but turbulence will increase the oxygen content rapidly to the point where it is adequate to satisfy the oxygen demand of the fish.

c. Dissolved mineral content - should be within the tolerance range of fish and the lower food chain. This may rule out some of the deeper sources of groundwater with very high concentrations of dissolved solids. Toxic components should be absent.

d. Absence of fine sediment from the water and the substratum. The upward movement of sediment-free groundwater through riverbed alluvium in combination with flow in the river channel should maintain a clean, coarse sand and gravel substratum, enhancing conditions for hatching eggs, fry and fingerlings, when compared to reaches of river without the benefit of concentrated groundwater discharge.

Information will have to be gathered on a number of parameters to enable determination of the sources that contribute water to a particular reach of river at any particular time, and also to enable identification of the major discharge areas of subpermafrost water. The parameters include: water temperatures, chemical compositions, discharge rates and location and extent of unfrozen reaches and aufeis deposits during the winter.

3. Methods for the Reconnaissance Study

During the third week of July, 1972, three areas in the Porcupine River drainage basin were visited to investigate the sources contributing water to streamflow. Transportation in the field was by helicopter and float-equipped, fixed-wing aircraft. Measurements were carried out, and water samples were taken for subsequent laboratory analysis. Instruments and methods used, and agencies that provided analytical services, are identified in Appendix I. The locations studied are marked on Figures 1, 3 and 5. The results of observations, measurements and analyses are described below. The figures and tables are all presented after the results for the Bluefish, Fishing Branch and Old Crow Rivers (pages 7-20).

4. Results

4.1 Bluefish River

Study of air photographs, taken on July 15, 1951, revealed that dry reaches and reaches carrying flowing water alternate in the lower course of the Bluefish River during summer. Reaches with flowing water, identified on the air photographs, are marked by heavier lines on Figure 1. The area studied on July 19, 1972, is located just downstream from the point of resumption of flow after a considerable stretch of dry riverbed (with only scattered ponds of stagnant water). Aerial observations indicated that the resumption of flowing conditions here was just as sudden as the renewed flowing conditions farther downstream, northwest of Twin Lakes. The alluvium in this part of the Bluefish River is underlain by lower Paleozoic limestone and dolomitic limestone.

Tables I, II and III present results of measurements and of chemical analyses on samples taken: (1) from the river itself; (2) from a small pond near the right bank, fed by seepage through fine-grained alluvium; and (3) from a small spring emerging from fine gravel in the right bank of the channel (locations are identified by numbers 1 to 3 on Figure 1). The water was clear and colourless in all three cases. Temperatures ranged from 12.2 to 14.8°C. Figure 2 presents a semilogarithmic plot of the major-ion concentrations found in the three samples.

4.2 Fishing Branch River Near Bear Cave Mountain

Discharge of groundwater into the Fishing Branch River of the Porcupine River, from large springs near Bear Cave Mountain, represents a major contribution to annual streamflow in this river. It appears to be the only source of sustained streamflow for the lower reach of the Fishing Branch River during the summer, fall and winter. Aerial photographs taken on July 15, 1951, indicated that the river carried water only in the reach marked by heavier lines on Figure 3. The start of flowing conditions at site 4 on Figure 3 was confirmed during the visit to the area on July 21, 1972. Middle Devonian limestones (and some shale) of the Bear Rock or Hume Formation are exposed on the west side of the river and on Bear Cave Mountain.

In the last stagnant pond upstream from site 4, water temperature and conductivity were 16.2°C and 145 micromhos/cm, respectively. Table IV gives the analysis for a sample from this pond. The water in the pond was clear, but slightly brownish in colour. The gravel bed was dirty and stained brown. At the first point of discharge of groundwater, the water temperature was 11°C, and the conductivity 270 micromhos/cm. The water was clear and colourless, and the gravel still somewhat dirty. Water discharging from the gravel in the riverbed and on both sides of the channel downstream from this point was perfectly clear and colourless, with a temperature of 4.5°C and a conductivity of 275 to 285 micromhos/cm.

The main springs around location 5 had water temperatures of 4.5 to 6.0°C, and a conductivity of 310 micromhos/cm. The analysis for the springwater is given in Table V. The riverwater at this point had a temperature of 8.0°C and conductivity fluctuating between 290 and 310 micromhos/cm. At location 6, about halfway between 4 and 5, a number of seepages and small springs had temperatures between 4.5 and 6.0°C, and conductivities between 285 and 290 micromhos/cm. The temperature of the riverwater at site 6 was 5.0°C, and its conductivity 285 micromhos/cm. Semilogarithmic plots of major-ion concentrations in the south fork of Fishing Branch River samples are given in Figure 4. Both riverwater and direct spring discharge at sites 5 and 6 were perfectly clear and colourless. The substratum in the spring sources consists of clean, medium to coarse sand and fine gravel. "Quick" conditions exist in the loose granular material in some of the spring sources. This will undoubtedly account, at least in part, for the lack of smaller grainsizes in the substratum.

The groundwater discharge, through a combination of water temperature and flow rate, maintains the only major open water reach during the winter in the Porcupine River drainage in Canada. Open water has been observed over a distance of at least 15 miles below the springs. Aufeis deposits appear not to be associated with the springs.

As this discharge area is the only known spawning area for chum and coho salmon in the Procupine River drainage, it may be desirable to protect it against adverse man-made influences (increased sediment load, etc.). It may also be desirable to investigate the flow system that feeds the springs, to identify the area of recharge and the major flow paths, because these may also have to be protected against deterioration.

4.3 Old Crow River

Permafrost, occurring in Cenozoic silt and mud from a depth of about 1.5 feet below the taiga surface downwards, is slowly melting where exposed in the high banks along the outside of a number of meanders of the Old Crow River. At the location indicated by sites 1 and 2 on Figure 5, samples were taken of the melting permafrost on July 20, 1972. Suspended solids in the samples were allowed to settle; the supernatant was subsequently filtered, and analysed in the laboratory for major ions. Results of the water analyses for the upper three feet thick brown layer, and for a mixture of the upper brown and underlying grey layers are given in Tables VI and VII; Figure 6 presents a semilogarithmic plot of the ion concentrations.

The sediments remaining after settling and filtration were analysed for grainsize distribution. Results for the brown layer, the underlying grey layer, and for a mixed sample are presented in Figure 7. The water-to-sediment ratio was 39:61 for the sample from the brown layer, and 56:44 for the mixed sample. These figures, although giving order of magnitude only, indicate that segregated ice was present in the permafrost. They also indictate that the melting permafrost contributes to the silt- and clay-size fraction of suspended sediments in the river. The water analyses indicate that a relatively large amount of dissolved solids may be contributed by the melting permafrost.

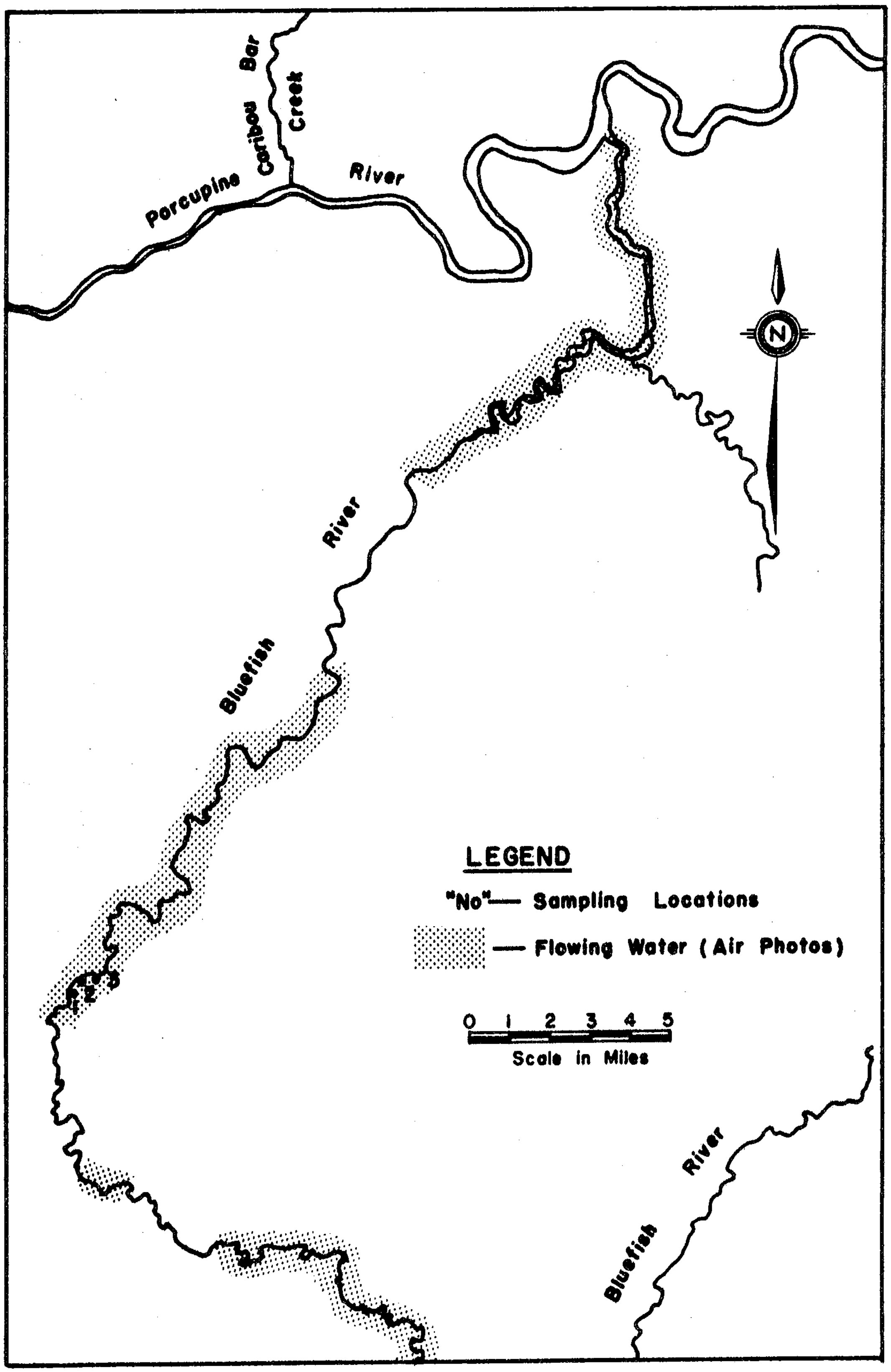


FIGURE I. Location Map, Bluefish River
Scale 1:250,000

Table I. Water chemistry results from the Bluefish River (Location 1, Figure 1).

No: E72-20

Name: Bluefish River just below dry reach 19-07-72

Location: 03/72/03634
116N(E½)

		e.p.m	%
Temperature, °C	(14.8)		
Conductivity, micromhos/cm	266 (270)		
pH, units	7.9 (7.8)		
Dissolved oxygen	(7.6)		
Ca	45.1	2.2504	78.5
Mg	6.9	0.5672	19.8
Sr	-		
Na	0.8	0.0347	1.2
K	0.6	0.0153	0.5
Li	-		
Fe	<0.010		
Mn	0.015		
Cu	0.005		
Pb	<0.004		
Zn	0.016		
HCO_3	161.0	2.6394	93.0
CO_3	0.0		
SO_4	8.2	0.1707	6.0
Cl	1.0	0.0282	1.0
F	-		
NO_3	-		
PO_4	0.010		
SiO_2	2.1		
Sum of constituents	225.8		

Eh = + 452 mvolt

O_2 diss. 7.6 ppm

Error +0.52%

where,

( ) values in parentheses refer to field measurements

Table II. Water chemistry results from the Bluefish River (Location 2, Figure 1).

No.: E72-21 Name: Bluefish River, spring pond 19-07-72

Location: 03/72/03635
116N(E½)

		e.p.m.	%
Temperature, °C	(12.2)		
Conductivity, micromhos/cm	394 (390)		
pH, units	7.9 (7.6)		
Dissolved oxygen	(6.4)		
Ca	67.9	3.3882	78.3
Mg	11.0	0.9083	21.0
Sr	-		
Na	<0.6	0.0217	0.5
K	0.4	0.0102	0.2
Li	-		
Fe	0.10		
Mn	0.045		
Cu	0.002		
Pb	0.004		
Zn	0.003		
HCO_3	249	4.0791	96.8
CO_3	0.0		
SO_4	5.7	0.1186	2.8
Cl	0.5	0.0141	0.3
F	-		
NO_3	-		
PO_4	0.003		
SiO_2	2.6		
Sum of constituents	337.7		

Eh = + 433 mvolt Error +1.37%

O_2 diss. 6.4 ppm

where,

( ) values in parentheses refer to field measurements

Table III. Water chemistry results from the Bluefish River (Location 3, Figure 1).

No.: E72-22 Name: Bluefish River, spring from gravel 19-07-72

Location: 03/72/03636
116N(E½)

		e.p.m.	%
Temperature, °C	(14.5)		
Conductivity, micromhos/cm	317 (310)		
pH, units	7.8 (7.6)		
Dissolved oxygen	(1.2)		
Ca	51.1	2.5498	74.4
Mg	10.1	0.8274	24.1
Sr	-		
Na	0.8	0.0347	1.0
K	0.6	0.0153	0.4
Li	-		
Fe	0.10		
Mn	0.010		
Cu	<0.002		
Pb	<0.004		
Zn	<0.001		
HCO_3	194	3.1793	95.7
CO_3	0.0		
SO_4	5.5	0.1145	3.4
Cl	1.0	0.0282	0.8
F	-		
NO_3	-		
PO_4	0.010		
SiO_2	2.6		
Sum of constituents	265.8		

Error +1.56%

O_2 diss. 1.2 ppm

where,

( ) values in parentheses refer to field measurements

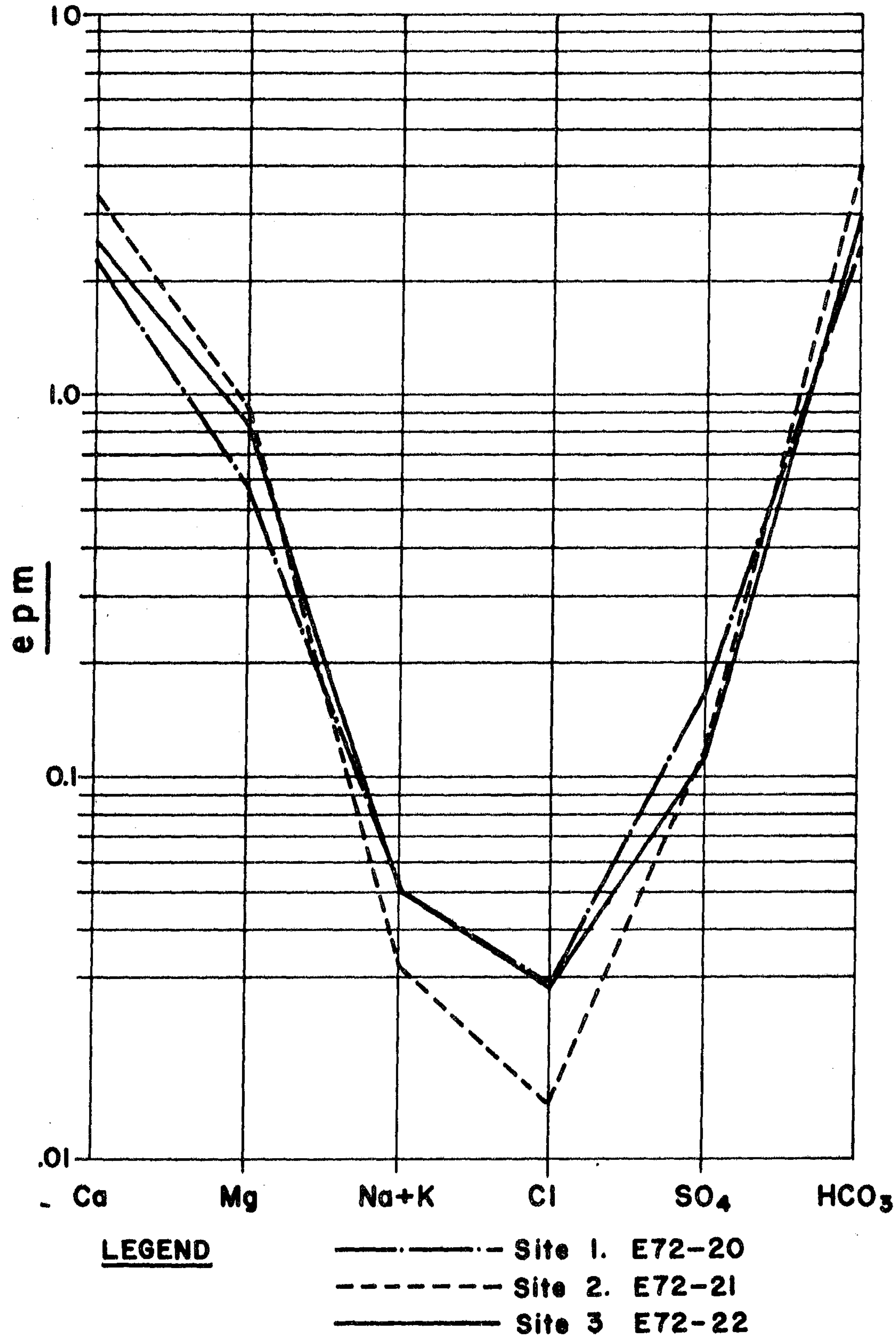


FIGURE 2. Semilog plot of major-ion concentrations in water samples from the Bluefish River (Figure 1). (equivalents per million)

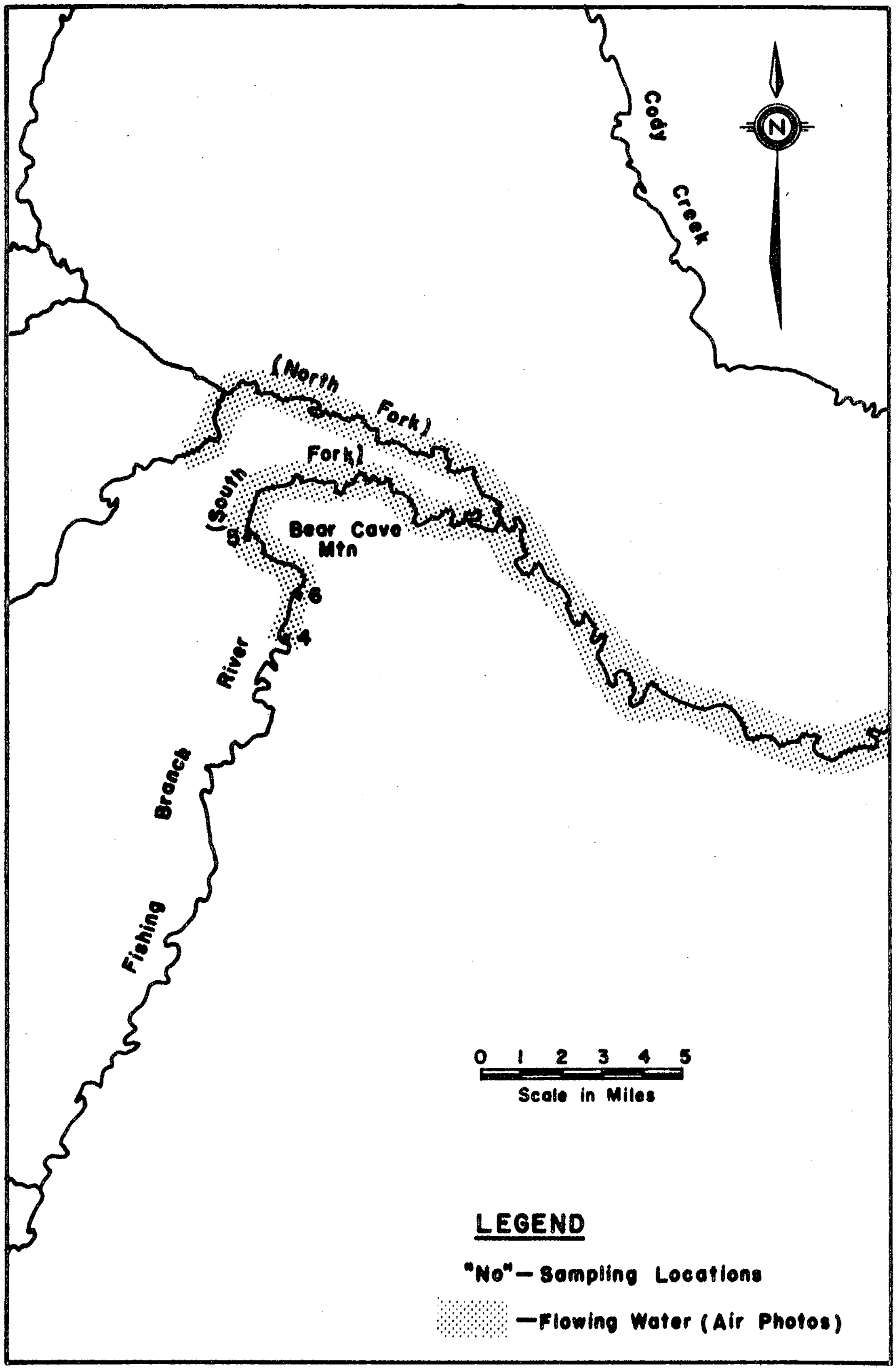


FIGURE 3. Location Map, Fishing Branch River
Scale 1:250,000

Table IV. Water chemistry results from the south fork of the Fishing Branch River (Location 4, Figure 3).

No.: E72-23 — Name: South Fishing Branch, last pond in dry reach 21-07-72

Location: 116J

		e.p.m.	%
Temperature, °C	(16.2)		
Conductivity, micromhos/cm	138 (145)		
pH, units	7.8 (7.7)		
Dissolved oxygen	(9.0)		
Ca	24.8	1.2375	78.7
Mg	3.7	0.3052	19.4
Sr	-		
Na	<0.6	0.0217	1.4
K	0.3	0.0076	0.5
Li	-		
Fe	0.50		
Mn	0.010		
Cu	0.003		
Pb	<0.004		
Zn	0.004		
HCO_3	82.2	1.3477	93.6
CO_3	0.0		
SO_4	3.6	0.0749	5.2
Cl	0.6	0.0169	1.2
F	-		
NO_3	-		
PO_4	0.011		
SiO_2	2.2		
Sum of constituents	118.5		

Error +4.4%

where,

( ) values in parentheses refer to field measurements

Table V. Water chemistry results from the south fork of the Fishing Branch River (Location 5, Figure 3).

No.: E72-24 Name: South Fishing Branch Springs 21-07-72

Location: 116J

		e.p.m.	%
Temperature, °C	(4.5 @ 5.0)		
Conductivity, micromhos/cm	316 (310)		
pH, units	7.6 (7.6)		
Dissolved oxygen	(6.4)		
Ca	46.9	2.3403	71.1
Mg	9.5	0.7772	23.6
Sr	-		
Na	3.5	0.1521	4.6
K	0.9	0.0230	0.7
Li	-		
Fe	0.10		
Mn	0.010		
Cu	0.007		
Pb	0.004		
Zn	0.063		
HCO_3	169.6	2.7794	85.3
CO_3	0.0		
SO_4	17.9	0.3726	11.4
Cl	3.8	0.1071	3.3
F	-		
NO_3	-		
PO_4	0.011		
SiO_2	2.5		
Sum of constituents	254.7		

Error +0.51%

where,

( ) values in parentheses refer to field measurements

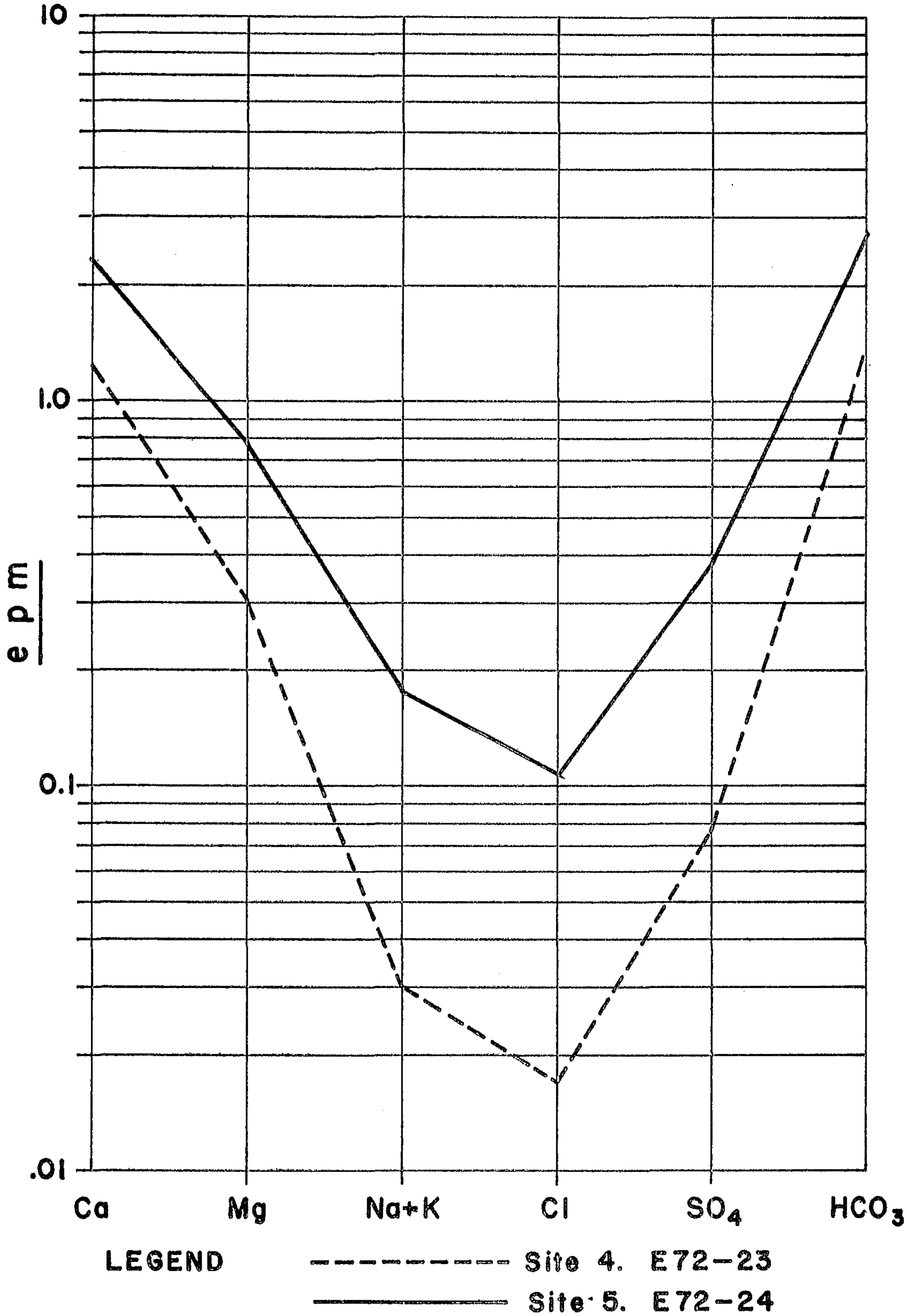


FIGURE 4. Semilog plot of major-ion concentrations in water samples from the south fork of the Fishing Branch River (Figure 3). (equivalents per million)

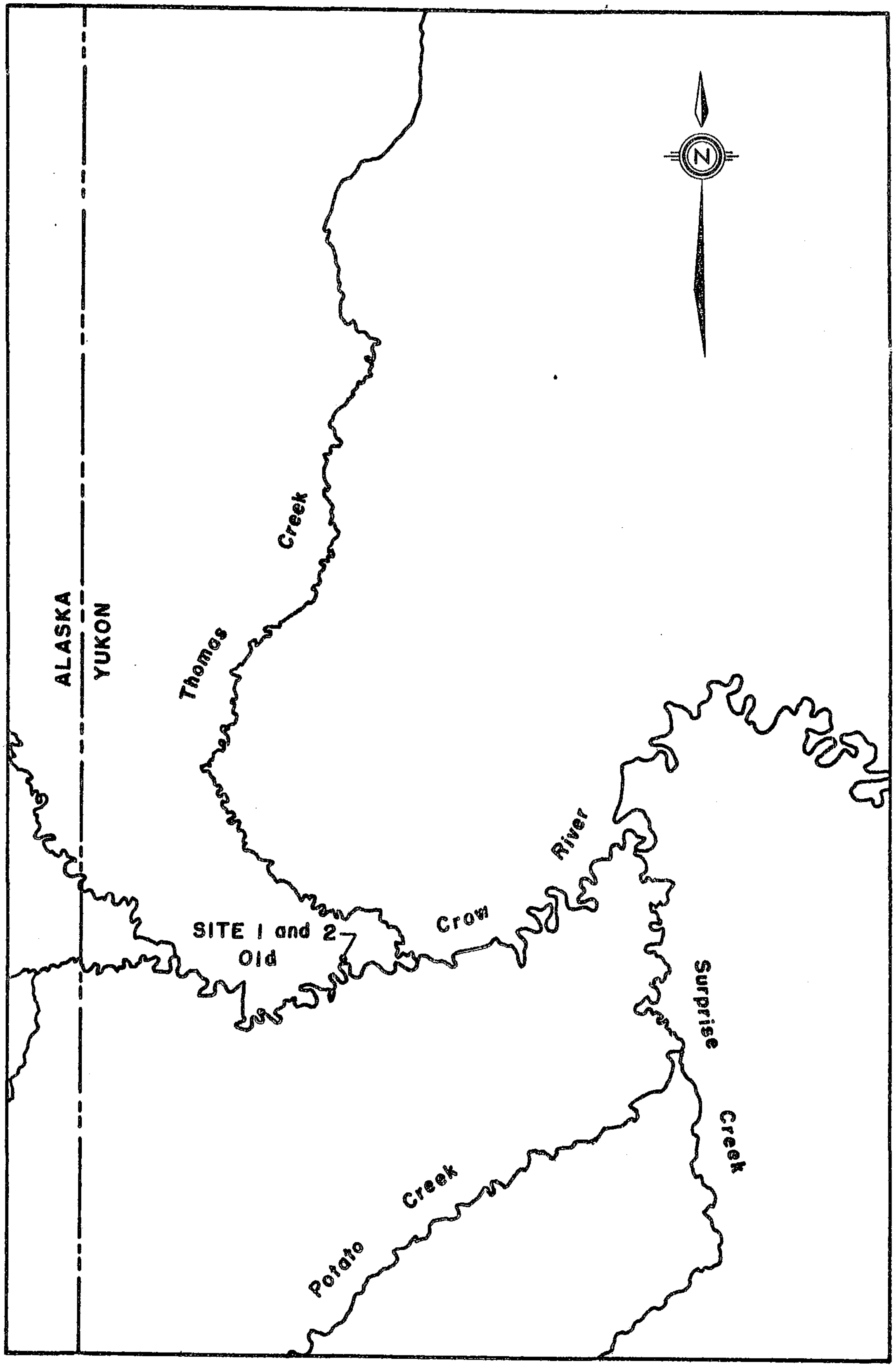


FIGURE 5. Location Map, Old Crow River
Scale 1:250,000

Table VI. Water chemistry results from the melting brown permafrost of the Old Crow River (Site 1, Figure 5).

No.: E72-40   Name: Melting brown permafrost Old Crow River 20-07-72

Location: 117B

Water constituted 38.6% of original wet sample, by weight.

		e.p.m.	%
Temperature, °C	(0.0)		
Conductivity, micromhos/cm	1856 (1650)		
pH, units	7.9		
Dissolved oxygen	0.0		
Ca	303	15.1197	69.7
Mg	68.4	5.6237	25.9
Sr	-		
Na	19.6	0.8522	3.9
K	4.0	0.1023	0.5
Li	-		
Fe	-		
Mn	-		
Cu	-		
Pb	-		
Zn	-		
HCO_3	343	5.6188	26.0
CO_3	0.0		
SO_4	752	15.6566	72.5
Cl	11.3	0.3186	1.5
F	-		
NO_3	-		
PO_4	0.094		
SiO_2	5.0		
Sum of constituents	1506.2	Error ±0.24%	

Ion Activity products:

Suspended solids: 38.6 mg/l

	T = 22.9°C	T = 0.0°C
CaSO4	-4.839	-4.818
Dolom.	-14.789*	-15.305*
Calc.	-7.192*	-7.450*

where,

* saturated solution
( ) values in parentheses refer to field measurements

Table VII. Water chemistry results from the melting mixture of grey and brown permafrost of the Old Crow River (Site 2, Figure 5).

No.: E72-41 | Name: Melting permafrost (grey and brown) Old Crow River 20-07-72

Location: 117B

		e.p.m.	%
Temperature, °C	0.0		
Conductivity, micromhos/cm	1358 (1180)		
pH, units	7.9		
Dissolved oxygen	0.0		
Ca	198	9.8802	64.6
Mg	53.8	4.4284	29.0
Sr	-		
Na	20.3	0.8826	5.7
K	4.0	0.1023	0.7
Li	-		
Fe	-		
Mn	-		
Cu	-		
Pb	-		
Zn	-		
HCO_3	340	5.5788	36.0
CO_3	0.0		
SO_4	462	9.6188	62.0
Cl	11.2	0.3158	2.0
F	-		
NO_3	-		
PO_4	0.072		
SiO_2	4.1		
Sum of constituents	1093.9	Error +0.71%	

Ion Activity products:

T = 22.0°C

Suspended solids: 55.8 mg/l

$CaSO_4$	-5.152
Dolom.	-15.013*
Calc.	-7.342*

where,

* saturated solution

( ) values in parentheses refer to field measurements

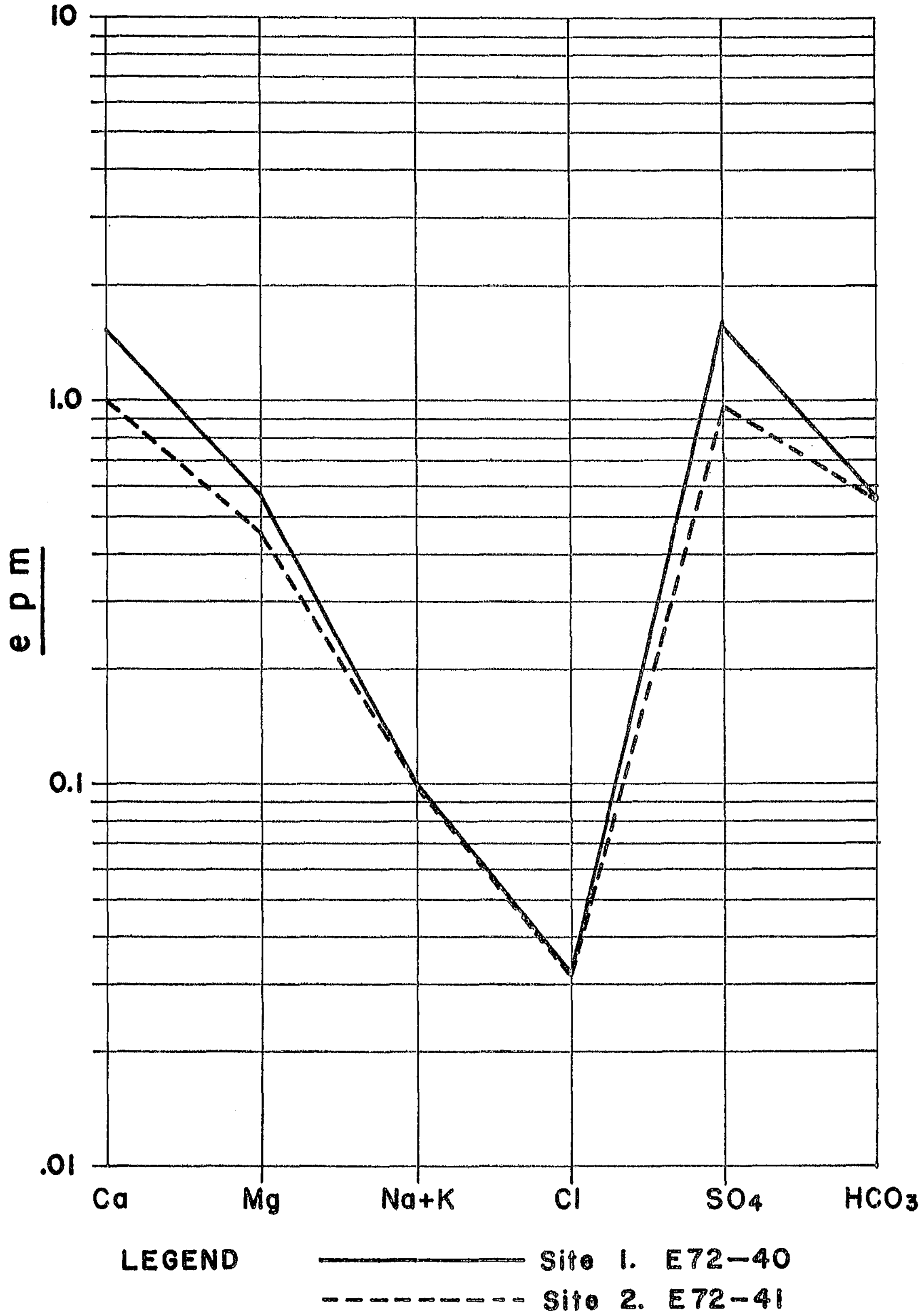


FIGURE 6. Semilog plot of major-ion concentrations in water released from melting permafrost along Old Crow River (Figure 5). (equivalents per million)

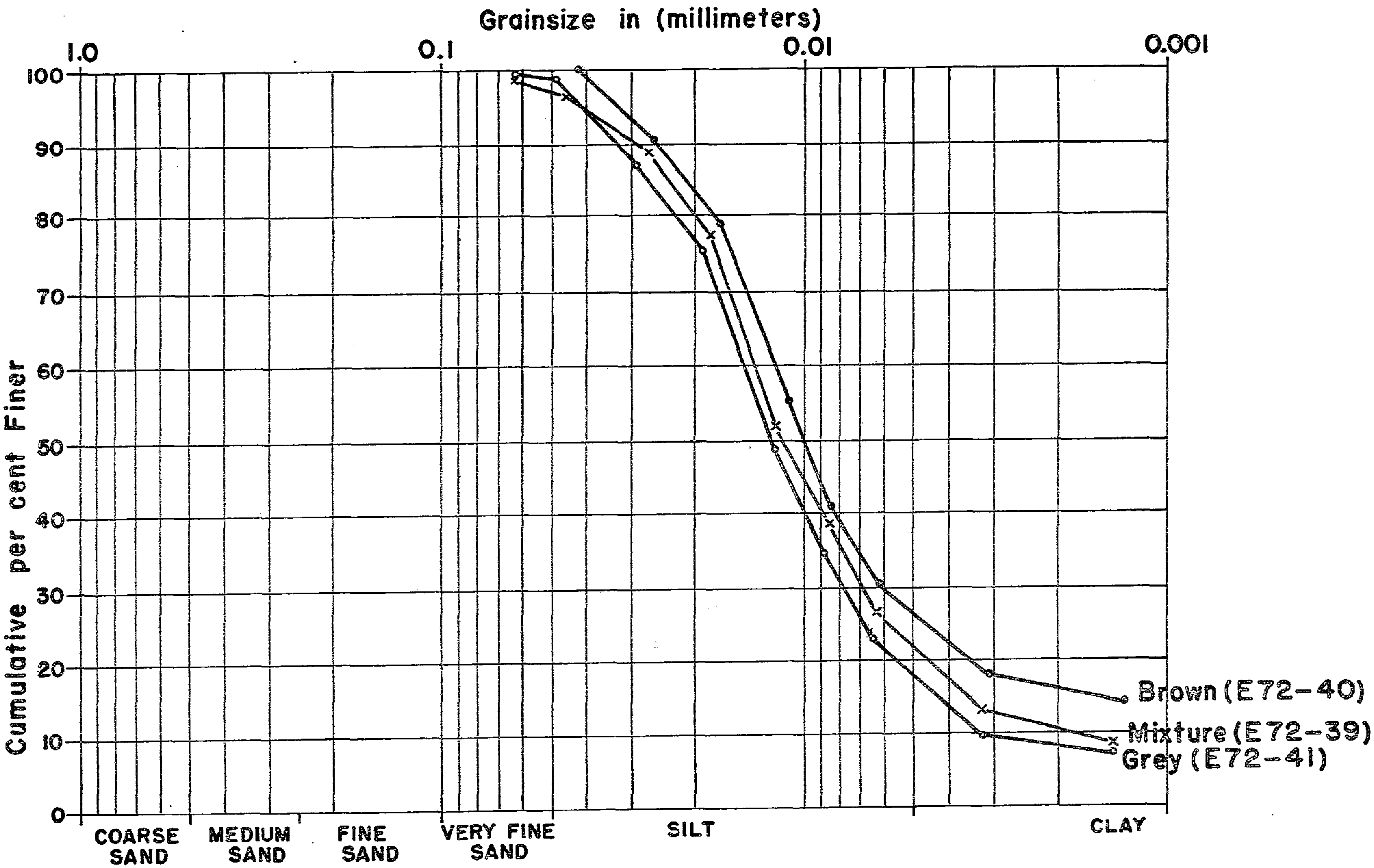


FIGURE 7. Results of grainsize analysis of suspended solids released from melting permafrost along the Old Crow River.

5. Conclusions

Ratios of major-ion concentrations for the Bluefish, Fishing Branch and Old Crow Rivers are presented in Table VIII. The values in Table VIII indicate the range of the ion ratios for the various sources sampled, which were all related to groundwater, with the possible exception of the Fishing Branch River sample from location 4 (Figure 3). The latter stands out through: low dissolved solids concentration, high oxygen content, a high Ca/Mg ratio, and a high temperature. The sample from the Fishing Branch River springs at location 5 (Figure 3), on the other hand, is distinguished by low water temperature, high Na/K ratio, low (Ca+Mg)/(Na+K) and HCO_3/SO_4 ratios, and a relatively low SO_4/Cl ratio. The latter two are the result of relatively high SO_4 and Cl concentrations. The tentative conclusions are:

(1) samples 1 to 3 (Figure 1, Bluefish River) represent largely drainage from the active zone, possibly with a minor contribution from deeper groundwater;

(2) sample 4 (Figure 3, Fishing Branch River) contains a high proportion of direct runoff from precipitation, with a smaller contribution by drainage from the active zone;

(3) sample 5 (Figure 3, Fishing Branch River) represents perennial discharge of groundwater through unfrozen zones in the permafrost, possibly with a minor contribution from the active zone during the summer months.

Of the locations studied, only the springs near Bear Cave Mountain on the south fork of the Fishing Branch River maintain an open water area during the winter. Wherever major open water is found in rivers in the permafrost area throughout the winter, groundwater discharge can be assumed to be responsible (unless large lakes form part of the drainage system). In many cases, detailed investigation can be expected to reveal that subpermafrost water, ascending through unfrozen zones in the permafrost below or beside the river channel, is the source for such discharge.

The clean river gravels that can be associated with major discharge areas would be an attractive source of clean granular material for construction purposes. On the other hand, the "quick" conditions sometimes associated with high-rate upward movement of groundwater would be unfavourable or even hazardous for any engineering structures (bridges, pipeline crossings, etc.). Those discharge areas that are

Table VIII. Comparison of major-ion ratios (in epm/epm) for the various sample sites in the Bluefish, Fishing Branch and Old Crow Rivers.

	Ca/Mg	Na/K	$\frac{Ca+Mg}{Na+K}$	HCO_3/SO_4	SO_4/Cl
Bluefish River					
Site 1	3.97	2.27	56.34	15.46	6.05
Site 2	3.71	<2.55*	>119.0*	34.36	8.42
Site 3	3.07	2.27	67.62	27.77	4.06
Fishing Branch River					
Site 4	4.07	<3.39*	>45.7*	17.97	4.43
Site 5	3.00	6.62	17.81	7.46	3.48
Old Crow River (permafrost filtrates)					
Site 1	2.69	8.33	21.73	0.36	49.13
Site 2	2.20	8.63	14.59	0.58	30.46

*Note: As sodium concentrations were below the limits employed in the analyses, only maximum and minimum values can be given for Na/K and Ca+Mg/Na+K, respectively.

favoured "one-only" spawning areas for some fish species will have to be protected, regardless of their value as construction sites. In addition, the recharge areas and main flow paths of the water discharged by these springs may have to be identified to enable adequate protection of the entire flow system.

The water samples from melting permafrost along Old Crow River (Figure 5), with very low HCO_3/SO_4 and high SO_4/Cl ratios, resulting from large SO_4 concentrations, are similar to samples from silty tertiary and quaternary deposits elsewhere. The melting permafrost contributes water, dissolved solids and suspended solids to streamflow. This occurrence indicates, qualitatively and on a small scale, the effects to be expected wherever development or construction activities lead to additional exposure and degradation of permafrost along riverbanks. For a quantitative assessment of such effects, further studies would be necessary to determine the rate of permafrost degradation and its relative contribution of suspended and dissolved solids.

Appendix Table I. Summary of the instruments and methods used in water chemistry analyses including agencies which provided analytical services.

pH and redox potential:

- Corning Model 6 pH and millivolt meter
- Fisher #13-639-52 saturated calomel reference electrode
- Fisher #13-639-102 platinum electrode
- Sargent #S-30072-15 combination glass and reference electrode

Electrical conductivity:

- Beckman Solubridge type RB-338, 50-8000 micromhos/cm
- manual temperature compensation 0-50^{o}C
- conductivity cell VS-2

Temperature:

- Atkins Technical Incorporated, Model 3L01, portable electronic thermometer
- thermistor probes Atkins #3
- mercury thermometer

Dissolved oxygen, CO_2 and H_2S:

- Hach Chemical Company test kit OX-2-P
- Hach Chemical Company test kit CA-23
- Hach Chemical Company test kit HS-1

Water samples:

- collected in 1-liter polyethylene bottles, were analysed by standard methods by the Western Regional Laboratory, Water Quality Branch, in Calgary

Grainsize analyses:

- on samples of "melting permafrost" were performed by the Institute of Sedimentary and Petroleum Geology, Geological Survey of Canada, in Calgary