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Northern Yukon Fisheries Studies, 1971 - 1974. Volume 2

Compiled and edited by L.W. Steigenberger
M.S. Elson P.G. Bruce Y.E. Yole

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NORTHERN YUKON FISHERIES STUDIES

1971 - 1974. VOLUME 2.

Compiled and Edited

by

L. W. STEIGENBERGER

M. S. ELSON

P. G. BRUCE

Y. E. YOLE

Northern Operations Branch
Fisheries and Marine Service
Department of the Environment

for the

Environmental-Social Program
Northern Pipelines

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Environmental-Social Committee
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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.

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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 by the Environmental-Social Committee, Northern Pipelines, Task Force on Northern Oil Development. 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]

This is the second of a series of volumes being prepared as a compilation of available information concerning freshwater aquatic habitats in northern Yukon, with emphasis on fisheries research. Volume 1 provided preliminary information concerning winter conditions in northern Yukon rivers, detailed information on fish populations utilizing specific areas of streams near the proposed southern pipeline route, and detailed chemical appraisals of two groundwater sources near the southern pipeline route. An evaluation of historical and present day exploitation of fish stocks in the northern Yukon Territory was included.

In Chapter I of this volume, summaries are given of the reproductive biology of fish found in northern Yukon freshwaters. The information is drawn from a preliminary bibliography of international literature concerning twenty-four species of fish. Chapter II details a study of fish populations and their habitat in rivers and lakes in the vicinity of Old Crow in the fall, at the time of freeze-up. Chapter III outlines a study of fish species present in the Porcupine River and in several lakes near Old Crow with emphasis on the availability of overwintering habitat for fish. Chapter IV summarizes the results of invertebrate sampling in rivers and lakes near proposed pipeline routes in the northern Yukon. Chapter V presents the results of studies conducted to establish reliable criteria for the aging of northern fish, both anadromous and resident freshwater species.

The information contained in the reports in both volumes is intended to provide preliminary appraisals 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 the conduct of industrial activity in the North.

Footnotes

1. Bryan, J. E. 1973. The influence of pipeline development on freshwater fishery resources of northern Yukon Territory. Aspects of research conducted in 1971 and 1972. Northern Operations Branch. Fisheries Service, Department of the Environment. Environmental-Social Committee. Task Force on Northern Oil Development. Report No. 73-6.

2. McCart, P. J. 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.

CHAPTER I

A PRELIMINARY BIBLIOGRAPHY AND SUMMARIES OF SPAWNING INFORMATION FOR FISH SPECIES PRESENT IN FRESHWATERS OF NORTHERN YUKON TERRITORY

by

M. S. ELSON

for the

Environmental-Social Program
Northern Pipelines

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

1. Abstract

Summaries are given of the reproductive biology of twenty-four species of freshwater and anadromous fish found in freshwaters of the northern Yukon Territory from approximately 65°N latitude to the coast of the Beaufort Sea. The information is drawn from a preliminary bibliography of international literature concerning the twenty-four species.

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Note: Data for Tables III-IX inclusive extracted from:

Steigenberger, L. W., R. T. DeLury, G. J. Birch and J. Fisher. 1973. Fish resources of the northern Yukon, fish survey 1972 base data, Appendix Volume I. Environmental-Social Committee, Task Force on Northern Oil Development. (Unpublished computer listing of data.)

2. Introduction

The discovery of oil at Prudhoe Bay on the Alaskan north slope in 1968 prompted proposals for the construction of oil and gas pipelines across Canadian Territory in the northern Yukon and Mackenzie River Valley. The potential impact on fishery resources in these areas resulted in the formation of scientific study groups by both government and industry to collect baseline fisheries data in broad corridors along proposed pipeline routes.

Specific biological information was minimal for the twenty-four species of freshwater and anadromous fish (Table I, Table II) inhabiting the northern Yukon Territory from 65°N latitude to the Arctic coast. The area is drained by both Pacific and Arctic river systems, notably the Porcupine River (Pacific) and Peel River (Arctic) and those rivers flowing directly into the Yukon section of the Beaufort Sea (Figure 1). As one of the first steps in the study of northern Yukon fisheries resources, it was decided to assemble a preliminary bibliography of available information concerning those species known to be present in the Porcupine River and in north coast drainages. The information was gathered without regard to geographic areas. The bibliography was subsequently enlarged to include references to those species inhabiting the Yukon section of the Peel River and to fisheries research conducted in northern Yukon since 1970.

It is recognized that fish populations are most susceptible to disruption during their spawning periods. The types of anticipated potential impact on spawning fish stocks by pipeline activity included the deflection of migrating spawning populations, the removal of spawning gravel, siltation on eggs, alevins, fry or juveniles, the removal or contamination of sufficient water for spawning, and interference with actual spawning activity. Spawning grounds within the northern Yukon were largely unknown, and as one tool in the location of these areas, summaries of spawning information were compiled from the available literature for the same species without regard to geography. It was thought that a basic knowledge of spawning ground preferences by the same species in other areas would be valuable in the identification of suitable spawning areas in northern Yukon.

The scientific classification of many northern fish species is complicated, especially for some members of the whitefish groups, where sometimes dozens of species have been described but their relationships are poorly understood. Also, in some cases the same species may have been given different names in North America, U.S.S.R. and in Europe.

For example, McPhail and Lindsey (1970) include several types of humpback whitefish in a broad group known as the "*Coregonus clupeaformis*" complex, while Berg (1948) separates one member of this group into 32 types, races or subspecies. In the literature search, attempts were made to adhere as closely as possible to the nomenclature given in McPhail and Lindsey (1970), but in some cases information extracted from the international literature may describe different species and may not be directly applicable to the behaviour of fish in northern Yukon. This, combined with the certainty of some geographic variation in spawning activity of the same species in different areas, may limit the effectiveness of this information in delineating potential spawning grounds in northern Canada. The information presented in this paper should be viewed as general reference material, and, if that is borne in mind, the material will undoubtedly be of value to future researchers.

Table I. Fish species present in northern Yukon Territory. Not all species are present in each of the three major drainages (Peel River, Porcupine River, Beaufort Sea drainages).

Arctic char - _Salvelinus alpinus_ (Linnaeus)

Arctic cisco - _Coregonus autumnalis_ (Pallas)

Arctic grayling - _Thymallus arcticus_ (Pallas)

Arctic lamprey - _Lampetra japonica_ (Martens)

Broad whitefish - _Coregonus nasus_ (Pallas)

Burbot - _Lota lota_ (Linnaeus)

Chum salmon - _Oncorhynchus keta_ (Walbaum)

Coho salmon - _Oncorhynchus kisutch_ (Walbaum)

Chinook salmon - _Oncorhynchus tshawytscha_ (Walbaum)

Flathead chub - _Platygobio gracilis_ (Richardson)

Fourhorn sculpin - _Myoxocephalus quadricornis_ (Girard)

Humpback whitefish - _Coregonus clupeaformis_ (Mitchill)

Inconnu - _Stenodus leucichthys nelma_ (Pallas)

Lake chub - _Couesius plumbeus_ (Agassiz)

Lake trout - _Salvelinus namaycush_ (Walbaum)

Least cisco - _Coregonus sardinella_ (Valenciennes)

Longnose dace - _Rhinichthys cataractae_ (Valenciennes)

Longnose sucker - _Catostomus catostomus_ (Forster)

Ninespine stickleback - _Pungitius pungitius_ (Linnaeus)

Northern pike - _Esox lucius_ (Linnaeus)

Pond smelt - _Hypomesus olidus_ (Pallas)

Round whitefish - _Prosopium cylindraceum_ (Pallas)

Slimy sculpin - _Cottus cognatus_ (Richardson)

Trout-perch - _Percopsis omiscomaycus_ (Walbaum)

TABLE II. Spawning periods of fish species present in the Peel River, Porcupine River and Beaufort Sea drainages within the northern Yukon Territory.

SPECIES			DRAINAGE		
Common Name	Scientific Name	Spawning Period*	Porcupine	Beaufort	Peel
Arctic grayling	*Thymallus arcticus*	S	X	X	X
Arctic char	*Salvelinus alpinus*	F		X	X
lake trout	*Salvelinus namaycush*	F		X	
coho salmon	*Oncorhynchus kisutch*	F	X		
chinook salmon	*Oncorhynchus tshawytscha*	F	X		
chum salmon	*Oncorhynchus keta*	F	X		
inconnu	*Stenodus leucichthys*	F	X	X	X
humpback whitefish	*Coregonus clupeaformis*	F	X	X	
round whitefish	*Prosopium cylindraceum*	F	X	X	X
broad whitefish	*Coregonus nasus*	F	X	X	
Arctic cisco	*Coregonus autumnalis*	F		X	X
least cisco	*Coregonus sardinella*	F	X	X	X
northern pike	*Esox lucius*	S	X	X	X
burbot	*Lota lota*	W	X	X	X
flathead chub	*Platygobio gracilis*	S			X
lake chub	*Couesius plumbeus*	S	X		X
longnose dace	*Rhinichthys cataractae*	S			X
Pond smelt	*Hypomesus olidus*	S		X	
ninespine stickleback	*Pungitius pungitius*	S	X	X	
Arctic lamprey	*Lampetra japonica*	S	X		
longnose sucker	*Catostomus catostomus*	S	X		X
trout perch	*Percopsis omiscomaycus*	S	X		
slimy sculpin	*Cottus cognatus*	S	X		
fourhorn sculpin	*Myoxocephalus quadricornis*	S		X	

*S = Spring
F = Fall
W = Winter

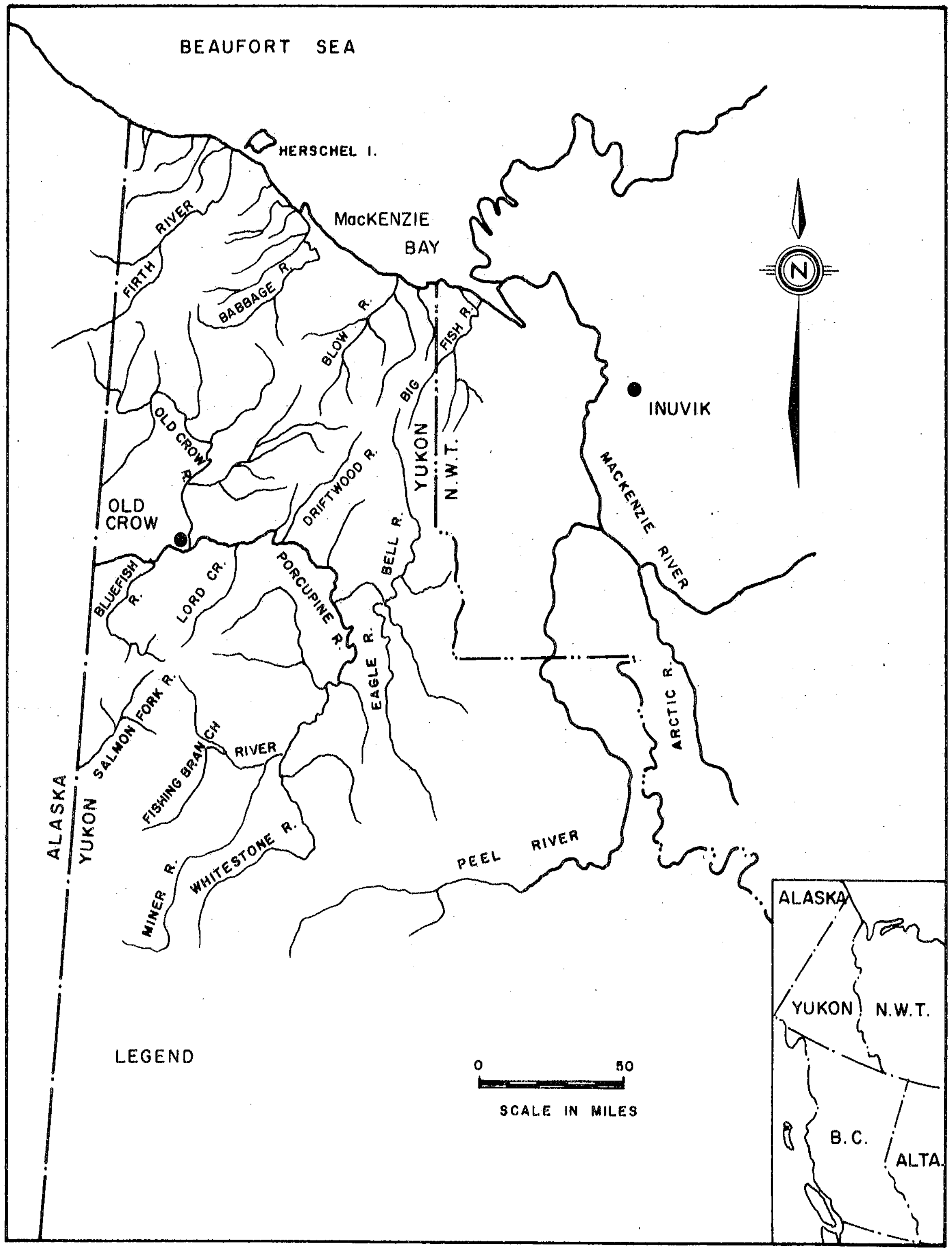

Figure 1. Location map of northern Yukon Territory.

3. Methods

Most of the references to international literature concerning northern Yukon fish species were extracted from the University of British Columbia volumes of Biological Abstracts for the years 1950 to 1970. Other references were obtained from the Fisheries and Marine Service Library in Vancouver from publications of the Fisheries Research Board of Canada, Copeia, and other journals. Recent publications on northern Canadian fisheries research were collected when available.

Data from our own field surveys and observations in northern Yukon were incorporated whenever possible.

In those cases where English translations were available for publications, all material concerning spawning activity was condensed and summarized. The types of information sought included data on the following parameters: geographic location, timing of spawning activity (time of year, time of day), water speed, water depths and water temperature, description of substratum and nest or redd, sexual dimorphism, territorialism and parental guarding, sex ratios of spawning fish, fecundity, incubation period and age of mature and spawning fish. Further information was extracted from English translation of the abstracts of references when these were available. Information obtained by our own observations on spawning activities in northern Yukon are included.

The literature search was initially conducted only for those species present in the Porcupine River and in the Beaufort Sea drainages. References to those species peculiar to the Yukon section of the Peel River are drawn essentially from material available in McPhail and Lindsey (1970). In addition, fisheries research conducted in the Peel River within Yukon Territory is very limited, and the check list of species present in the Peel may not be complete.

4. Results

The preliminary bibliography of references to each species (grouped by family) is preceded by a summary of spawning activity of that species from various geographic locations. In the summaries, the number in brackets immediately following the author's name indicates the number of the complete reference from which the information was extracted. The reader is referred to the appropriate reference for further information.

In many cases, especially in the Russian literature, an English translation of the abstract is not available. In other cases the English translation provides only limited information regarding spawning activity; more precise information may be available if the entire publication were available in translation.

Information on specific locations of spawning grounds within northern Yukon and along the Mackenzie River Valley is extremely sparse. Most recent surveys (since 1970) have been of a reconnaissance or synoptic nature, usually conducted by aircraft or boat along major waterways. Since the spawning periods of most northern species coincide with periods of adverse weather conditions (spring and fall) it has not often been possible to conduct field surveys in the times when spawning activity was in progress. In consequence, spawning locations and timing have often been inferred from information based on such data as the capture of large numbers of ripe and spent fish at the same time, the presence and size of fry in tributary streams and often only on the capture of ripe fish. Complicating the location of spawning areas in spring and fall is the fact that most northern streams have heavy, turbid water volumes at these times, preventing good visibility. Also, many northern species (especially whitefish) spawn under ice cover, where it is virtually impossible to conduct observations. Much of the information concerning spawning ground location which is based on inference is not included in this report, but is available from the appropriate references. Only when actual spawning activity was observed is the information presented.

The Tables listing data on the fecundity and size measurements of northern Yukon fish species are presented for comparison with similar data collected from other areas in the appropriate sections.

4.1 Coregonidae

Least cisco

Summaries of Spawning Information

Berg (1) reports two forms of the species from the Kara River, one spawning from September 15-30 and the other later, under the river ice. In the Ob River, the fecundity of 20-25 cm fish ranged from 9,000-14,300 eggs. In a tributary to the Ob, spawning occurred from October 1-15, with hatching from 20th May to 10th June. In the Gulf of Ob, spawning occurs under the ice in the littoral zone in approximately 1.5 meters of water over sand.

Bobrova (2) distinguishes two forms from the Yenesei River of U.S.S.R., one inhabiting the bay or estuary and one from the river proper. The fecundity of the Turukhan form (river) ranged from 2,440-23,600 eggs while the fecundity of the Kara form was 26,400 eggs. Maturity ranged from the fourth to fifth year of life.

McPhail and Lindsey (6) quote Preble (1908) that a run of least cisco passes Arctic Red River on the Mackenzie River in the 2nd or 3rd week of June, is abundant around Fort Good Hope all summer, and returns to the mouth of the Mackenzie in late autumn. In Siberia both summer and autumn spawning migrations are reported. Spawning occurs over sand and gravel in shallow areas, and the eggs are simply scattered over the bottom.

Hatfield _et al_ (A 15) quote Alt (personal communication) that in the Kobuk and Chatanika Rivers of Alaska spawning was observed in swift, clear water from 0.3-1.0 meters deep over gravel with some sand at 0^{o}-2^{o}C. These authors quote Nikolsky (1961) that feeding is suspended prior to spawning. Sexual maturity is reached at age 5 to 6 in Siberia.

Table III. Age, length, weight and fecundity of least cisco from the Porcupine and Old Crow Rivers.

Age	Length (mm)	Weight (g)	Fecundity
	311	374	22333
	314	375	28487
	316	378	17575
	322	459	27445
6	315	592	40422
3	280	279	13467
4	315	450	29356
*2	290	358	18433
5	280	398	7740
4	312	573	33935
3	300	376	14801
3	330	560	50439

Range 7740-50439

Average 25,369

No. of Fish 12

where,

*Age is suspect

data from,

Steigenberger, L. W., R. T. DeLury, G. J. Birch and J. Fisher. 1973. Fish resources of the northern Yukon, fish survey 1972 base data, Appendix Volume I. Environmental-Social Committee, Task Force on Northern Oil Development. (Unpublished computer listing of data.)

Least cisco - Coregonus sardinella (Valenciennes)

1. Berg, L. S., 1948-149. Freshwater fishes of the U.S.S.R. and adjacent countries. 4th ed. Zool. Inst. Akad. Nauk., USSR 27, 29 and 30. (In Russian; English transl. by Israel Program for Sci. Transl., Jerusalem, 1962, 1964, 1965).

2. Bobrova, N. N., 1958. Coregonus sardinella Valenciennes. Izvest. Vses. Nauchn-Issled. Inst. Ozernogo. Rechnogo. Rybn. Khoz. 44: 179-189. From: Referat. Zhur. Biol., 1959, No. 39866.

3. Kennedy, W. A., 1949. Some observations on the coregonine fish of Great Bear Lake, N.W.T. Bull. Fish. Res. Bd. Can. 82: 1-10.

4. Kurenkov, I. I. and A. G. Ostroumov, 1964. The Kamchatka cisco. IN: Problems of Kamchatkan geography. 115. From: Referat. Zhur. Biol., 1965, No. 12119.

5. Kurenkov, I. I. and A. G. Ostroumov, 1965. Finding of the cisco (Coregonus sardinella) on Kamchatka Peninsula. Voprosy Ikhtiol. 5(3): 558-560.

6. McPhail, J. D. and C. C. Lindsey, 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173: 97-101.

7. Wohlschlag, D. E., 1954. Growth peculiarities of the cisco, Coregonus sardinella (Valenciennes) near Pt. Barrow. Stanford Ichthyology Bull. 4: 189-209.

8. Wohlschlag, D. E., 1957. Differences in metabolic rates of migratory and resident freshwater forms of an arctic whitefish. Ecology. 38(3): 502-510.

9. Yukheva, V. S., 1955. The annual food cycle of the Tama whitefish (Coregonus sardinella Val.) Zoologoliskii Zhurnal. 34(1): 158-161.

Broad whitefish

Summaries of Spawning Information

Berg (1) states that during spawning, males have numerous round, white, epithelial tubercles on the head, fins and parts of the body. In females the first ray of the pectoral fins assumes an enamel-white tint. The eggs are light yellow in colour. Fecundities in the Kara River varied from 14,000-29,000 eggs. Spawning occurs in late October and early November in some rivers at water temperatures of 0^{o}C.

Spawning occurs in the Kolyma River from October 4 to the end of October. Hybridization is reported with Coregonus pidschian.

Lindroth (7) reports the spawning period in Sweden is from mid-October and that spawning is annual. The spawning location is on stony grounds of secluded bays. The age at maturity is variable, as low as two years.

McPhail and Lindsey (9) quote Wynne-Edwards (1952) that an upstream spawning migration occurs in the lower Mackenzie River in July and August. This migration is somewhat earlier than that of the humpback whitefish. McPhail and Lindsey indicate that spawning in the Yukon River occurs in September; one specimen had ripe eggs on October 4 in the Yukon River.

Table IV. Age, length, weight and fecundity of broad whitefish from the Porcupine and Old Crow Rivers.

Age	Length (mm)	Weight (g)	Fecundity
6	531	2445	68928
5	526	2329	63021
7	494	2237	86250
6	509	2400	89002
8	495	1966	49319
5	490	2232	80336

Range 49319-89002

Average 72809

No. of Fish 6

data from,

Steigenberger, L. W., R. T. DeLury, G. J. Birch and J. Fisher. 1973. Fish resources of the northern Yukon, fish survey 1972 base data, Appendix Volume I. Environmental-Social Committee, Task Force on Northern Oil Development. (Unpublished computer listing of data).

Broad whitefish - Coregonus nasus (Pallas)

1. Berg, L. S., 1948. Freshwater fishes of the U.S.S.R. and adjacent countries. 4th ed. Zool. Inst. Akad. Nauk. USSR 27, 29 and 30. (In Russian; English transl. by Israel Program for Sci. Transl., Jerusalem, 1962, 1964, 1965).

2. Chernikova, V. V., 1964. Physiological characteristics of young chir (Coregonus nasus) reared at various temperatures. Izv. Gos. Nauch-Issled. Inst. Ozern. Rechn. Ry. Khoz. 57: 286-289. 1964; from: Referat. Zhur. Biol., 1965, No. 8I100.

3. Golovkov, G. A., 1966. Perspectives for the use of broad whitefish in lake and pond fisheries. In: Conference on the biology of Siberian productive waters, 1966. Irkutsk: 86-88. From: Referat. Zhur. Biol., 1967, No. 7I173.

4. Korovina, V. M., 1963. Pathological phenomena during the incubation of broad whitefish (Coregonus nasus) spawn. Izvest. Gos. Nauchn-Issled. Inst. Ozernogo. Rechnogo. Rybn. Khoz. 54: 106-118. 1963; From: Referat. Zhur. Biol., 1964, No. 1I103.

5. Krest'yannikova, R. S., 1964. The food of some whitefishes of the Pysina River. Tr. Sibirsk. Otd. Nauch-Issled. Inst. Ozern. Rechn. Rybn. Khoz. 8: 161-169. From: Referat. Zhur. Biol., 1964, No. 24I55.

6. Kuz'min, A. N., 1969. Development of reproductive systems in female broad whitefish Coregonus nasus (Pallas) growing in ponds and lakes of northwest USSR. Voprosy Ikhtiol. 9(2): 260-269.

7. Lindroth, Arne, 1957. A study of the whitefish (Coregonus) of the Sundsvall Bay District. Rept. Inst. Freshwater Res. Drottningholm. 38: 70-108.

8. Lindsey, C. C., 1962. Distinctions between the broad whitefish, Coregonus nasus, and other North American whitefishes. J. Fish. Res. Bd. Can. 19(4): 687-714.

9. McPhail, J. D. and C. C. Lindsey, 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173: 87-89.

10. Muth, K. M., 1969. Age and growth of the broad whitefish, Coregonus nasus) in the Mackenzie and Coppermine Rivers, N.W.T. J. Fish. Res. Bd. Can. 26(8): 2253-2256.

11. Polymskii, V. N., 1964. Lakes of the Tyumen Oblast' and prospects of their commercial exploitation. Izv. Gos. Nauch-Issled. Inst. Ozern. Rechn. Rybn. Khoz. 57: 193-198. From: Referat. Zhur. Biol., 1965, No. 8I87.

12. Svardson, Gunnar, 1957. The coregonid problem. VI. The palearctic species and their intergrades. Rept. Inst. Freshwater Res. Drottningholm. 38: 267-356.

13. Vershinin, N. V., 1961. The nutrition of the coregonid young in the Lower Lena. Voprosy Ikhtiol. 1(3): 542-551. From: Referat. Zhur. Biol., 1962, No. 5I19.

14. Valtonen, T., 1970. The selected temperature of Coregonus nasus (Pallas) sensu Svardson, in natural waters compared with some other fish. IN: Lindsey, C. C. and C. S. Woods (eds.) Biology of Coregonid Fishes. Univ. Manitoba Press. Winnipeg. 347-362.

Inconnu

Summaries of Spawning Information

Alt (2) describes the spawning of inconnu in the Yukon River and some of its tributaries in Alaska. In the Kobuk River, the spawning migration begins immediately after ice-out (approx. May 31). The fish arrive in the vicinity of the spawning grounds in late August and early September. The peak of spawning occurred on September 28 between 4:04 and 5:30 p.m., in the swift main current in water depths ranging from 1.2-2.7 meters. In 1965 water temperatures ranged from 1.4-4.4°C and in 1966 from 4.4-4.6°C. In the optimum spawning habitat, the bottom is composed of differentially-sized coarse gravel with no silt and some sand present. Some spawning occurred over uniformly sized gravel and twice fish were observed spawning over 50% sand. It appears that the presence of differentially sized gravel is prerequisite to lodging of the eggs. No nest is constructed and the eggs are extruded at the surface. Russian workers found that females spawned accompanied by two males. One female had 148,000 eggs. Russian data indicates a fecundity of 100,000-350,000 eggs. The eggs were 2.5 mm in diameter and the weight of the ovaries was 20-25% of the body weight. Alt estimates that Alaskan fish would have an incubation period of approximately 182 days, similar to inconnu from the Ob River in U.S.S.R. Maturity ranges from 7-10 years.

Berg (5) reports that Stenodus leucichthys nelma "usually spawn in October" (Berg distinguishes between the nelma and the inconnu on osteological differences). In the Ob River the nelma spawns from September 15-October. In the Kolyma River spawning occurs about September 15. The inconnu spawns in the Ufa River from October 15-October 30. The nelma matures in the Pechora River at an age not less than 13 years; in the Yenisei River males mature at 8-9 years, females at 9-10 years. Berg gives a fecundity range of from 130,000-420,000 eggs. In the Irtysh River the fecundity is given as 195,000 eggs, and the average fecundity of 52 specimens from the Ufa River was 240,000 eggs. In the Ufa River 56% of spawners were male and 44% were female.

Fuller (7) studied inconnu in tributaries and rivers on the south shore of Great Slave Lake. Spawning occurred in late September and early October. Maturity was reached at 7-10 years.

Koneva (8 and 9) reported annual spawning in the Ob, Katun, and Charyth Rivers of U.S.S.R. and a range of sexual maturity from 6-7 years.

Nikonova (13) reported October spawning in the Ob River. Fecundity averaged 191,183 eggs and spawning age was 5 years for males and 7 years for females.

Table V. Age, length, weight and fecundity of inconnu from the Porcupine and Old Crow Rivers.

Age	Length (mm)	Weight (g)	Fecundity
10	647	3071	47294
9	721	4000	64971
9	655	3005	53793
		Range	47294-64971
		Average	55352
		No. of Fish	3

data from,

Steigenberger, L. W., R. T. DeLury, G. J. Birch and J. Fisher. 1973. Fish resources of the northern Yukon, fish survey 1972 base data, Appendix Volume I. Environmental-Social Committee, Task Force on Northern Oil Development. (Unpublished computer listing of data.)

Inconnu - Stenodus leucichthys nelma (Pallas)

1. Alt, K. T., 1965. Food habits of inconnu. Trans. Amer. Fish. Soc. 94(3): 272-274.

2. Alt, K. T., 1969. Taxonomy and ecology of the inconnu, Stenodus leucichthys nelma, in Alaska. Biol. Pap. Univ. Alaska. 12: 1-63.

3. Alt, K. T., 1971. Occurrence of Hybrids between Inconnu, Stenodus Leucichthys nelma (Pallas), and Humpback Whitefish, Coregonus pidschian (Linnaeus) in Chatanika River, Alaska. Trans. Amer. Fish. Soc. 100: 362-365.

4. Anisimova, I. M., 1961. Changes in the gonads of the inconnu (Stenodus leucichthys) in the pre-spawning period. Voprosy Ikhtiol. 17: 39-46. From: Referat. Zhur. Biol., 1961, No. 20D369.

5. Berg, L. S., 1948. Freshwater fishes of the U.S.S.R. and adjacent countries. 4th ed. Zool. Inst. Akad. Nauk. USSR 27, 29, and 30. (In Russian; English transl. by Israel Program for Sci. Transl., Jerusalem, 1962, 1964, 1965.)

6. Ereshchenko, V. I., 1966. Status of the nelma stock in the Bukhtarmin Reservoir. IN: Conference on the biology of Siberian productive waters, 1966. Irkutsk. 67. From: Referat. Zhur. Biol., 1967, No. 6I199.

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Arctic cisco

Summaries of Spawning Information

Anpilova (1) reports that maturity is reached at the age of 4 or 5 years in U.S.S.R.

Berg (2) describes the Pechora River spawning period from August to September 30. Females of 1.2 kg averaged fecundities of 90,000 eggs. In the Yenesei River spawning takes place in the middle of October. In Lake Baikal the "omul" enters several rivers to spawn. There are three races which are sexually mature from 6-8 years. Spawning occurs from August to October. Fecundity of 33-44 cm females ranged from 30,000 to 47,000. The water temperature at spawning time for one race was 8°C to 13°C. No nest was constructed.

Hatfield et al (A 15) believe that Arctic cisco do not feed during their extensive spawning migrations in the Mackenzie and Peel Rivers. Spawning occurs in late summer and early autumn, probably over gravel in fast water. After spawning a distinct downstream movement occurs in the Mackenzie River.

Shotten (A 24) took 24 near gravid specimens in the Arctic Red River (tributary to the Mackenzie) during the first half of July.

McPhail and Lindsey (10) report that in the Mackenzie River system spawning occurs in late summer and early autumn. Ripe adults were taken at the junction of the Peel and Caribou Rivers on August 1. Preble reports spawning in Arctic Red River in September. Spawning probably occurs over gravel in fast water. The eggs are scattered over the gravel. Rows of flat tubercles are present on the sides of spawning males, not in females. Fecundity is up to 90,000 eggs.

Elson (A 12) captured mature fish in early July at the confluence of the Peel and Snake Rivers in northern Yukon.

Arctic cisco - Coregonus autumnalis (Pallas)

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10. McPhail, J. D. and C. C. Lindsey, 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173: 103-105.

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13. Neiman, A. A., 1955. Contribution to a study of spawning of the omul, Coregonus migratorius (Georgi), in tributaries of the "Little Sea" of Lake Baikal. Voprosy Ikhtiol. 1955(5): 53-60. From: Referat. Zhur. Biol., 1957, No. 2251.

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Humpback whitefish

Summaries of Spawning Information

Berg (3) gives information for *Coregonus lavaretus* which is tentatively equated to *Coregonus clupeaformis* by Walters (1955). Berg divides this species into 32 types, races, or subspecies, and the information presented here is sifted from all types. In the Msta River spawning occurs from 18-26 October, and sometimes in the beginning of November. In the Volkhov River the fecundity varies from 26,300 eggs (4+ year old fish) to 53,000 eggs (7+ year old fish). In the Svir River (tributary to Lake Ladoga) these fish spawn in the fifth year of life. Another type spawns on sandy bottoms along the coast of the lake. Spawning occurs about November 15 near the shore over stony bottoms at 4-6 meters depth. In Lake Enare in northern Finland, an analogous form spawns in late September and early October in the lake at depths of 3-4 meters. In Lake Onega, a race which spawns from 20 October-10 November had an average fecundity (16 fish) of 9,300 eggs. In Lake Onega, there are populations of both lake and river spawning fish. The Lake Ladoga black whitefish spawns in the lake proper at depths of 2-10 meters on gravel or mud at the end of October or beginning of November. In the Suna River tributary to Lake Onega spawning begins at the end of October or beginning of November and terminates November 30. Spawning takes place in the river over coarse sand and gravel bottoms. The fry hatch in the 2nd half of May, 192 days after fertilization. The fecundity is 25,000 to 28,000 eggs. Spawning females are 5+-6+, spawning males 4+-5+. A form analogous to the Suna River form spawns in Lake Enare of Finland at 10-28 meter depths. A Lake Baikal form spawns in the lake at ages from 6 to 13 years. Fecundities of this form are up to 43,000 eggs.

Coregonus lavaretus pidschian is divided by Berg into ten varieties. McPhail and Lindsey consider it part of the *Coregonus clupeaformis* complex. Berg (3) reports that the Kara River whitefish males mature at 6+ and females at 7+ years of age. These fish spawn in September and October. The average fecundity was 20,000 eggs with a maximum of 50,800 in a fish 8 years old, 43 cm in length and weighing 870 grams. The Noril'sk Lake whitefish spawns in the lake not earlier than the end of October. The fecundity varies from 10,900-22,700. The Yenesei River whitefish spawns in the river, probably in late September. The fecundity ranges from 21,400 to 42,700. A lacustrine-fluvial subspecies which lives in Lake Baikal and spawns in the Barguzin River in September has an average fecundity of 56,000 eggs. In the

Kolyma River basin it is possible to distinguish fluvial whitefish which spawn in the river in October, and lacustrine types which spawn in lakes at the end of November, December and possibly in January.

Dryer (7) found that in Lake Superior the youngest mature fish was 5 years old, and all fish older than 7 were mature.

Kennedy (14) determined that females probably spawn only every second year in Great Slave Lake.

Lawler (22) reports that spawning of Lake Erie whitefish at temperatures above 43°F (6.1°C) is probably unsuccessful.

Lindsey (23) reports spawning of whitefish in Squanga Lake, Yukon Territory, in November or December. Six specimens were caught in 18 inches of water during the spawning run. The males develop hard, white conical tubercles on the sides and head.

McPhail and Lindsey (26) describe whitefish from Great Slave and Great Bear Lakes as spawning from late summer to at least as late as November or December. In Great Slave Lake spawning is reported from mid-September to mid-October. Spawning usually occurs over rocky reefs in lakes or in river shallows. Tens of thousands of yellowish eggs are laid. The eggs hatch in late winter or in the following spring. Half the fish mature in their 8th year; in more southerly lakes maturity comes at an earlier age. In some northern lakes females may spawn only every second year.

Mraz (27) reported that Lake Michigan male whitefish matured as early as age 2 and that the youngest mature females were age 3. All age 4 fish were mature.

Van Oosten and Hile (32) describe the commencement of spawning for Lake Erie whitefish in the second week of November and continuing past the first week of December. Males were not mature in appreciable numbers till after their 3rd year and females till after their 4th year.

Quadri (29) describes the spawning of lake whitefish from Lac La Ronge, Saskatchewan:

> "The spawning migration in the lake whitefish was observed in 1953; it took place between the 3rd and 4th weeks in October. In the open lake the fish migrated toward the south, southwest, east and southeast shores, and some toward the mouth of the

Montreal River. In the islands region most whitefish migrated to the north and northeast shores. In Hunter Bay they migrated to the north and east arms. The males reached the spawning grounds several days before females.

"Spawning fish were 8 years old or older. No external anatomical change was noticed in the females. The males, however, became rough with nuptial tubercles on the head, cheek, and opercle, and also on the scales on and adjacent to the lateral line. During their spawning period, which lasted from late October to mid-November, the fish swam off the bottom and stopped feeding. They were active, leaped out of the water, and splashed on the surface at sunset and during the night; spawning presumably occurred during the night. Similar observations on the spawning behaviour of lake whitefish were made by Hart (1930) and Van Oosten and Hile (1949).

"Generally, egg production in whitefish increased with the increased size of a fish. Some of the smaller fish produced more eggs than larger ones."

Lindroth (25) reports that Coregonus lavaretus in Sweden spawns on the stony and gravelly bottom in those parts of the stream having a faster flow and also on the gravelly and sandy areas where the water flows more slowly. Spawning began in the first half of November at water temperatures of 1-3°C (34-37°F). Fertilization was in mid-water and the eggs were swept along by the current as they sank to the river bottom. Lindroth believes that survival of the eggs depended on their becoming lodged.

Table VI. Age, length, weight and fecundity of humpback whitefish from the Porcupine and Old Crow Rivers.

Age	Length (mm)	Weight (g)	Fecundity
8	395	822	16500
8	435	1083	23020
9	323	1118	26005
8	401	765	14004
8	403	950	22268
7	422	1149	32651
	431	954	20250
7	410	891	25288
10	469	1353	21058
7	431	1087	48552
8	444	1272	38790
	449	1231	48582
	432	1223	47574
8	489	1752	54284
8	449	1295	44130
7	455	1561	35439
9	456	1357	40259
8	419	1218	51630
	453	1624	40768
7	473	1797	60066
	405	962	23739
7	445	1010	13547
8	295	909	15469

Range 13547-60066

Average 33211

No. of Fish 23

data from,

Steigenberger, L. W., R. T. DeLury, G. J. Birch and J. Fisher. 1973. Fish resources of the northern Yukon, fish survey 1972 base data, Appendix Volume I. Environmental-Social Committee, Task Force on Northern Oil Development. (Unpublished computer listing of data.)

Humpback whitefish - "Coregonus clupeaformis" complex

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3. Berg, L. S., 1948. Freshwater fishes of the U.S.S.R. and adjacent countries. 4th ed. Zool. Inst. Akad. Nauk. USSR 27, 29 and 30. (In Russian; English Transl. by Israel Program for Sci. Transl., Jerusalem, 1962, 1964, 1965).

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5. Carlander, K. D., 1947. Some trends in the commercial fisheries of Lake of the Woods, Minnesota. Trans. Am. Fish. Soc. 77: 13-25.

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8. Edsall, T. A., 1960. Age and growth of the whitefish, Coregonus clupeaformis, of Munising Bay, Lake Superior. Trans. Amer. Fish. Soc. 89(4): 323-332.

9. Godfrey, H., 1955. On the ecology of Skeena River whitefishes, Coregonus and Prosopium. J. Fish. Res. Bd. Can. 12(4): 499-542.

10. Hart, J. L., 1930. The spawning and early life history of the whitefish Coregonus clupeaformis (Mitchill) in the Bay of Quinte, Ontario. Contrib. Can. Biol. Fish. N. S. 6(7): 165-214.

11. Hewson, L. C., 1959. A seven year study of the fishery for Lake whitefish, Coregonus clupeaformis, on Lake Winnipeg. J. Fish. Res. Bd. Can. 16(1): 107-120.

12. Hewson, L. C., 1960. A history of the Lake Winnipeg fishery for whitefish, Coregonus clupeaformis, with some references to its economics. J. Fish. Res. Bd. Can. 17(5): 625-639.

13. Kennedy, W. A., 1954. Tagging returns, age studies and fluctuations in abundance of Lake Winnipeg whitefish, 1931-1951. J. Fish. Res. Bd. Can. 11(3): 284-309.

14. Kennedy, W. A., 1953. Growth, maturity, fecundity and mortality in the relatively unexploited whitefish, Coregonus clupeaformis, of Great Slave Lake. J. Fish. Res. Bd. Can. 10(7): 413-441.

15. Kennedy, W. A., 1949. Some observations on the coregonine fish of Great Bear Lake, N.W.T. Bull. Fish. Res. Bd. Can. 82: 1-10.

16. Kennedy, W. A., 1953. The morphometry of the coregonine fishes of Great Bear Lake. J. Fish. Res. Bd. Can. 10(2): 51-51.

17. Kennedy, W. A., 1963. Growth and mortality of whitefish in three unexploited lakes in northern Canada. J. Fish. Res. Bd. Can. 20(2): 265-272.

18. Kennedy, W. A., 1943. The whitefish Coregonus clupeaformis (Mitchill) of Lake Opeango, Algonquin Park, Ontario. Publ. Ont. Fish. Res. Bd. Lab. 62: 23-66.

19. Koelz, W., 1929. Coregonid fishes of the Great Lakes. Bull. U.S. Bur. Fish. 43: 297-643.

20. Lawler, G. H., 1961. Egg counts of Lake Erie whitefish. J. Fish. Res. Bd. Can. 18(2): 293-294.

21. Lawler, G. H., 1961. Abnormalities in Lake Erie whitefish. J. Fish. Res. Bd. Can. 18(2): 283-284.

22. Lawler, G. H., 1965. Fluctuations in the success of year-classes of whitefish populations with special reference to Lake Erie. J. Fish. Res. Bd. Can. 22(5): 1197-1227.

23. Lindsey, C. C., 1963. Sympatric occurrence of two species of humpback whitefish in Squanga Lake, Y.T. J. Fish. Res. Bd. Can. 20(3): 749-767.

24. Lindsey, C. C., 1963. Status of the whitefish species, *Coregonus nelsonii*, and designation of a new type. *Copeia 1963*: 173-174.

25. Lindroth, A., 1957. A study of the whitefish of the Sundovall Bay district. Rep. Inst. Freshwater Res. Drottningholm. 38: 70-108.

26. McPhail, J. D. and C. C. Lindsey, 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173: 79-85.

27. Mraz, D., 1964. Age, growth, sex ratio, and maturity of the whitefish in central Green Bay and adjacent waters of Lake Michigan. U.S. Fish. Wildl. Serv. Fish. Bull. 63(3): 619-634.

28. Quadri, S. U., 1961. Food and distribution of lake whitefish in Lac la Ronge, Saskatchewan. Trans. Amer. Fish. Soc. 90(3): 303-307.

29. Quadri, S. U., 1968. Growth and reproduction of the lake whitefish, *Coregonus clupeaformis*, in Lac la Ronge, Saskatchewan. J. Fish. Res. Bd. Can. 25(10): 2091-2100.

30. Reckahn, J. A., 1970. Ecology of young lake whitefish (*Coregonus clupeaformis*) in South Bay, Manatoulin Island, Lake Huron. IN: Lindsey, C. C. and C. S. Woods (eds.) Biology of Coregonid Fishes. Univ. Manitoba Press. Winnipeg: 437-460.

31. Tsuyuki, H., J. F. Uthe, E. Roberts and L. W. Clarke, 1966. Comparative electropherograms of *Coregonus clupeaformis*, *Salvelinus namaycush*, *S. alpinus*, *S. malma*, and *S. fontinalis* from the family Salmonidae. J. Fish. Res. Bd. Can. 23(10): 1599-1606.

32. Van Oosten, J. and R. Hile, 1947. Age and growth of the lake whitefish, *Coregonus clupeaformis* (Mitchill), in Lake Erie. Trans. Amer. Fish. Soc. 77: 178-249.

33. Watson, N. H. F., 1963. Summer food of lake whitefish, *Coregonus clupeaformis* (Mitchill), from Heming Lake, Manitoba. J. Fish. Res. Bd. Can. 20(2): 279-286.

Round whitefish

Summaries of Spawning Information

Bailey (1) in Lake Superior found an average fecundity of 5,330 eggs from 37 round whitefish. All males were mature at age group 5 and all females at age group 6.

Berg (2) reports that the round whitefish spawns from October 20-October 30 in the Pyasina River in northern U.S.S.R. Spawning occurs in the Anadyr River at the end of October and in early November.

McPhail and Lindsey (6) indicate that spawning occurs in autumn along the shores of lakes or in streams. Maturity is reached in the 6th or 7th year of life. These authors quote Harper (1948) that the eggs are shed over gravel, evidently without any nest construction or parental care. Up to 20,000 eggs are laid.

Mraz (7) reports that in Lake Michigan all fish over age 3 were mature.

Scott (8) quotes Koelz (1929) that spawning occurs in November in water depths from 2-8 fathoms. Koelz reports an inshore spawning migration in the fall in Lakes Michigan and Huron. Spawning occurred over honeycomb rock or gravel. The eggs were approximately 0.147 inches in diameter.

Hatfield *et al* (A 15) quote Krasikova (1968) that spawning occurs in streams or lake shallows. In Siberia spawning occurred in early October with a water temperature of 0°C, in widened stretches of the stream with a gravel bottom and fast current.

Round whitefish - <u>Prosopium cylindraceum</u> (Pallas)

1. Bailey, Merryll M., 1963. Age, growth and maturity of round whitefish (*Prosopium cylindraceum*) of the Apostle Islands and Isle Royale regions, Lake Superior. U.S. Fish. Wildl. Serv. Fish. Bull. 63(1): 63-75.

2. Berg, L. S., 1948. Freshwater fishes of the U.S.S.R. and adjacent countries. 4th ed. Zool. Inst. Akad. Nauk. USSR 27, 29 and 30. (In Russian; English transl. by Israel Program for Sci. Transl., Jerusalem, 1962, 1964, 1965.

3. Harper, F., 1948. Fishes of the Nueltin Lake Expedition, Keewatin, 1947, Pt. 2 - Historical and field notes. Proc. Acad. Nat. Sci. Phila. 100: 153-184.

4. Krasikova, V. A., 1968. Materials on the biology of the round whitefish (*Coregonus cylindraceum* (Pallas)) from the Noril'sk Lake and river system. Translated in: Problems of Ichthyol. 8(2): 301-303.

5. MacKay, Isobel, and G. Power, 1968. Age and growth of round whitefish (*Prosopium cylindraceum*) from Ungava. J. Fish. Res. Bd. Can. 24(5): 657-666.

6. McPhail, J. D. and C. C. Lindsey, 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173: 111-114.

7. Mraz, Donald, 1964. Age and growth of the round whitefish in Lake Michigan. Trans. Amer. Fish. Soc. 93(1): 46-52.

8. Scott, W. B., 1960. Summaries of current information on round whitefish and mountain whitefish. Ont. Dept. Lands and Forests. Res. Info. Pap. No. 8.

4.2 Salmonidae

Lake trout

Summaries of Spawning Information

McPhail and Lindsey (2) state that in Great Slave Lake some lake trout mature at about 5 years and most are mature by their 11th year. Spawning occurs in late summer and early autumn. Most spawning probably occurs in lakes, although river spawning populations are known from Lake Superior and in southern Quebec. These authors quote Royce (3) concerning the spawning behaviour of lake trout in New York. The fish congregate over rubble or gravel areas along the lake shore. Suitable areas are often associated with windy points. The males arrive on the spawning grounds earlier than the females, and often clean loose sand and mud from the spawning area. No redd is built and eggs are simply extruded over the bottom. Usually more than one male is associated with a spawning female. The males approach the female, press against her sides, and begin quivering. At this time the dorsal fins of the males are held erect. The fertilized eggs become lodged in crevices in the rubble on the bottom. A large female may contain up to 17,000 eggs, and probably spawns these in several different lots during a spawning season. The eggs are 4-5 mm in diameter, and in New York take about 4 months to develop. In Great Slave Lake most females appear to spawn every second year, and in Great Bear Lake they may spawn every 3rd year.

Lake trout - Salvelinus namaycush (Walbaum)

1. Kennedy, W. A., 1954. Growth, maturity and mortality in the relatively unexploited lake trout, *Cristivomer namaycush*, of Great Slave Lake. J. Fish. Res. Bd. Can. 11: 827-852.

2. McPhail, J. D. and C. C. Lindsey, 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173: 75-77.

3. Royce, W. F., 1951. Breeding habits of lake trout in New York. U.S. Fish Wildl. Serv. Fish. Bull. 52: 59-76.

Arctic char

Summaries of Spawning Information

Aass (1) reports that spawning is finished by the second half of October in Swedish lakes.

Fabricius (6) conducted laboratory aquarium experiments with spawning char. The spawning period was in September and October. Most spawning activity occurred in late afternoon. Water temperatures vary from $6^{\circ}C$-$12^{\circ}C$ in Swedish mountain lakes and these temperatures were reproduced in the aquaria. Two of three ripe females dug nests in the aquaria. Nests were dug in sand and gravel mixed with small stones and the eggs were covered by approximately 8 cm of sand. The nests were saucer-shaped, 40 cm in diameter and 10 cm deep. The pectoral, pelvic and anal fins of males are brilliant red, with bright white anterior margins. Some males also have white margins on dorsal fin. Territories are not always defended. Frequent fighting occurs in both sexes. Sexual maturity is reached at 3-5 years in Swedish mountain lakes. In Lakes Vattern and Ransaren, nests are dug in patches of gravel and smaller pebbles between larger stones.

Frost (8) reported char spawning in Lake Windermere (U.K.) in November-December and in February-March. The earlier spawners utilized water depths of 3-12 feet on a gravelly shore and the later spawners utilized water to depths of 60-80 feet over 5"-12" stones.

Grainger (10) studied Arctic char on Baffin Island in the Sylvia Grinnell River. Spawning probably occurs in the fall. The average fecundity of 23 fish was 3,589 yellowish eggs, 3-4 mm in diameter. The fish descend to salt water at the time of ice breakup and ascend into fresh water streams in late summer or early fall. Spawning is probably not annual. The fish are not mature until the 12th year, which is greater than in other areas. George River char from Ungava Bay mature in their 7th year.

McPhail and Lindsey (22) state autumn as the spawning time in North America. The fish spawn over gravel beds in lakes and in pools below rapids in rivers. Spawning anadromous males develop a hooked lower jaw. The fecundity is up to 7,200 eggs, 3-4 mm in diameter. Landlocked populations studied by Sprules matured in the 2nd or 3rd year.

McCart (24) studied the life history of anadromous Arctic char of the Sagavanirktok River of Alaska. In Accomplishment Creek, tributary to the Sagavanirktok, the first ripe males were taken on September 1, and the first spawned-out female was taken September 10. The peak of spawning was taken to be the second week of September and on into October. Water temperatures were 3.3°C on September 10 and 1.6°C on September 16. The spawning areas were associated with large pools, which serve as holding areas for unripe fish. Actual spawning occurs in gravel areas below the pools. Vivid spawning coloration is evidenced, especially in males. In non-migrant males parr marks are retained. A kype is present in anadromous males. The incubation period is about 9 months, with emergence in approximately the last week of June. Water temperature on July 1 was 5.5°C. The youngest mature male was judged to be age 7, and the youngest female age 6. For both sexes, the most abundant age group was 8.

On the west coast of Hudson Bay, Sprules (29) studied spawning Arctic char from late September through October. Water depth was 6'-15' in lakes over gravel beds and shallower pools below rapids in rivers. The eggs probably hatch soon after ice breakup.

Jessop _et al_ (A 18) studied two spawning populations of Arctic char in tributaries of the Mackenzie River (Fish Creek and Cache Creek). The spawning habits differed markedly in the two streams. Spawning occurred in pools in Fish Creek and in riffles in Cache Creek over a gravel substrate. The spawning period was late September and early October in Cache Creek, one month earlier in Fish Creek. The reason for this differential in spawning period is believed to be that Cache Creek has a large "warm" spring system which maintains the stream at a higher temperature later in the season. Water temperatures during the 1973 spawning period ranged from 4°C to 6°C in both areas.

McCart and Craig (27) give a definitive account of the reproductive biology of Arctic char along the Yukon and Alaskan north coasts. Spawning of Arctic char takes place in the late summer and fall (mid-August to December). All of the known spawning areas are in the vicinity of spring water sources. The eggs, which remain in the gravel 6-9 months, cannot tolerate freezing and these are the only stream areas in which winter flow is assured.

Young-of-the-year fry emerge from the gravel in April or May and spend their first summer in streams. They overwinter in spring areas and may spend several more summers in freshwater as juveniles. After a variable number of years they undergo a physiological change, and, in the spring, they migrate seaward as smolts. These migrant (anadromous) fish remain in the sea throughout the summer but return to the stream in late summer (July-August) as immature migrants to overwinter. The following spring they again migrate seaward. Arctic char apparently never remain at sea through the winter, probably because their body fluids would freeze at the temperatures which occur under the sea ice (DeVries, 1971). Migrants may take this return journey several times before they mature for the first time and return from the sea, not just to overwinter, but to spawn. Individuals of this species do not die immediately after spawning and some may overwinter and make additional seaward migrations, returning to spawn several times during their lifetime.

Small stream-dwelling char, residuals, remain in freshwater throughout their lives.

Arctic char typically spawn and overwinter in braided, gravel-bottomed stream channels in the vicinity of aufeis areas. Documented spawning grounds have been identified in Fish Creek, Firth Spring, Firth Delta, Joe Creek, Firth River, Babbage River, and Fish Hole Creek in Yukon Territory.

McCart and Craig (26) also studied two isolated populations of stream-resident non-migratory Arctic char in spring-fed tributaries of the Canning River in Alaska. These fish were characterized by small size (max. 235 mm), low fecundity (max. 199 eggs), and annual spawning after maturity. The spawning season appeared to be sometime in November, when the eggs of mature females averaged 3.8 mm in diameter. The youngest mature males were aged 2 and the youngest mature females were aged 3. There was little sexual dimorphism. Almost no kype was present, which is a characteristic feature of anadromous males. The ventral surface and lateral spots are bright orange; the leading edge of pectorals and pelvics are white.

Arctic char - <u>Salvelinus alpinus</u> (Linnaeus)

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2. Andrews, C. W. and E. Lear, 1956. The biology of Arctic char (Salvelinus alpinus) in northern Labrador. J. Fish. Res. Bd. Can. 13(6) 843-860.

3. Berg, L. S., 1948. Freshwater fishes of the U.S.S.R. and adjacent countries. 4th ed. Zool. Inst. Akad. Nauk. USSR 27, 29 and 30. (In Russian; English transl. by Israel Program for Sci. Transl., Jerusalem, 1962, 1964, 1965).

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9. Frost, W. E., 1955. An historical account of the char in Windermere. Salmon and Trout Mag. 143: 15-24.

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Coho salmon

Summaries of Spawning Information

Elson (A 26) observed a small population of spawning coho salmon in the Fishing Branch River in late November. Specific spawning information was not collected but for physical parameters of the spawning grounds see Elson (A 26) concerning chum salmon in northern Yukon Territory.

McPhail and Lindsey (2) note that in spawning males the upper jaw forms an elongate hooked snout. (This characteristic is common to the three species of Pacific salmon found in northern Yukon Territory. It is most pronounced in chum salmon, where the canines also become greatly elongated.) Most spawning occurs in November, usually in small streams tributary to larger rivers. Spawning behaviour is similar to that of chum salmon. The eggs are smaller than in most other salmon (4.5-6 mm diameter) and orange-red in colour. A large female may contain 5000 eggs. The eggs hatch in about 6-8 weeks depending on water temperature. The young emerge from the gravel 2-3 weeks after hatching. In the Yukon River system most young coho appear to remain 2 years in fresh water and migrate to sea in their third year. Yukon River coho spend 2 years at sea and the spawning adults range from 3 to 5 years of age.

Coho salmon - *Oncorhynchus kisutch* (Walbaum)

A 26. Elson, M. S., 1975. Enumeration of spawning chum salmon (*Oncorhynchus keta*) in the Fishing Branch River in 1971, 1972, 1973 and 1974. IN: Steigenberger, L. S., M. S. Elson and R. T. DeLury, 1975. Northern Yukon Fisheries Studies 1971-1974. Volume I, Chapter II. Environmental-Social Programme, Northern Pipelines. ALSO: Report No. PAC/T-75-19.

2. McPhail, J. D. and C. C. Lindsey, 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173: 170-173.

Chinook salmon

Summaries of Spawning Information

Elson (A 26) observed chinook salmon spawning in August in the Fishing Branch River and the Miner River in northern Yukon Territory. Actual spawning behaviour is not available (see Elson (A 26) for a description of the Fishing Branch River chum salmon spawning grounds). Two-year-old juvenile chinooks have been taken in the Miner River. The Miner River is a fast stream with clear water and good coarse-gravel riffle areas. Water temperatures in August range from 40-50^{o}F (Steigenberger *et al* (2)).

McPhail and Lindsey (1) describe the spawning behaviour, which is similar to that of chum and coho salmon. The eggs are large (6-7 mm in diameter) and orange-red. A large female may contain up to 8000 eggs. The eggs hatch in about 7-9 weeks depending on water temperatures. The young emerge from the gravel 2-3 weeks after hatching. Spawning adults return in their 4th or 6th year. Males mature earlier.

Chinook salmon - *Oncorhynchus tshawytshcha* (Walbaum)

A 26. Elson, N. S., 1975. Enumeration of spawning chum salmon (*Oncorhynchus keta*) in the Fishing Branch River in 1971, 1972, 1973 and 1974. IN: Steigenberger, L. S., M. S. Elson and R. T. DeLury, 1975. Northern Yukon Fisheries Studies 1971-1974. Volume I, Chapter II. Environmental-Social Programme, Northern Pipelines. ALSO: Report No. PAC/T-75-19.

1. McPhail, J. D. and C. C. Lindsey, 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173: 175-177.

2. Steigenberger, L. S., R. T. DeLury, M. S. Elson, 1975. Assessment of Chinook Salmon (*Oncorhynchus tshawytshcha*) stocks in the upper Porcupine River drainage in the northern Yukon Territory. IN: Northern Yukon Fisheries Studies 1971-1974. Volume I, Chapter III. Environmental-Social Programme, Northern Pipelines. ALSO: Report No. PAC/T 75-19.

Chum salmon

Summaries of Spawning Information

Berg (1) discusses two forms of chum salmon from Russian waters, the summer and autumn chum. Since it is believed that chum salmon from the Yukon Territory more closely resemble Berg's summer chum, only data for this species as reported in Berg are discussed here. Berg quotes Soldatov that of nearly 10,000 Amur River chum salmon, the sex ratio was males 46.5%, females 53.5%. The fecundity of the summer chum is 2008-2978 eggs, average 2515. The diameter of the egg is 7 mm. The summer chum spawns in mid-August. The hatchlings appear on the 68th-108th day after fertilization. Age at maturity is predominantly 4 years.

Elson (A 26) studied chum salmon in the Fishing Branch River of northern Yukon Territory. The spawning period was from September 1 to November 15. The sex ratio of 22,000 spawners was very close to 1:1. The fecundity was approximately 2500 eggs per female. Most spawners were 4 years old. Age composition, sex ratios, fecundity, size and spawning ground preference (near groundwater sources) are very similar to characteristics of summer chum salmon from the U.S.S.R. Water depths varied from 8" to 5' in the Fishing Branch River and water temperatures ranged from 1°C to 3°C in the spawning period. Most spawning occurred in riffle areas. Predation by Arctic grayling was observed on salmon eggs. Nothing is known about the incubation period or migrational behavioural patterns of fry in the Fishing Branch River.

McPhail and Lindsey (2) report that chum salmon ascend the Mackenzie River to above Great Slave Lake (location of spawning grounds are unknown in the Mackenzie). In the lower Yukon, spawning occurs in early July. Spawning occurs over a variety of substrates, usually in riffle areas with gravel size similar to that used by pink salmon (walnut-sized). The female builds a nest by turning on her side and beating with her tail. There is usually a dominant and several accessory males present. The female covers the eggs by swimming upstream and digging above the redd. A female may dig several redds and spawn with several males. Males may spawn with several females. The eggs are large (6-7 mm) and orange-red. A large female may contain as many as 4000 eggs. The egg development is dependent upon water temperature. The alevins remain in the gravel for several weeks after hatching, and a downstream migration towards the sea begins soon after emergence.

Chum salmon - *Oncorhynchus keta* (Walbaum)

1. Berg, L. S., 1948. Freshwater fishes of the U.S.S.R and adjacent countres. 4th ed. Zool. Inst. Akad. Nauk. USSR 27, 29 and 30. (In Russian; English transl. by Israel Program for Sci. Transl., Jerusalem, 1962, 1964, 1965).

A 26. Elson, M. S., 1975. Enumeration of spawning chum salmon (*Oncorhynchus keta*) in the Fishing Branch River in 1971, 1972, 1973 and 1974. IN: Steigenberger, L. S., M. S. Elson and R. T. DeLury, 1975. Northern Yukon Fisheries Studies 1971-1974. Volume I, Chapter II. Environmental-Social Programme, Northern Pipelines. ALSO: Report No. PAC/T-75-19.

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4.3 Petromyzontidae

Arctic lamprey

Summary of Spawning Information

Heard (1) reports that in the Naknek River system, Alaska, "Nesting sites, which were observed in streams ranging from five to more than 100' wide, were all located out of the main current in water from three to eight inches deep and flowing from 0.5 to one ft/sec. Gravel usually varied from 0.5 to two inches in diameter. Spawning was always confined to a specific nest site from 6 to 10 inches in diameter that varied from a two- to three-inch well defined depression to a shallow irregularity in the stream bottom. Water temperatures varied from 54° to 59°F. The earliest observed spawning was on 28 May, the latest on 2 July. The number of spawners per nest site varied from two to eight and was usually 5 or 6. There were usually fewer females per nest than males, and both sexes participated in nest building".

McPhail and Lindsey (2) quote Walters (1955) that lampreys probably spawn in Great Slave Lake and Artillery Lake in July. They quote Berg (1948-1949) that in the U.S.S.R. large females may lay over 100,000 eggs. Ammocoetes bury themselves in the soft mud of stream margins and backwaters.

Arctic lamprey - Lampetra japonica (Martens)

1. Heard, W. R., 1966. Observations on lampreys in the Naknek River system of southwest Alaska. Copeia 1966: 332-339.

2. McPhail, J. D. and C. C. Lindsey, 1970. Freshwater Fishes of Northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173: 50-55.

4.4 Thymallidae

Arctic grayling

Summaries of Spawning Information

Berg (1) states that the Baikal black grayling spawns in the beginning of May in almost all the tributaries of Lake Baikal. In the Angara River (tributary to Lake Baikal), the "marsovik" (Baikal black grayling) spawns from June 1 to August 15. The Kamchatka grayling spawns in the Anadyr River in mid-June.

Stein *et al* (A 27) identified spawning areas for Arctic grayling in several Mackenzie River tributaries. Spawning occurred in late May and early June in water temperatures ranging from 45°-$59^{\circ}F$ (7°-$15^{\circ}C$).

Nelson (19) in a study of Montana grayling found that eggs could not be located in bottom materials that were composed of sand and silt. Grayling were not observed spawning in pools. In one study of a creek consisting mostly of riffles, grayling eggs were found in practically every area sampled. Hatching took 14-19 days. Water temperatures varied from $38^{\circ}F$ ($3.3^{\circ}C$) to $61^{\circ}F$ ($16.1^{\circ}C$).

Kruse (13) found that grayling in Grebe Lake, Wyoming, spawned in all inlets and in the outlet. Water temperatures ranged from 40° to $57^{\circ}F$ (5.7°-$13.9^{\circ}C$). Water depth was not rated as being important since in some cases the backs of both sexes were out of the water during spawning. In other areas spawning occurred in depths of 4-5 feet. Hatching was completed in 19 days at water temperatures of $39^{\circ}F$ to $48.4^{\circ}F$.

de Bruyn and McCart (5) found that the sizes of grayling fry close to the Mackenzie River delta are larger than in Yukon north slope drainages at the same time in early summer. This is presumed not to be due to amounts of benthos or temperature differences since no definite patterns exist in these parameters. It is postulated that spawning times are earlier in Eastern streams, probably keyed to the time of breakup. Egg size immediately prior to spawning was 2.0-2.5 mm.

Fecundities from various north Yukon locations were:

Firth River	7 fish	7328.6 (Mean)	4077-10891 (Range)
Trout Lake	5 fish	11818	8787-14429
Lake 100	8 fish	8620	5429-12976
	Av.	8967	4077-14429 Range

It appears that females spawn every year after maturity. In most Arctic regions, the spawning period of grayling coincides with spring breakup. Spawning of grayling on the Yukon north slope begins around the middle of May and may continue until the latter part of June in some areas. Schallock (24) found that grayling in the Chatanika River, Alaska, often spawn at the height of the spring runoff when waters are turbid and muddy. Observations on the Yukon north slope suggest that in most areas grayling also spawn during the spring flood in turbid waters.

R. E. Kendel (unpublished data) observed spawning of Arctic grayling in Nares Creek near Carcross in the southern Yukon Territory. Water temperature was 49^{o}F and the bottom composition was 95% fine material with some sand. Each spawning act lasted from 3 to 6 seconds.

Bishop (2) studied grayling spawning in Providence Creek in the Northwest Territories. The spawning season was from April to May associated with ice breakup. Most fish moved onto the spawning grounds at about 12 noon and moved downstream at night. Water volume was 62 cfs and water velocity was about 2.5 ft/sec with a depth of 3' in the deeper parts. Water temperature was 8-10^{o}C during spawning activity (approximately 50^{o}F). Pure mud, sand and clay were not chosen as a spawning substrate. Only gravelled areas were used. No redd was formed, but the eggs were covered by the loosened bottom material. In spawning males, the dorsal fin usually extends to the adipose fin. Large males held territories approximately 6' x 12'. The male:female ratio was 1.3:1. The average fecundity of 15 fish was 9,670 eggs with a diameter of 2.6 mm. The eggs were adhesive when first stripped. Incubation period was 13.7 days in a controlled experiment in the creek. Ninety-three percent of the spawners were in the 6-9 year age group.

Brown (3) studied grayling in inlet streams to Hynes Lake in Montana. The peak of the run was obtained on April 16. The spawning period varied from May 1 to June 20 in various parts of Montana. Water volume was $1\frac{1}{2}$ cfs in one stream with a depth of 8-10" and a temperature of 10°C. Most fish concentrated directly downstream from riffles. One pair spawned in very clear water. Bottom was coarse sand. No nests were constructed. Males outnumbered females. It is probable that egg-laying interval lasts about 2-4 days. The average fecundity of 9 fish was 5,828 eggs. The adhesive eggs may represent an adaptation to spawning in a current over fine sand without a previously prepared nest. The incubation period was 11-22 days depending on the water temperature. Many fish spawned at the end of their second year, most were in third and fourth year class.

Degteva (6) found that Lake Chistoe (U.S.S.R.) grayling matured at 6 years of age.

Filonov (8) found that grayling spawned from May 15-May 23 in the Dausha River (U.S.S.R.).

Miller (17) found that Great Bear Lake grayling matured in the fifth year of life.

Soin (25) found that grayling spawned from 2nd half of May to early June in small, swift rivers emptying into Lake Baikal over a stony bottom. The eggs are slightly sticky. The incubation period was 15-20 days.

Tack (26) in Alaska found grayling spawning on May 18 in Mineral Lake outlet in water speeds of 2.6 ft/sec, water depths of approximately 1 foot and water temperature of approximately 45°F. All territories were over bottoms composed of peasize gravel. The territories were approximately 8' x 10' in area. Fecundities averaged 5,996 eggs for five fish. All fish six years old were mature. In the Chena River the spawning period was from May 14 to May 22 in water temperatures of 44°F.

Tryon (27) found grayling spawning on May 6 in the inlet to Rogers Lake, Montana, usually between 7 and 8 p.m. at 50°F. Territories were established over areas of sandy bottom. The eggs were amber-coloured, adhesive and 0.095 mm in diameter. The incubation period was approximately 23 days.

Zinov'ev (38) determined the fecundity of 106 fish from 516-29,000 eggs in the Kama River basin.

McPhail and Lindsey (16) describe the spawning period for grayling as May to mid-June in small streams over a gravel or rocky bottom. Males are more vividly coloured than females at spawning time. The eggs are heavy, amber-coloured, slightly adhesive and 2.5 mm in diameter. The incubation period is from 16-18 days at 9°C.

Jessop *et al* (A 18) indicate that grayling may spawn at ice breakup and even possibly under the ice in the Trail River (tributary to the Mackenzie River).

TABLE VII. Age, Length, Weight and Fecundity of Arctic grayling from the Porcupine and Old Crow Rivers.

Age	Length (mm)	Weight (g)	Fecundity
	310	402	3512
	330	347	2042
	354	485	1233
	252	181	2030
	271	225	1815
	274	226	1904
	279	253	1957
	296	295	3145
	299	308	3994
	301	317	3244
	257		1479
	263		1596
	270		1753
6	322	337	3240
	360	438	4910
	360	437	4168
	355	585	9049
3	320	407	6416
4	320	396	6980
5	363	670	10812
4	364	611	8303
3	340	497	9095
4	310	359	6073
5	390	718	12809
5	330	415	6220
3	295	329	7326
4	357	657	9388
4	330	433	6371
5	384	770	13435
5	363	605	10115
4	340	411	5284
4	351	478	8660
6	392	738	18580

Range 1233 - 18580

Average 5967

No. of Fish 33

data from,

Steigenberger, L. W., R. T. DeLury, G. J. Birch and J. Fisher. 1973. Fish resources of the northern Yukon, fish survey 1972 base data, Appendix Volume I. Environmental-Social Committee, Task Force on Northern Oil Development. (Unpublished computer listing of data.)

Arctic grayling - Thymallus arcticus (Pallas)

1. Berg, L. S., 1948. Freshwater fishes of the U.S.S.R. and adjacent countries. 4th ed. Zool. Inst. Akad. Nauk. USSR 27, 29 and 30. (In Russian; English transl. by Israel Program for Sci. Transl., Jerusalem, 1962, 1964, 1965.

2. Bishop, Frank G., 1971. Observations on spawning habits and fecundity of the Arctic grayling. Progr. Fish. Cult. 33(1): 12-19.

3. Brown, C. T. D., 1938. Observations on the life history and breeding habits of the Montana grayling. Copeia 3: 132-136.

4. Chitravadivelu, Karthigesu, 1971. Contribution to the growth of Thymallus arcticus (Pallas, 1776) from the upper Yenisei River of Mongolia. Vestn. Cesk. Spol. Zool. 35(3): 168-174.

5. de Bruyn, M. and P. McCart, 1974. Life history of the grayling (Thymallus arcticus) in Beaufort Sea drainages in the Yukon Territory. Arctic Gas Biological Report Series. Volume 15.

6. Degteva, G. K., 1965. Observations on the biology of Lake Chistoe grayling. Izv. Tikhookeanskogo. Nauch-Issled. Rybn. Khoz. Okeanogr. 59: 224-226.

7. Egorov, A. G., 1956. Tagging of grayling in the Anagara River. Voprosy Ikhtiol. 1956(6): 121. From: Referat. Zhur. Biol., No. 91059.

8. Filonov, K. P. and G. S. Kaplin, 1962. On the question of the spawning of grayling in the wild-life reserve. Tr. Barguzinsk. Gos. Zapovednika. 4: 230-232. From: Referat. Zhur. Biol., 1964, No. 1156.

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4.5 Esocidae

Northern pike

Summaries of Spawning Information

Berg (5) reports that males mature in the third year of life and females in the fourth year. In the Lake Chud basin there are three forms, one form spawning in March, one in April and one in May to June. In Lake Chany (at 55°N) pike begin to spawn on May 18 at 8° to 15°C and spawning is finished by May 30. In the Dneister River pike spawn from March 15 to April 10 at 3-6°C at an age of 2-3 years. In the Dneiper River near Kiev (52°N lat.) spawning occurs from late March to early April. In the delta of the Dneiper spawning occurs from March 15 to April 15 and the fecundity depends on the size of the fish, e.g., 33 cm fish had 7,140 eggs, 85 cm fish had 182,000 eggs. In the Volga River delta (on Caspian Sea at 46°N lat.) spawning occurs from April 1 to May 1. The maximum fecundity found was 213,300 eggs. Males mature at 3 years, females at 4. In the lower Yenesei River, in the Anadyr and Pechora Rivers (approximately 70°N lat.) spawning occurs in June (i.e., later at northern latitudes). The fecundity of Aral Sea pike is only about half that of Volga delta pike of the same size.

Threinen (52) determined that male pike matured at age 2 and females at age 3 in Wisconsin. Spawning occurred just as the ice began to leave (late March-early April). Spawning pike migrate at night and search out zones of shallow, warm water usually in marshy areas. Spawning takes place in less than 12 inches of water over flooded emergent vegetation at water temperatures approximating 40°F (4°C).

Stein *et al* (A 27) determined that pike spawn in late May in the southern Mackenzie valley tributaries to early July in the north. Water temperatures ranged from 45°-61°F.

Shotton (A 24) quotes Bryan (1967) that experiments in Minnesota pike indicate a definite preference in spawning for terrestrial or dense aquatic vegetation.

Bulgakova (8) reports that the spawning period of pike in the Kuibyshev Reservoir in U.S.S.R. is from the end of April to the beginning of May lasting 35-40 days. In artificially created spawning grounds there was massive spawning during the second half of May. Spawning occurred in water depths of 0.8-12 meters and temperatures of 5-7°C. Fecundity was 25,000-29,000 in 3-year-old fish and 51,000 in 5-year-old fish. A few larvae were found on May 12.

Bishop (2 in bibliography for Arctic grayling) reports that pike spawn in May in Providence Creek of N.W.T. The main spawning run arrived a little before the main run of grayling.

Domanevskii (15) reports that pike mature at age 2 in the Tsimlyansk Reservoir of U.S.S.R.

Evsin (20) reports maturity of 4 to 5 years in Lake Bolshoi of U.S.S.R.

Hassler (26) for North Dakota pike reports ages of maturity for males at 1 year and females at 2 years.

McPhail and Lindsey (39) report that pike spawn in spring shortly after ice breakup. Males were ripe on June 4th in Kotcho Lake in northern British Columbia. Spawning occurred in weedy, shallow areas. Several tens of thousands of adhesive eggs were laid. Hatching takes 12-14 days in southern areas. In Great Bear Lake males mature at 5 years and females at 6 years.

Potapova (44) reports pike spawning in the Karelian Lakes of U.S.S.R. after ice breakup in rivers and lakes in from 0.3-1 meter of water above 3°C on vegetation and the moss Fontinalis. Hatching took 14-21 days. Males mature at 2-3 years, females at 4-5 years.

Schultz (46) studies pike in Prince Albert National Park, Saskatchewan. The spawning run began as early as April 24, reached a maximum between May 3 and May 6 and was complete by May 15. In Heart Lakes spawning was observed on May 19 in a water depth of 3' in weedy areas close to shore. Fish remained above the bottom during the spawning act.

TABLE VIII. Age, length, weight and fecundity of Northern pike from the Porcupine and Old Crow Rivers.

Age	Length (mm)	Weight (g)	Fecundity
	575	1181	9937
	506	987	38908

Range 9937-38908

Average 24422

No. of Fish 2

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data from: Steigenberger, L. W., R. T. DeLury, G. J. Birch and J. Fisher. 1973. Fish resources of the northern Yukon, fish survey 1972 base data, Appendix Volume I. Environmental-Social Committee, Task Force on Northern Oil Development. (Unpublished computer listing of data.)

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4.6 Gadidae

Burbot

Summaries of Spawning Information

Askhaev (1) reports that a lacustrine-fluvial form of the species spawns from the fall through to March in streams tributary to Lake Baikal in water depths up to 1 meter over a sandy bottom.

Cahn (5) observed burbot to come into shallow water at night to spawn in Burntside Lake, Minnesota, from February 5 to February 18.

Chen (6) observed burbot spawning in early February in the Tanana River of Alaska. A ten-year-old fish contained 738,485 eggs. The eggs were demersal, non-adhesive, and contained a large oil globule. Egg diameter was 0.71 mm. The incubation period was estimated at less than three months. Chen quotes Anderson's data of a 41-day incubation period at 2°C in Sweden and 1.5 to 2.5 months in Russia (Nikolskii, 1954). He believes maturity is not reached until age 6 or 7 and states the possibility that spawning is not annual.

Clemens (8) reports spawning in Lake Erie from the last week of March to the first week of April. He states an incubation period of 1-2 months at 4°C and indicates that sexual maturity is reached in the 3rd and 4th years of life.

Fabricius (9) reports burbot spawning in Swedish lakes from the end of January to the beginning of March over sand or hard, smooth clay at a temperature of 3.2°C. Incubation periods are quoted as 4-5 weeks at 4°C (Ehrenbaum, 1909) and 41 days at 2°C (Vallin, 1942). In aquaria experiments, Fabricius noted spawning on February 5 from 9 a.m. to noon and in the evening at a water temperature of 3-4°C over fine sand. Territorialism was not noted.

Bjorn (4) reported spawning in Wyoming lakes from December and extending through February. He estimated the fecundity as 175,000 eggs per pound of fish. The eggs were a clear light yellow colour, semi-buoyant and 1.04 mm in diameter. The incubation period was 30 days at 43°F. Females matured at 12 inches and males at 9 inches.

In Lake Winnipeg, Hewson (10) reports the beginning of spawning on January 31 and lasting for three weeks. Water temperatures were from 0°C to 1°C and catches indicated that most spawning occurred near the surface. Some fish matured by age 2 and some mature fish do not spawn every year.

Lawler (11) thought that spawning in Heming Lake, Manitoba, probably occurred in early March. Water temperatures at this time were 0.3°C at the surface and 3.9°C at the bottom. Fecundity averaged 500,000 eggs with a diameter of 0.5 mm.

In Lake Simcoe, Ontario, McCrimmon (13) reports spawning in late January and early February. Spawning occurred over shoals in the open lake and the incubation period is given as approximately 2 months.

McPhail and Lindsey (14) state the spawning period as late winter, at night in from 1-4' of water. Fecundity is up to 1 million tiny, non-adhesive eggs 0.5 mm in diameter. The young hatch in early spring.

Mueller (15) reports spawning in the day over a fine sand bottom in Sweden.

Sergeev (17) reports the spawning period from January to mid-February on sand-shingle banks in the U.S.S.R. The spawning stock consisted of 2-4 year old fish and the incubation period was 3-4 months at 0.1 to 0.2°C.

Tyul'panov (21) reports that spawning is not annual in the Ob River basin of the U.S.S.R. He reports a fecundity range of 122,000 to 2,100,000 and a maturity age for males of 3+ to 4+, females 4+ to 5+.

Veber (24) in a study of Lake Syamozero (U.S.S.R.) reports spawning in February in 0.5 to 2 meters of water over a sandy bottom. The eggs were yellowish, non-adhesive, translucent, from 0.89 to 1.08 mm in diameter. Fecundity ranged from 67,000 to 1,424,000 eggs. Larvae appear at the end of May. Sexual maturity is attained at 4-5 years.

In the Rybinsk Reservoir of U.S.S.R. Volodin (26) reports spawning over fine sand and large rubble in the first half of January in from 80-120 cm of water.

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19. Sorokin, V. N., 1968. Biology of the young burbot (Lota lota L.). Voprosy Ikhtiol. 8(3): 586-591.

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25. Volgin, M. V., 1958. The burbot of the Yenisei River Lota lota. Izvest. Vses. Nauchn-Issled. Inst. Ozernogo. i Rechnogo. Rybn. Khoz. 44: 203-206. From: Referat. Zhur. Biol., 1959, No. 53850.

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4.7 Catostomidae

Longnose sucker

Summaries of Spawning Information

In the Brule River, tributary to Lake Superior, Baily (1) determined that the peak of spawning occurred about the middle of May. Spawning was annual. Spawning was closely related to a water temperature of approximately 55.4°F. Fish 14-17 cm long had an average fecundity of 24,000 eggs. The youngest mature male belonged to age group IV and the youngest mature female to age group V. Soon after hatching, the young drifted downstream to the lake.

Brown and Graham (2) studied a spawning run in Pelican Creek, tributary to Yellowstone Lake. Spawning run volume was directly related to high temperature. Spawning occurred in late June through most of July. Spawning females remained 19 days in the creek and spawning males 17 days. Males were mature at 4 years and females at 5 years. The first fry were taken on July 9.

Geen et al (3) noted variation in timing of spawning migrations from year to year in Frye Creek, tributary to Sixteen Mile Lake, B. C. Spawning runs varied from April 20 to well into May. The majority of spawners moved upstream between noon and midnight, with the greatest migration in the evening. The spawning migration was associated with water temperatures of 5°C. Spawning occurred in water depths of 30-45 cm over gravel from 0.5-10 cm diameter. No territorialism was observed. Males outnumbered females by 2-4 to 1. Incubation period was estimated at two weeks. In the laboratory, incubation period was 8 days at 15°C and 11 days at 10°C.

In the Hay River, N.W.T., Harris (5) studied suckers spawning from ice breakup in May to June 15. Water temperatures never exceeded 15°C. Fecundity varied from 17,000 to 60,000 eggs. Females may not spawn every year. Suckers were sexually mature at 7 years, but none younger than 9 years were observed spawning.

McPhail and Lindsey (7) state spawning times of April to late May in central B.C. and quote Nikolsky (1961) as June in the Kolyma River of the U.S.S.R. Breeding males have well-developed tubercles on the head and on the anal and caudal fins. The males are more vividly coloured. The eggs are whitish and adhesive. In B.C. males spawn at about 5 years, females at 6 or 7 years. Some spawn in consecutive years.

Rawson and Elsey (9) studied longnose suckers in Pyramid Lake and some of its tributary streams. Spawning occurred from June 10 to July 1 with a maximum intensity in the 3rd week of June.

Stein *et al* (A 27) determined that spawning times in the Mackenzie River varied with latitude. Spawning occurred after ice breakup from late May in southern tributaries to mid-June in northern tributaries at water temperatures from 46° to 61°F.

Longnose sucker - Catostomus catostomus (Forster)

1. Bailey, M. M., 1969. Age, growth, and maturity of the longnose sucker Catostomus catostomus, of Western Lake Superior. J. Fish. Res. Bd. Can. 26(5): 1289-1299.

2. Brown, C. J. D. and Richard J. Graham, 1954. Observations on the longnose sucker in Yellowstone Lake. Trans. Amer. Fish. Soc. 83: 38-46.

3. Geen, G. H., T. G. Northcote, G. F. Hartman and C. C. Lindsey, 1966. Life histories of two species of catostomid fishes in Sixteen Mile Lake, B. C., with particular reference to inlet stream spawning. J. Fish. Res. Bd. Can. 23(1): 1761-1788.

4. Geen, G. H. and T. G. Northcote, 1968. Latex injection as a method of marking catostomids for long term study. Trans. Amer. Fish. Soc. 9(3): 281-282.

5. Harris, R. H. D., 1962. Growth and reproduction of the longnose sucker, Catostomus catostomus (Forster) in Great Slave Lake. J. Fish. Res. Bd. Can. 19(1): 113-126.

6. Lalancette, Louis-Marie and Etienne Magnin, 1970. Growth in length of eastern suckers, Catostomus catostomus (Forster), from Saguenay. Natur. Can. 97(6): 667-677.

7. McPhail, J. D. and C. C. Lindsey, 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173: 285-287.

8. Novikov, A. S. and E. A. Streletskaya, 1966. Biology of Catostomus catostomus rostratus (Tilesius). Byull. Moskov. Obshcest. Ispytatelei. Prirody. Otd. Biol. 71(1): 133-136.

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10. Smith, G. R., 1966. Distribution and evolution of the North American catostomid fishes of the subgenus Pantosteus, genus Catostomus. Misc. Pub. Mus. Zool. Univ. Mich. 129: 1-133.

11. Weisel, G. F., 1967. The pharyngeal teeth of larval and juvenile suckers (Catostomus). Copeia 1: 50-54.

4.8 Cyprinidae

Lake chub

Summaries of Spawning Information

Brown *et al* (3) studied the breeding biology of the lake chub in the Montreal River in Saskatchewan. In 1967 the fish were in the river two weeks before spawning occurred. Spawning occurred from May 21-May 27. Males stayed longer on the spawning grounds, most returning to the lake by May 30. Most spawning occurred in the afternoon, some at night, usually in about 5 cm of water. Most breeding activity occurred after water temperature reached $10^{o}C$. Spawning occurred over rocks, some on silt and leaves. No nest is constructed. Both sexes develop nuptial tubercles. The males and some females develop orange breeding marks. The males outnumber females in spawning groups. In Lac La Ronge, Saskatchewan, the spawning season was from June 13-June 16, but some gravid females were captured up until September 13. Spawning occurred over shallow, rocky shoals.

McPhail and Lindsey (4) report spawning in Cariboo lakes of B.C. from late May to early June. In the southern Yukon females with ripe or near ripe eggs were taken in late May. The eggs are yellowish and maturity is reached in the 3rd or 4th year.

Lake chub - *Couesius plumbeus* (Agassiz)

1. Ahsan, S. N., 1966a. Cyclical changes in the testicular activity of Lake chub, *Couesius plumbeus* (Agassiz). Can. J. Zool. 44: 149-159.

2. Ahsan, S. N., 1966b. Effects of temperature and light on the cyclical changes in the spermatogenetic activity of the Lake chub, *Couesius plumbeus* (Agassiz). Can. J. Zool. 44: 161-171.

3. Brown, J. H., U. T. Hammer, and G. D. Koshinsky, 1970. Breeding biology of the Lake chub, *Couesius plumbeus* at Lac La Ronge, Sask. J. Fish. Res. Bd. Can. 27 (6): 1005-1015. Illus. Maps.

4. McPhail, J. D. and C. C. Lindsey, 1970. Freshwater fishes of Northerwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173: 243-245.

Flathead chub

Summary of Spawning Information

McPhail and Lindsey (1) state that little is known of the life history or breeding habits in northern Canada. Spawning was probably in progress on June 27 in the Mackenzie River at 64°N, for some females taken had large ovaries of almost free eggs, and one was spent. Spawning had probably ceased before August 4 in the Peace River at Fort Vermilion as females taken then were spent.

Flathead chub - *Platygobio gracilis* (Richardson)

1. McPhail, J. D. and C. C. Lindsey, 1975. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173: 237-241.

Lognose dace

Summary of Spawning Information

McPhail and Lindsey (1) report that spawning has not been observed in northern Canada, but in central B. C. this fish spawnins in June and early July. In Kananaskis Lake, Alberta, spawning may continue until lage August. Probably no nest is constructed, but the males guard a territory. Eggs are laid in a group down amongst stones, and are probably guarded by one parent. In Manitoba, females lay from 200 to 1,200 eggs which are adhesive, transparent and so colourless as to be almost invisible under water. These hatch in 7-10 days at 16°C (60°F). Sexual maturity probably occurs in their third year.

Longnose dace - Rhinichthys cataractae (Valenciennes)

1. McPhail, J. D. and C. C. Lindsey, 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173: 246-249.

4.9 Osmeridae

Pond smelt

Summary of Spawning Information

McPhail and Lindsey (1) state that in mature males the pelvic fins almost reach the anus. There are well-developed tubercles on the head, scales and fins of spawning males. Spawning is reported to occur in April or May near Vladivostok; in Copper River, Alaska, specimens were ripe on June 8. In Black Lake, Alaska, spawning occurs in late June in littoral areas over bottoms that are largely covered with organic debris. Some stream spawning may occur. The eggs are adhesive and hatch in about 18 days at 10°C (50°F).

Pond smelt - *Hypomesus olidus* (Pallas)

1. McPhail, J. D. and C. C. Lindsey, 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173: 200-203.

2. de Graf, D., 1974. The life history of the pond smelt, *Hypomesus olidus* (Pallas) (Osmeridae), in a small unnamed lake in the northern Yukon Territory. IN: P. J. McCart (ed.), Life histories of three freshwater fishes in Beaufort Sea drainages, Yukon Territory. Canadian Arctic Gas Study Limited, Biological Report Series. Vol. 18(2). 100 p. Also: M.Sc. Thesis, Dept. of Biology, University of Calgary, Calgary, Alberta.

4.10 Gasterosteidae

Ninespine stickleback

Summaries of Spawning Information

McPhail and Lindsey (3) indicate a spawning period of spring and summer and from May to late July. Spawning is usually associated with dense vegetation, although coastal fish near Churchill have been seen to build nests in more exposed areas. At spawning time males are jet black under the chin and along the belly and the membranes of the ventral spines are white. Thirty to eighty eggs are laid per spawning but usually spawning occurs more than once each season. The eggs are 1.0-1.5 mm in diameter, and adhesive. The eggs hatch in 7 days at 18°C. Fish are mature after 1 year.

Nelson (4) studied sticklebacks in Indiana. Fully ripe females were collected until July 22 between depths of 9 and 16 meters. Eggs were running freely on June 9. Nelson quotes Kobayashi (1933) that the spawning period is from March to April in Japan, Bertin (1925) that the spawning period is from June to July in Scandinavia, and Jones and Hynes (1950) that spawning in England occurs from April to May. Spawning probably occurs in the rooted aquatics. The eggs are from 1.4-1.8 mm in diameter.

Ninespine stickleback - *Pungitius pungitius* (Linnaeus)

1. Kulamowicz, A., 1964. Nine-spined stickleback, *Pungitius pungitius* L. (Gasterosteidae), in the Pilica River basin. Przegl Zool. 8(3): 265-268. (Engl. summ.)

2. McPhail, J. D. and C. C. Lindsey, 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173: 307-309.

3. McPhail, J. D., 1963. Geographic variation in North American ninespine sticklebacks, *Pungitius pungitius*. J. Fish. Res. Bd. Can. 20(1): 27-44.

4. Nelson, J. S., 1968. Deep-water ninespine sticklebacks, *Pungitius pungitius* in the Mississippi drainage, Crooked Lake, Indiana. Copeia 2: 326-334.

5. Scott, W. B., 1955. Occurrence of the ninespine stickleback, *Pungitius pungitius*, in Newfoundland, Canada. Copeia 1955(1): 56.

4.11 Percopsidae

Trout-perch

Summaries of Spawning Information

Lawler (1) states that trout-perch spawn in May in Heming Lake, Manitoba, in the shallows at a water temperature of 40°-50°F over silt or boulders. The average fecundity for 11 fish was 349 eggs averaging 1.36 mm in diameter.

Magnuson and Smith (2) studied trout-perch from the Red Lakes in Minnesota. The spawning run starts in May, progresses to a peak or several peaks in June or early July and ends before September. In 1966 the peak was in the period June 25-July 4. Two peaks occurred in 1967, one from June 5-14 and the other from June 25 to July 4. The largest spawning concentrations occurred between 7 p.m. and midnight. The water temperature was about 67°-68°F. Spawning in Mud Creek took place within 4-5 inches of the surface near the edges of the stream. Two or more males spawned per female. The eggs were adhesive, yellowish and 1.45 mm in diameter. The incubation period was about one week. Age group 2 females provided 73% of the eggs.

McPhail and Lindsey (4) estimate spawning of trout-perch in the Muskwa River of northern B. C. in early June. Ripe fish were taken from June 5 to July 21. Spawning occurs in slow streams or on lake beaches.

Trout-perch - *Percopsis omiscomaycus* (Walbaum)

1. Lawler, G. H., 1954. Observations on the trout-perch *Percopsis omiscomaycus* (Walbaum), at Heming Lake, Manitoba. J. Fish. Res. Bd. Can. 11(1): 1-4.

2. Magnuson, J. J. and L. L. Smith, Jr., 1963. Some phases of the life history of the trout-perch (*Percopsis omiscomaycus*). Ecology 44(1): 83-95.

3. McAllister, D. E., 1961. Northward range extension of the flathead chub and trout-perch to Aklavik, N.W.T. J. Fish. Res. Bd. Can. 18: 141.

4. McPhail, J. D. and C. C. Lindsey, 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173: 291-293.

4.12 Cottidae

Fourhorn sculpin

Summaries of Spawning Information

Kuderskii and Lotarev (1) report spawning in the winter months in U.S.S.R. They give a fecundity range of 345-1,404 eggs which is less than marine forms.

Luk'yanchikov and Tugarina (3) report spawning in Khatanga Bay (marine) in February over a rubble bottom. The spawning stock was dominated by females with a fecundity of 4,100 eggs. Most spawners were 6 years old.

McPhail and Lindsey (8) report that in Great Bear Lake, N.W.T., spawning apparently occurs in summer. In late July, well-developed eggs were present. Lake Ontario fish had nearly ripe eggs in early August. The second dorsal fin is much higher in spawning males and the pelvics are longer.

In Lake Keta (U.S.S.R.) Mikhalev (4) describes well-developed embryos in the gonads of females in late September, a fact suggesting viviparity in contrast to marine specimens.

Westin (5) describes spawning in Sweden in water depths of 15-20 meters. Nests were built in algal masses or on soft bottoms free from algae. The males protect nests for as long as three months. In aquaria, Westin (6) found that spawning occurred from mid-December to the end of January. As the amount of light decreased, spawning activity increased. Water temperatures were maintained from 1.5-2.0°C. A relatively small number of large eggs were laid. Eggs were adhesive, forming a clump. The incubation period was 97 days at 1.5°C, 74 days at 2.0°C and 55 days at 4.7°C. Westin quotes Lamp (1966) that internal fertilization does not take place in this species. Westin (7) quotes Ekman (1899) on the fertility of this species as 3,000-3,500 eggs. Westin found a range of fecundity from 792-5,900 eggs increasing with the size of the fish. The eggs are from 2.4 mm to 2.9 mm in diameter. The low fertility is believed to be balanced by the aggressive watch over the egg mass by the males.

Fourhorn sculpin - *Myoxocephalus quadricornis* (Linnaeus)

1. Kuderskii, L. A. and V. A. Lotarev, 1964. A record of Onega sculpin (*Myoxocephalus quadricornis onegensis* Berg) in a small lake of the Onega-Segozero isthmus. IN: Karelian Fisheries. Petrozavadsk. 8: 210-214. From: Referat. Zhur. Biol., 1964, No. 23115.

2. Kuderskii, L. A., 1966. Contributions to the biology of the Onega fourhorn sculpin (*Myoxocephalus quadricornis onegensis*). Tr. Karel. Otd. Gos. Nauch-Issled. Inst. Ozer. Rechn. Rybn. Khoz. 4(2): 119-135. From: Referat. Zhur. Biol., 1966, No. 111113.

3. Luk'yanchikov, F. V. and P. Y. Tugarina, 1965. Arctic Ocean sculpin *Myoxocephalus quadricornis labradoricus* of Khatanga Bay. Izv. Biol. Geogr. Nauch-Issled. Inst. Irkut. Univ. 18(½): 181-186. From: Referat. Zhur. Biol., 1966, No. 9111.

4. Mikhalev, Yu. V., 1964. The sculpin of the species *Myoxocephalus quadricornis* (Linne) from Lake Keta (Pyasina Basin). A morpho-biological characterization. Tr. Sibirsk. Otd. Gos. Nauch-Issled. Inst. Ozern. Rechn. Rybn. Hoz. 8: 171-183. From: Referat. Zhur. Biol., 1964, No. 2162.

5. Westin, Lars, 1970. Observations on the nest digging of fourhorn sculpin *Myoxocephalus quadricornis* (L.) Rept. Inst. Freshwater Res. Drottningholm. 50: 211-214.

6. Westin, Lars, 1969. The mode of fertilization, parental behaviour and time of egg development in fourhorn sculpin, *Myoxocephalus quadricornis* (L.) Rept. Inst. Freshwater Res. Drottningholm. 49: 175-182.

7. Westin, Lars, 1968. The fertility of Fourhorn sculpins, *Myoxocephalus quadricornis* (L.). Rept. Inst. Freshwater Res. Drottningholm. 48: 67-70.

8. McPhail, J. D. and C. C. Lindsey, 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173: 319-323.

Slimy sculpin

Summaries of Spawning Information

McPhail and Lindsey (4) quote Richardson(1836) that he took the species "in considerable numbers in the clear waters of Great Bear Lake during the month of May, at which period it resorts to the stony shallows to spawn.... some individuals, which are full of roe, measure only two and a half inches in total length."

Farther south it typically spawns in running water; the eggs are attached to the underside of stones and guarded by the males. The dark body colour of the male and orange-trimmed dorsal fin at this time probably serve for sexual recognition.

Slimy sculpin - *Cottus cognatus* (Richardson)

1. Dunbar, M. T. and H. H. Hildebrand, 1952. Contribution to the study of the fishes of Ungava Bay. J. Fish. Res. Bd. Can. 9: 83-128.

2. McAllister, D. E. and C. C. Lindsey, 1960. Systematics of the freshwater sculpin (*Cottus*) of B. C. Natl. Mus. Can. Bull. 172: 66-89.

3. McAllister, D. E., 1964. Distinguishing characters for the sculpins *Cottus bairdii* and *C. cognatus* in eastern Canada. J. Fish. Res. Bd. Can. 21(5): 1339-1342.

4. McPhail, J. D. and C. C. Lindsey, 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can. 173: 333-335.

5. Richardson, J. R., 1836b. Zoological appendix. Fishes. IN: G. Back (ed.). Narrative of the Arctic Land expedition to the mouth of the Great Fish River and along the shores of the Arctic Ocean in the years 1833, 1834 and 1835. John Murray, London, p. 518-522.

Table IX. Mean length at sexual maturity of some fish species in the Porcupine River.

Species	Mean Length (mm)	Standard Deviation	Sample Size
Coho salmon	585	3.45	5
Lake chub	110	0.54	4
Burbot	607	7.98	52
Chinook salmon	623	4.58	4
Round whitefish	304	0.0	1
Least cisco	283	4.19	218
Inconnu	580	8.27	32
Humpback whitefish	425	4.33	86
Broad whitefish	499	4.52	58
Northern pike	466	8.17	60
Longnose sucker	391	3.61	145
Chum salmon	661	4.19	78
Arctic grayling	348	4.30	167

data from,

Steigenberger, L. W., R. T. DeLury, G. J. Birch and J. Fisher. 1973. Fish resources of the northern Yukon, fish survey 1972 base data, Appendix Volume I. Environmental-Social Committee, Task Force on Northern Oil Development. (Unpublished computer listing of data.)

5. a) References to Fisheries Research conducted since 1970 in Northern Yukon Territory and in the Mackenzie River Valley.

A 1) Bain, L. H., 1974. Life histories and systematics of Arctic char (Salvelinus alpinus, Linn.) in the Babbage River system, Yukon Territory. IN: P. J. McCart (ed.), Life histories of three species of freshwater fishes in Beaufort Sea drainages, Yukon Territory. Canadian Arctic Gas Study Limited, Biological Report Series. Vol. 18(1). 100 p. ALSO: M.Sc. Thesis, Department of Biology, University of Calgary, Calgary, Alberta.

A 2) Bryan, J. E., C. E. Walker, R. E. Kendel, and M. S. Elson. MS 1972. The influence of pipeline development on freshwater aquatic ecology in northern Yukon Territory. Progress Report on research conducted in 1971. Fisheries Service, Department of the Environment, Vancouver, B.C.

A 3) 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.

A 4) Craig, P. C., and G. J. Mann, 1974. Life history and distribution of the Arctic cisco (Coregonus autumnalis) along the Beaufort Sea coastline in Alaska and the Yukon Territory. IN: P. J. McCart (ed.), Life histories of anadromous and freshwater fishes in the Western Arctic. Canadian Arctic Gas Study Limited, Biological Report Series. Vol. 20(4). 32 p.

A 5) Craig, P. C. and P. McCart, 1974. Fall spawning and overwintering areas of fish populations along routes of proposed pipeline between Prudhoe Bay and the Mackenzie Delta 1972-1973. IN: P. J. McCart (ed.), Fisheries research associated with proposed gas pipeline routes in Alaska, Yukon and Northwest Territories. Canadian Arctic Gas Study Limited, Biological Report Series. Vol. 15(3). 36 p.

A 6) de Bruyn, M. and P. McCart, 1974. Life history of the grayling (Thymallus arcticus) in Beaufort Sea drainages in the Yukon Territory. IN: P. J. McCart (ed.), Fisheries research associated with proposed gas pipeline routes in Alaska, Yukon and Northwest Territories. Canadian Arctic Gas Study Limited, Biological Report Series. Vol. 15(2). 39 p.

A 7) de Graaf, D., 1974. The life history of the pond smelt *Hypomesus olidus*, Pallas (Osmeridae) in a small *unnamed lake in* the northern Yukon Territory. IN: P. J. McCart (ed.), Life histories of three species of freshwater fishes in Beaufort Sea drainages, Yukon Territory. Canadian Arctic Gas Study Limited, Biological Report Series. Vol. 18(2). 100 p. ALSO: M. Sc. Thesis, Department of Biology, University of Calgary, Calgary, Alberta.

A 8) Doran, L. D., 1974. Environmental Impact Assessment of the portion of the Mackenzie Gas Pipeline from Alaska to Alberta. Chapter 8. Fish. For the Environment Protection Board.

A 9) Dryden, R. L., B. G. Sutherland and J. N. Stein, 1973. An evaluation of the fish resources of the Mackenzie River Valley as related to pipeline development. Vol. 11. Department of the Environment, Fisheries Service, Winnipeg, Man. 176 p.

A10) Elson, M. S., 1973. Enumeration of spawning chum salmon in the Fishing Branch River in 1971 and 1972. Canada Dept. Envir., Fish. Mar. Ser., Pacific Region. Technical Report 1973-5. 20 p.

A11) Elson, M. S., MS 1973. Fishing Branch Studies - 1973. Memorandum Report.

A12) Elson, M. S., 1974. Catalogue of Fish and Stream Resources of East Central Yukon Territory. Fisheries and Marine Service, Department of the Environment, Pacific Region. Report No. PAC/T-74-4.

A13) Glova, G. and P. McCart, 1974. Life history of Arctic char (*Salvelinus alpinus*) in the Firth River, Yukon *Territory. IN:* P. J. McCart (ed.), Life histories of anadromous and freshwater fishes in the Western Arctic. Canadian Arctic Gas Study Limited, Biological Report Series. Vol. 20(3). 37 p.

A14) Griffiths, W., A. Sekerak and M. Jones, 1974. Distribution of fish species along the alternative gas pipeline corridors in Alaska, the Yukon Territory and Northwest Territories. IN: P. J. McCart (ed.), Classification of streams in Beaufort Sea drainages and distribution of fish in Arctic and sub-Arctic drainages. Canadian Arctic Gas Study Limited, Biological Report Series. Vol. 17(2). 176 p.

A15) Hatfield, C. T., J. N. Stein, M. R. Falk and C. S. Jessop, 1972a. Fish resources of the Mackenzie River Valley, Interim Report 1, Vol. 1. Department of the Environment, Fisheries Service, Winnipeg, Man. 247 p.

A16) Hatfield, C. T., J. N. Stein, M. R. Falk, C. S. Jessop and D. N. Shepherd, 1972b. Fish resources of the Mackenzie River Valley. Interim Report 1, Vol. 11. Department of the Environment, Fisheries Service, Winnipeg, Man. 289 p.

A17) Jessop, C. S., T. R. Porter, M. Blouw and R. Sopuck, 1973. Fish resources of the Mackenzie River Valley. An intensive study of the fish resources of two main stem tributaries. Department of the Environment, Fisheries Service, Winnipeg, Man. 148 p.

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CHAPTER II

FISHERIES INVESTIGATIONS OF THE PORCUPINE RIVER DRAINAGE IN THE VICINITY OF OLD CROW IN THE NORTHERN YUKON TERRITORY, OCTOBER 1972

Extracted from an unpublished
memorandum by

G. J. BIRCH

Revised and edited

for the

Environmental-Social Program
Northern Pipelines

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This report was revised and prepared for publication by P. Bruce, M. Elson, and L. Steigenberger, Fisheries and Marine Service, Department of the Environment, Vancouver, British Colubmia.

1. Abstract

A study of fish populations and habitat was conducted during October, 1972, in the vicinity of Old Crow, northern Yukon Territory. Life history data and movements of the fish species present, and water quality data were recorded from the Porcupine and Old Crow Rivers, and from Chinneitlui and Fish Lakes. Aerial reconnaisance flights were made over the Bluefish and Porcupine Rivers and Lord Creek to record the extent of freeze-up during October.

The most abundant species in the Porcupine and Old Crow Rivers were Arctic grayling, least cisco, burbot, and suckers. The majority of the grayling were mature fish but least cisco and suckers were predominately immature fish. Age and growth data for fish species compared favorably with information collected previously.

The Old Crow River serves as a migratory route for fish spending the summer period in the Old Crow flats area, to overwintering areas in the Porcupine River.

Water quality was adequate for the support of fish life, in the areas sampled. The Porcupine River was partially frozen over, and smaller rivers and lakes, except in groundwater areas, were completely frozen over.

Groundwater areas in the Bluefish River were examined but no fish were observed. Over less than five miles of the Old Crow River headwaters, a groundwater area, 3,000 to 4,000 grayling were sighted.

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2. Introduction

During October 1972, a study of fish populations and their habitats was carried out in the Porcupine drainage of the northern Yukon Territory, in the vicinity of Old Crow. The objective of this study was to inventory some characteristics of the aquatic environment and the indigenous fish stocks in the northern Yukon, complementing the research of the summer 1972 period.

This project is a part of a program organized by the Yukon Pipeline Group, Fisheries and Marine Service, Vancouver, B. C., to prepare an impact assessment of a proposed oil-gas pipeline on the freshwater fisheries of the northern Yukon. This report is a presentation of the data collected, and a comprehensive discussion of the results will be left for evaluation reports that are to be published in the near future.

Ecological studies were conducted on the Porcupine and Old Crow Rivers, Fish Lake (Lake # 10) and Chinneitlui Lake (Lake # 8), and the groundwater areas of the Bluefish and Old Crow River headwaters. Aerial reconnaissance of open water areas and degree of ice formation were flown on the Porcupine and Bluefish Rivers and on Lord Creek. This preliminary data was used to record changes in the habitat in the transition to a winter environment, and to postulate fish migrations in these areas.

The domestic fish catch in Old Crow was recorded to aid life history studies of fish species in the area, and to estimate the native exploitation of this resource. This information has been published separately in Steigenberger et al, 1974.

3. Methods

3.1 Fish Studies

The study was conducted from the village of Old Crow between October 1 and October 27, 1972.

Cross country skis, snowshoes, and a snowmobile with a tobbogan were used for transport in the vicinity of Old Crow. Transportation to more distant sites was by fixed wing aircraft on skis and by helicopter.

A chain saw, axe, and ice chisels were used to saw and clear holes in the ice used in fishing and water chemistry analysis.

Gillnets, seine nets, a trap net, and dip nets were used to sample fish populations. Series of 0.5 inch, 1.5 inch, 2.5 inch, and 3.0 inch stretch mesh monofilament nylon gillnets were used as well as 4.0 inch and 4.5 inch polyfilament nets. Lead weights were added to gillnets set in the Old Crow River current to facilitate more efficient fishing.

Gillnets were available in 50 ft. by 8 ft. panels with lead lines and floats. Period of set varied from approximately 17 hours to 196 hours, or roughly one to eight days. A minimum set period of 24 hours was attempted.

A 4 ft. by 4 ft. small mesh trapnet without wings was set facing upstream in the Old Crow River (Figure 1, Site 14) to sample small fishes. The period of set varied between 22 and 26 hours.

Downstream seines in the Old Crow River headwaters (Figure 1, Site 30) were made with a 100 ft. by 6 ft. by ½ inch mesh beach seine net with a 20 ft. by ¼ inch mesh end bunt.

A dipnet was used to sample sculpins (Cottus cognatus) in the Bluefish River groundwater area (Figure 1, Site 36), as obstructions in the river prevented seining.

Whenever possible the following data were recorded from fish caught: fork length (mm), weight (g), sex and sexual maturity, scales and otoliths for aging, stomach contents, visceral fat deposition, and parasites present. Loss of scales and body decomposition occasionally limited data collection.

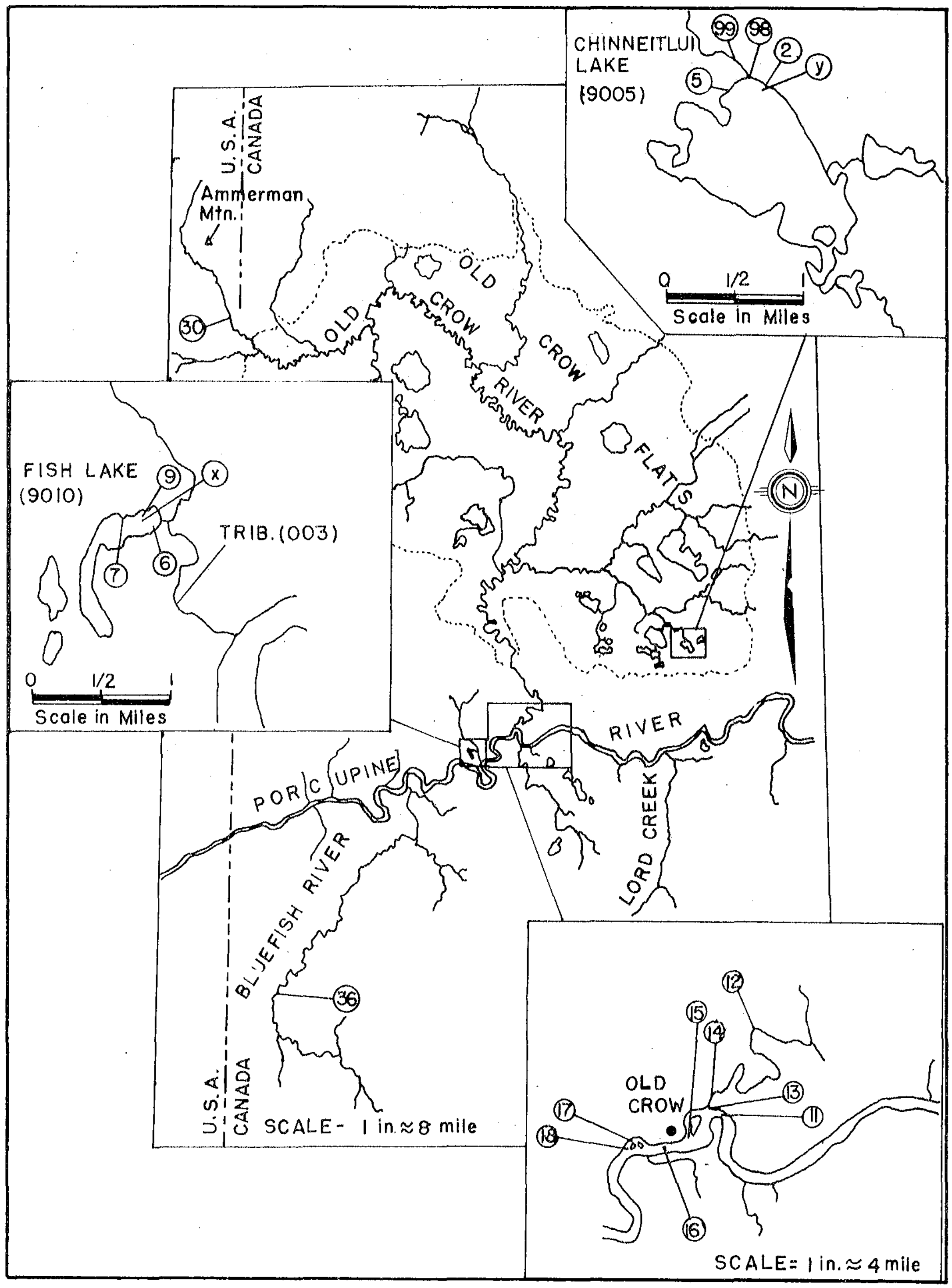


Figure 1. Gillnet, trapnet, and water chemistry sampling locations used during the October, 1972 studies in the northern Yukon.

Burbot (*Lota lota*) and inconnu (*Stenodus leucichthys*) were subsampled for otoliths, and small pike (*Esox lucius*) were preserved in a 10% formalin solution for aging later. Otoliths were preserved in a 50% glycerin and water solution with thymol crystals. Aging of scales and otoliths were conducted in Vancouver using techniques described by Birch and Yole (1974).

Sexual maturity was assigned on the basis of criteria defined by the Yukon Pipeline Group (Appendix II).

Analysis of stomach contents was carried out with a dissecting microscope with reference to a catalogue of commonly encountered food items prepared by Steigenberger et al (1973).

3.2 Water Quality Studies

Water chemistry, and ice and water depth measurements were carried out in Fish Lake (Figure 1, Site X), Chinneitlui Lake (Figure 1, Site Y), Bluefish River (Figure 1, Site 36) and several stations in the Porcupine and Old Crow Rivers (Figure 1, Site 11, 14, 15, 16, 18 and 30). Chemical analysis was carried out in the field using Hach kits for the following measurements: dissolved Oxygen, (Model OX-2P), pH (Model 17N), H_2S (Model HS-7), alkalinity (Model AL-AP), and hardness (Model HA-71A). Samples and chemicals were maintained in the field in heated polyethylene Coolers. Pocket and max.-min. thermometers were used to measure temperature. Specific conductance was recorded from frozen water samples sent to Vancouver, B. C., measured with a conductivity bridge (Model RC 16 BI).

Depth measurements of water bodies were made with a meter stick or a weighted line and velocity was measured by determining the time (seconds) for an object to float 100 feet downstream.

All biological data has been recorded by computer printout and is available for further analysis (Steigenberger et al, 1973).

4. Results and Discussion

4.1 Fish Studies in the vicinity of Old Crow

The Porcupine and Old Crow Rivers were sampled at several stations in an attempt to identify pre-winter aquatic habitats and possible migratory routes of fish. Aseries of gillnets were set in Fish Lake (Lake # 10) and Chinneitlui Lake (Lake # 8) to investigate the presence of any early winter fish populations.

Catch per unit effort was generally good throughout the study area (Appendix III), and was compatible to, or higher than, figures determined in an April 1973 study (Birch, 1974). Decrease in the catch of fish was usually due to the accumulation of slush ice in the gillnets, particularly in eddies and backwaters, or the obstruction of fish movements into the nets by native fishing activity. A large variety of mesh sizes were fished in a variety of locations in the Porcupine River in an attempt to obtain a representative sample of all fish species present.

4.1.1 Species Composition and fish movements.

A total of 444 fish were caught in the Porcupine River during the study. Arctic grayling (Thymallus arcticus) formed 33.3% of the total catch, followed by least cisco (Coregonus sardinella) forming 26.13% and burbot (Lota lota) comprising 11.71% of the catch (Figure 2). Other whitefish such as humpback whitefish (Coregonus clupeaformis), broad whitefish (Coregonus nasus), and inconnu (Stenodus leucichthys) were present in low numbers.

Two Stenodus - Coregonus hybrids, as described in Alt (1971) were caught. No round whitefish (Prosopium cylindraceum) were taken. Chum salmon (Oncorhyncus keta) and Coho salmon (Oncorhyncus kisutch) were netted during their upstream migration to spawning grounds and local fishermen concentrated their efforts on these species. The species composition of the catch during the study was generally comparable to the catch of the native fishermen.

Catches and species composition for 1971 as cited by Bryan et al (1973) are not comparable for this time of the year, but do indicate the importance of salmon in the domestic catch.

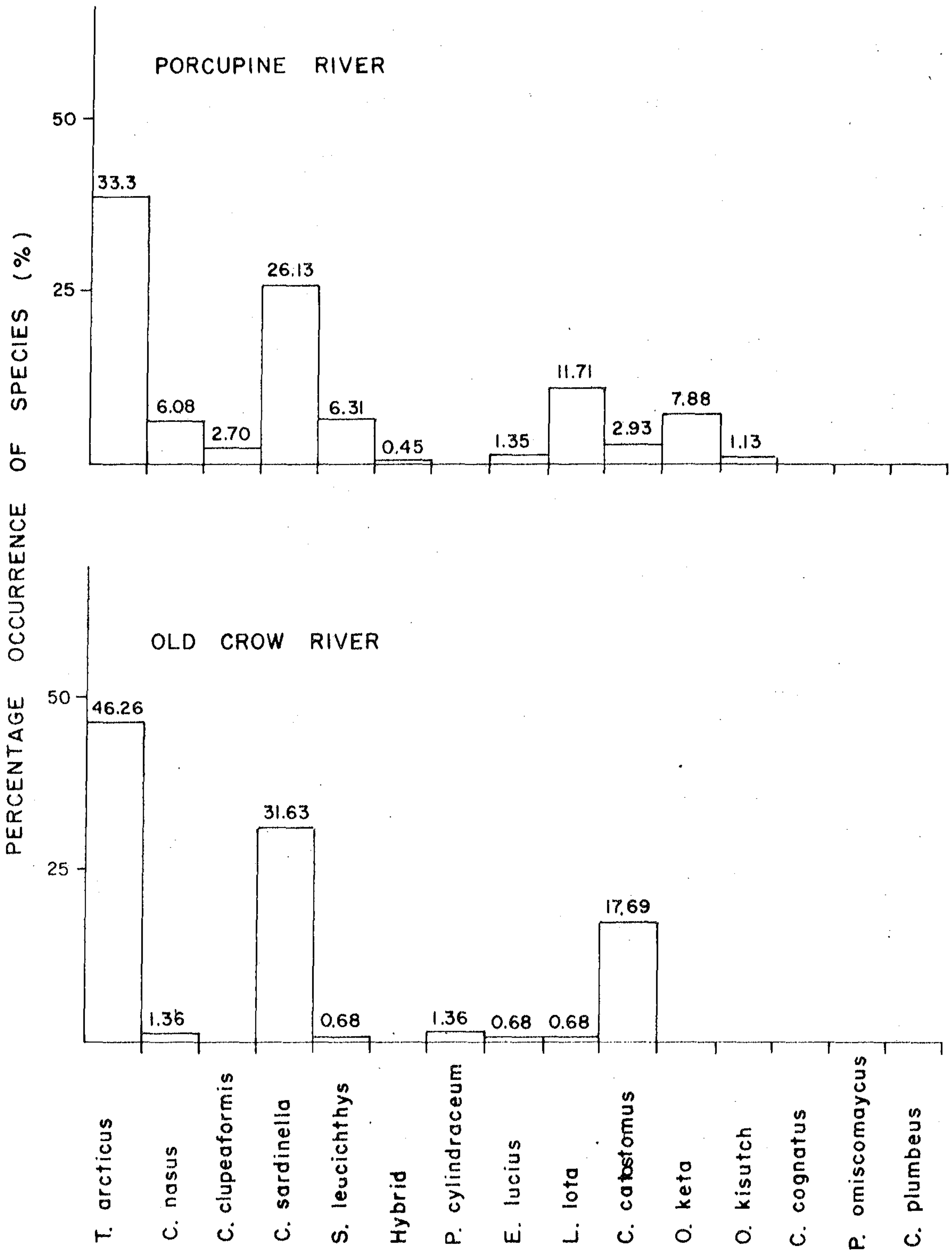


FIGURE 2. Species compositions in the Porcupine and Old Crow Rivers in October 1972. Samples are from gillnet catches.

From percentage occurrence of species at each station fished in the Porcupine River, several notes on habitat preference may be inferred (Appendix IV). Grayling and least cisco are taken at all sites but are particularly abundant in fast water mainstream areas where other species such as burbot are not found (Figure 1 site 16). The long-nose sucker (Catostomus catostomus) and burbot are found in slow moving backwaters (Figure 1 sites 15, 17 and 18). Food items may play a part in these habitat preferences. Salmon tend to be taken near or in the mainstream while on their spawning migration.

Of a total of 294 fish taken in the Old Crow River, grayling formed 46.26% of the total catch, followed by least cisco (31.63%) and suckers (17.69%). Broad whitefish and inconnu were caught only in low numbers and no humpback whitefish were taken in the Old Crow River. Burbot (0.68%) and northern pike (Esox lucius) were found in small numbers, only at the Old Crow River mouth. Round whitefish formed only 1.36% of the catch from the Old Crow River.

A trapnet set near the mouth of the Old Crow River was used to sample small fishes in the area (Figure 3). Grayling (5.16%), round whitefish (4.71%) and sucker (65.78%) fry were taken in relatively large numbers. The food fishes typically found in large muddy rivers (McPhail and Lindsey, 1970) such as Sculpins (Cottus cognatus), troutperch (Percopsis omiscomaycus), and lake chub (Couesius plumbeus) contributed to the catch.

The Old Crow River was found to be uninhabited by fish in April, 1973, (Birch, 1974) and fishes caught in the early winter appeared to be migratory forms. Grayling, round whitefish, and longnose sucker were taken in large numbers in the fall as both adults and fry. These species frequent clear water tributaries of the Porcupine and Old Crow Rivers during the summer months. Least cisco are abundant in lakes on the Old Crow flats in the summer, and were also caught as adults and fry in the Old Crow River during the October survey.

The data implies a migration route down the Old Crow River in the fall. Corroborating evidence of migration was supplied by the recapture of a tagged fish in the Porcupine River (Site 16 Figure 1). Three broad whitefish were caught by a local fisherman on October 23, 1972. All three were mature females, two in ripe spawning condition (Appendix II), the other spent. One of the ripe fish had been tagged on August 7, 1972, at Chinneitlui Lake which supports large summer populations of broad whitefish, humpback whitefish, least cisco, pike, suckers, and grayling and a few burbot.

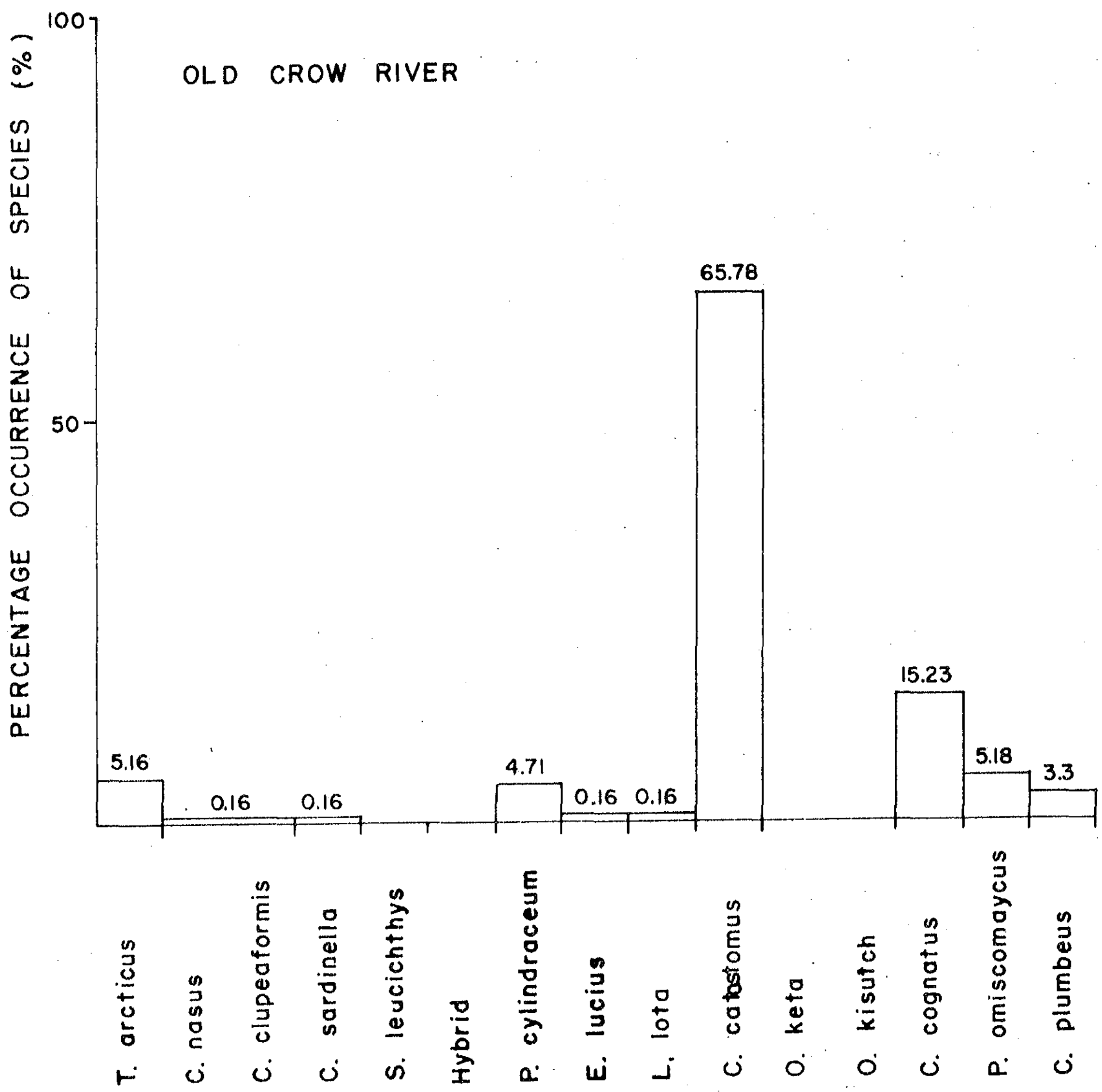


FIGURE 3. Species composition in the Old Crow River in October 1972. Samples are from trapnet catches.

Fish Lake and Chinneitlui Lake were fished with a wide range of gillnet mesh sizes (Appendix II) at several sites (Figure 1). Species composition of the catches are listed in Appendix IV.

In October, 1972, from a sample of 39 fish, Fish Lake was found to support the following species: broad whitefish (66.7%), least cisco (20.5%) and northern pike (12.8%). The percentage composition of the fish populations was somewhat different when the lake was sampled in August 1972. Of 89 fish taken in August, 48.3% of the catch were least cisco, 29.2% were broad whitefish, 19.1% were pike, 2.3% were grayling and 1.1% were suckers. In April 1973, only least cisco (66.6%) and broad whitefish (33.3%) were present in the total of 9 fish caught.

Fish Lake drains into the Porcupine River by a small tributary. Bryan (1973) has postulated a downstream movement of broad whitefish and least ciscoes in the spring from the lake to the Porcupine River. A small trapnet was set in the creek in August 1972, to catch downstream migrants. The majority of the 294 fish caught were juveniles and fry. Sculpins and suckers were the most numerous species with fewer numbers of round whitefish and one juvenile least cisco being caught. Many of these fry probably resulted from spawning activities in the creek above the trap, where gravel substrate conditions appear to be good. Fish Lake undoubtedly supports a resident population of broad whitefish, least cisco and possibly pike. All these species are assumed to spawn in the lake. The few grayling and suckers taken in the summer are probably from transient populations utilizing the tributary for spring spawning and summer feeding activities.

Pike (97.3%) and burbot (2.7%) fry were caught in Chinneitlui Lake near, and in, the outlet creek. The large summer populations of whitefish, grayling and suckers were absent. The fry probably are the result of spring spawning by pike, and late winter spawning by burbot in or near this lake system. It is expected that the fry move downstream to overwintering habitats of more suitable water quality and depth when the outlet creek freezes over. Water chemistry analysis of Chinneitlui Lake in April 1973, indicated uninhabitable conditions for fish (DO_2 = 0.0 mg/l) (Birch, 1974).

4.1.2 Length - Frequency relationships.

The sample size of grayling (n = 286) and least cisco (n = 217) caught using gillnets were considered adequate for length frequency analysis. The length-frequency relationships for the total population of each species, collected from the Porcupine and Old Crow Rivers, are plotted in Figures 4 and 5.

The peak frequencies of various fork lengths from the grayling examined were found to be similar in the samples from the Porcupine River and the Old Crow River (Table 1). The same similarity was found to exist for the least cisco population (Table 2).

When length-frequency distributions for each sex were calculated, the frequencies for males and females were comparable for each of the two species.

Male and female grayling appeared in peak numbers at much the same size groupings as for the entire population depicted in Figure 4. Male grayling, though, occurred in the highest numbers in the 390 mm interval, while female grayling peaked highest on the 360 mm to 379 mm intervals. Both peaks coincide with the mean fork lengths at 6 years of age for each sex. Six year old males are 380 $\pm$ 33.6 mm in length and 6 year old females are 367 $\pm$ 50.9 mm in length (Figure 6). Reed (1964) has stated that male grayling appear to be larger than mature females at the same age in Alaska, which supports the results determined for the Old Crow area.

In the least cisco, females outnumber males throughout the frequency distribution.

In April 1973, the highest number of grayling in the Porcupine River exhibited fork length of between 360 mm and 389 mm (Birch, 1974). The younger, smaller fish between 200 mm and 300 mm in fork length were missing from the sample. Bryan et al (1973) determined the greatest number of grayling in the Porcupine drainage to be between 350 mm and 400 mm in length. The largest number of least cisco reported by Bryan et al (1973) in the Porcupine drainage, occurred between fork lengths of 250 mm and 300 mm. Hatfield et al (1972b) observed that the greatest number of least cisco occurred between 270 mm and 290 mm of fork length in the MacKenzie River drainage, near the Arctic Red River , in 1971.

4.1.3 Length - Weight relationships.

Linear regression of ln fork length (x) versus ln weight (y) were calculated for the Porcupine River - Old Crow River populations of grayling and least cisco. The relationships are expressed as:

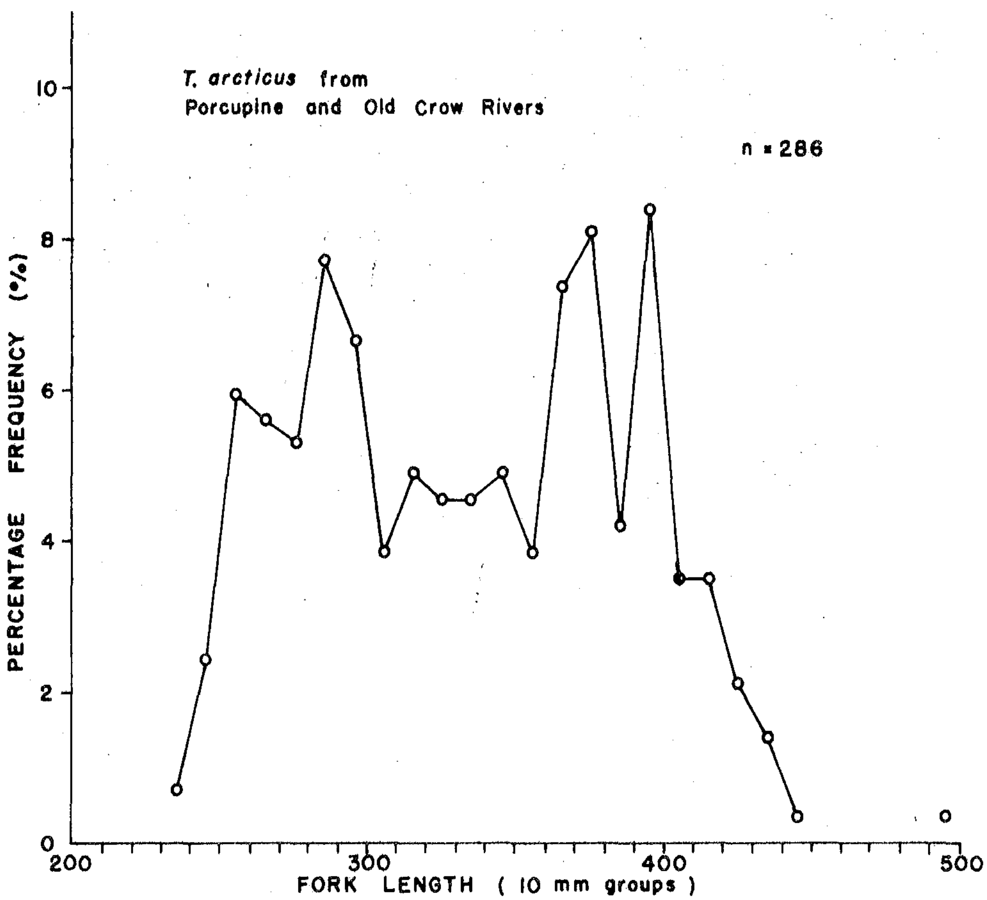


FIGURE 4 Weighted average frequency distribution for Thymallus arcticus from the Porcupine and Old Crow Rivers during October 1972.

FORK LENGTH (10 mm groups)

										300										400										500	Sample Size
PORCUPINE RIVER				0.68	1.35	6.08*	4.05	6.08*	7.43	8.11*	6.08	6.08	4.05	4.05	6.08	2.70	8.11*	8.11*	4.05	7.43*	4.73	2.70	0.68	0.68	0.68						148
OLD CROW RIVER				0.72	3.62	5.80	7.25*	4.35	7.97	5.07	1.45	3.62	5.07*	5.07*	3.62	5.07	6.52	7.97	4.35	9.42*	2.17	4.35*	3.62	2.17						0.72	138
Total (%)				0.70	2.45	5.94	5.59	5.24	7.69	6.64	3.85	4.90	4.55	4.55	4.90	3.85	7.34	8.04	4.20	8.39	3.50	3.50	2.10	1.40	0.35					0.35	286

TABLE I Percentage frequencies in T. arcticus populations from the Porcupine and Old Crow Rivers. Asterisks mark peak frequencies at size groupings, note comparibility.

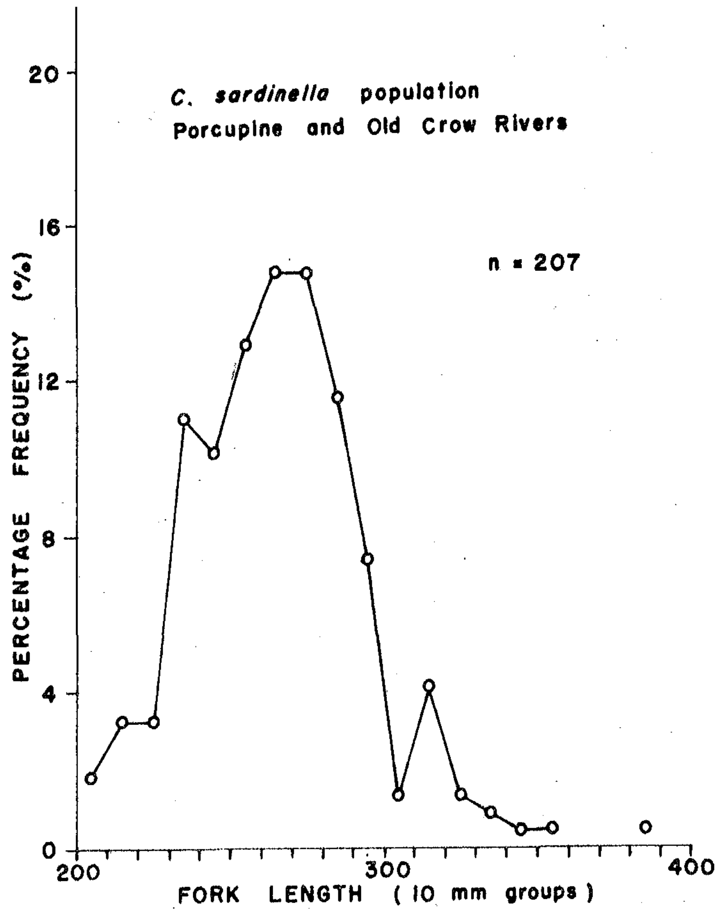


FIGURE 5 Weighted length frequency distribution for Coregonus sardinella from the Porcupine and Old Crow Rivers during October, 1972

	FORK LENGTH (10 mm groups)																				Sample Size
	200										300									400	
PORCUPINE RIVER	0.87		0.87	7.83*	6.09	14.8	19.1*	13.04	16.52*	8.69	1.74	6.09	0.87	1.74*	0.87			0.87			115
OLD CROW RIVER	3.26	7.60*	6.52	16.30*	16.30*	11.96	10.87	7.61	6.52*	6.52*	1.08	2.17*	2.17*			1.08					92
Total (%)	1.93	3.38	3.38	11.59	10.63	13.53	15.45	10.63	12.08	7.13	1.45	4.35	1.45	0.96	0.48	0.48		0.48			207

TABLE 2 Percentage frequencies in C. sardinella populations from the Porcupine and Old Crow Rivers. Asterisks mark peak frequencies at size groupings, note comparability.

$$\ln w = a + b\ (\ln L)$$

where a = y intercept
b = slope
w = weight (g)
L = fork length (mm)

For grayling the following was calculated:

$\ln w = -11.3356 = 2.9975\ (\ln L)$
for n = 286
When the correlation coefficient (r) = 0.9632
the standard error of the slope (SE) = 0.0496
and the 95% conficence limits of the slope are
2.8993 and 3.0957.

This relationship does not appear significantly different from that calculated for grayling from the Yukon north slope or Porcupine River drainage in 1971 (Bryan et al, 1973). In addition the equation appears similar to length - weight relationships for grayling populations in the Fishing Branch River of the Porcupine River headwaters (Bruce, 1974) and the Arctic Red River in the MacKenzie River Valley (Hatfield et al, 1972a).

For least cisco, the resulting formula was:

$\ln = -9.9193 + 2.7599\ (\ln L)$
for n = 208
When the correlation coefficient (r) = 0.8752
the standard error of the slope (SE) = 0.1063
and the 95% confidence limits of the slope are
2.5494.

This relationship does not appear significantly different from that calculated for least cisco from the Arctic Red River area of the MacKenzie River Valley (Hatfield et al, 1972a). Hatfield's equation is, in fact, very comparable having a slope of 2.619 and Y-intercept of -9.428 for a sample size of 177 cisco. A length weight relationship determined by Bryan et al, (1973) for this species from the northern Yukon in 1971 shows a much greater slope (b = 3.249, n = 60, correl. coeff. = 0.945, SE = 0.1432), thereby indicating the fish to be heavier at any given length. Seasonal varieties in degrees of maturity (gonadal weight) or greater numbers of the fatter lake or estuarine fed fishes may account for the difference. Bryan's sample is believed to have included north slope fishes.

4.1.4 Sex and maturity rates.

Percentage occurrence of male and female fish for most of the species caught are listed in Table 3. Table 4 shows the percentage of mature and immature fish by sex for the Porcupine River, Old Crow River and Fish Lake. Immatures are defined as being from maturity code 1 to 3; matures are from 4 to 8 (Appendix 2). Those fish caught by trapnet are not included and were probably all immature.

Grayling from the Porcupine River show a ratio of 1.17 males to one female, while those in the Old Crow River have a ratio of 1.26 females to one male. The reversal in ratios may indicate early migration of male grayling to the Porcupine River but neither result is significantly different from the expected 1:1 ratio. Similar ratios were found in mature grayling from the north slope and Porcupine River drainage (Bryan et al, 1973), from the Fishing Branch River (Bruce 1974), and from the MacKenzie River Valley (Hatfield et al, 1972a). The majority of grayling sampled, of both sexes, were mature (33.1 to 37.8%), and ready to spawn in the spring (maturity stages 5 and 6).

Whitefish spawn from autumn to early winter. Broad whitefish in the Porcupine River are present in a 2.2 males to one female ratio, and the majority of fish caught were immature. Of those taken in the Old Crow River, all mature fish (n = 2) were dormant females. Although several ripe and spent females were caught in the Porcupine River, due to the low numbers of mature fish, it appears that spawning primarily occurs elsewhere.

Least cisco in the Porcupine River are found at a ratio of 2.28 females to one male and in the Old Crow River, populations are present at a ratio of 1.63 females to one male in the sample (n = 115). Again, immature fish are predominant in both rivers. A few ripe (stage 7) and spent males and female fish were also taken in both rivers. Considering the magnitude of the least cisco population, spawning could occur in the lake and streams near the Old Crow area.

Broad whitefish taken from Fish Lake in October are predominantly male (1.36 males to one female) (n = 26) and immature. The least cisco in the lake are primarily female (3 females to one male) (n = 8) and the majority of both sexes are mature. Ripe individuals of both sexes were taken, indicating spawning may have been occurring.

Table 3. Relative percentage presence of male and female fish of species caught in the Porcupine River, Old Crow River and Fish Lake in October, 1972. Immatures with unidentifiable sex are not included.

	Species in each River or Lake	Sample Size	% Male	% Female
Porcupine River:	*T. arcticus*	148	54.0	46.0
	C. nasus	16	68.75	31.25
	C. clupeaformis	8	50.0	50.0
	C. sardinella	115	30.4	69.6
	S. leucichthys	25	44.0	56.0
	L. lota	48	35.4	64.6
	C. catostomous	9	33.33	66.67
	O. keta	35	60.0	40.0
Old Crow River:	*T. arcticus*	135	41.15	51.85
	C. sardinella	92	38.04	61.96
	C. catostomous	44	47.73	52.27
Fish Lake:	*C. nasus*	26	57.69	42.31
	C. sardinella	8	25	75
	E. lucius	5	60	40

Table 4. Percentage presence of mature and immature fish in each sex of species caught in the Porcupine River, Old Crow River and Fish Lake in October, 1972. Total percentage immatures include those specimens with unidentified sex.

	Species in Each River or Lake	Sample	Male Percent Mature	Male Percent Immature	Female Percent Mature	Female Percent Immature	Total Percent Mature	Total Percent Immature
Porcupine River:	*T. arcticus*	148	37.84	16.22	37.84	8.11	75.67	24.32
	C. nasus	24	25.0	20.83	8.33	12.5	33.33	66.67
	C. clupeaformis	12	0	33.3	8.33	25.0	8.33	91.67
	C. sardinella	116	11.21	18.97	26.72	42.24	37.93	62.07
	S. leucichthys	27	7.14	32.14	21.43	28.57	29.63	70.37
	L. lota	51	31.37	1.96	58.82	1.96	90.2	9.8
	C. catostomus	12	0	23.1	7.69	38.46	8.33	91.67
	O. keta	35	60.0		40.0		100	
Old Crow River:	*T. arcticus*	135	37.5	10.3	33.1	18.4	71.11	28.89
	C. nasus	4	0	0	50	0	50	50
	C. sardinella	93	6.45	31.2	18.3	43.0	24.73	75.27
	C. catostomus	49	3.85	36.5	17.3	26.9	22.45	77.55
Fish Lake:	*C. nasus*	26	0	57.7	19.2	23.1	19.23	80.77
	C. sardinella	8	25.0	0	50.0	25.0	75	25
	E. lucius	5	60.0	0	40.0	0	100	0

Inconnu occur in the Porcupine River at nearly a 1:1 sex ratio (1.27 females to one male). The majority of both sexes are immature, and of the mature fish caught, only a few were spent and dormant individuals. Alt (1969) believes inconnu in Alaska migrate to spawning grounds and exhibit a post spawning downstream migration. It appears safe to assume that the fish caught were either not spawning during the 1972 season or are the first downstream migrants from an upstream spawning ground.

The single Stenodus - Coregonus hybrid examined was a dormant male. The few round whitefish gillnetted in the Old Crow River were at a ratio of 3 males to 1 female (n = 4). The single female was immature, and only one male was mature (stage 6).

The longnose sucker was found in the Porcupine River at a ratio of 2 females to one male, and in the Old Crow River at a ratio of 1.1 females to one male. The low sample size (n = 9) of gillnetted suckers in the former area probably accounts for the female predominance. In both rivers and for each sex the majority of individual suckers were immature. Mature individuals can probably be located in the fall at the mouths of clear tributaries such as the Bluefish River and Lord Creek where large numbers feed in the summer and spawn upstream in the spring.

Most of the pike caught in the Porcupine and Old Crow Rivers were mature (86%) and present at nearly a 1:1 sex ratio (1.33 males to 1 female). All pike taken in Fish Lake were mature, at a ratio of 1.5 males to 1 female. Immature pike fry were taken from the outlet creek of Chinneitlui Lake.

Burbot from the Porcupine River were predominantly female (1.82 females to one male) and mature (90.2%). Dormant females were frequently caught (8 individuals) and a ripe female was also netted. Spawning is reported to occur in midwinter (Chen, 1968) and probably takes place in the Porcupine River near Old Crow.

Chum salmon were captured in a ratio of 6 males to one female during the upstream migration past Old Crow but in a ratio of one male to one female in the Fishing Branch River where they spawn (Elson, 1975). The difference is probably due to gillnet selectivity of males which because of their hooked upper jaw and large exposed teeth, are more easily caught in nets than females. Five mature male coho salmon were also netted. This was the beginning of a late upstream migration of coho that peaks in November.

4.1.5 Age and length relationships

Scale age (x) versus fork length (y) relationships were determined for grayling and least cisco from the Porcupine and Old Crow Rivers and are plotted in Figure 6. Mean fork lengths at any given age are comparable for fish from the Porcupine River and the Old Crow River in each of these species. The samples from these rivers were, therefore, considered segments of a population (Table 5, Figure 6) and analysed as such. This treatment may be questionable as there is considerable overlap in the range of fork lengths at each age, and large standard deviations (Table 5).

Equations of growth for grayling and least cisco populations were developed from the linear regression of scale age (x) on the natural logarithm of fork length (y) and expressed in the following manner:

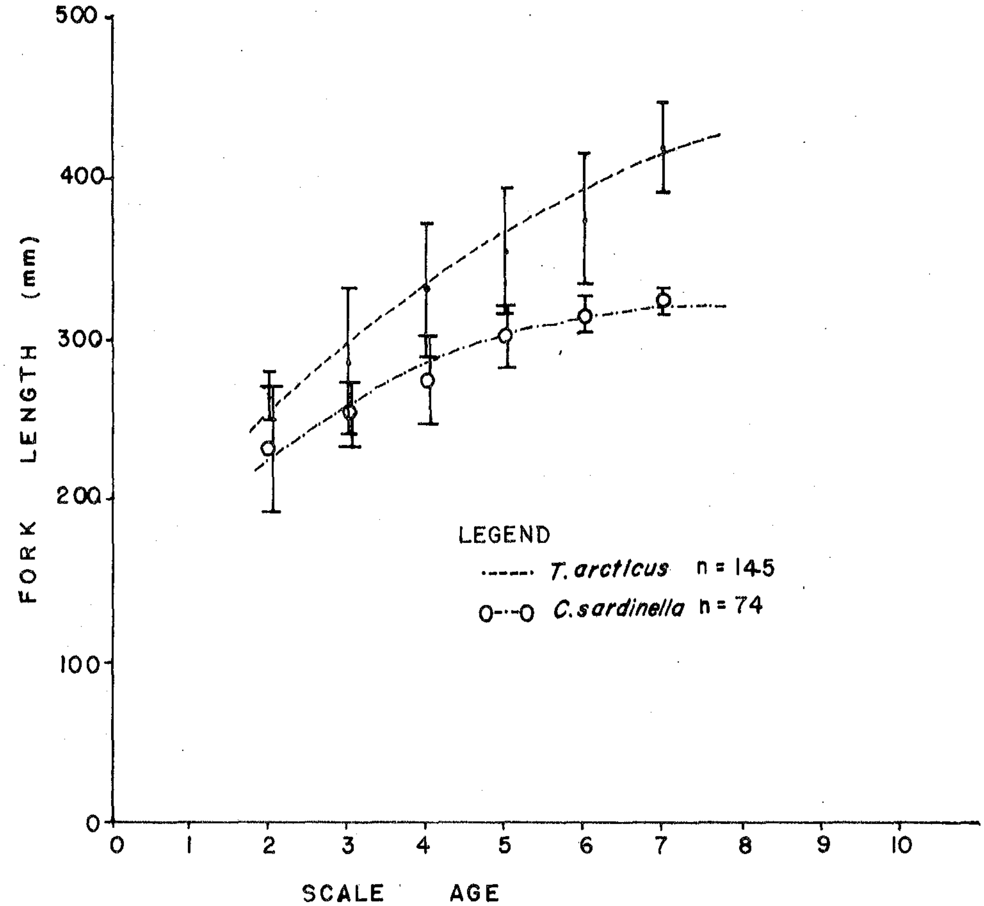
$\ln L = b\,ScA + a$
where L = fork length
ScA = Scale age
b = slope
a = Y - intercept

The equations are:

for <u>T. arcticus</u>
$\ln L = .0915\ (ScA) + 5.4014$
for $n = 157$
at correlation coefficient $(r) = .6687$
and standard error of slope $(SE) = .0085$
Slope limits are .0746 to .1083 at 95% confidence.

for <u>C. sardinella</u>
$\ln L = .0776\ (ScA) + 5.2959$
for $n = 74$
at correlation coefficient $(r) = .6766$
and standard error of slope $(SE) = .0100$
Slope limits are .0577 to 0.975 at 95% confidence.

The scale ages assigned to grayling are probably underestimates, as shown by Bryan et al (1973), Bruce, (1974) and de Bruyn et al (1973). The growth rate for grayling appears comparable to that found by Bryan et al (1973) for grayling from the Porcupine River drainage but is greater than that of grayling from the Yukon north slope (de Bruyn et al 1973, Bryan et al 1973). Grayling from the north slope though, are found to be much older (10 - 11 years) (Bryan et al 1973). The growth rate of these fish from the Porcupine and Old Crow Rivers also exceeds that of grayling studied in the groundwater area on Fishing Branch River (Bruce, 1974), interior Alaska grayling (Reed, 1964) and grayling from the Mackenzie River Valley (Hatfield et al, 1972a). The maximum scale age of 7 - 9 years reported by these authors compares well with this population.



GROWTH RATE BASED ON A SEMILOG REGRESSION OF SCALE AGE (X) vs. LN FORK LENGTH (Y) GIVES THE FOLLOWING EQUATIONS OF GROWTH:

Thymallus arcticus	Ln F.L. = .0915 ScA + 5.4014
	Correlation Coefficient = 0.6687
	Slope standard error ± .0085
Coregonus sardinella	Ln F.L. = .0776 ScA + 5.2959
	Correlation Coefficient = 0.6766
	Slope standard error = .0100

Figure 6. Age-length relationships for T. arcticus and C. sardinella from the Porcupine and Old Crow Rivers during October, 1972.

Table 5. The scale age, mean fork length $\pm$ one standard deviation, at 95% confidence intervals, the range in fork length and percentage age frequency for *T. arcticus* and *C. sardinella*, from the Porcupine and Old Crow Rivers during October, 1972. These relationships are plotted in Figure 6.

T. arcticus:	Scale Age	Sample	Mean F.L. (mm)	Range (mm)	Percent Age Frequency
	2	11	264 $\pm$ 12.8	245 - 294	7.6
	3	30	286 $\pm$ 45.7	237 - 408	20.7
	4	36	332 $\pm$ 43.3	252 - 436	24.8
	5	47	355 $\pm$ 39.3	278 - 435	32.4
	6	18	374 $\pm$ 41.4	285 - 425	12.4
	7	3	420 $\pm$ 27.8	390 - 445	2.1
		n=145			

C. sardinella:	Scale Age	Sample	Mean F.L. (mm)	Range (mm)	Percent Age Frequency
	2	8	232 $\pm$ 39.3	206 - 326	10.8
	3	12	253 $\pm$ 20.0	206 - 280	16.2
	4	39	274 $\pm$ 26.8	230 - 385	52.7
	5	8	302 $\pm$ 29.4	260 - 346	10.8
	6	5	317 $\pm$ 11.1	312 - 333	6.8
	7	2	324 $\pm$ 8.4	318 - 330	2.7
		n= 74			100

Bryan et al (1973), noted that this data may show an increased rate of growth because of fish lengths not being back-calculated to the scale age at the last annulus. However, the differences were so considerable that it was suspected that grayling from the Porcupine and Old Crow Rivers show a significantly greater rate of growth than do other northern populations cited.

The growth rate of the least cisco population is comparable with that observed by Bryan et al (1973) in the summer of 1971. The growth curve determined by Hatfield et al (1972a) from fish in the Arctic Red River area indicates a significantly slower growth rate for cisco from the Mackenzie River Valley. Hatfield reports scale ages ranging from 5 to 10+ years at fork lengths of 222.7 to 336.0 mm. In the present study, cisco ranged in age from 2 to 7 years at fork lengths of 232 to 324 mm.

Sample sizes for other species were considered too small to allow further analysis. Mean fork length ± one standard deviation and range of fork lengths are rated at each scale age for broad whitefish, humpback whitefish, inconnu and burbot populations (Appendix IV). The Porcupine River and Fish Lake populations of broad whitefish appear comparable in age structure. The growth data for inconnu is similar to that observed by Alt (1969) in Alaska, and Hatfield et al (1972a) in the Mackenzie River, except that maximum ages of 16 to 20 years were reported by these workers. The irregularities of any growth pattern determined by burbot otolith ages (n = 25) makes it difficult to compare the data with other workers' results. Age structure is similar to Mackenzie River burbot (Hatfield et al 1972a). Burbot collected from Chinneitlui Lake included a 4 year old mature male (F.L. = 315 mm) and two 5 year old mature males (F.L. = 282, 320 mm). The two *Stenodus* - *Coregonus* hybrids taken were 2 years and 5 years old, the latter being a dormant male (F.L. = 443 mm).

The chum salmon caught ranged from 2 to 4 years of age, which is comparable with Elson (1973) if the problem of scale resorption is taken into account. The few coho salmon caught were 3 and 4 years of age, having spent one (scale age 3_2) or two (scale age 4_3) years in freshwater.

4.1.6 Stomach contents analyses

Total analyses of stomach contents for each species are summarized in Tables 6, 7 and 8. Analyses are expressed as the percentage of stomachs containing the food items listed. In addition, comparisons of stomach contents for two samples each of grayling and of broad whitefish are shown in Figures 7 and 8. Percentages in the histograms are an expression of the number of times a food item occurred in the stomachs examines.

The diet of the grayling showed its usual wide range of food items. Trichoptera larvae and Hemipterans were the main food items for grayling in both the Porcupine and Old Crow Rivers. The exploitation of terrestrial insects is noticeably lower than that reported by Bryan et al (1973) and Hatfield et al (1972a). This is undoubtedly due to the time of year. The fish eggs observed in several samples probably came from fall spawning whitefish and indicate spawning grounds near Old Crow, possibly for least cisco.

The broad whitefish from Fish Lake appear to be much more opportunistic feeders and exploit a more diverse range of food items than do the broad whitefish in the Porcupine and Old Crow Rivers. The Fish Lake population feed primarily on Pelecypoda, Trichoptera larvae, Hemiptera, Gastropoda, Chironomidae larvae and Amphipoda, in that order. Porcupine and Old Crow Rivers broad whitefish feed on Dipteran larvae, Hemipteran, Chironomidae larvae and Plecoptera nymphs. The broad whitefish stomachs from Fish Lake also contained fish eggs. The mature and ripe least cisco, which probably spawn in the lake, are the likely source of these eggs. Bryan et al (1973) sampled Fish Lake during the summer of 1971 and found least cisco that had been feeding on fish eggs.

The low number of stomachs containing food in least cisco may be erroneous since many contained what may have been digested freshwater shrimp. The digested matter was not identified until late in the study.

Pike, inconnu, burbot and whitefish hybrids were found to feed entirely on small fishes in the Porcupine River and show a high reliance on sucker fry. These species have previously been noted as piscivorous (Chen 1968, Alt 1969, and Lawler 1965). Inconnu and burbot seem most successful in exploiting a number of food fishes. Particular notice should be given to the cannabalistic nature of the burbot. In the Porcupine River, 30% of the burbot stomachs examined, contained young burbot ranging in length from 45 mm to 260 mm.

Table 6: - Stomach contents analyses of fish in the Porcupine River, October 1972, expressed as a percentage of stomachs containing food items.

Number Examined	143	27	12	112	28	2	6	50
Percent With Food	87.4	18.5	41.7	10.7	89.3	100	100	100
Food Items (l) - Larvae (a) - Adult (n) - Nymph	Thymallus arcticus	Coregonus nasus	Coregonus clupeaformis	Coregonus sardinella	Stenodus leucichthys	Stenodus - Coregonus Hybrid	Esox lucius	Lota lota
T. arcticus					4.0			
C. catostomus					32.0		33.3	16.0
E. lucius	0.8				8.0			62.0
Coregonus sp.					8.0			2.0
S. leucichthys					4.0			
C. sardinella							16.7	
P. cylindraceum								20.0
L. lota					4.0			30.0
C. plumbeus					4.0			
P. omiscomaycus								2.0
C. cognatus	3.2				20.0			2.0
L. japonica					4.0			20.0
digested fish	1.6		20.0		48.0	50.0	50.0	24.0
fish eggs	0.8							
Gastropoda								
Pelecypoda			20.0					
Copepoda/Isopoda								
Ostracoda								
Amphipoda	0.8							
Chironomid (l)	3.2	20.0						
Ceratopogonid (l)	6.4							
Empidid (l)*								
Other Dipteran (l)	8.0	30.0	40.0					
Other Dipteran (a)	0.8							
Trichopteran (l)	85.6		40.0					
Plecopteran (n)	8.8			16.7				
Ephemeropteran (n)	2.4							
Odonata (n)								
Coleoptera (l)	2.4							
Coleoptera (a)	7.2		20.0					
Hemiptera	40.0	30.0	20.0	83.3				
Hydracarina			20.0					
Terr. insect (a)	3.2							
Digested matter	4.0			8.3	16.0	50		
debris	2.4			8.3		50		

Table 7:- Stomach contents analyses of fish in the Old Crow River, October 1972, expressed as a percentage of stomachs containing food items.

Number Examined	135	4	92	4	1
Percent With Food	84.4	50.0	28.3	75	100
Food Items (l) - Larvae (a) - Adult (n) - Nymph	Thymallus arcticus	Coregonus nasus	Coregonus sardinella	Prosopium cylindraceum	Lota lota
T. arcticus					
C. catostomus	0.9				
E. lucius					100
Coregonus sp.	1.7				
S. leucichthys					
C. sardinella					
P. cylindraceum					
L. lota					
C. plumbeus					
P. omiscomaycus					
C. cognatus	1.7				
L. japonica					
digested fish	7.9				
fish eggs	2.6				
Gastropoda					
Pelecypoda					
Copepoda/Isopoda			88.5		
Ostracoda	1.7				
Amphipoda					
Chironomid (l)	5.3	50			
Ceratopogonid (l)					
Empidid (l)*	0.9				
Other Dipteran (l)	2.6				
Other Dipteran (a)					
Trichopteran (l)	89.5	50		100	
Olecopteran (n)	3.5				
Ephemeropteran (n)					
Odonata (n)					
Coleoptera (l)	1.7				
Coleoptera (a)	7.0		3.8		
Hemiptera	18.4				
Hydracarina					
Terr. insect (a)					
Digested matter	8.8		3.8		
debris			3.8		

* identification may be mistaken, may belong to Family Dolichopodidae.

Table 8:- Stomach contents analyses of fish in the Fish Lake, October 1972, expressed as a percentage of stomachs containing food items.

Number Examined	19	7	15
Percent With Food	94.7	42.9	6.7
Food Items (l) - Larvae (a) - Adult (n) - Nymph	Coregonus nasus	Coregonus sardinella	Esox lucius
T. arcticus			
C. catostomus			
E. lucius			
Coregonus sp.			
S. leucichthys			
C. sardinella			
P. cylindraceum			
L. lota			
C. plumbeus			
P. omiscomaycus			
C. cognatus			
L. japonica			
digested fish			
fish eggs	5.6		
Gastropoda	38.9		
Pelecypoda	94.4		
Copepoda/Isopoda			
Ostracoda			
Amphipoda	27.8		
Chironomid (l)	33.3	66.7	
Ceratopogonid (l)	11.1		
Empidid (l)*			
Other Dipteran (l)	22.2		
Other Dipteran (a)			
Trichopteran (l)	83.3		
Olecopteran (n)	11.1		
Ephemeropteran (n)	5.6		
Odonata (n)	16.6		100
Coleoptera (l)	5.6		
Coleoptera (a)	22.2		
Hemiptera	55.6	33.3	
Hydracarina			
Terr. insect (a)	5.6		
Digested matter			
debris			

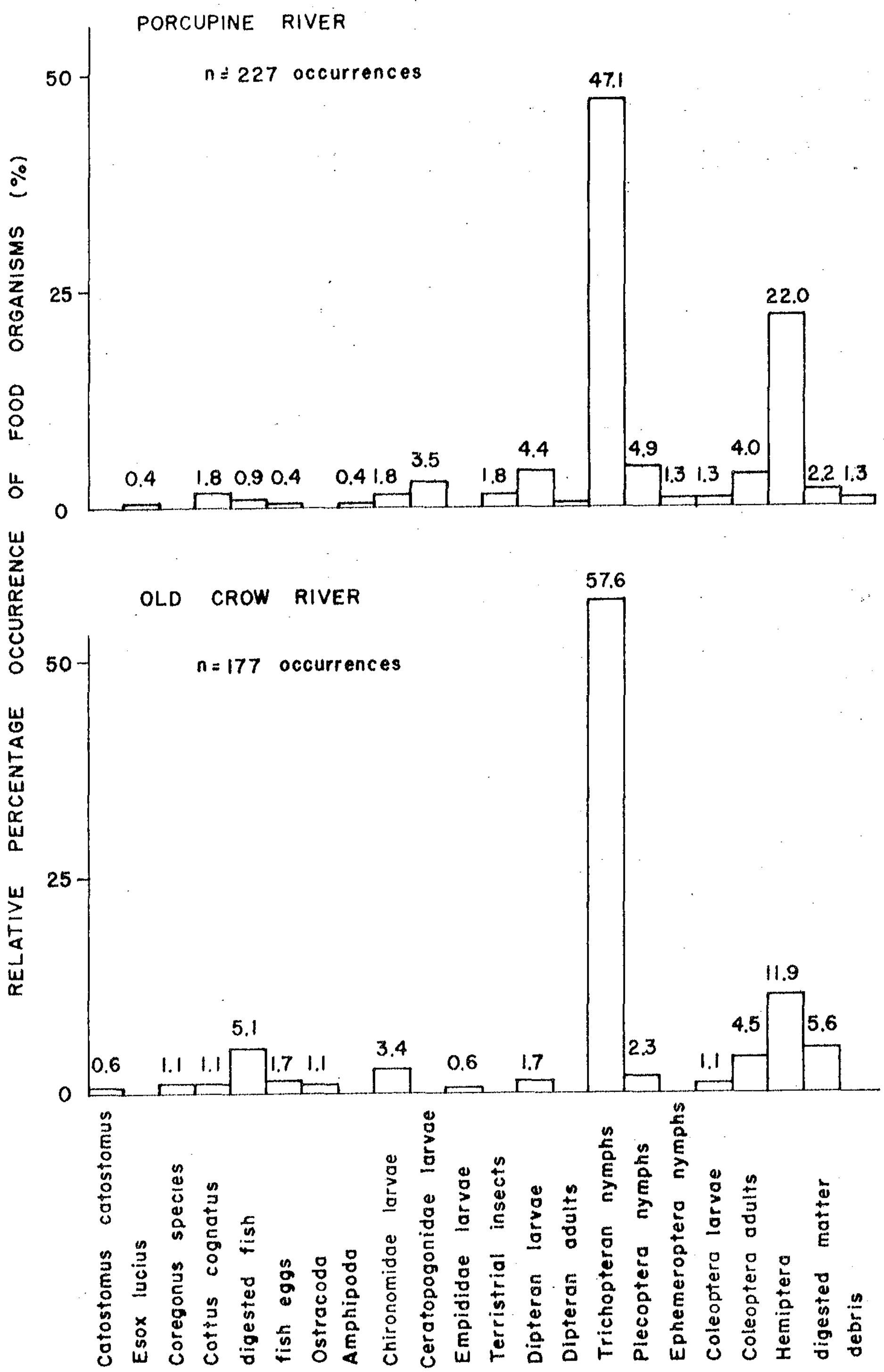


FIGURE 7 Relative percentage occurrence of food items in stomach samples of Thymallus articus from gillnet catches in the Porcupine River and Old Crow River, October 1972. Food items coded in Appendix Table. Percentages are expressed as the total number of times a food item occurred in analysing stomach contents.

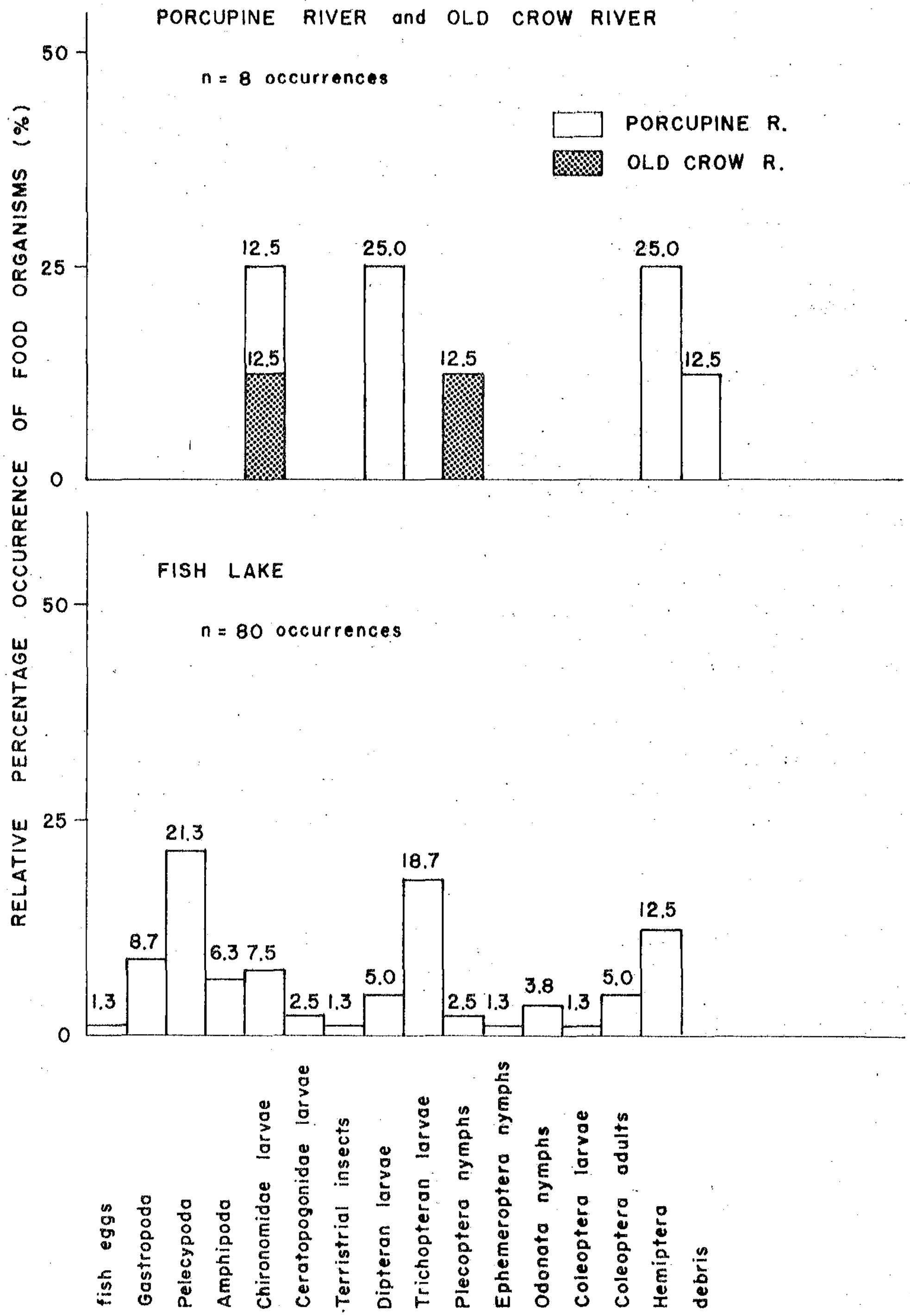


FIGURE 8 Relative percentage occurrence of food items in stomach samples of *Coregonus nasus* from gillnet catches in the Porcupine and Old Crow Rivers, and Fish Lake, October 1972. Food items coded in Appendix Table Percentages are expressed as the total number of times a food item occurred in analysing stomach contents.

Pike in Fish Lake feed completely on Odonata nymphs. The pike were mature individuals and should be piscivorous (Lawler, 1965). Use of invertebrate food sources may indicate the absence of small food fishes. The pike fry from Chinneitlui Lake fed on Gammarus, Ostracoda, Cladocera, Chironomid larvae and Oligochaeta. The burbot caught in this lake exploit the Gammarus, Chironomid larvae and Oligochaeta. As most of the stomachs of both species were very full, it would seem that these fry are utilizing a prime prewinter habitat.

4.1.7 Fat deposition.

A subjective notation of the presence of visceral fat bodies was made in all samples. In grayling, least cisco, broad whitefish and humpback whitefish, the majority of specimens examined in October showed moderate to large fat deposits. The majority of inconnu showed no fat deposits but several did contain moderate to large amounts of fat. Pike and burbot contained little or no fat. The reasons for this lack of fat deposition in piscivorous fishes are unknown. It may be merely a characteristic of the species.

In April, 1973, visceral fat bodies were present in grayling, least cisco, broad whitefish and humpback whitefish from the Porcupine River. Fish do not appear to absorb visceral fat to any extent during the winter period.

4.1.8 Parasites observed.

The only parasites observed were the usual tapeworm cyst infestations on stomach walls of many fish, and stomach nematodes. Broad whitefish in Fish Lake contained large numbers of these nematodes.

4.2 Water chemistry and physical measurements:

Water chemistry data are listed in Tables 9 and 10. Site numbers correspond to those in Figure 1.

Chemistry data from the Porcupine River is comparable to recordings collected by the Water Survey of Canada. Oxygen levels in the Porcupine and Old Crow Rivers were very high (10.0 to 15.2 mg/l) at saturation levels. Alkalinity, hardness and specific conductance were higher than summer recordings and continued to increase to late winter highs in March and April (Birch, 1974 and Water Survey Board, 1974, pers. comm.). pH readings tend to be slightly acidic. This may be due to inaccuracies in the equipment used.

Table 9. Water chemistry measurements taken in the Porcupine and Old Crow River during October 1972.

Sample site (Figure 1)	Date Oct.	Sample Depth (m)	Temp. (°C)	DO_2 (mg/l)	pH	Total Alkalinity (mg/l$CaCO_3$)	Total Hardness (mg/l$CaCO_3$)	Specific Conductivity (25°C)
Porcupine River:								
(11)	21	surface	0.56	14.2	8.4	138	138	280
		3.05		13.2		138	138	278
		6.1	0.56	14.2	8.4	138	138	278
(15)	6	surface	0.28	13.2	8.2			233
		3.66	0.56	13.2	8.0			227
	4	surface	0.56	15.2	8.4			235
		2.13	0.0	14.8	8.4			242
(18)	1	surface	0.56	12.0	8.2			215
		2.13	0.0	10.0				214
	4	surface	0.56	11.2	8.4			226
		2.13	-0.56	14.2	8.4			224
	6	surface	0.28	13.0	8.4			
		2.13	-1.12	13.0	8.4			
	7	surface	0.56	13.2	8.4			243
		2.13	0.56	13.4	8.4			235
	12	surface	0.56	13.4	8.4			240
		1.83	0.0	13.8	8.2			248
Old Crow River:								
(14)	14	surface	0.0	12.4	8.4	117	155	202
		1.37	-0.56	14.0	8.4			214
(30)	17		1.12	13.4	8.4	186	172	300

Table 10. Water chemistry measurements taken in Fish Lake, Chinneitlui Lake and outlet creek, and the Bluefish River during October, 1972.

Sample (Figure 1)	Date Oct.	Sample Depth (m)	Temp. (°C)	DO_2 (mg/l)	pH	H_2S (mg/l)	Total Alkalinity (mg/l $CaCO_3$)	Total Hardness (mg/l $CaCO_2$)	Specific Conductivity (25°C)
Fish Lake NE arm (x)	10	surface	0.56	11.8	7.3				45
		1.98	1.96	10.6	7.0	<0.1			39
	16	surface	1.12	10.2	7.0		28	34	42
		1.83	2.24	9.0	7.0	<0.1			
Chinneitlui Lake: near creek mouth (y)	26	surface	1.68	14.6	7.8		62	52	83
		0.61					62	52	86
		1.22	2.24	11.0	7.5	<0.1	34	52	86
Chinneitlui creek: 1/4 mile downstream (99)	26						55	52	86
Bluefish River: (36)	17		0.0	9.8	8.3		206	206	390

Water quality measured in Fish Lake and Chinneitlui Lake are comparable. Oxygen levels are high, 9.0 - 11.8 mg/l in Fish Lake and 11.0 to 14.6 mg/l in Chinneitlui Lake. The lower dissolved oxygen readings occur near the bottom of each lake and probably result from active decomposition of aquatic vegetation. No hydrogen sulphide odour was noticeable. Conductivity, alkalinity and hardness are much lower in lake waters than in the rivers studied.

Ice and water depths and water temperatures are listed in Tables 11 and 12. Temperatures may have an incorporated error of 1 or 2°C, due to the difficulty in calibrating maximum-minimum thermometers.

The extent of freezeup was observed in the Porcupine River, Bluefish River and Lord Creek on October 7, 17 and 23, 1972, respectively. Open water and overflow water and ice sighted are shown in Figure 9.

The Porcupine River was observed on October 7, to be partially frozen over with numerous small ice jams. By October 23, most of the river was frozen except for several riffles and other high flow velocity sites. The mouth of the Old Crow River was open, also due to the water current.

The Bluefish River, as shown in Figure 9, had four main openwater areas separated by stretches of river with ice cover on October 17. Areas B, C and possibly D are free of ice year round. Groundwater sources are fairly common along the river and probably account for the open water at several tributary mouths. Ice jams and floating ice were fairly common in area A. No fish were sighted in the Bluefish River.

Openwater areas in the Lord Creek observed on October 23, are also shown in Figure 9. Between areas A, B and C, ice was beginning to form and patches of thicker ice and floating ice were frequent. Upstream of area C, the creek was largely frozen over with numerous openwater patches. The mouth of Lord Creek was frozen over, and overflow ice and water were observed. Again, no fish were sighted.

The outlet creek of Chinneitlui Lake was observed to be open for several miles downstream of the lake on October 16. Much of the Old Crow Flats in this area were covered with ice and snow on this date.

Table 11. Ice and water depths, and temperature recordings in the Porcupine River, October 1972.

Sample Site (Figure 1)	Date Oct.	Ice Depth (m)	Max. Water Depth (m)	Temperature (°C) Present	Minimum	Maximum	Time (Hours)
Porcupine River: (11)	22	0.22	6.1	0.56	0.0	1.12	27
(15)	6	0.15 -0.19	3.66	-0.56	0.0	-1.68	24
(16)	4	0.10	2.44				
(18)	3	0.13 -0.15	2.13	0.0	-0.56	0.0	24
	6			-1.12	-1.68	0.0	24
	8			0.56	-0.56	1.12	24
	10			0.56	0.28	1.12	
	12	0.20	1.83	0.0	-1.68	0.0	
	13	0.30	0.91	0.56	0.0	1.12	
	18			-1.12	-1.68	0.28	46
	20	0.30	1.52	0.56	-0.56	1.12	51

Table 12. Ice and water depths, and temperature recordings in the Old Crow River, Fish Lake, and Chinneitlui Lake, October 1972.

Sample Site (Figure 1)	Date Oct.	Ice Depth (m)	Max. Water Depth (m)	Temperature (·C)			Time (Hours)
				Present	Minimum	Maximum	
Old Crow River: (14)	18	0.22	1.83	0.0	-0.56	0.56	50
Fish Lake: NE Arm (x)	10	0.20	1.98				
Chinneitlui Lake: near creek mouth (y)	26	0.20	1.22	2.24	0.0	3.36	19

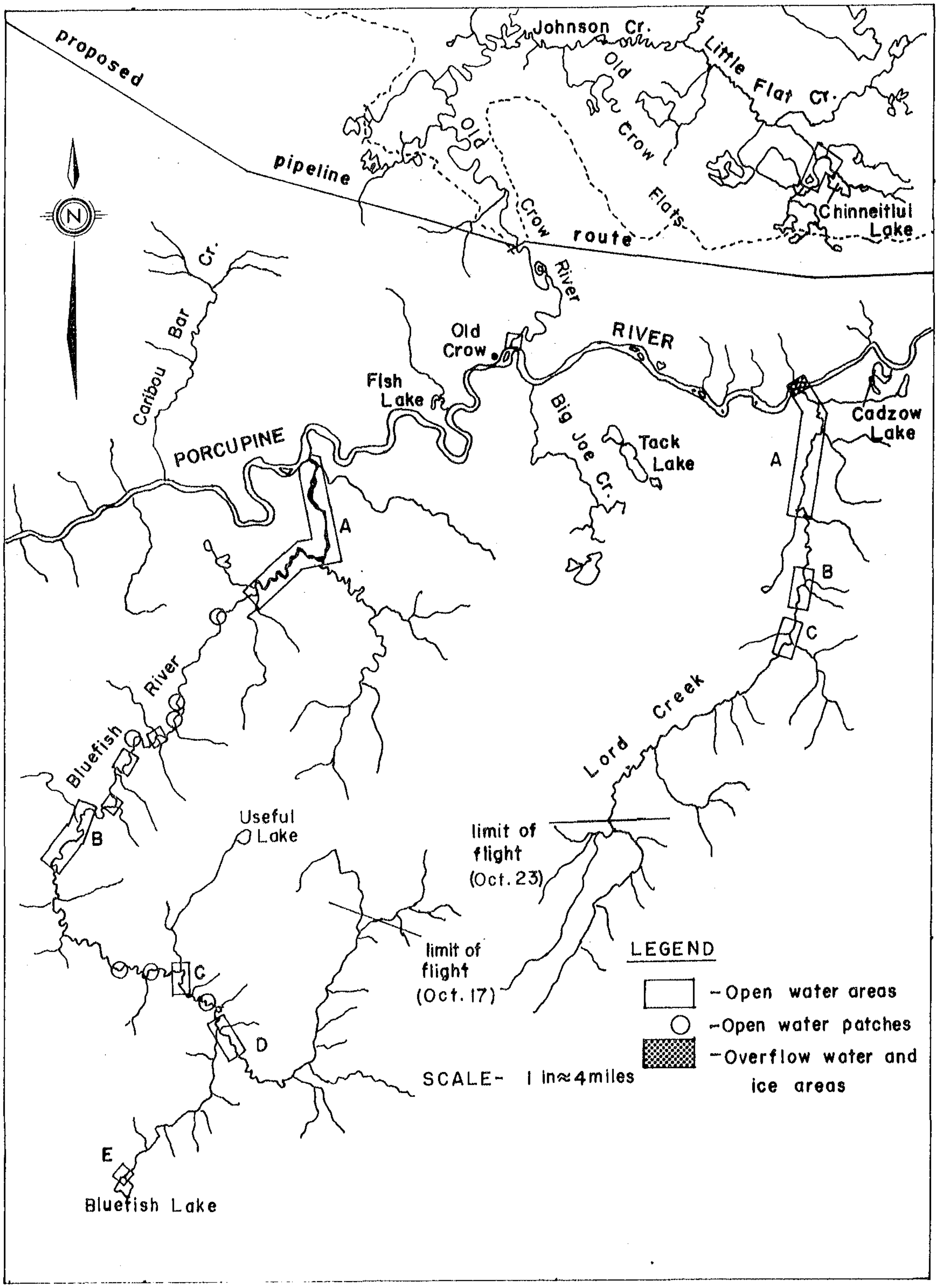


Figure 9. Rate of freezeup in the Bluefish River, and Lord Creek during October 1972.

4.3 Groundwater areas surveyed

Two groundwater areas were investigated during this study. The Bluefish River (Figure 9 area B) was surveyed on October 17, 1972. Water chemistry analyses were conducted near the upstream end of the openwater area (Figure 1, Site 36) and are presented in Table 10. The dissolved oxygen level was good (9.8 mg/l) but no fish were sighted during an aerial survey throughout the groundwater area. Current velocity was estimated at 0.514 m/sec. and discharge at 0.655 m^3/sec. Seining was impossible due to the thick ice ledges in areas of good gravel and due to large rocks in the other areas. Several sculpins (C. cognatus), the only fish observed, were dipnetted. This groundwater area is in a shallow valley where the river is bordered by poplar, alder, spruce and birch with willow overhanging the bank. The area supports several families of beaver (Castor canadensis). Trichopteran larvae and other invertebrates were observed on the stream bottom. Bryan et al (1973), reported comparable data in the summer and fall of 1971. A section of bedrock was observed during the summer of 1972, across the river just upstream of area A (Figure 9). This bedrock noticeably blocks waterflow and may act as a partial barrier. Groundwater may go underground at this point. The absence of fish in this area does not appear to be due to inadequate water quality.

The groundwater area at the headwaters of the Old Crow River was also surveyed on October 17, 1972. Water chemistry measurements were taken just inside the Alaska border (Figure 1, site 30) and are listed in Table 9. Oxygen levels were high (13.4 mg/l). Large schools of grayling were observed during an aerial survey and the total estimate for several miles of river ($<$ 5 miles) was 3,000 to 4,000 fish. Only sculpins were caught by seining (n = 10) and the mean fork length was 43.3 mm for a sample ranging in fork length from 20 mm to 70 mm. Local natives state that fish migrate upstream from Potato, Surprise, Thomas and Timber Creeks and the area draining into these rivers, to this area to overwinter. (P. Lord, 1973, pers. comm.).

Further discussion of the characteristics of these two groundwater areas are presented by Van Everdingen (1972).

5. Conclusions

1. The Porcupine and Old Crow Rivers provide adequate early winter habitats for Arctic grayling, least cisco, longnose sucker, burbot, broad whitefish, inconnu, humpback whitefish, round whitefish, northern pike, whitefish hybrid and chum and coho salmon. Sculpins, trout-perch, lamprey ammocoetes and lake chub are also found in the rivers in October.

2. Fish Lake supports a resident population of broad whitefish, least cisco and probably pike.

3. Chinneitlui Lake and its creek outlet support an early winter population of pike and burbot fry which probably move downstream later in the winter.

4. The Old Crow River headwaters support large numbers of grayling during the winter. Sculpins also inhabit this groundwater area. Fish species migrate upstream to this area in the fall.

5. The headwaters of the Bluefish River appear not to support any overwintering fish populations with the exception of a few sculpins. A physical barrier may partially account for the lack of overwintering fish.

6. All rivers and lakes examined during this study have water quality highly suitable to supporting fish life (early fall-winter).

7. The Old Crow River is a major downstream migratory route during the fall by fish from the Old Crow Flats. Grayling, least cisco and suckers occur in large numbers in the river in October. A broad whitefish, tagged at Chinneitlui Lake in August, 1972, was caught at Old Crow on October 23, 1972. By mid-winter (December) the Old Crow River is probably uninhabited by fish (Birch, 1974).

8. A good representation of all sizes and probably age ranges of grayling and least cisco, occur in the Porcupine River in October. Length-frequency data indicates no apparent differences between populations in the Porcupine and Old Crow Rivers. Variations in length-frequency relationships according to sex in these two species are minimal.

9. The length-weight relationship for grayling from the Porcupine and Old Crow Rivers is not significantly different from populations previously studied in the Porcupine River drainage (Bryan et al, 1973, Bruce, 1974) and the Arctic Red River area of the Mackenzie River Valley (Hatfield et al, 1972a).

10. The length-weight relationship for least cisco from the Porcupine and Old Crow Rivers is not significantly different from a population studied in the Arctic Red River area in the Mackenzie River Valley (Hatfield et al, 1972a). Significant differences occur with previously studied populations in the northern Yukon (Bryan et al, 1973).

11. Grayling in the study area exhibited a sex ratio not significantly different from a 1:1 ratio.

12. Least cisco are predominantly female (3:1) in the rivers and lakes studied. The large number of mature cisco, many of which had ripe or spent gonads, indicates spawning is occurring in Fish Lake and possibly the Porcupine and Old Crow Rivers.

13. Inconnu occurred at a 1:1 sex ratio. The few spent and dormant fish caught indicates spawning does not occur in the study area. Since inconnu exhibit a downstream post-spawning migration (Alt, 1969), spawning probably occurs upstream of Old Crow in the Porcupine drainage.

14. Burbot were predominantly mature females. Spawning probably occurs in mid-winter near Old Crow. Dormant gonads in many fish caught corroborates previous contentions that burbot do not spawn every year.

15. Age-length relationships and growth rates using scale age were determined for grayling and least cisco in the study area. Growth rates for these two species are comparable to other data from the Porcupine River drainage (Bryan et al, 1973) and significantly higher than the growth rates determined in other northern areas (Hatfield et al, 1972a, Bruce, 1974, Reed, 1964).

16. Stomach contents analyses indicates that grayling are opportunistic feeders in the Porcupine and Old Crow Rivers. Primary food sources include Pelecypoda, Trichopteran larvae and Hemiptera.

17. Pike, burbot and inconnu are piscivorous fishes in the Porcupine River, feeding heavily on sucker fry. Burbot are cannibalistic, feeding voraciously on young burbot as well as young pike.

18. Pike and burbot fry, near or in the outlet creek at Chinneitlui Lake, are utilizing a prime early winter habitat as indicated by the amount of invertebrate food in the stomachs examined.

19. Mature pike in Fish Lake were found to feed exclusively on Odonata nymphs, which may indicate the absence of small food fishes.

6. Recommendations

The data from this study can only provide preliminary information on freshwater habitats in the fall. Factually backed recommendations should be based on comparisons with data from other time periods, thereby evaluating migration routes, spawning times and sites and habitat utilization.

From the study reported here, it has been concluded that the Old Crow River appears to be an active migratory route for fish during the pre-winter period. The Porcupine River and Fish Lake support large overwintering and winter spawning fish populations. The Old Crow River headwaters support large overwintering grayling populations. These areas should receive particular protection from any form of industrial development, including pipeline construction and operation.

Future work should be concentrated on the location and examination of overwintering areas. Principal areas suspected of harbouring overwintering fish populations are the mouths of tributaries of the Porcupine River, the lower limits of the Bell River and Eagle River, deep lake systems in the drainage area and uninvestigated groundwater areas. The Old Crow flats should also receive particular attention in future work.

The identification of the locations of overwintering populations should facilitate the determination of winter spawning areas. Effort should be concentrated on those species comprising the domestic catch (Steigenberger et al, 1973). It is believed that inconnu spawn upstream of Old Crow, probably in the Bell or Eagle Rivers, as subsequent survey work has indicated large numbers of ripe inconnu in the Bell River at the confluence of the Rat River in late August, 1973.

Due to the difficulty of river travel at freezeup and the prohibitive expenses and limited nature of aerial survey work, it is suggested that localized camps be established for specific purposes during particular time periods. In this way, maximum results could be obtained for short term effort.

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Appendix I - Taxonomic and common names of fish caught during a study in October 1972 in the northern Yukon.

Taxonomic Name	Common Name
Thymallus arcticus	Arctic grayling
Coregonus nasus	Broad whitefish
Coregonus clupeaformis	Humpback whitefish
Coregonus sardinella	Least cisco
Stenodus leucichthys	Inconnu
Prosopium cylindraceum	Round whitefish
Coregonus sp.	Coregonid species
Stenodus-Coregonus hybrid	Whitefish hybrid
Catostomus catostomus	Longnose sucker
Lota lota	Burbot
Esox lucius	Northern pike
Oncorhynchus keta	Chum salmon
Oncorhynchus kisutch	Coho salmon
Couesius plumbeus	Lake chub
Percopsis omiscomaycus	Trout-perch
Cottus cognatus	Slimy sculpins
Lampetra japonica	Lamprey, ammoceote

Appendix II - Fish Maturity codes used in a study in the northern Yukon.

Code	Description
0	maturity not observed
1	gonads undifferentiated and visual sex determination impossible
2	gonads differentiated, but not well developed
3	gonads differentiated and developing but fish incapable of spawning in the coming season
4	fish capable of spawning, but gonads dormant
5	fish capable of spawning and gonads developing for spawning in coming season
6	fish nearly ripe
7	milt or eggs expressed with gentle pressure
8	sex products recently released - retained eggs present or flacid tests with little new development
9	no maturity determination possible because of visceral breakdown

Appendix III :- Catches per unit effort for gillnets set in the Porcupine River, Old Crow River, Fish Lake, and Chinneitlui Lake during October. One unit effort is defined as one gillnet of any mesh size, set for 24 hours.

Sample Site (Figure 1)	Date (1972)	Time Period (hrs)	Gillnet mesh size	Catch/unit effort
Porcupine River: (10)	Oct. 21	18.5	2.5 mono*	7.78
	Oct. 22	27.5	2.5 mono	13.09
	Oct. 27	68.5	2.5 mono	0.029
	Oct. 21	19.0	4.0 poly*	7.58
	Oct. 22	27.0	4.5 poly	10.67
	Oct. 23	24.0	4.5 poly	3.0
	Oct. 27	68.5	4.5 poly	7.01
(15)	Oct. 6	23.0	2.5 mono	39.65
	Oct. 7	23.0	2.5 mono	26.09
	Oct. 8	26.5	2.5 mono	3.62
	Oct. 6	23.0	4.0 polu	1.04
	Oct. 8	26.5	3.0 mono	3.62
(16)	Oct. 12	17.0	2.5 mono	21.18
	Oct. 21	17.0	4.0 poly	1.41

Trapnet Site	Date (1972)	Time Period (hrs.)	Trapnet Size	Catch/unit effort
Old Crow River: 1/4 mile upstream of (14) mouth	Oct. 14	24.0	4 by 4,	214
	Oct. 15	24.0		231
	Oct. 20	25.5		118.59
	Oct. 23	22.0		75.27

where

* mono - monofilament gillnet
** poly - polyfilament gillnet

Appendix III : (continued).

Sample Site (Figure 1)	Date (1972)	Time period (hrs)	Gillent mesh size (in)	Catch/unit effort
Old Crow River: (12)	Oct. 22	22.0	2.5 mono	13.09
	Oct. 22	23.5	4.0 poly	1.02
	Oct. 27	114.0	4.0 poly	0.21
(14)	Oct. 14	21.5	2.5 mono	62.51
	Oct. 16	44.5	2.5 mono	31.28
	Oct. 18	50.0	2.5 mono	33.12
	Oct. 20	46.0	2.5 mono	19.30
	Oct. 22	50.0	2.5 mono	11.52
	Oct. 23	26.0	2.5 mono	12.0
(13)	Oct. 16	44.5	4.0 poly	3.77
	Oct. 18	50.0	4.0 poly	5.76
	Oct. 20	46.0	4.0 poly	5.22
	Oct. 22	51.0	4.0 poly	4.24
	Oct. 23	24.5	4.0 poly	5.88
Fish Lake: NE arm	Oct. 18	195.5	1.5 mono	0.12
	Oct. 18	195.5	2.5 mono	0.61
	Oct. 10	19.5	3.0 mono	4.92
Fish Lake: NE arm	Oct. 10	19.5	4.0 mono	9.85
	Oct. 18	195.5	4.0 mono	0.86
	Oct. 10	19.5	5.0 mono	11.08
	Oct. 18	195.5	5.0 mono	2.34
Chinneitlui Creek outlet	Oct. 27	20.0	1.0 mono	40.8
Chinneitlui Creek trapnet site	Oct. 27	19.-	0.5 mono	48.0

Appendix III: (continued).

Sample Site (Figure 1)	Date (1972)	Time Period (hrs)	Gillnet mesh size	Catch/unit effort
Porcupine River:				
(18)	Oct. 2	25.0	2.5 mono	17.29
	Oct. 3	24.0	2.5 mono	7.0
	Oct. 4	24.5	2.5 mono	5.88
	Oct. 5	23.0	2.5 mono	5.22
	Oct. 6	24.0	2.5 mono	11.0
	Oct. 7	22.5	2.5 mono	14.93
	Oct. 8	26.5	2.5 mono	15.4
	Oct. 10	48.5	2.5 mono	13.86
	Oct. 12	45.0	2.5 mono	11.73
	Oct. 13	24.5	2.5 mono	13.71
	Oct. 14	21.5	2.5 mono	11.16
	Oct. 16	50.0	2.5 mono	6.72
	Oct. 18	46.0	2.5 mono	10.96
	Oct. 20	50.5	2.5 mono	8.55
	Oct. 23	49.5	2.5 mono	8.73
	Oct. 2	25.0	4.0 poly	3.84
	Oct. 3	24.0	4.0 poly	2.0
	Oct. 4	24.5	4.0 poly	0.0
	Oct. 5	23.0	4.0 poly	0.0
	Oct. 6	24.0	4.0 poly	1.0
	Oct. 7	22.5	4.0 poly	1.07
	Oct. 8	26.5	4.0 poly	0.0
	Oct. 10	48.5	4.0 poly	0.99
	Oct. 12	45.0	4.0 poly	0.53
	Oct. 13	24.5	4.0 poly	0.0
	Oct. 14	21.5	4.0 poly	2.23
	Oct. 16	50.0	4.0 poly	0.48
	Oct. 18	46.0	4.0 poly	1.04
	Oct. 20	50.5	4.0 poly	0.48
	Oct. 23	49.5	4.0 poly	3.88
	Oct. 27	67.5	4.0 poly	0.71
	Oct. 2	25.0	4.5 poly	3.84
	Oct 3	24.0	4.5 poly	2.0
	Oct. 4	24.5	4.5 poly	0.0
	Oct. 5	23.0	4.5 poly	2.09
	Oct. 6	24.0	4.5 poly	3.0
	Oct. 7	22.5	4.5 poly	1.07
	Oct. 8	26.5	4.5 poly	1.81
	Oct. 10	48.5	4.5 poly	0.49
	Oct. 12	45.0	4.5 poly	0.53
	Oct. 13	24.5	4.5 poly	0.0
	Oct. 14	21.5	4.5 poly	1.12
	Oct. 16	50.0	4.5 poly	1.92
	Oct. 18	46.0	4.5 poly	0.52
	Oct. 20	50.5	4.5 poly	1.43
	Oct. 23	49.5	4.5 poly	1.94
	Oct. 18	46.0	1.0 mono	0.52
(17)	Oct. 16	50.0	4.0 poly	0.48
	Oct. 18	46.0	4.0 poly	3.13

Appendix IV. Percentage species composition of gillnet catches taken from the Old Crow River, Porcupine River, Fish Lake and Chinneitlui Lake during October, 1972.

FISH SPECIES	Gillnet Sites (Figure 1)							
	17 & 18	16	11	15	12 & 14	13	6, 7 & 9	2, 5, 98 & 99
Thymallus arcticus	42.2	31.6	4.6	27.0	41.3	76.2		
Coregonus nasus	4.2	15.8	9.2	8.1	1.2	2.4	66.7	
Coregonus clupeaformis	1.4		4.6	6.8				
Coregonus sardinella	27.5	42.1	10.8	29.7	36.9		20.5	
Stenodus leucichthys	3.1	10.5	9.2	14.9	0.4			
Stenodus-Coregonus hybrid	0.35		1.5					
Prosopium cylindraceum					1.6			
Esox lucius	2.1				0.4	2.4	12.8	97.3
Lota lota	17.1		1.5	1.4		4.8		2.7
Catostomus catostomus	1.7			10.8	18.3	14.3		
Oncorhyncus keta	0.35		50.8	1.4				
Oncorhyncus kisutch			7.7					

Appendix V :- Relative percentage occurrence of each age at mean fork length + one standard deviation in fish populations from the Porcupine River, Old Crow River, and Fish Lake during October 1972.

Porcupine River grayling population:

Scale age	n	Mean F.L. + Std.Dev.(mm)	Range(mm)	%occurrence
2	6	262 + 10.1	245-272	618
3	21	295 + 50.9	239-408	21.65
4	31	331 + 46.25	252-436	31.96
5	30	354 + 40.03	278-426	30.93
6	8	352 + 50.9	285-410	825
7	1	445.		1.03
	E=97			100%

Old Crow River grayling population:

Scale age	n	Mean F.L. + Std.Dev.(mm)	Range(mm)	%occurrence
2	5	267 + 16.3	255-294	10.42
3	9	264 + 18.6	237-286	18.75
4	5	334 + 17.8	310-359	10.42
5	17	355 + 39.3	300-435	35.42
6	10	392 + 20.7	359-425	20.83
7	2	408 + 24.7	390-425	4.16
	E=48			100%

Porcupine River least cisco population:

Scale age	n	Mean F.L. + Std.Dev.(mm)	Range(mm)	%occurrence
2	2	233 + 2.8	231-235	4.0
3	9	256 + 22.5	206-280	18.0
4	28	276 + 29.8	230-285	56.0
5	5	307 + 29.8	265-346	10.0
6	5	317 + 11.1	312-333	10.0
7	1	330		2.0
	E=50			100%

Old Crow River least cisco population:

Scale age	n	Mean F.L. + Std.Dev.(mm)	Range(mm)	%occurrence
2	6	232 + 46.5	206-326	25.0
3	3	246 + 7.37	240-254	12.5
4	11	268 + 17.2	242-295	45.83
5	3	293 + 32.5	260-325	12.5
7	1	318		4.17
	E=24			100%

Fish Lake least cisco population:

Scale age	n	Mean F.L. + Std.Dev.	Range	%occurrence
5	3	326 + 9.29	315-332	37.5
6	5	322 + 21.39	302-355	62.5
	E=8			100%

Porcupine and Old Crow Rivers and C.nasus population:

Scale age	n	Mean F.L. + Std.Dev.	Range	%occurrence
1	10	261 + 52.01	135-313	31.25
2	7	298 + 24.1	269-345	21.88
3	5	396 + 32.14	351-436	15.63
5	4	470 + 34.16	438-505	12.5
6	3	456 + 17.69	432-503	9.37
7	3	527 + 17.69	508-543	9.37
	E=32			100%

Appendix V : (continued)

Fish Lake C. nasus population:

Scale age	n	Mean F.L. + Std.Dev.	Range	%occurrence
3	6	395 + 25.76	352-415	24.0
4	5	434 + 28.01	390-460	20.0
5	2	472 + 11.31	464-480	8.0
6	6	489 + 18.57	466-515	24.0
7	6	507 + 22.02	466-525	24.0
	E=25			100%

Porcupine and Old Crow Rivers C. clupeaformis population:

Scale age	n	Mean F.L.Std.Dev.	Range	%occurrence
3	6	271 + 27.96	230-315	66.7
4	1	294		11.1
5	1	274		11.1
6	1	280		11.1
	E=9			100%

Porcupine and Old Crow Rivers S. leucichthys population:

Scale age	n	Mean F.L. + Std.Dev.	Range	%occurrence
1	2	246 + 8.49	240-252	7.14
2	4	302 + 26.01	274-332	14.3
3	7	374 + 33.78	306-411	25.0
4	7	435 + 55.61	345-505	25.0
5	1	435		3.57
6	2	523 + 25.46	505-541	7.14
7	2	655 + 71.42	604-705	7.14
8	2	708 + 66.47	661-755	7.14
10	1	615		3.57
	E=28			100%

Porcupine and Old Crow River L. lota population:

Otolith age	n	Mean F.L. + Std.Dev.	Range	%occurrence
4	2	365 + 13.4	355-374	8.0
5	1	530		4.0
7	1	638		4.0
8	1	565		4.0
9	8	590 + 48.34	495-651	32.0
10	4	627 + 44.91	560-654	16.0
11	4	598 + 38.24	541-622	16.0
12	3	597 + 18.5	576-609	12.0
17	1	860		4.0
	E=25			100%

Appendix VI - Food items encountered in analyses of stomach contents and their common names. Fish species are listed in Appendix I.

Food items	Common Name
Digested fish	
Fish eggs	
Gastropoda	snails
Pelecypoda	clams
Copepoda	copepods
Isopoda	sow bugs
Anostraca	fairy shrimp
Ostracoda	seed shrimp
Chironomidae larvae	midges
Ceratopogonidae larvae	biting midges
Empididae larvae	dance flies
other Dipteran adults	
Trichopteran larvae	caddis flies
Plecoptera nymphs	stone flies
Ephemeroptera nymphs	mayflies
Coleoptera larvae	beetles
Coleoptera adults	beetles
Hemiptera	back swimmers/boatmen
Hydracarina	water mites
Terrestrial insects	winged insect adults
digested matter	
debris	rocks, sticks, etc.
Amphipoda	shrimp, Gammarus sp.
Odonata nymphs	dragon and damselflies

C H A P T E R I I I

FISHERIES INVESTIGATIONS OF THE PORCUPINE RIVER DRAINAGE IN THE VICINITY OF OLD CROW IN THE NORTHERN YUKON TERRITORY, APRIL 1973

Extracted from an unpublished
memorandum by

G. J. BIRCH

Revised and edited

for the

Environmental-Social Program
Northern Pipelines

Acknowledgement

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The Pacific Environmental Institute Laboratory, Vancouver, analyzed the preserved water samples.

P. Bruce, M. Elson and L. Steigenberger edited, revised and prepared the report for publication.

1. Abstract

In April, 1973 a field study was conducted by the Yukon Pipeline Study Group, Department of the Environment, Fisheries Service, Vancouver, in the vicinity of Old Crow, northern Yukon Territory.

The objectives of the study were to conduct preliminary investigations of the overwintering habitat and the fish species present in the Porcupine River, and in several lakes near Old Crow.

Arctic grayling were found to be the most abundant species in the Porcupine River. Other fish species present were less numerous than previously expected. Only one of the two lakes studied had an overwintering population of fish. The species found in Fish Lake were broad whitefish and least cisco.

Based on dissolved oxygen readings, the overwintering habitat in the Porcupine River appeared to be of acceptable quality for the support of fish life throughout the area studied.

The Old Crow River downstream from the proposed pipeline crossing to the Porcupine River appeared to be uninhabited by fish during April, 1973.

There is preliminary evidence for preference of certain food items and a resulting division of exploitation by some fish species present in the Porcupine River and Fish Lake.

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2. Introduction

Previous aquatic winter studies in the northern Yukon Territory have been very limited in nature, restricted primarily to measurements of water chemistry and discharge. The Water Survey Board of Canada has examined the discharge of the Porcupine River at various times of the year, over many years. The Fisheries Research Board of Canada conducted water chemistry on the Porcupine River in the early spring of 1972, and McCart reported on the water quality of pipeline crossing sites studied in April, 1973 (McCart 1973).

Data from this April, 1973 survey supplement that collected during a survey initiated in March, 1972 by the Yukon Pipeline Study Group to delineate potential overwintering areas for fish, as indicated by open water and overflow water and ice (Steigenberger et al, 1975).

Also reported separately is an evaluation of various types of transportation, instruments, equipment and clothing used during the survey (Birch MS, 1974).

This report, which is somewhat limited due to the broad scope of the survey, concerns two additional objectives of the project. These were to conduct preliminary investigations relating to the biology of overwintering fish species in the Porcupine River in the vicinity of Old Crow, and to describe some of the chemical and physical parameters of the aquatic environment during the winter period.

3. Methods

Transportation in the vicinity of Old Crow was by snowmobile, towing equipment on toboggans. Information from more distant sites was collected by means of a DHC Beaver aircraft on skis.

A powered ice auger and ice chisels were used to drill the holes required to set nets and conduct water chemistry tests.

Fishing was conducted at several sites (Figure 1) using monofilament 50' X 8' gillnets with lead lines and floats. Mesh sizes used were 2½, 3 and 4½ inches. Period of the set varied from 20 to 50 hours, with a minimum of 24 hours attempted. The river bottom was also fished using two or three baited hooks on a weighted jig or set line.

From each specimen captured, the following data were collected: species, fork length (mm), weight(g), sex and maturity, scale samples for aging, stomach contents, the presence of parasites and the degree of visceral fat. Sexual maturity was assessed by criteria established during earlier studies (Appendix 3). Aging and the majority of the analysis of stomach contents, from stomachs preserved in 10 percent formalin, were conducted in Vancouver. Organisms from stomach contents were identified to order and family from a prepared listing (Steigenberger et al, 1973).

Water chemistry measurements were conducted by several types of equipment (Appendix 2). Attempts were made to measure the following parameters: temperature, dissolved oxygen, free carbon dioxide, alkalinity, hardness, pH, color, turbidity and conductivity. Kerosene heaters were used to prevent freezing of the dissolved oxygen sample while preserving it in the field.

Water samples were collected and preserved with chloroform (1 ml chloroform to 100 ml sample), frozen and shipped to the Pacific Environmental Laboratory, Vancouver, for analysis. Analyses were conducted for the following: hardness, nutrients (phosphorus and nitrogen), and residues (total, filterable and non-filterable).

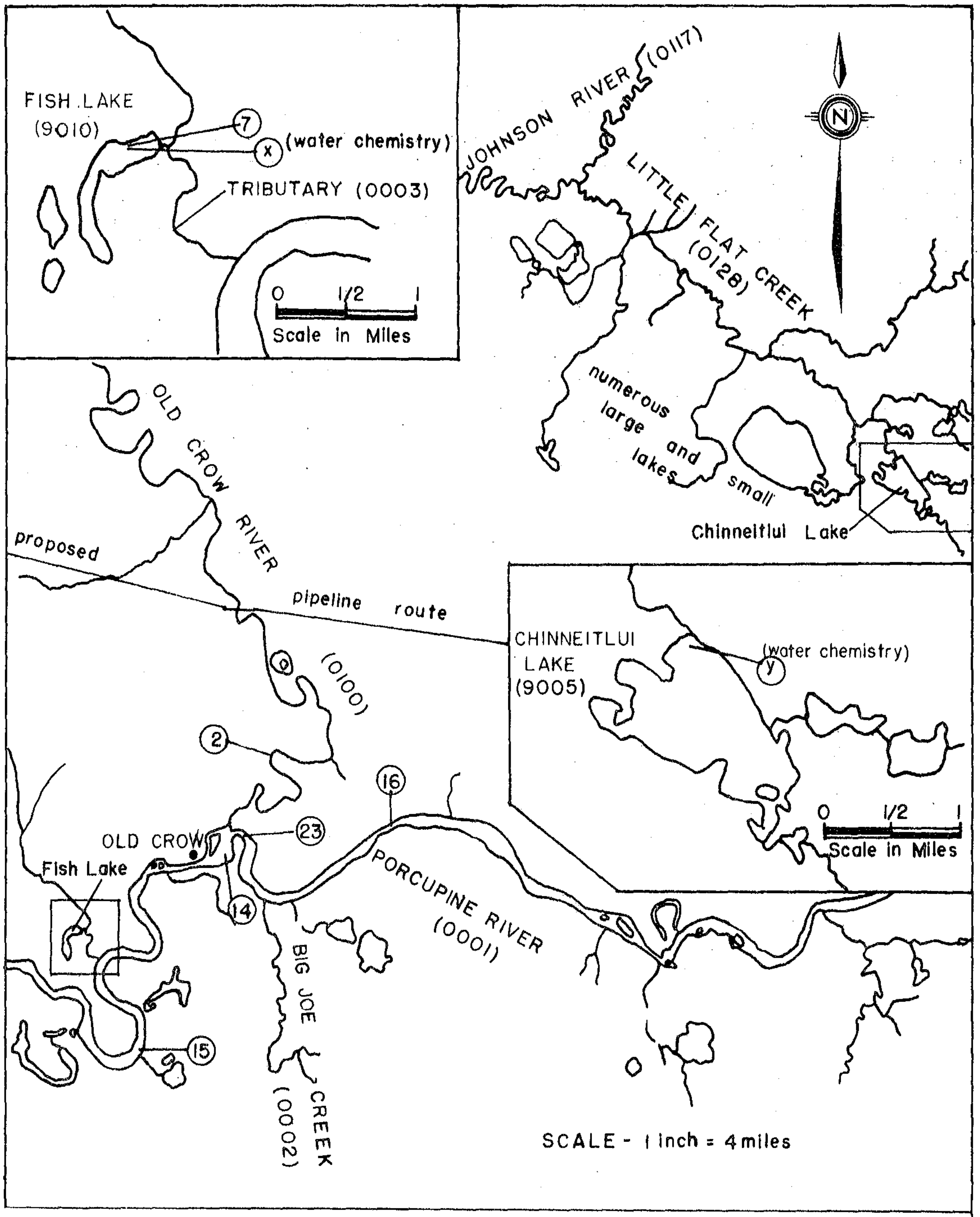

Figure 1: The study area near Old Crow during April, 1973. Numbered locations refer to gillnet and setline sites, lettered locations refer to water chemistry sites which are not adequately located in Figure 7.

Water velocity measurements were attempted with an OTT current meter. The meter was not successful and instead a container to release air bubbles into the water column to indicate the presence or absence of a current was employed. Snow, ice, and water depths were measured with a meter stick.

4. Results and Discussion

4.1 Overwintering Fish Species in the vicinity of Old Crow.

4.1.1 Gillnet and Set line program.

Set lines under the ice unsuccessfully fished at sites 2, 14, 15 and 16 (Figure 1).

Gillnets were fished at sites 15, 16 and 23 in the Porcupine River. One 3 inch mesh gillnet was set in Fish Lake, at site 7, and another 3 inch gillnet was set for one week in the Old Crow River at site 2. Refer to Figure 1 for site locations.

Only on the Porcupine River and the Fish Lake sites were fish caught. The catch per unit effort for the various gillnet sites was calculated and the results are shown in Table 1.

Species composition of gillnet catch data in the Porcupine River is shown in Figure 2. Arctic Grayling (*Thymallus arcticus*) were the most abundant species captured (n = 158). Grayling were the only species for which the catch data indicated a substantial overwintering fish population in the vicinity of Old Crow.

The recorded low percentage of all whitefish species in the catch was unexpected. Local catches of whitefish are high in the fall, and downstream fall migrations of broad whitefish (*Coregonus nasus*, n = 12), humpback whitefish (*Coregonus clupeaformis*, n = 13), and least cisco (*Coregonus sardinella*, n = 10) are documented from the Old Crow River and various tributaries, into the Porcupine River. These facts would have appeared to indicate the establishment of overwintering sites by these species in the Porcupine River, and in particular, the vicinity of Old Crow.

Only one round whitefish (*Prosopium cylindraceum*) and two longnose sucker (*Catostomus catostomus*) were caught in the Porcupine River. The longnose sucker is abundant in the area during the summer and fall (Bryan et al, 1973). Round whitefish are not caught in high numbers at any time of the year. In the summer of 1972, out of approximately 1600 fish sampled, only six were round whitefish.

Five northern pike (*Esox lucius*) and six burbot (*lota lota*) were captured. Burbot and pike are caught

Table 1: Catches per unit effort for gillnets set in the Porcupine River, Old Crow River, and Fish Lake during April, 1973.

Sampling Site (Figure 1)	Date April (1973)	Fishing Time (Hours)	Gillnet Mesh Size (in.)	Catch/unit effort
Porcupine R. (23)	12	19.5	4.5	3.69
	13	28.5	4.5	14.32
	12	19.5	3.0	1.23
	13	28.5	3.0	12.63
	15	44.0	3.0	9.27
	16	28.0	3.0	10.71
	17	25.0	3.0	9.12
	19	41.0	3.0	9.66
	15	44.0	2.5	7.09
	16	28.0	2.5	2.57
	17	25.0	2.5	5.76
	19	41.0	2.5	7.02
Porcupine R. (16)	April 18	46.5	3.0	7.23
	April 19	24.0	3.0	13
Porcupine R. (15)	April 19	21.0	2.5	3.43
Old Crow R. (2)	April 15	23.0	3.0	0
	April 17	50.5	3.0	0
	April 19	41.5	3.0	0
Fish Lake (7)	April 19	22.0	3.0	9.82

* One unit effort is defined as one 8' X 50' gillnet of any mesh size set for a 24 hour period.

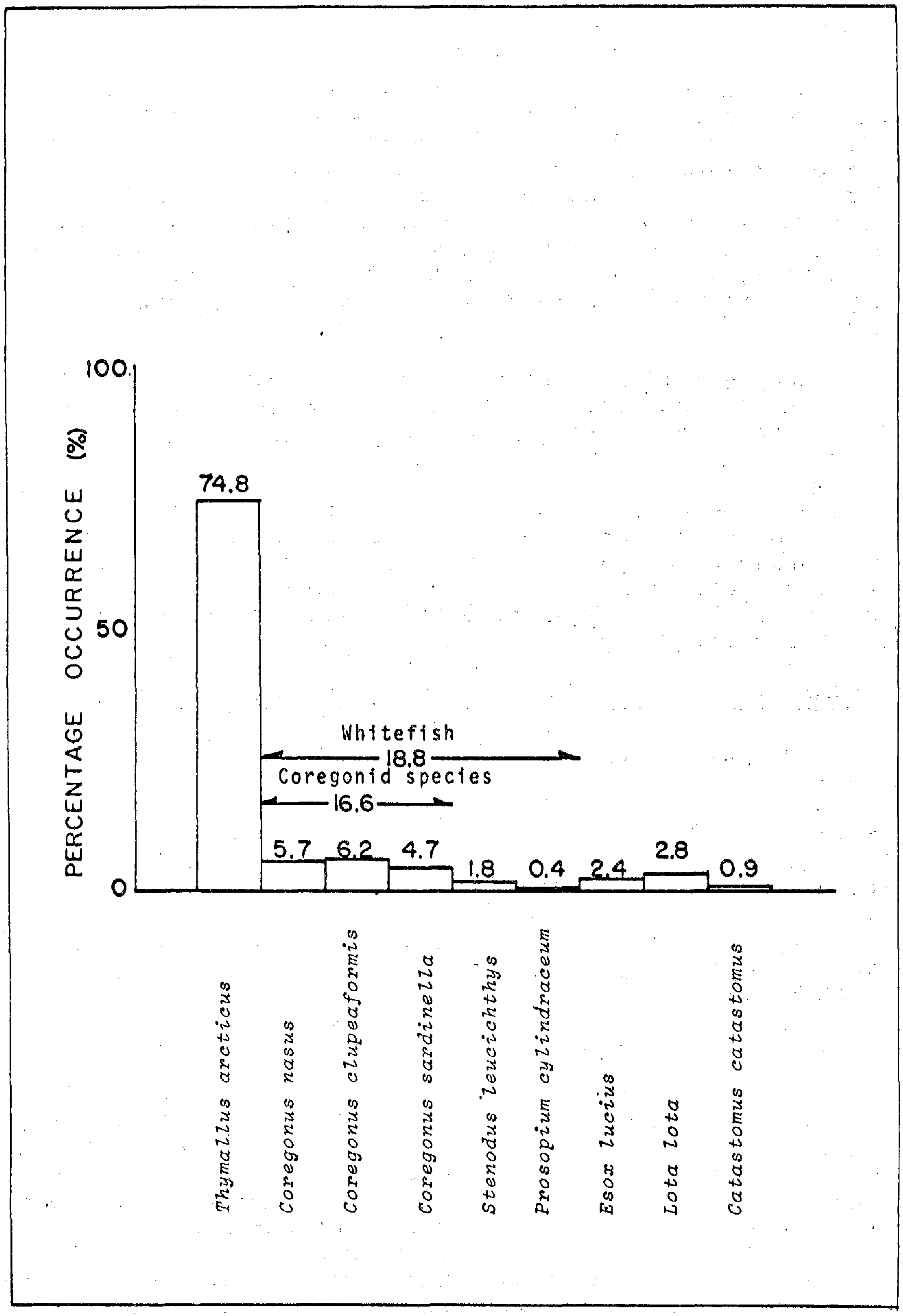

Figure 2: Species composition of fish from gillnet catches in the Porcupine River, April, 1973.

with varying frequency throughout the year. Pike are captured with greatest frequency in June through August (Bryan et al, 1973), and are found most often during the summer in slow backwaters and eddies, which were not fished during this survey. Burbot are caught in large numbers in October through December (Bryan et al, 1973), and the people of Old Crow take approximately 150 burbot each year, from set lines in the Porcupine River. This may account for relatively low numbers being caught in April.

Samples of the resident populations of broad whitefish (n = 3) and least cisco (n = 6) were removed from Fish Lake in one 22-hour fishing period during April, 1973.

Poor numerical representation of species other than grayling in the Porcupine River is immediately noticeable. The ranked percentage of abundance of each species in the total catch is contrasted below, between April, 1973 and summer, 1972 (unpublished) data of fish gillnetted in the Porcupine River.

Comparison of fish samples from the Porcupine River

April 1973 (n = 211)		Summer 1972 (n = 1403)	
Grayling	74.8%	Least cisco	30.0%
Humpback whitefish	6.2	Grayling	16.8
Broad whitefish	5.7	Longnose sucker	15.2
Least cisco	4.7	Humpback whitefish	11.9
Burbot	2.8	Pike	8.2
Pike	2.4	Inconnu	6.4
Inconnu	1.8	Broad whitefish	6.1
Longnose suckers	0.9	Burbot	4.9
Round whitefish	0.4	Round whitefish	0.4
		(+6 additional species not included in the total.)	

From this comparison, albeit crude, and based on low sample sizes from the April, 1973 survey, least cisco and longnose suckers appear to be much more plentiful during the summer period, and grayling have a higher relative abundance in the winter time in the Porcupine River. Least cisco were caught in large numbers from breakup to the first week of July and again from early September to late October (unpublished data). These catches are believed to relate to upstream and downstream migrations, respectively.

Many of the tributaries and lake systems associated with the Porcupine River are uninhabitable during the winter due to complete freezing of the water body. Thus, it was expected that the Porcupine River would represent the most likely overwintering area for most species. The low catch for species other than grayling in the Porcupine River may be due to various reasons, such as the following:

1) Ineffective catch methods. A technique successful in the summer may be less effective under winter conditions. It is difficult if not impossible to locate and effectively sample all representative habitat types in the Porcupine River that are available in the winter. Sampling sites are selected as to the feasibility of setting nets under the ice and not strictly for their representativeness. Catch results may be adversely influenced by domestic fishing activity after freeze-up.

2) Some species may migrate further downstream in the Porcupine River than others, and therefore may be absent, or present only in low numbers in the Old Crow area. There is much more to be learned of seasonal movements of most fish species in the Porcupine River.

3) Certain species may display less mobility at low temperatures, decreasing their chance of capture.

4) Sampling in the Porcupine River was restricted to the immediate vicinity of Old Crow, and larger and more important overwintering sites may exist that have not yet been documented.

5) A combination of the four previous statements is the most probable reason for the low population levels of most species in the April, 1973 survey of the Porcupine River.

4.1.2 Size and Sexual Maturity of Overwintering Fish.

Arctic grayling are the most abundant arctic fish in the Porcupine River near Old Crow during the winter. A length frequency distribution indicates that the majority of fish caught are between 350mm and 400mm long (Figure 3). This appears to be due to the preponderance of four and five year old fish in the catch (Table 2) and agrees with the length-age relationship found by Bryan et al (1973). The majority of the grayling are mature and approaching a ripe spawning stage. Of the sexually mature fish, 41.8 percent are male and 58.2 percent are female (Table 3). Refer to Appendix 3 for the classification of sexual maturity. The sample for each age class is not large enough to statistically distinguish growth variations between sexes.

Gillnet selectivity undoubtedly contributes to some extent to a preponderance in the sample of older and larger fish, or larger young fish such as the two and three year old grayling (Table 2). The presence of a large percentage of mature grayling near the mouth of the Old Crow River seems to indicate that the area is utilized as a staging area prior to a spawning migration up either the Old Crow River or the Porcupine River, or both.

It is difficult if not impossible to conclude any life history patterns of the other fish species present due to the small sample sizes involved. Species that were not present in statistically adequate numbers (< 10) were not included in the reference tables (Tables 3 and 4).

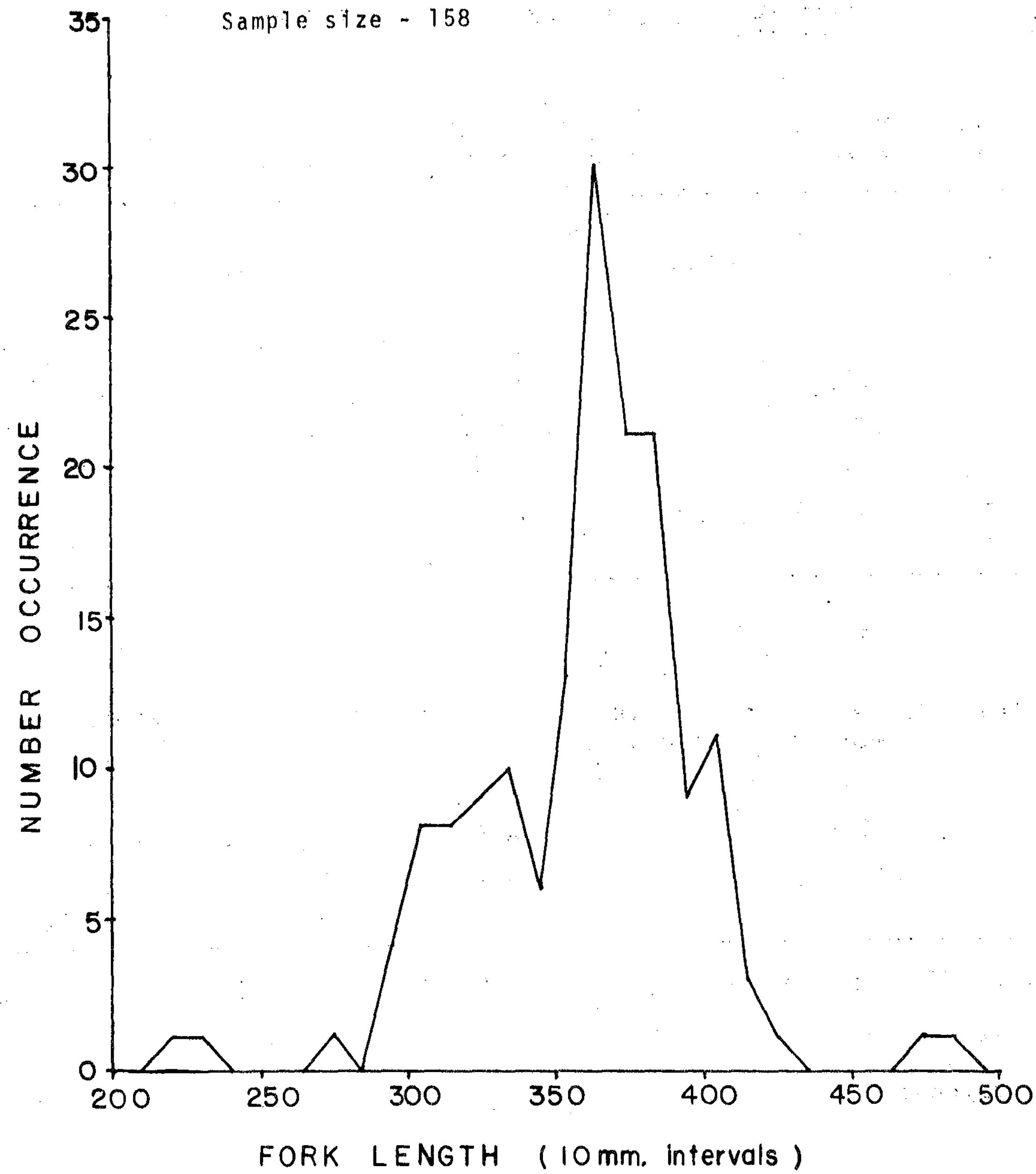

Figure 3: Length frequency distribution for *Thymallus arcticus* from the Porcupine River, April, 1973.

Table 2. The mean fork length and range for each age present, and the percentage occurrence of each age in the Thymallus arcticus population.Porcupine River, April 1973.

Scale Age	Sample Size	Mean F.L. (mm) ± Standard Deviation	Range of F.L.(mm)	Percentage frequency
2	2	338.0 ± 65.1	292-384	3.4
3	4	330.8 ± 22.5	307-358	6.9
4	34	357.4 ± 33.2	295-419	58.6
5	18	368.6 ± 24.8	315-410	31.1
	Σ 58			100%

Table 3. Sex ratios of fish species captured in the mainstem Porcupine River, April 1973.

FISH SPECIES	SAMPLE SIZE	SEX RATIO	
		% Male	% Female
Thymallus arcticus	158	41.8	58.2
Coregonus sardinella	10	40	60
Coregonus clupeaformis	12	83.3	16.7

Table 4. Maturity ratios of fish species captured in the mainstem Porcupine River, April 1973.

FISH SPECIES	SAMPLE SIZE	MATURITY RATE	
		% mature	% immature
Thymallus arcticus	158	98.7	1.3
Coregonus sardinella	10	90	10
Coregonus nasus	12		100
Coregonus clupeaformis	13	58.8	46.2

Of the whitefish species, the humpback is more evident, not only in its higher percentage presence (6.2 percent) (Figure 2), but also with ages ranging from three years to six years and the presence of both immature and mature fish (Table 4). The broad whitefish was present in low numbers from one year to four years of age, all of which were immature fish. The least cisco shows a large number (90 percent) of mature fish present which were three or four years old.

Only two (n = 4) of the inconnu caught were mature, and these included a dormant five-year-old male and a large (fork length 685mm) nine-year-old female. It would appear spawning has occurred within the drainage area, and since inconnu exhibit a post-spawning downstream movement (Alt, 1969), spawning probably occurs upstream of Old Crow. The single round whitefish caught was a sexually dormant eight-year-old female.

Pike (n = 5) and burbot (n = 5) from the Porcupine River were also aged. Pike ages ranged from three to six years, while burbot were from five to fourteen years of age. Sixty percent of both species were males and all of the pike were mature fish, either dormant or in ripe spawning condition. The oldest burbot (14 years) was a female with a fork length of 721mm. All of the four mature burbot caught displayed dormant gonadal tissue, indicating they did not spawn this year. Chen (1969) has previously noted that burbot do not spawn every year.

Fish caught in Fish Lake display a wider range of year classes. The least cisco (n = 6) were found to be from two to six years of age although all fish sampled were mature, and the broad whitefish (n = 3) were found to be from one to four years of age, and two were immature.

4.1.3 Analyses of Stomach Contents of Overwintering Fish.

Analyses were conducted on the stomach contents from 190 fish from the Porcupine River, and from nine fish from Fish Lake, the results of which are given in Tables 5 and 6. Low sample size of all fish species, with the exception of Arctic grayling, make conclusions on the winter diet of fish species questionable. However, the results should indicate the general availability, and utilization of food items by the various fish species present during the winter. Table 7 describes the generalized stratification of food items within the water column.

Table 5 : - Analysis of food organisms utilized during April, 1973 by fishes in the mainstem of the Porcupine River, expressed as the percentage of stomachs containing the following food items:

Fish Species	Total # Stomachs Examined	% with food	*P. cylindraceum*	*C. cognatus*	*L. japonica*	unidentified fish	chironomid larvae	Plecoptera nymph	Ephemeroptera nymph	Hemiptera	Amphipoda	Trichoptera nymph	Gastropoda	Pelecypoda	Digested Matter	unidentified matter	debris
			Percentage Occurrence of Food Organisms in the Stomachs Examined.														
T. arcticus	157	82		0.7			1.6	76.	4.7	6.2		11.6			24.	3.1	8.5
C. sardinella	10	20						100.									
C. clupeaformis	11	45		16.7	16.7	16.7										16.7	16.7
S. leucichthys																	
Immature	2	50						100.	100.								
Mature	2	100				100.											
Lota lota	5	60			33.3	100.											
E. lucius	3	100	33.3			33.3									33.3		

Table 6 : - Analysis of food organisms utilized during April, 1973 by fishes in Fish Lake, expressed as the percentage of stomachs containing the following food items:

Percentage occurrence of Food Organisms in the Stomachs Examined

Fish Species	Total # Stomachs Examined	% with food	*P. cylindraceum*	*C. cognatus*	*L. japonica*	unidentified fish	chironomid larvae	Plecoptera nymph	Ephemeroptera nymph	Hemiptera	Amphipoda	Trichoptera nymph	Gastropoda	Pelecypoda	Digested matter	Unidentified matter	Debris
C. sardinella	6	100					50								50	50	
C. nasus	3	100					100				33.3	66.3	33.3	33.3			

Table 7 :- Food organisms: a list of their taxonomic classification, common names, and general aquatic habitat.

Taxonomic Name	Common Name	Habitat
Prosopium cylindraceum	- Round whitefish	- a nektonic fish species usually found near the bottom.
Cottus cognatus	- Slimy sculpin)	- two fish species usually found near and associated with stream bottoms.
Lampetra japonica	- Arctic lamprey)	
Unidentified fish		
Plecoptera nymph	- Stoneflies)	- free moving nymph forms associated with rocky bottom in running water, not associated with mud bottoms.
Ephemeroptera nymph	- Mayflies)	
Trichoptera larva	- Caddisflies	- a characteristic larval case restricts this form to benthic life, usually associated with rock stream bottoms.
Gastropoda	- Freshwater snails)	- benthic molluscs crawling on or buried in river and lake bottoms.
Pelecypoda	- Freshwater clams)	
Chironomid larvae	- Midges	- tend to be free-swimming larval forms found in rivers and lakes, known to be associated with the bottom in running water.
Hemiptera	- Water boatmen and back swimmers	- pelagic adult insects, free-swimming aquatic forms found in rivers and lakes.
Amphipoda	- Freshwater shrimp	- pelagic crustacean usually found in lake waters.
Digested matter		
Unidentified matter	- Insect part, etc.	
Debris	- Sticks, rocks, etc.	

Arctic grayling utilize most food sources throughout the water column (Figure 4), with the exception of benthic snails and clams. The main food sources of the grayling were Plecopteran nymphs and Trichopteran larvae (Table 5), both of which are bottom organisms. Bryan et al (1973) found that grayling consumed chironomid larvae and pupae, adult insects and fish eggs during the summer. It would appear that grayling feed on the most available food items, and that the food source utilized varies through the year.

In the Porcupine River, many of the species present are piscivorous (Table 5). Pike, burbot, mature inconnu and humpback whitefish appeared to feed solely on smaller forms of fishes. In most cases these food fish are bottom species including sculpins (C. cognatus) and ammocoete larvae (L. japonica). Only pike appear to feed on the more pelagic round whitefish. Burbot, pike and inconnu have previously been noted as being piscivorous (Chen 1969, Alt 1969, and Lawler 1965).

Young inconnu fed on only Plecopteran and Ephemeropteran nymphs, and shared this food source with the least cisco. Unfortunately more complete food analyses are hampered by the often prevalent digested and unidentifiable fish and food matter found in many stomachs.

In Fish Lake, broad whitefish appear to utilize both benthic and pelagic organisms (Tables 5 and 6). The least cisco in Fish Lake appear to feed primarily on Chironomid larvae, while in the Porcupine River the stomachs examined, though few in number, contained only Plecoptera nymphs. Large numbers of back swimmers (Hemiptera, Corixidae) were observed in Fish Lake though none were observed in any of the stomach samples.

In all samples a subjective notation of the presence of visceral fat bodies was made. In most species the majority of fish exhibited moderate to large deposits of visceral fat. An exception were the few northern pike caught which showed little or no fat bodies. This may be a reflection of the diet utilized, the utilization of fat in preparation for spawning activities , or merely a characteristic of the species. Grayling exhibit both gonadal development and fat deposition in the winter. That both can be utilized as energy sources during any difficult winter months is disputable, but should be considered.

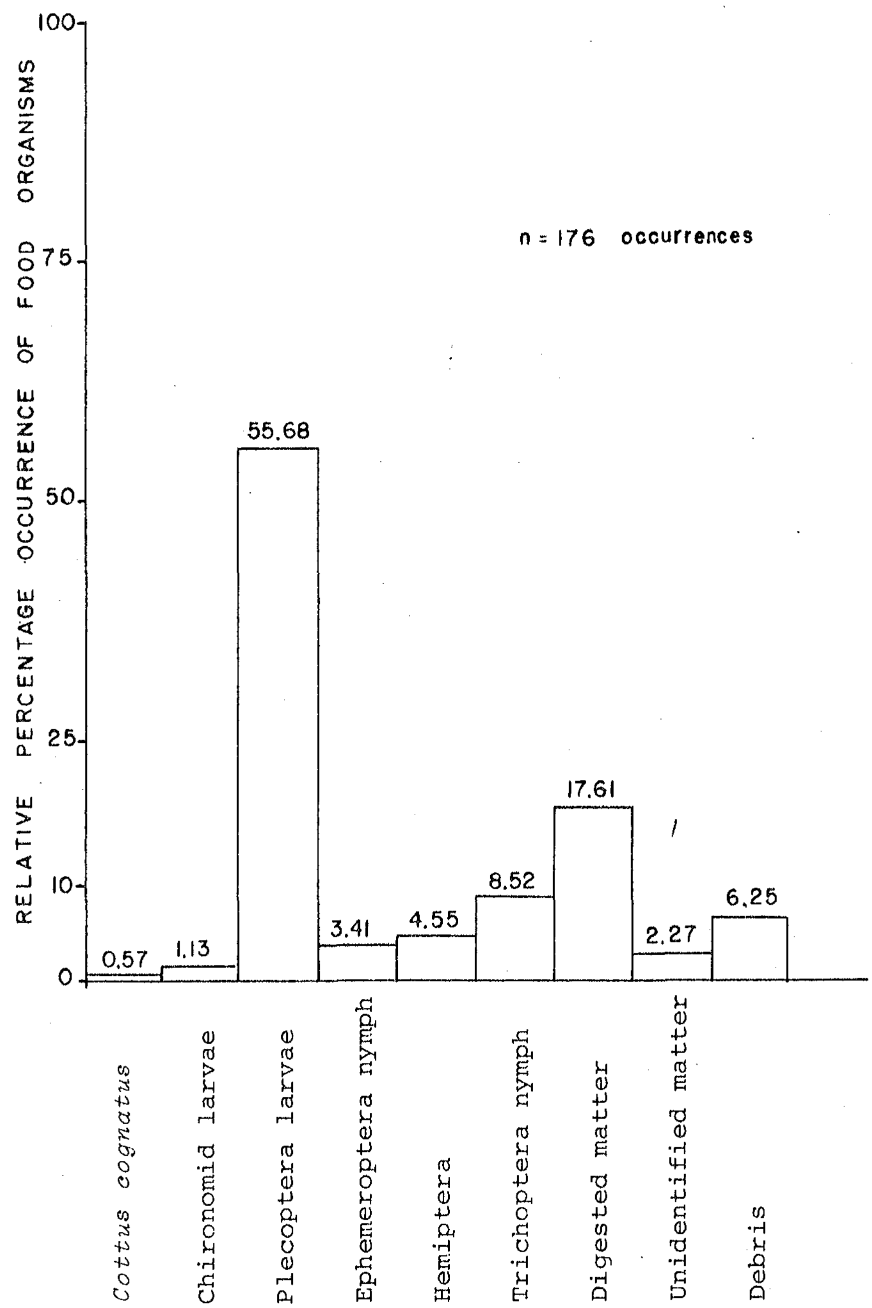

Figure 4: Relative percentage occurrence of food items in stomach samples of *Thymallus arcticus* from gill-net catches, Porcupine River, April, 1973. Percentages are an expression of the total number of times a food item occurred in analysing stomach contents.

Parasites were noted when observed. There was the usual visceral infestation of tapeworm cysts and stomach nematodes. In one instance, a grayling was captured with a raw hole, surrounded by rotting flesh on its side. The cause is unknown.

4.2 Chemical and Physical Measurements of Overwintering Habitat.

4.2.1 Chemical Parameters.

The sites where ice drilling and water chemistry analysis were completed are depicted in Figure 5. Lake localities are more accurately shown in Figure 1.

Chemistry recordings taken in the Porcupine River agree comparably with data collected by the Water Survey of Canada for the past several years. Characteristically, turbidity is low while conductance is very high (Table 9), as much as four times the early summer low. Total alkalinity and hardness are proportionately high also (Table 8). Thus a seasonal habitat for primary productivity should exist if not for the limitations of low temperatures and dissolved oxygen levels.

Dissolved oxygen levels throughout the Porcupine River appear moderate but habitable by fish (Tables 8 and 11). Comparable data has been collected by P. McCart (1973). Oxygen levels appear to range from 4.3 to 6.1 mg/l.

Chinneitlui Lake, with 0.3 m of water, in the Old Crow Flats is uninhabitable in the late winter. Dissolved oxygen was not detectable, and a hydrogen sulphide odour was very evident. Fish Lake has a resident population of broad whitefish and least cisco at a very restrictive oxygen level. Repeated recordings give the level in one area of the lake as less than 1.0 mg/l (Table 8). This oxygen level is not expected to support fishes and suggests other areas of the lake support the main populations.

The Old Crow River also had low dissolved oxygen levels of less than 1.0 mg/l (Table 8). As repetitive gillnetting and jigging resulted in no fish being caught it was concluded that the lower section of the Old Crow River at and below the proposed pipeline crossing was probably not inhabitable by fish in the late winter.

The nutrients nitrogen (as No_2, No_3, and NH_4 compounds) and phosphorous were measured on preserved samples and listed in Table 13. It is commonly believed that the

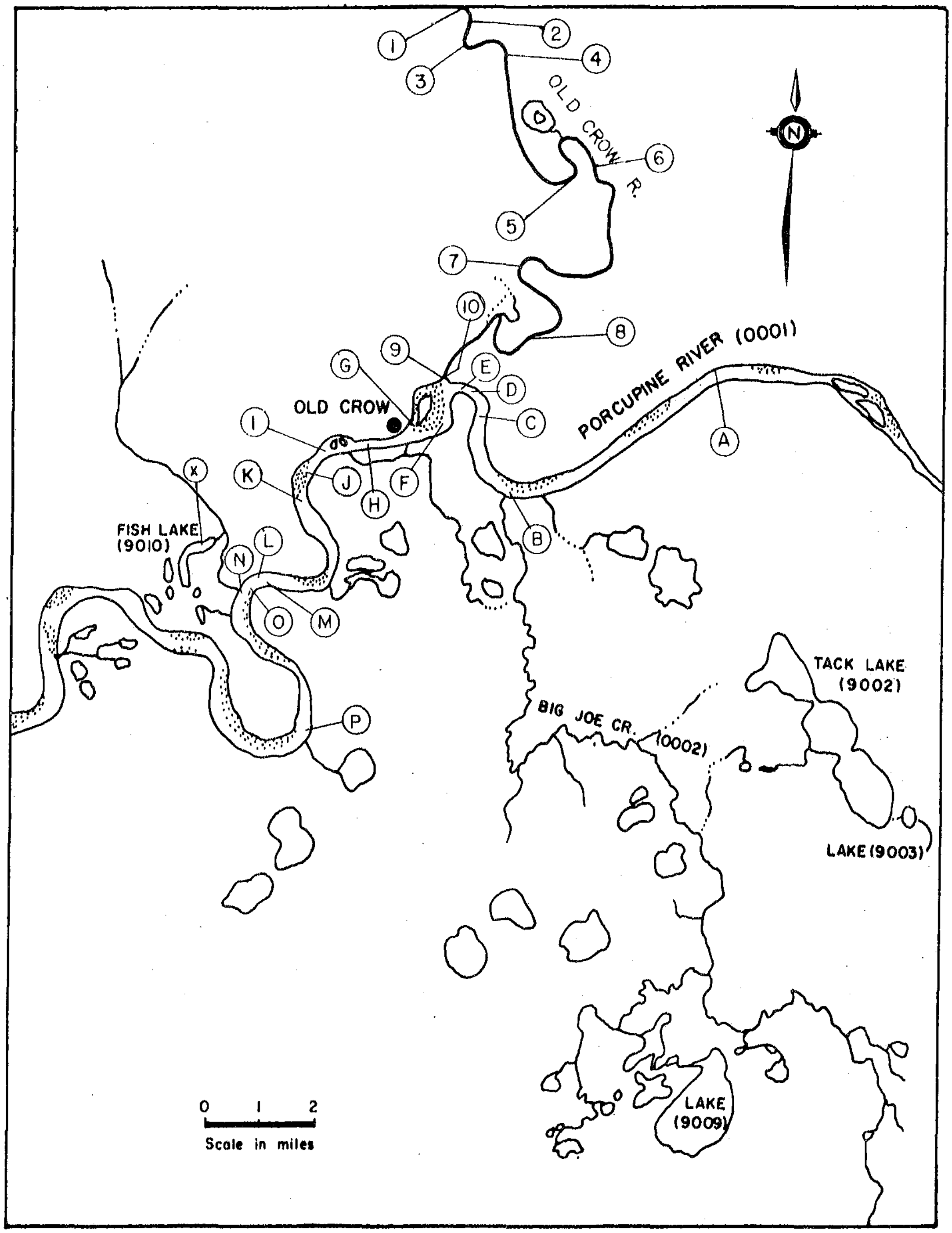

Figure 5: Sites where ice drilling and water chemistry analyses were conducted during a limited winter investigation, April, 1973. Numbered sites in this Figure do not correspond to site numbers for gillnetting in Figure 1.

Table 8. Water chemistry data collected from the Porcupine River, Old Crow River, Chinneitlui Lake, and Fish Lake (April 1973) and comparable methods of measurement.

Sampling Site Figures 5&1	Date/Time (hrs.)	Temp. (°C)	Color	DO_2 (mg/l)		pH		Total Alkalinity (mg/l $CaCO_3$)	Total Hardness (mg/l $CaCO_3$)		
				Meter (Model OX-2P)	Titri-metric Hach Model OX-2P)	Meter Orion (Model 404)	Color Comp. (Model 17N)	Hach Model (AL-AP)	Pre-served sample	Hach Model HA-71-A	Hach DR-EL kit
PORCUPINE RIVER:											
below Old Chief Creek (A)	April 16 @ 1400 hrs.	0.5	12		4.3	inop.	8.0	177.8	127.4	222.3	190
Old Crow Point(E)	April 10	0	10	approx. 5.0	5.0	7.25	8.0	184.7	151.5	205.2	180
Fisheries Camp(H)	April 19 @ 1500 hrs.	0	10		4.8	inop.		177.8	sample lost	205.2	192
8 Mile Bluff (P)	April 18 @ 1630 hrs.	0.5	15		4.4	inop.	8.0	191.5	169.8	222.3	190
OLD CROW RIVER:											
pipeline crossing site (2)	April 16 @ 1100 hrs.	0.5	36		approx. 0.2	inop.	7.5	246.2	197.2	256.5	240
6 Mile Point (7)	April 14 @ 1300 hrs.	0.5	60		<0.2	6.75	7.5	191.3	174.6	290.7	
CHINNEITLUI LAKE:											
near creek outlet (Y)	April 13 @ 1030 hrs.	1.0	760		0		7.4	51.3	128.0	0	
FISH LAKE:											
NE Arm (X)	April 18 @ 1500 hrs.	0.5	195		approx. 0.2	inop.	6.6	54.7	30.3	34.2	30

NOTE:- inop. - refers to an inoperable meter.

Table 9:- Measurements of sediment conditions in the Porcupine River, Old Crow River, Chinneitlui Lake, and Fish Lake (April 1973).

Sampling Site Figures 5&1	Date/Time (hrs.)	Total Residues (mg/l)	Filterable Residues (mg/l)	Non-Filterable Residues (mg/l)	Turbidity as suspended material (mg/l)	Turbidity Formazin Standard (JTU)	Specific Conductance (μmho/cm)
Porcupine River:							
below Old Chief Creek (A)	April 16 @ 1400	205	136	18.7	69	4	493
Old Crow Point (E)	April 10 @ 1400	225	158	31.1	67	4	452
Fisheries Camp (H)	April 19 @ 1530					5	353
8 Mile Bluff(P)	April 18 @ 1630	223	175	20.3	28	2	460
Old Crow River:							
pipeline crossing site (2)	April 16 @ 1100	296	229	38.8	67	8	529
6 Mile Point Fish Camp (7)	April 14 @ 1300	251	153	19.2	98	16	597
Chinneitlui Lake:							
near creek outlet: (Y)	April 13 @ 1030	305	154	165.	151	192	291
Fish Lake:							
NE arm: (X)	April 18 @ 1500	103	49.4	23.3	53.6	45	79.0

quantity of plankton, in particular phytoplankton, that can develop in any water is more likely to be determined by the concentration of these nutrients than any other factor. More specifically, phosphorous tends to be the limiting factor in winter, while nitrogen may be in the summer (Hutchinson, 1967). In all cases, total phosphate measurements were low and probably limiting.

4.2.2 Physical Parameters.

Subsequent to the documentation of the uninhabitable nature of the Old Crow River in this area, the question arose of what the state of water flow was and whether this state, static or dynamic, contributed to the uninhabitable nature of the river. A series of drillings were conducted to determine the structure of the river below the pipeline crossing site. Drill sites 1 to 10 are depicted in Figure 5, and depth measurements of snow, ice, and water are documented in Table 10. Current was recorded as "present" if bubbles released from a container did not rise up the drill hole, and if the water column was low in the drill hole and fluctuated somewhat. It is realized that this method is questionable, however, no indication of any water current was observed in the section of the Old Crow River downstream of the proposed pipeline crossing site. Repeatedly, ice depth was substantial and oxygen levels low, and in several instances the river appeared frozen to the bottom (Sites 1, 3 and 8, Figure 5). From this preliminary investigation, a river structure of uninhabited water pools isolated between frozen riffle areas is postulated for the lower limits of the Old Crow River.

Consequently, drilling was continued in the Porcupine River from Station A above Old Crow, downstream to Station D below Fish Lake (Figure 5). Ice depths were more moderate, possibly due to current velocity and the insulating quality of a substantial depth of water (up to 5.94m).

It appears that the water flow is not greatly impeded by formations of slush ice under the surface of the river ice. Slush ice, where formed, (Sites L to O, Table 11), appear to form at least a partial barrier to the movement of fish. It is postulated that slush ice may, in some instances, isolate groups of fish in some parts of the river, and if such is the case, the detrimental effects of the introduction of high silt loads during pipeline construction would be high.

Snow, ice and water depth were also recorded at one site each for Fish Lake and Chinneitui Lake. The data is recorded in Table 12.

Table 10: Winter structure in the Old Crow River, and habitat quality at sample sites. (April, 1973).

Sample Site (Figure 5)	No. of holes drilled	Snow depth (m)	Ice depth (m)	Water depth (m)	Current	Temp. (°C)	Dissolved Oxygen (mg/l)
1*	3	0.45	0.91	0			
2	5	0.56	0.86	0.28	absent	0.5	0.2
3	2	0.61	0.76	0			
4	3	0.61	0.91	0.20	absent		
5	2	0.91	0.76	0.20	absent		
6	3	0.56	0.56	0.05	absent		
7	9	0.91	0.61	1.37	absent	0.5	0.2
8	2	0.30	0.86-1.12	0			
9	1	0.61	0.99	0.46	absent	0	1.8
10	1	0.61	1.02	0.15	absent	0	1.7

Note: no slush ice formation observed to any extent in this section of the Old Crow River

* data from McCart 1973

Table 11:- Winter structure in the Porcupine River around Old Crow, and habitat quality at sample sites (April, 1973)

Sample site (Figure 5)	No. of holes drilled	Snow depth (m)	Ice depth (m)	Water depth (m)	Slush	Current	Temp. (°C)	Diss. O_2 (mg/l)
A	4	0.53	0.43	1.85	absent	present	0.5	4.3
B**					present	absent		
C	2				present			
D	4	0.30	0.94	5.94	absent	present	0	5.0
E	4	0.20	1.37	3.12	absent	present	0	6.1
F	1	0.74	0.71	0.97	absent	present	0	3.0
G**					present	absent		
H	2	0.18	1.69	0.38	absent	present	0	4.8
I**					present	absent		
J**					present	absent		
K	2	0.76	1.35	0.28	present			
L	1	0.20	1.37	0.15	present	absent		
M	1	0.25	1.37	0.30	present	absent		
N	3	0.76	1.52	0.30	present			
O	1	0.25	1.52	0.71	present	present		
P	5	0.20-0.30	0.61-0.86	2.08-2.57	absent	present	0.5	4.4

** - data from personal communication with local residents.

Table 12: Winter structure in two lakes, and habitat quality at sample sites (April, 1973).

Sample site (Figures 5&1)	No of holes	Snow depth (m)	Ice depth (m)	Water depth (m)	Temp (°C)	Dissolved oxygen (mg/l)
Fish Lake (x)	4	0.41	0.81	1.98	0.5	0.2
Chinneitlui Lake, near outlet (y)	2	0.61	1.32	0.30	1.0	0

Table 13:- Elements affecting primary productivity as found in the Porcupine River, Old Crow River, Chinneitlui Lake and Fish Lake (April 1973)

Sampling Site (Figures 5&1)	Date/Time (hrs.)	Nitrogen (mg/l)			Ortho-phos-phate (mg/l)	Total Phos-phate (mg/l)
		Nitrite (NO_2)	Nitrate (NO_3)	Ammonia (NH_3)		
Porcupine River:						
Old Crow Pt. (E)	April 10 @ 1400 hrs.	N/D	<0.015	.37	<.02	.026
8 Mile Bluff (P)	April 18 @ 1630 hrs.	N/D	0.015	.052	<.02	.015
Old Crow River:						
6 Mile Point (7)	April 14 @ 1300 hrs.	N/D	<0.015	.33	<.02	.018
Chinneitlui Lake:						
near creek outlet (y)	April 13 @ 1030 hrs.	0.008	<0.015	2.37	<.02	.088
Fish Lake:						
NE arm (x)	April 18 @ 1500 hrs.	N/D	0.015	0.046	<.02	.106

NOTE: N/D refers to a negligible and not measurable chemical level.

4. Conclusions

(1) An overwintering habitat of acceptable water quality based on dissolved oxygen readings exist throughout the area of the Porcupine River studied.

(2) Arctic grayling, humpback whitefish, broad whitefish, least cisco, burbot, northern pike, inconnu, longnose sucker, round whitefish, sculpins, and ammocoete larvae all inhabit the winter environment of the Porcupine River. Arctic grayling are the most abundant of active fish present.

(3) The Old Crow River at and below the proposed pipeline crossing site was found to be uninhabitable in the late winter month of April, 1973.

(4) Fish Lake (Lake #10 maintains a resident population of broad whitefish and least cisco throughout the winter.

(5) Chinneitlui Lake (Lake #8) was found to be uninhabitable in the late winter months of 1973.

(6) Some division of food exploitation by fish species exists in the Porcupine River and Fish Lake. Arctic grayling successfully exploit most available food sources, with the exception of benthic snails and clams.

6. Recommendations and Further Study

Very few factually supported recommendations can be made from this work. The Porcupine River and Fish Lake are shown to support fish populations during the critical winter season, and should be protected from industrial intervention. The postulated winter structure of the river has yet to be proven, but even if true only in a limited manner, it further indicates the vulnerability of the aquatic environment and the need for protection of overwintering river habitats from pollution.

Subsequent studies in 1973 and 1974 have done little to discover major overwintering areas for fish. Further study must therefore concentrate on areas downstream of groundwater sources, and on those areas that have not received adequate investigation. Sections of the Bell River, Eagle River and Porcupine River should be examined in more detail. The Old Crow Flats and Eagle Flats are still, largely, uninvestigated and are perhaps the most productive areas in the northern Yukon.

Gillnets were found to be unsatisfactory for winter life history studies due to their inherent size selectivity, the technical difficulties of setting nets, and the restriction of sampling to sites where there is sufficient depth of water to set nets. Efforts should be directed toward the development of alternative techniques for fishing under the ice that would be more effective in obtaining representative samples of both adult and juveniles of all fish species present, throughout the range of available habitat.

Field measurement of chemical and physical aquatic parameters should be kept to a minimum thereby limiting the use of chemicals and meters that appear unreliable in the freezing temperatures, and limiting the exposure time of the workers. Instead, this work should be relegated to the field lab and conducted upon collected samples whenever possible.

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Appendix I:- A list of all fish species encountered during this study, their common and taxonomic names.

Common Name	Taxonomic Name
Arctic grayling	*Thymallus arcticus*
Broad whitefish	*Coregonus nasus*
Humpback whitefish	*Coregonus clupeaformis*
Least cisco	*Coregonus sardinella*
Inconnu	*Stenodus leucichthys*
Round whitefish	*Prosopium cylindraceum*
Northern pike	*Esox lucius*
Burbot	*Lota lota*
Longnose sucker	*Catostomus catostomus*
Slimy sculpin	*Cottus cognatus*
Arctic lamprey	*Lampetra japonica*

Appendix II:- A list of equipment and methods used in conducting water chemistry analyses. Asterisks refer to methods that can reliably be used in future winter work.

Chemical or Hydrologic Measurement	Equipment
Field and Field Lab:	
a) Temperature	- hand thermometer.
b) Dissolved oxygen (mg/l)	- titrametric modified Winkler method Hach kit - model OX-2P * - oxygen meter and diaphrgm probe
c) Free carbon dioxide (mg/l)	- titrametric method Hach kit - models DR-EL Hach kit - model CA-23
d) pH	- color comparator method Hach kit - model 17N - specific ion (pH) meter Orion ionalyzer - model 404 *
e) Alkalinity (mg/l)	- titrametric method Hach kit - model DR-EL Hach kit - model AL-AP *
f) Hardness (mg/l)	- titrametric EDTA method Hach kit - model DR-EL Hach kit - model HA-71A
g) Hydrogen sulphide (mg/l)	- test measuring aerated H_2S Hach kit - model HS-7
h) Turbidity (JTU)	- absorption method - meter Hach kit - model DR-EL
i) Color	- Color meter Hach kit - model DR-EL
j) Conductivity (umho/cm)	- Conductivity bridge Industrial Instruments Model RC16BI *
Preserved sample:	
k) Orthophosphate and total phosphates	- preservative: 1 ml. chloroform to 100 ml.sample, sample frozen*, sample size: 400 ml.

Appendix II - cont'd.

Chemical or Hydrologic Measurement	Equipment
Preserved sample:	
l) Nitrogen as nitrites, nitrates, and ammonia	- preservative: 1 ml. chloroform to 100 ml. sample, sample frozen*, sample size: 500 ml.
m) Hardness	- preservative: none* sample size: 200 ml.
n) Residues as total, filterable, and non-filterable residues.	- preservative: sample frozen* sample size: 600 ml.

Appendix III. Classification of stages of sexual maturity of fish in the northern Yukon, developed by the Yukon Pipeline Study Group (Steigenberger et al, 1973).

Code	Description
0	maturity not observed
1	gonads undifferentiated and visual sex determination impossible
2	gonads differentiated, but not well developed
3	gonads differentiated and developing but fish incapable of spawning in the coming season
4	fish capable of spawning, but gonads dormant
5	fish capable of spawning and gonads developing for spawning in coming season
6	fish nearly ripe
7	milt or eggs expressed with gentle pressure
8	sex products recently released - retained eggs present or flacid tests with little new development
9	no maturity determination possible because of visceral breakdown

CHAPTER IV

A PRELIMINARY REPORT OF FRESHWATER INVERTEBRATES IN THE NORTHERN YUKON TERRITORY, SUMMER 1973 AND WINTER 1974

Extracted from an unpublished
memorandum by

D. H. GALLUP

A. CLEMENTS

Revised and edited

for the

Environmental-Social Program
Northern Pipelines

Acknowledgement

The data on which this report is based are a result of studies carried out under the Environmental-Social Program, Northern Pipelines, of the Task Force on Northern Oil Development, Government of Canada.

Field survey data and samples were collected by G. J. Birch, P. G. Bruce, L. Steigenberger and P. Nukon for the Environment Canada Fisheries and Marine Service, Pacific Region, Vancouver. The surveys were part of a programme initiated to study and assess the impact of proposed pipeline development on the Fisheries resource in the Northern Yukon.

This report, detailed analysis of the invertebrate samples, species identification and drawings were completed by A. Clements, D. H. Gallup and G. Hutchinson of the Department of Zoology, University of Alberta, Edmonton.

The completion of the winter synoptic survey, 1974 was made possible by the support services and personnel of Komakuk Beach and Shingle Point Dewline Stations operated by OMS Corporation, Colorado Springs, Colorado, U. S. A., under the supervision of the Canadian Department of National Defence, Ottawa.

Mr. A. Gibson and Mr. C. E. Walker helped to administrate the study.

The report was edited by P. Bruce, M. Elson and L. Steigenberger, Fisheries and Marine Service, Vancouver.

1. Abstract

During the summer 1973 and winter 1974 field surveys conducted by the Fisheries and Marine Service, Pacific Region, invertebrate samples were collected from rivers and lakes associated with the northern prime route and the southern or interior alternate route of a proposed pipeline development in the northern Yukon.

River samples of invertebrates were collected with a Kussat and a Surber sampler. Lake samples were obtained with an Ekman dredge and a plankton net. All samples were preserved and sent to the University of Alberta for detailed analysis.

A species collection was made and identification of invertebrates was carried out.

During the summer survey the rivers on both routes seemed to be of equal value in terms of food chain production for fish. Lakes on the interior route appeared to have a higher plankton production than those of the northern route.

During the winter there appears to be little planktonic or macro invertebrate growth in lakes on either route, and the only lakes with evidence of planktonic overwintering were on the interior route. Winter open water areas sampled showed that while those rivers on the interior route support considerable invertebrate life, those on the northern route support very little.

Due to the numerous variables present, the results cannot be considered as representative of all invertebrate populations present, but merely as indicators of life stages at a specific point in time and ecological conclusions must await the inclusions of additional data from further research.

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2. Introduction

> "In 1971 the Department of the Environment, Fisheries Service, Pacific Region, began a three-year investigation of the freshwater fishery resources of the northern Yukon to determine the potential impact of gas and oil pipelines. As outlined by the governmental agencies, two general pipeline routes were identified within the Yukon. One proposed route followed the coastal plain near the Beaufort Sea, and the second route crossed the interior (through the Old Crow area (Walker, 1971)) approximately 120 miles south of the coast." (Steigenberger et al., 1974).

Field surveys were conducted during the summer of 1973 (July to September) and during the winter of 1974 (March to April). Samples were collected to determine the invertebrate species present and their relative abundance. The samples were analyzed by Dr. D. Gallup at the University of Alberta, where species lists, the number of organisms of each species and the dry weights were determined. In addition, the biomass of plankton samples were calculated.

The rivers and lakes sampled along the prime northern and interior alternate routes are shown in Figure 1, and the geographical positions of lakes studied are given in Table 1.

This report, prepared by Dr. Gallup's group and edited and prepared for publication by the Fisheries and Marine Service, Vancouver, B. C., deals with the results of the invertebrate studies during the summer and winter survey periods.

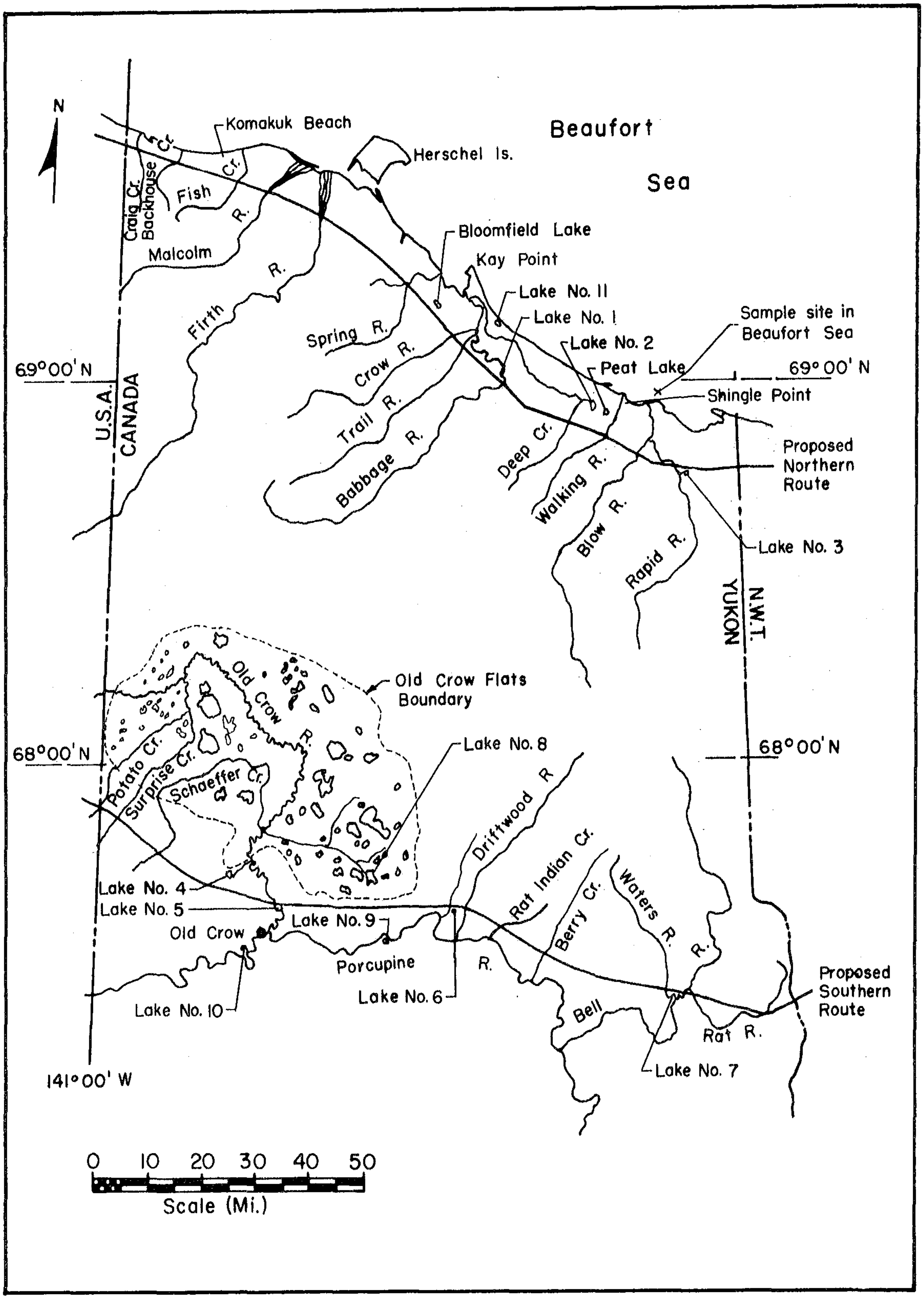

Figure 1. A reference map of rivers and lakes sampled along both proposed pipeline routes in the northern Yukon during the summer 1973 and winter 1974 surveys.

Table I. Geographical position of lakes studied during the summer 1973 and winter 1974 surveys on northern and interior pipeline routes in the northern Yukon.

NORTHERN ROUTE

Lake	Geographical Position Latitude	Longitude
Lake #1	69°02' N	138°12' W
Lake #2	68°58' N	137°12' W
Lake #3	68°44' N	136°52' W
Bloomfield Lake	69°11' N	138°37' W
Lake #11	69°06' N	138°10' W
Peat Lake	69°55' N	137°22' W
Beaufort Sea, ¼ mile east of Shingle Point	68°59' N	137°20' W

INTERIOR ROUTE

Lake	Geographical Position Latitude	Longitude
Lake #4	67°43' N	140°06' W
Lake #5 (Vunnutulka)	67°57' N	139°45' W
Lake #6	67°37' N	138°31' W
Lake #7	67°24' N	137°00' W
Lake #8 (Chinneitlui)	67°43' N	139°03' W
Lake #9 (Cadzow)	67°33' N	138°58' W
Lake #10	67°31' N	139°58' W

3. Methods

3.1 Sample Collection

During the summer 1973 field survey rivers on the northern prime pipeline route were sampled with a "Kussat" sampler, a cylindrical sampler 34 cm in diameter, with a mesh size of 200 microns, and an area of 0.3633 m^2. The rivers of the southern route were sampled with a Surber sampler with a mesh size of 200 microns and an area of 0.0929 m^2. Only the Surber sampler was used for sample collection during the winter survey of 1974. Samples collected from rivers were collected at or near the proposed crossing site of the pipeline and descriptions of types of invertebrate habitat in the locality were recorded.

River samples of invertebrates were collected from depths of 10 to 25 cm of water. The contents of mesh seines were transferred to four-ounce glass, screw cap jars, and preserved in 70% ethanol to which glycerin had been added to prevent desiccation should the alcohol leak or evaporate.

A plankton net and an Ekman dredge were used to sample lake invertebrates in both the summer 1973 and winter 1974 surveys. The plankton samples were collected with a Wisconsin Style Number 40 plankton net (diameter 13 cm, mesh size 200 microns, and a straining area of 58.07 cm^2). For each of the two stations within a lake 2 vertical hauls at each station were pooled and preserved in 4-ounce jars with a 10% formalin solution buffered with magnesium carbonate. A sample from a diagonal tow of 100 feet in length was also collected from each lake. Preservation was similar to the pooled vertical hauls.

The sediment and lake bottom benthic samples were collected with a messenger operated weighted Ekman dredge (area 225 cm^2). The bottom sample and water was placed in a plastic bucket and diluted. The sample was screened through a Tyler Number 45 testing sieve (mesh size 354 microns). This method does lose some oligochaetes, but hopefully it is not too critical in terms of fish food organisms. The remaining material after washing was transferred to 4-ounce glass jars and preserved in 70% ethanol and glycerin mixture.

A sample of bottom sediments (approximately 3 ounces) was added to a 4-ounce glass jar and formalin added to produce a 15% solution by volume. These samples were collected to investigate the benthic diatoms in the food chain. To date, the results are not available.

Over seventy samples were collected and investigated as a result of the summer 1973 survey. Ekman dredge and plankton samples were taken from ten lakes (3 on the northern route, 7 on the interior route). "Kussat" samples were taken from eleven rivers on the northern pipeline route and Surber samples were taken from nine rivers on the interior pipeline route.

During the winter survey of 1974, Ekman dredge samples were taken from two lakes on both northern and interior routes. Plankton samples were taken from two lakes on the northern route and from five lakes on the interior route. Surber samples were taken from three rivers on the northern route and from five rivers on or near the interior route, all of which were open water areas.

3.2 Sample Analysis

The following sections are descriptions of the methods utilized in the detailed analysis of the samples collected from the Ekman dredge, "Kussat" and Surber samplers, and from the plankton sampler. The processing methods utilized were identical in the analysis of both summer 1973 and winter 1974 survey data.

Where feasible, the total number of organisms in the sample were utilized. However, in the case of half of the plankton haul samples it was necessary to subsample to make counting practical. The macro invertebrates were placed in vials according to Order for later speciation, counting and dry weight estimation. A species collection was made for return to Vancouver, and all results were collected and tabulated.

3.2.1 Ekman Dredge Samples

Each sample was placed in a large enamel tray with a moderate quantity of water, and painstakingly cleared of all organisms. These were placed in vials of alcohol according to Order for later speciation, counting and dry weight estimation.

When all the samples had been picked, the organisms from each were speciated and counted, the species being assigned using the literature listed at the end of this account. Whenever a new species was encountered an example was placed in a labelled vial for the species collection. Since photographing Chironomid larvae would be of limited help taxonomically, they were treated and mounted in the following manner:

each was individually digested overnight in 1 N potassium hydroxide, then passed through solutions of 100% alcohol and pure xylene, a few minutes in each will suffice. The larvae were then placed in a microscope slide, orientated so as to show all the relevant taxonomic features and mounted in a Permount medium.

When all the samples had been treated in the above fashion it was possible to determine the dry weights of the organisms. It must be remembered that after drying the organisms will be useless for any sort of identification, so the dry weight determination must be the last operation. The organisms were placed in aluminium weighing dishes according to Families and then dried in an oven at $60^{o}C$ for 18 hours. The dishes were removed, allowed to equilibrate with room temperature, then weighed with and without the carcasses. The difference in values gives the dry weight. The results are tabulated with Families against collection sites.

3.2.2 "Kussat" and Surber Samples

The methods used were the same as for the dredge samples. It must be noted that all Mollusca were weighed <u>with</u> their shells and the Trichoptera larvae were weighed <u>with</u> their cases except where indicated. The results were tabulated in a similar fashion.

3.2.3 Plankton Samples

Half of these samples were counted in total, the other half were large enough to require subsampling. This was done by making the sample up to a known volume, say 100 cc, with alcohol and then removing a certain percentage, say 10 cc, the volume removed being dependent on the size of the sample. The removal was carried out using a syringe with the needle attachment cut off at the base. If necessary the volume of liquid with the subsample can be reduced using a wide-mouthed pipette with 80μ gauze (#20) secured over the opening. The liquid is sucked up, a small amount released to wash the organisms from the gauze, and the rest discarded.

The sample, or subsample is placed in a plastic petri dish marked off into eight counting sections. Three ml of a 50% mixture of glycerin and alcohol, coloured with a drop of lignin pink, are added to the dish and the alcohol allowed to evaporate overnight. The organisms are now fairly stable in a glycerin/lignin pink medium. Using a dissecting scope they can be counted in the following groups:

(a) Cladocera

Daphnia type (anything resembling the basic Daphnia body shape)

Bosmina type (anything resembling the basic Bosmina body shape)

(b) Copepods

Cyclopoid

Calanoid

Harpacticoid

Nauplii

(c) Ostracods

(d) Occasionally other organisms were found and noted.

The cladocerans were placed in such general groups because the constants for the Pechen formula (Pechen, 1965) relating length to biomass have only been worked out for a few individuals. For use in this formula at least 15 specimens in each group were measured and the lengths averaged. The biomass was then estimated with the following formulae:

Daphnia type $W = 0.052 \times L^{3.012}$

Bosmina type $W = 0.124 \times L^{2.181}$

Copepods $W = 0.055 \times L^{2.73}$

This gives the weight of one specimen in mg. After correcting for any subsampling simple multiplication gives us the biomass of the total sample.

After counting and measuring, the samples were thoroughly examined and all species separated and identified, relative abundance of each species is indicated by +++, ++, +, few or scarce.

3.3 Species Identification

Speciation of organisms collected in the Ekman dredge, "Kussat" and Surber was carried out by using the following references for the particular invertebrate forms indicated.

(a) Chironomidae larvae - all Chironomids were larval forms unless otherwise stated.

Chironominae - Hamilton (1971).

All other Chironomids were taken to subfamily with the key in Hamilton, 1971, and Tanypodinae was keyed to genus.

Further keying of Orthocladinae was attempted where possible using Roback (1957).

(b) Other Diptera - keyed by reference to Usinger (1956).

(c) Mollusca - keyed by reference to Clarke (1973).

(d) Crustacea - keyed by reference to Ward and Whipple (1959).

Speciation of plankton samples was carried out by referring to Ward and Whipple (1959), Brooks (1957), and Ray Society (1933).

To determine the biomass of plankton samples, reference was made to Pechen (1965).

4. Results

The organization of the results are presented in three sections in the following sequence; Ekman dredge samples, Surber and "Kussat" samples, and plankton samples.

Within each section, a species list of invertebrates found in the samples, a summary of the results of the summer 1973 survey, and a summary of the results of the winter 1974 survey are given. The detailed results of the organisms collected in each individual sample by the various sampling methods is given in the Appendices.

4.1 Ekman Dredge Samples

A species list of the invertebrates collected from lakes during the summer 1973 and winter 1974 surveys on the northern and interior pipeline routes is shown in Table II.

The results of the analysis of summer 1973 survey samples are tabulated in Tables III and IV, and the results of the winter 1974 survey samples are shown in Tables V and VI.

4.2 "Kussat" and Surber Samples

A species list of the invertebrates collected by "Kussat" and Surber samplers in the summer 1973 survey along both routes is presented in Table VII, and a species list of the invertebrates collected by Surber sampler in winter open water areas on both routes during the winter 1974 survey is presented in Table X.

Results of analysis of the samples collected in the summer 1973 survey are shown in Tables VIII and IX, and from samples collected during the winter 1974 survey in Tables XI and XII.

4.3 Plankton Samples

A species list of plankton sampled during the summer 1973 and winter 1974 surveys, on both routes, is presented in Table XIII.

Results from the analysis of the summer 1973 samples are shown in Tables XIV and XV, and results of the winter 1974 samples are shown in Tables XVI and XVII.

Table II Species list of invertebrates in Ekman dredge samples collected from lakes during summer 1973 and winter 1974 surveys along northern and interior pipeline routes.

DIPTERA
- Chironomidae
  - Chironominae
    - Chironomini
      - *Chironomus* (*Chironomus*) sp1
      - *Chironomus* (*Chironomus*) sp2
      - *Cryptochironomus* sp1
      - *Glyptotendipes* (*Phytotendipes*) sp1
      - *Glyptotendipes* (*Phytotendipes*) sp2
      - *Harnischia* sp1
      - *Kiefferulus* sp1
      - *Microtendipes* sp1
      - *Paratendipes* sp1
      - *Phenopsectra* sp1
      - *Wirthiella* sp1
      - *Wirthiella* sp2
    - Tanytarsini
      - *Cladotanytarsus* sp1
      - *Corynocera* sp1
      - *Micropsectra* (*Paratanytarsus*) sp1
  - Tanypodinae
    - *Procladius* sp1
    - *Procladius* sp2
    - *Procladius* sp3
    - *Procladius* sp4
    - *Procladius* sp5
  - Orthocladinae
    - *Cricotopus* sp1
    - *Hydrobaenus* sp2

(N.B. As the literature on Northern chironomid species is very sketchy it is possible that when keys are compiled the genera of certain individuals will change and others may merge. Taxonomy of chironomid larvae is in a constant state of flux.)

MOLLUSCA
- Pelecypoda
  - *Pisidium* sp (nr. *casertanum*)
  - *Pisidium lilljeborgii*
  - *Pisidium subtruncatum*
  - *Sphaerium rhomboidium*
- Gastropoda
  - *Valvata sincera helicoides*

CRUSTACEA
- Cladocera
  - *Daphnia middendorfiana*
- Copepoda
  - Calanoida
    - *Heterocope septentrionalis*
- Amphipoda
  - *Gammarus lacustris*

Table III Summer 1973. Dry weights of invertebrates collected from Ekman dredge samples along the northern pipeline route.

DRY WEIGHTS of DREDGE SAMPLES

(mgs)

Invertebrate Family	Lake Station	Babbage Lake Lake #1	Cold Lake Lake #2	Book Lake Lake #3
Chironomidae	1	3.4	—	
	2			0.2
Mollusca	1	3.4	11.4	
	2			5.1
Trichoptera	1	—	1.0	—
	2			
Crustacea	1	—	—	
	2			0.6
Cullicidae	1	—	—	—
	2			
TOTAL	1	6.8	12.4	
	2			5.9

Table IV Summer 1973. Dry weights of invertebrates collected from Ekman dredge samples along the interior pipeline route.

DRY WEIGHTS of DREDGE SAMPLES

(mgs)

Invertebrate Family	Lake Station	Lake #4	Vunnut -ulka Lake #5	Lake #6	Lake #7	Chinniet -lui Lake #8	Cadzow Lake #9	Lake #10
Chironomidae	1	0.2	—	—		29.3	28.4	
	2	0.5			0.7	6.3	2.3	2.3
Mollusca	1	0.6	—	4.9	7.5	8.0	144.5	
	2					31.3	1.3	1.4
Trichoptera	1	—	—	—	—	—	—	—
	2							
Crustacea	1	—	—	—	—		1.0	—
	2					0.3		
Cullicidae	1	—	—	—	—	—	—	9.4
	2							
Total	1	0.8	—	4.9	7.5	37.3	172.9	9.4
	2	0.5			0.7	37.9	3.6	3.7

Table V. Winter 1974. Dry weights of invertebrates collected from Ekman Dredge samples along the northern pipeline route.

	Lake#11	Beaufort Sea, ¼ mi. east of Shingle Point
Dry wt. (mgs).	0	0
Invertebrate species	-	1 Tendipedini (decomposed)

Table VI Winter 1974. Dry weights of invertebrates collected from Ekman Dredge samples along the interior pipeline route.

	Lake #7	Lake #8 (Chinneitlui)
Dry wt. (mgs.)	0	0
Invertebrate species	-	-

Table VII Species list of invertebrates collected in "Kussat" and surber samples in rivers along northern and interior pipeline routes in the summer 1973 survey.

DIPTERA
- Chironomidae
  - Orthocladinae
    - *Hydrobaenus* sp1
    - *Hydrobaenus* sp3
    - *Hydrobaenus* sp4
    - *Hydrobaenus* sp5
    - *Hydrobaenus* sp7
    - *Hydrobaenus* sp8
    - *Hydrobaenus* sp9
    - *Smittia* sp1
    - *Eukiefferiella* sp1
    - *Eukiefferiella* sp2
    - *Eukiefferiella* sp3
    - *Eukiefferiella* sp4
    - *Cardiocladius* sp1
    - *Corynoneura* sp1
    - *Corynoneura* sp2
    - *Corynoneura* sp3
  - Tanypodinae
    - Pentaneurini
      - *Natarsia* sp1
  - Diamesinae
    - Diamesini
      - *Pseudodiamesa* sp1
      - *Pseudodiamesa* sp2
      - *Diamesa* sp1
      - *Diamesa* sp2
- Tipulidae
  - *Tipula* sp.
- Simulidae
  - *Simulium* sp1
  - *Simulium* sp2
  - *Prosimulium fulvum*
  - *Cnephia* sp.

PLECOPTERA
- Nemouridae
  - Capniinae
    - *Allocapnia* sp1
  - Taeniopteryginae
    - *Brachyptera* sp1
    - *Brachyptera* sp2
    - *Brachyptera* sp3
  - Nemourinae
    - *Nemoura* sp1
    - *Nemoura* sp2

PLECOPTERA (cont'd....)
Chloroperlidae
Chloroperlinae
Chloroperla sp.

Paraperlinae
Paraperla sp.

EPHEMEROPTERA

Baetidae
Ephemerellinae
Ephemerella sp. (invaria group)

Metrotopinae
Siphloplecton sp.

Baetinae
Pseudocloeon sp.
Baetis sp.
Centroptilum sp.

Heptageniidae
Cinygmula sp.

TICHOPTERA

Brachycentridae
Brachycentrus sp.

Rhyacophilidae
Rhyacophila sp.

CRUSTACEA

Amphipoda
Gammaridae
Synurella sp.

HYDRACARINA

Tyrelliidae
Tyrellia sp.

COLEOPTERA

Dytiscidae
Hydroporinae
Hydroporus sp.

Table VIII Summer 1973. Dry weights of invertebrates collected from samples along the interior pipeline route.

DRY WEIGHTS OF "KUSSAT" SAMPLES (mgs.)

	Craig Creek	Fish Creek	Mal-colm River	Spring River	Crow River	Trail River	Babb-age River	Deep Creek	Walk-ing River	Blow River	Rapid River
Chironomidae	0.2		0.05	0.1	1.3	0.2			1.4		0.5
Simulidae					0.3			0.6	1.2		0.4
Tipulidae				3.3	16.1						
Ephemeroptera		4.5			0.6		0.1	0.1	0.8		1.4
Plecoptera	1.5			0.2	0.3	0.3		0.1	1.2	0.1	0.2
Trichoptera		55.2									
Mollusca											
Crustacea		5.6			0.7	0.5					
Totals	1.7	65.3	0.05	3.6	19.3	1.0	0.1	0.8	4.6	0.1	2.5

Table IX Summer 1973. Dry weights of invertebrates collected from Surber samples along the interior pipeline route.

DRY WEIGHTS OF SURBER SAMPLES (in mgs.)

	Potatoe Creek	Surprise Creek	Schaeffer Creek	Old Crow River	Driftwood River	Rat Indian River	Berry River River	Waters River	Trib. of Rat River
Chironomidae			0.1			0.05		0.8	1.0
Simulidae			0.1						21.0
Tipulidae	7.7	0.2	4.0		0.3			0.3	6.9
Ephemeroptera		1.6	4.8				2.4	1.8	10.9
Plecoptera	1.6		0.1					0.1	0.8
Trichoptera		4.4 (no cases)	23.1				2.8		
Crustacea									0.2
TOTALS	9.3	6.2	32.2	0.0	0.3	0.05	5.2	3.0	40.8

Table X Species list of invertebrates in Surber samples collected in winter 1974 along northern and interior pipeline routes.

DIPTERA
- Tendipedidae
  - Diamesinae
    - Diamesini
      - Pseudodiamesa sp3
      - Pseudodiamesa sp4
  - Orthocladinae
    - Hydrobaenus sp1
    - Hydrobaenus sp2
    - Hydrobaenus sp10
    - Diplocladius sp1
    - Diplocladius sp2
    - Smittia sp1
    - Criotopus sp2
  - Tendipedinae
    - Tanytarsini
      - Micropsectra sp2

PLECOPTERA
- Perlodidae
  - Isoperlinae
    - Isoperta sp
- Nemouridae
  - Capniinae
    - Isocapnia spa
    - Isocapnia spb
  - Nemourinae
    - Nemoura spa
    - Nemoura spb
  - Taeniopteryginae
    - Brachyptera sp (2 species)

EPHEMEROPTERA
- Heptageniidae
  - Arthroplea sp
  - Baetidae
    - Baetinae
      - Centroptilum sp
      - Baetis sp
  - Baetidae
    - Ephemerellinae
      - Ephemerella doddsi
- Trichoptera
  - Limnephilidae
    - Ecclisomyia sp

Table XI Winter 1974. Dry weights of invertebrates collected from Surber samples along the northern pipeline route.

Dry Weights (mgs.)

Invertebrate Groups	Craig Creek	Malcolm River	Fish Creek
Tendipedidae	-	-	-
Rhagionidae	-	-	0.2
Empedidae	-	-	-
Ephemeroptera	-	-	-
Plecoptera	-	0.2	-
Trichoptera	-	-	-
Oligochaetae	-	-	-

Table XII Winter 1974. Dry weights of invertebrates collected from Surber samples along the interior pipeline route.

Dry Weights (mgs.)

Invertebrate Groups	Salmon Fork	Blue Fish River	Fishing Branch River	Miner River
Tendipedidae	12.4	3.0	30.4	-
Rhagionidae	-	2.0	-	0.9
Empedidae	-	-	0.6	-
Ephemeroptera	17.5	0.6	27.6	0.2
Plecoptera	51.8	9.3	13.3	1.5
Trichoptera	-	32.4	4022.8	6.5
Oligochaetae	-	0.4	8.1	-

Table XIII Species list for plankton samples collected on summer 1973 and winter 1974 surveys along the northern and interior pipeline routes.

CRUSTACEA
- Cladocera
  - Eucladocera
    - Chydoroidea
      - Daphnidae
        - *Daphnia middendorfiana*
        - *Daphnia longiremis*
        - *Daphnia ambigua*
        - *Ceriodaphnia pulchella*
      - Chydorinae
        - *Chydorus sphaericus*
      - Bosminidae
        - *Bosmina longirostris*
        - *Eubosmina longispina*
    - Sidoidea
      - Holopedidae
        - *Holopedium gibberum*
- Copepoda
  - Harpacticoida
    - *Atheyella (Mrazekiella) americana*
  - Calanoida
    - Temoridae
      - *Heterocope septentrionalis*
      - *Epischura nevadensis*
    - Diaptomidae
      - *Diaptomus pribilofensis*
  - Cyclopoida
    - *Cyclops scutifer*
    - *Cyclops strenuus*
    - *Mesocyclops inversus*

INSECTA
- Coleoptera
  - Dytiscidae
    - Dytiscinae
      - *Dytiscus* spp

Table XIV Summer 1973. Number and weight of organisms per plankton haul collected from lakes along northern pipeline route.

Lake	organisms/haul	mgs./haul
Lake #1	834.7	105.2031
Lake #2	119.7	1.1169
Lake #3	2758.3	477.5366

Table XV Summer 1973. Number and weight of organisms per plankton haul collected from lakes along interior pipeline route.

Lake	organisms/haul	mgs./haul
Lake #4	223.7	81.7764
Lake #5 (Vunnutulka)	2418.7 (+341n)	245.8276
(Sept. 15, 1973)	128.0	64.4224
Lake #6	820.7	28.7228
Lake #7	9012.3 (+160n)	47.5316
Lake #8 (Chinneitlui)	7969.7	7480.7467
Lake #9 (Cadzow)	3195.3 (+1752n)	199.9662
Lake #10	4714.7	103.5988
	where, n = nauplii	

Table XVI Winter 1974. Number and weight of organisms per plankton haul collected from lakes along northern pipeline route.

Lake	organisms/haul	mgs./haul
Beaufort Sea, ¼ mi. east of Shingle Point	3	.03
Lake #11	65	.29

Table XVII Winter 1974. Number and weight of organisms per plankton haul collected from lakes along interior pipeline route.

Lake	organisms/haul	mgs./haul
Lake #5 (Vunnutulka)	0	0
Lake #7	10	1.013
Lake #8	5	.6875
Lake #9	970	195.81
Lake #10	1180	15.46

5. Discussion

Summer Survey 1973

Before any discussion of the results is possible we must first be aware of the numerous variables involved in the systems we are examining. It is impossible not to compare results from one place to the next, but with such a widespread study we must accept the limitations that go hand in hand with the enormity of the project. Starting on the gross level we have seasonal variation, the melt and the ice-breakup are far from occurring at a set time of year; the gross weather differences that can occur during summers will vary the amount of fauna produced and perhaps the time of maximum production. Minor variations within each locality can also induce high or low yield. Also the time of sampling will directly relate to the amount and type of fauna discovered especially with the species that have a mono-annual reproductive cycle; the time of year that the "bloom" of any particular species occurs will likely differ with such things as the spring melt, the presence or lack of favourable conditions through the summer, etc. Finally we have the limitations of the sampling; with such a small number of samples the area we are examining is a very small percentage of the total area we are attempting to discuss (e.g. two dredge samples from one lake).

All that this forbidding list of negatives is saying is that although these results are valid they are completely flexible to the incorporation of results taken in further years. Ecological conclusions cannot be made from one year's data, merely tentative assumptions.

On general inspection it seems that the inland rivers have a slightly higher yield of fauna than those on the north slope, but the difference is not outstanding (Tables VIII and IX). Two of the inland rivers, Schaeffer Creek and the Tributary of Rat River, and one north slope river, Fish Creek, gave exceptionally high yields. On closer inspection we find that the high yields of Schaeffer Creek and Fish Creek are due to the presence of Trichopteran larvae and pupae whose dry weight is taken with their cases; with the Tributary of Rat River there was an abundance of large Tipulids. So from a food chain and fish nourishment point of view, the biomass results tend to indicate that the rivers of both areas are of equal value. There are those that gave an exceptionally low result, Old Crow River and Rat Indian Creek inland; Babbage River, Blow River and Malcolm River on the north slope.

Looking at the plankton results (Tables XIV and XV), we have high returns from Lake #8 and Lake #9 inland, and Lake #3 on the north slope; but these high returns (weight-wise) are fairly closely related to the percentage of juveniles, especially in Lake #8. So let us take a look at total numbers of organisms in the plankton samples. On a numerical and weight analysis we have an increase in the number of high output lakes within the inland area. We can add Lake #10 and Lake #7 to the two above. Both Lake #8 and Lake #9 have high dredge values too (Tables III and IV), but this is partially due to the presence of high proportions of molluscs (weighed with their shells).

The number of species within one location is very limited, but with only a small number of samples taken these may only be the most common species, with a number of other rare species only showing up with an increase in sampling. The species variation, however, is very great, with little apparent overlap in different locations; in other words, there may be only four species appearing in a "Kussat" sample when all the "Kussat" samples produce over thirty species. How can we explain this anomaly? Essentially it is the same reasoning as above in that with only three samples it is impossible to cover the diversity of microhabitat which is present in any lake or river. Again a large number of samples could well unify the spectra of species within all the localities. In other words it would seem more likely that the species diversity within each locality is very similar and the variation in the results is due to the enormous difficulties involved in carrying out comprehensive sampling in such a vast area and on so many differing localities. Further studies will continue to shed light on the total organisation of these ecosystems for some time to come.

Winter Survey 1974

All the rivers sampled, on both routes, were winter open water areas (Tables XI and XII).

The three rivers sampled on the northern pipeline route seem to support little life during the winter. Two of these rivers, Craig Creek and Malcolm River, possess only a limited fauna during the summer months.

The four rivers sampled on the interior pipeline route support considerable life, mainly those forms which likely have a two-year maturation cycle. No summer data for these rivers is available for comparison.

The majority of the lakes sampled do not seem to support any amount of planktonic or macro invertebrate growth during the winter months (Tables V, VI, XVII and XVII). Only Lake #9 and Lake #10 show any degree of planktonic overwintering and both are situated near the interior pipeline route.

6. Conclusions

The main conclusions from this study may be summarized as follows:

(1) The samples taken are representative only of a point in time and do not accurately reflect the species diversity present or their relative abundances. The results are largely a function of the phenology of the species at the time of sampling.

(2) In terms of food chain production and of fish nourishment the rivers of the northern and interior routes are equal in value during the summer.

(3) During the summer survey it was found that lakes on the interior route have a higher plankton production than those of the northern route. However this result may be an artifact of the time in which the samples were taken.

(4) There appears to be little planktonic or macro invertebrate growth occurring in lakes on both routes during the winter. Only two lakes on the interior route showed evidence of planktonic overwintering and many of the lakes on the northern route were frozen to the bottom.

(5) Of the winter open water areas sampled, rivers of the northern route support little invertebrate life, while those of the interior route supported considerable invertebrate life.

(6) It appears that species diversity within each locality is similar and that the variation in the results is due to the inherent problems of carrying out extensive and comprehensive sampling procedures.

Ecological conclusions on the invertebrates of the northern Yukon cannot be made at this time as much additional data are required.

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Appendix I

Appendix I Invertebrate species collection from the northern Yukon summer 1973 survey.

Vial No.	Species
1.	Valvata Sincera helicoides
2.	Pisidium sp.nr. casertanum
3.	Pisidium lilliborgii
4.	Pisidium subtruncatum
5.	Sphaerium rhomboidium
6.	Hydroptila sp. (Trichoptera)
	1 - 6 species from Dredge samples
7.	Simulium sp.1
8.	Simulium sp.2
9.	Prosimulium
10.	Cnephia sp.
11.	Tipula sp.
12.	Hydrobaenus sp. (pupa)
13.	Brachycentrus sp. (Trichoptera)
14.	Rhyacophila sp. (Trichoptera)
15.	Hydroporus sp. (Coleoptera)
16.	Baetis sp. (Ephemeroptera)
17.	Centroptilum sp. (Ephemeroptera)
18.	Pseudocloeon sp.
19.	Ephemerella sp. (invaria group)
20.	Siphloplecton sp.
21.	Cinygmula sp.
22.	Nemoura sp. 1 (Plecoptera)
23.	Nemoura sp.2
24.	Nemoura sp. (adult)
25.	Allocapnia sp.1

26. *Brachyptera* sp.1

27. *Brachyptera* sp.2

28. *Brachyptera* sp.3

29. *Paraperla* sp.

30. *Synurella* sp. (Amphipoda)

31. *Tyrellia* sp. (Hydracarina)

7 - 31 species from Kussat and Surber samples

Appendix II

Appendix II Invertebrate species collection from the northern Yukon winter 1974 survey.

Vial No.	Species
1.	_Isoperla_ sp.
2.	_Isocapnia_ sp.a
3.	_Isocapnia_ sp.b
4.	_Nemoura_ sp.b
5.	
6.	
7.	
8.	
9.	
10.	
11.	_Arthroplea_ sp.
12.	_Ephemerella_ _doddsi_
13.	_Centroptilum_ sp.
14.	
15.	
16.	
17.	
18.	
19.	
20.	
21.	Tanyderidae
22.	Limnephilidae - _Ecclisomyia_ sp.
23.	Empedidae
24.	Heleidae - _Palpomyia_ sp.
25.	
26.	

27.

28.

29.

30.

31. Pseudodiamesa sp.3

32. Micropsectra sp.2

33. Pseudodiamesa sp.4

34. Diplocladius sp.1

35. Hydrobaenus sp.

36. Hydrobaenus sp.10

37. Criotopus sp.2

Appendix III

Appendix III Summer 1973. Invertebrates from Ekman Dredge samples collected from lakes along both northern and interior pipeline routes.

Northern Route	No.	Dry wt (mgs)
1. LAKE #1		
two halves of two samples July 17th Depth : 13-15 ft. Substrate : large amounts of black detritus.		
Diptera		
Chironomidae		
Chironominae		3.4
Chironomini		
Phenopsectra (Tribelos) sp.1 (larvae)	14	
Tanypodinae		
Procladius sp.1 (nr. culiciformis) Roback '57 (larva)	1	
plus one adult Chironomidae which was not in good enough condition to key; was probably dead when the sample was taken. Similarly with a larger dipteran adult, which appears terrestrial.		
Mollusca		
Pelecypoda		
Sphaeriidae		
Pisidium sp. (not in good enough condition to key)	4	3.4

2. LAKE #2

	No.	Dry wt (mgs)
Sample 1 July 18th Depth : 8 ft. Substrate : sand and light gravel (small sample)		
Diptera		
Chironomidae		
Orthocladinae		
Cricotopus sp.1 (nr. *fugax*) (larva)	1	
Hydrobaenus sp.2 Roback '57 (larva)	1	
Mollusca		
Valvatidae		
Valvata sincera helicoides	5	11.4
Trichoptera		
Hydroptilidae		
Hydroptila sp. (adult)	1	1.0
Sample 2 July 18th Depth : 9 ft. Substrate : sandy (very small sample)		
Only two tubes occupied; larvae were in very poor condition. From the tubes alone the genus was		
Chironominae		
Chironomini		
Paratendipes sp.1	2	

3. LAKE #3

	No.	Dry wt (mgs)
Sample 1 July 19th Depth : 4 ft. Substrate : fine mud with much detritus.		
<u>Diptera</u>		
Chironomidae		
Chironominae		
Chironomini		
<u>Glyptotendipes</u> (<u>Phytotendipes</u>) sp.1 (larva)	1	
Tanypodinae		
<u>Procladius</u> sp.1 (nr. <u>culiciformis</u>) (larvae) Roback '57	3	
Sample 2 July 19th Depth : 6 ft. Substrate : sand and fine clay. (small sample)		
<u>Diptera</u>		
Chironomidae		0.2
Tanypodinae		
<u>Procladius</u> sp.1 (larvae)	4	
<u>Procladius</u> sp.2 (larva)	1	
<u>Mollusca</u>		
Pelecypoda		5.1
Sphaeriidae		
<u>Pisidium</u> <u>lilljeborgii</u> (Clarke '73)	1	
<u>Pisidium</u> sp. (unable to key)	10	
<u>Crustacea</u>		
Cladocera		0.6
<u>Daphnia</u> <u>middendorfiana</u>	4	
Copepoda		
Calanoida		
<u>Heterocope</u> <u>septentrionalis</u>	1	
Conchostraca	2	

Interior Route

1. LAKE #4	No.	Dry wt (mgs)
Sample 1 July 28th Depth : 5 ft. Substrate : fine silt-like clay		
Diptera		
Chironomidae		0.2
Chironominae		
Chironomini		
Microtendipes sp.1	4	
Tanytarsini		
Micropsectra (Paratanytarsus) sp.1	1	
Tanypodinae		
Procladius sp.3		
Mollusca		
Pelecypoda		
Sphaerium rhomboidium (Clarke '73)	2	0.6
Sample 2 July 28th Depth : ? (not marked) Substrate : silt-like clay.		
Diptera		
Chironomidae		0.5
Chironominae		
Chironomini		
Microtendipes sp.1	2	
Tanypodinae		
Procladius sp. 1	1	

2. LAKE #5 (Vunnutulka)

Sample 1
September 15th
Depth : 12 ft.
Substrate : fine mud. (many Paratendipes sp.1 tubes, but all empty)

	No.	Dry wt (mgs)
Diptera		
Chironomidae		
Chironominae		
Tanytarsini		
Cladotanytarsus sp.1	1	

Sample 2
September 15th
Depth : 9 ft.
Substrate : fine black mud and some detritus.

	No.	Dry wt (mgs)
Diptera		
Chironomidae		
Chironominae		
Chironomini		
Harnischia sp.1	1	
Tanytarsini		
Corynocera sp.1	1	
Micropsectra (*Paratanytarsus*) sp.1	1	
Tanypodinae		
Procladius sp.4	1	
Procladius sp.5	1	

3. LAKE #6

two half samples
July 30th
Depth : 6-7 ft.
Substrate : black mud and detritus (large sample but almost totally lacking in life)

	No.	Dry wt (mgs)
<u>Mollusca</u>		
Pelecypoda		
Sphaeriidae		
<u>Sphaerium</u> <u>rhomboidium</u> (Clarke '73)	2	4.9

4. LAKE #7

Sample 1
August 2nd
Depth : ? (not marked)
Substrate : gravel and mud with much detritus.

	No.	Dry wt (mgs)
<u>Diptera</u>		
Chironomidae		
Chironominae		
Chironomini		
<u>Chironomus</u> (<u>Chironomus</u>) sp.2	2	
<u>Mollusca</u>		
Pelecypoda		
Sphaeriidae		
<u>Pisidium</u> sp. (nr. <u>casertanum</u>)	9	7.5

Sample 2
August 2nd
Depth : ? (not marked)
Substrate : gravel and mud, with much detritus.

	No.	Dry wt (mgs)
<u>Diptera</u>		
Chironomidae		0.7
Chironominae		
Chironomini		
<u>Cryptochironomus</u> sp. 1	2	
<u>Chironomus</u> (<u>Chironomus</u>) sp.2	1	
Tanypodinae		
<u>Procladius</u> sp. 3	7	

5. LAKE #8 (Chinneitlui)

Sample 1
August 9th
Depth : 5 ft.
Substrate : coarse sand.

	No.	Dry wt (mgs)
Diptera		
Chironomidae		29.3
Chironominae		
Chironomini		
Chironomus (*Chironomus*) sp.1	54	
Wirthiella sp.2	2	
Mollusca		
Pelecypoda		8.0
Sphaeriidae		
Sphaerium rhomboidium	2	
Pisidium sp. (nr.*casertanum*)	7	

Sample 2
August 9th
Depth : 6 ft.
Substrate : sand and detritus.

	No.	Dry wt (mgs)
Diptera		
Chironomidae		6.3
Chironominae		
Chironomini		
Chironomus (*Chironomus*) sp.1	5	
Wirthiella sp.2	1	
Mollusca		
Pelecypoda		31.3
Sphaeriidae		
Sphaerium rhomboidium	1	
Pisidium sp. (nr.*casertanum*)	7	
Crustacea		
Cladocera		
Daphnia middendorfiana	1	0.3

7. LAKE #9 (Cadzow)

Sample 1
August 12th
Depth : 12 ft.
Substrate : black mud and detritus.

	No.	Dry wt (mgs)
Diptera		
Chironomidae		28.4
Chironominae		
Chironomini		
Wirthiella sp.2	1	
Cryptochironomus sp.1	1	
Paratendipes sp.1 (tube dwelling)	189	
Glyptotendipes (*Phytotendipes*) sp.2	31	
Tanypodinae		
Procladius sp.2	3	
Crustacea		
Amphipoda		1.0
Gammarus lacustris	2	
Copepoda		
Calanoida		
Heterocope septentrionalis	5	
Mollusca		144.5
Gastropoda		
Valvatidae		
Valvata helicoides	1	
Pelecypoda		
Sphaeriidae		
Pisidium sp. (nr. *casertanum*)	45	
Pisidium subtruncatum	1	
Sphaerium rhomboidium	2	

Sample 2
August 12th
Depth : 13 ft.
Substrate : black mud and some detritus.

	No.	Dry wt (mgs)
Diptera		
Chironomidae		2.3
Chironominae		
Chironomini		
Cryptochironomus sp.1	1	
Microtendipes sp.1		

	No.	Dry wt (mgs)
Mollusca		
Pelecypoda		1.3
Sphaeriidae		
Sphaerium rhomboidium	1	
Pisidium subtruncatum	2	

8. LAKE #10

Sample 1
August 13th
Depth : 15 ft.
Substrate : brown mud and much detritus.

Diptera		
Chironomidae		9.4
Chironominae		
Chironomini		
Kiefferulus sp.1	2	
Wirthiella sp.1	1	
Culicidae		
Chaoborinae		
Chaoborus sp.	54	

Sample 2
August 13th
Depth : ? (not marked)
Substrate : coarse black mud and much detritus.

Diptera		
Chironomidae		2.3
Chironominae		
Chironomini		
Kiefferulus sp.1	5	
Tanypodinae		
Procladius sp.1	1	
Mollusca		
Pelecypoda		1.4
Sphaeriidae		
Pisidium sp. (nr. *casertanum*)	1	
Pisidium subtruncatum	1	

Appendix IV

Appendix IV Number of invertebrates collected from Ekman dredge samples from lakes along both northern and interior pipeline routes, Winter 1974.

Northern Route	No.	Dry wt (mgs)

1. LAKE #11

   April 3rd, 1974

   Nothing

2. BEAUFORT SEA, ¼ mi. East of Shingle Point

   March 30th, 1974

	No.	Dry wt (mgs)
Diptera		
Tendipedidae		
Tendipedinae		
Tendipedini (Decomposed)	1	

Interior Route

1. LAKE #8

   March 18th, 1974 18:00 hrs.

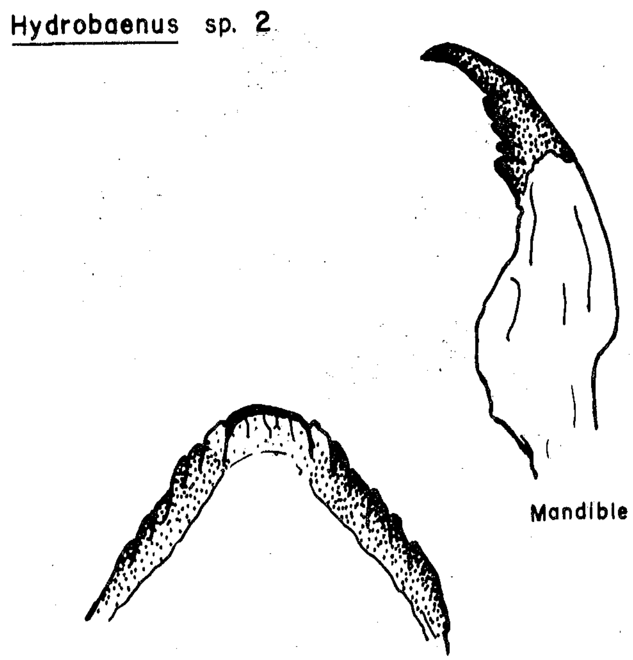
   Nothing

2. LAKE #7

   March 18th, 1974 13:00 hrs.

   Nothing.

Appendix V Morphological characteristics of Chironomid species collected from Ekman dredge samples during summer 1973 and winter 1974 surveys from lakes along both northern and interior pipeline routes.

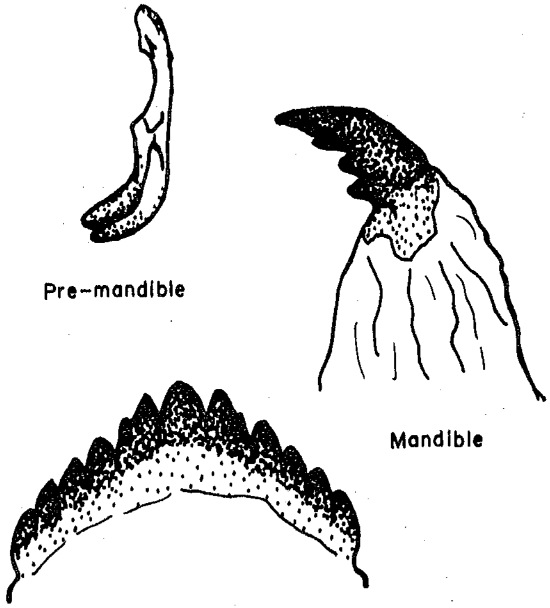


Orthocladinae

Hydrobaenus sp.2

Hypostomial Plate :	13 teeth, median tooth broad and flat. median and first laterals light brown, the whole plate pyramid-shaped. No stellate lateral hairs.
Mandibles :	slim with a long apical tooth, four laterals, all dark, no pre-apical comb.
Premandibles :	simple and dark.
Antennae :	blade up to middle of fifth segment.

Cricotopus sp. l



Cricotopus sp.1

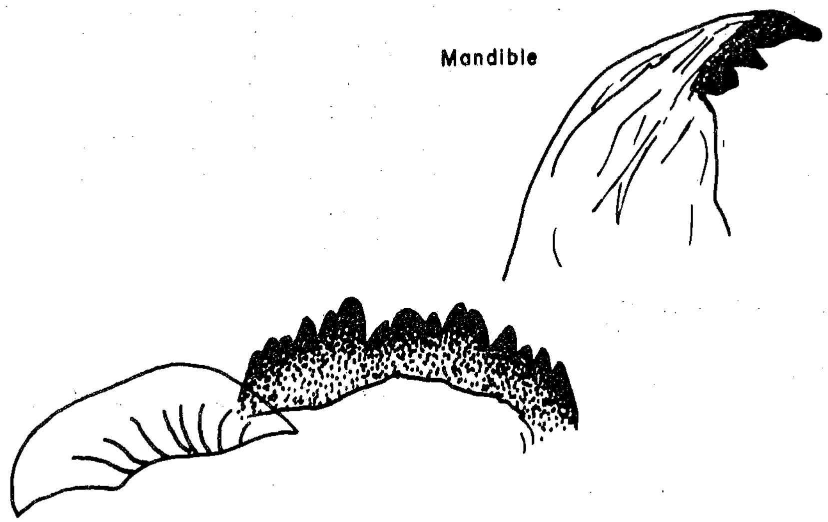
Hypostomial Plate : 11 dark teeth, first laterals notched.

Mandibles : fairly stout, apical tooth fairly short, three heavy black laterals; outside edge crenulated, comb absent, brush from one main stem with seven simple, unilateral branches.

Premandibles : bifid, outer blade slimmer than inner.

Antennae : very short, blade reaches tip of fifth segment.
ratio : 38:9:5:3:2.

Tendipes (Tendipes) sp. 1
Chironomus (Chironomus) sp. 1



Paralabial and Hypostomial Plates

Chironominae

Chironomini   Chironomus (Chironomus) sp.1

Hypostomial Plate : 13 teeth, all dark, median tooth trifid, first laterals large.

Paralabial Plate : 3 times as long as broad, tips of median apices pointing backwards.

Mandibles : stout, two large, black, pear-shaped lateral teeth; light dorso-mesal tooth; comb made up of ten bristles; brush reduced.

Epipharyngeal Pecten : with 16 teeth.

Antennae : ratio : 45:14:4:6:1 blade to middle of 4th. segment.

<u>Chironomus</u> (<u>Chironomus</u>) sp.2

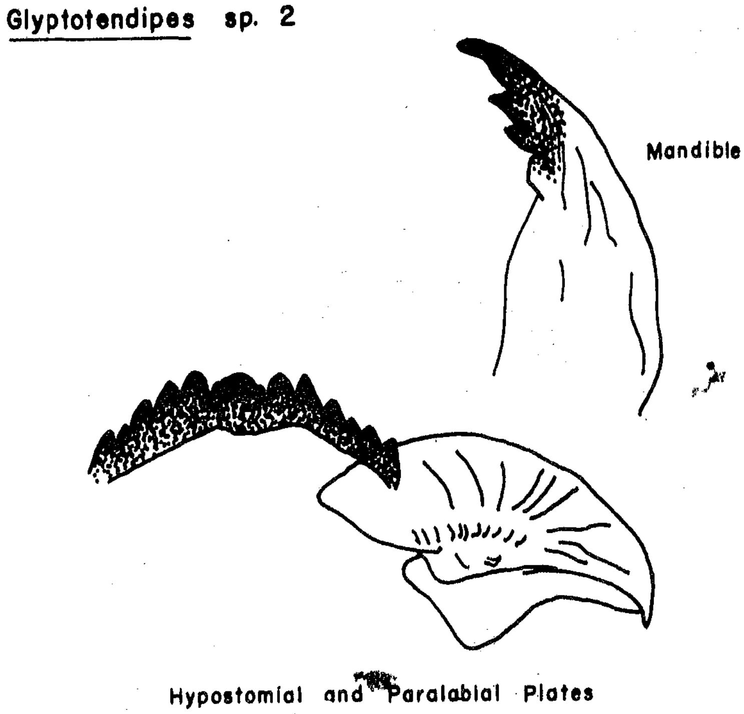
Hypostomial Plate :	15 teeth, first laterals reduced, second laterals large.
Paralabial Plate :	2.5 times as long as broad, tip of median apices pointed backwards.
Mandibles :	stout, three large, dark, pear-shaped lateral teeth, lighter dorso-mesal tooth; pre-apical comb only 3-4 bristles, brush is large and complex : 4 main branches; the posterior two breaking up into many small branches.
Epipharyngeal Pecten :	with 18-20 teeth.
Antennae :	ratio : 65:18:4:5:2 blade to middle of 4th. segment.

Glyptotendipes sp. I

Chironomini

Glyptotendipes (Phytotendipes) sp.1

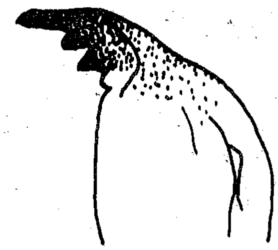
Hypostomial Plate :	13 teeth, median tooth slightly notched laterally, 6th. lateral pointing away from centre.
Paralabial Plate :	nearly 4 times as long as broad.
Mandible :	heavy, 2 dark laterals, one light. light dorso-mesal tooth.
Pre-mandibles :	bifid, inner blade finer and shorter than outer.
Labrum :	with a pair of palmate bristles.
Antennae :	ratio: 40:14:12:9:2.



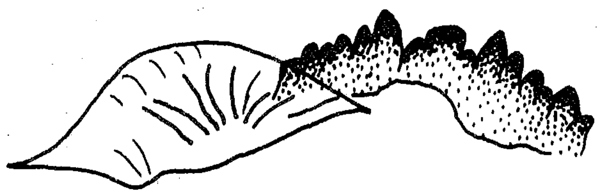
Glyptotendipes (Phytotendipes) sp.2 (tube dwelling)

Hypostomial Plate :	13 teeth, broad recessed middle tooth only slightly lighter than laterals, laterals 1 and 2 large.
Paralabial Plate :	1.5 times as long as broad.
Mandible :	slender, long apical tooth, 2 dark laterals, one lighter, long, light dorso-mesal tooth. Pre-apical comb with ten bifurcate bristles.
Antennae :	ratio: 22:9:7:5:1.

Kiefferulus sp. I



Mandible



Paralabial and Hypostomial Plates

Chironomini

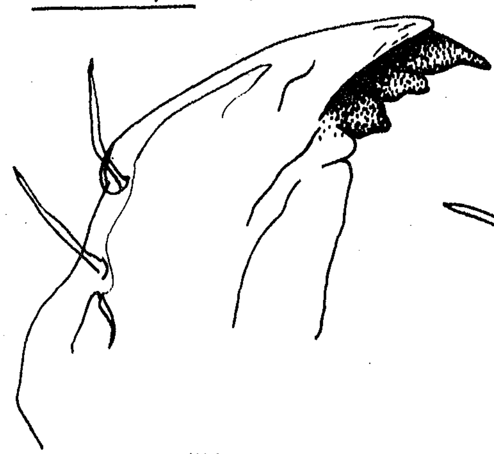
Kiefferulus sp.1 (very similar to Chironomus (Chironomus) sp.1 and 2)
(only one pair of ventral gills)

Hypostomial Plate : 13 teeth, median tooth recessed, dark and strongly trifid, 4th. lateral small.

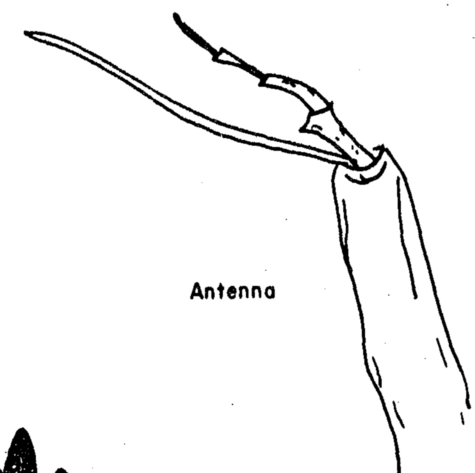
Mandible : only 2 dark lateral teeth, the complex brush is the same.

Pre-mandibles : 4 blades.

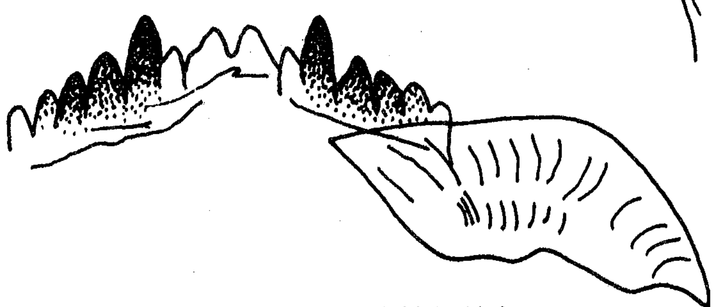
Paratendipes sp. I



Mandible



Antenna

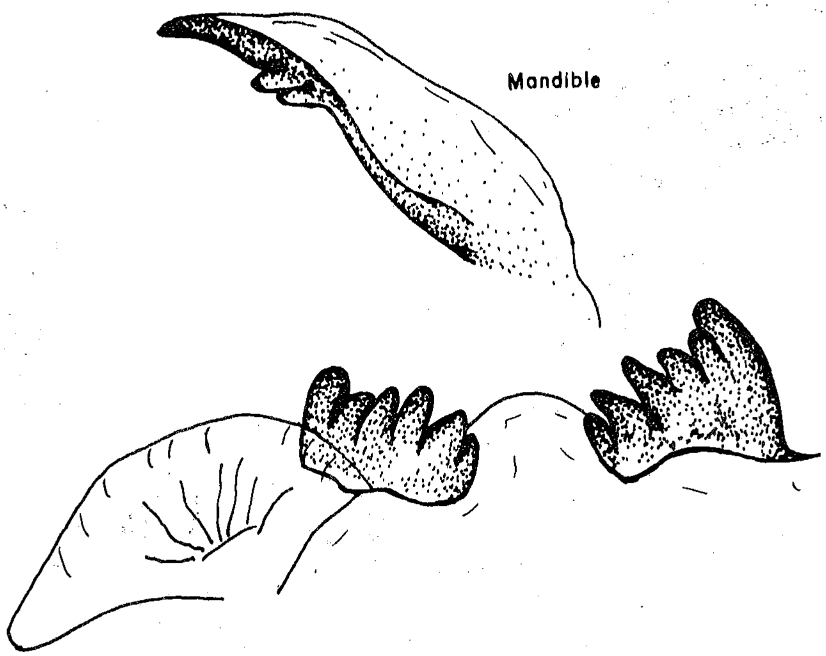


Hypostomial and Paralabial Plates

Paratendipes sp.1

Hypostomial Plate :	14 teeth, all light brown, median teeth lighter and sharp, 2nd. lateral large, no caudo-lateral bristles.
Mandibles :	fairly heavy, apical tooth short and light brown, 3 light brown laterals, 1 light dorso-mesal.
Pre-mandibles :	bifurcate, short broad blades.
Antennae :	ratio: 35:9:8:7:6:2 blade extending beyond the last five segments, segment 2 expended distally, segment 3 sinuate.

Cryptochironomus sp. I

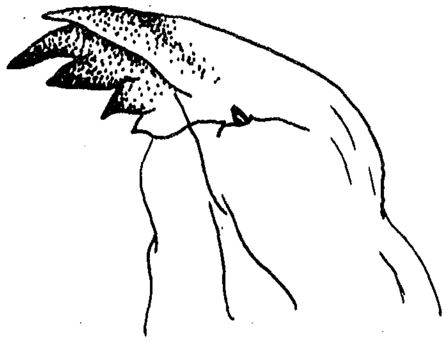


Paralabial and Hypostomial Plates

Cryptochironomus sp.1

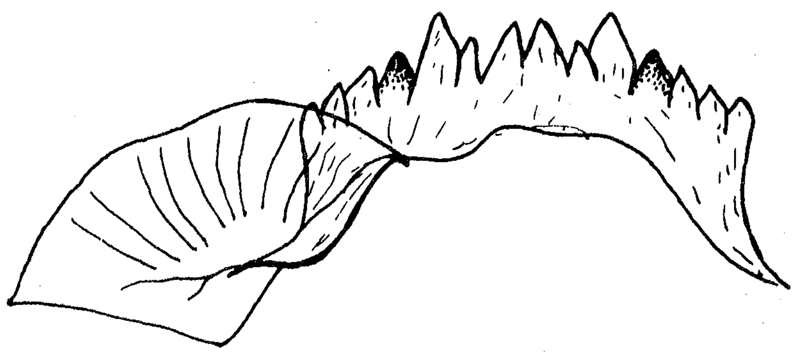
Hypostomial Plate :	broad light median tooth, 5 dark laterals in forward curving arc.
Mandibles :	fairly slender , long dark apical tooth 3 times the width of the lighter laterals-two of.
Maxillary palpus :	3 times as long as wide.
Antennae :	ratio: 22:12:8 for the first 3 segments.
Pre-mandibles:	with 5 blades

Microtendipes sp. I



Mandible

Pre-mandible



Paralabial and Hypostomial Plates

Chironomini

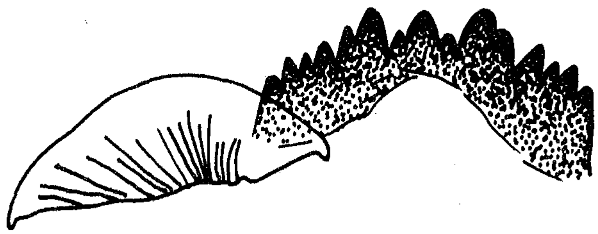
Microtendipes sp.1

Hypostomial Plate :	14 teeth, medians light and pointed, 2nd. lateral large, only slight curve.
Mandible :	medium length dark apical tooth, twice as long as width of dark laterals, two of. Long light dorso-mesal tooth, comb consists of 10 simple bristles, brush is many-branched from 3 main trunks.
Pre-mandibles :	bifid, both blades stout.
Labrum :	18 long sense bristles present.

<u>Wirthiella</u> sp.1 (previously found only in California)

Hypostomial Plate :	15 teeth, median tooth medially and strongly notched, median and small first laterals recessed large 2nd. laterals, small 5th. lateral.
Mandible :	stout, apical tooth and 2 large laterals almost pear-shaped, dark, light dorso-mesal tooth, comb with 8 bristles, brush many-branched.
Pre-mandibles :	bifid, slender blades, outer longer than inner.
Labrum :	2 palmate spines present.
Antennae :	ratio : 36:13:4:6:2, blade reaches to middle of 4th. segment.

Wirthiella sp. 2

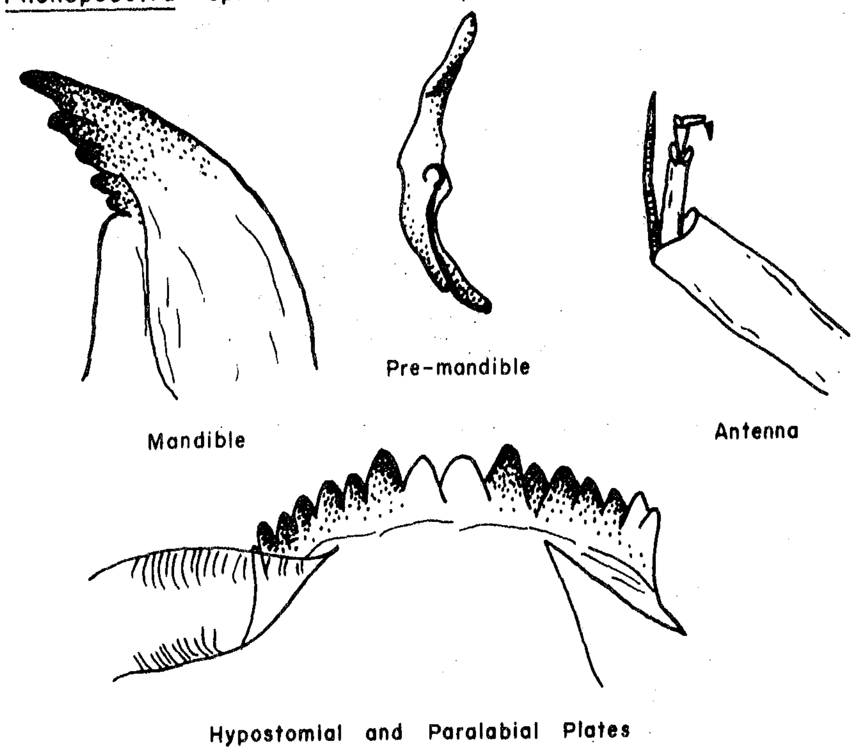


Paralabial and Hypostomial Plates

Wirthiella sp.2 (no ventral gills)

Hypostomial Plate :	13 teeth, median tooth distinctly trifid, reduced 4th. lateral.
Paralabial Plate :	nearly three times as long as broad, tips of median apices pointing backwards.
Mandibles :	very heavy, 3 stout pear-shaped laterals, two dark, one light, comb present, many-branched brush.
Pre-mandibles :	bifid, outer blade longer and slimmer than inner.

Phenopsectra sp. I



Chironomini

Phenopsectra sp.1 nr. (Tribelos) jucundus. (Roback '57)

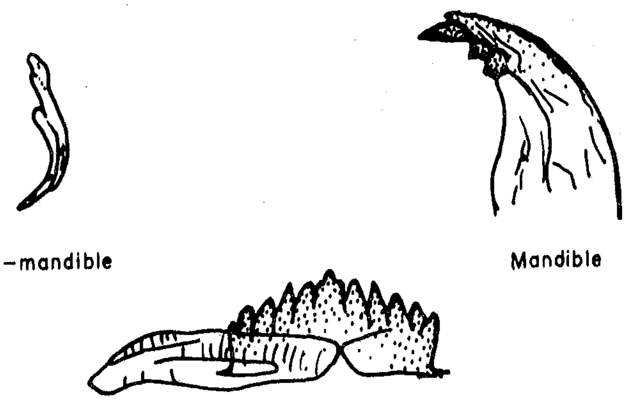
Hypostomial Plate : 16 teeth, 2nd. laterals large, 7th. lateral small and light.

Paralabial Plates : elongate, 4 times as long as broad.

Mandibles : stout, short toothed region, 4 dark laterals, comb and brush present.

Antennae : ratio: 25:8:4:3:2, blade longer than remaining four segments.

Micropsectra (Paratanytarsus) sp. I



Paralabial and Hypostomial Plates

Tanytarsini

Micropsectra (Paratanytarsus) sp.1

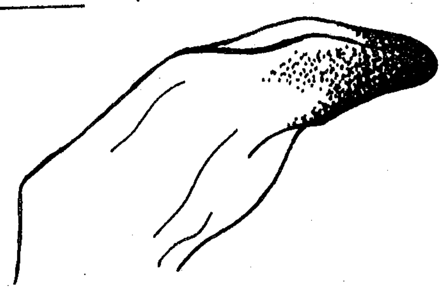
Hypostomial Plate :	11 teeth fairly light, median tooth lightest and laterally notched, pointed on top.
Paralabial Plates :	join at mid-line, blunt at inner apices.
Mandibles :	fairly slender, light apical and 2 small light lateral teeth, long slender accessory tooth.
Antennae :	ratio: 48:18:5:3:1, lauterborn organs and petioles extremely long.

Tanytarsini

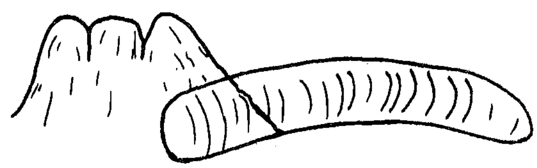
Cladotanytarsus sp.1

Hypostomial Plate :	11 teeth, uniformly brown, median tooth truncate.
Paralabial Plates :	almost meet at centre line, inner apices blunt.
Mandibles :	stout with brown teeth, 3 laterals, one dorso-mesal.

Corynocera sp. I



Mandible



Hypostomial and Paralabial Plates

Corynocera sp.1

Hypostomial Plate :	only 3 light teeth visible, median broadest, all rounded;
Paralabial Plates :	almost meet at centre line, inner apices blunt.
Mandibles :	apical and lateral teeth bonded to form a plate, simple brush present.
Labrum :	two groups of four sense bristles and two pairs of spines present.

<u>Tanypodinae</u>

<u>Procladius</u>	(keying to species seems to depend on the structure of the superlingua (paraglossa))
<u>Procladius</u> sp.1	(nr. culiciformis (Roback '57))
Superlingua :	long apical spine, 1 spine inside, 3-4 outside.
<u>Procladius</u> sp.2	
Superlingua :	long apical spine, 2 spines inside, 4 outside.
<u>Procladius</u> sp.3	(nr. <u>adumbratus</u> (Roback '57))
Superlingua :	short apical spine, 1 spine inside, 3 outside.
<u>Procladius</u> sp.4	
Superlingua :	long apical spine, 1 spine inside, 7 outside.
<u>Procladius</u> sp.5	
Superlingua :	short apical spine, 2 spines inside, 4 outside.

Appendix VI

Appendix VI Summer 1973. Numbers and dry weights of invertebrates collected from "Kussat" samples from rivers along the northern pipeline route.

1. CRAIG CREEK

3 samples
Crossing site
July 7, 1973
15:15 hrs.

	No.	Dry wt (mgs)
Diptera		
Chironomidae		0.2
Orthocladinae		
Hydrobaenus sp.4	6	
Hydrobaenus sp.5	3	
Diamesinae		
Diamesini		
Pseudodiamesa sp.1	8	
Simulidae larva	1	
Plecoptera		1.5
Nemouridae		
Taeniopteryginae		
Brachyptera sp.1	28	
Brachyptera sp.2	10	
Nemourinae		
Nemoura sp. (adult)	1	

2. FISH CREEK

3 samples
Crossing site
July 8, 1973
12:30 hrs.

	No.	Dry wt (mgs)
Diptera		
Chironomidae		
Orthocladinae		
Eukiefferiella sp.1	2	
Ephemeroptera		
Heptageniidae	4	4.5
(1 sub-imago, 3 nymphs, too damaged to key further)		
Trichoptera		
(1 pupa with case made of tiny stones)	1	55.2
Amphipoda		
Gammaridae		
Synurella sp.1	76	5.6

3. MALCOLM RIVER

3 samples
Crossing site
July 7, 1973
15:30 hrs.

	No.	Dry wt (mgs)
Diptera		
Chironomidae		
Orthocladinae		
Hydrobaenus sp.1	1	0.05

	No.	Dry wt (mgs)
4. FIRTH RIVER		
4 samples Crossing site July 22nd, 1973 13:00 hrs.		
Plecoptera		
Nemouridae		
Taeniopteryginae		
Brachyptera sp.1	1	
5. SPRING RIVER		
Crossing site July 5th, 1973		
Diptera		
Tipulidae		
Tipula sp.1	3	3.3
Chironomidae		0.1
Orthocladinae		
Hydrobaenus sp.3	1	
Cardiocladius sp.1	4	
Plecoptera		
Nemouridae		
Capniinae		
Allocapnia sp.1	2	0.2

6. CROW RIVER

3 samples
July 9th, 1973
19:00 hrs.

			No.	Dry wt (mgs)
Diptera				
Tipulidae		Tipula sp.	3	16.1
Simulidae		larvae	5	0.3
Chironomidae				1.3
	Diamesinae			
	+ two pupae	Pseudodiamesa sp.2	4	
	Orthocladinae			
		Hydrobaenus sp.4	5	
		Hydrobaenus sp.7	5	
		Hydrobaenus sp.8	1	
		Eukiefferiella sp.2	24	
		Eukiefferiella sp.3	1	
		Smittia sp.1	24	
		Corynoneura sp.1	6	
Amphipoda				
Gammaridae				
		Synurella sp.1	4	0.7
Plecoptera				
Nemouridae				0.3
	Nemourinae			
		Nemoura sp.	2	
	Taeniopteryginae			
		Brachyptera sp.3	2	
Ephemeroptera				0.6
Baetidae				
	Baetinae			
		Pseudocloeon sp.	32	
Heptageniidae				
		Cinygmula sp.	1	

7. TRAIL RIVER

3 samples
Crossing site
July 5th, 1973
13:00 hrs.

		No.	Dry wt (mgs)
Diptera			
Chironomidae			0.2
Tanypodinae			
Pentaneurini			
	Natarsia sp.1	3	
Orthocladinae			
	Smittia sp.1	1	
	Hydrobaenus sp.1	1	
Plecoptera			
Nemouridae			
Capniinae			
	Allocapnia sp.1	1	0.3
Coleoptera			
Dytiscidae			
Hydroporinae			
	Hydroporus sp.1	1	
Amphipoda			
Gammaridae			
	Synurella sp.1	9	0.5

8. BABBAGE RIVER

3 samples
Crossing site
July 10th, 1973
14:00 hrs.

		No.	Dry wt (mgs)
Diptera			
Chironomidae			
Orthocladinae			
	Eukiefferiella sp.4	1	
Ephemeroptera			
Heptageniidae			
	Cinygmula sp.	2	0.1

9. DEEP CREEK

3 samples
Crossing site
July 11th, 1973
14:00 hrs.

		No.	Dry wt (mgs)
<u>Diptera</u>			
Simulidae			
	larva	1	0.6
<u>Plecoptera</u>			
Nemouridae			
Taeniopteryginae			
	Brachyptera sp.3	1	0.1
<u>Ephemeroptera</u>			0.1
Baetidae			
Baetinae			
	Baetis sp.	1	
	Pseudocloeon sp.	1	

10. WALKING RIVER

3 samples
Crossing site
July 12th, 1973
14:00 hrs.

		No.	Dry wt (mgs)
Diptera			
Simulidae			1.2
	larvae	10	
	Simulium sp.1 (pupa)	1	
	Simulium sp.2 (pupa)	1	
Chironomidae			1.4
Orthocladinae			
	Hydrobaenus sp.1	3	
	Hydrobaenus sp.4	1	
	Corynoneura sp.2	3	
	Corynoneura sp.3	1	
	Eukiefferiella sp.3	1	
+ 1 pupa			
Plecoptera			
Nemouridae			1.2
Taeniopteryginae			
	Brachyptera sp.1	4	
Nemourinae			
	Nemoura sp.1	2	
	Nemoura sp.2	1	
Ephemeroptera			
Baetidae			
Baetinae			
	Baetis sp.	6	0.8

11. BLOW RIVER

5 samples
Crossing site
July 13th, 1973
17:45 hrs.

		No.	Dry wt (mgs)
Diptera			
Chironomidae			0.5
Orthocladinae			
	Hydrobaenus sp. 1	1	
	Hydrobaenus sp. 3	1	
+ 1 terrestrial adult			
Plecoptera			
Nemouridae			
Nemourinae			
	Nemoura sp.1	1	0.1

12. RAPID RIVER

3 samples
Crossing site
July 14th, 1973
22:00 hrs.

			No.	Dry wt (mgs)
Diptera				
Simulidae		larvae	2	0.4
Chironomidae				0.5
	Orthocladinae			
		Smittia sp.1	16	
		Hydrobaenus sp.1	1	
		Hydrobaenus sp.4	1	
		Hydrobaenus sp. (pupa)	1	
Plecoptera				
Nemouridae				0.2
	Taeniopteryginae			
		Brachyptera sp.1	2	
		Brachyptera sp.2	2	
Ephemeroptera				1.4
Heptageniidae				
		Cinygmula sp.	4	
Baetidae				
	Baetinae			
		Pseudocloeon sp.	19	

Appendix VII

Appendix VII Summer 1973. Numbers and dry weights of invertebrates collected from Surber samples from rivers along the interior pipeline route.

			No.	Dry wt (mgs)
1. POTATO CREEK				
4 samples Downstream of Crossing site July 27th 16:30 hrs.				
Diptera				
	Tipulidae	*Tipula* sp.	25	7.7
Plecoptera				
	Nemouridae Nemourinae	*Nemoura* sp.1	15	1.6
2. SURPRISE CREEK				
3 samples Crossing site July 27th 19:00 hrs.				
Diptera				
	Tipulidae	*Tipula* sp.	2	0.2
Ephemeroptera				1.6
	Baetidae Metrotopinae	*Siphloplecton* sp.	2	
	Baetinae	*Pseudocloeon* sp.	5	
		Baetis sp.	3	
	Heptageniidae	*Cinygmula* sp.	9	
Trichoptera				
	Brachycentridae (no cases)	*Brachycentrus*	5	4.4

3. SCHAEFFER CREEK

3 samples
Half a mile up from Crossing site
July 27th
20:00 hrs.

Taxon	Genus	No.	Dry wt (mgs)
Diptera			
Tipulidae			
	Tipula sp.	6	4.0
Simulidae			
	larva	1	0.1
Chironomidae			0.1
Tanypodinae			
Pentaneurini			
	Natarsia sp.	1	
Orthocladinae			
	Hydrobaenus sp. (pupa)	1	
(1 other pupa, could not key)			
Plecoptera			
Chloroperlidae			
Chloroperlinae			
	Chloroperla sp.	1	0.1
Ephemeroptera			4.8
Baetidae			
Metrotopinae			
	Siphloplecton sp.	1	
Baetinae			
	Centroptilum sp.	33	
	Pseudocloeon sp.	7	
Heptageniidae			
	Cinygmula sp.	20	
Trichoptera			
Brachycentridae			
	Brachycentrus sp.	9	23.1
Hydracarina			
Tyrelliidae			
	Tyrellia sp.	1	

	No.	Dry wt (mgs)
4. OLD CROW RIVER		
6 samples Crossing site July 28th 15:00 hrs.		
No organisms were found in these samples.		
5. DRIFTWOOD RIVER		
4 samples Crossing site July 30th 23:00 hrs.		
Diptera		
Tipulidae		
Tipula sp.	1	0.3
+ 1 terrestrial adult		0.2
6. RAT INDIAN RIVER		
3 samples Half a mile above Crossing site July 31st 14:00 hrs.		
Diptera		
Chironomidae		
Orthocladinae		
Hydrobaenus sp.1	1	
+ 3 terrestrial adults		1.1

7. WATERS RIVER

3 samples
Crossing site
July 31st
18:00 hrs.

Taxon	Species	No.	Dry wt (mgs)
Diptera			
Tipulidae			
	Tipula sp.	3	0.3
Chironomidae			
Orthocladinae			
	Hydrobaenus sp.4	6	
	Hydrobaenus sp.9	7	
	Cardiocladius sp.1	3	
Ephemeroptera			1.8
Baetidae			
Baetinae			
	Pseudocloeon sp.	10	
Haptageniidae			
	Cinygmula sp.	3	
Plecoptera			
Chloroperlidae			
Paraperlinae			
	Paraperla sp.	1	0.1

8. BERRY RIVER		No.	Dry wt (mgs)
5 samples Crossing site July 31st 16:00 hrs.			
Diptera			
Chironomidae			
Orthocladinae			
	Hydrobaenus sp.9	1	
(+ 1 chironomid adult, cannot key.			0.4
(+ 1 terrestrial adult.			
Ephemeroptera			2.4
Baetidae			
Metrotropinae			
	Siphloplecton sp.	3	
Ephemerellinae			
	Ephemerella sp. (invaria group)	1	
Trichoptera			2.8
Lepidostomatidae			
	Lepidostoma sp.	2	
Rhyacophilidae			
	Rhyacophila sp.	2	

9. TRIBUTARY OF RAT RIVER		No.	Dry wt (mgs)
5 samples Crossing site August 2nd 21:00 hrs.			
Diptera			
Simulidae			21.0
	larvae (at least 3 species)	113	
	Prosimulium fulvum (pupae) or *hirtipes*	2	
	Cnephia sp. (pupae)	2	
Tipulidae			6.9
	Tipula sp.	1	
Chironomidae			1.0
Orthocladinae			
	Hydrobaenus sp.1	1	
	Hydrobaenus sp.9	3	
+ 5 pupae, 1 species, cannot key due to lack of respiratory organs.			
Diamesinae			
Diamesini			
	Diamesa sp.1	3	
	Diamesa sp.2	4	
+ adults			
	Diamesa sp.	5	
Plecoptera			0.8
Nemouridae			
Taeniopteryginae			
	Brachyptera sp.2	15	
Nemourinae			
	Nemoura sp.	1	
Ephemeroptera			10.9
Baetidae			
Baetinae			
	Baetis sp.	105	
	Pseudocloeon sp.	9	
Heptageniidae			
	Cinygmula sp.	16	
Amphipoda			
Gammaridae			
	Synurella sp.	5	0.2

<u>Hydracarina</u>
Tyrelliidae

Tyrellia sp.	5

Appendix VIII

Appendix VIII Winter 1974. Numbers and dry weights of invertebrates collected from Surber samples of open water areas on rivers along both northern and interior pipeline routes.

Northern Route

1. CRAIG CREEK

March 23, 1974
16:00 hrs.

		No.	Dry wt (mgs)
Diptera			
Tendipedidae (weight below balance sensitivity)			
Orthocladinae			
	Diplocladius sp.2	5	
	Hydrobaenus sp.	2	
	Smittia sp.1	2	

2. FISH CREEK

March 25, 1974
16:00 hrs.

		No.	Dry wt (mgs)
Diptera			
Rhagionidae			10.0002
Tendipedidae (weight below sensitivity of balance)			
Orthocladiane			
	Cricotopus sp.2	12	
	Hydrobaenus sp.1	7	
+ Oligochaetae		1	
Turbellaria		2	

3. MALCOLM RIVER

March 24, 1974
14:30 hrs.

		No.	Dry wt. (mgs)
<u>Plecoptera</u>			0.0002
Nemouridae			
Taeniopteryginae			
	<u>Brachyptera</u> sp.	1	
Nemourinae			
	<u>Nemoura</u> sp.	1	
<u>Ephemeroptera</u>			
Heptageniidae (damaged)		1	
<u>Diptera</u>			
Tendipedidae			
Diamesinae			
	<u>Pseudodiamesa</u> sp.3	1	

Interior Route

1. BLUE FISH RIVER

2 samples
March 20, 1974
11:00 hrs.

		No.	Dry wt (mgs)
Plecoptera			0.0093
Nemouridae			
Capniinae			
	Isocapnia sp.b	15	
Taeniopteryginae			
	Brachyptera sp.	13	
	Brachyptera sp.	3	
+ Damaged		3	
Ephemeroptera			0.0006
Baetidae			
Baetinae			
	Baetis sp.	6	
Trichoptera			
Limnephilidae			0.0324
	Ecclisomyia sp.	1	
Diptera			
Rhagionidae		3	0.0020
Tendipedidae			0.0030
Diamesinae			
Diamesini			
	Pseudodiamesa sp.3	7	
	Pseudodiamesa sp.4	2	
Orthocladinae			
	Diplocladius sp.1	6	
	Hydrobaenus sp.2	25	
Tendipedinae			
Tanytarsini			
	Micropsectra sp.2	1	
+ 6 Oligochaetae			0.0004

2. SALMON FORK

2 samples
March 20, 1974
12:00 hrs.

		No.	Dry wt (mgs)
Plecoptera			0.0518
Perlodidae			
Isoperlinae			
	Isoperla sp.	6	
Nemouridae			
Capniinae			
	Isocapnia sp.a	3	
	Isocapnia sp.b	23	
+ 2 immatures			
Ephemeroptera			0.0175
Heptageniidae			
	Arthroplea sp.	14	
	immatures	67	
Baetidae			
	Centroptilum sp.	17	
Diptera			0.0124
Tendipedidae			
Diamesinae			
Diamesini			
	Pseudodiamesa sp.3	11	
	Pseudodiamesa sp.4	19	
Tendipedinae			
Tanytarsini			
	Micropsectra sp.2	7	
Orthocladinae			
	Hydrobaenus sp.2	2	

+ 1 Oligochaetae

3. FISHING BRANCH RIVER

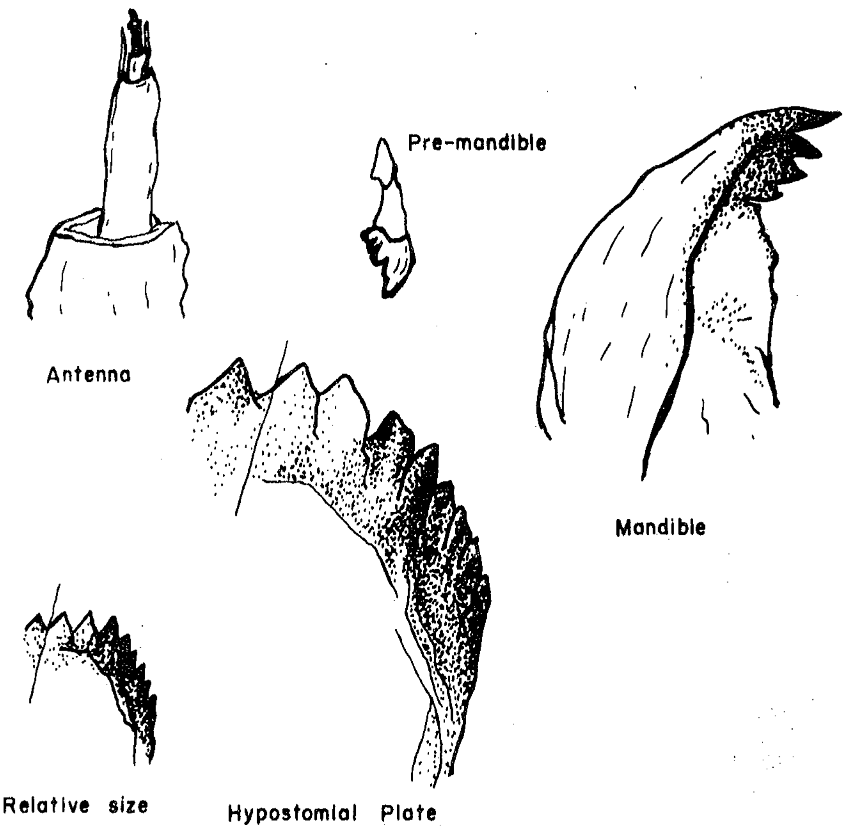
2 samples
March 20, 1974
14:00 hrs.

		No.	Dry wt (mgs)
Plecoptera			0.0133
Nemouridae			
Taeniopteryginae			
	Brachyptera sp.	8	
Capniinae			
	Isocapnia sp.a	14	
	Isocapnia sp.b	7	
Nemourinae			
	Nemoura sp.a	1	
	Nemoura sp.b	5	
Ephemeroptera			0.0276
Baetidae			
Ephemerellinae			
	Ephemerella doddsi	6	
Baetinae			
	Centroptilum sp.	9	
Heptageniidae			
	immature	3	
Trichoptera			
Limnephilidae			
	Ecclisomyia sp. (all weighed with cases)	84	4.0228
Diptera			
Empedidae			40.0006
Heleidae			
Heleinae			
	Palpomyia sp.	1	
Tendipedidae			0.0304
Orthocladinae			
	Hydrobaenus sp.1	102	
	Hydrobaenus sp.10	9	
Diamesinae			
	Pseudodiamesa sp.4	1	
+ Oligochaetae		25	

4. MINER RIVER	No.	Dry wt (mgs)
2 samples March 20, 1974 16:00 hrs.		
Plecoptera		0.0015
Perlodidae		
Isoperlinae		
Isoperla sp.	1	
Ephemeroptera		0.0002
Baetidae		
Ephemerellinae		
Ephemerella doddsi	1	
Heptageniidae (damaged)	1	
Trichoptera		0.0005
Limnephilidae (immature)	1	
Diptera		
Rhagionidae		10.0009
Tanyderidae		

Appendix IX Morphological characteristics of Chironomid species collected from "Kussat" samples during the summer 1973 survey of rivers along the norther pipeline route, and from Surber samples collected from rivers of both northern and interior routes during summer 1973 and winter 1974 surveys.

Pseudodiamesa sp. I



DIAMESINAE

Diamesini — *Pseudodiamesa* sp.1

Hypostomial Plate : 18 teeth, medians peaked. Paralabials absent.

Mandibles : very short, long apical and 4 dark laterals. brush made up of 24 strong, long bristles.

Premandibles : short, 4 short blades,outer wide.

Antennae : 5 segmented, 3rd. segment annulated, blade reaches to middle of segment 5, Lauterborn organ from top of segment 2 to tip of segment 4.

Pseudodiamesa sp.2

Hypostomial Plate :	15 teeth, median truncated and trifid, paralabials absent.
Mandibles :	long apical and 4 dark laterals.
Premandibles :	
Antennae :	blade to tip of 4th. segment, ratio 16:3:2:1:1
Posterior :	anal papillae short with 7 long bristles, and gills longer than posterior prolegs.

DIAMESINAE

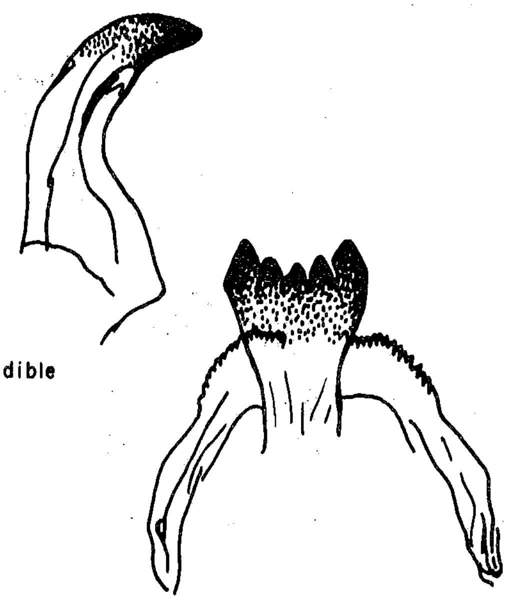
Diamesini Diamesa sp.1

Hypostomial Plate :	22 teeth, 6 rounded on horizontal plane, paralabials absent.
Mandibles :	heavy at base, long apical and 3 sharp, long laterals, very long dorso-mesal tooth, almost extending to the tip of the apical tooth, large fan-like brush.
Premandibles :	short with 7 short blades on palmate pattern.
Antennae :	3rd. segment annulated.

Diamesa sp.2

Hypostomial Plate :	20 teeth, 6 on a horizontal plane, paralabials absent.
Mandibles :	stout, apical and 4 dark laterals, all stout and blunt, fan-shaped brush present.
Premandibles :	4 slender blades.
Antennae :	3rd segment annulated, ratio 18:4:3:1:1

<u>Natarsia</u> sp. I



Mandible

Glossa

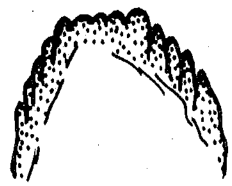
TANYPODINAE

Pentaneurini — <u>Natarsia</u> sp.1

Hypostomial Plate :	absent. hypostomial comb absent.
Mandibles :	slender with dark tip, no lateral teeth.
Head :	1.66 times as long as broad,
Premandibles :	glossa with 5 teeth and concave anterior margin, paraglossa bifid.
Antennae :	one third the length of the head, 1st. segment 4.5 times as long as the remainder.

Smittia sp. I

Mandible



Hypostomial Plate

ORTHOCLADINAE

Smittia sp.1

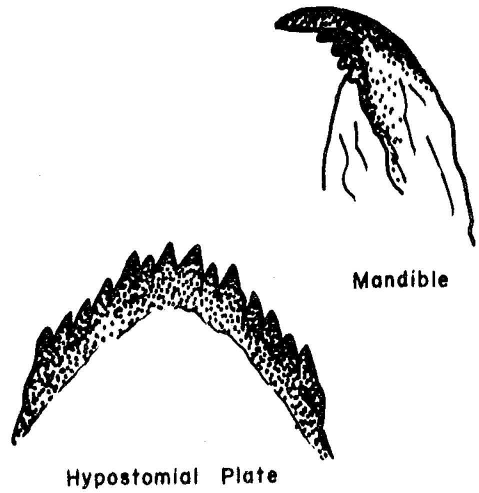
Hypostomial Plate :	large flattened median area with 5 arched teeth across it, 5 laterals each side at sharp angle to these, the whole plate light in colour though laterals are a shade darker.
Mandibles :	short and light in color, 4 lateral teeth,
Premandibles :	simple with a broad blade.
Antennae :	very short, blade extends to tip of 5th. segment ratio 28:6:3:2:2

ORTHOCLADINAE

Hydrobaenus sp.1

Hypostomial Plate :	13 teeth, pyramid shaped, median largest, 1st. laterals large, no paralabial beard.
Mandibles :	broad base, slender toothed region, dark apical and 3 dark laterals, comb and brush absent.
Premandibles :	simple.
Antennae :	very short, blade reaches top of 4th. segment, ratio 30:8:4:3:2

Hydrobaenus sp. 3



Hydrobaenus sp.3

Hypostomial Plate :	14 teeth, all brown, medians largest, reduced first laterals.
Mandibles :	brown in colour, long apical and 3 laterals, comb absent, brush simple.
Premandibles :	short and simple.
Antennae :	short but 6 segmented, blade longer than last 5 segments.

ORTHOCLADINAE

Hydrobaenus sp.4

Hypostomial Plate : 17 teeth, median broad and truncated.

Mandibles : very broad at base, toothed section slim, long apical tooth, 4 dark laterals comb and brush absent.

Premandibles : short and simple.

Antennae : very short and 5 segmented, blade to tip of 5th. segment, ratio 46:8:4:3:3

Posterior :

....

Hydrobaenus sp.5

Hypostomial Plate : 19 teeth, median broad and flat, all light.

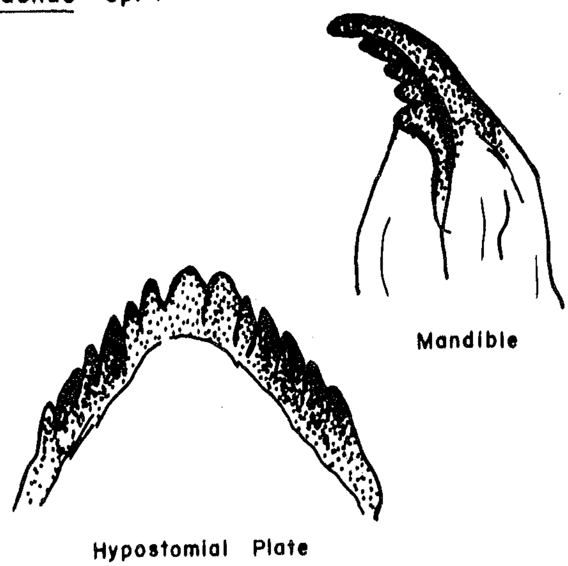
Mandibles : short, broad at base, 4 light laterals same size as the light apical tooth, brush and comb absent.

Premandibles : bifid, slender blades.

Antennae : very short, blade reaches tip of 5th. segment, ratio 35:8:2:2:2

Posterior : anal papillae very small with 6 bristles.

Hydrobaenus sp. 7



ORTHOCLADINAE

Hydrobaenus sp.7

Hypostomial Plate : 14 teeth, medians peaked and slightly the larger, paralabials absent.

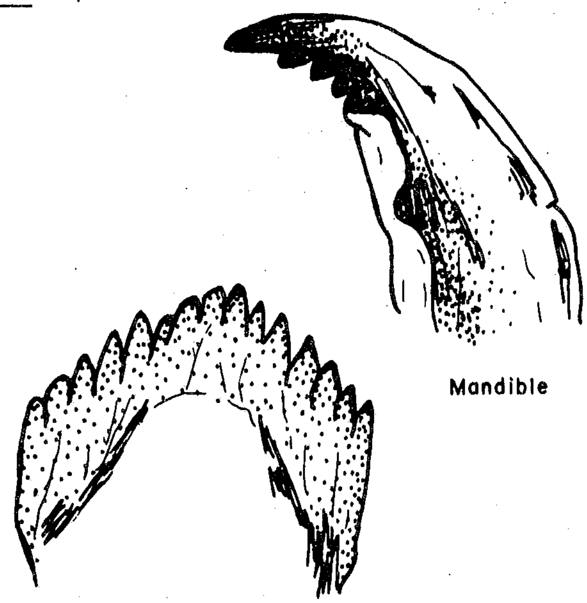
Mandibles : slim and light coloured, fairly long apical and 3 laterals simple brush present.

Premandibles : dark and bidid, blades of equal length.

Antennae : 4 segmented, blade to top of segment 3, ratio 37:20:8:3

Posterior : short posterior prolegs, long anal gills, preanal papillae with 6 long bristles.

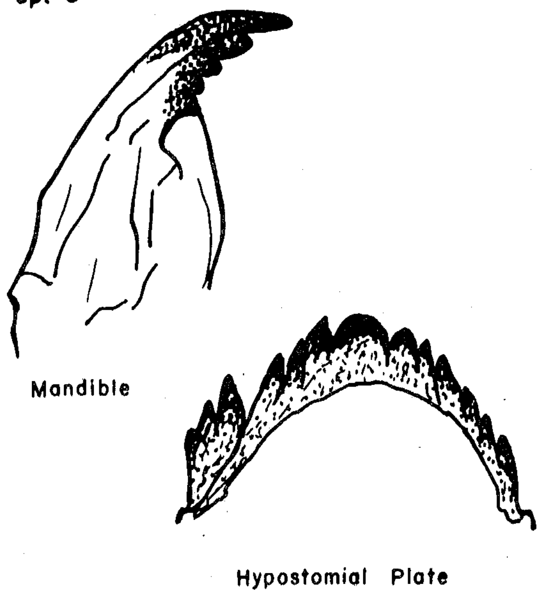
Hydrobaenus sp. 8



Hydrobaenus sp.8

Hypostomial Plate :	15 teeth median slightly smaller than 1st. laterals, plate weakly convex, paralabials absent.
Mandibles :	long dark apical and 4 dark laterals.
Premandibles :	
Antennae :	blade to top of 4th. segment, ratio 44:12:3:2:1
Posterior :	large C-shaped claws on posterior prolegs, pre-anal papillae short with 6 bristles.

Hydrobaenus sp. 9

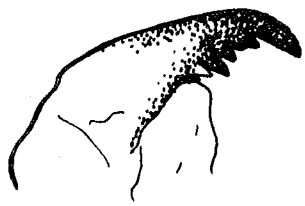


ORTHOCLADINAE

Hydrobaenus sp. 9

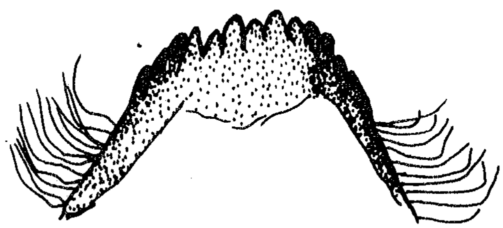
Hypostomial Plate :	13 teeth, all dark, median broad and rounded, 1st. laterals large, on same level as median, paralabials absent.
Mandibles :	long sout apical, 3 stout and dark laterals, simple brush.
Premandibles :	simple.
Antennae :	5 segmented, blade to middle of 5th. segment, ratio 32:9:5:4:2

Diplocladius **sp. I**



Mandible

Antenna



Paralabial Beard

Hypostomial Plate

Diplocladius sp.1

Hypostomial Plate : 13 teeth, all dark brown, long paralabial beard.

Mandibles : dark apical tooth, three dark and one light lateral teeth.

Premandibles :

Antennae : short, first segment longer than the last three combined.

ORTHOCLADINAE

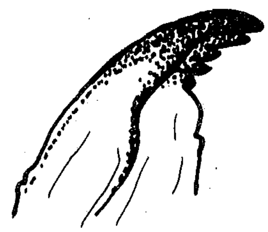
Eukiefferiella sp.1

Hypostomial Plate :	11 teeth, light brown, large broad median.
Mandibles :	dark apical, 4 laterals, one dark 3 light, comb and brush absent.
Premandibles :	trifid.
Antennae :	4 segmented, blade almost twice as long as last 3 segments, ratio 30:14:6:3
Posterior :	anal papillae short with seven bristles, long anal gills, even longer than posterior prolegs.

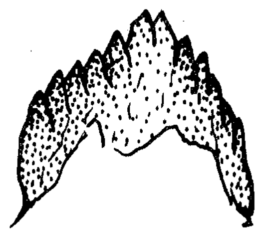
Eukiefferiella sp.2

Hypostomial Plate :	9 teeth, median broad, truncated and trifid, all an even brown colour, paralabials absent.
Mandibles :	long apical and 4 laterals, all even brown colour, small accessory tooth present, comb and brush absent.
Premandibles :	simple, with a broad blade.
Antennae :	5 segmented, blade to tip of 5th. segment, ratio 25:11:2:3:2

Eukiefferiella sp. 3



Mandible



Hypostomial Plate

Eukiefferiella sp.3

Hypostomial Plate : 12 teeth, medians largest, paralabials absent.

Mandibles : dark apical and 4 dark laterals, comb and brush absent.

Premandibles :

Antennae : blade almost to tip of 5th. segment, ratio 42:10:4:4:3

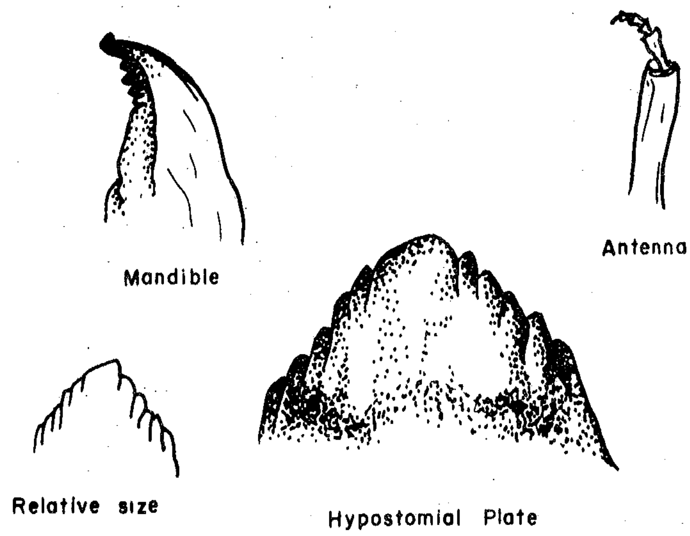
Posterior : fairly large anal gills with dark tips, claws on posterior prolegs light, pre-anal papillae about twice as long as broad with 7 bristles plus one originating midway along the length of the papilla.

ORTHOCLADINAE

<u>Eukiefferiella</u> sp.4

Hypostomial Plate :	12 teeth, medians largest, paralabials absent.
Mandibles :	slender, apical plus 4 laterals, all even brown colour.
Premandibles :	
Antennae :	4 segmented, blade only to tip of second segment, ratio 21:6:2:2
Posterior :	anal papillae short with 7 bristles, long posterior prolegs.

Cardiocladius sp. I



Cardiocladius sp.1

Hypostomial Plate :	11 teeth, median broadly truncate, laterals at steep angle to top of median.
Mandibles :	stout and dark though not black, 4 short laterals, comb and brush absent.
Premandibles :	simple.
Antennae :	5 segmented, blade to middle of 4th. segment, ratio 28:10:4:5:3

ORTHOCLADINAE

Corynoneura sp.1

Hypostomial Plate :	11 light teeth, median broadest, anterior to rest, paralabials absent.
Mandibles :	long apical and 4 laterals, comb and brush absent.
Premandibles :	bifid, fairly dark.
Antennae :	4 segmented, 1st. segment less than half the length of the head, Lauterborn organ to halfway up the 2nd. segment, sense pit in middle of 1st. segment, ratio 26:12:14:1
Posterior :	spur on posterior prolegs with hairs at base.

Corynoneura sp.2

Hypostomial Plate :	18 teeth all pale, 10 on a horizontal plane, paralabials absent.
Mandibles :	8 teeth, all pale.
Premandibles :	simple.
Epipharynx :	4 strong curved spines projecting from the epipharyngeal area, labrum with two long simple spines.
Antennae :	4 segmented, blade not quite reaching tip of the second segment, ratio 48:56:2:10
Posterior :	anal papillae short with 4 long bristles, spur absent from posterior proleg.

Corynoneura sp.3

Hypostomial Plate :	13 teeth, very large 1st. laterals, minute recessed median, paralabials absent.
Mandibles :	apical and 3 laterals light brown.
Antennae :	5 segmented, last two segments very small, small blade reaches halfway along the 2nd. segment, ratio 52:26:32:0.5:0.5

Appendix X

Appendix X — Summer 1973. The total number, average size and percentage juveniles of plankton species, and the biomass of the sample taken from lakes along northern and interior pipeline routes, including reference maps of lakes sampled.

Northern Route

1. LAKE #1

Station 1
2 vertical hauls (Depth 10' - 12')
July 16, 1973
18:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	70	0.95 mm	15
Calanoid	301	0.52 mm	85
Daphnia type	26	1.27 mm	45
Bosmina type	--	--	--
Ostracods	6	--	--

Species

Cladocera	Copepods
+ Daphnia middendorfiana	Heterocope septentrionalis +++
+ Holopedium gibberum	Epischura nevadensis scarce
	Cyclops scutifer ++

Biomass

Copepods	(3.346 + 2.7692)	=	6.1152 mgs
Daphnia type		=	2.7768 mgs

Station 2
2 vertical hauls (Depth 12' - 15')
July 16, 1973
18:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	34	1.1 mm	10
Calanoid	170	0.95 mm	90
Daphnia type	223	2.1 mm	40
Bosmina type	--	--	--
Ostracods	10	--	--

Species

Cladocera

+++ Daphnia middendorfiana

+ Holopedium gibberum

Copepods

Heterocope septentrionalis ++

Cyclops scutifer +

Biomass

Copepods	(2.4276 + 8.126)	=	10.5536 mgs
Daphnia type		=	108.3557 mgs

100' horizontal haul
July 16, 1973
18:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	30	0.87 mm	10
Calanoid	520	1.4 mm	70
Daphnia type	1130	1.25 mm	40
Bosmina type	--	--	--
Ostracods	2	--	--

Species

Cladocera

+++ Daphnia middendorfiana

++ Holopedium gibberum

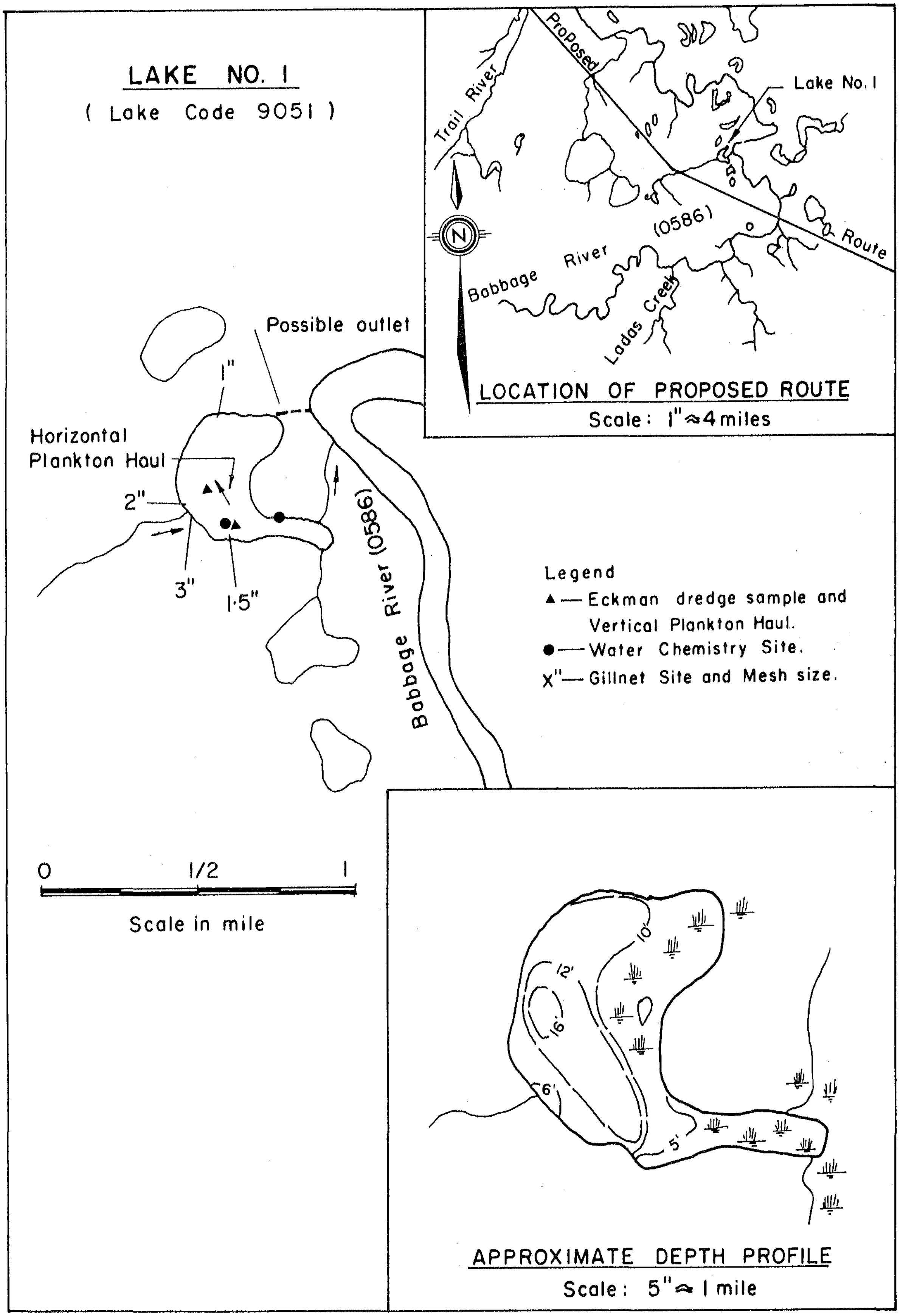
Copepods

Heterocope septentrionalis +

Cyclops scutifer few

Biomass

Copepods	(1.128 + 71.656)	=	72.774	mgs
Daphnia type		=	115.034	mgs


LAKE NO. 1
(Lake Code 9051)
Possible outlet
1"
Horizontal
Plankton Haul
2"
3"
1.5"
Babbage River (0586)
0
1/2
1
Scale in mile
Trail River
Proposed
Route
Lake No. 1
Babbage River (0586)
Ladas Creek
N
LOCATION OF PROPOSED ROUTE
Scale: 1" ≈ 4 miles
Legend
▲— Eckman dredge sample and Vertical Plankton Haul.
●— Water Chemistry Site.
X"— Gillnet Site and Mesh size.
10'
12'
16'
6'
5'
APPROXIMATE DEPTH PROFILE
Scale: 5" ≈ 1 mile

2. LAKE #2

Station 1
2 vertical hauls (Depth 12' - 15')
July 18, 1973
18:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	15	0.65 mm	60
Calanoid	22	0.625mm	95
Daphnia type	15	1.025mm	30
Bosmina type	1	0.325mm	--
Ostracods	4	--	--
+ one Harpacticoid		0.625mm	

<u>Species</u>

<u>Cladocera</u>	<u>Copepods</u>
++ <u>Daphnia middendorfiana</u>	<u>Heterocope septentrionalis</u> +
+ <u>Holopedium gibberum</u>	<u>Diaptomus pribilofensis</u> ++
<u>Bosmina longirostris</u>	<u>Cyclops scutifer</u> +

<u>Biomass</u>

Copepods	(0.255 + 0.3344)	=	0.5894 mgs
Daphnia type		=	0.84 mgs
Bosmina type		=	0.0107 mgs

Station 2
2 vertical hauls (Depth 6' - 7')
July 18, 1973

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	8	0.45 mm	90
Calanoid	34	0.6 mm	90
Daphnia type	22	0.85 mm	70
Bosmina type	9	0.25 mm	30
Ostracods	9	--	--

Species

Cladocera	Copepods
+ *Daphnia middendorfiana*	*Heterocope septentrionalis* +
+ *Holopedium gibberum*	*Diaptomus pribilofensis* +
few *Chydorus sphaerius*	*Cyclops strenuus* few
	Cyclops scutifer few

Biomass

Copepods	(0.0496 + 0.4624)	=	0.5120 mgs
Daphnia type		=	0.7018 mgs
Bosmina type		=	0.054 mgs

100' horizontal haul
July 18, 1973

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	140	0.35 mm	100
Calanoid	13	0.45 mm	100
Daphnia type	52	0.625mm	60
Bosmina type	28	0.25 mm	--
Ostracods	119	--	--

Species

Cladocera

few *Daphnia middendorfiana*

+ *Holopedium gibberum*

+ *Chydorus sphaerius*

few *Bosmina coregoni*

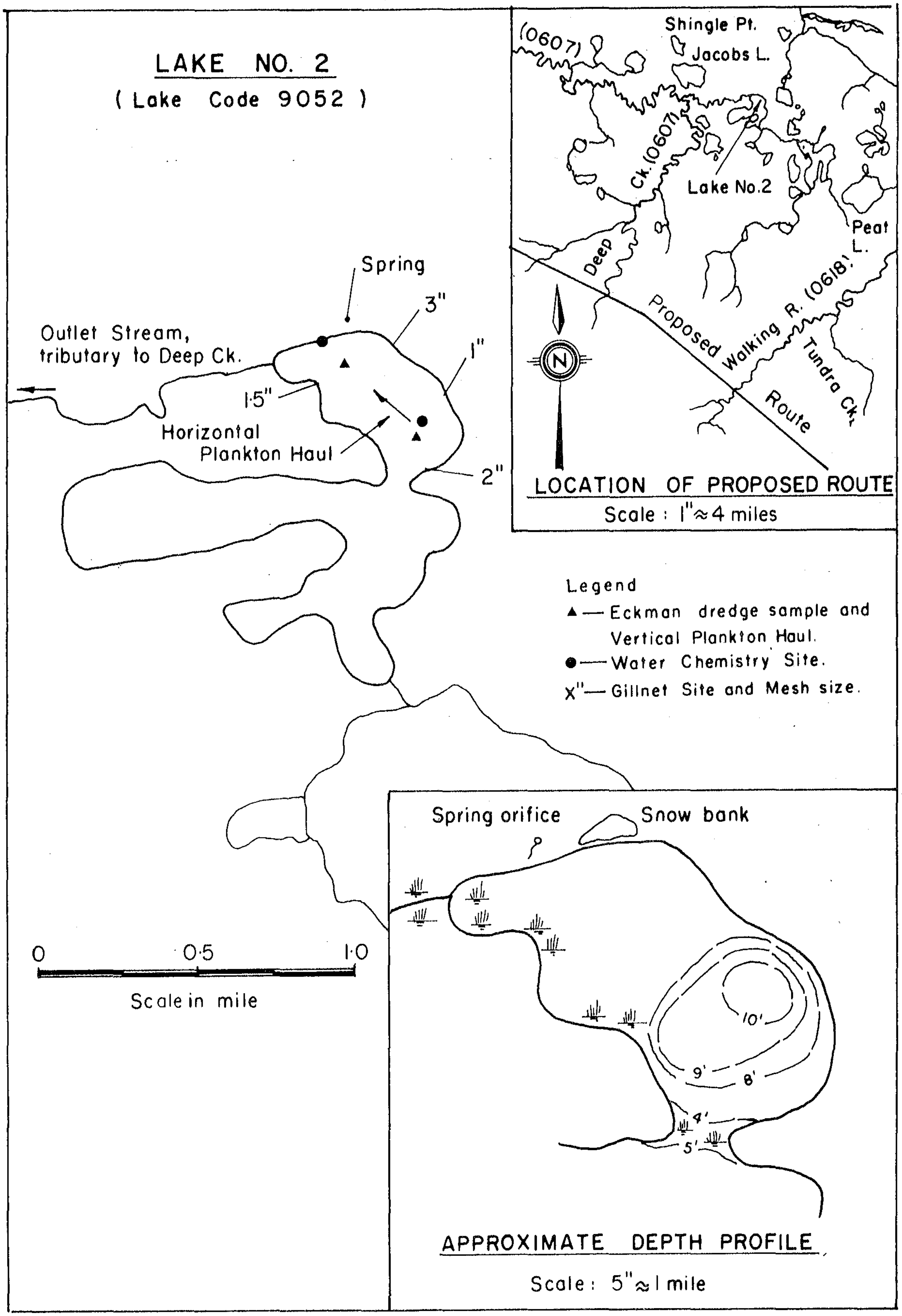
Copepods

Diaptomus pribilofensis few

Cyclops scutifer +++

Biomass

Copepods	(0.434 + 0.0806)	=	0.5146 mgs
Daphnia type		=	0.6552 mgs
Bosmina type		=	0.168 mgs


LAKE NO. 2
(Lake Code 9052)
Spring
3"
1"
Outlet Stream,
tributary to Deep Ck.
1·5"
Horizontal
Plankton Haul
2"
0
0·5
1·0
Scale in mile
Shingle Pt.
(0607)
Jacobs L.
Ck. (0607)
Lake No.2
Peat L.
Deep
Proposed Walking R. (0618)
Tundra Ck.
Route
N
LOCATION OF PROPOSED ROUTE
Scale : 1"≈4 miles
Legend
▲ — Eckman dredge sample and Vertical Plankton Haul.
● — Water Chemistry Site.
X" — Gillnet Site and Mesh size.
Spring orifice
Snow bank
10'
9'
8'
4'
5'
APPROXIMATE DEPTH PROFILE
Scale: 5"≈1 mile

3. LAKE #3

Station 1
2 vertical hauls (Depth 5')
July 19, 1973

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	5	0.75 mm	
Calanoid	660	0.85 mm	90
Daphnia type	270	2.05 mm	40
Bosmina type	--	--	--
Ostracods	--	--	--

Species

Cladocera	Copepods
++ Daphnia middendorfiana	Heterocope septentrionalis +++
	Diaptomus pribilofensis +
	Cyclops scutifer

Biomass

Copepods	(0.1255 + 23.2320)	=	23.3575 mgs
Daphnia type		=	122.013 mgs

Station 2
2 vertical hauls (Depth 6')
July 19, 1973

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	--	--	--
Calanoid	1005	0.675mm	98
Daphnia type	335	1.525mm	70
Bosmina type	--	--	--
Ostracods	5	--	--

Species

Cladocera

+++ Daphnia middendorfiana

Copepods

Heterocope septentrionalis +

Diaptomus pribilofensis +++

Biomass

Copepods = 18.894 mgs

Daphnia type = 62.109 mgs

100' horizontal haul
July 19, 1973

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	20	0.875mm	--
Calanoid	3100	1.0 mm	65
Daphnia type	2880	1.9 mm	60
Bosmina type	--	--	--
Ostracods	20	--	--

+ 20 Conchostracans

Species

Cladocera

+++ Daphnia middendorfiana

Copepods

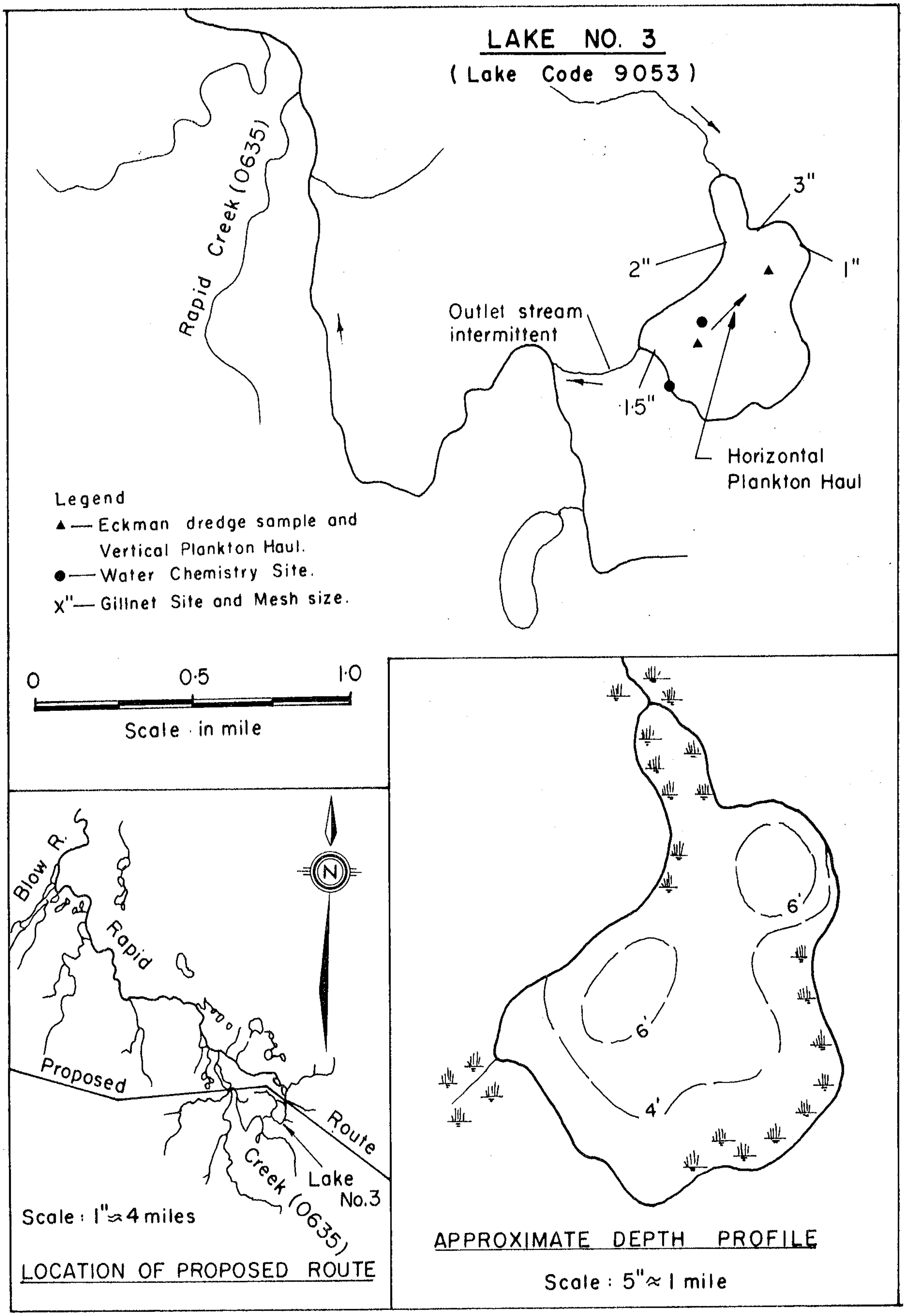
Heterocope septentrionalis +

Diaptomus pribilofensis ++

Cyclops scutifer

Biomass

Copepods	(0.764 + 170.500)	=	171.264 mgs
Daphnia type		=	1035.072 mgs


LAKE NO. 3
(Lake Code 9053)
Rapid Creek (0635)
3"
2"
1"
Outlet stream intermittent
1.5"
Horizontal Plankton Haul
Legend
▲— Eckman dredge sample and Vertical Plankton Haul.
●— Water Chemistry Site.
X"— Gillnet Site and Mesh size.
0
0.5
1.0
Scale in mile
Blow R.
Rapid
N
Proposed
Route
Creek (0635)
Lake No.3
Scale : 1"≈4 miles
LOCATION OF PROPOSED ROUTE
6'
6'
4'
APPROXIMATE DEPTH PROFILE
Scale : 5"≈1 mile

Interior Route

1. LAKE #4

Station 1
2 vertical hauls (Depth 5')
July 28, 1973
22:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	2	0.575mm	--
Calanoid	5	1.425mm	--
Daphnia type	8	1.1 mm	--
Bosmina type	--	--	--
Ostracods	--	--	--

Species

Cladocera

Daphnia middendorfiana

Copepods

Heterocope septentrionalis

Diaptomus pribilofensis

Cyclops scutifer

Biomass

Copepods	(0.0242 + 0.7230)	=	0.7472 mgs
Daphnia type		=	0.5544 mgs

Station 2
1 vertical haul (Depth 6½')
July 28, 1973
22:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	--	--	--
Calanoid	4	0.625mm	--
Daphnia type	363	1.8 mm	75
Bosmina type	--	--	--
Ostracods	--	--	--

Species

Cladocera	Copepods
+++ Daphnia middendorfiana	Heterocope septentrionalis
one Holopedium gibberum	Diaptomus pribilofensis

Biomass

Copepods	=	0.0608 mgs
Daphnia type	=	110.8602 mgs

100' horizontal haul
July 28, 1973
22:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	6	0.5 mm	--
Calanoid	26	1.5 mm	50
Daphnia type	257	1.1 mm	90
Bosmina type	--	--	--
Ostracods	2	--	--

Species

Cladocera

+++ Daphnia middendorfiana

3 Holopedium gibberum

Copepods

Heterocope septentrionalis +

Diaptomus pribilofensis few

Cyclops scutifer few

+ one Hydracarina

+ 39 Chaoborus larvae, + one Chaoborus pupa - 14.3 mgs (dry weight)

+ one Tanypodinae larva, Tribe Anatopyniini.

Biomass

Copepods	(0.0493 + 4.3264)	=	4.3757 mgs
Daphnia type		=	17.8101 mgs

mid-lake
3 surface hauls
July 28, 1973
22:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	3	0.55 mm	--
Calanoid	1	0.5 mm	--
Daphnia type	5	1.25 mm	--
Bosmina type	--	--	--
Ostracods	--	--	--

Species

Cladocera

Daphnia middendorfiana

Copepods

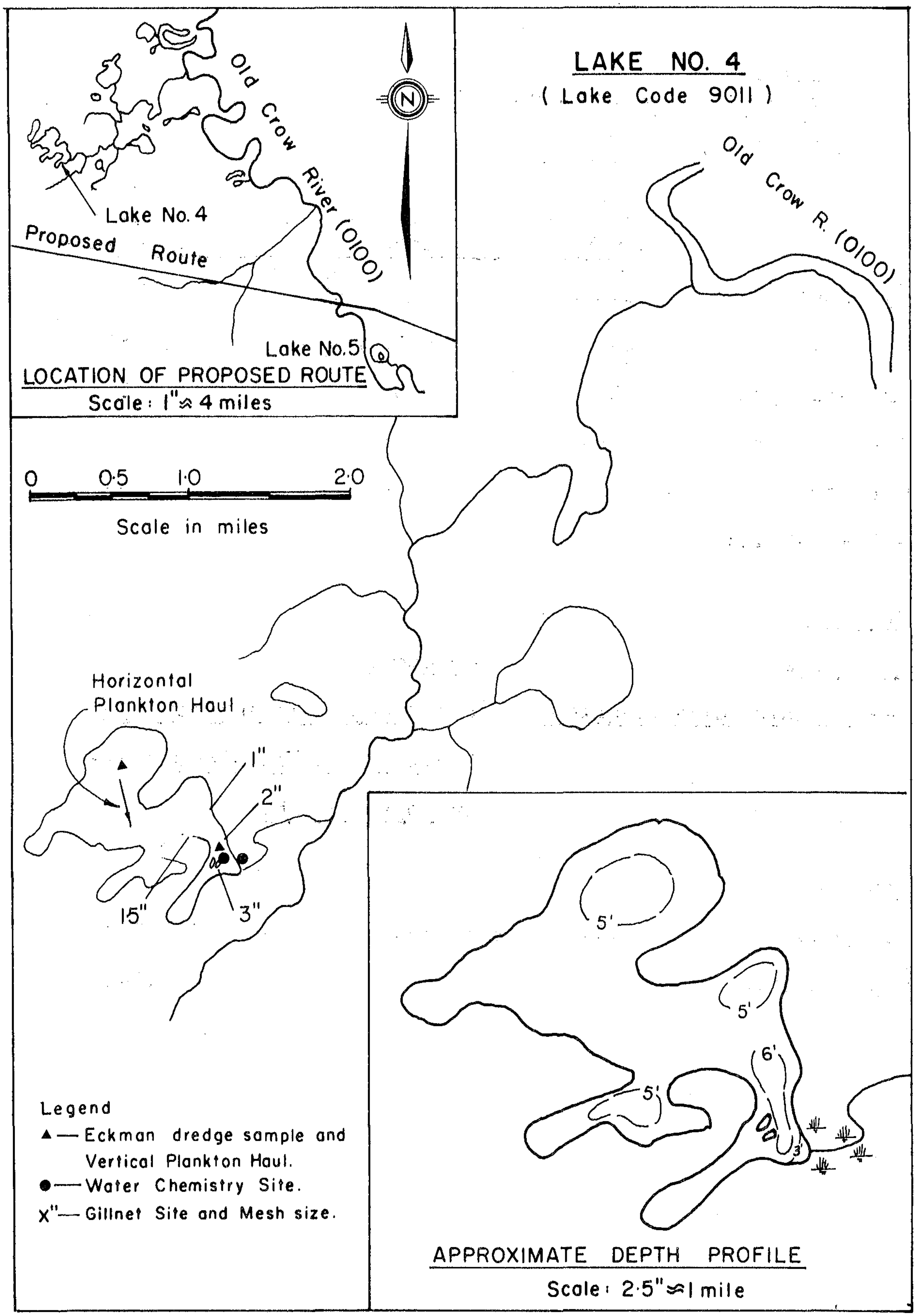
Diaptomus pribilofensis

Cyclops scutifer

+ one Tanypodinae larva, Tribe Anatopyniini.

Biomass

Copepods	(0.0324 + 0.0083)	=	0.0407 mgs
Daphnia type		=	0.509 mgs


LAKE NO. 4
(Lake Code 9011)
Old Crow R. (0100)
Old Crow River (0100)
Lake No. 4
Proposed Route
Lake No. 5
LOCATION OF PROPOSED ROUTE
Scale: 1" ≈ 4 miles
0 0.5 1.0 2.0
Scale in miles
Horizontal Plankton Haul
1"
2"
15"
3"
Legend
▲— Eckman dredge sample and Vertical Plankton Haul.
●— Water Chemistry Site.
X"— Gillnet Site and Mesh size.
5'
5'
6'
5'
3'
APPROXIMATE DEPTH PROFILE
Scale: 2.5" ≈ 1 mile

2. LAKE #5 (Vunnutulka)

Station 1
2 vertical hauls (Depth 12')
July 29, 1973
22:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	116	0.45 mm	100
Calanoid	644	0.95 mm	80
Daphnia type	136	1.8 mm	50
Bosmina type	--	--	--
Ostracods	12	--	--

+ 544 nauplii

Species

Cladocera

++ Daphnia middendorfiana

Copepods

Heterocope septentrionalis +

Diaptomus pribilofensis +++

Cyclops scutifer

Biomass

Copepods	(0.7192 + 30.7832)	=	31.5024 mgs
Daphnia type		=	41.5344 mgs

Station 2
2 vertical hauls (Depth 8' - 9')
July 29, 1973
22:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	40	0.65 mm	--
Calanoid	540	1.5 mm	70
Daphnia type	420	2.1 mm	58
Bosmina type	--	--	--
Ostracods	10	--	--

Species

Cladocera

++ Daphnia middendorfiana

Copepods

Heterocope septentrionalis ++

Diaptomus pribilofensis ++

Cyclops scutifer

Biomass

Copepods	(0.6800 + 89.8560)	=	90.5360 mgs
Daphnia type		=	204.078 mgs

100' horizontal haul
July 29, 1973
23:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	320	0.3 mm	100
Calanoid	4840	1.075mm	50
Daphnia type	200	1.625mm	--
Bosmina type	--	--	--
Ostracods	20	--	--

\+ 480 nauplii

Species

Cladocera

few Daphnia middendorfiana

Copepods

Heterocope septentrionalis +

Diaptomus pribilofensis +++

Cyclops scutifer few

Biomass

Copepods	(0.6720 + 324.2800)	=	324.9520 mgs
Daphnia type		=	44.88 mgs

Surface haul
September 15, 1973

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	--	--	--
Calanoid	128	2.25 mm	--
Daphnia type	--	--	--
Bosmina type	--	--	--
Ostracods	--	--	--

Species

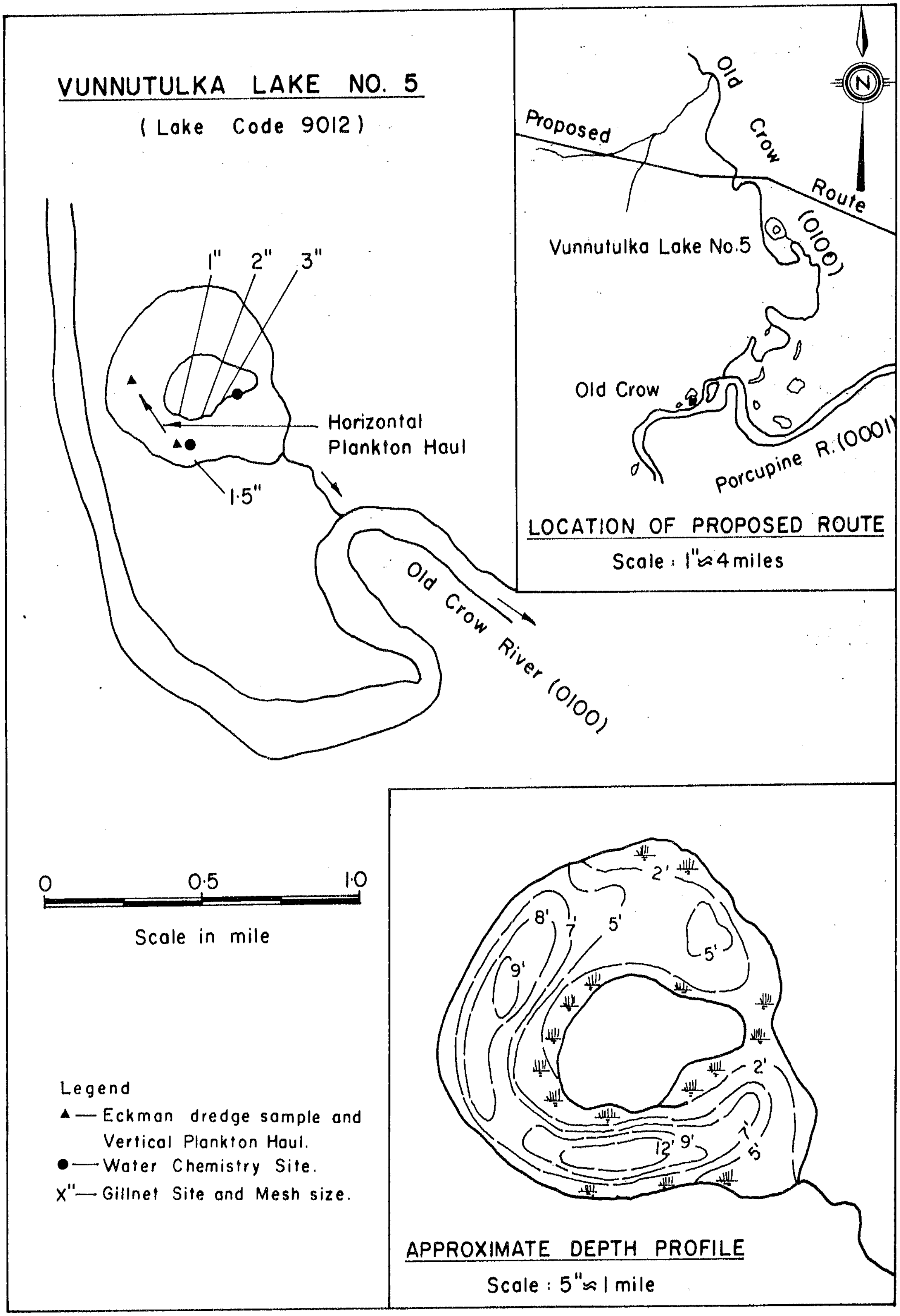
Cladocera

Copepods

Heterocope septentrionalis +++

Biomass

Copepods = 64.4224 mgs


VUNNUTULKA LAKE NO. 5
(Lake Code 9012)
1"
2"
3"
1.5"
Horizontal Plankton Haul
Old Crow River (0100)
0
0.5
1.0
Scale in mile
Legend
▲ — Eckman dredge sample and Vertical Plankton Haul.
● — Water Chemistry Site.
X" — Gillnet Site and Mesh size.
Old Crow
Proposed
Route
(0100)
Vunnutulka Lake No.5
Old Crow
Porcupine R. (0001)
N
LOCATION OF PROPOSED ROUTE
Scale : 1" ≈ 4 miles
2'
8'
7'
5'
5'
9'
2'
12'
9'
7'
5'
APPROXIMATE DEPTH PROFILE
Scale : 5" ≈ 1 mile

3. LAKE #6

Station 1
2 vertical hauls (Depth 6')
July 30, 1973
19:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	--	--	--
Calanoid	225	0.775mm	90
Daphnia type	57	1.3 mm	95
Bosmina type	--	--	--
Ostracods	18	--	--

Species

Cladocera

few *Daphnia middendorfiana*

+ *Holopedium gibberum*

Copepods

Diaoptomus pribilofensis +++

Biomass

Copepods = 6.165 mgs

Daphnia type = 6.5322 mgs

Station 2
2 vertical hauls (Depth 5' - 6')
July 30, 1973
20:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	--	--	--
Calanoid	325	0.9 mm	90
Daphnia type	155	1.4 mm	70
Bosmina type	--	--	--
Ostracods	10	--	--

Species

Cladocera

\+ Daphnia middendorfiana

++ Holopedium gibberum

Copepods

Heterocope septentrionalis +

Diaptomus pribilofensis +++

Biomass

Copepods	=	13.4225 mgs
Daphnia type	=	22.2115 mgs

100' horizontal haul
July 30, 1973
20:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	10	0.65 mm	--
Calanoid	1240	0.675mm	75
Daphnia type	450	0.85 mm	90
Bosmina type	--	--	--
Ostracods	10	--	--

Species

Cladocera

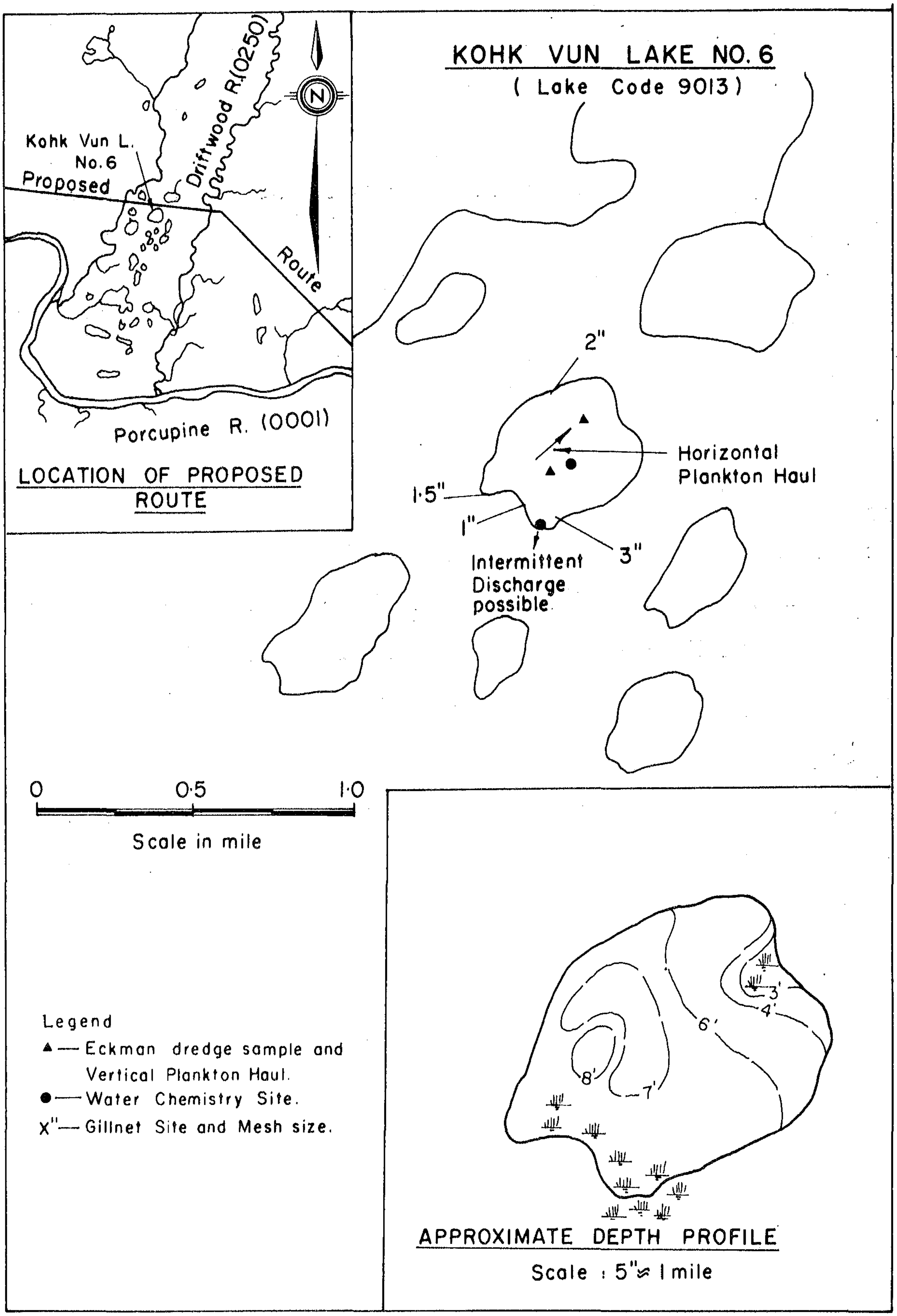
+ Daphnia middendorfiana
+ Holopedium gibberum

Copepods

Heterocope septentrionalis few
Diaptomus pribilofensis +++
Cyclops sp.

Biomass

Copepods	(0.1700 + 23.3120)	=	23.4820 mgs
Daphnia type		=	14.355 mgs


KOHK VUN LAKE NO. 6
(Lake Code 9013)
Kohk Vun L.
No. 6
Proposed
Route
Driftwood R.(0250)
N
Porcupine R. (0001)
LOCATION OF PROPOSED ROUTE
2"
1·5"
1"
3"
Horizontal Plankton Haul
Intermittent Discharge possible
0
0·5
1·0
Scale in mile
Legend
▲ — Eckman dredge sample and Vertical Plankton Haul.
● — Water Chemistry Site.
X" — Gillnet Site and Mesh size.
3'
4'
6'
7'
8'
APPROXIMATE DEPTH PROFILE
Scale : 5" ≈ 1 mile

4. LAKE #7

Station 1
2 vertical hauls (Depth 20')
August 2, 1973
24:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	3615	0.425mm	90
Calanoid	1125	0.675mm	80
Daphnia type	915	1.025mm	40
Bosmina type	30	0.25 mm	--
Ostracods	--	--	--

Species

Cladocera	Copepods
++ Daphnia middendorfiana	Diaptomus pribilofensis ++
+ Daphnia longiremis	Cyclops scutifer +++
Bosmina longirostris	

Biomass

Copepods	(19.1595 + 21.1500)	=	40.3095	mgs
Daphnia type		=	51.24	mgs
Bosmina type		=	0.18	mgs

Station 2
2 vertical hauls (Depth 7')
August 2, 1973
24:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	244	0.6 mm	90
Calanoid	528	0.75 mm	60
Daphnia type	240	0.95 mm	95
Bosmina type	--	--	--
Ostracods	--	--	--

+ 472 nauplii

Species

Cladocera

++ Daphnia middendorfiana

+ Daphnia longiremis

Copepods

Diaptomus pribilofensis +++

Cyclops scutifer +++

Biomass

Copepods	(3.3184 + 13.2528)	=	16.5712 mgs
Daphnia type		=	10.704 mgs

Station 1
100' horizontal haul
August 2, 1973
24:00 hrs.

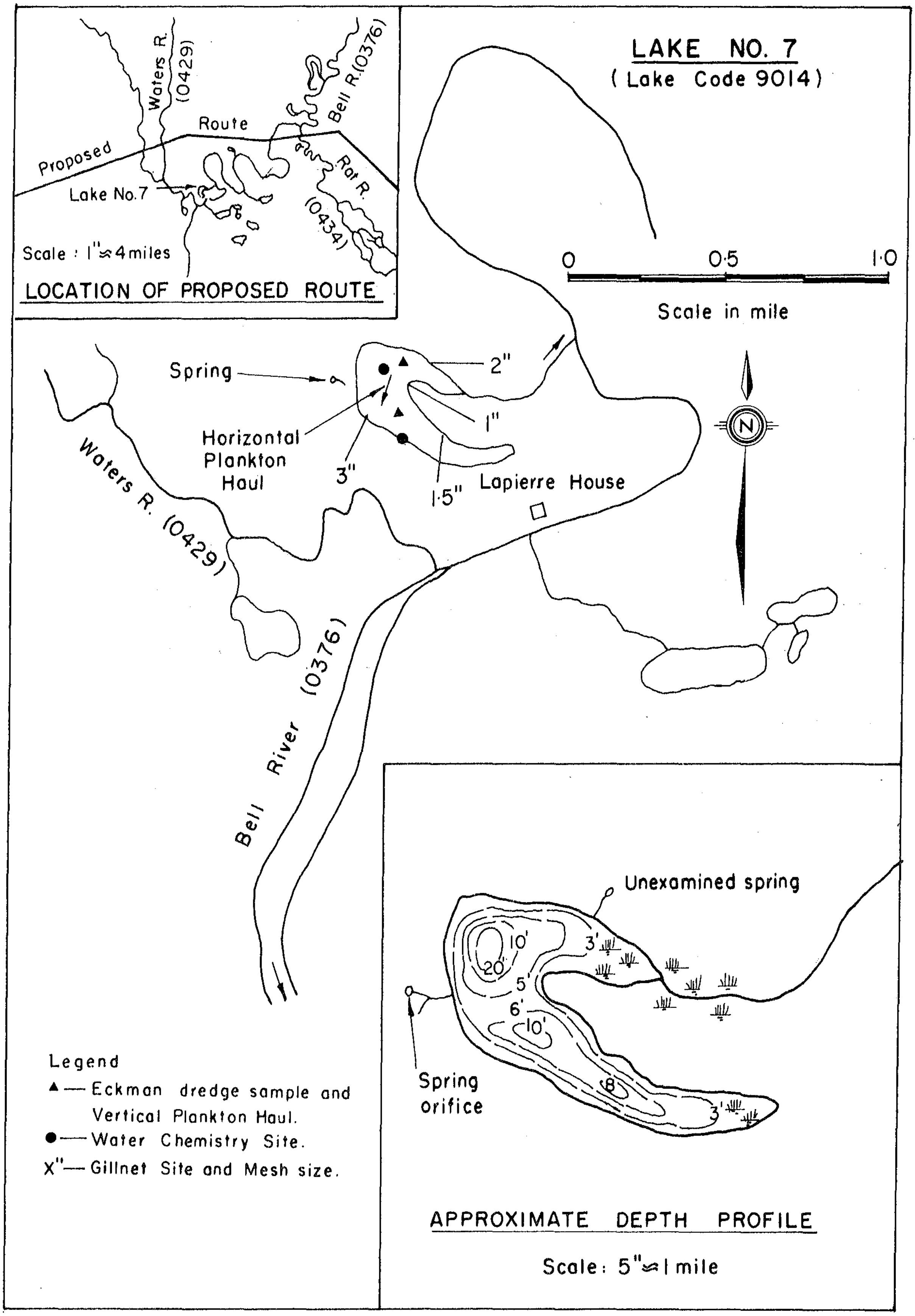
	Total Number	Average Size	Percentage Juveniles
Cyclopoid	8240	0.475mm	85
Calanoid	6640	0.725mm	60
Daphnia type	5460	0.925mm	45
Bosmina type	--	--	--
Ostracods	--	--	--

Species

Cladocera	Copepods
++ Daphnia middendorfiana	Diaptomus pribilofensis +++
Daphnia longiremis	Cyclops scutifer +++

Biomass

Copepods	(3.4443 + 8.3631)	=	11.8074 mgs
Daphnia type		=	11.7827 mgs


LAKE NO. 7
(Lake Code 9014)
LOCATION OF PROPOSED ROUTE
Scale : 1" ≈ 4 miles
Proposed Route
Lake No. 7
Waters R. (0429)
Bell R. (0376)
Rat R. (0434)
0 0.5 1.0
Scale in mile
Spring
2"
1"
3"
1.5"
Horizontal Plankton Haul
Lapierre House
Waters R. (0429)
Bell River (0376)
N
Legend
▲ — Eckman dredge sample and Vertical Plankton Haul.
● — Water Chemistry Site.
X" — Gillnet Site and Mesh size.
Unexamined spring
Spring orifice
10'
20'
3'
5'
6'
10'
8'
3'
APPROXIMATE DEPTH PROFILE
Scale: 5" ≈ 1 mile

5. LAKE #8 (Chinneitlui)

Station 1
2 vertical hauls (Depth 15')
August 9, 1973

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	71	0.525mm	90
Calanoid	174	0.775mm	65
Daphnia type	53	1.575mm	30
Bosmina type	1	0.35 mm	--
Ostracods	--	--	--

Species

Cladocera	Copepods
++ Daphnia middendorfiana	Heterocope septentrionalis +
Chydorus sphaerius	Diaptomus pribilofensis +++
	Cyclops scutifer ++

Biomass

Copepods	(0.6887 + 4.7676)	=	5.4563 mgs
Daphnia type		=	10.8279 mgs
Bosmina type		=	0.0126 mgs

Station 2
2 vertical hauls (Depth 6')
August 9, 1973

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	395	0.555mm	90
Calanoid	420	0.725mm	80
Daphnia type	475	1.325mm	40
Bosmina type	--	--	--
Ostracods	--	--	--

Species

Cladocera	Copepods
+++ *Daphnia middendorfiana*	*Diaptomus pribilofensis* +++
+ *Ceriodaphnia pulchella*	*Cyclops scutifer* +++

Biomass

Copepods	(4.3450 + 9.6180)	=	13.9630 mgs
Daphnia type		=	57.665 mgs

Station 1
100' horizontal haul
August 9, 1973

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	400	0.6 mm	100
Calanoid	8560	2.55 mm	10
Daphnia type	13360	2.85 mm	10
Bosmina type	--	--	--
Ostracods	--	--	--

Species

Cladocera

+++ Daphnia middendorfiana

Copepods

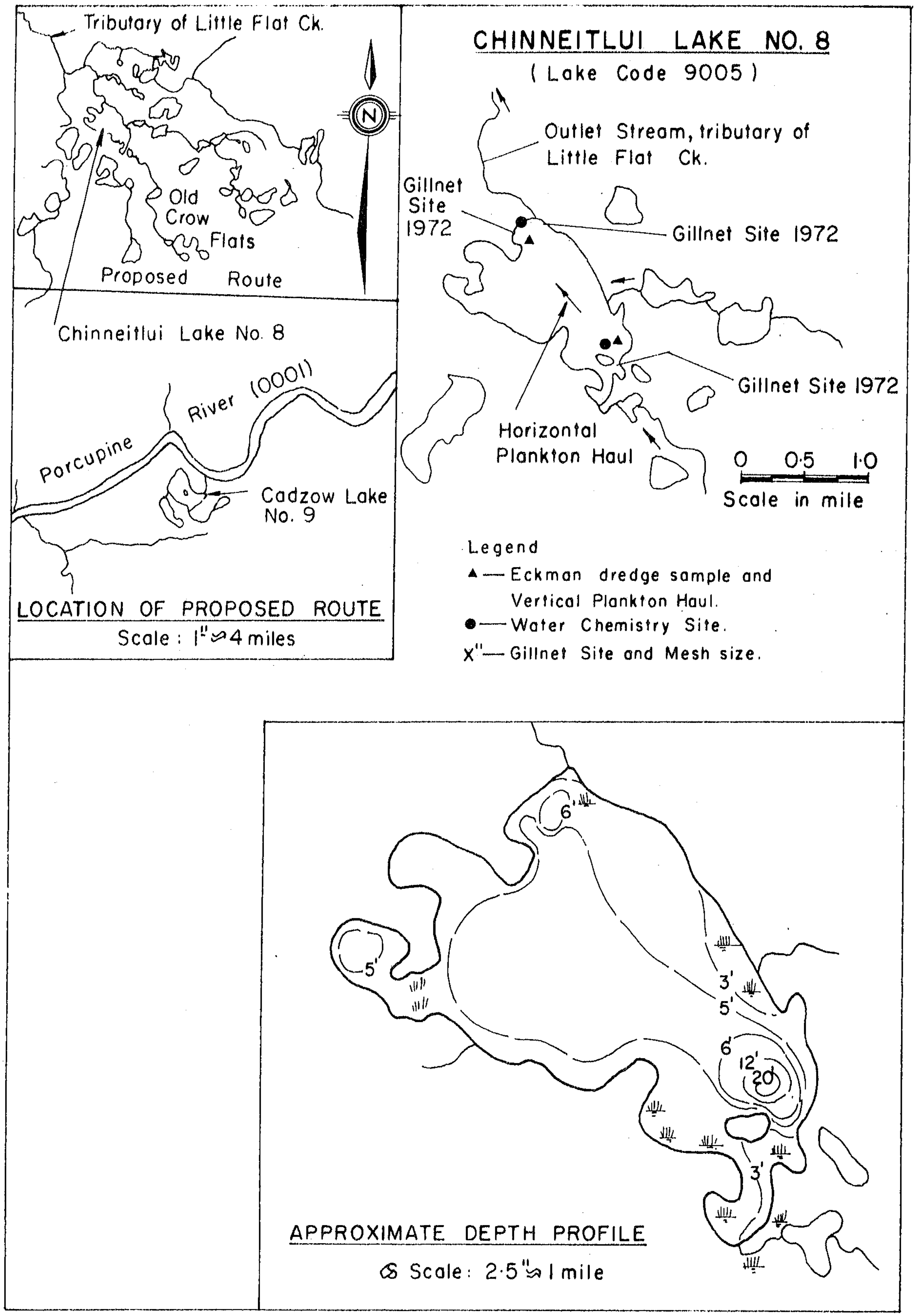
Heterocope septentrionalis +++

Diaptomus pribilofensis few

Biomass

Copepods (5.4400 + 6063.0480) = 6068.4880 mgs

Daphnia type 16285.84 mgs



CHINNEITLUI LAKE NO. 8
(Lake Code 9005)
Outlet Stream, tributary of Little Flat Ck.
Gillnet Site 1972
Gillnet Site 1972
Gillnet Site 1972
Horizontal Plankton Haul
0 0·5 1·0
Scale in mile
Legend
▲— Eckman dredge sample and Vertical Plankton Haul.
●— Water Chemistry Site.
X"— Gillnet Site and Mesh size.
Tributary of Little Flat Ck.
N
Old Crow Flats
Proposed Route
Chinneitlui Lake No. 8
Porcupine River (0001)
Cadzow Lake No. 9
LOCATION OF PROPOSED ROUTE
Scale : 1" ≈ 4 miles
6'
5'
3'
5'
6'
12'
20'
3'
APPROXIMATE DEPTH PROFILE
Scale: 2·5" ≈ 1 mile

6. LAKE #9 (Cadzow)

Station 1
2 vertical hauls (Depth 12')
August 12, 1973
15:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	156	0.325mm	100
Calanoid	580	0.75 mm	70
Daphnia type	76	1.225mm	10
Bosmina type	--	--	--
Ostracods	--	--	--

+ 1,828 nauplii

Species

Cladocera

+ Daphnia middendorfiana

Copepods

Heterocope septentrionalis +

Diaptomus pribilofensis +++

Cyclops scutifer ++

Biomass

Copepods	(0.4056 + 14.5580)	=	14.9636 mgs
Daphnia type		=	7.2808 mgs

Station 2
2 vertical hauls (Depth 15")
August 12, 1973
19:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	50	0.4 mm	95
Calanoid	812	0.925mm	80
Daphnia type	352	2.15 mm	40
Bosmina type	--	--	--
Ostracods	--	--	--

+ 2,528 nauplii, + one conchostracan

Species

Cladocera

+++ Daphnia middendorfiana

Copepods

Heterocope septentrionalis +

Diaptomus pribilofensis +++

Cyclops scutifer +

Biomass

Copepods	(0.2250 + 36.1340)	=	36.3590 mgs
Daphnia type		=	183.6032 mgs

100' horizontal haul
August 12, 1973
18:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	780	0.375mm	90
Calanoid	6420	0.95 mm	60
Daphnia type	360	1.375mm	30
Bosmina type	--	--	--
Ostracods	--	--	--
+ 900 nauplii			

Species

Cladocera

+ Daphnia middendorfiana

Copepods

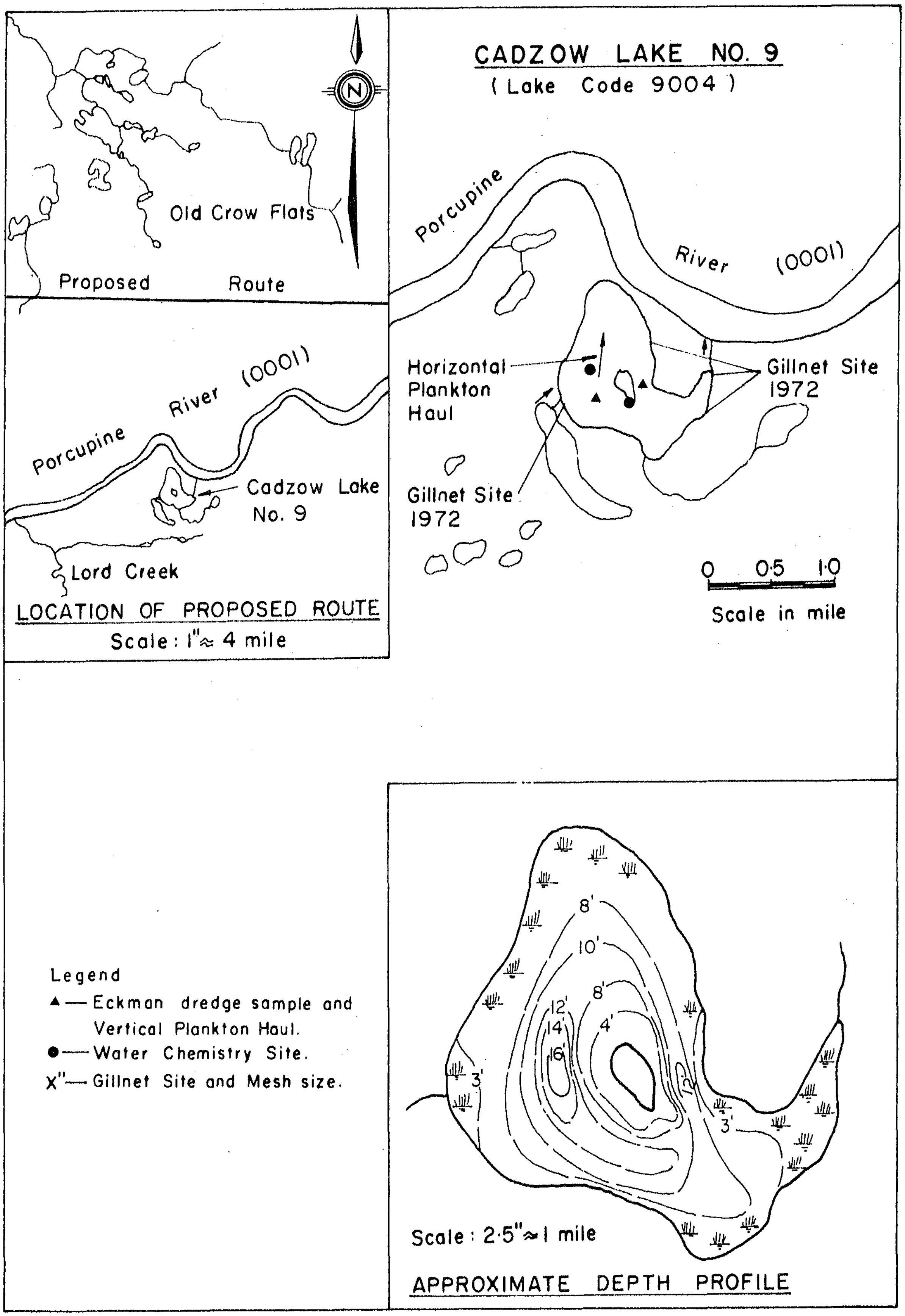
Heterocope septentrionalis +

Diaptomus pribilofensis +++

Cyclops scutifer +

Biomass

Copepods	(2.9640 + 306.8760)	=	309.8400 mgs
Daphnia type		=	48.852 mgs


CADZOW LAKE NO. 9
(Lake Code 9004)
Porcupine River (0001)
Horizontal Plankton Haul
Gillnet Site 1972
Gillnet Site 1972
0 0.5 1.0
Scale in mile
N
Old Crow Flats
Proposed Route
Porcupine River (0001)
Cadzow Lake No. 9
Lord Creek
LOCATION OF PROPOSED ROUTE
Scale : 1" ≈ 4 mile
Legend
▲ — Eckman dredge sample and Vertical Plankton Haul.
● — Water Chemistry Site.
X" — Gillnet Site and Mesh size.
8'
10'
8'
12'
14'
4'
16'
3'
12'
3'
Scale : 2.5" ≈ 1 mile
APPROXIMATE DEPTH PROFILE

7. LAKE #10

Station 1
2 vertical hauls (Depth 15')
August 13, 1973

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	540	0.525mm	90
Calanoid	390	0.675mm	85
Daphnia type	5010	0.85 mm	65
Bosmina type	850	0.325mm	70
Ostracods	--	--	--

Species

Cladocera	Copepods
+++ Daphnia longiremis	Diaptomus pribilofensis ++
+ Daphnia ambigua	Cyclops scutifer +++
+++ Eubosmina longispina	

Biomass

Copepods	(5.2380 + 7.3320)	=	12.5700 mgs
Daphnia type		=	159.819 mgs
Bosmina type		=	9.095 mgs

Station 2
2 vertical hauls (Depth 12')
August 13, 1973

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	144	0.525mm	80
Calanoid	36	0.85 mm	90
Daphnia type	1382	0.725mm	70
Bosmina type	672	0.325mm	75
Ostracods	--	--	--

Species

Cladocera

few *Daphnia middendorfiana*

+++ *Daphnia longiremis*

+ *Daphnia* ambigua

+++ *Eubosmina longispina*

Copepods

Diaptomus pribilofensis +

Cyclops scutifer ++

Biomass

Copepods	(1.3968 + 1.2708)	=	2.6676 mgs
Daphnia type		=	27.2254 mgs
Bosmina type		=	7.1904 mgs

Station 1
100' horizontal haul
August 13, 1973

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	440	0.555mm	75
Calanoid	130	0.755mm	80
Daphnia type	3720	0.725mm	60
Bosmina type	830	0.355mm	65
Ostracods	--	--	--

Species

Cladocera

+++ Daphnia longiremis

+ Daphnia ambigua

++ Eubosmina longispina

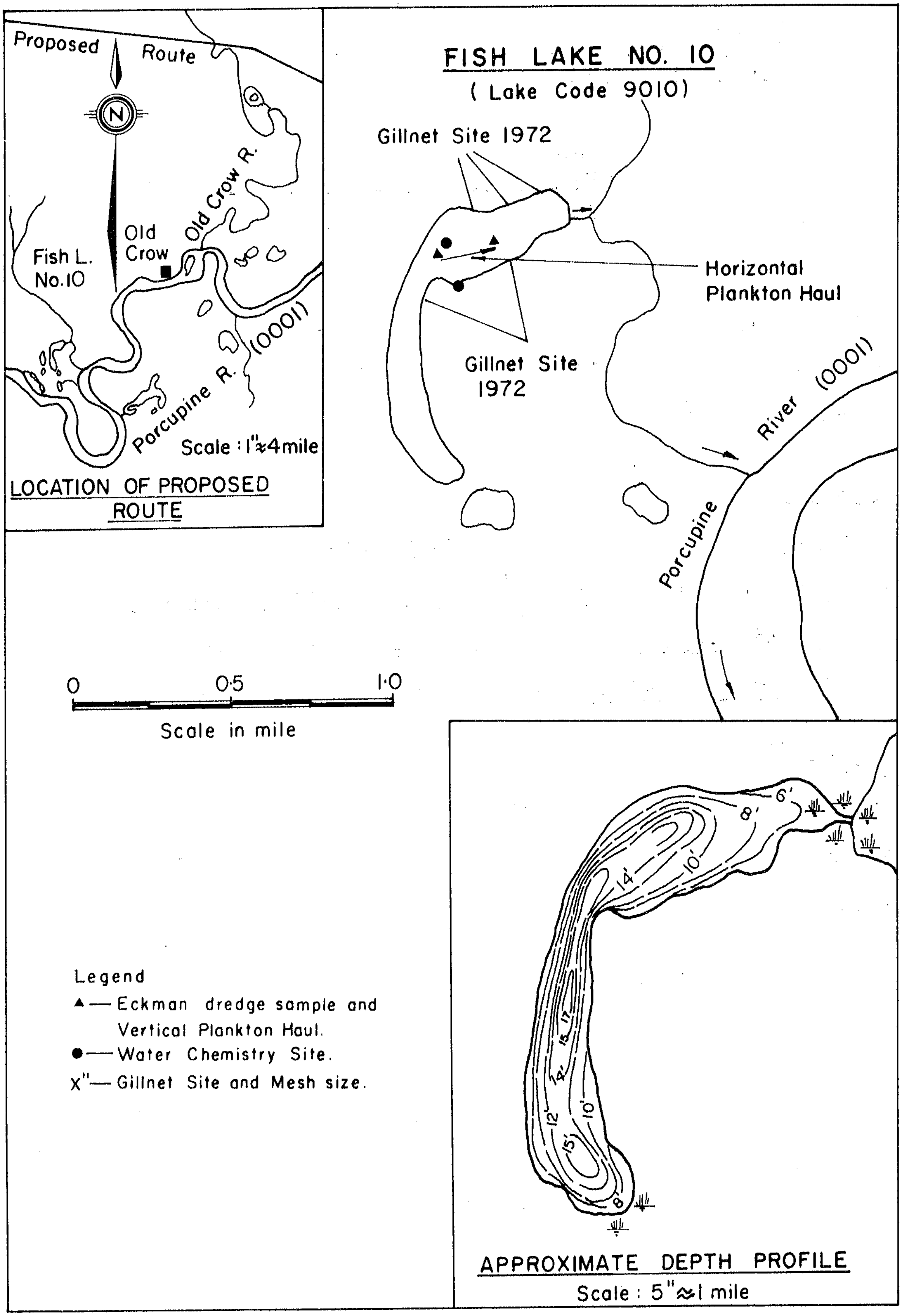
Copepods

Diaptomus pribilofensis +

Cyclops scutifer ++

Biomass

Copepods	(4.8400 + 3.3150)	=	8.1550 mgs
Daphnia type		=	73.284 mgs
Bosmina type		=	10.79 mgs


FISH LAKE NO. 10
(Lake Code 9010)
Gillnet Site 1972
Horizontal
Plankton Haul
Gillnet Site
1972
River (0001)
Porcupine
Proposed Route
N
Old Crow R.
Old
Crow
Fish L.
No.10
(0001)
Porcupine R.
Scale : 1"≈4 mile
LOCATION OF PROPOSED
ROUTE
0 0.5 1.0
Scale in mile
Legend
▲— Eckman dredge sample and
Vertical Plankton Haul.
●— Water Chemistry Site.
X"— Gillnet Site and Mesh size.
6'
8'
10'
14'
17
15
12'
10'
12'
15'
8'
APPROXIMATE DEPTH PROFILE
Scale : 5"≈1 mile

Appendix XI

Appendix XI Winter 1974. The total number, average size and percentage juveniles of plankton species, and the biomass of the sample taken from lakes along northern and interior pipeline routes.

Northern Route

1. BEAUFORT SEA - ¼ mile East of Shingle Point

2 vertical hauls (Depth 2' - 3')
March 30, 1974

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	6	0.525mm	--
Calanoid	--	--	--
Daphnia type	--	--	--
Bosmina type	--	--	--
Ostracods	2	--	--

Species

Cladocera

Copepods

Cyclops scutifer

Biomass

Cyclopoid = 0.06 mgs

2. LAKE #11

2 vertical hauls (Depth 7')
April 3, 1974

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	40	0.475mm	--
Calanoid	--	--	--
Daphnia type	90	0.425mm	--
Bosmina type	--	--	--
Ostracods	--	--	--

Species

Cladocera

Daphnia ambigua

Copepods

Mesocyclops inversus +

Cyclops scutifer ++

Biomass

Cyclopoid = 0.20 mgs

Cladocera = 0.37 mgs

Interior Route

1. LAKE #5 (Vunnutulka)

2 vertical hauls (Depth 7')
March 29, 1974
12:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid			
Calanoid		NOTHING FOUND	
Daphnia type			
Bosmina type			
Ostracods			

Species

Cladocera — Copepods

MISCELLANEOUS

March 19, 1974		No.
Dystiscidae		
Dystiscinae		
	Dytiscus sp.a	1

N.B. In species a, the posterior of hind tarsi does have cilia - but the beetle is far too large to fit the other half of the couplet, species b and c, found in LAKE #8.

2. LAKE #7

2 vertical hauls (Depth 17½')
March 18, 1974
13:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	--	--	--
Calanoid	--	--	--
Daphnia type	20	1.25 mm	--
Bosmina type	--	--	--
Ostracods	--	--	--

Species

Cladocera

Daphnia middendorfiana

Copepods

Biomass

Cladocera = 2.026 mgs

3. LAKE #8 (Chinneitlui)

2 vertical hauls (Depth 17')
March 18, 1974
17:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	--	--	--
Calanoid	--	--	--
Daphnia type	10	1.375mm	--
Bosmina type	--	--	--
Ostracods			
+ one Chaoborus larvae			

<u>Species</u>

<u>Cladocera</u>   <u>Copepods</u>

Holopedium gibberum

<u>Biomass</u>

Cladocera = 1.375 mgs

MISCELLANEOUS

March 18, 1974		No.
Dytiscidae		
Dytiscinae		
	Dytiscus sp.b	1
	Dytiscus sp.c	3

4. LAKE #9 (Cadzow)

2 vertical hauls (Depth 7' - 8')
March 16, 1974
15:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	360	0.625mm	--
Calanoid	--	--	--
Daphnia type	1580	1.65 mm	--
Bosmina type	--	--	--
Ostracods	--	--	--

Species

Cladocera

Daphnia middendorfiana

Copepods

Cyclops scutifer

Biomass

Cyclopoid	=	5.47 mgs
Cladocera	=	386.15 mgs

5. LAKE #10

2 vertical hauls (Depth 13')
March 21, 1974
11:00 hrs.

	Total Number	Average Size	Percentage Juveniles
Cyclopoid	1460	0.475mm	30
Calanoid	--	--	--
Daphnia type	900	0.775mm	40
Bosmina type	--	--	--
Ostracods	--	--	--

Species

Cladocera

\+ Daphnia middendorfiana

+++ Daphnia ambigua

Copepods

Cyclops scutifer

Biomass

Cyclopoid = 10.66 mgs

Cladocera = 20.25 mgs

C H A P T E R V

METHODS OF AGING FISH SPECIES COMMON TO RIVERS AND LAKES OF THE NORTHERN YUKON TERRITORY 1972 - 1974

by

F. Y. E. YOLE

for the

Environmental-Social Program
Northern Pipelines

Acknowledgement

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The author wishes to express an appreciation to L. W. Steigenberger, G. J. Birch and P. G. Bruce for conducting the field studies and collecting the data. The basis for this report and some of the information included herein have been extracted from the unpublished memorandum report by Birch and Yole, 1974. G. J. Birch deserves a special acknowledgement for initially providing inspiration, guidance and analysis of data forming the basis for this report.

Several persons aided in data collection including P. Nukon, L. Charlie, E. Peter, and many other residents of Old Crow.

L. W. Steigenberger and M. Elson reviewed the final manuscript. C. E. Walker and A. Gibson helped administrate the study.

1. Abstract

Studies were conducted to establish reliable criteria for the aging of fish species common to the northern Yukon Territory. Samples from the 1971 research study included fish from Porcupine River at Old Crow, captured from July to September. In 1972 and 1973 more detailed studies during spring, summer and fall provided data for comparisons of growth and development for various species at different times of the year.

Collections of data were concentrated on rivers, streams and lakes along the proposed pipeline routes. A large number of whitefish and Arctic grayling samples were collected for study. Smaller sized samples of other species, including salmon, were also collected.

Standard collection methods were developed to obtain the most preferred, readable scale samples from each species. New "preferred" areas for scale collections, in addition to those already established for salmonids, were tested. The preferred sites for scale collections on some species of northern fish are noted in the text.

To improve quality and readability in scale impressions, several cleaning and mounting techniques were tested. Soaking and cleaning the scales in a soapy solution was the most successful method. Equipment for processing and viewing the scale images, in both field and laboratory, were studied and evaluated. The large hydraulic press and modified Leitz projector gave a good quality of impression on acetate sheets.

Additional aging methods became available for study, with the collection of otoliths (ear bones) and opercular covers from fish samples. Otoliths provided ages for several species when scale samples were not practical or readable.

To date, criteria for aging scales of various fish species had been based on information from well known fish species only (i.e. salmon). Attempts to apply these criteria to the northern species resulted in reader disagreement and other inconsistencies. To establish a more reliable and therefore usable aging criteria, a number of factors were considered. Included were the size of fish at initial scale formation, the identification of the annulus or year mark on the scale, the designation of the best axis on the scale for scale aging, and readability comparisons with preferences for scales or otoliths of some northern species. Experience of the reader was found to be the most important asset in ascribing ages to fish species common to the northern Yukon.

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2. Introduction

The Department of Environment, Fisheries and Marine Service has conducted research since 1971 in the northern Yukon, under the auspices of the Environmental-Social Committee on Northern Pipelines. Data and sampling collection was limited to two main areas proposed to be affected by pipeline construction. All samples were collected with seine or gill nets.

In order to assess productivity and potential effects of pipeline construction and operation, it has been necessary to develop methods to age fishes from rivers of the north slope and Porcupine River drainages, using bony parts. To date, aging has been conducted solely upon scales and otoliths. The resulting information will assist in establishing a standard criteria for aging certain northern species of fish. Age determination and subsequent comparisons of growth rates will aid in assessing productive areas for fish populations.

The results and aging criteria included in this report concentrated primarily on Arctic grayling and round whitefish. However, additional information on other species in the study area is also included. Hopefully this information should be useful for other researchers involved in similar studies.

3. Methods

The following methods were employed for collection, preparation and aging of scales and otoliths, sampled from two main study areas, the southern interior pipeline route, including the Old Crow and Porcupine River drainages, and some north slope rivers, including Babbage, Trail and Malcolm, and some lakes.

Scales and otoliths will be discussed separately in this report.

3.1 Scales

3.1.1 Collection of scales

In 1971 and 1972 scales were collected in the field and mounted, sculptured side up on adhesive pages in numbered scale booklets. Two scales were collected from the left side of the fish using tweezers or a probe. The established area for scale collection for salmonids (Figure 1, site X) was used almost exclusively in sampling, for all species. There are some indications that this is not the best area for scale collection in all species. Alt (1969) and Cohen (1954) describe the preferred scale sampling location for whitefish as "an area midway between the lateral line and origin of the dorsal fin". Reed (1964) lists the preferred scale for the Arctic grayling as in "the third row along the lateral line directly below the origin of the dorsal fin". Re-establishment of new preferred scale collection areas is noted in Figure 1 for each group of species. Typical scale formations for each category are illustrated (after Birch and Yole, 1974).

In 1973 and 1974 a number of scales (6-10) were collected from the newly established "preferred area" for each group of species sampled (Figure 1). The scales were placed in numbered scale envelopes, to be cleaned, mounted and pressed in the Vancouver laboratory.

Additional studies have been attempted in the laboratory to select scale sampling areas on the fish, which exhibit earliest formation and characteristic scale development.

Using tweezers and a probe 5-8 scales were sampled from various test areas on the fish (Figure 2). Area A in front of the dorsal fin, Area B under the dorsal fin, and Area C between the dorsal and caudal fins. The equivalent areas below the lateral line were also examined (areas A_1, B_1, C_1) for general shape of the scale, size and compactness of nucleus, stage of annulus formation and total circuli count.

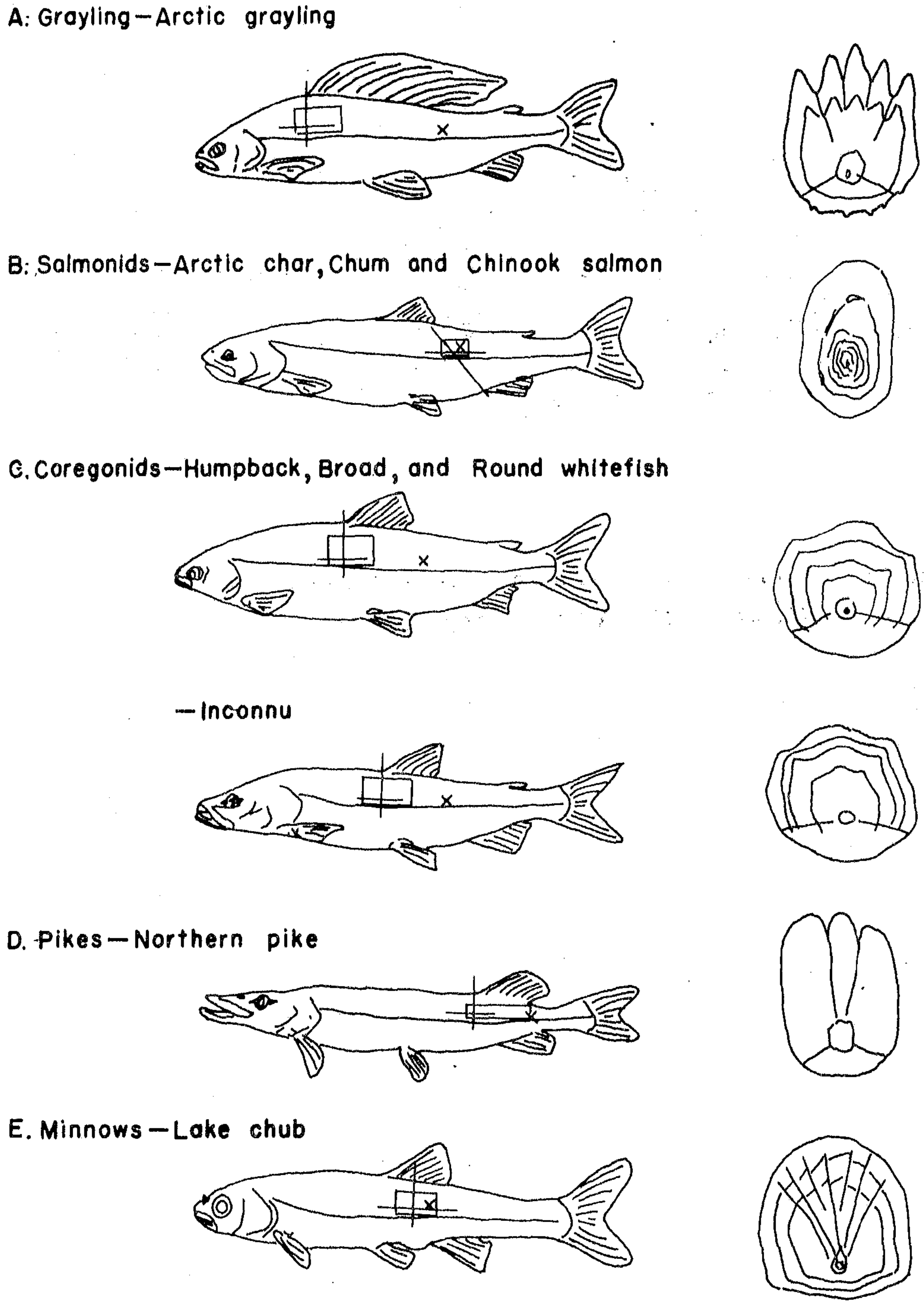

FIGURE I. Illustrations of common Arctic fish species with representative scale patterns. Scale collection areas for 1971-1972 (×) and 1973 (⊞) are noted. Drawings are after McPhail & Lindsey, 1970.
(from Birch and Yole, 1974).

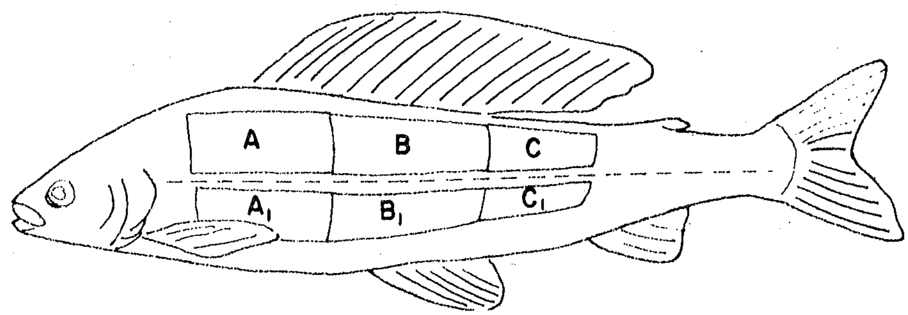

FIGURE 2 Detailed scale sampling areas studied.
Diagram after McPhail and Lindsey, 1970

The studies were directed to solving the continuing problems of:

- Regenerate or enlarged nucleus on the scale causing distortion of the first year growth and possible loss of the first annulus.
- Indiscriminate variance in general scale shape, occurring in some species and affecting accurate, standardized growth measurements and calculations.

3.1.2 Preparation of scales

The scales mounted in the field in 1971 and 1972 produced poor impressions on the acetate sheets. The excessive water caused streaking of the gummed scale cards, making a large number of unreadable impressions. In some whitefish and grayling scales, dirt and pigmentation adhering to the exposed portion of the scale (Figure 3) caused the anterior/posterior margin to be obscured. To improve quality of acetate impressions, 1973 and 1974 scales were collected in numbered envelopes, and cleaned thoroughly in the laboratory before mounting.

Some cleaning solutions were applied when pigmentation or surface dirt adhering to scales was evident.

(a) Acetic acid solution

A 20 percent acetic acid solution, buffered with baking soda was tested. Each scale was soaked in the solution for approximately one minute, rinsed in a baking soda solution 3-4 minutes, and rubbed between the thumb and forefinger to remove pigmentation and dirt.

(b) Soapy solution using an ultrasonic cleaner

An ultrasonic cleaner (Heat Systems Ultrasonic Inc.) was employed using a soapy solution for several minutes agitation.

(c) Mild soapy solution

Scale samples (6-10) were soaked in a petri dish 10-20 minutes using a mild soapy solution before cleaning between fingers, rinsing and mounting. Five good scales from each fish were selected from the cleaned scales, and mounted on gummed scale booklets, using a minimum of water, and discarding any regenerate scales.

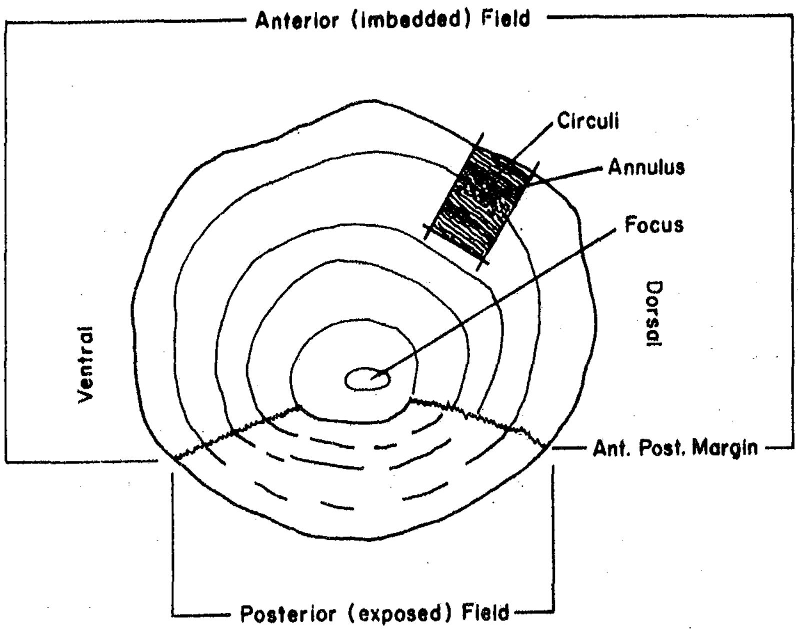

Figure 3. Diagramatic whitefish scale illustrating scale terminology

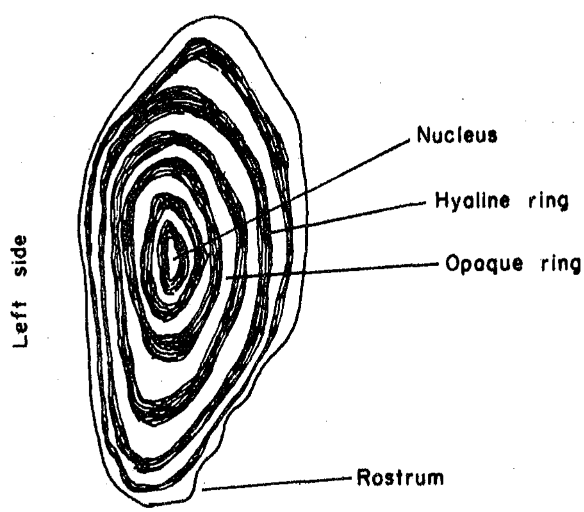

Figure 4. Diagramatic burbot otolith illustrating terminology (concave exposure)

3.1.3 Equipment for pressing and reading scales

(a) Hydraulic scale press

An hydraulic scale press initially designed by Clutter and Whitesel (1956), Koo (1962) and later modified by Ryan (1973) was used to make impressions of the scales for reading. Scales were placed between precision machined 10½" x 12" metal plates and pressed at a temperature of 110-112°C for five minutes, using 5000 pounds pressure. The metal plates were removed and scale cards allowed to cool. This equipment can process up to 6 scale books simultaneously. For details, consult Ryan (1973).

(b) Portable scale press

A small, one-card portable press was designed for field use (Ryan, 1973). Where electrical power for heat is available, the scale impressions are similar in quality to the larger model. Twenty foot pounds applied via a torque wrench to a screw jack on this model produces approximately 160 psi over the scale card. A fixed thermostat provides temperature control. Two minutes under pressure at 110°C produces good impressions.

(c) Scale projector

Scale reading or actual reading of scale impressions was conducted on a modified Leitz projector described by Ryan (1973). By varying the overhead mirror position, a wide variety of magnifications was possible. In general, 100X magnification was normally used; however, 250X magnification was used on smaller scales, and freshwater zones of the salmonids. Scale images were projected by the mirror onto a flat surface to facilitate reading and scale measurements. A quartz-iodide bulb provided the maximum quality of lighting required for effective contrast.

(d) Microscope

Both the Bausch and Lomb, and Nikon binocular microscopes have been used with limited success, to age scales of fish (i.e. chum salmon), primarily in field locations where immediate aging was required.

(e) "Microscan" (Microfiche Projector) and Microcom 1600 (Microfilm Recording Co. Ltd.)

The portable microscan has been used in the field for aging and identifying scales for some fish species. The equipment is basically a microfilm reader, modified by Ryan (1973) to utilize acetate scale impression sheets. Readings are conducted in a darkened room. The unmodified Microcom 1600 offers a brighter image, easily read in a lighted room. The 11½" x 15½" screen and floating 40X lens with constant focus are useful features.

3.1.4 Size of fish at initial scale formation

Results of the 1971 and 1972 data indicated that additional small fish in each species should be sampled. To establish length at initial scale formation and early growth patterns, Arctic grayling and round whitefish were selected from 1973 sampling. For aging comparisons, otoliths were taken whenever possible.

(a) Skin samples

Small grayling and whitefish were preserved in the field. Measurements and scale or skin samples were taken in the laboratory. Sections of skin from the "preferred areas" (Figure 1) were mounted on gummed scale cards and pressed. The results were not conclusive, as the impressions were not readable.

Another method involved skin samples, mounted between glass slides after the addition of a small amount of glycerine. This method was satisfactory for viewing under the scale projector. Skin pigmentation and early stages of scale development were clearly visible. The samples remained in satisfactory condition after several months.

(b) Scales

When scales were visibly formed on young fish, a smear was mounted on gummed scale cards. This method produces a good quality of readable scale impressions providing 5 or 6 scales from each sample can be examined, and are clear and well separated.

3.1.5 Aging scales of northern species (Appendix I)

(a) Identification of annulus

General patterns laid down by circuli are representative in scales of all species. Bands of circuli appear to be alternately widely spaced (in periods of rapid growth) or closely packed together, fragmented and irregular (in periods of slow growth). After one year's growth the term "annulus" is taken to mean the last circuli of the compact band of circuli, and is followed by a more widely spaced circulus of new growth (Bilton and Ludwig, 1966).

Identification of annuli in this study generally followed the criteria determined by Alt (1969) for inconnu (*S. leucichthys*).

1. "Cutting across must occur in the posterior-lateral radii (the last few circuli laid down at the end of the growing season are not complete in the posterior field). The first circulus laid down at the beginning of the new growing season, being complete, 'cuts across' the ends of these circuli.

2. "It must be possible to follow the first circulus of the new year's growth completely around the scale.

3. "There should be a definite break in the anterior field. The break is formed by irregularities in one or more circuli.

4. "There should be a clear unsculptured region in the posterior field (circuli laid down toward the end of the growing season are incomplete, resulting in unsculptured areas).

5. "Circuli laid down at the end of the growing season should be close together while those laid down at the beginning of the growing season should be far apart."

At least two of the above criteria should be present, to identify an annulus, with the first two noted as the most significant (Plate 1). In situations where two annuli were close together, the criteria for establishing an annulus (Alt, 1969) were always met.

The number of annuli, visible as crossover of circuli (Alt, 1969) at the anterior/posterior margin were interpreted as the scale age. Both ventral and dorsal fields at this margin were checked in aging. One field was usually indicatively more clear and defined than the other. False checks on scales from some species, caused by stresses on the fish during the growing season, are evident in the anterior portion of the scale. These checks do not circumvent the scale and therefore can be separated from the true annulus. Plus growth or circuli beyond the annulus around the periphery of the scale was not noted in the readings, or used in 1972, 1973 data assessments. However, it is an important factor to verify the true annulus, especially in young fish. Cooper (1951), Bilton and Ludwig (1966) state that the scale of fishes must grow anew before the annulus can be identified.

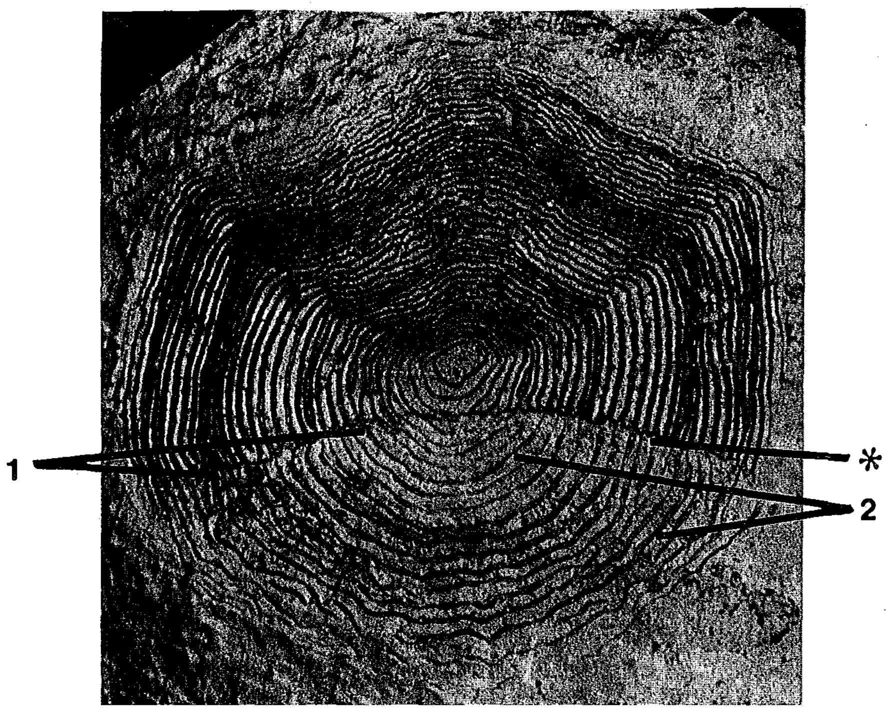

Plate 1. <u>Coregonus</u> <u>clupeaformis</u> scale aged 4 years, caught September 21, 1973, Porcupine River, Y.T., illustrating first two criteria established by Alt (1969) for annulus identification. (fork length 385mm)

1. "Cutting across must occur in the posterior-lateral radii..."
2. "It must be possible to follow the first circulus of new year's growth completely around the scale."

*- anterior/posterior margin

In the future, plus growth beyond the annulus should be used to assess growth patterns in some species, and differences occurring in scale growth within specific areas or sampling seasons.

(b) Circuli counts

(1) Number of circuli to first annulus

To establish the mean number of circuli formed during first year's growth, counts were completed on scale samples collected from Porcupine and Old Crow Rivers and some north slope rivers and lakes. Aged Arctic grayling and round whitefish scales were selected and circuli counted from projected scale images, at the anterior/posterior margin. Scales of various ages were selected exhibiting small compact nuclei, to avoid loss of the first two or three circuli due to regeneracy (Plate 2). Comparisons between counts from rivers and lakes in both sampling areas for the species sampled were attempted.

(2) Comparison between circuli counts at two different axes

The two main areas on the scale tested were:

- Anterior/posterior margin - as this axis projects an easily identified formation to facilitate the counts.

- A 45^{o} ventral axis - selected as it appears to indicate the typical wide (fast growing) and narrow (slow growing) circuli patterns more specifically, involving a higher number of circuli in most species.

Circuli counts were determined for 1, 2, and 3 year old Arctic grayling and round whitefish scales from the Old Crow and Porcupine Rivers.

(c) Spawning time and annulus formation

To determine accurate and meaningful ages of scales and otoliths of the various northern species, consideration should be given to:

(i) Position of the peripheral annulus on the scale and otolith

(ii) Plus growth beyond the annulus in relationship to:
- capture date
- time of annulus formation
- spawning time (spring and fall spawners)

The above factors must be assessed when assigning scale ages.

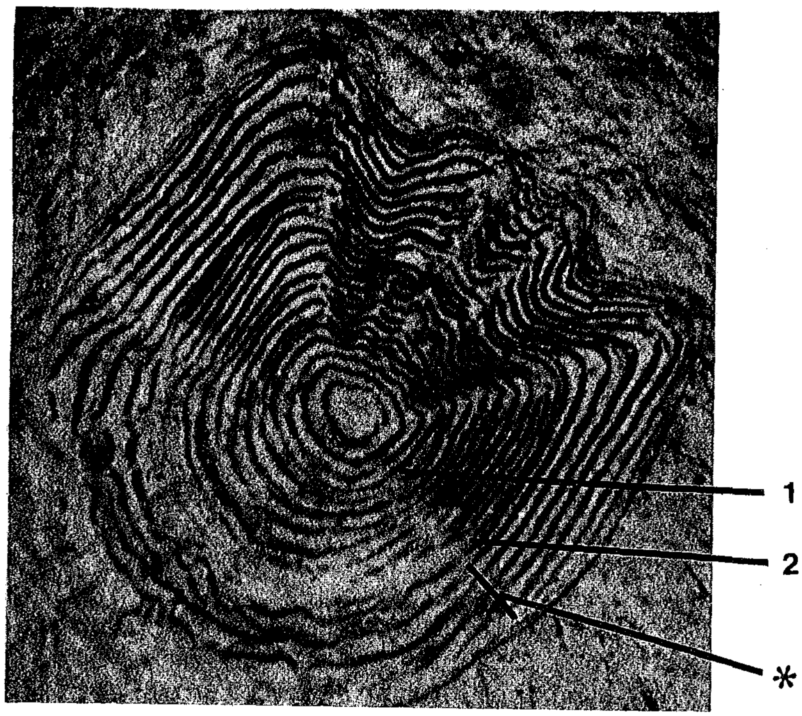

Plate 2. Scale of an Arctic grayling, aged 2 years, caught July 7, 1973, Trail River, Y.T. Nucleus of scale is slightly regenerate. First and second annuli are indicated, followed by good plus growth. (*). (fork length 186mm)

3.2 Otoliths

Scale sampling for age determination was extensively used during the 1971 and 1972 field seasons. In species with embedded scales (L. lota) and extremely small scales (S. alpinus) age determination using scales is impossible or inaccurate. Aging the otoliths of these species provides more accurate results and also gives a general verification to scale aging in other species. During the 1973 field season otoliths were therefore collected, in addition to scales.

3.2.1 Collection

Otoliths were collected by dissecting the head sagitally and removing the samples from the ear sacs. Although varying in position in some species, the otoliths can be quickly and precisely located after practice. Two otoliths were taken if possible. The samples were stored in numbered vials in a 50 percent glycerine and water solution to which thymol crystals had been added.

3.2.2 Preparation

After removing the outer sac surrounding each sagitta, otoliths can usually be read without any preparation. However, on certain species, opaqueness requires that the otoliths be ground to expose more clearly the centre and growth rings. Hand grinding, on a carborundum stone, was found too time consuming and ineffective; however, a method using a motorized grinder tool has been used successfully. Otoliths are first pressed securely on the concave side into a piece of plastercine, and then gently ground with an emery stone. Care must be taken not to break the sample, or destroy the thinner, outer edges of the otolith. A DREMEL (Model 280), fitted with a plain shaped emery wheel 5/8" diameter and 3/8" thickness provided dimensional control and was used for our samples. Pointed silicone grinding stones tend to embed bone matter on the grinding surface and are therefore not suitable.

3.2.3 Reading

For reading, the otolith is placed on a black background, moistened, and viewed through a dissecting microscope using reflected light. A Bausch and LOmb dissecting microscope (Model 31-26-84) with a 0.7X to 3X magnification was used. An American Optical Corp. Lamp (Model 370) directed a narrow diffused light beam onto the otolith.

Otoliths are characterized by a series of clear and opaque rings (Figure 4). The whitish opaque ring indicates increased calcification which occurs during the fast growth period (summer), while the clear hyaline rings result from less calcification and are laid down during the slow growth period (winter). In this report two methods have been used in assigning otolith ages to the growth rings.

For comparison purposes, the criteria described by Chen (1968) have been used to age the burbot (Lota lota). Chen interprets the opaque nucleus, the first hyaline ring, and the first opaque ring as the first year's growth. Each successive hyaline and opaque ring is considered an additional year of growth. Consequently, the first "year" is actually 14 to 15 months, and each successive growth period is slightly less than a year.

The more standard method of interpreting a year's growth from an otolith was described by Jessop (1972) for Prosopium cylindraceum, and Kelly and Wolf (1959) for Sebastes marinus. Assuming that the hyaline ring represents winter growth, and the opaque ring represents summer growth, then each pair of opaque and hyaline zones represent one year of growth, and the outermost edge of a complete hyaline zone can be regarded as an annual ring. Therefore, the hyaline zone in an otolith corresponds to the scale annulus. The otoliths of all fish species, except L. lota, were assigned otolith ages using the above criteria.

Upon inspection otoliths were discarded if found to be broken, calcified, or too opaque, after grinding. Otoliths were also discarded if a reader disagreement of two or more years in age assignment was noted.

Incomplete or false checks may occur in parts of the otoliths, so only complete circumventing hyaline zones are used to interpret an annual ring. It appears that the north slope fish populations may be better aged using otoliths, and the Porcupine River drainage populations frequently have otoliths that are too opaque (scales appear to be more easily read).

3.3 Reader agreement and scale/otolith comparisons

The lack of established aging criteria and differences in interpretation between scale readers initially created problems in assigning ages to scales from some northern species. Before attempting to age samples collected, available references were studied to obtain scale characteristics and possible aging criteria. Reader agreement tests were conducted to determine which scales were more difficult to age, and for which species otoliths would be more preferable.

The collection of otoliths was a definite asset for age verification. Although otoliths found in broad whitefish and inconnu were not reliable, most northern species indicated a significantly high agreement between scale and otolith aging. Young grayling, round whitefish and broad whitefish (aged 0+-2 years) clearly exhibit scale/otolith agreement in initial stages of growth.

3.4 Collection and aging of operculum

Due to reported problems in aging northern pike (*E. lucius*) by the traditional scale or otolith methods, attempts were made to age the species using the left opercle bone and rays from the left pectoral fin. The bony parts were dissected from a sample of fish and stored.

4. Results

4.1 Scales

4.1.1 Collection and preferred areas tested

The collection of five good scales from each fish usually gives at least one readable scale. In 1973 samples were collected from new preferred areas on most fish species (Figure 1). The established salmonid area for scale collection has been replaced for many of the northern fish. Further studies are required to locate the most symmetrical and fully developed scales for accurate readability. In 1974, to test other sampling areas, grayling and broad whitefish scales were selected from six areas on the body of each fish (Figure 2). Total readability of each sampling area was rated after the following considerations:

a) General shape of the scale -
   A - good, normal
   B - slightly misshapen
   C - elongated
   D - squashed (laterally)

b) Structure of nucleus -
   1 - compact and uniform
   2 - slightly enlarged
   3 - regenerate

c) Annulus formation -
   N - normal and easily identified
   P - poor, not evident

d) Total circuli count (number to 1st annulus plus growth) -
   Assuming the highest circuli count would occur at the most developed scale sampling area.

e) Total readability -
   + very poor
   ++ poor
   +++ readable
   ++++ best

The results (Table I) of scale sampling areas studied indicate that for grayling Areas B and B_1 under the dorsal fin and above or below the lateral line have the best general shape for scale measurements. The best nucleus appears to

Table I - Test for total readability of various scale sampling areas of Arctic grayling and round whitefish from the northern Yukon.

Thymallus arcticus - Fork length 100 mm (Age 1)
Coregonus nasus Fork length 82 mm (Age 1)

Observations	Areas above the lateral line A	B	C	Areas below the lateral line A_1	B_1	C_1
T. arcticus						
General scale shape	D	A	C	3	A	C
Nucleus	2	2	1	3	1	2
Annulus formation	P	N	N	P	N	N
Total Circuli	13	7+6	8+7	-	7+8	7+8
Total Readability	++	+++	++++	+	++++	+++
C. nasus						
General Scale shape	D	B	A	B	A	A
Nucleus	2	1	2	3	2	1
Annulus formation	not evident	not evident	not evident	not evident	not evident	not evident
Total Circuli	8	10	11	9	12	12
Total Readability	++	++++	+++	++	+++	++++

be on scales from Area C between dorsal and caudal fins; also, total circuli count is greater in this area, indicating earliest and best formation of scales. Annulus formation was not evident in scales from Area A.

In broad whitefish (Table I) Area C shows the best scale shape, above and below the lateral line. Scales sampled above the lateral line in Area C were slightly smaller in size than those sampled in Areas A and B. Scales from below the lateral line exhibit a more compact nucleus and a higher circuli count. Annulus formation was not evident in any area except Area C_1 (below the lateral line), where crossing over of circuli was beginning to occur at the outer edge of the scale.

Results indicate that more studies on larger sample sizes would be valuable in all species, to obtain the areas most significant for readable scale samples.

4.1.2 Preparation (cleaning solutions)

Three cleaning solutions were tested; the results follow:

(a) Acetic acid and baking soda

This method had some success, as it removed the difficult pigmentation adhering to the posterior portion of the scales, but it also partially disintegrated the circuli. When the scales were pressed, the clear contrast was lost and impressions appeared more indistinct.

(b) Ultrasonic cleaner

This method removed surface dirt only. Pigmentation remained, even after 5-10 minutes of agitation.

(c) Mild soapy solution

This was the most effective method for removing all dirt and pigmentation from the scales. After soaking for 10-20 minutes, pigmentation could be removed with a fingernail fairly easily. In removing pigmentation, care must be taken not to scratch the scale surface with tweezers or probe. Any scratches on the scale surface will be reproduced during pressing and interfere with the quality of impressions and thus the readings.

4.1.3 Scale pressing and reading equipment

(a) Pressing

The scale press, modified by Ryan (1973), has provided clear distinct scale impressions. Up to six cards can be pressed efficiently in one operation. Multiple copies of scale impressions can be made for cooperative research programmes. No deterioration in scale impressions has been observed after 14 years storage.

The smaller portable scale press has proved satisfactory in field locations.

(b) Reading

The modified Leitz projector used for scale reading in this report provides a large flat field for viewing, with minimum distortion. Adjustments to the overhead mirror and selection of various lenses provide different magnifications as required. The high contrast provided by the quartz-iodide bulb and special rotating microscope stage, enables readers to obtain scale ages, measurements and circuli counts with maximum efficiency.

The use of the microscope to age scales is limited, due mainly to low magnification. Its use was restricted to selecting good scales from regenerate samples before mounting on scale cards.

The microscan is useful for demonstrations and field studies where immediate aging is required. Use of this equipment requires a darkened room for viewing, magnification is limited, and focal control is poor. The Microcom 1600 provides a higher, more acceptable magnification (40X) enabling readers to age freshwater zones on salmon fairly easily. The simplicity of operation, accuracy and clear image produced in a lighted room, are desirable factors in this equipment. For circuli counts and measurements, however, the Microcom would not be as effective as the modified Leitz projector.

4.1.4 Size of fish at initial scale formation

In Arctic grayling, the smallest fork length at which scales were formed was 32 mm (Berry Creek, July 31, 1973) with an average of 4 circuli visible at 35-39 mm (Table II). No otoliths were located in any of the samples.

Table II - Early scale formation in Age 0+ <u>Thymallus arcticus</u>

Sampling Site	Date (1973)	Fork length (mm)	Number of Circuli	Otolith Age
Rat River (Tributary	1 August	26	0	*
		26	0	*
		26	0	*
		27	0	*
		29	0	*
		30	0	*
		31	0	*
lower Rat River	1 August	39	0	*
		44	0	*
		45	4	*
		47	4	*
		49	4	*
		49	5	*
Berry Creek	30 July	39	4	*
		42	0	*
		42	4	*
		42	poor	*
		44	4	*
		45	5	*
		45	4	*
		45	5	*
		48	5	*
		50	4	*
		65	8	*
	31 July	32	4	*
		35	4	*
		37	2	*
		42	4	*
		43	4	*
		43	4	*
		44	4	*
		45	4	*
		46	6	*
		48	4	*
		49	4	*

where
* attempts were made to collect otoliths but none were found.

Round whitefish (range in fork length 52-54 mm) had 3-4 circuli formed (Table III). Development of otoliths from round whitefish in this test indicates agreement with scale growth. Most samples were exhibiting the nucleus with additional plus growth, at the sampling times indicated (Table III).

Additional tests for other northern species, to establish lengths at early scale formation, would be an asset. The information would be useful for back calculations of the size of fish at emergence and growth curves.

4.1.5 Aging scales of northern species

(a) Identification of annulus

Alt's method of establishing annulus formation on scales of northern species appears consistent and more acceptable for aging. Criteria listed previously were used for all scale analyses in this report, dealing with northern freshwater species. In the lateral fields of the scale, both ventrally and dorsally, the crossover of circuli is usually evident.

Scale readers determined the exact annulus on Arctic grayling scales more easily at the anterior/posterior margin of the scale than in the anterior field. The circuli growth patterns associated with annuli formation are less evident in the anterior portion of grayling scales.

Scales from whitefish exhibited many false annuli in the anterior field. Over-aging was common when using this field for annuli counts. Scale/otolith comparisons verify this. Therefore, annulus identification based on crossing over of circuli at the anterior/posterior margin is recommended for reliable and consistent scale aging in most northern freshwater species.

(b) Circuli counts (grayling and round whitefish)

(1) Number of circuli to first annulus

In Arctic grayling the results of circuli counts at the anterior/posterior margin on scales collected at two sampling areas, the southern interior or the north slope rivers, creeks and lakes, are presented (Table IV).

Counts of the mean number of circuli from Arctic grayling are similar for samples taken from either the southern

Table III - Early scale formation in <u>Prosopium</u> <u>cylindraceum</u>. Age 0+.

Sampling site	Date (1973)	length	Number of Circuli	Otolith Age
Old Crow (seine 1)	27 July	52	3	-
		52	4	-
		53	3	-
		54	3	-
		55	5	-
		58	6	-
		59	5	-
		60	4	-
		61	5	-
		61	6	-
		61	5	-
		63	6	-
		64	6	-
		65	6	-
		66	7	-
		68	6	-
		52	7	*
		56	5	-
		60	-	0+
		61	6	-
		62	6	0+
		63	6	-
		63	7	*
		64	6	0+
		64	6	-
		57	-	0+
		60	-	0+
		63	-	0+

where
* attempts were made to collect otoliths but none were found

Table IV - Circuli counts from Arctic grayling scales collected in the two main study areas.

A. Rivers and Creeks

	Southern Interior	North Slope
	Old Crow River, Surprise, Potato and Schaeffer Creeks.	Trail, Malcolm, Crow and Babbage Rivers.
Sample Size	33	22
Mean	10.39	8.73
Standard deviation	2.52	2.29
S.E. of mean	.43	.49

B. Lakes

	Southern Interior	North Slope
	Tack Lake	Lake 1, Lake 2, Lake 3
Sample Size	19	11
Mean	9.63	6.55
Standard deviation	1.77	2.62
S.E. of mean	.41	.79

interior or north slope rivers and creeks. Scales of Arctic grayling laid down an average of 9 circuli in the first growing season. Grayling scales from the two lake areas tested indicate that samples from the southern interior route had a higher mean number of circuli. Lakes from the north slope appeared to have the lowest circuli count (6-7), which may be related to the timing of ice breakup and other factors affecting growth rates; however, there is no statistical difference in counts, which may be a reflection of the small sample size.

In round whitefish results of circuli counts at the anterior/posterior margin of scales from rivers and creeks in the southern interior route for 1972 and 1973 are presented below.

	May-June 1972 Old Crow River	April-Nov. 1973 Old Crow and Porcupine Rivers
Number of samples	20	20
Mean	9.5	8.00
Standard deviation	1.95	2.10
S.E. of mean	0.31	0.47

Mean number of circuli formed on scales in the first year of growth for round whitefish in the Old Crow and Porcupine Rivers averaged 8-9 circuli. Round whitefish samples were not available from the north slope areas to compare counts.

(2) Comparison between circuli counts at two different axes

The results of the number of circuli to annulus formation, on both anterior/posterior margin and the 45° ventral axes, are presented in Appendices II and III.

For Arctic grayling samples from Old Crow, the mean number of circuli to first annulus at the anterior/posterior margin on the scales of 1, 2, and 3 year old fish is 7.7±0.2, 13.7±3.6, and 10.0±2.2, based on a sample size of 3, 6, and 7, respectively. Results are within a 95% confidence interval with those counts determined at a 45° ventral axis. Although the grayling scales tested had significantly similar counts at both axes, the difficulty in establishing an annulus at the 45° ventral axes, compared to the anterior/

posterior margin, indicates the former to be a poor axis for counts and measurements.

In round whitefish circuli counts for 1, 2 and 3 year old fish from the Old Crow River had a mean number of circuli at the anterior/posterior margin of 7.9 ± 1.4, 9.0, and 7.7 ± 2.1 for a sample size of 15, 1 and 3 respectively. Counts at the 45^{o} ventral axis were higher in every case, although the upper limits of confidence interval showed an overlap between the two axes tested. However, these differences would not be significant as the increase in number of circuli at the 45^{o} ventral axis is probably a result of constriction between circuli at the anterior/posterior margin. The apparent differences between counts at the two axes could influence the results for calculations and measurements studies. Therefore, the best procedure for measuring growth patterns would be at the anterior/posterior margin of the scale. This would ensure standardized results in comparisons of northern fish species.

(c) Spawning time and annulus formation

When aging scales of northern species the position of the annulus and the amount of plus growth should be considered in relationship to the time of year the fish was sampled.

The scale age assigned should consider the plus growth formed past the last annulus. In some samples the plus growth indicates an additional year's growth, with the new annulus starting to form (crossing over of circuli) on the periphery of the scale. Fish collected in early July usually had sufficient plus growth on the scale to establish whether the annulus had been formed. However, it was observed that younger fish (i.e. grayling) often did not exhibit this annulus until late July or August. This apparent lag in the timing of annulus formation has been observed and is a source of speculation and error in all species of fish. Approximate timing of annulus formation and spawning times are listed in Table V. These should be noted and considered when aging each of the species in the northern Yukon.

Table V. Spawning times and periods in which annuli are formed for each species studied.

Species	Spawning Time	Annulus Formation
T. arcticus	May to mid-June	May-June, later in 1 and 2 year old fish
C. nasus	Early fall to December	June
C. clupeaformis	Early fall to December	May to June
C. sardinella	Fall, October to November	June to July
S. leucichthys	Late September to October	June
C. autumnalis	Late summer to early autumn	Mid to late July
P. cylindraceum	Autumn	May to June
C. catostomus	Spring	
E. lucius	Spring	June
C. plumbeus	May to summer	June-July
S. alpinus	Mid-August to September	Late spring, summer with younger fish
O. keta	October to November	Spring to summer
O. kisutch	November-December	Spring to summer
O. tshawytscha	Mid-August	Spring to summer

(From Birch and Yole, 1974)

4.2 Otoliths

4.2.1 Initial growth and development

Otoliths sampled from round whitefish (age 0+) from the Old Crow River during July 1973 exhibit early development of growth bands. A central nucleus, surrounded by plus growth was observed in fish measuring 52-63 mm fork length (Table III).

Evidence of otolith formation was not found in young grayling 42-65 mm fork length, although the same fish exhibited definite scale formation with 4-8 circuli. It is probable that the minute otoliths were lost during the dissection. The smallest grayling sampled exhibiting both scale and otolith growth patterns was 68 mm fork length (Blow River, July 1973) and one year old. Development of the otolith appears to be occurring initially in the top section, opposite to the rostrum (Figure 2). This specific growth has been observed while examining otoliths 0+ to one year old from samples of Arctic char found in the north slope rivers, and grayling from the Fishing Branch and Trail Rivers and Deep Creek, and whitefish caught in the Old Crow River in July 1973. Consequently, otolith aging was conducted considering the top section (opposite the rostrum) assuming it to be the most developed section of the otolith in northern fish species.

Otoliths from two year old Arctic grayling, sampled in July 1973, exhibited one hyaline band and a large amount of plus growth (Plate 3), or in some cases, two complete hyaline bands. Scales from these samples all indicated two complete annuli formed, with a small amount of additional plus growth. This would indicate that in small grayling the scale is further developed than the otolith up to age 2. Although stated additional studies should be conducted to completely clarify this point.

4.3 Reader agreement

In 1971, Fisheries Service sampled scales and otoliths from fishes of the northern Yukon. Problems were encountered while aging the fish in the Vancouver laboratory. From this preliminary work, a reference was compiled and reliability of scale and otolith aging methods were estimated according to percentage agreement between two readers (Table VI) (Peterson and Pope, 1971). Upon examination of the memorandum it became evident that the reader agreement for scales was usually less than 80 percent and only 3 species could be aged using otoliths. This prompted further studies in subsequent years.

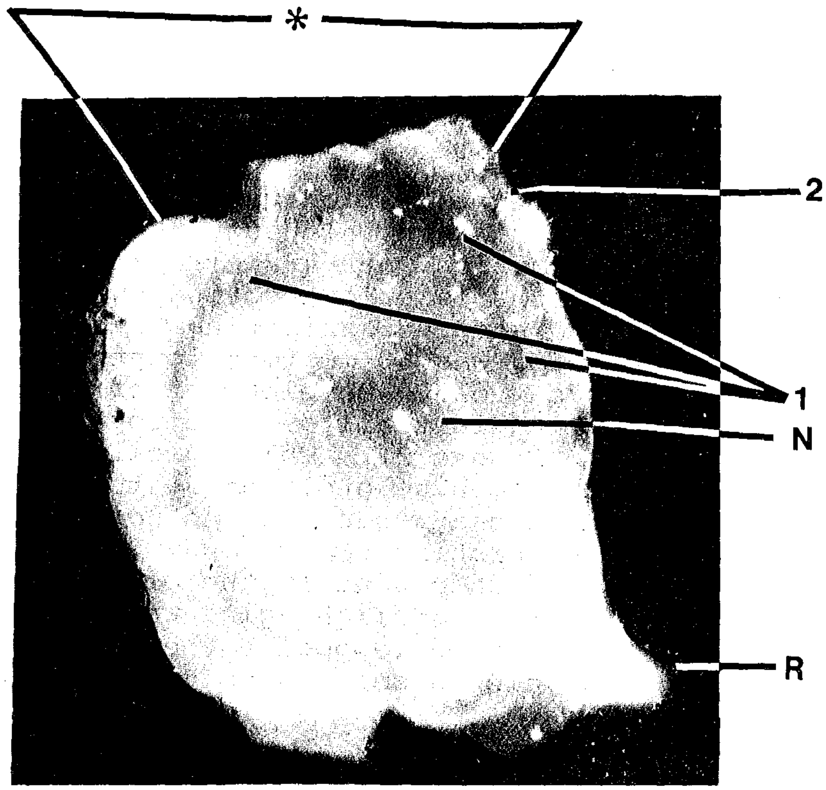

Plate 3. Otolith from young Arctic grayling (mag. X90), fork length 112 mm, caught July, 1973, Rapid Creek, Y.T., indicating the rostrum (R), the nucleus (N), first hyaline band (1) and good plus growth. Start of second hyaline band (2) is indicated in top section of otolith.(*) - Section of otolith where new growth initiates.

Table VI - Comparison of reader agreement and preferences for scales and otoliths of some northern fish species Yukon Pipeline Studies, 1971.

Species	SCALES Reader Agreement >90%	SCALES Reader Agreement 80-90%	SCALES Reader Agreement 60-80%	OTOLITHS Reader Agreement >90%	OTOLITHS Reader Agreement 80-90%	OTOLITHS Reader Agreement 60-80%	Ranked Preference Scales	Ranked Preference Otoliths
T. arcticus		+			+		1	2
C. clupeaformis		+					1	-
C. nasus		+					1	-
C. sardmella		+				+	1	2
S. leucichthys		+					1	-
E. lucius			+			+	2	1
C. plumbeus				+			-	-
O. keta							-	1
O. tshawytscha			+	+			1	-
O. kisutch			+				1	2
L. lota						+	-	1
S. alpinus				+			-	1

(from Peterson and Pope, 1971)

In 1972, reader agreement was tabulated for three readers (Table VII) and can be used to indicate those fish species having scales more difficult to age. The percentage of agreement between readers with the "established" scale age, was notably dependent on experience. Difficulties encountered by reader "C", in scale interpretation can be attributed to inexperience with northern species of fish common to the Yukon Territory.

Since compiling Table VI, when the salmon scales from the Yukon area were initially aged using the established salmon aging criteria, it has become evident that certain factors affecting scale age determination must be considered. Re-evaluation of these scales has significantly altered the data presented in Table VII. No longer is reader agreement for salmon 100%. The following considerations alter previous aging methods for scales of northern Yukon salmon:

- high resorption factor in spawning salmon
- cessation of growth during the last year.

Resorption or the breaking down of the salmon scale at the periphery, continues until the loss of one or two years' growth has occurred (Plates 4 and 5). This has been attributed to the long distances travelled by migrating salmon in the Yukon and Porcupine Rivers. This advanced resorption is more evident in northern salmon stocks than has been observed in salmon from more southern water bodies and must be assessed accordingly. Gilbert (1922) states that chum and chinook salmon from the Yukon River system often exhibit no growth during the year the fish were captured, the margin of the scale being formed by the close-ringed check of the previous winter. Scales from tagged salmon recaptured in the Yukon River system have also indicated this cessation of growth. After considering these two factors, chum and chinook ages were increased one year, although coho ages remained the same. When these factors are considered in future salmon scale analysis, reader agreement should approach 100 percent.

4.3.1 Scale and otolith comparisons

Preliminary testing as to the reliability and accuracy of scale and otolith aging has been conducted for Arctic grayling, and further comparisons should be completed for all the remaining species. McCart (1973, pers. comm.) states that otoliths are the more reliable and easier aging method for fish species from the rivers of the Yukon north slope. It has been observed that the otolith samples from this area are clearer for aging but tend to have greater numbers of annual rings than the scales from the same fish. This appears especially true in older fish. In the Porcupine River

Table VII - Comparison of reader agreement for scale aging of some northern fish species - Yukon Pipeline Studies 1972. (from Birch and Yole, 1974)

Scale reading tests between three readers (A,B and C) were conducted to establish a more consistent criteria for aging. Percentages indicate agreement between each reader with the established age*. Number of scales examined by each reader, indicated by (n).

Species	Number Readable Scales	Reader A		Reader B		Reader C	
		Percent	n	Percent	n	Percent	n
T. arcticus	228	81	224	85	228	39	195
C. clupeaformis	166	80	163	79	163	51	162
P. cylindraceum	24	42	24	100	24	42	23
C. nasus	165	92	165	88	164	45	160
C. sardinella	263	90	260	89	263	48	263
S. leucichthys	124	77	121	80	124	41	124
Hybrid	31	55	21	58	21	6	8
O. keta	12	(100)	12	(100)	12	(100)	12
O. tshawytscha	10	(100)	10	(100)	10	(100)	10
O. kisutch	5	(100)	5	(100)	5	(100)	5

where

- Scales were discarded when differences in assigned ages were higher than two years between any two readers.
- *"Established" scale age, when readers disagreed by one or two years, was assigned only after a fourth reading and unanimity between two readers.
- ( ) required explanation, see test, section 4.3.

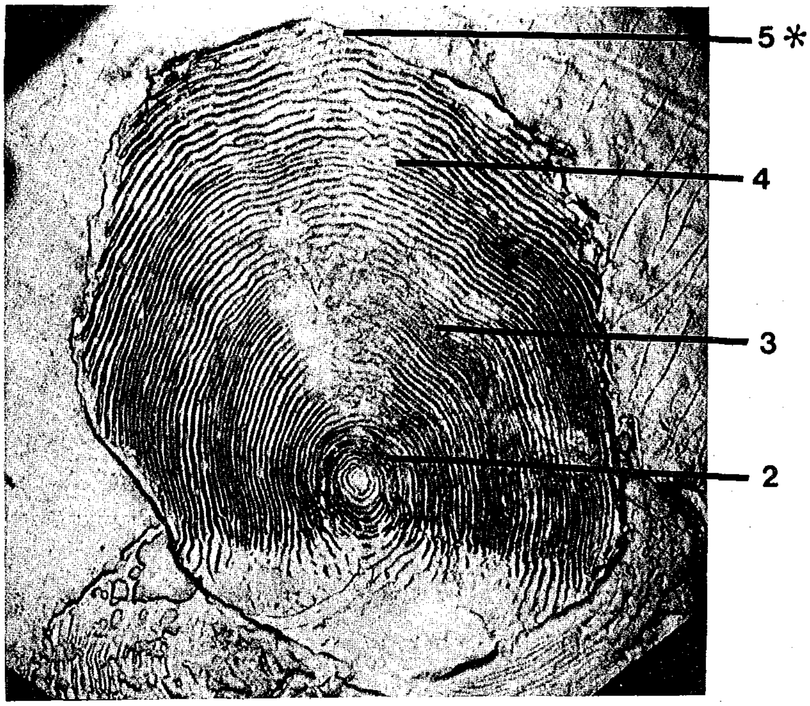

Plate 4. Chinook scale aged 5_2, caught Pelly River, July, 1973, showing high resorption occurring on outer edges of scale.(*)- 5th year resorbed.(fork length 743mm)

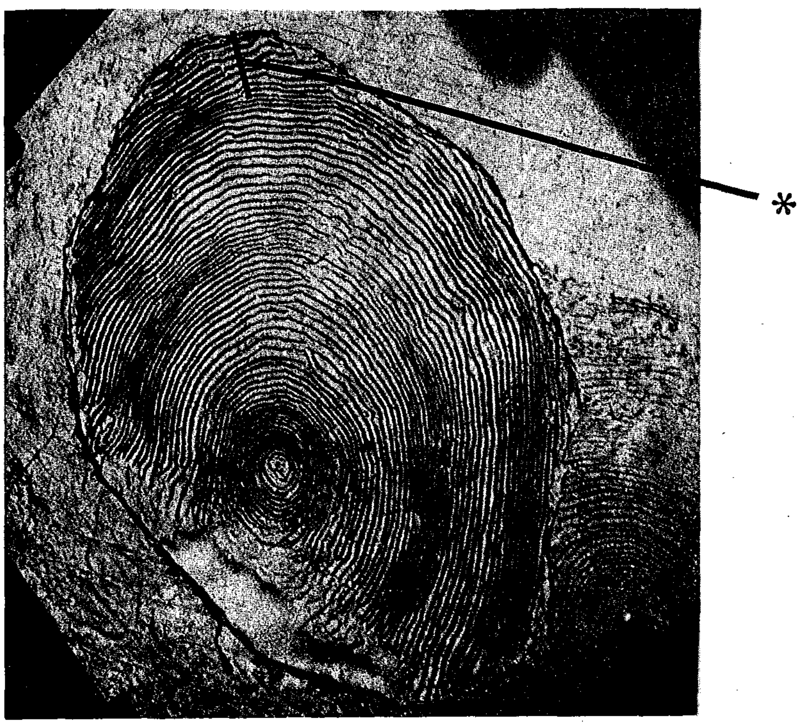

Plate 5. Badly resorbed chinook scale aged 5_2, caught Pelly River, 1973, indicating the loss of one full year of growth from the outer edge of the scale. Note large amount of plus growth in upper (anterior) section, indicating at least one year's growth past the last visible annulus.(*) - plus growth of 5th year.(fork length 788mm)

Plate 6. Chum scale aged 5 years, showing absorption of almost two full years growth from the periphery; caught Pelly River, 1973. Note false annulus (narrowing of circuli) in early growth of the scale.(*) - False annuli.
R - resorption of annuli.

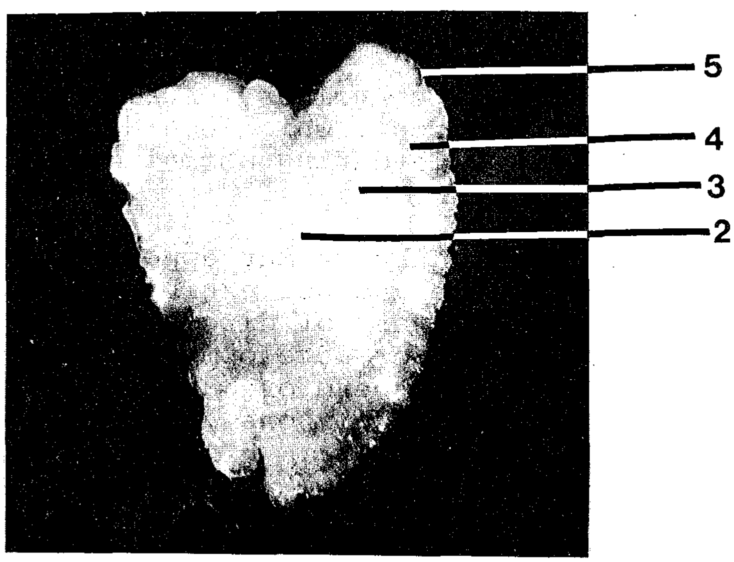

Plate 7. Chum otolith aged 5 years, fork length 650 mm, caught in the Old Crow River, clearly exhibiting growth bands.

drainage, it has been observed that the otoliths are often opaque and difficult, if not impossible, to read. In this area, scales are the preferred aging method, however, the species must also be considered. In addition, the development of sex organs and spawning activities appears to be a factor affecting otolith calcification. It has been suggested by Rollefsen (1935) that some of the annual rings in otoliths are caused by spawning in some species. In the future, information on spawning behaviour of fish must be considered as a factor which may alter the annulus formation in otoliths.

An initial comparison of scale and otolith ages for Arctic grayling from the Fishing Branch River has been completed (Bruce, 1974). The results indicate a probable relationship between growth rates determined from each method. "The otolith is 0.68 years older than the scale at any given age" (Birch and Yole, 1974). If this is true for other parts of the study area, then aging can be conducted using the more easily collected scales, while employing an additive factor to determine actual age. This information is speculative and requires further study.

It is felt that most of the discrepancies between scale and otolith aging in northern fish species are a result of two main reasons.

1. An indefinite first annulus on the scale. Readers may overlook the first annulus as it may not be evident. This may be caused by:

    - a regenerate nucleus, causing the loss of some circuli which would be laid down on the scale during normal growth (Plate 2);

    - the first annulus may appear as a slight disturbance and not exhibit a good "crossing over" of circuli during the early stage of development. The first annulus may therefore appear as a fragmentation of only one or two closely spaced circuli.

2. Interpretation of the last annulus formed on the scale.

   - Inexperienced readers may not assess the plus growth beyond the last annulus on the scale. It has been observed that fish from Fishing Branch River are subjected to water temperature levels not typical of other rivers in the northern Yukon. The interpretation of growth patterns on these scales and possible time lag in annulus formation may be attributed to this particular area, and not necessarily to other river systems.

5. Specific Results

5.1 Characteristics and readability of scales from northern species sampled, using scales and otoliths

5.1.1 Salmonids

(a) Aging northern salmon species

Scales of all salmonids are aged in the anterior field, with particular attention given to the anterior/posterior margin of the scale. The great distances spawning salmon migrate (approximately 2,000 miles) causes erosion and resorption of the outer edges of the scale, at an accelerated rate. One or more years' growth can be lost as a result. Thus, in determining scale ages from scales of these species, consideration must be given to this high resorption factor (Plates 4, 5, 6).

In comparing salmon scales from more southern waters, which show different growth patterns and resorption rates, the age from northern Yukon salmon scales is often underestimated by at least one year. Differences in agreement and related problems between scale readers can result, as has previously been discussed.

It is evident that experience in aging these scales is an all important factor, for more meaningful and consistent results. To standardize methods for dealing with this problem, the following considerations are suggested for aging salmon scales from the northern Yukon system.

Add one full year to scale age if an annulus is visible on the outer edge of the scale, or 3-4 circuli of plus growth are evident on any portion of the periphery. If the scale does not exhibit an annulus at or near the periphery, and if a large amount of plus growth (8-9 circuli) beyond the last annulus is visible, assume the annulus of that year has been resorbed, and fish is one year older than the total number of annuli counts. Care must be taken to check the periphery of the scale carefully for signs of partial or broken annulus formation.

Koo (1962) notes that "incidental or false checks instead of genuine annulus on salmon scales can occur with no definite criteria to separate the two" and that "personal interpretation is applied in doubtful cases". Gilbert (1913, from Koo, 1962) states "a considerable experience is requisite for correct interpretation in many cases". Similar problems occur in the scale aging of other northern species of fish, indicating the necessity of experience in providing accurate age determination.

It is suggested that whenever possible (i.e. chum salmon) otoliths should be taken, to verify the scale ages assigned, particularly in cases of advanced resorption.

There is much more information available for the aging of salmon species than has been presented in this paper. Although many of the references have been concerned with salmon from more southern water systems, it was felt the basic criteria was of value in aging the northern salmon stocks.

(1) Chum salmon - Oncorhynchus keta

Chum scales are perhaps the most easily read salmonid scales encountered. Migration to the sea occurs during the first year, and as a result, the first annulus occurs after some sea growth.

Incidental checks occur in the freshwater growth but these should not be mistaken for annuli. The greatest percentage of chum salmon of the norther Yukon spawn in the Fishing Branch River. The fry emerge in a groundwater area before breakup. It appears that a slight check is formed at the time the fish migrate downstream, out of the groundwater spawning area. Another check is often formed when the chum salmon reach the productive sea water.

Occasionally these false checks have been observed in otoliths as well (Birch and Yole, 1974).

Resorption and erosion are common along the margin of the scale, and should be considered in aging (Plate 6). For best results aging should be conducted in the anterior field.

The otoliths from chum salmon are easily read, verifying the total age (Plate 7). This is important when the scale is badly resorbed. Chum salmon taken at Old Crow were usually four or five years of age. Sample size was approximately 50 chum salmon.

(2) Coho salmon - Oncorhynchus kisutch

Coho salmon scales are fairly easy to read, the annuli being clearly indicated, especially in the anterior field. The annuli are identified by a few broken, closely spaced circuli. In aging coho salmon scales, it has been observed that these fish usually spend one year in the ocean. Coho fry can remain for one full year in fresh water and migrate to sea early in the second year of life, or remain two full years in the fresh water and migrate in the third year of life. It is possible that the amount of growth attained in the early stages of the fish's life affects the time of its migration.

According to the Gilbert-Rich formula for aging salmon scales, the fresh water growth would be signified as either a sub"2" or sub"3" in each case, dependent on length of time spent in fresh water. Marine growth is shown as one additional year, making a total age of either 3_2 or 4_3. These ages were assigned to the 7 coho salmon caught in the Porcupine River.

As the focus of coho salmon scales is often regenerate it is important to collect enough scales from each fish to ensure obtaining a scale with a readable focus. It is suggested that 5 or more scales be taken.

The first annulus may occur after only eight circuli in coho from the Yukon River systems. Very little growth occurs after the last freshwater annulus, during the downstream migration. This is not consistent with coho from more southern waters which have scales showing 14-16 circuli formed during first year of growth.

To date the otoliths from coho salmon are very opaque and have not been used satisfactorily for aging.

(3) Chinook salmon - Oncorhynchus tshawytscha

Chinook salmon scales are the most difficult to age of all the northern salmon species, although the marine annulus is usually distinctive and easily defined. False checks may be prevalent in the anterior field of the scale and must be separated from the true annulus. The high resorption rate common in scales from the northern Yukon areas must be assessed during and prior to aging (Plates 4, 5).

Chinook scales from the northern Yukon illustrate that this salmon migrates to sea during its second year, having spent one full year in freshwater. Climatic conditions and the distances to the marine environment may be contributing factors that influence the growth patterns on chinook scales. The nucleus of the scale is usually small and compact, and the circuli are not as broken or widely spaced as in coho salmon scales. Unlike other salmon scales, the chinook should be aged in the lateral, in addition to the anterior field of the scale. Scale age of the chinook salmon sampled in Porcupine River near Old Crow ranged from 4_2 to 6_2 years of age (Gilbert-Rich formula for aging). Data was based on a sample size of approximately 12 fish captured from this location.

Chinook otoliths have not been aged successfully, due to opaqueness, even after grinding. Studies being conducted using a form of staining (i.e. fluorescene) to emphasize the annuli may prove effective in the future.

(b) Arctic char - Salvelinus alpinus

The oval Arctic char scales from the northern Yukon are perhaps some of the smallest salmonid scales collected. Circuli are fine, and tend to be broken and overlap frequently. Breakage is common and should be more apparent in the more compressed lateral fields. Due to the small size, the scales are very difficult to mount individually. Mounting a smear is more realistic. A 250X magnification was necessary to successfully read the scales.

Arctic char scales are usually aged in the anterior field where annuli are marked by closely spaced, excessively broken and overlapping circuli. The first annulus in Arctic char scales is located within five to eight circuli of the focus. The small scale size tends to cause crowding of annuli. Arctic char can be old (greater than 10 years), and as a result, the scale age tends to be underestimated as to the actual age of the fish (Birch and Yole, 1974).

The otoliths of Arctic char are more easily read and provide a more accurate and reliable aging method. Some otoliths exhibit very opaque centres, however, since the char is a slower growing fish, the growth bands are quite distinct (Nordeng, 1961). Readings are frequently more successful on the rostrum, but the reader should also use the regions lateral and posterior to this projection. A total of 19 char samples were examined during this study.

5.1.2 Arctic grayling - Thymallus arcticus

The grayling scale exhibits three or more prominent ridges in the anterior field and frequency ctenii (teeth-like projections) on the posterior edge. The circuli are thick and give good contrast when projected.

Aging is determined in the lateral field at the margin between the exposed and embedded portions. Thorough cleaning of these areas is necessary to facilitate this. The annulus is characterized by closely spaced, broken circuli and over-lapping (cutting across) at the margin or at least in the lateral fields. This is usually followed by a thick complete circulus which continues through all four fields. Scales from Old Crow area illustrate this. Many Arctic grayling scales sampled from the north slope exhibit a broad clear band, or absence of circuli at forming of the annulus (Plate 8).

False checks, although not frequent, do occur. These checks can be distinguished as they are not evident in all fields.

Grayling scales are difficult to age in fish over five years. Growth is slower and the annuli are narrower and crowded together. False checks may be more frequent. The result is that the greater percentage of older fish have scales that are unreadable. The annulus appears to be laid down in July in the first year and earlier in each successive year. The first annulus may appear after only four or five circuli and therefore even a partial regeneration could eliminate the first annulus (Plate 2 and Table I, fish 1, Area A). The number of circuli developed on the scale to the first annulus has been sampled for grayling of different ages (Table IV). A total of more than 800 grayling provided data for this report.

The otoliths are easily read in the areas posterior and lateral to the rostrum without grinding.

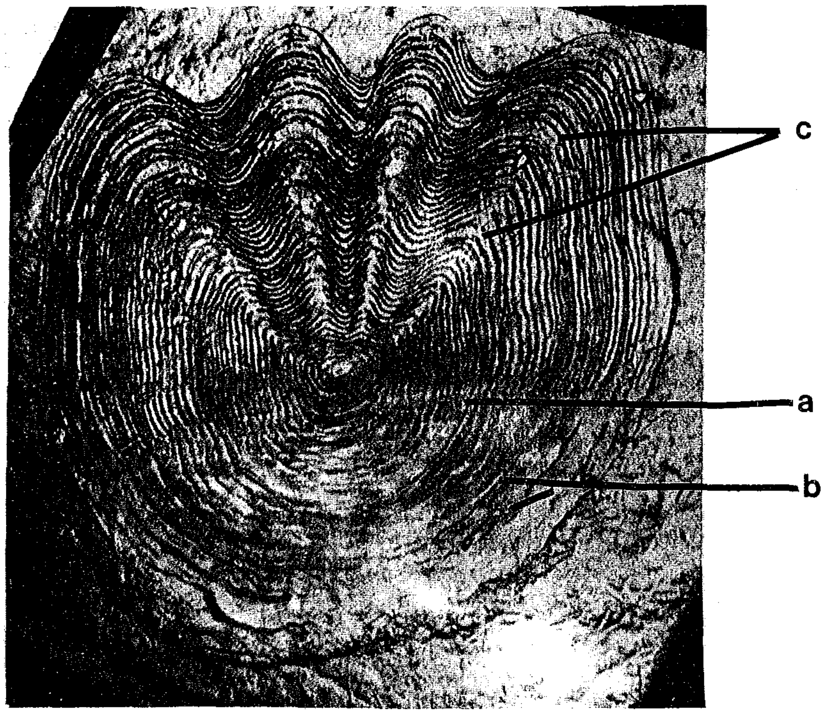

Plate 8. Arctic grayling scale, caught in the north slope, Y.T., indicating: (fork length 333mm)

a) crossing-over of circuli at anterior/posterior margin
b) annuli patterns continuing in posterior field for identification
c) clear areas (absence of circuli growth) in the anterior field

5.1.3 Whitefish - Coregonidae

All whitefish exhibit the same scale shape (Figure 3). No ctenii are present in the posterior field, and only two laterally positioned ridges are found in the anterior field. Occasionally a central incomplete radius may be found in the anterior field (Plate 1).

Coregonids are fall spawners and, therefore, the first annulus may be as close as four circuli from the focus. As a result, the first and second annuli can be distinguished by a definite circuli overlap at or near the anterior/posterior margin rather than another axis in the anterior field. Spawning checks have been reported to regularly occur in whitefish scales (Hogman, 1968, 1970) but have not been observed in this study. If the criteria (Alt, 1969) are followed, spawning and false checks should be eliminated. In older fish annuli crowding due to decrease in growth and lack of annulus formation is reported to occur (Hile, 1970).

(1) Broad whitefish - <u>Coregonus nasus</u>

Broad whitefish have the largest scales for any given age, of all whitefish sampled in the northern Yukon. Circuli patterns are definite, and laid down alternately in bands of widely spaced circuli followed by narrow bands of more closely spaced circuli. Fragmented circuli occur in the anterior field. Annuli are identified in the ventral or dorsal field at the exposed/embedded margin of the scales (Alt, 1969).

Otoliths are frequently very calcified and opaque, especially in the centres. Broad whitefish otoliths are also brittle and tend to break on grinding. Otoliths from young broad whitefish (age 0+) captured in Old Crow River 1973, were more opaque than similarly aged Arctic grayling, and did not exhibit any definite nucleus, or growth bands at this stage of development. However, otoliths from three year old broad whitefish show widely spaced growth bands, formed in the first three years, which would indicate a fast growing period. Following this pattern, as the fish grows older (i.e. observed on 5-6 year old fish), growth bands are closer together, causing some difficulty in aging. For this report more than 80 samples of broad whitefish were studied.

(2) Humpback whitefish - Coregonus clupeaformis

Scales of the humpback whitefish illustrate typical characteristics of the species. Circuli may be more broken in the lateral fields than broad whitefish. False checks are more frequent and annuli formation not as evident. Circuli and annuli formation in the posterior field is not clearly visible. To age humpback whitefish, special care must be paid to the cutting across of circuli and the circumventing circuli of new growth. Establishment of annuli is usually more evident in one lateral field than the other, and care should be taken to observe both ventral and dorsal fields before making a final decision of age assignment.

Otoliths of humpback whitefish are usually very opaque and most require grinding to clarify the growth bands. More than 500 humpback whitefish samples were studied for this report.

(3) Least cisco - Coregonus sardinella

The scales of the least cisco are typically whitefish-like in shape and appearance, but are the smallest of the coregonid scales. The annuli are interpreted using the standard criteria (Alt, 1969). The cutting across of the circulus in the lateral fields is necessary in identifying the annulus. The first annulus is often close to the focus of the scale. The first two or three years of growth in least cisco tend to be made up of thicker, more closely spaced circuli (Plate 9). The older ciscoes have less contracted circuli patterns. Fragmented circuli in the anterior field may be laid down during summer growth.

The least cisco scales are characterized by a great variation in the amount of growth per year. This pattern probably reflects the interchange from lake to river habitats and, subsequently, the change in availability of food sources.

Otoliths from least ciscoes can be opaque, but dark hyaline bands are usually evident, allowing aging without much difficulty. Otoliths sampled from the Spring River estuary and Lake #2 on the north slope of the Yukon (Plate 10) were easily read, whereas those from Porcupine River drainage (July 26, 1973) were more calcified and difficult to age. The otoliths from least cisco are brittle, and breakage often occurs during grinding.

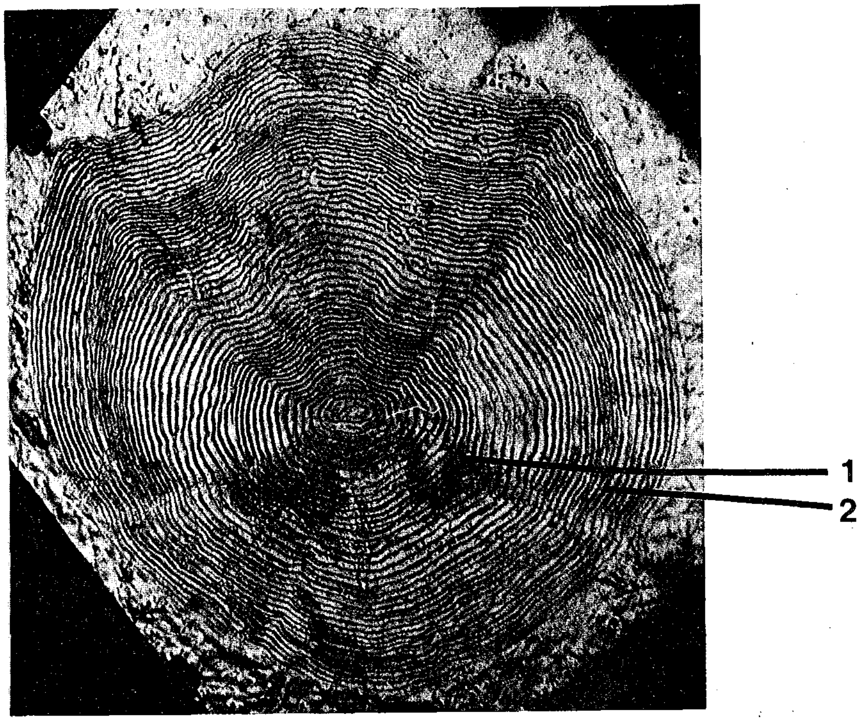

Plate 9. Coregonus sardinella scale, aged 2 years, caught Old Crow River, September, 1973. Note large amount of summer growth past last annulus on scale.

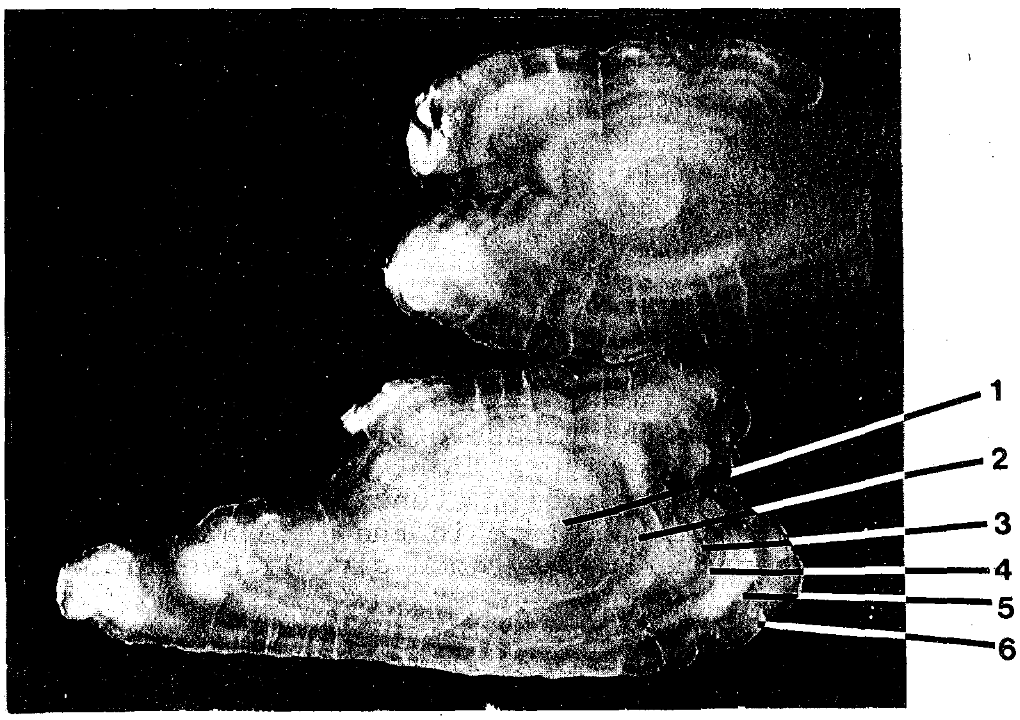

Plate 10. Otoliths from Coregonus sardinella, aged 6 years, fork length 323 mm, captured July, 1973, Cold Lake, Y.T. (Lake Number 2). (fork length 144)

False checks have been observed on scales and otoliths from six year old ciscoes captured in July, 1973 from Lake #2 occurring in the fifth year of growth. This disturbance could be attributed to the time of sexual maturity in this species. Samples of least cisco collected by Hatfield et al (1972) were all sexually mature at five years of age. The data for this report was compiled from approximately 500 samples of least ciscoes.

(4) Inconnu - Stenodus leucichthys

The inconnu scales were successfully read due to Alt's (1969) comprehensive description of aging methods. The scale is whitefish-like in appearance, although more rounded and with less definite lateral ridges. The circuli and annuli give a lighter scale impression on acetate sheets, but are clearly visible in both the exposed and embedded portions of the scale. Usually one lateral field may be more easily read than the other.

False or spawning checks appear fairly frequently on inconnu scales. The lateral area where the circuli overlap indicates an annuli. The annuli usually continues into the posterior field to establish verification. More than 200 inconnu samples were studied from the 1972 to 1974 data collections.

The otoliths, especially those from the Porcupine River drainage, tend to be small and very opaque. Grinding is difficult due to the brittle nature of the otolith. Very often it is impossible to grind the otolith thin enough to age.

(5) Arctic cisco - Coregonus autumnalis

The Arctic cisco is an anadromous fish that was collected in estuaries of the Beaufort Sea. The typical Arctic cisco scale is smaller than those of most other whitefish species, and the circuli give a light impression on acetate, although they are usually clear, even in the posterior field. The circuli are usually complete in the lateral fields and the annuli are characterized by good circuli overlap.

The Arctic cisco appears to be a slow but steadily growing species, with the first annulus close to the focus. Unfortunately, the centres are often poor and may be slightly regenerate. This could force elimination or misinterpretation of the position of first annulus. Scale samples collected in mid-July from the mouth of Spring River (less than five years of age) tended to be underaged by a year when compared to the otolith ages. Samples older than five years were more accurate. It appears that fish less than five years old develop the otolith annual ring earlier in the season than the scale annulus. Most of these otoliths are fairly easy to read, and frequently the left side of the rostrum had growth rings more clearly read. A sample size of less than 30 Arctic ciscoes provided data for study.

(6) Round whitefish - Prosopium cylindraceum

The round whitefish scale is characterized by very fragmented bands of broken circuli representing winter growth. The scale may also be characterized by a section of finely broken circuli, occurring between the shoulders of the anterior field, on both sides of the longest axis. Fragmented circuli are also indicative of the frequent false or spawning checks present in the anterior field. Often there is a false check for every annulus in this field. Extensions of the annuli are clearly present in the posterior field. Therefore, aging is done in the lateral to posterior field. Overlap of circuli is the primary criterion used.

The nucleus of the scale in this species is usually well formed, and the completed circuli tend to be closely spaced and thick. Slight regeneration can occur, though, and one should watch for the elimination of the first annulus (Plate 11). Analysis of data included over 400 samples of round whitefish.

Round whitefish otoliths are smaller in size than those from similar aged least ciscoes, but are usually easily read without grinding.

5.1.4 Longnose sucker - Catostomus catostomus

The cycloid sucker scales have very fine "spiderweb"-like circuli which are transected by many radii in the anterior and posterior fields.

Young suckers sampled from the Old Crow River in July, 1973 (fork length 80, 81 mm) had scales exhibiting circuli growth and one annulus (age 1+). Otoliths were not collected on these samples.

Reader agreement was found to be very poor on older fish and the samples were finally omitted from the data. Stein et al (1973) has suggested that fin rays may be a more successful aging technique for this species. Approximately 15 longnose suckers were included in the sampling data.

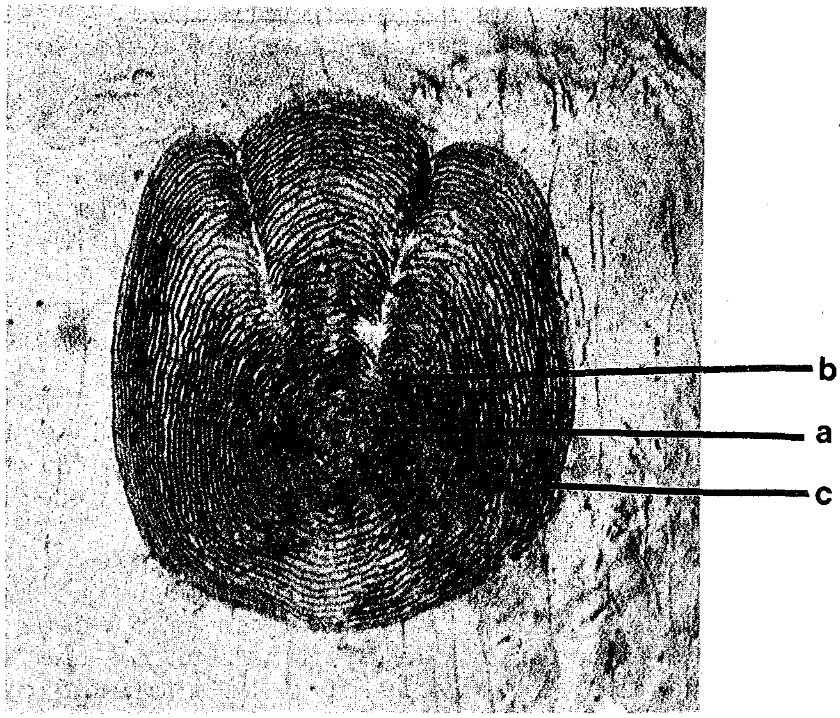

Plate 11. Prosopium cylindraceum scale aged 2 years, captured Potato Creek, July 26, 1973.

5.1.5 Northern pike - Esox lucius

The pike scale has three or more very prominent ridges in the anterior field separated by two or more deep radii, and is characterized by fine, evenly spaced circuli. The scale nucleus is not easily defined and is surrounded by a large area of criss-crossed lines. It appears that some researchers have designated this area to be the extent of first year's growth. However, a sample of twenty-three young pike captured in October 1972, ranging from 100-185 mm fork length, were examined for scale formation. All scales displayed circuli formation developing at the outer edge of the "criss-crossed" area. Most of the scales exhibited this circuli growth pattern to the outer edges of the scale, while others had similar circuli growth becoming more closely spaced with a crossing-over of circuli (start of annulus formation) near the edge of the scale. It was assumed then, that these were fish of the year and therefore the "criss-crossed" area near the nucleus is only a segment of initial scale development and does not indicate the first annulus (Plate 12). The first annulus on pike in general then is distinguishable only after definite circuli growth patterns have occurred. Variable densities on the pike scale are often misleading, some areas being too dark to accurately age.

Usually, closely spaced circuli and overlap at the anterior/posterior margin before and after these circuli, indicate the position of the first two or three annuli. Occasionally annuli are characterized by light bands (less dense areas) on the scale. False checks, which are very difficult to distinguish from annuli, and crowding of circuli after the third or fourth annulus results in an overestimation of age in old fishes. Readings, therefore, tend to be inaccurate. A sample size of over 180 pike were examined during this study.

The otoliths are small and very opaque, but with careful grinding can be successfully read. Otolith age is believed to be more accurate than scale age. Some work is being attempted to age pike using opercle bones.

5.1.6 Lake chub - Couesius plumbeus

These cycloid cyprinid scales are characterized by a wedge-shaped angle at the margin between the exposed and embedded portions of the scale and radial grooves in the anterior field. The circuli are fine but still provide clear impressions. Difficulties in reading these scales make aging difficult and not very reliable in this species.

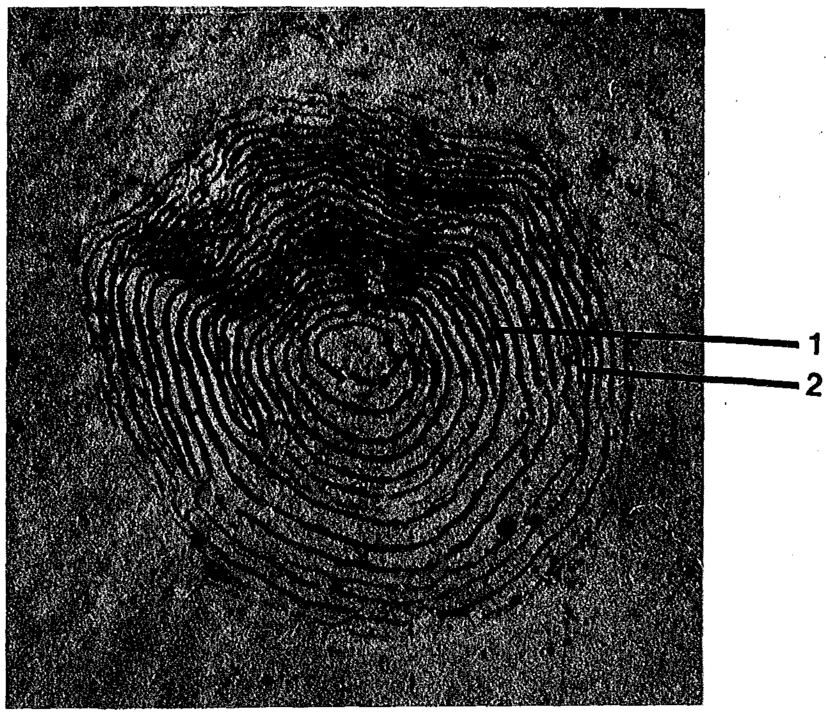

Plate 12. Esox lucius scale aged 0+, fork length 166 mm, caught Chinneitlui Lake, October, 1972.

a) criss-cross area
b) start of circuli growth
c) start of annulus formation

Annuli were interpreted by a few close, more broken circuli, and frequently, although not always, overlap at the exposed/embedded margin. The formation of two or three solid new circumventing circuli help in locating the annulus. A total sample size of 80 lake chub were examined from data collections.

The nucleus is difficult to locate, and there is a tendency for some regeneration. Therefore, it is suggested that the reader examine both lateral fields for overlapping circuli to distinguish the annuli.

Otoliths were not collected in this species.

5.1.7 Burbot - *Lota lota*

The very large otoliths are used in aging this freshwater cod. The annual opaque and hyaline rings are usually very clear without any preparation. Occasional opaque centres are easily remedied with grinding. As mentioned previously, scales from burbot are embedded and not practical for aging purposes. Approximately 40 burbot otoliths were read in compiling the data.

Otolith age has been assigned using Chen's method described previously, and to date, all burbot ages have been based on this method.

6. Fin Rays and Opercular Aging

Preliminary work on fin rays has not proved encouraging for whitefish or pike.

Sectioning of the rays with a microsaw has indicated that pike fin rays are characterized by a hollow centre which makes any aging attempt difficult. The saw used was developed from an L. & R. Manufacturing Co. polishing motor (Model VJ), which is capable of 60 cycles/sec at 10 h.p.

Fin ray clips have been successfully used for aging of sockeye when live sampling is required and scales are resorbed. Other salmon species have not been aged by this method, although salt water growth appears distinctly on prepared fin sections. The addition of a small amount of oil assists viewing through a microscope, allowing marine growth of the sockeye to verify ages of resorbed scales. Freshwater growth is clearly visible on most resorbed scales and with this combination of aging techniques, meaningful aging results.

Aging of opercular bones has been attempted for pike samples and may prove to be a successful method for additional aging techniques.

7. Conclusions

Results of aging methods using scales and otoliths from northern fish species, indicated the following:

1) The collection of five good scale samples from each species provides a sufficient number of scales for aging, usually eliminating loss through regeneration and distortion.

2) Further studies may be required to obtain scale samples exhibiting earliest development and best scale shape. The importance of establishing new "preferred" areas of scale collection on these northern fish species has been indicated. Tests have been completed on Arctic grayling and broad whitefish and would be advisable on other species to obtain most characteristic scales useful for growth measurements.

3) Scale cleaning methods indicated a soapy solution was preferred to produce clean, clear impressions on the acetate sheets.

4) The hydraulic scale press gave quality scale impressions, which were produced most effectively by the modified Leitz projector. This equipment has controlled, adjustable magnification, minimum distortion and high contrast required in reliable scale aging.

5) The crossing-over of circuli at the anterior/posterior margin of the scale is indicative of the annulus or year's growth, and has proved a more consistent method for aging scales of the northern freshwater species studied. False annuli occurring in the anterior portion of the scale cause problems in over-aging.

6) Spawning times and time of annulus formation differ in various northern fish species and should be considered in assessing plus growth beyond the annulus on these scales.

7) The early growth pattern on scales of Arctic grayling and round whitefish has been tested to establish size of fish at initial scale formation and assist in back calculations of fish samples where sufficient number of samples for age composition is limited. The equivalent information would be valuable for other northern fish species.

8) The sampling of otoliths has provided an additional aging method and assisted in verifying the ages established by scales for various fish species. In assessing ages, early growth in the otolith appears to be developing in the upper section, opposite to the rostrum. This area may prove to be most reliable and preferred to aging at the rostrum.

9) Otolith samples from rivers of the north slope exhibit more clearly defined growth bands than otoliths collected from fish of the southern interior rivers and lakes. The method used for grinding the more opaque otoliths has resulted in a large number of readable samples.

10) Salmon species of the northern Yukon have scales exhibiting differences in growth patterns and resorption factors specific to this area. Initially readers under-aged these species by one full year. Considerations of distance travelled, time of ice breakup and cessation of growth in last year of fish's life, must be assessed to give meaningful ages to these scales.

11) The use of fin rays and opercular covers for aging requires more study and will be reported in a later publication.

Previously, available scale aging techniques were restricted to those basically established for salmonids. It is hoped this report will indicate new additional methods and criteria, to be considered in assessing ages to species of the northern Yukon. Experience in dealing with these lesser known and different species is indicated as a prime asset.

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APPENDIX TABLE I - Taxonomic and common names of aged fish species from the northern Yukon. *

Taxonomic Name	Common Name
Thymallus arcticus	Arctic grayling
Coregonus nasus	Broad whitefish
Coregonus clupeaformis	Humpback whitefish
Coregonus sardinella	Least cisco
Stenodus leucichthys	Inconnu
Coregonus autumnalis	Arctic cisco
Prosopium cylindraceum	Round whitefish
Catostomus catostomus	Longnose sucker
Esox lucius	Northern Pike
Couesius plumbeus	Lake chub
Salvelinus alpinus	Arctic char
Oncorhynchus keta	Chum salmon
Oncorhynchus kisutch	Coho salmon
Oncorhynchus tshawytscha	Chinook salmon

* from Birch and Yole, 1974

Appendix Table II. Circuli counts to annulus formation in age 1, 2 and 3 year old Arctic grayling. Old Crow, Driftwood Rivers sampled April - October, 1973. Comparison of counts using anterior/posterior margin (NC-1, NC-2, NC-3) and a 45° ventral axis (a).

Date	Age	Mean Standard Deviation Standard Error	n	Fork Length (mm)	Reference Number	NC-1	(a)	Plus Growth	(a)	NC-2	(a)	Plus Growth	(a)	NC-3	(a)	Plus Growth	(a)	Total Circuli	(a)
July 25	1		3	101	3-3	9	(10)	5	(6)									14	(16)
July 25				100	4A-1	7	(7)	7	(7)									14	(14)
July 25				80	4A-2	7	(7)	4	(4)									11	(11)
July 26	2		6	212	2-16	16	(16)			10	(10)	4	(4)					30	(30)
July 26				215	4-38	15	(14)			11	(14)	6	(7)					32	(35)
July 26				248	5-48	17	(16)			9	(8)	7	(5)					33	(29)
July 26				210	5-49	7	(7)			17	(17)	8	(8)					32	(32)
Sept. 14				229	2-19	13	(13)			8	(8)	17	(17)					38	(38)
Oct. 5				227	7-60	14	(13)			15	(14)	8	(8)					37	(35)
April	3		7	307	4-16	11	(10)			16	(16)			12	(12)	6	(6)	45	(44)
April				342	10- 7	14	(12)			24	(23)			8	(8)	4	(4)	50	(47)
April				316	10-10	10	(10)			18	(17)			14	(13)	4	(4)	46	(44)
July 26				240	2-11	12	(11)			9	(8)			8	(8)	4	(5)	33	(32)
July 26				222	2-12	7	(7)			11	(10)			6	(6)	4	(5)	28	(28)
July 26				210	2-14	9	(8)			11	(11)			9	(7)	6	(5)	35	(31)
July 26				260	2-18	7	(6)			10	(9)			14	(12)	6	(5)	37	(33)
	1	$\bar{x}$	3	93.7		7.7	(8.0)	5.3	(5.7)									13.0	(13.7)
		Standard Deviation		11.8		1.2	(1.7)	1.5	(1.5)									1.7	(2.5)
		S.E. of mean		6.8		0.7	(1.0)	0.9	(0.9)									1.0	(1.5)
	2	$\bar{x}$	6	223.7		13.7	(13.2)			14.1	(11.8)	8.3	(8.2)					33.7	(33.2)
		Standard Deviation		14.3		3.6	(3.3)			5.5	(3.7)	4.5	(4.6)					3.1	(3.4)
		S.E. of mean		5.9		1.5	(1.4)			2.1	(1.5)	1.8	(1.9)					1.3	(1.4)
	3	$\bar{x}$	7	271.0		10.0	(9.1)			14.1	(13.4)			10.1	(9.4)	4.8	(5.0)	39.1	(37.0)
		Standard Deviation		50.9		2.6	(2.2)			5.5	(5.4)			3.2	(2.8)	1.1	(0.8)	8.0	(7.7)
		S.E. of mean		19.3		1.0	(0.8)			2.1	(2.1)			1.2	(1.1)	0.4	(0.3)	3.0	(2.9)

Appendix Table III. Circuli counts to annulus formation in age 1, 2 and 3 year old round whitefish. Old Crow River sampled July 25,28, 1973. Rapid and Blow Rivers sampled April, 1973. Comparison of counts using anterior/posterior margin (NC-1, NC-2, NC-3) and a 45° ventral axis (a).

Date	Age	Mean Standard Deviation Standard Error	n	Fork Length (mm)	Reference Number	NC-1	(a)	Plus Growth	(a)	NC-2	(a)	Plus Growth	(a)	NC-3	(a)	Plus Growth	(a)	Total Circuli	(a)
July 25	1		15	103	1-2	9	(11)	3	(5)									12	(16)
July 25				115	1-3	8	(11)	5	(5)									13	(16)
July 25				113	1-4	9	(12)	4	(5)									13	(17)
July 25				115	1-5	10	(12)	4	(3)									14	(15)
July 25				94	1-6	6	(9)	5	(4)									11	(13)
July 25				113	1-7	10	(13)	5	(5)									15	(18)
July 25				109	2-23	9	(13)	5	(4)									14	(17)
July 25				104	2-4	6	(11)	5	(6)									11	(17)
July 25				108	2-5	6	(7)	5	(7)									11	(14)
July 25				105	2-6	7	(9)	5	(6)									12	(15)
July 25				115	2-7	9	(14)	5	(5)									14	(19)
July 25				110	2-8	8	(10)	5	(5)									13	(15)
July 25				102	2-9	7	(9)	5	(7)									12	(16)
July 25				102	2-10	8	(13)	7	(5)									15	(18)
July 25				106	2-11	7	(11)	5	(5)									12	(16)
July 28	2		1	144	1-7	9	(11)			6	(8)	3	(4)					18	(21)
April	3		3	267	3-11	7	(10)			11	(13)			8	(10)	9	(10)	35	(43)
April				235	3-15	6	(7)			8	(10)			10	(11)	10	(13)	34	(41)
April				229	9-2	10	(10)			13	(17)			10	(11)	7	(11)	40	(49)
	1	$\bar{x}$	15	107		7.9	(11.0)	4.9	(5.0)										
		Standard Deviation		6.1		1.4	(1.9)	0.8	(1.1)										
		S.E. of mean		1.6		0.4	(0.5)	0.2	(0.3)										
	2	$\bar{x}$	1			9.0	(11.0)			6	(8)	3	(4)					18	(21)
		Standard Deviation																	
		S.E. of mean																	
	3	$\bar{x}$	3	243.7		7.7	(9.0)			10.7	(13.3)			9.3	(10.7)	8.7	(11.0)	36.	(44.3)
		Standard Deviation		20.4		2.1	(1.7)			2.5	(3.5)			1.2	(0.6)	1.5	(1.5)	3.2	(4.2)
		S.E. of mean		11.8		1.2	(1.0)			1.4	(2.0)			0.7	(0.3)	0.9	(0.9)	1.9	(2.4)