Natural Resource Institute

University of Manitoba

Practicum

THE FISHERIES POTENTIAL OF THE NORTHWEST TERRITORIES: A METHOD OF INVENTORY AND ASSESSMENT AND THE ORGANIZATION AND TRANSPORTATION TRENDS AFFECTING FUTURE FISHERIES DEVELOPMENT

Submitted by

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In Partial Fulfillment of Requirements for the Degree Master of Natural Resource Management.

1973

ABSTRACT

Fish resources of the Northwest Territories are receiving increased pressure by sports and commercial fisheries. This pressure is a result of northern resource development and an expanding tourist industry. The Fisheries Service of the Federal Department of Environment formed a Fisheries Management Division in 1971 to manage existing and proposed fisheries on a sustained yield basis. This study deals with compiling an inventory and assessment method to evaluate the fisheries potential of the Northwest Territories for the purpose of fisheries management. The method is based on an ecological framework and a classification of factors required for the fisheries management decision and the effective utilization of fish resources. Trends in transportation and fisheries organization were discussed for determining areas where fishing industries may potentially develop. Three time scales to area development potential in the Northwest Territories are used as priorities for field application of the method.

The inventory and assessment method was proposed from a classification of five groups of factors; morphometric, edaphic, biological, landscape and transportation and organization. Previous literature was reviewed to determine the factors within each classification. Individual factors were judged by their usefulness in making the fisheries management decision for the allocation of sports and commercial fisheries. Field techniques were proposed and tested on ten lakes throughout the Northwest Territories during the summers of 1971 and 1972. It was essential that field surveys be conducted in a minimum, yet sufficient, period of time to accurately sample the proposed factors. The inventory and assessment of Little Doctor Lake was used to illustrate the application of the method.

Results indicated that the major effort of the field survey should be directed towards fish sampling. The remaining biological factors and the other four classification groups define the limitations and restrictions to the allocation of the fisheries potential. Generally, the longer and deeper the lake the less abundant the fish catch per unit effort. Fish species diversity and relative abundance were greatest in the Mackenzie Valley, decreasing north and east of this imaginary boundary. The suitability for either sports or commercial fishery use was also dependent on fish species distribution, species size, market acceptability and access to the fishing location. The opportunity for multiple recreational use was a consideration for sports fisheries.

It is recommended that the method be applied on a priority basis in areas with a potential for fisheries development. Three time scales to development potential were proposed by using future trends in transportation and fisheries organization. Fishing industries develop as transportation and organization infrastructure grows to a point where such industries can be supported. It is also recommended that greater communication and cooperation be established between government agencies involved with utilization of Northwest Territories fish resources. Sound long-range planning for the use of fish resources is essential to both the future welfare of northern Canadians and the resource base.

ACKNOWLEDGEMENTS

I wish to express my gratitude to Dr. M. Healey of the Freshwater Institute, Fisheries Service, Research, Professor P. Laut, Department of Geography and Professor E. Terchniewicz, Department of Agricultural Economics.

I am indebted to the Department of the Environment, Resource Management Branch, Fisheries Management Section for allowing me to work on this project during the summers of 1971 and 1972. In particular, I would like to thank Mr. R. J. Paterson, Chief, Resource Management Branch and Mr. M. R. Robertson, Head, Fisheries Management Division. Special thanks are extended to Mr. R. Martin for his invaluable assistance in preparing the field survey reports. The assistance of Mr. T. Turnbull and Mr. G. Bogdan in the early stages of the study work is greatly appreciated. The guidance and technical assistance of many other people too numerous to thank individually are gratefully acknowledged.

Finally, I am indebted to the Indian and Eskimo people of the north who have allowed me an insight into man's capability of living with and managing his natural resources.

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Vilhjalmur Stefansson

CHAPTER I

INTRODUCTION

The potential for sports and commercial fishing is considered a major asset for the future of the Northwest Territories. There are innumerable lakes and rivers scattered throughout the landscape ranging from the Mackenzie Mountains to the Arctic Islands. Many of these waters have never been fished.

Historically, the fishing industry was located near and confined to communities with access to Hay River and Great Slave Lake. Transportation modes and the access provided by them have continually played a major role in the growth of the fishing industry. The organization through government policy, regulation and market structure also had a major impact on the fishing industry. Transportation will remain as the economical limitation to sports and commercial fishing. The organization factors will limit the quota, allowable species and define the market demands for the products of the fishing industry.

In most cases with the major exceptions of Great Bear Lake, Great Slave Lake and Lac La Martre fishing industries developed haphazardly and with little knowledge of the fish stocks and fishing pressure they could withstand. In 1961 the "Control Area" system, a system to provide some means of commercial fishing management was introduced in the Northwest Territories.[1] The lakes in the Control Area are managed on a six year cycle with the quota based on one-half pounds of fish per acre per year (Fig. 1). Angling and domestic fishing are not regulated by the Control Area system.[2] Outside the Control Area each water body is assigned an individual quota based on an assessment of the water's capacity to produce fish. Few lakes and rivers have actually been assessed, and where they were the majority were problem oriented.

There is a definite need for an inventory and assessment of the fishery potential in the Northwest Territories. The Control Area quota system does not account for the variability in species, size and abundance of fish in the controlled lakes. There is limited and often unreliable information on morphometry, water chemistry, biological stocks and surrounding landscape of most water in the Northwest Territories. An inventory of the fish stocks and a basic fisheries potential assessment is needed to plan the further use of the fish resources. Fisheries management should not be problem oriented but responsible for the planned use of fish resources. The decision must be made to manage the resource for sports, commercial, both sports and commercial or no fishery at all. For this decision to be made an inventory and assessment method is needed now for the rational and planned use of the fish resource.

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[1] Canada Gazette, P.C. 1966 - 2230. Office Consolidation of the Northwest Territories Fisheries Regulations, Fisheries Act, SOR/66 - 545.

[2] Great Slave Lake is managed separate from the Control Area.

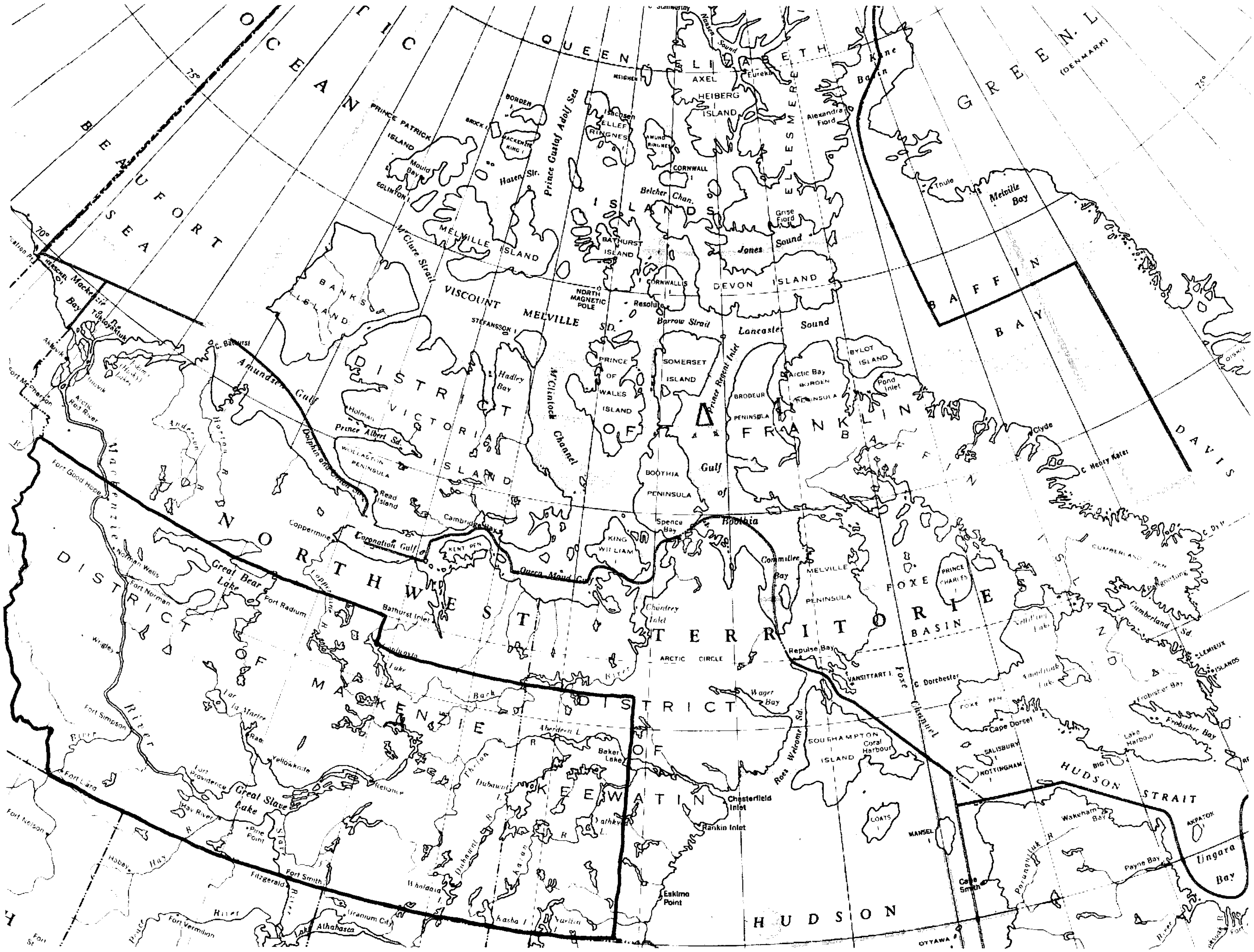

FIGURE 1: Fisheries Control Area, Northwest Territories.

Study Objectives:

Primary objectives of this practicum are:

(i) devising a method of inventory to measure the physical and biological factors of freshwater lakes (Fig. 1a)

(ii) devising a method of assessment for fisheries management decisions using the inventory data

(iii) determining the fisheries organization and transportation trends that will effect future fisheries development (Fig. 2a)

(iv) applying the inventory and assessment method to Little Doctor Lake, N.W.T., to illustrate the method's use to fisheries management

(v) forecasting the areas of potential fisheries development from the organization and transportation trends where the method of inventory and assessment should be applied (Fig. 1b).

The Inventory and Assessment Method was determined by critically evaluating existing methods used for fisheries management. It was a prime consideration to develop minimum time survey techniques that would allow for a complete inventory and a basic, accurate assessment of the fisheries potential. The proposed factors for the method were tested by summer lake surveys in the Northwest Territories.

"Organization of fisheries" refers to the markets, fishing regulations and government policy respecting sports and commercial fisheries. The markets for sports and commercial fisheries are dependant on tourists for the former and the

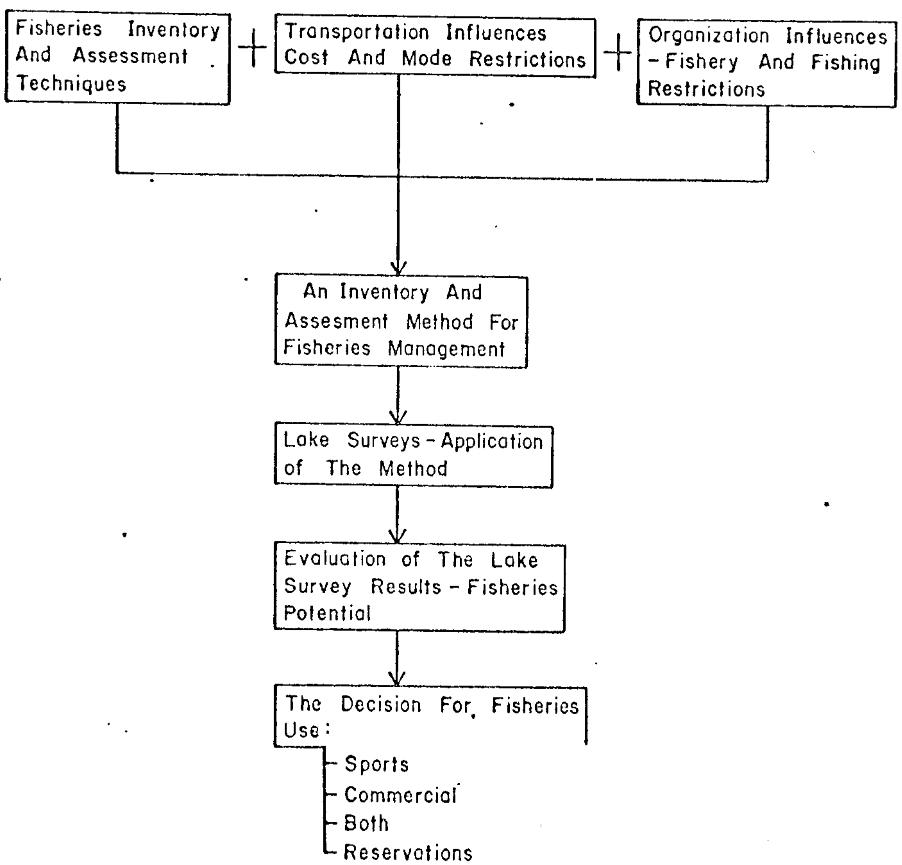

Figure 2a The Fisheries Management Approach to The Evaluation And Allocation of Fish Resources.

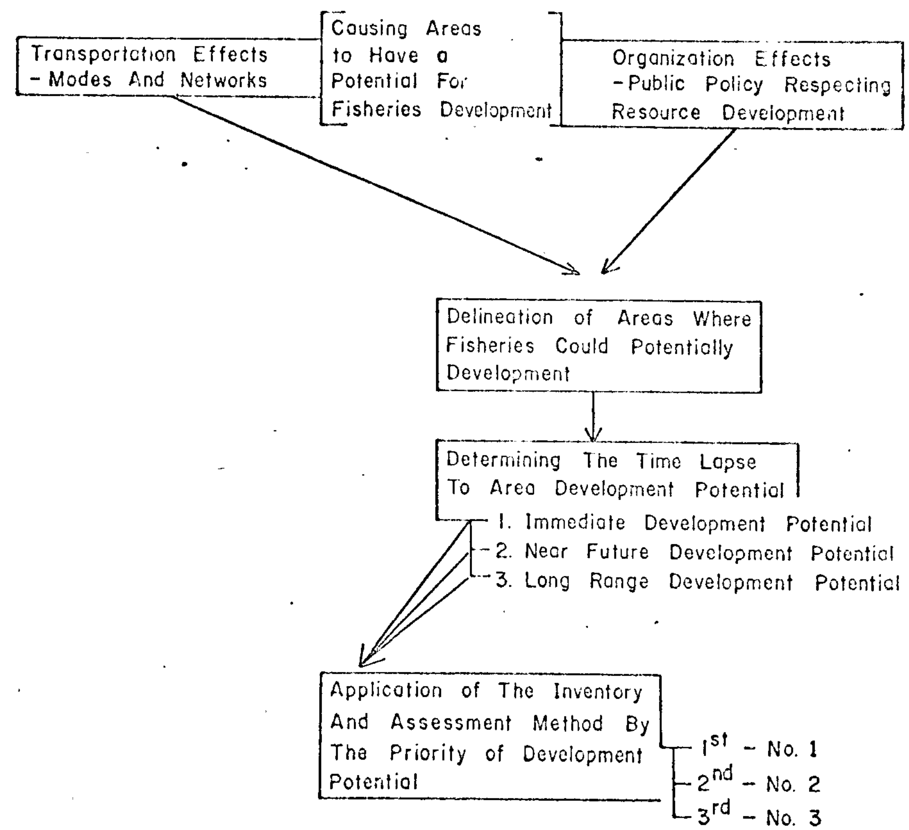

Figure 2b The Approach For Determining The Areas And Their Corresponding Time Spans Where Fisheries Use Could Potentially Develop.

established food market for the latter. The sports market is often influenced by non-fishing factors such as the opportunity for recreation and the outdoor experience. The effects of regulation on both fisheries are through quota's and restrictions in fish species, fishing gear and fishing areas.

Transportation is the major limiting factor in the development of fish resources in the North. In this study highways, air services, off-road transportation and water transportation are considered. Each mode of transportation has an impact on fishing industry development and growth. Future trends for the organization, regulation and transportation effects on fishing industries can be determined and used to forecast areas of potential fisheries development.

With increasing tourist and resident use of renewable resources there will be greater pressure to expand existing fishing enterprises. The factors of organization, regulation and transportation will continue to influence the location and growth of sports and commercial fishing. With a knowledge of these deterministic effects, an Inventory and Assessment Method allows for a more reliable evaluation and a better management decision for the use of a fisheries potential.

CHAPTER II

THE ECOSYSTEM CONCEPT IN FISHERIES MANAGEMENT

The aquatic and terrestrial environments cannot be separated for the purpose of fisheries management. The fish population is the major component of the aquatic environment. Other components such as morphometry, water chemistry and nutrient supply determine the species productivity but their effects are difficult to interpret. The fisheries manager is commonly required to make a quick decision for fishing use; often from incomplete and inaccurate data. For this reason the manager must concentrate on measuring the fish population as it exists now and those factors that are useful in making the management decision.

The terrestrial environment is an integral part of the management decision for the optimal allocation of fisheries. The landscape directly effects who can use the water and the intensity of fishing pressure they are liable to exert. Land by itself has a variable aesthetic appeal and through its topography effects access and thereby use. The fisheries manager must be a resource manager and not consider his aquatic interest in a vacuum, independant of other ecosystems.

The Basis for an Inventory and Assessment Method

The purpose of considering ecological concepts is three-fold. Firstly, the concepts illustrate the relationships between the components of the aquatic environment and the fish population. Secondly, the concepts provide a means of determining the factors that have the greatest effect on the fish population. The factors will form the basis of an inventory and assessment method. Thirdly, the best way to manage fisheries in my opinion is through ecological concepts. All the qualifications can be accounted for by ecological concepts in the following definition of fisheries management.

Fisheries management can be defined as the manipulation of the aquatic ecosystem to maximize the returns from the resource to man.[3] Manipulation can vary from simply harvesting the existing stock to altering the ecosystem to produce a greater abundance of existing or new species. This definition is subject to the following qualifications:

(i) the fish resource must be managed, not just man, as society benefits from proper management and suffers a loss from collapsed and subsidized fisheries. Acts and Regulations respecting man's use of a fishery must also intend the maximum long-run return from the resource.

(ii) the terms maximum and optimum differ in meaning when applied to fisheries management. Maximum should be used when there are several alternatives for use (type of fishery) and return (species combination and fish production). The term optimum more explicitly refers to the condition where there is an obvious greatest maximum use and return or no alternatives.

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[3]Van Dyne, George M. 1969. The Ecosystem Concept in Natural Resource Management. Academic Press, New York. 383 pp. Page 3.

Seldom are there no alternatives. Because these terms are applied to fisheries management, neither one may satisfy maximum and optimal use to some individual interests.

(iii) the definition is directed towards a sustained yield from the fish stock which in reality is subject to fluctuation. The implication is that fisheries management must be dynamic yet flexible towards unpredictable biological changes within fish stocks. Re-assessment is essential.

(iv) maximizing the returns from the resource may involve multiple or shared use between fisheries i.e. sports and commercial fisheries. A greater attempt to mix fisheries should be made if only to reduce problems associated with single species exploitation. Multiple use may extend into non-fishery uses in which case the maximum return to man may override the new maximum use of fish stocks.

(v) at the core of the definition there is the overall management of resources. Overall management is the sum of all social, economic and institutional factors that influence fisheries management in maximizing the resources. Fisheries management cannot be practiced in a vacuum ignoring the influences of non-biological factors in the fisheries use decision. The overall management of resources has yet to be achieved.

The Framework of an Inventory and Assessment Method

An Inventory and Assessment Method is proposed from an integration of ecological concepts and the definition of fisheries management. The ecological framework for the method is based on the work of Lindemann (1942)[4], Rawson (Hrbacek, 1969)[5], and Nikolsky (1963)[6].

The application of ecology in resource management has followed three principal approaches; population statistics, trophic (food) level energy transfer and rates of nutrient assimilation within populations. Although methods from all three approaches can be applied to developing an Inventory and Assessment Method, the concepts of Lindemann (1942)[7] are the most suitable. Lindemann (1942)[8] clearly identifies the inter-relationships between species in the aquatic environment. The limitation to the model (Fig. 3) is that non-biological factors which effect fish production and fisheries management are not identified.

This limitation is overcome by stating that only two kinds of parameters exist in aquatic ecosystems; the static and the dynamic (Hrbacek, 1969).[9] The former refers to nutrient concentrations and biomass, the latter to nutrient turnover or energy flow. Lindemann's (1942)[10] model reasonably

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[4]Lindemann, R. L. 1942. The trophic dynamic aspect of ecology. Ecology 23: 399 - 418.

[5]Hrbacek, J. 1969. Relations between some environmental parameters and the fish yield as a basis for a predictive model. Verh. Internat. Verein. Limnol. 17:1069 - 1081.

[6]Nikolsky, G. V. 1963. The Ecology of Fishes. Academic Press, Linden. 352 pp.

[7]Lindemann, Op. Cit.

[8]Ibid.

[9]Hrbacek, Op. Cit.

[10]Lindemann, Op. Cit.

illustrates the dynamic parameters while Rawson (Hrbacek, 1969)[11] has described the static parameters (Fig.4). Thus specific static parameters from a dynamic system can be measured.

The cohesion of the Inventory and Assessment Method is provided by the objectives of fisheries management. Nikolsky (1963)[12] describes these objectives in the organization of a rational fishery from a management viewpoint as follows:

1. allow the fish population to be harvested over a period of time that will best facilitate cropping the species desired.
2. that harvesting will not interfere with other migratory populations, young-of-the-year, nursery grounds, and spaning runs and grounds.
3. that harvesting will ensure the replacement of harvested stock at a constant rate.
4. that harvesting will crop the population when it is of good quality, its quality can be maintained and its niche will not become occupied by less desirable species.

The framework of the Inventory and Assessment Method will be proposed from a consolidation of concepts developed by Lindemann (1942), Rawson (Hrbacek, 1969) and Nikolsky (1963).

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[11] Lindemann, Op. Cit.

[12] Nikolsky, Op. Cit.

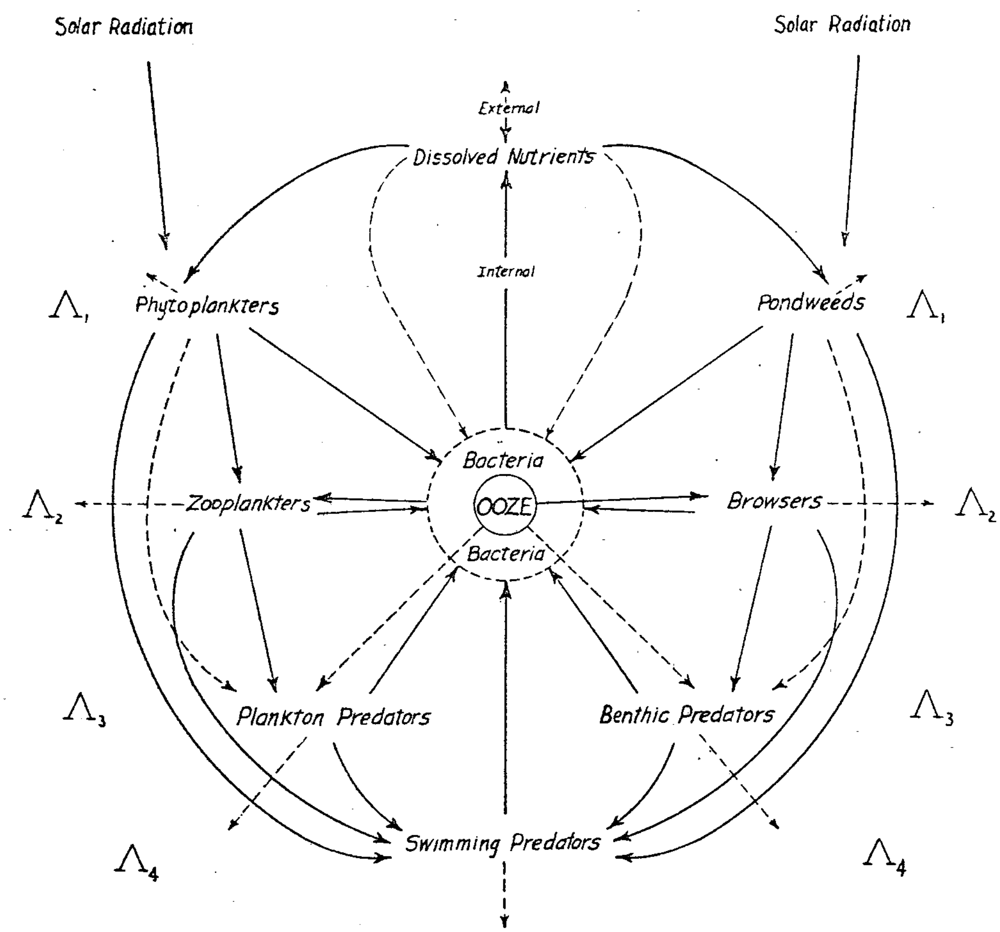

Figure 3. Generalized lacustrine food-cycle relationships (Lindemann, 1942).

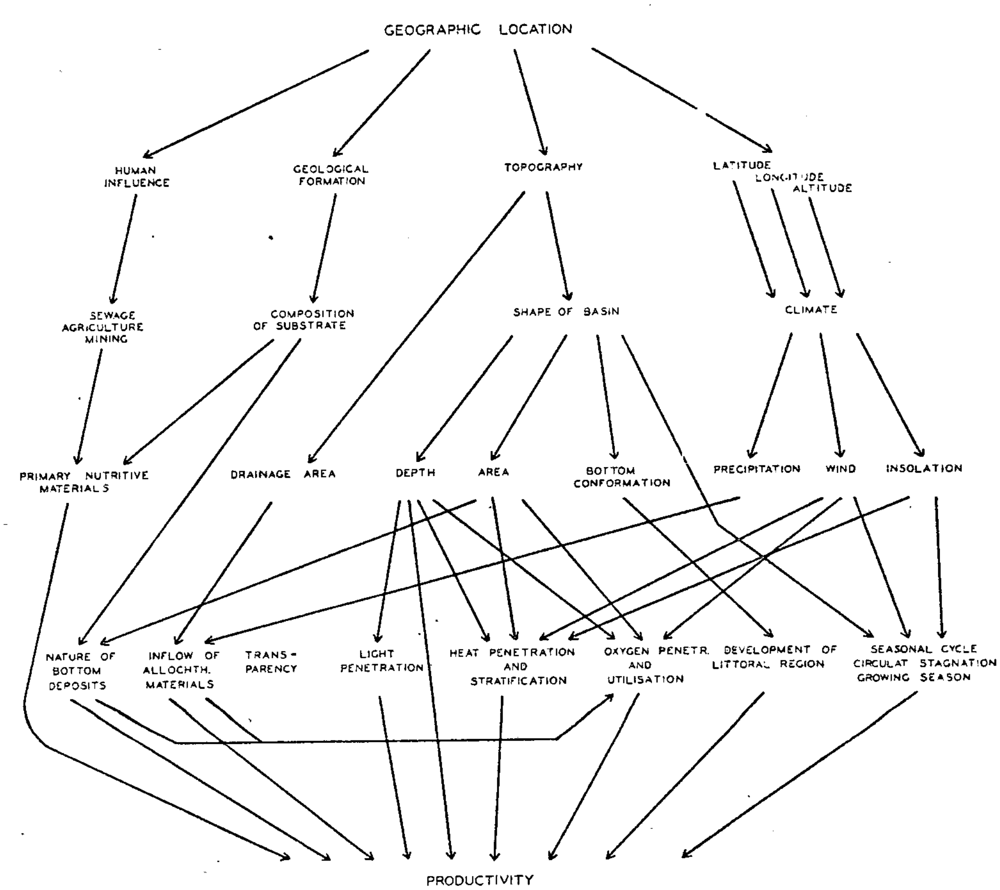

Figure 4. Diagram of certain inaminate and animate influences in the metabolism of a lake community (after Rawson in Allee et. als. 1949).

CHAPTER III

AN INVENTORY AND ASSESSMENT METHOD FOR FISHERIES MANAGEMENT

A. 1. Literature Review

Existing techniques of aquatic Inventory and Assessment methods for Fisheries Management stemmed from a desire to predict fish productivity and annual yields from a limited number of biotic and abiotic factors. Two general approaches in the methods are noticed; the theoretical approach and the empirical approach. The former involves the postulation that some stated factor(s) will explain or measure what is observed in practice i.e. mean depth and fish production. The latter is a more recent approach commonly associated with the isolation of factors from collected data i.e. multiple regression analysis. Improvements and new techniques in methodology have undoubtedly influenced both approaches and the precision of measurement.

Six Inventory and Assessment Methods are presented as a general introduction to this section. Each method will be evaluated by its usefulness and limitations as applied to fisheries management. Only the major points of each are considered and no distinction is made between the theoretical and empirical approaches. Both are considered equally valid approaches.

A. Saskatchewan Fisheries Laboratory

The early Inventory and Assessment concepts used by

The Department of Natural Resources were developed by Rawson in the thirty's, mainly as a compilation of ideas on lake productivity.[13] Since that time several innovations were made specifically in respect to the importance of lake morphometry.[14]

In the 1950's surveys were being done on Saskatchewan lakes particularily in the northern areas. As an example of the early Rawson approach the assessment of Cree and Wallaston Lakes is presented.[15]

The major effort of the assessment was directed towards the factors that determine the fish production; morphometry (area, mean and maximum depth), seasonal water temperature, oxygen concentration, pH, water transparency, total dissolved solids and the standing crop of plankton and bottom fauna. The fish population was sampled with the "standard" gill net gang; 1 1/2", 2", 3", 4", 5", 5 1/2" stretched mesh, 50 yds. per net each approximately 8 feet deep. The growth rate and food preference (stomach content analysis) were determined for the major fish species. On the basis of all these measurements and the average long run catch of Whitefish and Lake Trout the commercial quotas for the two species were established.

This type of survey depended on a long time period and intensive sampling of the lake's biological parameters. In attempting an assessment it was necessary to make a complete inventory of the biotic and abiotic parameters of the lake.

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[13] Rawson, D.D. 1939. Some physical and chemical factors in the metabolism of lakes. Problems of Lake Biology. Am. Assoc. Advance Sci., Pub. No. 10, pp. 9-26.

[14] Rawson, D.S. 1955. Morphometry as a dominant factor in the productivity of large lakes. Verh. Int. Ver. Limnol. 12:164-175.

[15] Rawson, D.S. 1959. Limnology and fisheries of Cree and Wallaston Lakes in Northern Saskatchewan. Fisheries Branch. Dept. Nat. Res.

However, the major function of the assessment was apparently to determine the limiting factors of lake productivity; the previous fishing effort was the basis of the commercial quota.

The completion of the Hanson Lake Road in Northeast central Saskatchewan in 1963 prompted a fisheries potential survey from 1964 to 1966.[16] The type of survey conducted for this report was less research oriented than the previous report, but directed towards a comprehensive inventory and assessment of the potential for sports and commercial fishing.

The methodology was essentially the same as for the Cree and Wallaston Lakes report and has since been standardized for all Saskatchewan fisheries surveys.[17] The physical and chemical observations were made in the summer and winter seasons. The inventory was comprised of a detailed sampling of morphometry, physical and chemical properties, plankton, benthos, fish species and their growth and food preference. In addition small fish and/ or "minnows" were sampled by seining. The absolute weights and numbers of the biological parameters were measured with some emphasis being placed on relative abundance. The occurrence of various species (sphaeriids and glacial relicts) was noted in an attempt to illustrate the productivity limitations of each lake. As in the previous report there was a reliance on previous fishing intensity to assess present fish quotas. The assessment for sports fishing included the species and ease

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[16] Lane, C.B. 1967. The limnology, fisheries and management potential of 17 lakes located along the Hanson Lake Road, 1964 - 66. Sask. Fish. Fab. Rept. 116 pp.

[17] Atton, F. M. and R. P. Johnson. 1970. Procedures manual for Saskatchewan Fisheries Laboratory, Dept. Nat. Res., Saskatoon.

of catching but not aesthetics and influence of other forms of recreation.

The major advantages to the Saskatchewan approach is the methodology of inventory collection and assessment. The disadvantage is that the surveys are directed towards a final rather than an initial assessment as is being attempted for the Northwest Territories. There is some lack of accounting for the aesthetics and alternate forms of recreation that will influence the fishing use of a lake.

B. British Columbia Lakes

In 1956 Northcote and Larkin published a report on productivity indices in British Columbia lakes.[18] The limnological data were collected in 1949 from lakes that had been surveyed from two or three days to two weeks depending on lake size.

The considerations for lake productivity were based on a sounding map, area calculations, mean depth and volume, water mineral analysis, temperature stratification, transparency, dissolved oxygen, total vertical plankton hauls, benthos samples, gill net samples of fish and other pertinent information. The detailed methodology for each type of information was stated.

In an attempt to assess the usefulness of these measurements (or parameters) a graphical relationship was applied between the biological standing crops and abiotic parameters i.e. total dissolved solids and the standing crop of

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[18] Northcote, T. G. and P. A. Larkin. 1956. Indicis of productivity British Columbia Lakes. J. Fish. Res. Bl. Canada. 13(4): 515-540.

plankton, mean depth and fish quantities. From a multiple regression analysis there was a significant relation between total dissolved solids (T.D.S.) but not mean depth on the summed indices of lake fauna. However, the T.D.S. correlation with standing crop failed when applied with a narrow range of T.D.S. measurements (i.e. necessary to have a wide variety of lakes). The most significant morphometric factor was mean depth but mainly when used with shallow lakes; the loss of the littoral zone productivity in deeper lakes may be offset by a greater plankton and profundal benthos production. The edaphic factors (quality and quantity of nutrients) as measured by T.D.S. appeared to be the most significant in determining the general productivity of the lakes sampled.

The major significance of this paper is both the identification of relevant productivity factors and the observation that no factor of lake productivity is independant; the separate and combined effects of each must be considered. A limitation is that relative abundance and not the expected productivity of fish per unit area was measured.

C. Alberta Fish and Wildlife Division - C.L.I.P. Fisheries Surveys[19]

In 1968 the Federal and Alberta Governments under the Canada Land Inventory Project (C.L.I.P.) agreement commenced a four year inventory of Alberta's fishery potential. The methodology used for the surveys gradually evolved in the early

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[19] Province of Alberta, Dept. of Lands and Forests.

years of the program but the basic productivity factors measured have remained relatively constant. The second survey report is used as an illustration of inventory and assessment methodology.[20]

In the summer of 1968 and 1969, seven lakes in the Peerless Lake area (North-Central Alberta) were surveyed. An inventory of each lake was made on the basis of morphometry, dissolved oxygen, temperature stratification, pH, mineral nutrients, benthic organisms, plankton and fish catch from a standard gang net set. The infestation rates of *Triaenophorus crassus* in whitefish and ciscoes were determined. In addition to previous catch records the water inlets, outlets and accessibility to each location were described. Approximately six days were taken for each lake survey.

Since the primary purpose of the A.R.D.A. fisheries surveys were for an inventory purpose, only an estimate of annual fish production based on Peerless and Graham Lakes was given. However, the standardization of sampling methodology allowed for a reasonable comparison among lakes and gill net selectivity, age frequency, and growth rates provided a basic assessment of fish productivity. More detailed surveys indicate an expected catch and composition for future fisheries.

The major achievement of the A.R.D.A. fisheries surveys was the inventory of physical measurements and biological stocks. A standardized survey technique was developed for use throughout

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[20] Smith, A.R. 1970. Preliminary biological survey of lakes in the Peerless Lake Area, Report No. 2. Fish and Wildlife Division, Alberta Dept. Lands and Forests. Survey Report No. 9. 140 pp.

Alberta allowing for a reasonable comparison of relative productivity among lakes. The major restriction to the commercial market, the rate of infestation was also determined for whitefish, The major limitation was a lack of information on small fishes (minnows and young age classes of large fish) and stomach content analysis. The latter is useful in determining food competition between species and the restrictions of lower food level abundance on species productivity. Some comparison should have been made between the surveyed lakes and as compared to lakes of known productivity. The morphometric, edaphic and biological limits to productivity would be more apparent and useful in planning future fisheries.

D. Manitoba Dept. of Mines, Resources and Environmental Management C.L.I.P. Fisheries Surveys[21]

In 1971 the Manitoba section of the Canada Land Inventory Program proposed a format for the systematic fisheries inventory throughout the Province of Manitoba.[22] As a result of the program several lakes and streams have been surveyed although no reports have been published.[23] The inventory manual is used as a general illustration of the types of information that are

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[21]Dept. of Mines, Resources and Environmental Management, Resources Planning Branch, Fisheries Section.

[22]Nelson, G. and W. Falkner. 1971. A fisheries inventory for Manitoba waters. Manitoba Dept of Mines, Resources and Environmental Management. Resource Planning Branch. Winnipeg. 63 pp.

[23]George Nelson, personal communication.

collected for the fisheries inventory.

Two types of lake surveys were proposed; the preliminary and the standard lake surveys. The purpose of the former is to provide an initial assessment of parameters that indicate the capacity to support fish. The latter is a more detailed follow-up survey of lakes with an apparent fisheries potential.

The type of information collected in the preliminary survey includes water clarity, zone of aquatic vegetation, inflow and outflow, shoreline and backshore description, topography and vegetation cover, water temperature, specific conductance, maximum depth and past fishing history.

The standard lake survey is a more detailed examination of the preliminary survey areas with a fisheries potential. In addition, total dissolved solids (T.D.S.), transparency, water colour, dissolved oxygen, pH, mean depth (contour map), mineral nutrients, small fish and large fish samples (by standard gang net) are collected. Plankton and benthic organism are not sampled in either the preliminary or standard lake survey. The standard stream survey is similar to the standard lake survey but adapted for rivers and streams.

The major significance of the program is the systematic survey based on the watershed unit.[24] The division of the surveys into two levels of intensity is a sound approach when a large number of lakes with little previous information must be surveyed. There is no information on the plankton and benthos productivity

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[24] Fedoruk, A. N. 1969. Checklist of and key to the freshwater fishes of Manitoba. Report No. 6. C.L.I.P. (Manitoba). Manitoba Dept. of Mines and Natural Resources. Winnipeg.

which may be equally as important as morphometry and water chemistry in indicating the capacity to support fish. The standard gang (1 1/2", 2", 3", 3 3/4", 4 1/4", 5") is composed of a different mesh size arrangement, net length and hanging depth than the gillnets used in Alberta and Saskatchewan. The difficulty arises in comparing the relative productivity of Manitoba lakes to other Provinces. In addition, some of the larger fish may not be sampled.

E. Alaska Division of Sport Fish - Lake and Stream Surveys[25]

The State of Alaska is involved in continuing studies of the fisheries potential of the State's lakes and streams. In 1971 the Division of Sports Fish published a fisheries inventory survey manual to standardize the types of information collected for future assessment.[26]

The inventory of lakes and streams is directed towards the sports fishing assessment rather than commercial fishing. Thus the creel census (angler catch) has been intensively used in the survey methodology. The general types of information collected for streams are land topography and vegetation soil type, accessibility, bottom type, pool description and frequency, barriers, spawning areas, fish species, fishing history, invertebrates and abundance and aquatic vegetation. A similar general summary is used for the lake survey; surface

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[25] State of Alaska, Department of Fish and Game.

[26] ___________ 1971. Lake and stream survey manual. Division of Sport Fish, Alaska Dept. of Fish and Game. Juneau, Alaska. 36 pp.

area, shoals, aquatic vegetation, spawning areas, topography and vegetation, access and a description of the aquatic regime including fish species. Water analysis as dissolved oxygen, carbon dioxide, pH and total alkalinity are determined for both lakes and streams. The method of fish sampling is variable; poisoning, angling, electro-fishing, live-trapping and netting. Generally the assessment includes the analysis of fish species, age class, number of samples, catch per hours of effort, mean length and range and mean weight and range. The creel census includes the assessment of fish species caught, number of fish, length and weight range and fish catch per hour.

Similar to other approaches described the systematic inventory provides for a standardized approach for fisheries assessment. This survey method is more suited to monitoring fisheries and determining expected catch and species composition for future fisheries. The inventory information appears to be very complete with exception to the biological stocks. This type of inventory and assessment approach is best suited to areas that can be intensively managed. For a basic inventory and assessment more emphasis should be given to the limitations of fish productivity.

It was noted that the Alaska survey method is directed towards sports fishing of anadromous fish. An inventory of spawning rivers is essential for this type of sports fishing.

F. Wisconsin Bureau of Fish Management - Lake and Stream Classification[27]

The State of Wisconsin has developed an intensive survey porgram as a three stage process consisting of inventory, planning and implementation for fisheries development.[28] The types of information collected and methodology is abstracted from the Department of Natural Resources manual.[29]

Several types of general information are collected under the divisions of public access and game assets, management and fish species and general waters information (land use, watershed, inlets and outlets, flow rates and spot water chemistry and colour). A high priority is the contour mapping of large lakes and lakes over 100 acres. The lake mapping includes bottom types, shore character, improvements, access, water vegetation, topography and land titles.

Trout streams are intensively managed and detailed descriptions of streams are necessary. In addition to water chemistry the stream bottom composition, poolgrade, aquatic vegetation, bank cover and composition, aquatic life and barrier information were collected in the trout stream inventory.

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[27] State of Wisconsin, Department of Natural Resources.

[28] C. W. Threinen, Asst. Director. Bureau of Fish Management, personal communication.

[29] complete reference to this manual is unknown.

Basic limnological and fish surveys are being attempted for all Wisconsin lakes. The limnological data includes area, dimensions, maximum and mean depth, shoreline length, littoral bottom composition, land cover (topography and vegetation), inlets and outlets, pH, phosphates (total and dissolved), conductance, water colour and transparency, thermocline position, dissolved oxygen and chloride. The method of determining the fish species includes angling, seining, trap netting, gill netting and shocking. The growth rate for each species is determined. Plankton and benthic organisms apparently were not collected or considered in the assessment. The fish production appears to be based on catch per unit effort (numbers or weight of fish per unit hours).

This type of inventory and assessment is particularily suited towards intensive fisheries management and the multiple-competitive use of water.[30] The inventory methodology appears to be very complete with the exception of the biological stocks. The limiting factors to fish production may not be nutrient supply and other biological stocks but summer oxygen stagnation and winterkill. As with the Alaskan surveys the fish production is based on angling catch per unit time and species composition and relative abundance. For a basic inventory and assessment more emphasis should be given to the limitations of fish productivity.

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[30] Sather, L. M. et al. 1971. Surface water resources of Rusk County. Land and Stream Classification Project. Dept. of Natural Resources, Madison, Wisconsin. 93 pp.

The author attempted to locate and discuss several types of inventory and assessment methods used in fisheries evaluation.[31] It is apparent that the majority of methods were directed towards specific fishery interests; a difficulty in evaluating methods or parts of methods that could be applied in the Northwest Territories.

A. 2. The Factors of Biological Productivity

In addition to the factors discussed in the six previous methods several additional factors have been proposed in individual studies. These factors are presented according to their intended application in explaining or influencing biological productivity (Table I). The components in the left-hand column are considered as applicable for both a fisheries inventory and assessment. The components are measured by the factors given in the centre column. The theoretical and empirical are equally represented.

The table illustrates the variety of considerations that can be made respecting biological productivity. As with the six previous reports the only factors that I consider useful for my proposal are those that measure the fish population as it exists. The factors that are useful in explaining or defining the limitations to fish production are also considered as applicable. Finally, all factors that can be used for the inventory are considered in my proposal for the Northwest Territories.

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[31] An important survey method being used in Ontario could not be obtained due to the revising of format and methodology.

TABLE I: The factors of biological productivity.

	Productivity Explanation Or Influence	Factors	Source
1.	Habitat Differentiation	Area and character of littoral, pelagial and profundal zones based on bathymetric maps and vegetation distribution.	Patalas, K. and J. Zawisza. 1966.
2.	Thermal and Oxygen Curves	Temperature and oxygen regimes indicating fish distribution.	Ibid
3.	Zooplankton Species Composition	Frequency occurrence by number at various times.	Ibid
4.	Fish Species	Quantity and year class.	Ibid
5.	Standing crop per acre	Negative regression between maximum depth.	Carlander, K.D. 1955.
6.	Standing crop per acre	Positive correlation between carbonate content.	Ibid
7.	Standing crop per species	Shorter food chain the more abundance.	Ibid
8.	Standing crop per body of water	Fish species diversity	Ibid
9.	Morphoedaphic Index	Mean depth Total dissolved solids.	Ryder, R.A. 1965.
10.	Physico-chemical Measurements	Mean depth, Mean summer temperature °C from 0 to 10 metres, Secchi Disc transparency, Average bottom oxygen (July - August), Total dissolved solids.	Rawson, D.S. 1961.
11.	Biological Measurements	Quantity of plankton, Quantity of bottom fauna, Weight of fish per standard net.	Ibid
12.	Morphometry	Mean depth, Morphometric indices (parameters).	Larkin, P.A. 1964.
13.	Productivity Index	Area of lake, Mean depth, Methyl Orange (total) alkalinity.	Hayes, F.R. and E.H. Anthony. 1964.

Table I. (Continued)

14.	Indices of Lake Productivity	Total alkalinity, Total phosphorus, Fish population structure, Nature of lake basin.	Moyle, J.B. 1946.
15.	Coefficient of Productivity	Based on: Average annual water temperature, Acidity or Alkalinity, Type of fish species, Age of fish species.	Huet, M. 1964.
16.	Limnology	Dissolved oxygen, Secchi Disc Transparency, Lake color, Volume, Mean depth, Maximum depth, Shoreline length, Shoreline development, Ratio of mean depth to maximum depth.	Hutchinson, G.E. 1957.

A. 3. Observations from the Inventory and Assessment Methods and the factors of biological productivity

(i) There is a tendency to gather an excessive amount of information that is not used in the fisheries assessment. Generally, the lake surveys provided for a sufficient inventory of the aquatic stocks and terrestrial features. However, only a few very specific factors were used for the productivity estimations and fisheries assessment of the inventory data.

(ii) Several of the surveys reviewed were directed towards specific fish species and types of fisheries i.e. Alaska Stream surveys. An inventory and assessment method must be adaptable primarily for an overall use in a variety of water types. More specific surveys according to fish species and types of fishing should evolve from the general method.

(iii) The multiple use of water was not considered in the majority of the surveys. Competition and the alternate uses of water resourves will often influence the type of fishery (angling or commercial) and reflect the degree of pressure from the fishing activity.

(iv) The Saskatchewan survey reports contain information on the marketability of the fish species sampled. In Canadian lakes it is essential to note limiting factors such as parasite infestation, flesh and exterior colour. Generally, the larger the fish the higher the price per pound paid to a commercial fisherman. Thus the relative abundance of size classes in an expected catch is important to the commercial fishery.

(v) Most of the reports measured the standing crop of fish and avoided the setting of quotas. The methodology for an inventory and assessment method should allow for the estimation of a minimum quota.

(vi) In addition to survey methods there are several factors that indicate or influence a lake's capacity to produce fish. These factors can be measured factors, i.e. mean depth, depth of epilimnion and total dissolved solids. Several of these factors have been used as indices of productivity and may be useful in estimating minimum quotas. Other factors may be useful in determining fish species stability (length of food chain, species diversity) and effects of fishing pressure (catch per unit effort and changing catchable age classes). Factors that are difficult to interpret and only indirectly effect the fish population should be avoided.

(vii) Few of the reports attach much importance to the non-biological factors that influence fishery use, i.e. transportation cost. Any inventory should be considered incomplete without such observations however pragmatic.

The primary consideration is to develop a method of inventory and assessment, the latter being dependant on the former. The method must be adaptable to a variety of survey conditions and initially not directed towards single fish species. Once the method is acceptable for the primary purpose it can be applied throughout the Northwest Territories with few changes in technique. Since time is limiting it is important to measure the most meaningful and useful factors.

B. A Fisheries Inventory and Assessment Method for the Northwest Territories

B. 1. The Method as a Fisheries Management Model

The basic framework of the model is developed from ecological concepts and methods previously discussed. In addition, the model incorporates the terrestrial and non-biological factors that effect fisheries assessment (Fig. 5).

In the model, components are defined as the natural characteristics and surroundings of a water body that indicate what type of fishery the water could be used for. The determinants are the specific requirements for sports and commercial fisheries. Thus the former becomes the basis of the inventory. The determinants plus the inventory becomes the basis of the assessment.

In order to design an inventory method that could be used for assessing the fisheries potential three questions were asked:

1. Are the best parameters measured?
2. Can the measurements be made quickly and accurately to give a true representation of the specific figures?
3. Do the measurements allow a reasonable assessment and allocation of fisheries?

A classification of five types of factors is proposed to meet the questions of design and the expectations of an inventory

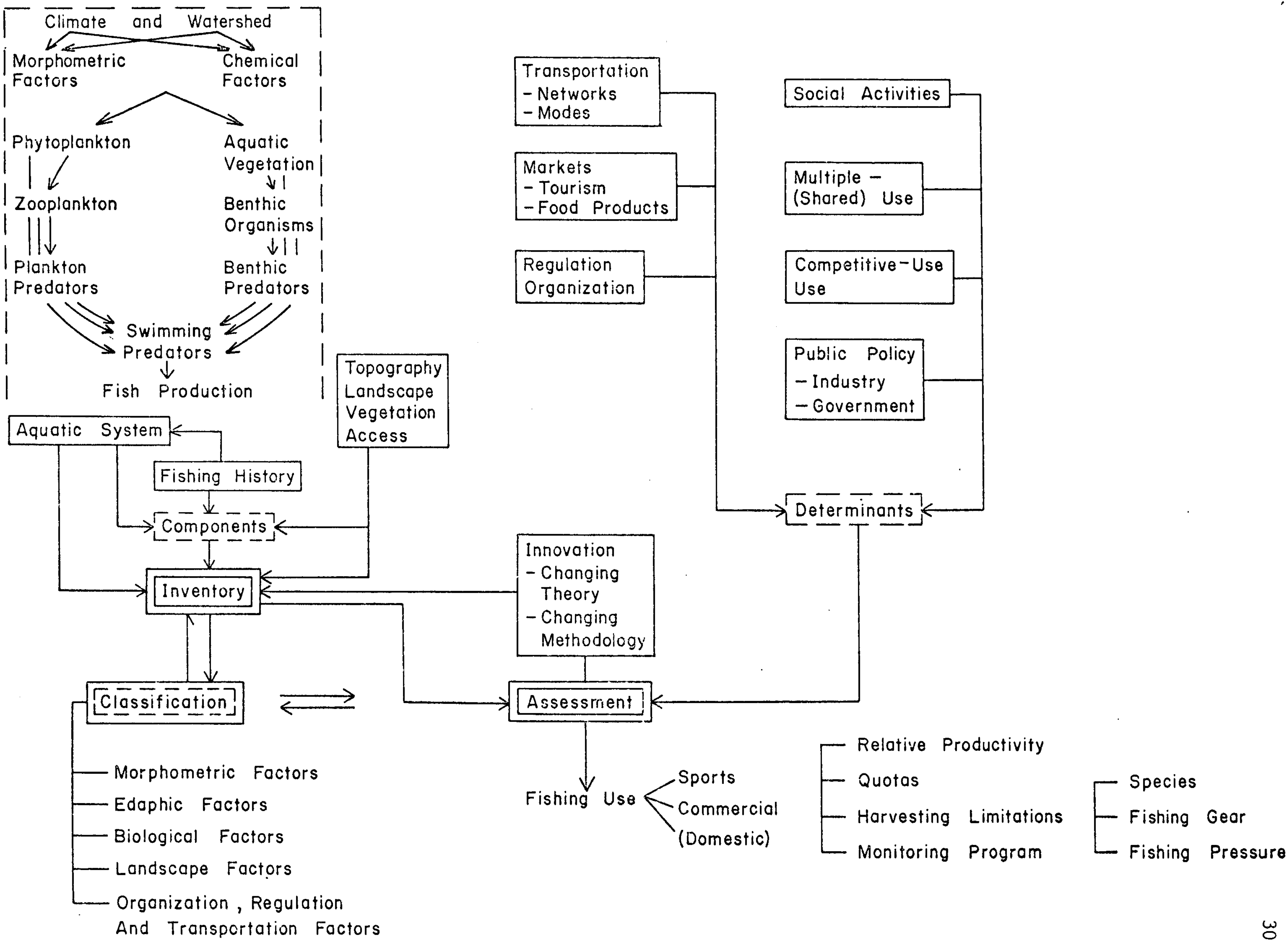

Figure 5 An Inventory And Assessment Method For Fisheries Management.

and assessment method. Each factor in the classification can be measured (Fig. 6). The value of the classification is that the factor measurements can be used for both an inventory and an assessment of the fisheries potential.

B. 2. Materials and Methods

During the summer of 1971 five lakes were surveyed using materials and methods proposed at that time. The lakes surveyed were Little Doctor, Stagg, Harding, North Henik and Markham. Five more lakes were surveyed during the summer of 1972; Nonacho, Lady Grey, Duncan, Indis and Stark (Fig. 7). Some changes were made in technique as a result of the two field seasons. These changes or modifications are noted in the following discussion. The procedures described are standard for all lake surveys unless otherwise indicated. The survey period was four days in 1971 and one week in 1972.

(i) Morphometic Factors

Each lake was sounded for depth using a Furuno FG 200A/Mark III or a FG 11A/Mark III echo sounder. All transects were made at a constant speed and the depth profile recorded on tape. Where the lakes were too large to adequately construct a contour map, representative sounding transects were made. The tapes from such transects were used to calculate an estimated mean and maximum depth. The remaining parameters were calculated from topographical maps (National Topographical Series) Area and length measurements were calculated by dot-girds, planimeter and map measurer. The drainage system and watershed

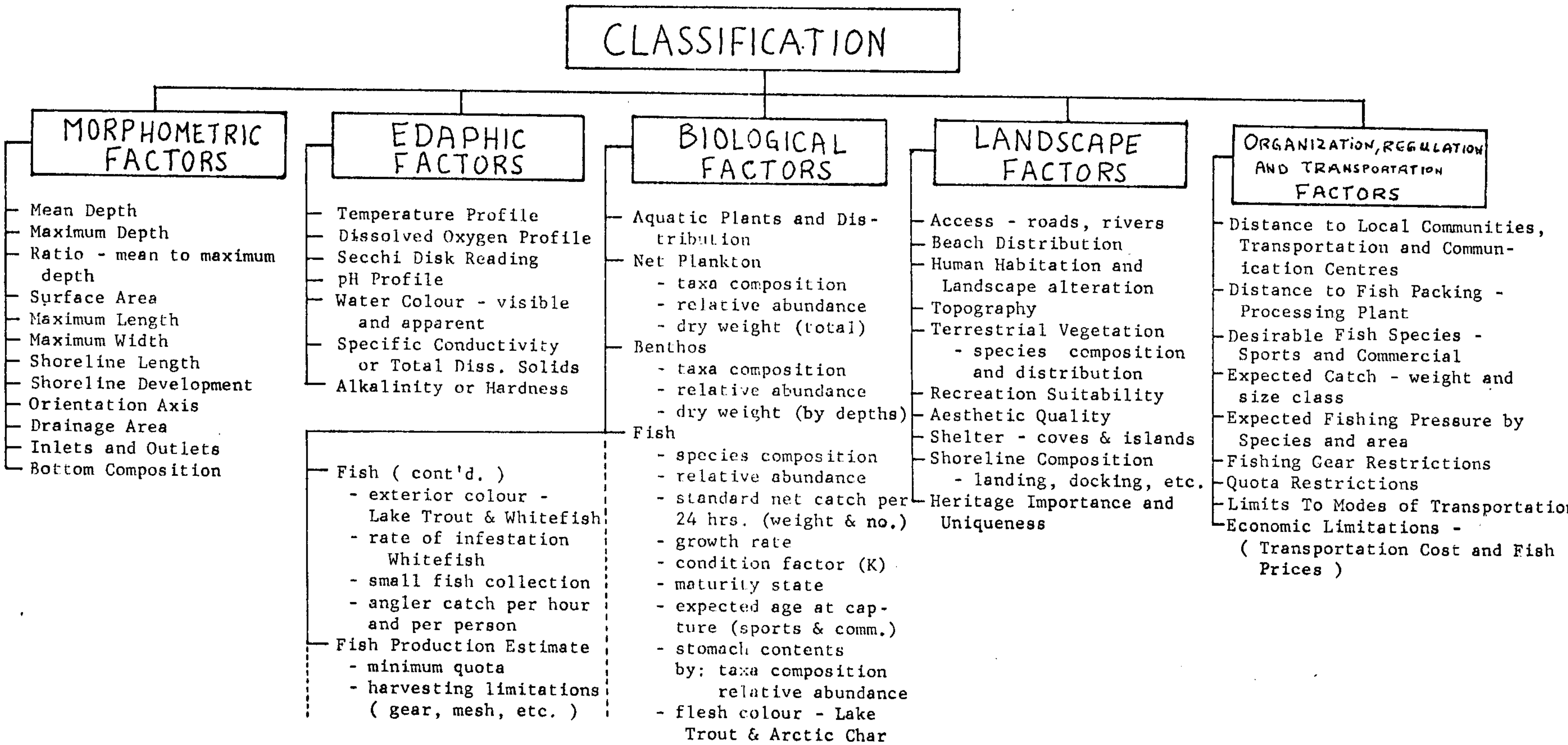

Figure 6. The classification of factors.

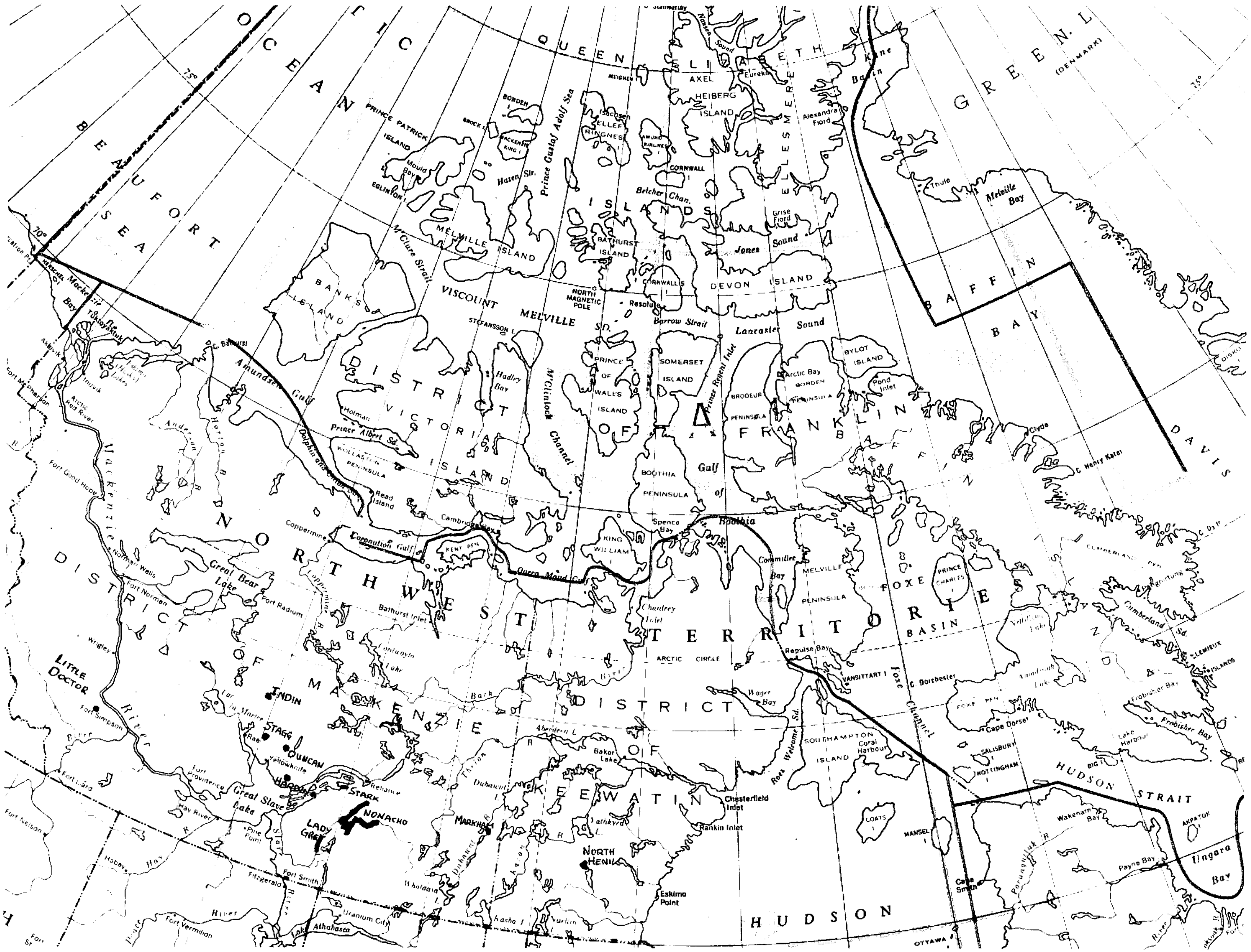

FIGURE 7: Lakes Surveyed in 1971 and 1972.

were obtained from Inland Waters Branch, Hydrometric Station map for the Northwest Territories.[32] Arbitrary boundaries had to be imposed on a lake's drainage system. The borders included only the major watersheds feeding the lake. The definition and measurement of the limnological factors is given by Welch (1948)[33] and Hutchinson (1957).[34]

(ii) Edaphic Factors

A limnological station was established at the deepest point in the major basin of each lake. Profile measurements were made for temperature, dissolved oxygen, hydrogen ion concentration, hardness, alkalinity and specific conductivity. Water samples were taken for future detailed analysis.

Water transparency was determined with a black and white Secchi Disc 20 cm. in diameter. The water temperature was measured for each meter of descent using a FT3M Hydrographic Thermistor (Hydrolab Corp., Austin, Texas). A TC-2 combined Thermistor and Conductivity Meter was used in 1972. All water samples were taken with a Kemmerer 1200 ml. brass

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[32] Department of Energy, Mines and Resources. Ottawa, Canada. Surface Water Data for 1968.

[33] Welch, P. S. 1948. Limnological Methods. McGraw-Hill. Toronto, Ontario. 381 pp.

[34] Hutchinson, G. E. 1957. A Treatise on Limnology. Vol. I. Wiley, New York. 1015 pp.

water sampler. Dissolved oxygen, hardness and alkalinity were determined in the field with a Hach water analysis kit. The pH values were determined with a Hellige Comparator kit with a range above and below the neutral value. Three two-litre water samples were collected for detailed analysis. The samples were taken at the surface, thermocline and bottom. The samples were not filtered but were frozen prior to shipment to the Inland Waters Branch in Calgary, Alberta. Water colour (true colour) was measured in platinum cobalt units from a surface water sample. Apparent colour was recorded as the colour of the water as it appeared from the air.

(iii) Biological Factors

Plankton samples were collected with a Wisconsin Plankton Net (#20 bolting silk - 173 threads per inch, 12 cm. mouth diameter). In 1971 two samples were taken from each lake, each sample being comprised of two total vertical hauls. One sample was taken from a depth of nine metres to the surface, and the other sample from 26 metres to the surface. In 1972 this procedure was changed to two total vertical hauls from 30 metres or bottom to the surface, one at the beginning of the week and the other at the end. Hauls were made at one metre per second. All samples were preserved in 4% Formalin.

In the laboratory a 1cc aliquot from each forty millilitre plankton sample was placed in a Sedgewick-Rafter counting cell and examined under a binocular microscope. Zooplankton were counted throughout the cell; phytoplankton were counted individually in ten random areas using an ocular micrometer. All the zooplankton and phytoplankton were identified to their respective taxonomic familes, and further when possible. The total plankton sample was then dried for 24 hours at 105°C and the dry weight recorded.

An intensive benthic sampling was conducted for the first lake survey in 1971. Four dredgings using a six inch standard Ekman Dredge were taken from each 10 metre zone to a depth of thrity metres. This was changed to four dredgings each at less than 10 metres and greater than ten metres for the remaining four lakes. In 1972 four dredgings were taken from each of three depth zones; up to 5 metres, 5 to 15 metres. and greater than 15 metres. The dredging sites were chosen at randon within their respective depth ranges. The dredged contents were washed through a screening bucket, the finest mesh being 38 meshes per inch. All organisms were preserved in 10% Formalin and in 1972 were stained with rose bengal to facilitate sorting in the screen. The bottom substrate composition was recorded during the washing procedure. Later the organisms were identified and counted. Wet blotted weight and dry weight (24 hours at 105°C) were determined for each taxonomic division by depth zone.

The fish population was sampled with a standard net gang; 1 1/2", 2 1/2", 3 1/2", 4 1/2", 5 1/2", stretched mesh, each 50 yards long and approximately 8 feet deep. The five nets were joined together by a bridle. The standard gang was set at a random orientation and various depths. After setting the gang, the water depth was recorded at each end and the nets left for precisely 24 hours. An attempt was made to sample all the depths of each lake. The net gang was generally pulled around mid-day and the following information recorded:

1. total fish catch per net
2. fish species and quantity per net
3. weight, length, sex and maturity of each fish
4. scale and/or otolith from each fish
5. determination of the *Triaenophorus* sp. cyst numbers in the musculature of each Whitefish.
6. notation of the exterior colour of all Lake Trout and Whitefish and flesh colour of all Lake Trout.

A minimum sample of 30 fish per species was attempted, The sample was taken from all mesh sizes and independant of location and depth of the standard gang net set.

Scale samples were taken from the left side between the dorsal fin and lateral line for soft rayed fishes. Scales were removed from the left side between the pectoral fin and dorsal fin below the lateral line for spiny-rayed fishes.

Stomach samples were collected from each of the first twenty fish of a species, then randomly from every fifth fish thereafter. Each species was sampled in every mesh size in which it was caught. A more detailed sampling schedule was considered too time consuming as only limited use could be made of the results. All stomachs were preserved in 10% formalin.

Small fish and minnows were collected with a beach seine 30 feet long, 8 feet deep and 1/4" mesh. The use of the net was confined to the littoral zone from the shore. The net was "walked" by two people or one end towed by a boat. The fish species, number and seining distance were recorded. Neither seining nor test netting were conducted from the surface of the pelagic zone. Where fish were angled by the survey crew the same information was recorded as for the standard gang catch. In addition the catch rate per hour was recorded for each angler.

The stomachs were analyzed by age class per each species. The species composition, wet weight, dry weight (24 hours at 105°C) and total stomach contents volume was recorded for each sample.

Fish scales were enclosed wet (Lake Trout, Walleye) or dry (other) between two glass slides and the annuli counted via microprojection. Otoliths were gound with fine emery cloth, placed in a tear-drop slide and immersed in a solution of methyl salicylate and benzyl benzoate (3:1). The annuli were determined upon clearing using a binocular low magnification, microscope.

The species and approximate distribution of aquatic vegetation (submergent and emergent) was recorded from each 1972 survey. The plants were pressed and dried for later identification.

(iv) <u>Landscape Factors</u>

A lake outline map was prepared prior to each lake survey. The topography and species distribution were subsequently recorded on the survey landscape map. In addition the shoreline, rivers and river substrate were recorded. Highways and areas of human habitation and/or influence were noted. Occasionally an area of historical or archeological importance was found.

In addition to the above an attempt was made to determine the recreational importance of the lake area. This tended to be a subjective judgement on the scenery, aesthetic appeal, occurrence of unique plants and wildlife and a "feeling" of the quality of outdoor experience. Colour pictures of the landscape and specific features were taken to support the subjective assessment of the area. A botanical collection was also made and the occurrence of all forms of wildlife were recorded.

Landscape features were categorized in five general topics:

FLORA	FAUNA	TERRAIN	RECREATIONAL SUITABILITY	AESTHETICS
Shoreline Backshore -species distribution and abundance	-species distribution and abundance	-Geology -Land Slope -Ease of Traversing	-campsites available -exposure -sheltered bays -variety of landscape -access -recreation mix	-wildernes and outdoo appeal -subjectiv feeling about the area -condition under whic judgement made

An overall impression of the area was then made based on the five groups of factors considered together. Ranking the factors was not attempted. For my purpose the landscape appraisal must be simple, flexible and useful in making the fisheries management decision.

(v) Organization, Regulation and Transportation Factors

The distance to the nearest fish packing plant and the nearest communities were determined. The limits to modes of transportation were also noted; highways, waterways, airports and pontoon aircraft (space, shore and shoals).

The sports and commercial fish species demand can be readily determined indicating the expected fishing pressure. The fishing restriction are given for both sports and commercial fishing in the Northwest Territories Fisheries Regulations. The quotas for both fishing activities are also contained in the regulations.

The economic limitations are indicated by transportation costs to each lake respecting feasible modes and market restrictions for the fish species. Transportation cost by air as a function of payload and distance is determined in a forthcoming section of the Practicum. Market restrictions are predominantly indicated by the Whitefish rate of infestation, the flesh colour of Lake Trout and the exterior colour of Lake Trout and Whitefish. The rate of infestation is contained in the Northwest Territories Fisheries Regulations. The colour preferences are also discussed in a forthcoming section.

The Inventory and Assessment Method has been proposed. It remains to determine the organization and transportation factors that are an integral part of the proposal. In addition, organization and transportation factors will influence and direct the growth of the Northwest Territories fishing industry. The trends determined from the two following sections will be used to predict the areas of development where the method initially should be applied. Finally, a case study will be presented to illustrate the application of the Method.

CHAPTER IV

THE ORGANIZATION OF FISHERIES IN THE N.W.T.

Historically, fisheries developments were located along transportation networks in the Northwest Territories.[35] As the transport networks improved fishing activities expanded and specific structures formed from the influence of product markets and fishing regulations. Along with transportation these structural factors will continue to direct and effect fisheries development. Thus past trends in the fisheries expansion can be used by fisheries management to predict their effects on future fisheries development.

A. Types of Fisheries Structures

For the purpose of fisheries management fisheries structures are divided into three components:

1. Commercial Fisheries
2. Sports Fisheries
3. Domestic Fisheries.

Domestic fisheries refers to the harvest of fish by Indians and Eskimos. The fish is regularily used for domestic consumption and as dog food. The Fisheries Act states that the domestic fish harvest cannot be sold outside an immediate residence locality.[36] The Act does not restrict catch and

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[35]Keleher, J.J. 1962. A documented review of Great Slave Lake Commercial Catch Regulations. Fish. Res. Bd. Canada. M.S. Report #715. 148 pp.

[36]The Canada Gazette. P.C. 1966-2230. Office Consolidation of the Northwest Territories Fisheries Regulations. Fisheries Act, S.O.R./66-545, as amended. Info. Can. Ottawa.

fishing methods of the domestic fishery.[37] Such fisheries are confined to small settlements scattered throughout the Northwest Territories and presently do not form a business enterprise.[38]

Domestic fisheries developed independant of transportation networks and are confined to communities with immediate access to water. For these reasons the domestic fishery will not be considered in this study. However, problems will soon appear. The future demand for a settlement commercial quota must include the fish harvest from the domestic fishery for effective fisheries management. Fish caught for either fishery are still part of the common fish population.

Commercial and sports fishing have diverse histories in the Northwest Territories. Initially, both depended on access improvement and better modes of transportation that resulted from the resource rush in the late forties and early fifties.

B. <u>The Control Area Quota System</u>

In 1961 the "Control Area System," a system to provide some measure of commercial fishing management was introduced

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[37]Ibid.

[38]It should be noted that the replacement of dogs by snowmobiles for winter travel there has been a dramatic decrease in domestic fisheries. Indians and Eskimos are now pressing to have the domestic harvest converted into a commercial quota to provide their communities with a new economic base. A policy to allow inter-settlement trade will probably develop in the near future.

in the Northwest Territories.[39] The Control Area lies roughly between latitude 60° North and the Arctic Circle, and longitude 96° West and the Northwest Territories-Yukon boundary (Fig. 1). Not all the lakes in the Control Area can be commercially fished; although all can be used for angling and domestic fishing. Some are exclusively reserved for these two fishery types. The commercially fished lakes are managed on a six year cycle.[40] The quota for each lake must be taken in the first two years. The lake then lies fallow for the remaining four years. The six year cycle then starts over again. The quota for Whitefish and Lake Trout that may be taken from any lake in the Control Area is equal to the number of acres of water surface in the lake multiplied by three. In waters containing pickerel there is an annual quota for this species only equal to the water surface area in acres divided by two. Each Whitefish and Lake Trout lake is closed after two years even if the quota is not taken. Presently the allowable legal mesh is five and one-half inches (stretched mesh) for all fish species except pickerel. The use of four and one-half inches is permitted in all waters containing pickerel. The quota, mesh size and cycle apply regardless of a lake's location or its capacity to produce fish.

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[39]Canada Gazette, P.C. 1966 - 2230. Office Consolidation of the Northwest Territories Fisheries Regulations. Fisheries Act SOR/66 - 545. Information Canada, Ottawa.

[40]Great Slave Lake is managed separate from the Control Area.

Outside the Control Area each lake is assigned an individual quota based on an assessment of the lake's capacity to produce fish. Few lakes and rivers have actually been assessed and in the past there were no standardized methods of inventory and assessment applied outside the Control Area. Generally, the Area Development Officer (employee of the Government of the N.W.T.) requests that commercial fishing be allowed on a lake or river. The request for fishing includes a recommended quota. The officer's superiors then direct the request to the Department of the Environment, Fisheries Service for approval. The original requests are usually based on social rather than biological considerations with the requested quota's far in excess of what is biologically reasonable. The end result is confrontation between the two levels of government and disappointment and frustration in the area for which the request was made. There is clearly a need for closer co-operation between community, Territorial and Federal agencies for all areas not included in the Control Area.

C. The Commercial Fishery

C. 1. The Present Industry

The first commercial fishery in the Northwest Territories began operations on Great Slave Lake in 1945.[42] Twelve years

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[42] Sinclair et al. op. cit.

passed before commercial fishing expanded into the lakes near Great Slave Lake. The Kakisa Lake fishery commenced operations in the winter of 1957-58.[43] Commercial fishing expanded into the lakes around Yellowknife and the Tolston River System by 1969. The number of lakes being fished reached a peak in 1966 with the distribution extending into Keewatin (Table II). Since 1967 the number of lakes fished has decreased and fisheries are now mainly confined to the Hay river, Cambridge Bay and Rankin Inlet areas. Throughout the commercial fishing history of inland lakes the average distance from Hay River to the fished lakes has remained between 100 and 200 miles (Appendix A).

A significant change is noted in the ratio of production to landed value (Table II). The ratio illustrates the fishing effort in terms of the fish catch to dollar return for this effort in terms of the catch landed value. The relationship suggests that the value of commercial fishing is increasing at a faster rate than the increase in fish harvest. This may in part be explained by greater efficiency in the fishing industry, less costly transportation and higher prices due to the Freshwater Fish Marketing Corporation.[44] Improved and increased handling facilities may be equally as important. In addition to the facilities at Hay River a cannery has operated in Rankin Inlet since 1965. Fish processing plants have commercially operated in Cambridge Bay since 1962 (new plant

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[43] Ibid

[44] The Corporation began operating in the Winter of 1969-70.

TABLE II: N.W.T. - Commercial Fish Production other than Great Slave Lake, 1958 - 1972 (Calendar Year).

Year	No. Lakes	Prod.[a] lbs.	Landed[b] Value	P[c] / L.V.	Distance to Hay River 0-100	100-200	200-300	300	Position Unknown
1958	3	153,431	15,107	10.2	2	-	1	-	-
1959	8	276,535	34,118	8.1	2	4	2	-	-
1960	8	289,087	30,671	9.4	2	5	1	-	-
1961	8	248,701	24,827	10.0	2	5	1	-	-
1962	7	321,735	45,090	7.1	-	3	3	1	-
1963	14	870,019	92,549	9.4	1	7	4	2	-
1964	17	1,332,467	120,285	11.1	1	11	4	1	-
1965	10	664,349	66,351	10.0	2	1	5	2	-
1966	26	738,021	99,020	7.5	2	7	12	3	2
1967	19	479,779	89,980	5.3	2	8	3	5	1
1968	12	406,389	41,856	9.7	2	4	1	5	-
1969	14	796,693	169,611	4.5	2	7	3	2	-
1970	32	1,168,462	317,206	3.7	2	16	7	6	1
1971	25	883,807	132,236	6.7	2	14	8	1	-
1972	7	704,367	174,477	4.0	2	4	1	-	-

a Round weight

b Landed value is the return to the fisherman and does not necessarily refer to gross or net value of the catch (due to variation in points of delivery, transport costs and other deductions).

c Production (lbs) divided by landed value to fisherman ($).

Source: Environment Canada, Fisheries Service, Economics Branch, Central Region Fisheries Statistics.

in 1970) and Pelly Bay since 1971.

A major effect of the Great Slave Lake fishery was the formation of a central fish handling location for the Northwest Territories. Hay River was the obvious location for these handling facilities; a good port and the highway link to the railway-transportation head at Grimshaw, Alberta. Hay River as a transportation centre was firmly established by the Canadian National Railway extension, marine re-supply terminal and an airport. The Freshwater Fish Marketing Corporation is taking full advantage of Hay River's transportation function through the recent construction of a fish processing plant.

C. 2. Commercial Fishery Species Demand

The fish species demanded have remained much the same over the years of commercial fishing; Whitefish, Lake Trout, Inconnu, and to a lesser extent Northern Pike and Yellow Pickerel. Markets are being sought for Arctic Char and the rough fish (mullet, cisco and burbot) from Great Slave Lake.

The greatest demand is for light coloured, high fat content Whitefish required by the American smoked-fish market. The flesh and exterior colour of Lake Trout have a market significance as well; light green to olive exterior and orange to red interior are required. There is little market for light-fleshed, dark Lake Trout. There is no market significance for the colour of the remaining fish species.

The infestation of Whitefish by the parasite *Triaenophorus crassus* has considerable bearing on its marketability. The limits of infestation are stated in the Fish Inspection Act and enforced by the Fisheries Inspection Service.[45] Many of the lakes in the Northwest Territories have been tested for the rate of infestation and given a grade based on this rate. The parasite may be removed by "candling" but the process increases the production cost and places the product into a lower return market.

The major demand for all the marketable fish species is in the form of fresh, whole, dressed fish. The market for frozen, whole, dressed fish is substantial for Lake Trout and Arctic Char. The Freshwater Fish Marketing Corporation is attempting to increase the market demand with better quality fish and new food products. New products include dark Lake Trout steaks, skin-on dressed dark Whitefish, institutional portion packaging and rough fish pet food.

Transportation has played a significant role in the Northwest Territories commercial fishery specially with respect to quality problems and high shipment costs. Since the major market for Northwest Territories commercial fish is in the United States, the product must be exceptionally high quality to withstand the distance and maximize the difference between

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[45]Fish Inspection Act. loc. cit.

transport cost and market price. Only recently has an attempt been made to determine markets closer to the fish source, specifically within the Northwest Territories. It was determined that a domestic market in the Southwestern Northwest Territories was feasible and should be developed.[46] Other markets may exist in several of the northern communities given competitive pricing and a reliable supply of good quality fish.

3. Government Interest in the Commercial Fishery

The major agencies involved in the control of the commercial fishery are as follows:

1. Department of the Environment - Fisheries Service (Federal)
2. Department of Indian Affairs and Northern Development (Federal)
3. Department of Industry and Development (Govt. of the N.W.T
4. The Freshwater Fish Marketing Corporation (Crown Corporation)

The control, i.e. setting of seasons, quotas, restrictions, licenses, and enforcement is the responsibility of the Department of the Environment under the Fisheries Act and Northwest Territories Fisheries Regulations.[47] The Fisheries Service is divided into several branches of which the Inspection Branch and the Resource Management Branch are the most active in the N.W.T. The Inspection Branch is responsible for quality and

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[46] McLeod, R. H. 1973. M.S. A fish marketing study, Northwest Territories. Freshwater Fish Marketing Corporation, Winnipeg, Manitoba. 81 pp.

[47] Canada Gazette, Northwest Territories Fisheries Regulations. loc. cit.

infestation control, fish plant sanitation, producer and consumer education programs and the specific responsbilities of the Fish Inspection Act and Regulations.[48] The Resource Management Branch, through its four divisions is responsible for environmental control, enforcement, and fisheries management. The first refers to impact assessment of industrial development and pollution control.[49] The third refers to the management of sports and commercial fisheries through on-going programs of inventory, monitoring exploitation and assessment of potential fisheries.[50] Enforcement is self explanatory and refers to the conservation and protection of the fish resources. The Environmental Protection Service of Environment Canada has recently extended its operation into the Northwest Territories. The Industrial Development Branch of Fisheries Service, Operations began a fishing gear assessment on Great Slave Lake in 1972 and in future may play a significant role in introducing new methods of commercial fishing.

The involvement of the Department of Indian Affairs and Northern Development in commercial fisheries is threefold; obligations to native people; northern development (resources, industry and social) and administration of water and land-use

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[48] Canada Gazette, S.O.R./71-221. Fish Inspection Act. Part II, Vol. 105, No. 11.

[49] R. J. Paterson, Chief, Resource Management Branch. Branch Organization Chart.

[50] M. R. Robertson, Head, Fisheries Management Division.

acts. A large part of the commercial fishery centres around native communities and the majority of the fishermen are of native extraction. Through the northern development programs fish handling facilities, boats, fishing gear and transportation networks have been assisted or subsidized for the native people and communities.[51,52] The land and water-use regulations may be effective controls in developing fishing industries i.e. pollution, transportation networks, and development at the expense of northern residents. More time is required before the impact of these acts can be assessed.

The Department of Industry and Development is involved in commercial fisheries mainly through local industry promotion. The policy of the Department is to seek commercial quotas only if the fish stock is in excess of the local domestic demand.[53] The Fisherman's Loan Board, administered by the Government of the Northwest Territories is designed to assist fishermen with insufficient capital to enter commercial fishing. Both commercial export and intersettlement commercial fisheries are supported and if economically feasible, are subsidized.[54]

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[51] Chretien, J. 1972. Northern Canada in the 70's. A report by the Honourable Minister of Indian Affairs and Northern Development. O Hana. 11 pp.

[52] Naysmith, J.K. 1971. Canada North-Man and the Land. Northern Economic Development Branch. D.I.A.N.D. Information Canada, OHana. 44 pp.

[53] P. Cove, Development Officer, Division of Tourism, Dept. of Industry and Development, Yellowknife, N.W.T. Personal communication.

[54] Ibid.

The Freshwater Fish Marketing Corporation was established in 1969 as the sole marketing agent for freshwater fish produced in the three Prairie Provinces, North-West Ontario and the Northwest Territories.[55] The Corporation must buy all marketable species from a fisherman at a predetermined price.[56] The price paid is determined by the market but the actual return to a fisherman is reduced by transportation, storage and handling charges. As a single dealer agency the Corporation has considerable market influence as well as being able to reduce operating costs enabling a greater return to the fisherman. Advertising, specialty products and new product innovation are used to promote the consumption of freshwater fish.

D. The Sports Fishery

D. 1. The Present Industry

The development and expansion of sports fishing closely followed that of the commercial fishery. Angling licenses were first issued in 1951 at Hay River although undoubtedly angling did take place long before that date.[57] Originally, sports fishing activity developed around fishing lodges scattered

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[55] Canada Gazette. Freshwater Fish Marketing Corporation Act. 17-18 Elizabeth II. Chapt. 21. 1969. Info. Canada, Ottawa.

[56] R. Brooker, Sales Department, F.F.M.C. Interview December,1972.

[57] Sinclair et als. op. cit. p. 58.

throughout the Northwest Territories; each offering some particular fishing attraction peculiar to the area. Non-lodge oriented sports fishing has expanded with an increase in tourist mobility and the improvement and extension of highway networks. The convenience of air transportation continues to play a major role in the sports fishery.

In studying the structure of the Northwest Territories sports fishery, a distinction must be made between the tourist and fisherman population. Although only a fraction of the tourists are in the Territories to sports fish, many tourists utilize the same areas as the fisherman for camping, swimming, boating and hiking. The distinction is illustrated by comparing the increase in tourists and angling license sales over a period of years (Table III, Table IV). It is estimated that an average of 15 to 25 percent of the tourists obtained angling licenses from 1969 to 1972. During the years from 1960 to 1971 tourist numbers increased at an average rate of three times the rate of angling license sales.

In pursuing trophy or recreational fishing the fisherman may do so through his own efforts or through the agency of a fishing lodge. For the former the individual is limited to the access provided by the Mackenzie System or by chartering an aircraft; the latter through a package plan from one of the fishing lodges. As of May, 1972, 40 fishing lodges are available.[58]

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[58] D. Dowler, Environment Canada, Fisheries Service, Yellowknife N.W.T. Personal record of fishing lodges.

TABLE III: History of Tourism in the N.W.T. - 1959 to 1971.

Year	Number of Tourists	Tourist Expenditures	Number of Tourist Establishments
1971	17,700	$5,536,000	80
1970	20,650	5,163,000	72
1969	12,380	4,112,000	69
1968	9,000	3,190,000	61
1967	6,500	2,100,000	51
1966	6,000	2,000,000	39
1965	6,000	1,500,000	23
1964	5,000	1,300,000	14
1963	3,500	1,000,000	10
1962	2,200	850,000	14
1961	1,300	600,000	10
1960	1,000	450,000	8
1959	600	350,000	4

NOTE: 1. 1959 to 1964 includes lodges and outfitters only. 1965 to 1971 includes lodges, outfitters, hotels and motels.

2. In 1971 the licensed accommodation available to tourists consisted of the following types and numbers of establishments:

Sport Fishing Lodges	33
Sport Fishing Outfitters	12
Big Game Outfitters	9
Hotels	12
Motels	12
Others	2
TOTAL	80

Source: Travelarctic, Report on Tourism, 1971. Department of Industry and Development, Yellowknife.

TABLE IV: Number of N.W.T. Angling Licences Issued - Selected Years[1].

Year of Issue	Total Issued	Licences Issued Residents	Res. Lic. as % of Total	Licences Issued Non-Res.	Non-Res. Lic. as % Total
1954-55	133	27	20	106	80
1955-56	270	106	39	164	61
1956-57	743	120	16	623	84
1957-58	839	126	15	713	85
1958-59	1,100	229	21	871	79
1959-60	1,204	407	34	797	66
1960-61	1,406	504	36	902	64
1961-62	1,605	810	51	795	49
1962-63	2,153	928	43	1,225	57
1963-64	2,381	985	41	1,396	59
1969-70	4,689	1,045	22	3,644	78
1970-71	5,989	1,439	24	4,550	76
1971-72	6,565	3,373	51	3,192	49

1 a. For the years preceding 1971-72, a resident was defined as an angler who resided in the N.W.T. For the year 71-72 the definition was changed so that a resident was defined as an angler who resided in Canada.

b. Licences were sold by a number of agencies so that it is impossible to determine the exact number of licences sold in the years stated above. However, the figures for 1971-72 are true and complete figures.

c. Although angling licences are sold on the fiscal year basis, their sales and usage are concentrated overwhelmingling in the summer within the particular year.

Compiled From: Cumming, K. 1972. M. S. A Consideration of the Sports Fishery in the N.W.T. Environment Canada, Fisheries Service, Economics Branch, Central Region, Winnipeg, Man.

Seven others are new, not licensed, temporarily closed or restricted in their clientel. Costs for utilizing the lodges vary according to the time of year, location, fishing and services offered. In 1970, the typical user of fishing lodges and outpost camps was over fifty years old and stayed at the lodge from two to four nights.[59] This typical lodge visitor had an annual income greater than $20,000 per year and fifty percent spent from $750 to $1,250 for the stay at the lodge.

The mode of travel is significant in determining the duration of stay and time fished while in the Northwest Territories (Table V). The average duration of stay is one week to ten days and the heaviest fishing by the charter air group. With few exceptions the charter air groups are the lodge users fishing twice as often as the next closest group.

Table V. Duration of Stay and Days Fished by Mode of Travel to the Northwest Territories. (adapted from Cummings,K. op. cit.)

MODE OF TRAVEL	% OF TOTAL VALUES	MEAN NO. OF DAYS IN N.W.T.	MEAN DURATION OF DAYS FISHED IN N.W.T.
Car	6.11	9.9	0.22
Commercial Air	12.78	8.8	0.35
Chartered Air	65.44	7.3	0.68
Private Air	5.67	7.6	0.35

59Cummings, K. 1972. A consideration of the sports fishery in the N.W.T. Environment Canada, Fisheries Service, Economics Branch, Central Region, Freshwater Institute, Winnipeg, Manitoba.Manuscript.

Transportation has not limited the development of the sports fishery to the same extent as the commercial fishery. However, the sports fisherman must be a relatively high income earner in order to bear not only the cost of travelling to the Northwest Territories but also to pay for the cost of reaching the location of the desired fishing activity.

D. 2. Sports Fishing Species Demand

The fish species prefered by sports fishermen were determined from a 1971 angling licence questionaire.* The preferences were as follows:

Lake Trout	- 44%	
Grayling	- 23%	
Northern Pike	- 15%	(not equal to 100%
Arctic Char	- 13%	due to rounding
Yellow Pickerel	- 2%	of figures)

Trophy fish are sought after for all the above species, specially Lake Trout.

The above five fish species are not evenly distributed throughout the Northwest Territories.[60] Lake Trout are ubiquitous to the cold oligotrophic lakes present over the entirety of the Territories. In some of the northern lakes north-east of Great Slave Lake, Lake Trout are often morphologically deformed; skinny

*Description of the questionaire as per Cummings, Loc. Cit.

[60] McPhail, J.D. and C.C. Lindsey, 1970. Freshwater Fishes of Northwestern Canada and Alaska. Fish. Res. Bd. Canada, Bull. 173. Information Canada, Ottawa. 381 pp.

and big-headed causing them to be undesirable for sports fishing.

Northern Pike and Yellow Pickerel are usually found in the same location although in the Northwest Territories, Yellow Pickerel are confined to the Mackenzie River Valley. Northern Pike are found farther East into the Central Territories and Hudson Bay Coast river systems. Northern Pike are not recorded in Northern Keewatin or the Arctic Islands.

Grayling are found in the lakes and rivers of the Mackenzie River drainage as well as in areas of the Western Arctic and along Hudson Bay. Grayling have not been reported in the eastern Arctic or the Arctic Islands. Arctic Char are confined exclusively to lakes, rivers and estuaries throughout the Arctic and Hudson Bay coastline. In many Arctic lakes Lake Trout and landlocked Arctic Char are found together. However, landlocked char are generally much smaller than the sea-going anadromous char.

In view of the distribution of fish species the sports fishermen preference areas can be predicted. From the licence questionnaire of 1971 the preference areas were determined and are illustrated in Table VI. The report information should have noted the Yellowknife area as separate from Great Slave Lake. Since both Bathurst Inlet and Victoria Island were not mentioned in the returns it is very probable that several other active sports fishing areas were excluded.

The greatest demand for fish species and fishing areas is apprently within the range of accessibility provided

TABLE VI: Number of mentions of water fished by area and by modes of travel.

Area	Total Mentions By Area	Car	Commercial Air	Charter Air	Private Air
Great Slave Lake	502	107	60	306	29
Great Bear Lake	260	3	54	193	10
North-East Coast	203	1	30	164	8
Central N.W.T. & Keewatin	170	0	15	147	8
West. Dist. of Mackenzie	63	48	10	2	3
N.W. Coast, Coppermine	0	0	0	0	0
Great Slave Lake Alone	359	11	42	284	22
Total	1,198	159	169	812	58

NOTE: The areas contain the following waters:

Great Slave Lake: Great Slave Lake, Artillery Lake, Kakisa River, Hay River, Prelude Lake, Stark Lake.

Great Bear Lake: Great Bear Lake.

North-East Coast: Chantrey Inlet, Tree River

Central N.W.T. & Keewatin: Dubawnt Lake and River, Kasba Lake, Mosquito Lake, North Henik Lake, Snowbird Lake, Tebesjuak Lake.

West. Dist. of Mackenzie: Mackenzie Delta.

N.W. Coast & Coppermine: Coppermine and Coast.

Source: Cummings. loc. cit.

by Great Slave Lake, Great Bear Lake and the Mackenzie River (Table VI). Undoubtedly this is also influenced by the greatest mix and abundance of fish species in these areas. However, there is a significant demand to fish the Arctic coastal areas for Arctic Char.

D. 3. Government Involvement in the Sports Fishery

The major agencies involved in the control of the sports fishery are as follows:

1. Department of Environment - Fisheries Service (Federal)
2. Department of Indian Affairs and Northern Development (Federal)
3. Department of Industry and Development (Govt. of the N.W.T.)

The involvement of the Department of the Environment remains the same as discussed in the previous section regarding the commercial fishery. The authority is exercised by virtue of the Fisheries Act and the Northwest Territories Fisheries Regulations.[61] There are no sports fishing lake quotas other than individual quotas for the licence holder. Provisions are stated for the capture and export of trophy and non-trophy fish. The Regulations are presently being changed to better ensure the survival of sports fish stocks.[62]

The involvement of Indian Affairs and Northern Development in sports fishing is the same as in the commercial fishery.

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[61] Canada Gazette, loc. cit.

[62] M. R. Robertson, Head, Fisheries Management, personal communication.

Generally, sports fishing development is encouraged providing it is to the benefit of northern residents.

The Department of Industry and Development is involved in both the promotion of Tourism through the Divison of Tourism (Travelarctic) and industrial development through the Industrial Division, Fisheries Section. Travelarctic actively promotes sports fishing in specific areas and generally throughout the Northwest Territories. Travelarctic also undertakes tourist surveys that are necessary for planning methods of attracting and servicing the tourist requirements.

The involvement of the Fisheries Section is essentially the same as for commercial fisheries. However, there is an underlying notion that sports fishing is a major component in the future tourist trade and economy of the Northwest Territories. Thus there is a strong support for combining sports and commercial fishing where feasible.

Even though the Government of the Northwest Territories depends on the Federal Fisheries Service for assessment, monitoring and managing the fish stocks, it effectively controls the development of the sports fishing industry. This control is exercised through Ordinance's and the policy of separating sports fishing lodges. This separation policy and pertinent Ordinances are discussed in following paragraphs.

The number of lodges and guests at a lodge on any lake is based on a rule of 2.5 shoreline miles per guest bed per season.[63] The figure of 2.5 shoreline miles was based on an allowable harvest of 2 ounces per acre per year recommended by Dr. J. Hunter.[64] The actual use must not exceed the allowable harvest and whatever poundage of fish per guest bed is determined, the seasonable turnover must allow a reasonable catch for each guest.

There are several ordinances effecting the operation of sports fishing lodge operations and regulated by the Government of the Northwest Territories (Appendix B). In addition there are several Federal Acts and Regulations indirectly effecting fisheries; taxation, customes and exise, air transportation, land, mineral and water use, shipping and navigation.

It is apparent that Federal agencies exercise their greatest influence on the assessment, marketing, regulation and protection of fish resources. The major effect of the Government of the Northwest Territories is the promotion, development and control of fishing industries. It remains then to determine, through the policy of respective agencies, the actual organization effect on future fisheries development.

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[63]Thompson, K.D. 1971. Separation of Sport Fishing Lodges in the Northwest Territories, Division of Tourism, Yellowknife, N.W.T. File No. 61-715-000.

[64]Dr. J. Hunter, Fisheries Research Board of Canada, Arctic Institute. Ste. Anne de Bellville.

E. Factors for the Inventory and Assessment Method

Transportation and organization factors are included in the fifth classification of factors (Fig. 6). The organization factors are compiled from the previous discussion on sports and commercial fisheries in the Northwest Territories (Table VII).

The factors respecting each fishery must be considered in a total perspective rather than on an individual basis. However, there are two major factors that control the establishment of a commercial fishery. Firstly, the whitefish rate of infestation must be below the export rate of 35 cysts per 100 pounds of fish. Secondly, the quota must be large enough to make a commercial fishery economically feasible i.e. the transportation cost effect. The obvious distance limitation is the point where transportation cost per pound of fish is equal to the price per pound of the lowest priced fish species.

Sports fishing is also influenced by transportation costs and access. Because of these limitations, transportation and organization factors must be jointly considered in the assessment of fisheries potential.

The use of organization factors will be illustrated by the application of the Inventory and Assessment Method on Little Doctor Lake in a forthcoming section.

TABLE VII. Organization factors for the inventory and assessment method.

	Sports Fisheries	Commercial Fisheries
A. Market Factors		
1. Fish species	Lake Trout Grayling Northern Pike Arctic Char Walleye Pike	Lake Trout Whitefish Arctic Char Walleye Pike Northern Pike Inconnu
2. Size of fish	Trophy fish	Larger the fish the greater the price per pound
3. Colour		
- Flesh	Red and orange most desirable for Lake Trout and Arctic Char. Generally not important for other species.	
- Exterior	Olive most desirable for Lake Trout, sports and commercial.	Light - backed Whitefish bring the best market price
4. Shape of fish	Big-headed Lake Trout unacceptable to both fisheries. Generally unimportant for other species.	
5. Abundance of fish	Greater the abundance, greater the fisherman satisfaction (measured as catch per unit effort)	Greater the abundance, lower the unit production cost (measured as catch per unit effort)
B. Legislation-Regulation Factors		
1. Quota- Control Area	Daily species quota the same throughout the N.W.T.	Quota preset as puonds per acre according to lake area
- Outside Control Area	Ibid	Assessed quota according to the productive capacity of the lake or river
2. Use of lakes and rivers for fishing	No restrictions other than protected areas	Some lakes and rivers restricted to sports and domestic fishing only
3. Fishing seasons - Control Area	No seasonal restrictions	Restricted by the six year cycle

- Outside Control Area	No seasonal restrictions	Restrictions to prevent over-exploitation according to individual assessment
4. Fishing Gear	Some restrictions. Desirable to have the opportunity to use various types of fishing gear	Restricted by the legal mesh size
5. Fish Inspection Act	Not applicable	Whitefish rate of infestation. Packing-processing plant requirements. Quality requirements.
6. Government of the Northwest Territories - Ordinances and Policy	Lodge location and number of guest beds	Industrial incentives

F. Public Policy and Future Fisheries Development

Public Policy respecting fisheries development is influenced by a host of public and private agencies. The major impact is directed from two federal government departments and the Government of the N.W.T. The Federal Agencies are the Department of the Environment and the Department of Indian Affairs and Northern Development. In the Territorial Government this influence is shared by the Fisheries Development Section and the Tourist Development Section both of the Department of Industry and Development. There is a tendency to maintain a national interest in the N.W.T. rather than territorial.

In 1971 the Federal and Territorial Governments established a Task Force to investigate fisheries development in the N.W.T. with the following objectives:[65]

1. The preparation of a specific plan or proposal for the development of the freshwater, marine and anadramous fishery resources of the N.W.T. during the period 1972-71.

2. The development of a continuing management system through which existing programmes can be assessed for their continuing adequacy, as well as past efficacy, and through which new proposals can be evaluated.

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[65]Federal-Provincial Task Force. Where to Now? Fisheries Development in the Northwest Territories. Sec. 1, Dept. of the Environment. Fisheries Service, Winnipeg. April. 1962.

The Task Force made nine recommendations:

1. Fisheries development should be for the benefit of the long-term residents of the north.

2. To keep development options open, exploitation methods which depress the resource base for an extended period should be discouraged.

3. Harvesting fish for domestic purposes should take precedence over commercial or sports development.

4. Development should meet the following criteria:

(i) there should be an adequate supply of fish
(ii) the development should be economically viable within a five-year period
(iii) the residents should want it

5. Existing fisheries should be re-assessed in light of the criteria recommended above.

6. Fisheries managers should be consulted in planning the use of other natural resources.

7. A program review committee should be created immediately.

8. More consideration should be given to encouraging sports fisheries in the N.W.T.

9. Information on N.W.T. fisheries should be readily accessible to those involved in fisheries development, and to the general public.

These nine points outline specific policy direction that hopefully will be followed by the two levels of government. There is no single policy directive for fisheries development by the Department of the Environment other than Inter-Department Directives that have arisen to clarify or solve short-run problems (personal observation). The purpose of the Department is defined in the Fisheries Act and Regulations. The Government of the N.W.T. however, has taken a more active stand because of the potential revenues that could be obtained through Industry and Tourism. In brief, the policy of the Division of Tourism "is to encourage the growth of tourism both in numbers of travellers and in the facilities to accommodate them."[66] Grant programs are available to finance enterprises. As the Govt. of the N.W.T. also establishes ordinances, there is the direct legislative control over development of licencing commercial enterprises (fishing lodges, supply infrastructure) labour standards (guides, summer help) and public works (new lodge developments).

The policy of the Department of Indian Affairs and Northern Development (D.I.A.N.D.) is very wide ranging and because of the variety in legislative control this Department has a large vested interest and responsibility to development in the Northwest Territories. It is to be noted that under the terms of the Northwest Territories Act, the Commissioner is responsible to the Governor in Council (of Canada) and the Minister of Indian Affairs and Northern Development. There could be an obvious influence of Federal policy upon territorial

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[66] P. Cove, Development Officer. Div. of Tourism. Department of Industry and Development, Yellowknife. Personal communication.

legislation although in practice it is more likely that the territorial government would "attempt" to follow the advice of its council. Public sentiment in the Territories has of late made several issues against federal influence which they feel is akin to an absentee landlord.

Other than the D.I.A.N.D. direction in the Northwest Territories Act, legislation under the Territorials Lands Act[67] as amended in 1970[68] states the following objectives:[69]

> "to provide a legislative base for the promulgation of regulations which will provide a measure of control over the types and methods of northern resource exploration, development and restoration procedures in order to minimize degradation of the land surface."

By virtue of this Act and amendments the D.I.A.N.D. controls all land use in the Territories. While this act provides control by restriction, there are several assistance programs that are incentives to development, i.e.

The Northern Roads Program

The Northern Mineral Exploration Assistance Program

Northern Resource Airports Program

Small Business Loan Funds

While often these programs are shared between the N.W.T. and the Yukon, considerable overall effort is being made to "develop"

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[67] Territorial Lands Act, Chapt. 263. Revised Stats. of Canada. 1952

[68] Bill C-212 passed June 22, 1970

[69] Naysmith, J.K. 1971. Canada North-Man and the Land. Information Canada, Ottawa.

the North. The Northern Development Program[70] has five sub-objectives for the development of the Yukon and the Northwest Territories:

Sub-objective 1 - referring to the structure of the Govt. of the Territories.

2 - referring to economic expansion, social adjustment, and develop and manage natural resources.

3 - referring to industrial and infrastructure expansion.

4 - referring to social services.

5 - referring to a forum to review federal and territorial government activities.

In his report to the Standing Committee on Indian Affairs and Northern Development, the Hon. Jean Cretien outlined the Government's northern objectives, priorities and strategies for the 70's.[71] His objectives on resource development are quite clear:[72]

- development of renewable and non-renewable resources where they were socially beneficial, economically viable and ecologically feasible.

The policy of D. I.A.N.D. is contained in a magnitude of legislation

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[70] D.I.A.N.D. Annual Report 1970-71.

[71] Press release, March 28, 1972.

[72] Ibid, page8.

and a multitude of policy objectives. Essentially, however, the Department policy is contained in the objectives for the 70's as outlined by the Hon. Jean Cretien. Given the present determination of the Department, it is doubtful that there will be any hinderance to fisheries development in most areas of the Northwest Territories.

G. Future Trends in Organization

Due to the structure of Government in the N.W.T. and the responsibility of Federal agencies in the Territories, the policy of fisheries resource development is both variable, wide ranging and immense. The major influencing agencies are as follows:

1. Federal - The Department of the Environment, Fisheries Service. Dept. of Indian Affairs & Northern Development - I & E affairs.
2. Territorial - The Government of the N.W.T.
   - Industry and Development
3. Crown Corporations - Freshwater Fish Marketing Corporation

From the Discussion in the previous section, the future trends can be determined subject to some basic conditions and assumptions.

Assumptions:

1. The North must be developed for Northern residents.
2. Native peoples must be considered and involved in resource projects.
3. Resource projects must be both economically

feasible and socially beneficial.

4. The Northern environment must be protected and soundly managed.

5. That Government agencies will cooperate to ensure controlled development.

The following trends in fisheries development can be expected:

1. The commercial fishery will both become more efficient and expand in lakes close to Hay River and Yellowknife.

2. As distance to points in 1. increases, consideration should be given to intensively manage the lakes within the following areas:

(i) through the Taltson River System
(ii) through the Camsell River System
(iii) the large area East of Yellowknife

3. Commercial fishing areas will increase to develop around the following areas:

(i) Cambridge Bay (Victoria Island)
(ii) Nahanni Mountains
(iii) The Mackenzie Delta
(iv) Rankin Inlet Area - Keewatin Lakes
(v) Pelly Bay-Spence Bay - Gjoa Haven Areas
(vi) Frobisher Bay Area

4. As tourism and recreational demands increase, sports fishing development will take place in several southern and western N.W.T. areas.

A. Easy Access Areas:

(i) lakes and rivers along the Mackenzie Highway
(ii) lakes and rivers along the Ft. Providence - Ft. Simpson and Inuvik Highway
(iii) along the Dempster Highway
(iv) along the Ft. Simpson - Ft. St. John Highway

B. Air Transport Areas:

(i) Fly in areas with central locations at Hay River, Yellowknife, Uranium City, Churchill, Inuvik, and Ft. Simpson.
(ii) Fly-in areas around or into more remote areas,i.e. Nahanni Mountains, Mackenzie Range, Bathurst Inlet, Baffin Island (Frobisher Bay) and other remote Arctic settlements.

Some additional trends in a more general sense can be expected due to both public pressure and changes in management techniques:

1. Allowing domestic fisheries to be used for commercial sale either within or outside the N.W.T. The domestic fishery was normally spaced over the calendar year with greater effort expended during spring and fall runs. To be economically feasible, a commercial enterprise would have to harvest the largest volume of fish in the shortest period of time as these domestic fishery locations tend to be isolated to all transportation other than air. It is most likely that the fish population would not support such heavy short-run pressure.

2. Allowing fishing lodges to establish at the centre of a group of lakes would greatly diminish the possibility that any one lake would be overfished. Commercial Fishing enterprises could be grouped for the same reason plus the fact that having a central shipping location supplied by a group of lakes would greatly increase the probability that full loads could be hauled out. The group of lakes could either be operated by one or several fishermen.

3. The use of barbless hooks to diminish damage to unwanted fish would be a significant conservation effort in low productive lakes in the N.W.T. In the majority of sports fishermen the greatest thrill is in attempting to catch and then landing the fish that gives the sporting experience- not taking the dead fish unless it is of trophy size.

4. New fisheries management techniques should be designed to achieve the greatest long term return from the fish resources to the benefit of both the biological and social well-being of the Northwest Territories. The Control Area quota should be modified to allow for the variability in species abundance throughout the controlled lakes. This modification is illustrated as follows:

Quota -	20,000 lbs.	
Relative abundance of commercial species -	Lake Trout Whitefish	40% 60%
Quota Composition should be -	Lake Trout Whitefish	8,000 lbs. 12,000 lbs.

Presumably the total species productivity of a lake is 1/2 pound per acre per year. The species and relative abundance are determined by the biological and non-biological peculiarities of each lake. To avoid upsetting the natural balance the quota for each species should not be more than its natural abundance. Once the determined poundage for any one species is reached the fishery should be closed. Several lakes with a similar percentage abundance could be grouped together for administrative and management purposes.

At present considerable sport fishing activity is located on Great Slave and Great Bear Lakes. Undoubtedly the controlling factor in the implementation of the four trend divisions will be influenced by changes in transportation, industrial (resource base) activity and the changes in patterns of human recreation activity. Transportation remains as the major factor, thus its consideration in the following section.

A common fault of managing a natural resource is that people are managed and not the resource. Legislation and regulation must manage the resource and attempt to obtain an optimum yield that will return the greatest (Maximum) benefit to society as a whole, not just the resource user. Where resources can be used the user must be considered as well.

The problems associated with fisheries development are enormous and complex. The components of the industry and the factors effecting its development can be roughly determined. But time, the whims of governments and people can only near-sightedly be dealt with; and they may be the most influencial of all.

CHAPTER V

TRANSPORTATION

Transportation has played a major role in developing Canada's resources not only by providing access but as a means of settlement directed towards future economic viability. However the benefits of intensive transportation networks have been confined to southern communities. Many northern communities remain isolated due to inefficient and expensive modes of transportation; at the expense of lower value resources such as fisheries.[73]

Transportation both determines where fisheries can potentially develop and how the development will proceed. Generally, fishing industries must depend on pre-existing transportation services that located for reasons other than fish resources. Once the location function of transportation is present the use of the resource and growth rate of the industry is dependant on the modes and costs provided by the transportation services. Thus there are factors for fisheries managers to consider in the use allocation of fisheries potential. The trends and effects of transportation can also be used to preduct the areas where fisheries can potentially develop due to the availability of industry support services.

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[73]Manitoba, Province of. 1969. Royal Commission Inquiry Into Northern Transportation. Queen's Printer for Manitoba. 601 pp.

Northwest Territories Climate and Geography

The general climatic and geographical conditions of the land indicate the variety of problems that have and will be encountered in developing transportation systems. The cost of northern transportation is high due to severity of climate, rugged landscape and technology that must be vastly different from that in southern Canada.

The Northwest Territories comprise an area of some 1,304,903 square miles representing 33.9% of the land in Canada. On the Western border it is bounded by the Mackenzie Mountain range to a height of approximately 8,000 feet. The actual mainland is composed of two distinct geological regeins; the Interior Plains and the Precambrian Shield. The former, an extension of the Great Plains, is dominated by its principle drainage system, the Mackenzie River. The Precambrian Shield extends Eastward to Baffin Island being replaced by sedimentary rock in the Eastern Arctic Islands.

The climate of the Northwest Territories is typically cold and dry. Annual precipitation is greatest in the Mackenzie Valley area (10 to 15 inches) decreases in the Central and Arctic areas (5 to 8 inches) then increases again in the Eastern Coastal areas (10 to 15 inches). Snow covers the landscape for nearly eight months of the year with breakup from late May to early June and freezeup in October. The wind is a persisent phenomenon expecially in the open areas North of the treeline.

In addition to these climatic conditions the problems associated with permafrost effect all modes of transportation. Although interrupted by moraines, eskers and rock outcrops, the major part of the soil present is fine grained from pleistocene glacial and post-glacial deposits. These soil types contain a high ice-water content and have taken centuries to form the delicate balance that exists between sufficient surface insulation and severe erosion. The line marking the boundary between the continuous and discontinuous permafrost is approximately a great circle from 68°N 141°W to 60°N 98°W. Roughly one-quarter of the Northwest Territories comprising the Mackenzie Plains is in the discontinuous zone. Because of this discontinuity for the Plains region great topsoil instability exists posing severe limits to surface development i.e. roads, pipelines, airports and railways.

A. <u>Road Transportation</u>

A. 1. <u>Present Facilities</u>

Highways in the Northwest Territories are confined to the southwestern border area specifically around Great Slave Lake and along the Mackenzie River (Fig. 8). These highways are part of the Mackenzie Highway System that originated at Grimshaw, Alberta in 1948 and joined Hay River to the north. At the present this highway links Fort Smith, Pine Point, Fort Resolution, Fort Providence, Fort Simpson and Yellowknife. The impact of the Mackenzie Highway on tourism is illustrated in the following table.[74]

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[74] Northwest Territories, Govt. of the. 1969, 1970, 1971. Report on Tourism Travelarctic, Dept. of Industry and Development. Yellowknife.

TABLE VIII. Mackenzie Highway Motorists, 1969 - 1971

	1969	1970	1971
Highway (Total)	6,300	12,150	9,000
Independant Camper		6,760	
Non-Camper		4,700	
Caravan Camper		340	
Bus Passenger		350	

In 1965 the Territorial Road Policy and Northern Road Program were initiated by Federal-Territorial agreement.[75] The programs were developed for a ten year period from 1965 - 1975. Road development was divided into two main groups.[76]

1. Communication Roads
   - (i) Trunk Highways
   - (ii) Secondary Trunk Roads
   - (iii) Airport Roads
   - (iv) Local Roads
2. Resource Roads
   - (i) Area Development Roads
   - (ii) Resource Development Roads
   - (iii) Permanent Access Roads
   - (iv) Initial Access Roads
   - (v) Tote Trails

The policy to develop these sub-classifications has centered mainly on the Resource Roads of which (iii), (iv) and (v) have been cost-shared with industrial concerns. The Communication Roads have not been ignored as they require continued maintenance and improvement. In referring to Fig. 8 on Road Construction,

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[75] Canada. 1971. Arctic Transport. Proceedings of the Arctic Transportation Conference, MOT & DIAND, Yellowknife, Dec. 8 & 9, 1970. Vol. 2

[76] Ibid.

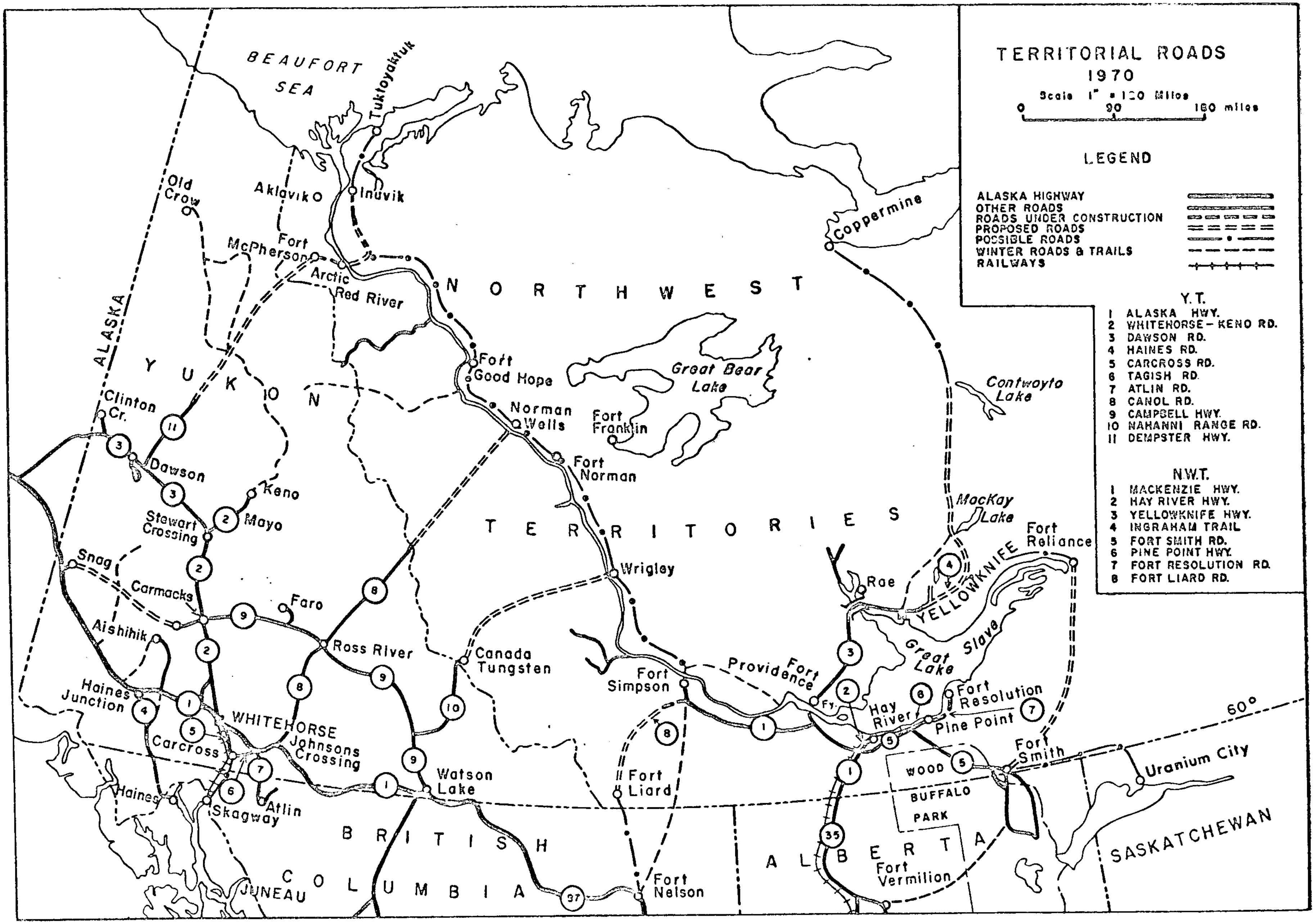

FIGURE 8. Territorial Roads, 1970.

proposed roads are those that tentatively will be constructed in a second ten year phase from 1976 to 1985 (Appendix C). In this period the south-eastern areas will be opened for resource development.

Winter roads played a significant role in the development of the N.W.T. until the early 1960's. Because the road bed is often frozen lakes, little maintenance other than grading and snow-clearing to ensure a greater ice depth for support. However, significant problems arise off the lakes, i.e. streams rivers, Precambrian Shield relief and muskeg swamps. Initial construction problems can be countless even when a route has been chosen by flying over an area and using airphoto interpretation techniques.

At the present winter roads mainly exist to supply mining companies and exploration crews. Cat trains still operate out of Yellowknife to the mines on Great Bear Lake passing over the long chain of lakes comprising the Camsell River System.[77] With the availability of high freight capacity aircraft the hauling of fish over winter roads is now considered obsolete. Recently the Province of Manitoba announced that winter road freighting would cease for this very reason.[78] The use of bombardiers and similar snow machines will likely continue but only in areas within close access to central shipping-receiving points.

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[77]Byers Transport, Hay River, N.W.T. Personal Communication.

[78]The Winnipeg Free Press, December, 1972.

A. 2. Proposed Facilities

The greatest potential for road development and the opening of new and "widerness" country remains along the Mackenzie River Corridor with its extension to Fort Liard (under construction), the Dempster Highway from Fort McPherson (partially completed) and the southward extension from Inuvik to Arctic Red River (initiated summer of 1971).[79] The Ingraham Trail East of Yellowknife will probably be extended in the very near future.

As a result of interest in the island mineral potential of the Northwest Territories the highway extension North of Fort Simpson is in progress. Gravel surfacing is not expected until 1975[80] (Table II, Appendix D).

The most probable roads to be constructed are those along the Mackenzie River and East of Yellowknife and Hay River. The expansion of winter roads is not foreseen. Technological change with respect to all Terrain Vehicles could cause new winter roads to be built. Such changes are too unpredictable.

A. 3. Impact on Fisheries Development

The impact on extent and type of fisheries development is dependant upon the use of highways by personal and freight

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[79] Naysmith, John K. 1972. Canada-North of 60. Dept. of Indian Affairs and Northern Development. Information Canada. 44 pp.

[80] Western Canada Business Letter, Century Publishing Company, Winnipeg, Manitoba. Oct. 13, 1972.

vehicles. The former includes tourists and specifically sports fishermen; the latter includes trucking of equipment, supplies and fish for commercial fisheries. Highways provide both access and a means of mobility and where roads are present, road transportation remains as the least cost, most desirable method of movement.

The Northern Road Program policy will affect more than 250,000 square miles of wilderness. For the reasons given above the greatest demand for water within this wilderness will come from the users of highway transportation. As the highways are extended and completed along the Mackenzie Corridor there will be a large influx of tourists into the most spectacular Mackenzie and Franklin Mountain areas. The area East of Yellowknife will also receive considerable attention from tourists as well as commercial fishermen. The extension of the Ingraham Trail may be slow due to pressure on the Mackenzie Corridor. The areas of the Nahanni Mountain Range and Tcltson River System will remain primarily as wilderness areas for the next few years.

The utilization of winter roads will have limited impact on fisheries development unless other means of surface transportation are introduced. It is unlikely that a sufficient volume of fish could be gathered in a short period of time to support the cost respecting both development and continued use of new winter roads. As an alternative, Bombardiers and other snow-machines could be used in conjunction with other modes of transportation i.e. aircraft or large All Terrain Vehicles. Present modes of winter road transport will not expand unless there is new access provided by highways thus decreasing high costs, risk and time, the major limits to winter road transportation.

There is an obvious impact on the extent and type of fishery development by road transportation. The opening of new highways will provide access for the sports and commercial fisherman and decrease transportation costs vital to commercial fisheries.

B. Air Transportation

Air transportation has played a dominant role in the development of fisheries resources in the Northwest Territories. Aircraft are an obvious necessity due to the lack of roads and climatic restrictions to the use of other modes of transportation. Both sports and commercial fishermen have made an intensive use of existing although scattered, air services and facilities. Aircraft availability is still subject to climatic and seasonal restrictions. With the recent introduction of turbo-prop aircraft many changes are taking place in the structure of the flying industry with a potentially large impact on fisheries development.

B. 1. Present Facilities

The structure of transporting passengers and freight is mainly dependant on two factors; airport facilities and air service.

(i) Airports

By 1970 there were approximately 88 land airfields and 62 seaplane bases recorded for both the Yukon and Northwest Territories.[81] The terminal and airport facilities are illustrated in Figure 9.[82] In addition there are several airports developed for resource projects and the military that are now abandoned. Besides the recorded bases, aircraft equipment with skis or pontoons are virtually unlimited as to landing areas.

Northern airports can be divided into regions on the basis of mainline regional services as follows (Fig. 10):[83]

Region	Mainline Centre	Route Origin	Sub-Centres Scheduled Service
Mackenzie	Yellowknife	Edmonton	Cambridge Bay Fort Smith Hay River Norman Wells
Mackenzie Delta	Inuvik	Yellowknife & Edmonton	Delta and West
Keewatin	Churchill	Winnipeg	Rankin Inlet Baker Lake Eskimo Point
South Baffin	Frobisher Bay	Montreal Churchill	South Baffin Area
High Arctic	Resolute Bay	Frobisher Bay Yellowknife	High Arctic

The importance of defining these regions is based on the fact that the facilities allow for the use of large transport aircraft on scheduled runs. These centres become the departure hub for

[81]Canada. 1971. Arctic Transport. loc, cit.

[82]Ibid.

[83]Canada. 1971. Northern Air Transport Study. Vol. II. Canadian Transport Commission, Research Branch. Ottawa.

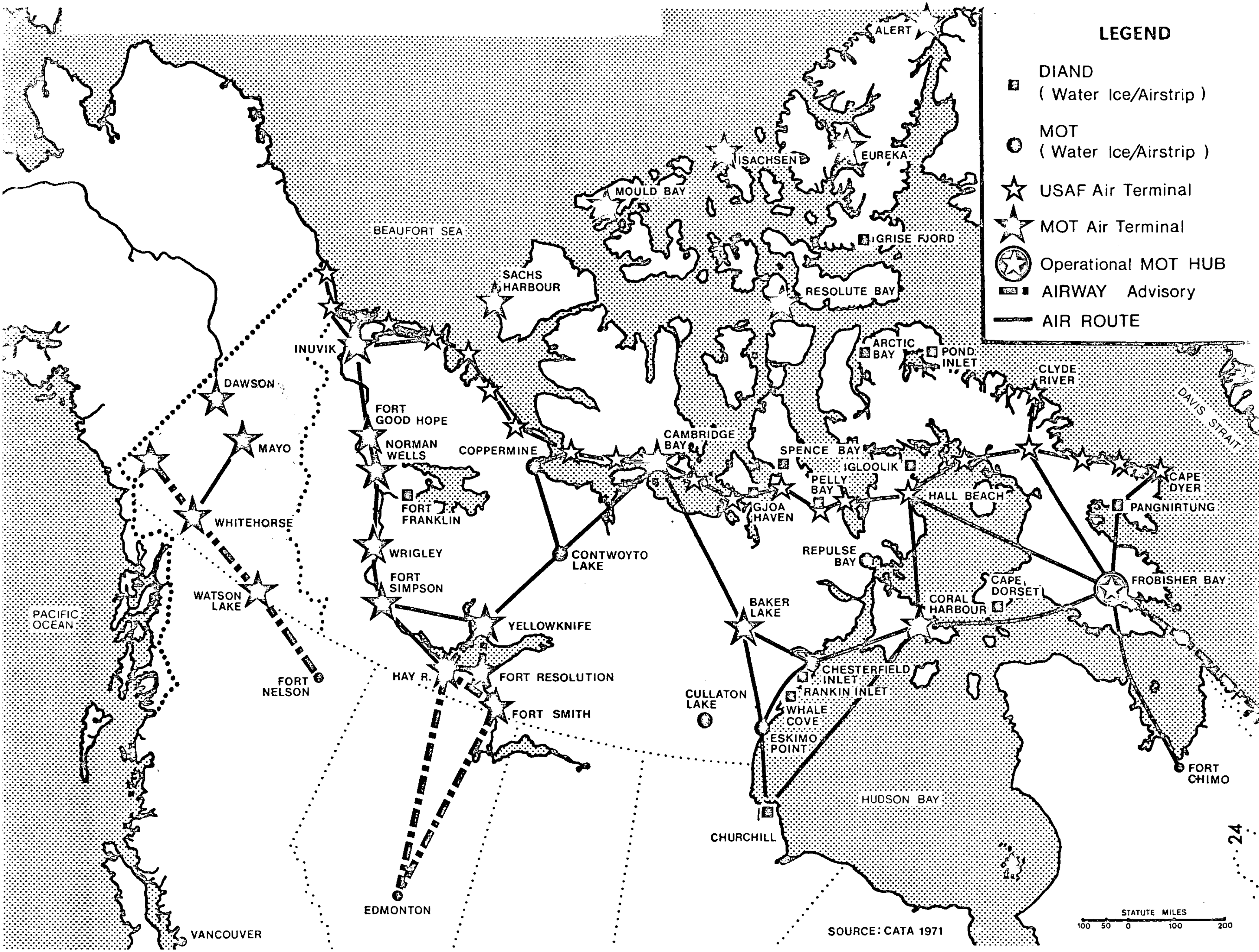

FIGURE 9: Terminal and Airway Facilities - Northern Canada.

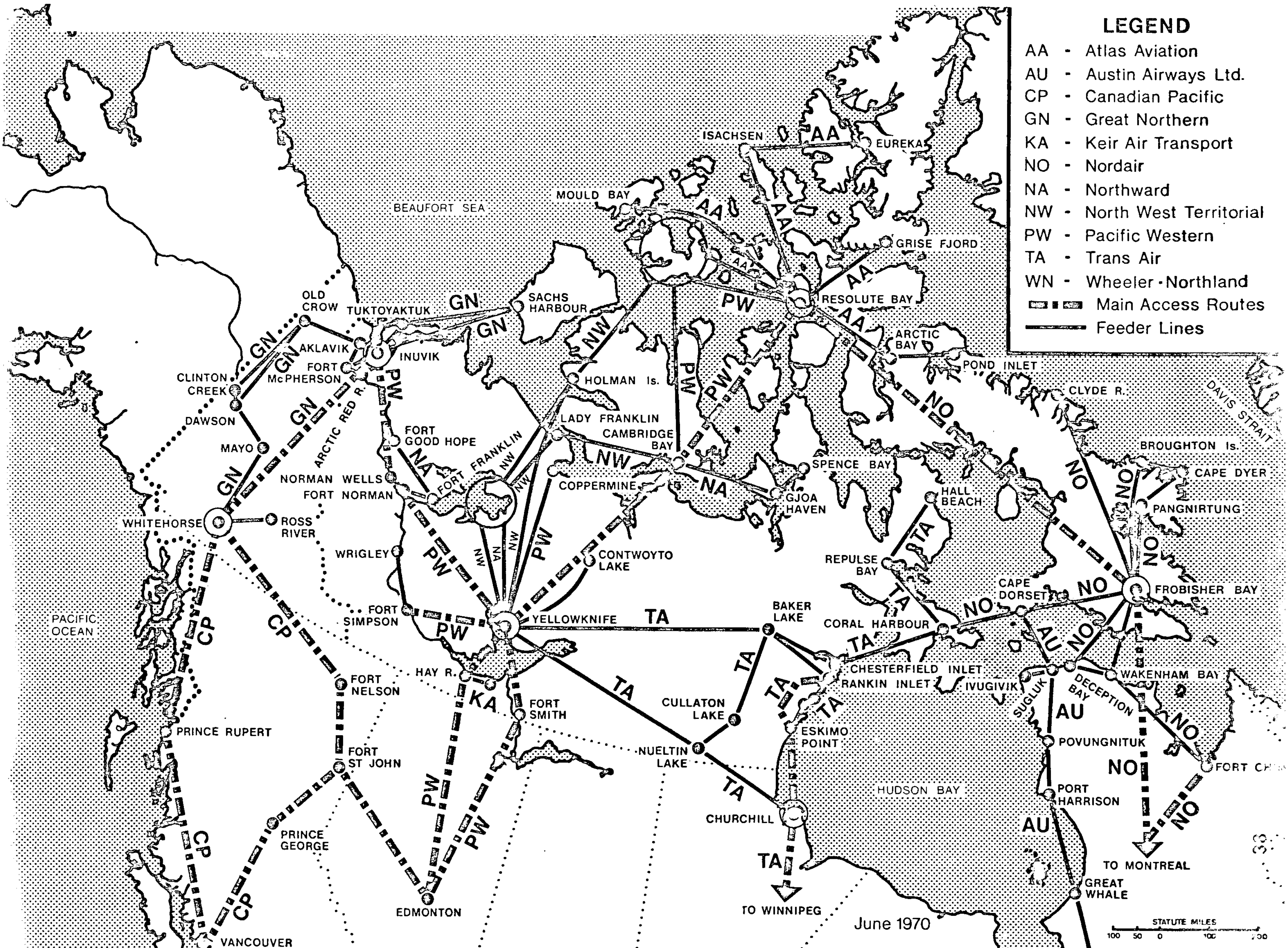

FIGURE 10: Commercial Air Services - Northern Canada

smaller aircraft flying into the hinterland composed of tourist lodges, resource exploration bases and commercial fishing areas. Thus, any one location on the mainline route may support one or more small local carriers servicing the hinterland. The establishment of route stops appears to cause carriers to locate and provide various degrees of service according to the passenger freight supply of the mainline carrier (Fig.9)[84] Air carrier centres are factors that influence the location of a fishing industry. At least one of the thirteen regional carriers is located at each mainline base.

(ii) Air Services

This section on air services concerns the types of aircraft available and the service they provide in the Northwest Territories. Service includes payload, range and operational requirements. The aircraft and service are of little consequence to the lodge tourist as there is seldom any aircraft choice and cost may be included in the total lodge cost. However, both the non-lodge tourist and commercial fisherman must be concerned with aircraft types, range and payload in order to minimize costs.

The Canadian Transport Commission has designated four groups of commercial air services according to the weight of the aircraft.[85] Three of these groups with the type of

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[84]Northern Air Transport Study. Ibid.

[85]Canada. 1972. Directory of Canadian Commercial Air Services. Canadian Transport Commission, Air Transport Committee. Ottawa. 5th Rev.

aircraft available in the Northwest Territories are illustrated as follows:

Group AA	Group A	Group B
Hercules	Bristol Freighter	DHC-6 Twin Otter
Boeing 727	DC-6	DHC-3 Otter
Boeing 737	DC-4	Turbo Beaver
	DC-3	Beaver
		PA-23 Piper
		Beech 18
		Cessna 206
		Cessna 185
		Cessna 180

Performance of these aircraft is contained in Appendix C. Group C is excluded as aircraft lighter than 2,500 pounds are generally too small to be considered for passenger or freight cargo on a commercial scale.

The tourist traffic arrival in the Northwest Territories is generally by mainline carrier of Group AA. Both Groups A And AA are used for freight and passenger hauling. Group B aircraft are nearly exclusively confined to regional transportation. With the exception of the Beech 18 and PA-23 all aircraft in Group B are capable of ski and pontoon landings .

The basic decision concerning the use of any aircraft for transportation must be based on the following:

1. payload capacity
2. distance to be travelled
3. charter costs.

The payload varies by type of aricraft, undercarriage and distance due mainly to the weight of required fuel. Each charter company must have the charges and conditions of service posted once approved by the Air Transport Commission. The problem of chosing an aircraft then becomes three dimensional; a function of distance, payload and cost.

Tables IX and X are constructed from the information in Appendix D. The payload capacity varies considerably according to aircraft type (Table VIII). At present the Cessna 180, 185 and 206 are the most common in the four to six place size class. The Twin Otter is steadily replacing the single Otter and Beaver aircraft. It appears that most charter fishing trips are within 50 to 75 miles of a float plane base. The twin Otter would be the logical choice for long distant and moderate payload transportation.

TABLE IX: Aircraft choice based on charter cost as a function of distance and payload (float equipped aircraft)

Payload (lbs.) and Choice		DISTANCE (ONE WAY) MILES 25	50	75	100	150	200
500	1st	180	180	206 →			
	2nd	206	206	185 →			
1,000	1st	206 →			Beaver →		
	2nd	Beaver →			T. Beaver →		
1,500	1st	T. Beaver →					
	2nd	Otter →					
2,000	1st	Otter →				T.Otter →	
	2nd	T. Otter →					
3,000		NONE AVAILABLE					

The use of least transport cost is a refinement of Table IX (Table X). It is apparent that the Twin Otter is the most suitable aircraft for distances greater than fifty miles

TABLE X: Least transport cost by aircraft as a function of' distance (based on full load)

Undercarriage & Choice		Distance (One Way) Miles 25	50	75	100	150	200
Wheels	1st	Beech 18	Beech 18	Beech 18	Beech 18	Beech 18	Beech 18
	2nd	Otter	Tw.Otter	Tw.Otter	Tw.Otter	Tw.Otter	Tw.Otter
	3rd	Tw.Otter	Otter	Otter	Otter	Otter	Otter
	4th	Beaver	Beaver	Beaver	Beaver	Beaver	Beaver
Skis	1st	Norseman V	→	→	→	→	→
	2nd	Beaver	→	→	→	→	Tw.Otter
	3rd	Otter	→	→	→	Tw.Otter	Beaver
	4th	Tw.Otter or Beech 18	Tw.Otter	→	→	Otter	Otter
Floats	1st	Norseman	→	→	→	→	→
	2nd	Cessna 206	→	→	→	Tw.Otter	Tw.Otter
	3rd	Beaver	→	→	→	Tw.Otter	Tw.Otter
	4th	Otter	→	→	→	Beaver	Beaver

(there are very few Beech 18, Beaver and Norseman in the N.W.T.). Since the commercially fished inland lakes are greater than fifty miles from Hay River, the Twin Otter is an obvious choice for air-freighting fish.

Since sports fishing is a summer activity there is a large demand for small,inexpensive float-equipped aircraft. The Cessna 206 carries up to five passengers (depending on the model) and is both the least cost and most common aircraft within the likely range of fly-in fishing (Table X). The Cessna 185 could be substituted for the 206 for a slighly extra cost but little difference in payload.

B. 2. Proposed Facilities

The future of northern airports was discussed at the Arctic Transport symposium in 1970.[86] In forecasting future trends airports were divided into six categories:

1. Transportation Transhipment Hubs Airports
2. Resource Development Airports
3. Research Support Airports
4. Military Airports
5. Local Community Airports
6. Technical Support Airports

It was expected that the Transhipment Hubs would continue to expand their facilities and service to receive larger and more diverse aircraft. There would be only periodical requirements for Resource (mine sites and oil fields) airports and very limited requirements for Research (weather stations) airports.

The most promising source of future airports will be military and Local Community Airports. The military have abandoned several airstrips as DEW Line repeater stations in the various sectors became obsolete. These airstrips are now controlled by the Ministry of Transport and providing they are serviceable can be used by public aircraft. Military airport policy may be changed in the near future to allow non-military use of their facilities. Two major obstacles are extremely high costs for services (fuel and lubricants) and interference with the defense function of the site. Shared facilities are already in use at Cambridge Bay and Resolute.

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[86] Canada. Arctic Transport. Vol. 2. loc. cit.

Local Community Airports will develop with the availability of funds as normally airports are constructed for a community and not a national need. The Department of Indian Affairs and Northern Development will continue to play a major role in the type of airport construction. Communities that have received such assistance are Rankin Inlet, Fort Franklin, Gjoa Haven, Pelly Bay and Pond Inlet.

It is doubtful that Technical Support Airports will develop any further as more sophisticated meteorlogical and navigation equipment can be located at existing airports. Present airports installing this type of equipment may attract the longer range, more versatile aircraft allowing access to previously isolated areas. The use of scheduled, high speed and all weather service into areas of the Eastern Arctic creates an entirely new sports fishery potential.

Piston aircraft are being replaced by more efficient jet and turbo-jet aircraft; efficient in operation, maintenance, speed and versatility. Significant advances are being made in the field of Short Takeoff and Landing (S.T.O.L.) aircraft such as the Turbo Beaver and Twin Otter. Technological change will undoubtedly have a major impact in fisheries development as fewer and fewer areas will be isolated or inaccessible.

B. 3. Impact on Fisheries Development

Air transportation is related to fisheries development generally as follows:

Passengers - flying to sports fishing lodges
- flying to lodge outcamps
- flying to wilderness fishing areas
- lodge personnel transport
- commercial fisherman transport
- mainline carrier tourist transport

Freight - lodge and outcamp supplies (food and equipment
- commercial fishing camp supplies
- fish freight.

Generally, most communities in the Northwest Territories have developed around a resource base. These resources are both diverse (minerals, petroleum, fish) and scattered thus isolating many communities. Air transportation has allowed these communities, spread over a 1,304,000 square mile land mass to reach southern markets in only a few hours.

Hub transportation centres caused the development of regional carriers to service the inland resources near these centres. Aircraft are now flying more efficiently, carrying more cargo at a faster speed and with greater versatility of use. Few areas are inaccessible to any type of fisheries development given a market demand for the resources.

The trends in air transportation indicate that the area surrounding the Mackenzie River, Great Slave Lake, Hay River and Yellowknife have the greatest potential for fisheries development. The most probable distance from these locations would be between 50 and 100 miles. Because of its hub function and general availability of aircraft, the abundance of lakes in the area East of Yellowknife will be a major attracting feature to sports fisheries.

The Western Arctic will probably receive improved airport and service facilities in the near future. Because of unique landscape features and the Arctic Char, fisheries development will tend towards sports fisheries. This likely applies to the Eastern Arctic North Coast and Hudson Bay. Although less costly aircraft are being introduced, low fish production and extensive distances will continue to limit commercial fisheries in these areas.

The lakes in the District of Keewatin will remain on the fringe of sports and commercial fishing development. However there are several large lakes towards the southern boundary of the District that could be feasible to fish and transport by large aircraft. The major limiting factor to this entire area is the lack of airports and an abundance of small lakes. The most practical solution would be to develop sports fisheries even though they are seasonally restricted.

C. Water Transportation

Historically, the use of water transportation became firmly established in the Northwest Territories by the fur trade and exploration for the Northwest Passage. The Mackenzie River has remained the major route, joining the Beaufort Sea and the railway terminal at Hay River.

1. Present Facilities

Presently there are two transportation companies using the Mackenzie River System; Northern Transportation Company Limited (N.T.C.L.), a crown corporation, and Kaps Transport, a private corporation. Both enterprises are based at Hay River. Navigation facilities (lights, beacons, markers and channel maps) are provided by the Ministry of Transport based in Hay River. The Ministry's public service also includes dredging of channels and maintenance of facilities throughout the shipping season. The Western Arctic is serviced by both the aforementioned corporations while freight movement in Hudson Bay and the Arctic Islands is co-ordinated by the Federal Ministry of Transport from Churchill and Montreal.[87]

The service provided along the Mackenzie River System is the movement of large tonnage, open or containerized goods. The barges are hauled in series to their destination. Since the Mackenzie River flows into the Beaufort Sea, both shipping time and movement of full barges is facilitated.

The seasons of the year closely control water transportation. The major factors are ice and water level. River traffic usually begins around mid-June and by the end of July for the coastal areas. (Table XI)[88] The summer of 1972 was very atypical in that river breakup was two to three weeks late and the sea lift into areas of the Western Arctic could not be completed without ice-breaking.

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87 Northwest Territories, 1969, 1970, 1971. Northwest Territories Tourism Investor's Handbook. Division of Tourism, Dept. of Industry and Development, Yellowknife.

88 Arctic Transport. Vol. 2. loc. cit.

TABLE XI: Water routes and seasons of Northern Transportation Company Limited in the N.W.T.

From	To	Period	Days
Hay River, N.W.T.	Great Slave Lake & Upper Mackenzie River	June 15 - Oct. 20	127
" " "	Great Bear Lake	July 15 - Oct. 10	80
" " "	Lower Mackenzie River	June 20 - Oct. 5	107
" " "	Tuktoyaktuk	July 5 - Sept. 25	82
" " "	Arctic Coastline	July 15 - Sept. 25	72

NOTE: Depending on type of vessel, the minimum average sailing time between Hay River and Tuktoyaktuk (1122 miles) is:

	Continuous sailing	With stops & relays
Northbound	4½ - 5½ days	9 days
Southbound	7½ - 9½ days	12 days

Because large tonnage can be hauled, the shipping rates are the least expensive of all methods of transportation in the N.W.T. Normally, a minimum weight is required by the shipper. The rates charged by N.T.C.L. on the Mackenzie River range from approximately $.20 per ton mile for a distance of 100 miles to approximately $.07 per ton mile for distances of of 1000 miles.[89] The present water routes of Northern

89 Arctic Transport. Vol. 2. loc. cit.

Transportation Company Limited extend from Northeast Alberta, Northern Saskatchewan and into the Central and Eastern Arctic. (Fig. 11).

The communities along Hudson Bay and Baffin Island receive yearly marine re-supply of bulk commodities.[90] With weather and ice permitting, the major communities receive additional summer service. Because of the climatic factors and isolation the far Eastern Arctic areas greatly depend on air transportation either as a replacement to or supplementing marine re-supply.

C. 2. Proposed Facilities

Existing facilities will be improved at the terminal points along the present water routes. As dredged depth along the Mackenzie River increases larger capacity barges will be accommodated. Improved tugs will be able to operate in shallow water increasing their versitility.[91] There is a possibility that refrigerated barges could be used to back-haul frozen but not fresh fish.

The major future advantage of water transportation will be from freighting commercial fishery plant facilities,

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90 Tourism Investors Handbook. loc. cit.

91 Arctic Transport. Vol. 3. loc. cit.

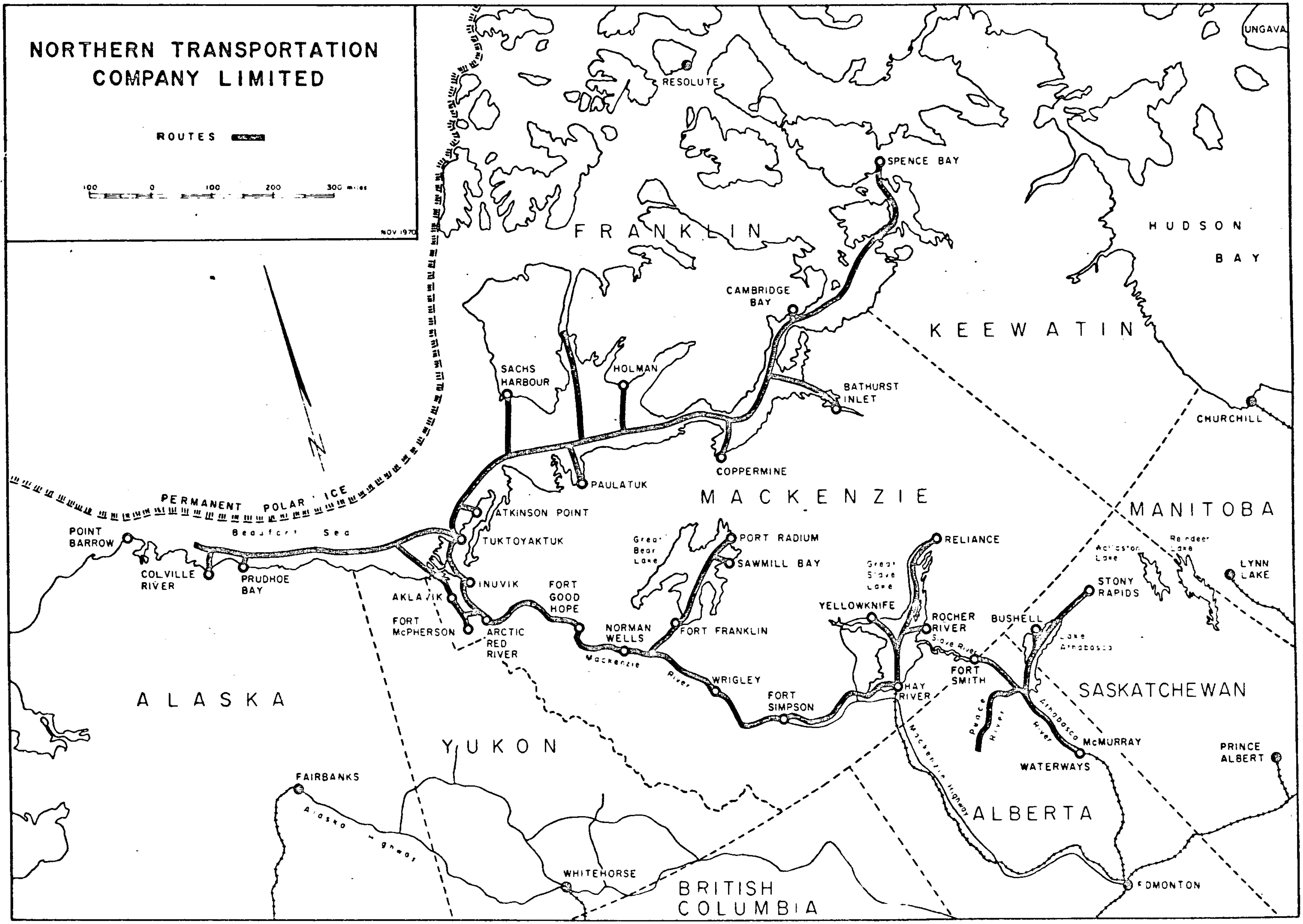

FIGURE 11: Northern Transportation Company Limited - Northern Water Routes.

equipment and supplies. This advantage will be confined to Mackenzie River Communities as other Arctic communities only receive once a year service from the sea lift. The future for improved service to Arctic settlements is not very probable unless shipping problems associated with ice and weather are overcome.

C. 3. Impact on Fisheries Development

Water transportation will likely remain feasible for Great Slave Lake only. Future fish harvests in areas along the Mackenzie River will have little advantage from water transportation due to the small volume of fish. There is a good possibility of a commercial fishery being developed in the Mackenzie Delta which could capitalize on a back-haul arrangement. The limits to this proposal would be the barge refrigeration facilities and present freighting time of 7½ to 12 days. Transport of fresh fish would not be possible. Once the Mackenzie Highway is completed the highway transport of fresh fish would be more convenient if not economical.

There are no existing or proposed waterways into inland lakes other than Great Bear Lake. It may be practical in the future to commercially fish the lakes close to Great Slave Lake, fly the product to a fish plant on Great Slave, process and freight by water to Hay River. However, the farther the distance from the Great Slave Lake packing plants a greater abundance of high priced fish are required to pay for the transportation cost, i.e. jumbo Whitefish and large Lake Trout. Such a proposal would be confined to the following four areas:

1. The Camsell River System lakes;
2. The Taltson River System lakes;
3. The lakes East of Yellowknife;
4. The Dubawnt River System lakes.

This proposal for future development of commercial fisheries will be limited by weather, air transport cost and unpredictable fish catches.

Water transportation will have little direct effect on sports fisheries. Indirect effects would be reduced costs in lodge construction and services. However sports fishing excursions using large, self-contained vessels could develop around the larger communities throughout the Northwest Territories. The short summer season in the Arctic could limit such development to southern communities.

D. OFF-ROAD TRANSPORTATION

This section deals with a relatively new aspect in transportation in which the vehicles can travel without special land modification. These vehicles include the All Terrain Vehicle (A.T.V.) and hovercrafts.

1. Vehicle Development and Limitations

The necessity to move large volumes of equipment, supplies and personnel to areas not accessible by roads or water generated the development of All Terrain Vehicles. Air freighting is limited in many areas because of the lack of airports or suitable construction locations. Thus oil and mineral exploration has capitalized on A.T.V.'s. However, some limitations do exist i.e. climatic extremes, muskeg, permafrost, snow and some types of terrain.

Research has extended into these limiting factors resulting in a wide variety of machine designs to overcome them. Snow has been a major problem because of its variable density, degree of packing by wind action and its ground-insulating properties. Generally the deeper and less packed the snow the more insulation is given to the sub-grade which results in various degrees of instability.[92 *] Research on

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92 Canada, 1971, Arctic Transport. <u>Proceedings of the Arctic Transportation Conference</u>. Vol. 2. Yellowknife, Dec.1970.

* The Western sub-arctic is characterized by fluffy, low density deep snow, the Eastern sub-arctic by compact, high density, shallow snow and the Barrens by hard wind blown snowdrifts.

muskeg has found that several areas of this surface type can be traversed by A.T.V.'s due to the matting effect of the vegetation.[93] Muskegs were formerly thought to be impassable because of moisture content and instability.

D. 2. Present Facilities

Off-road vehicles have been classed into eight groups on the basis of their running gear:[94]

(1) Archimedian screw vehicles
(2) Propellor ski vehicles
(3) Half-tracked vehicles
(4) Full-tracked vehicles
(5) Wheeled vehicles
(6) Air roll vehicles
(7) Air supported vehicles
(8) Articulated tracked vehicles

Several other carriers including the hovercraft are described in recent publications of the Arctic Institute of North America.[95. 96]

The majority of the vehicles are too complex and thus not practical for use in northern and isolated areas;

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93 Ibid.

94 Ibid.

95 Sater, B.F. 1969. Ed. Arctic and Middle North Transportation. The Arctic Institute of North America, Washington, D.C. 204 pp.

96 Slater, J.E. 1969. Ed. The Arctic Basin. The Arctic Institute of North America, Washington, D.C. 377 pp.

Type 8 apparently the most promising. Several vehicles of this type are now in use in the North such as the Nodwell Model RN200 having a payload of 20,000 pounds. Air supported vehicles (hovercraft) are also being used but are extremely expensive to operate.[97] The Bombardier snowmobile will remain as the dominant vehicle of all off-road carriers. However, the vehicle is limited by payload capacity (maximum of 3,000 pounds total freight according to distance travelled) and the risk of breakdown.[98]

D. 3. Impact on Fisheries Development

The future of off-road transportation is very uncertain for the Northwest Territories. After several years of testing hovercraft have yet to be used to haul freight or passengers on a commercial scale in the north. It is unlikely that either A.T.V.'s or hovercraft will be used for even limited commercial enterprises until governments or high-priced resources pay for the development costs.

Commercial fishermen will continue to make use of snowmobiles but confined to areas near northern communities.

With my present information off-road vehicles will not have a significant impact on fish resources. Changes in technology could rapidly change present conditions and opinions.

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97 Manitoba, 1969. Northern Commission Enquiry into Northern Transportation. Report. Province of Manitoba. Winnipeg. 601 pp.

98 The Arctic Basin. loc. cit.

E. Factors for the Inventory and Assessment Method

Transportation and Organization factors are included in the fifth classification of factors (Fig. 6). The Transportation factors are compiled from the previous discussion respecting the effects of the four transportation modes on fisheries development.

The major Transportation factors that must be considered for fisheries management are as follows:

A. Access modes to a fishing location
- Air
- Water
- Highway, road and trail

B. Access restrictions
- Operational restrictions to each craft within A, the mode category
- Seasonal
- Geographical
- Physical restrictions of a water body

C. Limits to the use of any one craft within A. mode category
- Payload capacity
- User cost as cost per pound of fish

The access and access restrictions are important because they indicate the type of fishery activity and the corresponding fishing pressure that can be expected on a water body.

Compared to sports fishing, commercial fishing is far more sensitive to transportation costs. Such costs will directly determine whether or not a commercial fishery is economically feasible. The transportation influence is not as obvious with the sports fisherman. Generally however, the more accessible an area the greater the expected use. This transportation cost, specifically by air is the major consideration for the commercial fisheries assessment. A more general and subjective judgement is sufficient for the sports fishery assessment. The remaining factors should be considered in a total perspective rather than on an individual basis.

The importance of the cost factor to the commercial fishery cannot be over-emphasized. The cost per pound of full payload (fish) was determined for a Twin Otter on floats 50 miles and 100 miles around Yellowknife and 100 miles around Hay River (Fig. 12). The basic data is contained in Appendix D. The price per pound of fish by species is preset by the Freshwater Fish Marketing Corporation. If the price per pound is not equal to or greater than cost plus profit per pound then the lake should not be commercially fished. The figures in Appendix D are average values and should not be used for more than a general application. There are complications if the values are applied in areas where fuel and operational costs are abnormally high i.e.,

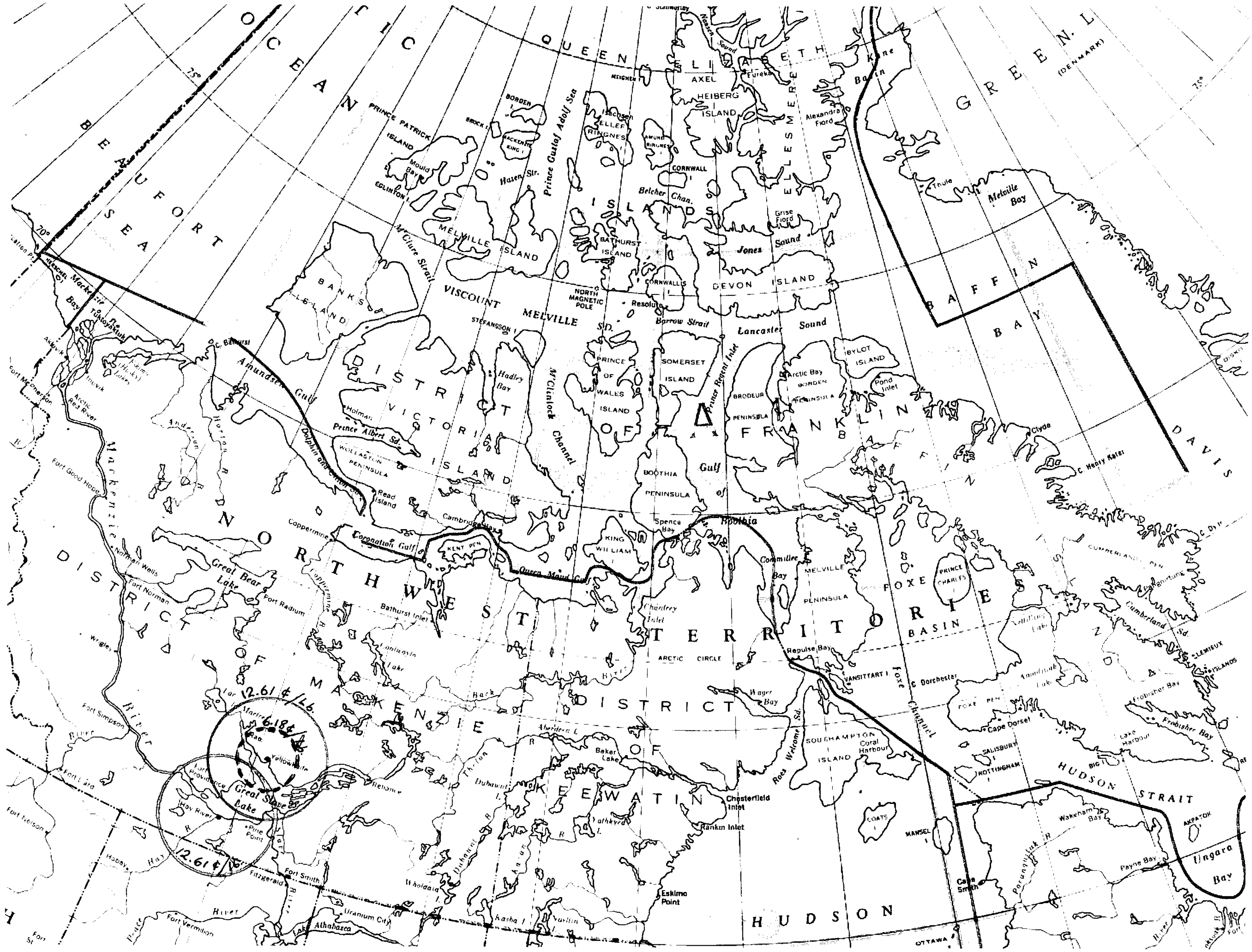

FIGURE 12: Transportation Cost of a Twin Otter on Floats 50 Miles and 100 Miles from Yellowknife; 100 Miles from Hay River.

Scale: 1 inch ≃ 228 miles

------ 50 miles

―――― 100 miles

most of the areas in the Northwest Territories other than the lower Mackenzie Valley.

The expansion of the existing tables in Appendix D. would be extremely useful in assessing the commercial fishing use of a water body.[99]

The use of transportation factors will be illustrated by the application of the Inventory and Assessment method on Little Doctor Lake in the following section.

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99 The Economics Branch, Dept. of the Environment, Fisheries Service, Central Region, is presently working on least-cost transportation models for use by the commercial fishing industry. D. Topolnisky, Economics Branch, Winnipeg. Personal communication.

F. TRANSPORTATION AND FISHERIES DEVELOPMENT

This section is a compilation of the results from trends determined in each of the areas of transportation.

(1) Areas of Immediate Fisheries Development Potential

Because of air, water, present and near future road development, the Mackenzie River area offers the greatest potential. The climate and capacity of the lakes and rivers both to produce and sustain fisheries will place few restrictions on the resource potential if properly managed. Several large lakes other than Great Slave, and the Mackenzie Delta are within the scope of viable commercial developments. Sports fisheries will follow road access and suitable areas within close flying distance from the hub transportation.

The limited commercial fisheries in the Arctic Communities of Cambridge Bay and Pelly Bay are not restricted as much by transportation as the lack of a continuous supply of fish. The dependancy on sea-run Arctic Char could possibly be supplemented by Char and Lake Trout contained in nearby lakes. The cannery at Rankin Inlet is in a similar situation and in addition fish must be flown a greater distance to the plant site.

(2) Areas of Near Future Fisheries Development Potential

A common characteristic of these areas is the lack of water transport and summer roads. Winter roads and the possible use of large All Terrain Vehicles show promising development but the mainstay is air transport. Airport facilities and air services are reasonably accessible.

Two major areas in this category are the lakes East and Northeast from Yellowknife to the treeline and the lakes surrounding the Taltson River System. Commercial fisheries may be more practical in the winter than the summer if lakes were fished in a group surrounding a central shipping location. Tracked vehicles could replace small aircraft for initial shipment to a receiving location then a large capacity aircraft could move the freight direct to the shipping centre. The opportunity for sports fishing exists in these areas but the high small aircraft costs will be limiting. Sports fishing lodges will continue to expand farther into these areas as the scenic and wilderness quality is superb.

The lakes and rivers of the Mackenzie Mountain Range also fall into this category. Road building will not be as quick as along the Mackenzie Corridor. Nevertheless, access to the Yukon Territory and British Columbia will arrive in the near future opening unexcelled sports fishing areas. The dependance on air and road transport will remain as the main limiting factors.

Limited commercial fisheries will possibly be established for Arctic Char at several Arctic communities i.e. Spence Bay, Gjoa Haven, Coppermine, Frobisher Bay and Igloolik. Each of these communities have airports. In the planning of these fisheries sea run Char processing should be supplemented by Char and Lake Trout in nearby lakes. Because of many abandoned DEW Line and present military airstrips, lakes and rivers in their vicinity could possibly be fished and transported by air to the community economically. In these Arctic areas it may be far more economical and beneficial to the fish population if sports rather than commercial fisheries were developed. Fewer facilities, weather and other unpredictables will limit the sports enterprise.

Finally, the areas of the Mackenzie Delta and Camsell River Systems have a potential for commercial fishing in the former and sport fishing as well in the latter. The Delta has access to air and water transport and in the near future, road as well. The Camsell River System has superb scenic qualities and several large lakes i.e. Hottah Lake. A major winter road passes through the System and there is no shortage of air services. A pioneer (dry weather) road already extends into the Southern portion of the Camsell River.

(3) Areas of Long Range Fisheries Development Potential

Because of various degrees of isolation, mainly due to distance from or a general lack of airport-air services and other transportation networks, these areas will probably not be rushed into any fisheries development.

Generally, the areas would include the Keewatin Lakes (Dubawnt River System, etc.), Baffin Island Coast and perhaps some of the Arctic fisheries previously mentioned. The Keewatin Lakes are not too conducive to sports fisheries due to the isolation, climate and open, gently rolling landscape. Commercial fisheries on the large lakes are possible depending on the use of large, long-range aircraft. The Baffin Island coastline is endowed with excellent scenery as are several of the other Arctic communities; a sports fishing advantage. Because of restrictions previously mentioned for Keewatin Lakes, it may be far more sensible to develop the sports potential. Smaller, although costlier aircraft may have to be used. Servicing, storage and mobility could offset these higher costs.

CHAPTER VI

LITTLE DOCTOR LAKE
AN APPLICATION OF THE INVENTORY AND ASSESSMENT METHOD

The inventory and assessment of the fisheries potential of Little Doctor Lake, N.W.T. is presented as an application of the Method. Little Doctor was the first lake surveyed for the field application of techniques. The format for the remaining surveys is similar, although a few techniques were modified or changed.

Little Doctor Lake was chosen for this practicum as it was the only one for which the survey results were available at the time of writing. The lake is considered to be atypical due to its location and changes in methodology that resulted from this first field survey. However, it serves to illustrate how the Method was originally applied and the deficiencies that had to be overcome.

A. Introduction

Little Doctor Lake is situated in the Nahanni Mountain range (Fig. 13) about 65 air miles west of Fort Simpson, N.W.T. The mountain range orients in a north and south direction, and "hogbacks" (generally steep-sided with broad bare summits of undulating rock surfaces, varying in width from one to three hundred yards) are common in the vicinity of the lake. Rolling countryside surrounds the area.

The lake lies at an elevation of seven hundred and twenty-five feet above sea level, and dissects the Nahanni range at almost a ninety degree angle, resulting in the formation of two well defined basins, one on each side of the range (Fig. 14). A sheer-sided channel, approximately three-quarters of a mile wide and about two miles long, cuts through the range, connecting the two basins.

The eastern slope on the south side of the lake is completely vertical to within about one hundred feet of its base, where it flares out, forming several talus slopes composed of fine grey sedimentary rock. These miniature slopes support various lichen communities, with a few scattered grass communities lower down. At the base, the country rolls gently away for many miles and is dominated by a poplar-spruce (Pinus spp. and Populus spp.) overstory, and a reasonably well-defined understory of Labrador tea (Ledum groenlandicum), willow (Salix spp.) and birch (Betula spp.). This blend of vegetation remains constant around the east basin to the northern base of the east slope. There are some steep talus slopes on the north side near the channel, but the rest of the slope is quite gentle and supports a lush grass community from summit to base (Fig. 15b). The grass community extends northward for quite a distance and this portion of the range is utilized by the dall sheep (Ovis dalli) of the area. The slopes of the mountain, surrounding the west basin, are similar in terrain and vegetation. A series of rugged and jagged cliffs and crevasses form a network among the many small valleys on their descent towards the valley floor. Stands of spruce dot most of the slopes while scattered clumps of poplar occur around the perimeter of the west basin.

The lake is fed by three small streams and a shallow, meandering river, all of which flow into the east basin (Fig. 14a). Since these inflows drain a predominantly bog country, the water in the lake carries a clear brown colour imparted by the organic colloids and humic acids.

There is only one outlet, a river of some twenty to thirty feet wide and approximately four to eight feet deep during the first mile from the mouth. It was learned from an exploration crew that the velocity of the river increases along its course and that a small set of rapids exists

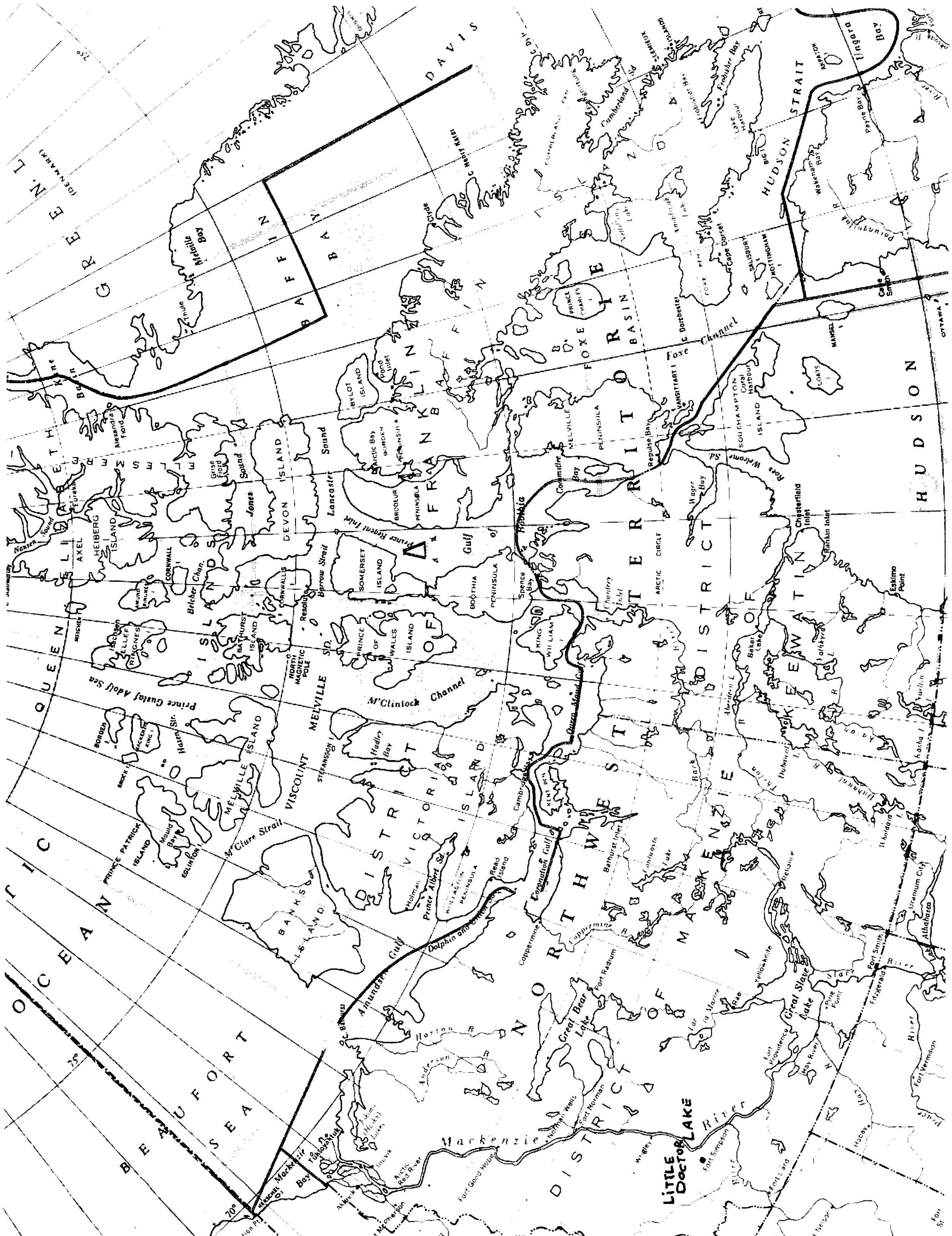


FIGURE 13: Little Doctor Lake, N.W.T.

about four miles downstream from the mouth.

The aquatic vegetation in the lake is confined to the vicinity of two major river mouths. The outlet river mouth contains some small sedges (Carex spp.) and reeds, while the vegetation in the east river mouth consists exclusively of Potamogeton sp.

The composition and character of the shoreline differs greatly around the lake. For example, in the west basin, a strip of sandy beach three-quarters of a mile long and twenty to thirty feet wide occupies the south edge of the lake (Fig. 15b). At the east end of this beach, a spring (which is reputed to remain active during the winter) runs into the lake. The channel area of the lake has no shoreline interuptions; the opposing cliffs drop vertically (800-1,000 feet) from their summits to the lake surface and continue downward in the same manner, some 200 to 250 feet below the lake surface (Fig. 14a).

The shoreline of the east basin has several interrupted beaches (Fig. 14a). In most places trees reach very close to the water's edge. Mud bottoms are common along the south-eastern shoreline.

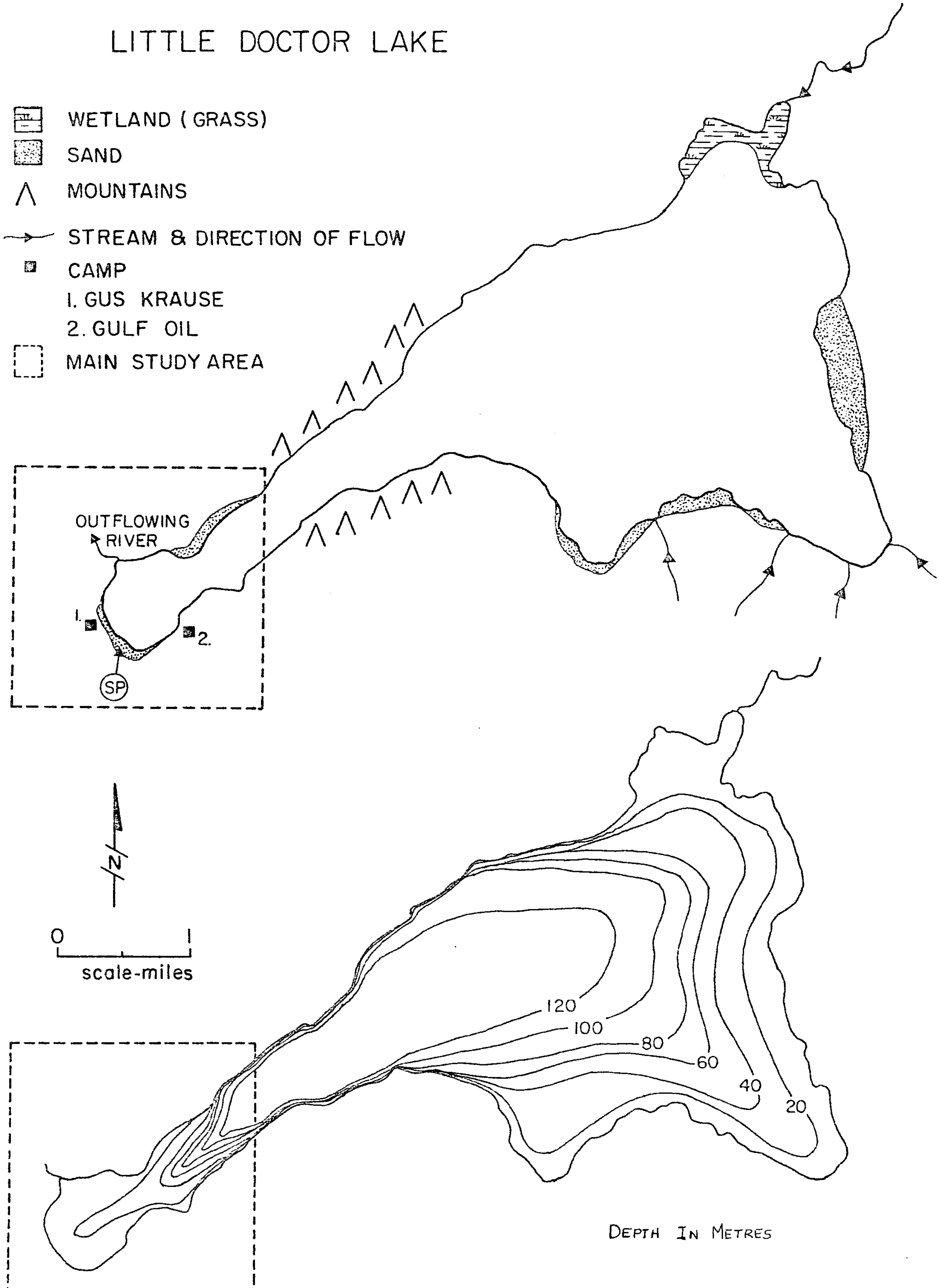
The following climatic figures are for the Fort Simpson region, lying sixty-five miles west of Little Doctor Lake.[100]

Total Annual Precipitation		12.94 inches
Annual Rainfall		47.9 inches
Annual Snowfall		8.13 inches
Temperature:	July means	high 73.5°F (23.6°C)
		low 50.5°F (10.3°C)
	January means	high -8.0°F (-22.2°C)
		low -23.6°F (-30.8°C)
	Yearly mean	25°F (-3.9°C)
Prevailing Wind		Northeast
Average Wind Velocity		6.5 mph

[100] Northwest Territories, 1972, Northwest Territories Community Data, Dept. of Industry and Development, Yellowknife.

FIGURE 14 a: Little Doctor Lake showing the main study area.

b: Little Doctor Lake bathymetric map.


LITTLE DOCTOR LAKE
WETLAND (GRASS)
SAND
MOUNTAINS
STREAM & DIRECTION OF FLOW
CAMP
1. GUS KRAUSE
2. GULF OIL
MAIN STUDY AREA
OUTFLOWING RIVER
1.
2.
SP
N
0
1
scale-miles
120
100
80
60
40
20
DEPTH IN METRES

Two game species of mammal were observed: moose (*Alces alces*) and Dall sheep (*Ovis dalli*). Wolves (*Canis lupus*) and grizzlies (*Ursus horribilis*) are reported to inhabit the region.

There has been no development or modern settlement of any kind in the area. The only year-round occupants in the area are Mr. and Mrs. Gus Krause, who have a tent camp in the west basin. The summer of the survey a minimg exploration outfit was using the lake area as a base camp for their crews which were conducting exploration surveys in the general vicinity.

Evidence of an old mining exploration camp, in the form of numerous old rusty oil drums and oil cans, was found on the beach not far from our campsite. Other than these localized disturbances, the area remains virtually untouched.

From all indications, this survey from July 2 - 6, 1971, is the first documented fisheries survey to take place on the lake.

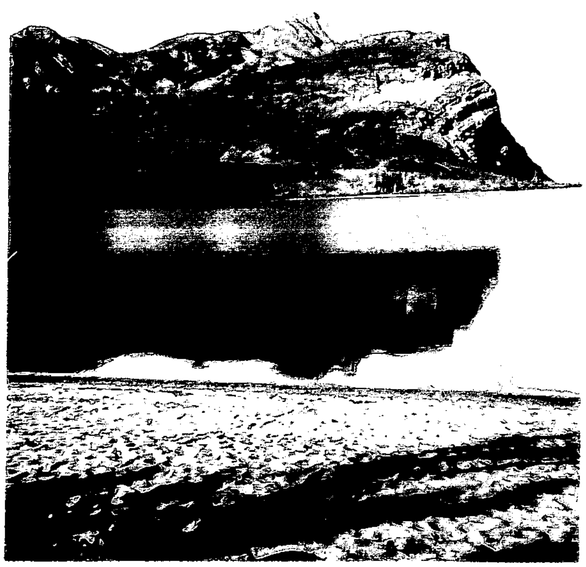
B. Results

B. 1. Morphometric Factors

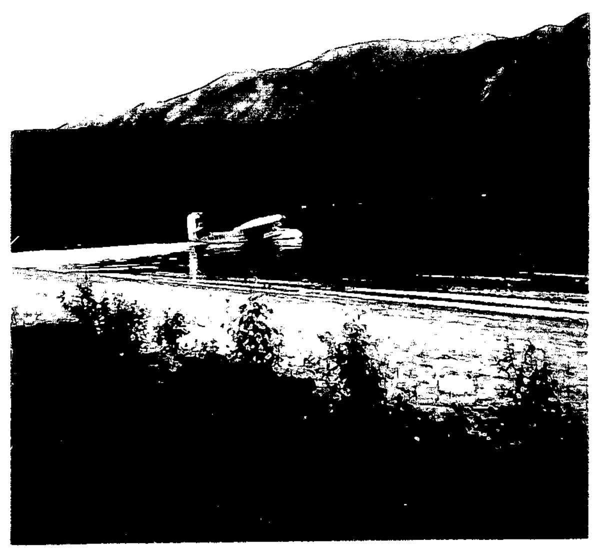
Little Doctor Lake drains Sibbeston Lake and a number of other lakes to the south-east. The lake is joined to the Mackenzie River system through the Tetcela River and the North Nahanni River.

Little Doctor Lake is small and very deep (Table XII). The lake appears to have formed as a result of a slice of the mountain slumping and leaving a deep below-surface depression. Water drainage into the basin then formed the lake basin through erosion. The eastern section of the lake is considerably more shallow than the western section, due to the lack of drainage restrictions outside the mountain range.

15 a



15 b



15 c

FIGURE 15 a: The view of Little Doctor Lake looking East through the gourge which joins the two basins.

b: Vegetation grows to the summits of the mountains on the North side of Little Doctor Lake.

c: The lowlands around Little Doctor Lake are thickly forested.

TABLE XII: The morphometry of Little Doctor Lake, N.W.T.

Surface Area	22.73 $km.^2$	8.78 $mi.^2$
Drainage Area	98.34 $km.^2$	37.97 $mi.^2$
Mean Depth	67.00 m.	220.00 ft.
Maximum Depth	120.00 m.	394.00 ft.
Mean Depth/Max. Depth	.56	
Maximum Length	10.46 km.	6.50 mi.
Maximum Width	5.23 km.	3.25 mi.
Shoreline Length	23.17 km.	14.40 mi.
Shoreline Development	1.4	
Direction of Major Axis	East - West	
Watershed Number (Inland Waters Branch)	10 G D	

The majority of the shoreline is composed of sand changing to gravel and talus near the base of the mountain range. Shallow water is mainly confined to the eastern section of the lake (Fig. 14b). The deep mean depth combined with the relatively small size of the lake indicates that morphometry is significant in limiting biological productivity.

The lake bottom is composed of sand covered by a thin layer (approximately 1 to 3 cm.) of black organic material, ie. pine cones and needles, twigs and invertebrate case remains. At depths lower than 10 meters there is a thin layer (approximately 1 mm.) of hard, compact mineralization separating the sand and organic material. Occasionally a mud-clay bottom is found, although usually below 15 meters.

B. 2. Physico-chemical (Edaphic) Factors

Temperature, pH and dissolved oxygen were sampled down to a depth of 30 meters (Fig. 16 a, b, c, d). Water samples were also collected for ion determination at the Calgary laboratory of Inland Waters Branch, Department of the Environment. The specific conductance was expected to be higher than precambian lakes, due to extensive limestone deposits and acid bogs in the drainage area (Table XIII).

TABLE XIII: The water chemistry of Little Doctor Lake, July 6, 1971. (All figures in parts per million unless otherwise specified.)

	Surface	19 Meters	25 Meters
Specific Conductivity: umhos/cm.	147.0	155.0	155.0
Alkalinity: Total	61.9	64.9	65.5
pH	7.7	7.8	7.6
Temperature: °C	13.0	5.4	4.5
Colour: Pt. - Co. Units, True	55.0	55.0	65.0
Dissolved Oxygen	10.0	11.0	11.0
Secchi Disc Transparency (Visibility)			2.5 Meters

A complete ion analysis is contained in Appendix E.

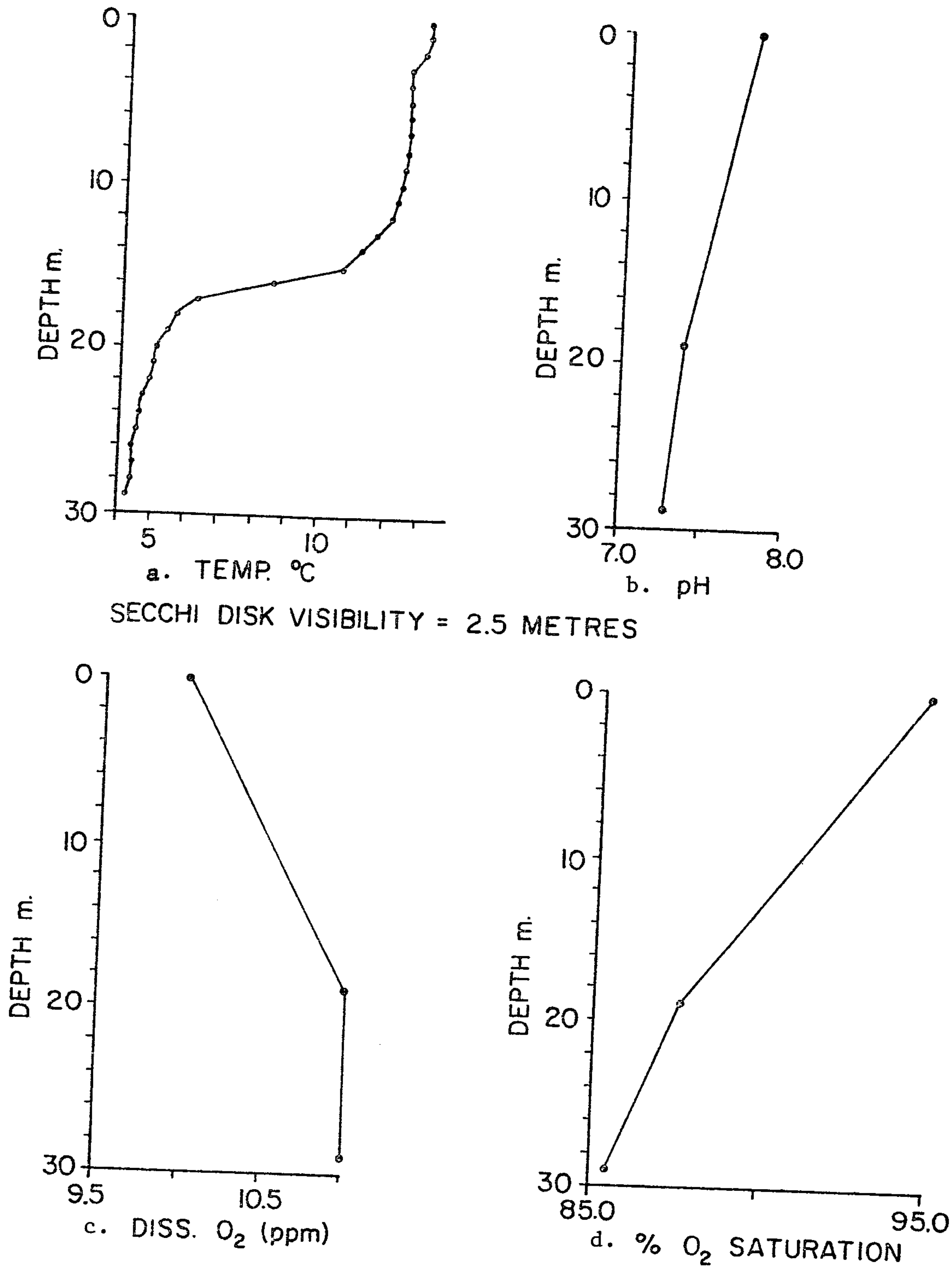
A well defined metalimnion was present between twelve and twenty-four meters at the time of study. The Secchi Disc Transparency is low due to the deep brown stain of the water. The water colour would reduce the depth of light penetration into the lake, restricting the sublittoral vegetation to within a few meters of the lake surface. Dissolved oxygen concentrations were high throughout the water column, exceeding 85% saturation at the three sample depths. The alkalinity and pH are undoubtedly influenced by the surface water drainage over the extensive limestone deposits.

FIGURE 16 a: Thermal regime of Little Doctor Lake, July 6, 1971.

b: pH vs. depth of Little Doctor Lake, July 6, 1971.

c: Dissolved oxygen (p.p.m.) vs. depth of Little Doctor Lake, July 6, 1971.

d: Percent oxygen saturation vs. depth of Little Doctor Lake, July 6, 1971.


0
10
20
30
DEPTH m.
5
10
a. TEMP. °C
0
10
20
30
DEPTH m.
7.0
8.0
b. pH
SECCHI DISK VISIBILITY = 2.5 METRES
0
10
20
30
DEPTH m.
9.5
10.5
c. DISS. O2 (ppm)
0
10
20
30
DEPTH m.
85.0
95.0
d. % O2 SATURATION

B. 3. Biological Factors

a) Net Plankton

The Little Doctor Lake plankton sample consisted of one total vertical haul (T.V.H.) from 26 meters to the surface. An additional sample was taken from 9 meters to the surface for comparative purposes.

The phytoplankton are dominated by a species of *Dinobryon* (Table XIV).

TABLE XIV: Phytoplankton taxa composition and relative abundance as percentage by number, Little Doctor Lake, July 5, 1971.

Phytoplankton	0 - 9 Meters % of Total No.	0 - 26 Meters % of Total No.
Dinobryon sp.	97.97	95.2
Asterionella sp.	.31	3.47
Melosira sp.	.31	
Oscillatoria sp.	.15	
Tabellaria fenestrata		.87
Algae (colonial, unidentified)	.62	.44
Algae (filamentoris, unidentified)	.62	

Asterionella sp., *Melosira* sp., and *Dinobryon* sp. are common in oligotrophic lakes and may be expected in a high altitude, low productivity lake such as Little Doctor. The high proportional occurrence of *Dynobryon* sp. could be the result of the colony being damaged by preservation. Each individual was counted as one organism and, therefore, if colonial fragmentation occurred, it would have given an erroneous count. The exclusion of some genera in the deep T.V.H. that were in the shallow T.V.H. cannot be explained. Bottle samples are preferable to net samples for the qualitative determination of phytoplankton (Vollenweider, 1969).[101]

The zooplankton are dominated by rotifers although copepods are the greatest contributor by weight in the sample (Table XV). The difference in relative abundance between the deep T.V.H. and the shallow T.V.H. cannot be explained. The 12 cm Wisconsin plankton net appears to be inadequate for qualitative determination of zooplankton. The use of a 25 cm Wisconsin net is presently being investigated.

The standing crop of plankton (T.V.H., 26 meters to surface) was calculated as 17.37 Kg/hectare corrected for 27% efficiency of the net.[102]

b) Bottom Fauna

The bottom composition ranges from sand and gravel to ooze. The sandy areas around the streams have dense vegetation consisting mostly of sedges. All dredgings taken contained large amounts of vegetative debris, which greatly inhibited the performance of the Ekman dredge.

The largest concentration of macro-benthic fauna occurred between ten and fifteen metres (Table XVI). Species composition remained quite constant throughout all depths after the ten to fifteen meter range, probably due to the consistency of the bottom composition.

Oligochaetes were the most common organisms in the lower depths, giving way to chironomidae and sphaeriidae in the upper regions.

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101 Vollenweider, R.A. 1969. A manual on methods for measuring primary production in aquatic environments. I.B.P. Handbook No. 12. Blackwell, Oxford. 213 pp.

102 The figure of 27% was determined as the mean summer efficiency on Hottah Lake, N.W.T., 1972. B. Wong, personal communication.

TABLE XV. Zooplankton taxa composition and relative abundance as percentage by number, Little Doctor Lake, July 5, 1971.

Zooplankton	0 - 9 Metres Average No. per Litre	0 - 9 Metres % Frequency	0 - 26 Metres Average No. per Litre	0 - 26 Metres % Frequency
Copepods				
unidentified	4.62	3.91	2.61	6.35
Calanoids	1.60	1.35	1.70	4.14
Rotifers				
total	90.91	76.95	24.52	59.67
Kellicottia sp.	6.97	5.90	3.39	8.25
Keratella sp.	.47	.40	.46	1.12
Ceratium hirudinella	13.47	11.40	8.35	20.32
Cladocera	.10	.08	.06	.15

TABLE XVI. Taxa, number, relative abundance by number and wet weight of benthic organisms per depth zone, Little Doctor Lake, July, 1971.

Depth-meters	0-5 Meters		5-10 Meters		10-15 Meters		15-20 Meters		20-25 Meters		25-30 Meters	
Substrate	Sandy mud with heavy vegetative debris in all samples											
Species	No/m^2	%	No/m^2	%	No/m^2	%	No/m^2	%	No/m^2	%	No/m^2	%
Chironomidae	54.10	55.6			108.21	25.0	75.74	31.8	43.28	20.0	10.82	3.4
Gastropoda	10.82	11.1			173.13	40.0						
Sphaeridae	10.82	11.1	32.46	75.0	151.49	35.0	10.82	4.6	10.82	5.0		
Oligochaeta	21.64	22.2									194.77	62.1
Pontoporeia sp.			10.82	25.0			75.74	31.8	162.31	75.0	108.20	34.5
Nemata							75.74	31.8				
Total	97.38	100.00	43.28	100.00	432.83	100.00	238.04	100.00	216.41	100.00	313.79	100.0[illegible]
Average wet weight- g/m^2	1.08		1.08		6.49		1.08		1.08		1.08	

Sphaeriidae show a consistent increase in numbers with a decrease of depth until the littoral zone is reached. The organic muck bottom of the east end, which was not sampled, is probably more productive. However, the sampling done is probably a fairly accurate reflection of the lake's overall productivity.

The steeply sloped lake bottom severely limits the bottom surface area available for bottom fauna production.

c) Fish

Species of fish taken by gill netting, angling and seining were: lake whitefish (*Coregonus clupeaformis*), lake trout (*Salvelinus namaycush*), longnose sucker (*Catostomus catostomus*), white sucker (*Catostomus commersoni*), northern pike (*Esox lucius*), yellow walleye (*Stizostedion v. vitreum*), lake cisco (*Coregonus artedii*), Arctic grayling (*Thymallus arcticus*), three spined sticklebacks (*Gasterosteus aculeatus*), and emerald shiners (*Notropis atherinoides*).

1. Gill Netting

Exterior color darkening of the grayling, trout and some whitefish has occurred, reducing commercial marketability. Pike catches were quite low (possibly due to failure to set in preferred areas) and probably not indicative of the true numbers. Local inhabitants reported very large pike are common in the east basin near the inlet river. It was reported that walleye could be found further up this river.

Longnose sucker were the predominant fish netted followed by whitefish, lake trout and yellow pickerel or walleye (Table XVII). The

TABLE XVII: Total standard gang net catch for Little Doctor Lake, July, 1971. Percentage by weight and number as per species totals per net. Summary percentages by weight and number as per net totals per standard gang.

TABLE XVII

MESH		1½	2½	3½	4½	5½	Total Per Species
Whitefish	No.	4	3	2	1	1	11
	%	50.0	9.7	33.3	12.5	1.0	
	Wt.(g)	60.0	2410	1100	1100	1400	6610
	%	13.7	8.0	22.4	13.5	8.0	
Lake Trout	No.	1	7	1		1	10
	%	12.5	22.6	16.7		10	
	Wt.(g)	1060	9544	1450		1100	13154
	%	24.3	31.8	29.5		6.3	
Longnose Sucker	No.	1	9	2	4	7	23
	%	12.5	29.0	33.3	50.0	70.0	
	Wt.(g)	1300	7420	1460	3820	13400	27400
	%	29.7	24.8	29.7	47.0	80.2	
Northern Pike	No.		4				4
	%		12.9				
	Wt.(g)		6050				6050
	%		20.2				
Yellow Pickerel	No.	1	3	1	3	1	9
	%	12.5	9.6	16.7	37.5	10.0	
	Wt.(g)	1260	2690	900	3200	980	9030
	%	28.9	9.1	18.4	39.5	5.5	
White Sucker	No.		5				5
	%		16.1				
	Wt.(g)		1840				1840
	%		6.1				
Lake cisco	No.	1					1
	%	3.4					
	Wt.(g)	150					150
	%	3.4					
Total	%	100	100	100	100	100	
Total No. Per Mesh		8	31	6	8	10	Total 63 No.
% of Total No.		12.7	49.2	9.5	12.7	15.8	
Total Wt. (g) Per Mesh		4370	29954	4910	8120	16880	Total 64234 No.
% of Total Wt.		6.8	46.6	7.6	12.6	26.3	

TABLE XVIII: The percentage by weight and number of each species caught per mesh. Total percentages by weight and number by species as per total of all species, Little Doctor Lake, July 1971.

MESH		1½	2½	3½	4½	5½	Total Percentage	Species As Percentage Total Catch
WHITEFISH	No.	36.4	27.3	18.2	9.1	9.0	100	17.5
	Wt. (g)	9.2	36.4	16.6	16.6	21.2	100	10.3
TROUT	No.	10	70	10		10	100	15.8
	Wt. (g)	8.1	72.5	10.1		8.3	100	20.5
LONGNOSE SUCKER	No.	4.3	39.2	8.7	17.4	30.4	100	36.5
	Wt. (g)	4.6	26.4	5.2	13.6	50.2	100	42.7
NORTHERN PIKE	No.		100				100	6.3
	Wt. (g)		100				100	9.4
WALLEYE	No.	11.1	33.3	11.2	33.3	11.1	100	14.3
	Wt. (g)	14.0	29.8	10.0	35.4	10.8	100	14.1
WHITE SUCKER	No.		100				100	7.9
	Wt. (g)		100				100	2.9
CISCO	No.	100					100	1.5
	Wt. (g)	100					100	.2
Total Percentage								100

TABLE XIX. Catch per unit effort* by mesh size and by fish species for Little Doctor Lake, July, 1971.

MESH	Depth (M)		Lake Whitefish	Lake Trout	Longnose Sucker	Northern Pike	Yellow Walleye	White Sucker	Cisco	TOTAL
1½	3-6.5	No.	1.33	.33	.33		.33		.33	2.66
		Wt.	200.0	353.3	433.3		420.0		50	1456.6
2½		No.	1.00	2.33	3.00	1.33	1.00	1.66		10.33
		Wt.	803.3	3181.3	2473.3	2016.6	896.6	613.3		9984.4
3½		No.	.66	.33	.66		.33			2.00
		Wt.	366.6	483.3	486.6		300.0			1636.5
4½		No.	.33		1.33		1.00			2.66
		Wt.	366.6		1273.3		1066.6			2706.5
5½	3-17.5	No.	.33	.33	2.33		.33			3.33
		Wt.	466.6	366.6	4466.6		326.6			5626.4
Total No.			3.66	3.33	7.66	1.33	3.00	1.66	.33	21
Total Wt.			2203.1	4384.5	9133.1	2016.6	3009.8	613.3	50	21411

* Catch per unit effort = catch per 24 hours per 50 yards of net.

low number of cisco may be limiting the lake trout population. The species diversity is apparently influenced by the adjacent Mackenzie Valley drainage area.

The 2½" net captured the greatest weight and number of fish, 49.2% and 46.6% of the total, respectively (Table XVII). The greatest weight per standard gang of lake trout, whitefish and northern pike was from the 2½" net and for walleye, the 4½" net (Table XVIII). The commercial 5½" net yielded 26% by weight of the total catch (Table XVI).

The expected catch per 24 hours for the standard gang (catch per unit effort) was 24 fish weighing 21.4 killograms (Table XIX). Longnose suckers dominated the average catch.

Due to the small sample size only very general statements can be made concerning the species in the fish population.

i) Whitefish

The whitefish sampled tended to grow approximately 3.6 cm in length and 170 grams on an average per year from the 5th to 13th annuli (Table X X).

TABLE X X: Growth characteristics of the lake whitefish, Little Doctor Lake, July, 1971.

No. Annuli	K-Factor	no.	%	$\bar{x}$ FL(cm)	Range	$\bar{x}$ Wt.(gm)	Range
5	3.1	1	10	17	-	150	-
6	3.1	2	20	17.9	17.9-18.0	175	150-200
7	1.4	2	20	34.6	34.1-35.1	550	550-550
8	-	-	-	-	-	-	-
9	1.52	1	10	37.5	-	800	-
10	1.3	1	10	44.0	-	1100	-
11	1.31	1	10	41.0	-	900	-
12	0.95	1	10	42.1	-	710	-
13	1.49	1	10	45.5	-	1400	-

The lack of data on younger age classes may have been caused by failure to set in preferred areas. All net sets were made on the lake bottom.

The ratio of males to females was 4:1 in the total catch (Appendix E). Immature fish were classed as those that had previously spawned. The lack of information on age at spawning makes it difficult to distinguish juvenile from immature fish. The whitefish with 5.7 and 9 annuli were classed as immature although the 5 annuli fish may have been a juvenile. The two fish with 11 and 12 annuli were maturing although the 13 annuli fish was immature. There is the possibility that whitefish do not spawn every year.

The majority of whitefish are dark in exterior colour. The rate of Triaenophorus sp. infestation is greater than 35 per hundred pounds of round fish.

ii) Lake Trout

The lake trout sampled tended to grow approximately 2.6 cm in length and 141 grams on an average per year from the 9th to 14th annuli (Table XXI). The mean condition (K) is 1.07 suggesting reasonably plump fish.

TABLE XXI. Growth characteristics of lake trout, Little Doctor Lake, July, 1971.

No. Annuli	K-Factor	no.	%	$\bar{x}$ FL(cm)	Range	$\bar{x}$ Wt.(gm)	Range
9	1.08	1	11.1	44.2	-	800	-
10	1.00	2	22.2	50.8	47.5-54.1	1310	1100-1520
11	.98	2	22.2	52.6	47.1-58.0	1480	1100-1860
12	1.07	3	33.3	53.2	50.2-56.9	1403	1260-1500
13	-	-	-	-	-	-	-
14	1.24	1	11.1	57.2	-	1504	-

The majority of the lake trout were small although one gang was set in 80 meters of water. One lake trout was 50.9 cm long, weighed 1060 grams, and female of unknown age and maturity. The lack of information on age at spawning makes it difficult to distinguish juvenile from immature fish. Only one fish of the 9 captured was maturing (Appendix E). It is possible that the lake trout do not spawn every year.

All lake trout captured were black in exterior colour. People of the area stated that the trout have a deep red flesh colour. All trout sampled during the survey were white-fleshed. The ratio of males to females was 1:8.

iii) Yellow Pickerel (Walleye)

A total of seven walleye were captured, the majority in the eastern section of the lake. The fish tended to be plump ($\bar{K}$ = .94) although somewhat small in size (Table XXII).

TABLE XXII: Growth characteristics of the Yellow Walleye, Little Doctor Lake, July, 1971.

No. Annuli	K-Factor	no.	%	$\bar{x}$ FL(cm)	Range	$\bar{x}$ Wt.(gm)	Range
11	1.03	1	14.3	42.0	-	760	-
scales	0.96	1	14.3	45.5	-	900	-
could not	1.02	1	14.3	45.8	-	980	-
be read	0.86	1	14.3	48.9	-	1000	-
accurately	0.90	1	14.3	49.6	-	1100	-
	0.88	1	14.3	50.0	-	1100	-
14	0.94	1	14.3	51.2	-	1260	-

The male to female ratio was 1:3.5 but the maturity by age class could not be determined (Appendix 6). The inability to accurately read the scales suggests that a different aging method should be determined.

Since sports fishing was confined to the western section of the lake no walleye were caught. The presence of this species adds to the potential for a varied sports fishery.

iv) Northern Pike

Four northern pike were captured in the standard gang. These fish are probably confined to the eastern section which was not intensively sampled. The mean length is 57 cm and mean weight 1,558 grams for the total catch (Table XXIII). Large pike were not captured.

TABLE XXIII: Growth characteristics of the northern pike population, Little Doctor Lake, July 1971.

No. Annuli	K-Factor	no.	%	$\bar{x}$ FL(cm)	Range	$\bar{x}$ Wt(gm)	Range
7	1.24	1	25	54.0	-	1950	-
8	0.75	2	50	56.8	56.2-57.3	1375	1200-1550
10	0.61	1	25	60.4	-	1350	-

The male to female ratio was 3:1 (Appendix E). Most of the pike were caught in the east basin, where the slope of the bottom is more gradual and a greater littoral area exists. Northern pike should be common throughout the inlet river and in the weedy shallows along the south-eastern margin of the lake. The presence of this species adds to the potential for a varied sports fishery.

v) Longnose Sucker

The longnose sucker dominated the total catch for all standard gang net sets. A total of 23 fish were caught representing all age classes between 4 and 13 annuli with the exception of the 12th annuli class (Table XXIV). The annual average growth rate was 3.2 cm and 282.2 grams between 4 and 13 annuli based on the total catch. The mean condition (K) was approximately 1.2 indicating relatively short, plump fish.

TABLE XXIV: Growth characteristics of the Longnose Sucker, Little Doctor Lake, July, 1971.

No. Annuli	K-Factor	No.	%	$\bar{x}$ FL(cm)	Range	$\bar{x}$ Wt.(gm)	Range
4	0.96	1	4	30	-	260	-
5	1.25	3	14	32.2	29.9-35.7	417	300-600
6	1.15	1	4	29.7	-	300	-
7	1.25	7	30	43.7	35.9-49.5	1042	650-1390
8	1.15	2	8	43.3	42.0-44.5	930	810-1050
9	1.21	3	14	48.4	44.6-51.5	1368	1000-1675
10	1.17	3	14	53.1	50.4-57.0	1758	1525-2150
11	1.25	2	8	58.3	54.0-62.5	2475	2050-2900
12	-	-	-	-	-	-	-
13	1.40	1	4	58.5	-	2800	-

The male to female ratio of 1:1 with maturity occurring at five years (Appendix E). Forty percent of the fish captured were ripe. The occurrence of ripe fish in July cannot be explained. It is more probable that the fish were in an advanced stage of maturing. However, if the longnose suckers do spawn once a year in the Spring they recover their reproductive capacity very quickly. They may spawn once every two years.

Further studies should be done to determine the population structure of longnose suckers if the harvest of the other species is begun.

vi) White Sucker

A total of five white suckers were captured in the standard gang net set (Table XVII). The fish were generally small and probably competitive with the longnose sucker. The mean condition (K) is 1.17, mean length 31.9 cm and mean weight 380 grams (Table XXV).

TABLE XXV: Growth characteristics of the white sucker, Little Doctor Lake, July, 1971.

No. Annuli	K-Factor	no.	%	$\bar{x}$ FL(cm)	Range	$\bar{x}$ Wt.(gm)	Range
3	1.04	1	20	28.9	-	250	-
4	1.11	2	40	30.7	30.0-31.2	320	300-340
5	1.16	1	20	35.1	-	500	-
7	1.27	1	20	32.8	-	450	-

The ratio of males to females was not determined.

2. Sports Fishing

Angling indicated that the lake does have a potential for limiting sports fishing. The average catch per person per day is 1.66 fish weighing 766 grams (1.67 lbs) (Table XXVI). Angling was confined to the mouth and along the shore of river draining the lake.

Catches of grayling were all made on flies while the trout was caught while trolling using spinning gear. Pike and walleye are also available although none were caught by angling during the survey. No sport fishing was done in the east basin of the lake where the latter two species are probably more plentiful because of the more gradual slope.

3. Stomach Content Analysis

A possible dietary overlap may exist between the whitefish and longnose sucker population (Fig. 17). Both species feed mainly on benthic organisms and consequently they may be competitive for the same food. There appears to be ample feed for both species as neither had amphipods in their diet (Fig. 17). Amphipods (Pontoporeia sp.) are most abundant between 20 and 25 meters (Table XVI). Longnose sucker were captured in all gill net sets while whitefish were taken at depths above 40 meters.

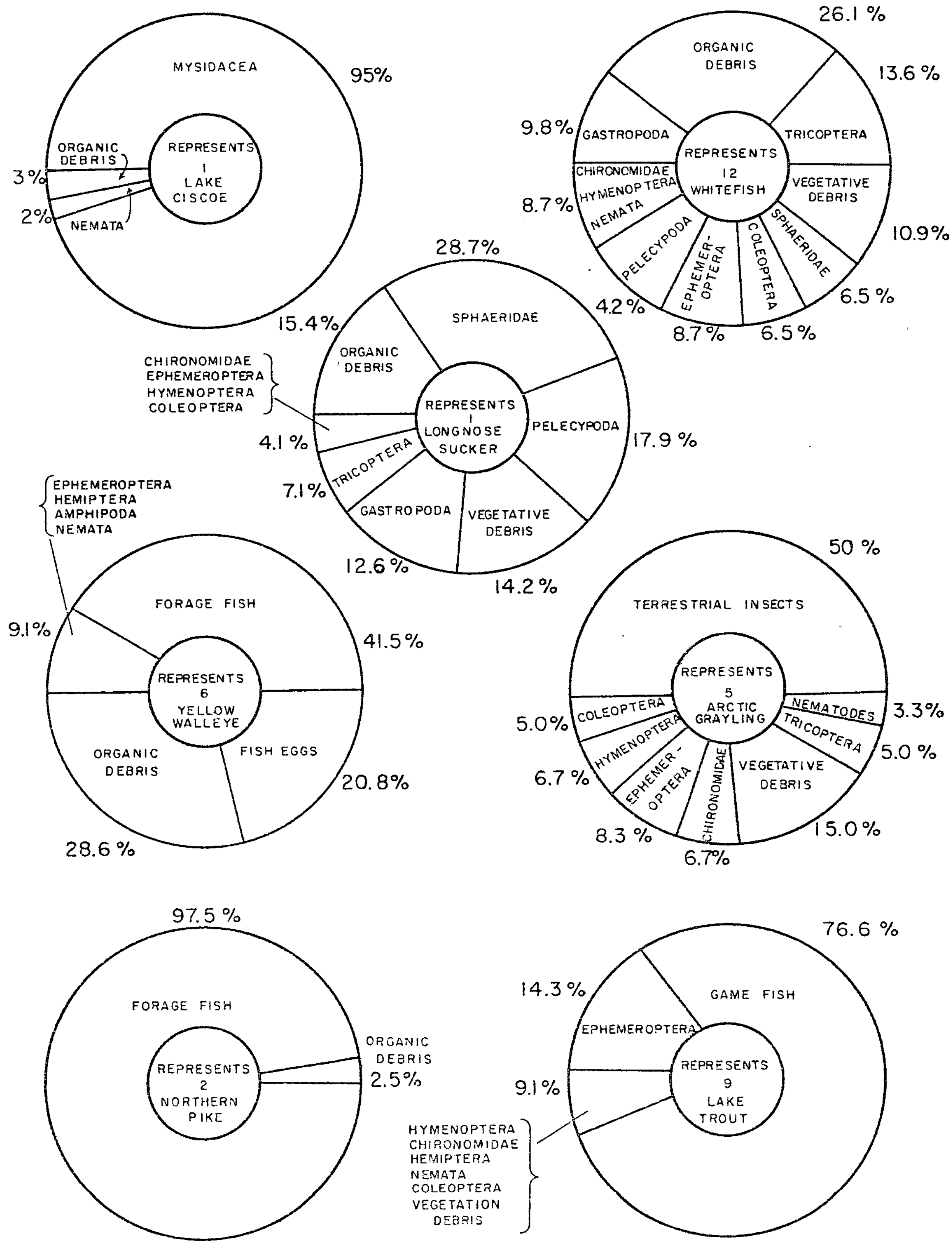
The main diet of the 9 lake trout was game fish i.e. small pike, walleye and grayling (Fig. 17). The apparent lack of ciscos may have caused this unusual diet. This dietary preference of the lake trout may be limiting the overall game fish population and thus the sport fishing success for the lake. Both walleye and northern pike

TABLE XXVI. Angling catch per unit effort, Little Doctor Lake, July, 1971.

Date	Species	Fork L (mm)	Weight (gm)	K-Factor	Number Fishing	Total time fished (hrs)	Catch per person per hour
July 2, 1971	Arctic Grayling	188	80	1.2	2	4	.75
		400	620	.97			
		151	30	.87			
July 3, 1971	Lake Trout	510	1300	.98	1	.5	2
July 4, 1971	Arctic Grayling	384	270	.47	1	.5	2

Total number fish caught	5	Average number per day	1.66	Total Weight (gms)	2300	Average Weight per day (gms)	766
Average catch per person per hour	1.58						

FIGURE 17: Stomach contents as percentage by volume of fish from Little Doctor Lake, July, 1972.


MYSIDACEA
95%
ORGANIC DEBRIS
3%
2%
NEMATA
REPRESENTS
1
LAKE
CISCOE
ORGANIC DEBRIS
26.1 %
13.6 %
GASTROPODA
9.8%
TRICOPTERA
REPRESENTS
12
WHITEFISH
CHIRONOMIDAE
HYMENOPTERA
NEMATA
8.7%
VEGETATIVE DEBRIS
10.9%
PELECYPODA
EPHEMER-OPTERA
COLEOPTERA
SPHAERIDAE
6.5 %
4.2 %
8.7 %
6.5 %
28.7%
SPHAERIDAE
ORGANIC DEBRIS
15.4%
CHIRONOMIDAE
EPHEMEROPTERA
HYMENOPTERA
COLEOPTERA
4.1 %
REPRESENTS
1
LONGNOSE
SUCKER
PELECYPODA
17.9 %
TRICOPTERA
7.1%
GASTROPODA
VEGETATIVE DEBRIS
12.6 %
14.2 %
EPHEMEROPTERA
HEMIPTERA
AMPHIPODA
NEMATA
9.1%
FORAGE FISH
41.5%
REPRESENTS
6
YELLOW
WALLEYE
ORGANIC DEBRIS
FISH EGGS
20.8%
28.6 %
50 %
TERRESTRIAL INSECTS
REPRESENTS
5
ARCTIC
GRAYLING
COLEOPTERA
5.0%
NEMATODES
3.3%
TRICOPTERA
5.0 %
HYMENOPTERA
6.7 %
EPHEMER-OPTERA
CHIRONOMIDAE
VEGETATIVE DEBRIS
8.3 %
6.7%
15.0 %
97.5 %
FORAGE FISH
REPRESENTS
2
NORTHERN
PIKE
ORGANIC DEBRIS
2.5%
76.6 %
14.3 %
GAME FISH
EPHEMEROPTERA
REPRESENTS
9
LAKE
TROUT
9.1%
HYMENOPTERA
CHIRONOMIDAE
HEMIPTERA
NEMATA
COLEOPTERA
VEGETATION DEBRIS

feed on forage fish i.e. ciscoe, minnows and suckers. A larger stomach contents sample is required before the degree of competition can be better determined.

The grayling sampled were feeding mainly on terrestrial insects (Fig. 17). It is doubtful that the food source is limiting the population. The grayling are confined to the river mouth and the swift boulder-strewn river. The river should have been more intensively fished to determine the abundance and distribution of this species.

4. Comparison between other surveys

Little Doctor Lake is one of the lowest in relative productivity compared to the other lakes surveyed (Tables XXVII and XXVIII). The deep mean depth and small littoral zone are probably the major limiting factors to productivity.

The fish population is the most diverse of all the lakes. However the population is dominated by longnose sucker which may be limiting the whitefish. The diet of the lake trout depends greatly on game fish and may limit the overall sports fishing success of the lake.

The ratio between specific conductivity and mean depth also suggests that the productivity is low (Table XXVII). Specific conductivity was determined at a later date with an increased probability of error in measurement. The mean total phosphate was 0.02 ppm for the upper 25 meters. Compared to the other lakes phosphate does not appear as a limiting factor in Little Doctor Lake.

TABLE XXVII: Morphoedaphic and biological comparison between N.W.T. survey lakes, 1971 and 1972.

Lake	Mean depth m	Depth of thermo-cline m	Secchi disc trans. m	Bottom oxygen mg/1	Spec. cond. umhos/cm	Mean total phos. p.p.m.	Quantity of plankton kg/ha	Quantity of benthos g/m^2 [d]	Wt. of fish per standard net - lbs.	Ratio spec. cond.: mean depth	Maximum depth m
Little Doctor	67	16	2.5	11[b]	152	.02	17.37	2.0	47	2.27	120
Stagg	12.5	7.5	5	12	72	.03	29.8	2.8	77	5.76	40
Harding	29	11	10.5	13	142	.02	26.22	6.0	67	4.90	61
North Henik	17.6[c]	10	7	9	18.6	.02	20.79	24	68	1.06	37.5[c]
Markham	-	-	6	11	30.6	.015	3.27[a]	6.5	47	-	-
Nonacho	14	5	6.3	10	36.7	.05	20.96	1.16	87	2.62	41
Lady Grey	10.3	10	6.3	12	34.5	-	25.85	1.8	102	3.35	40
Duncan	28.7	24	8.5	8	383	.006	21.93	2.59	25	13.35	60
Indin	39	15	6.0	10	100	.004	18.34	.80	126	2.56	72
Stark	30.5	1.5	3.7	-	28	.01	19.33	-	100	.92	88

a T.V.H. from 17 meters.

b Sample taken from 30 meters.

c Incomplete depth soundings.

d Mean values per both sampling depth ranges.

TABLE XXVIII: The standard gang gillnet set comparison between N.W.T. and Saskatchewan fish catches.

Lake	No. of sets	Numerical % of fish species based on the total catch: Whitefish	Lake Trout	Walleye	Pike	Cisco	Suckers (all sp.)	Burbot	Weight and number of fish per standard-gang per 24 hours: No.	Weight lbs.	Weight Kg.
Little Doctor	3	17.5	15.8	14.3	6.3	1.5	44.4	-	21.00	47.16	21.411
Stagg	3	69.2	6.5	16.8	1.9			5.6	35.60	77.17	35.035
Harding	3	67.7	14.5		17.1				20.65	67.07	30.540
North Henik	3	1.5	73.8			24.6			21.67	67.76	30.762
Markham	3	45.3	45.3			2.4	7.1		13.98	46.49	21.107
Nonacho	4	52.0	36.0		10.7			1.33	18.75	87.30	39.635
Lady Grey	4	72.3	23.4		3.19		1.1		23.50	101.99	46.302
Duncan	4	29.16	70.8						6.00	24.57	11.153
Indin	3	49.37	50.63	Grayling			Wh. sucker	Round			
							L.N.sucker	W.fish	26.33	125.9	57.158
Stark	4	38.28	10.53	1.44	.96	39.71	5.74	3.35	52.25	100.18	45.482
*Black	15	57.9	9.5	3.3	0.8	7.9	14.5		103	172	78.088
*Athabasca	36	56.2	2.4	5.6	1.8	15.5	7.2		86	81	36.774
*Cree	26	30.5	4.5	1.4	1.1	4.1	54.0		80	86	39.044
*Wollaston	18	42.1	11.2	5.7	2.8	2.2	31.0		53	83	37.682
*Reindeer	44	54.4	16.8	2.9	2.6	13.9	8.6		57	85	38.590
*Hunter Bay (Lac La Ronge)	15	60.6	4.8	4.9	2.4	23.2	2.6		79	105	47.67

* Absolute weights and numbers reduced by 1/6 to approximate the 5 net standard gang used in the N.W.T.

A 6 net standard gang is used in Saskatchewan.

4. Observations - Survey Techniques and Methodology

1. Within a limited period of time a given lake could be surveyed and a preliminary inventory and assessment proposed for the fisheries potential. The inventory and assessment was based on a series of measureable factors.
2. Where the lakes were too large to sound completely for a depth contour map a reasonable basin profile could be determined from the sounding tapes. The mean depth was determined from the sounding tapes in eight of the ten lakes.
3. The present technique is adequate for sampling and determining water chemistry. All future water samples should be filtered and/or preserved if they are to be used for detailed ion analysis.
4. The species composition and abundance of plankton (dry weight per unit surface area) is of major importance to the fish population. The 12 cm Wisconsin net used for this survey is too small for the accurate determination of plankton species and standing crop. A larger and more efficient net of the Wisconsin design is presently being developed. (Patalas, personal communication).[103] Phytoplankton sampling should be separate from zooplankton sampling and confined to the species identification and relative abundance.
5. The 6 inch Ekman dredge is apparently suitable for the present field surveys (Flannagan, 1970).[104] The sampling is very tedious and for

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103 K. Patalas, Freshwater Institute, Fisheries Research Board of Canada, Winnipeg, Manitoba.

104 Flannagan, J.F., 1970. Efficiencies of various grabs and corers in sampling freshwater benthos. J. Fish. Res. Bd. Canada, 27: 1691-1700.

accuracy the procedure requires a detailed sampling schedule by depth. The present survey should be modified as follows:

4 dredgings in the following depth zones -
0 - 5 m., 6 - 15 m., 16 - 25 m

The samples will serve for a relative comparison between lakes. The substrate must be precisely noted in all cases.

6. The standard-gang gill net appears to adequately suit the field survey technique. It was noted that fish with less than 5 annuli were not captured in most net sets. The beach-seining should be intensified and a small mesh net (½", 3/4", 1", 1¼", 1½") should be floated in the pelagic zone. The more intensive efforts to sample the surface waters should yield better information on minnows and the early age-classes of fish.

7. A major effort should be directed towards interpreting the quality of the landscape. The interpretation should be supplement with colour photographs, botanical collections, description of access areas and the limitations to commercial development.

8. The estimation of lake quotas was not attempted. The biological results from all the lake surveys should be studied in greater detail before quotas are estimated. It is recommended that a few "typical" lakes based on morphometry and water chemistry, i.e. perhaps a watershed, be set aside for a detailed study of the fish population. The results of the study may then be used to estimate quotas for the lakes in the "typical" area.

9. Considering the whitefish rate of infestation and the dark, white-fleshed lake trout, Little Doctor Lake is unsuitable for a

commercial fishery. The lake is accessible by air only from Fort Simpson. The distance of 65 air miles is not considered as restrictive to a sports fishery.

5. Conclusions and Recommendations - Little Doctor Lake

Little Doctor Lake is a small oligotrophic lake containing a small but diverse fish population. Longnose suckers dominate the fish population and may be competing with whitefish for food. Lake trout depend on game fish for their diet and may limit the overall fishing potential of the lake.

Economically valuable fish i.e. lake trout, whitefish and walleye are low in numbers. The colour of the lake trout and whitefish are unsuitable for the commercial fishery food market. The lake has a moderate sports fishing potential and a high overall recreation value. The position of the lake in the picturesque surroundings of the Mackenzie Mountains makes the area very attractive to both the sportsman and casual sightseer.

Considering the scenic and aesthetic qualities and the fishing limitations of Little Doctor Lake the following recommendations are made for management:

1. That the lake and surrounding area be left as a wilderness area;
2. That commercial utilization (if begun) be directed towards the appreciation of the landscape through multiple recreational use;
3. That exploitation of the fish population be conducted only through a domestic and strictly monitored sports fishery.
4. That Cli Lake to the North be used in conjunction with a Little Doctor Lake sports fishery to reduce angling pressure and the chance of an overall change in the fish population.

CHAPTER VII

CONCLUSIONS

1. An Inventory and Assessment method can be proposed on the basis of ecological concepts applied to fisheries management.
2. The inventory data can be used for the assessment of fisheries potential by the use of measurable factors. The factors are classified into five groups; Morphometric, Edaphic, Biological, Landscape and collectively, Transportation and Organization of fisheries.
3. The factors in each classification should be considered in a total perspective rather than on an individual basis. The Biological Factors are dominant in the Inventory and Assessment Method. The remaining four groups of factors generally define the limits and restrictions to fish production and fisheries use.
4. Many of the Morphometric, Edaphic and Biological Factors must be measured in the field. Considering the time restriction survey techniques must be simple, accurate and practical in the field. Factors and techniques are unsuitable if these three requirements cannot be met.

5. The most useful information to fisheries managers is that which measures the characteristics of the fish population. The age, growth and feeding characteristics are measured in as much detail as possible for commercial and sports fish. There is little information available on species spawning age. Present ageing methods are insufficient for some fish species. Benthic sampling is time consuming and seldom accurate without an intensive depth zone analysis. Plankton sampling and water chemistry are simple and require little effort. The dry weight of plankton is one useful indicator of the overall productivity of a lake. Benthic species and relative abundance, plankton species, relative abundance and dry weight and simple edaphic factors are useful for determining the restrictions and limitations to the fish population. They could also form the basis of an aquatic classification system for the Northwest Territories.
6. Catch per unit effort tables indicate the expected catch and fish species composition for sports and commercial fishing. Such tables are useful in determining the fish production in a given lake and relative production compared to other Northwest Territories lakes.
7. Landscape factors influence sports fisheries but have

little direct effect on commercial fisheries. Landscape evaluation tends to be very subjective but within a set of relevant guidelines i.e. aesthetics, campsites and topographical features.

8. The Organization of fisheries through market demands and regulation both determines fishery locations and influences the development of fishing industries. Sports fishing is dependant on tourism and the quality of the Northwest Territories fishing experience. The fish species and species quota that can be angled are pre-set and with few exceptions, constant throughout the Northwest Territories.

9. The commercial fish quota is based on the water surface area within the control area. The Control Area does not allow for the variation in fish species abundance nor the fact that a lake may not be able to support a commercial fishery due to biological and market restrictions. Outside the Control Area quota requests are influenced by social demands rather than biological capabilities. The lack of information on fish stocks and productivity necessitates the setting of conservative quotas. The number and diversity of legislative jurisdictions over Northwest Territories resources compounds the communication problem between government agencies.

10. Transportation has a significant role in the location of fishing industries and the use of fish resources. Trunk highways are confined to the Mackenzie Valley; the remaining areas are served by air and periodically by water along the coastal zones. Air transportation remains as the dominant means of transportation.

11. Off-road transportation could have a significant use in the Northwest Territories. Due to technological problems and excessive cost the use of off-road transportation remains for the future. The present water transportation system is too slow and not geared for shipping commercial fishing products.

12. The Organization and Transportation factors that affect the use of fish resources should be considered by fisheries managers for the allocation of an assessed fisheries potential. These "use" factors are included and grouped together in the Inventory and Assessment Method. The major effects of transportation are due to access and cost. The major organization effects are due to regulation restrictions, generally with respect to sports fishing and specifically with respect to commercial fishing.

13. Trends within Organization and Regulation indicate the

areas where fishing industries can potentially locate. This location effect is mainly due to transportation infrastructure and government policy respecting direction and assistance to northern development. The areas and time span to development is indicated by three scales i.e. immediate, near future and long range (Fig. 18).

14. Sports fishing will become a major industry in the lake areas near Yellowknife, along the Camsell River System, West of Great Slave Lake in the vicinity of the Mackenzie Mountains and East in the Taltson River System. Arctic Char sports fisheries will continue to develop and expand in the vicinity of Arctic coastal communities.

15. Commercial fisheries will tend to locate closer to Hay River mainly on the lakes in the Taltson River System and East of Yellowknife. Transportation cost directly determines whether or not a commercial fishery is viable and should be considered in fisheries management.

16. Air transportation will remain as the dominant mode of northern transportation. An expanding highways program will be opening a vast wilderness area along the Mackenzie Highway. Future fisheries development will be dependant on improvements and technological change within the transportation field.

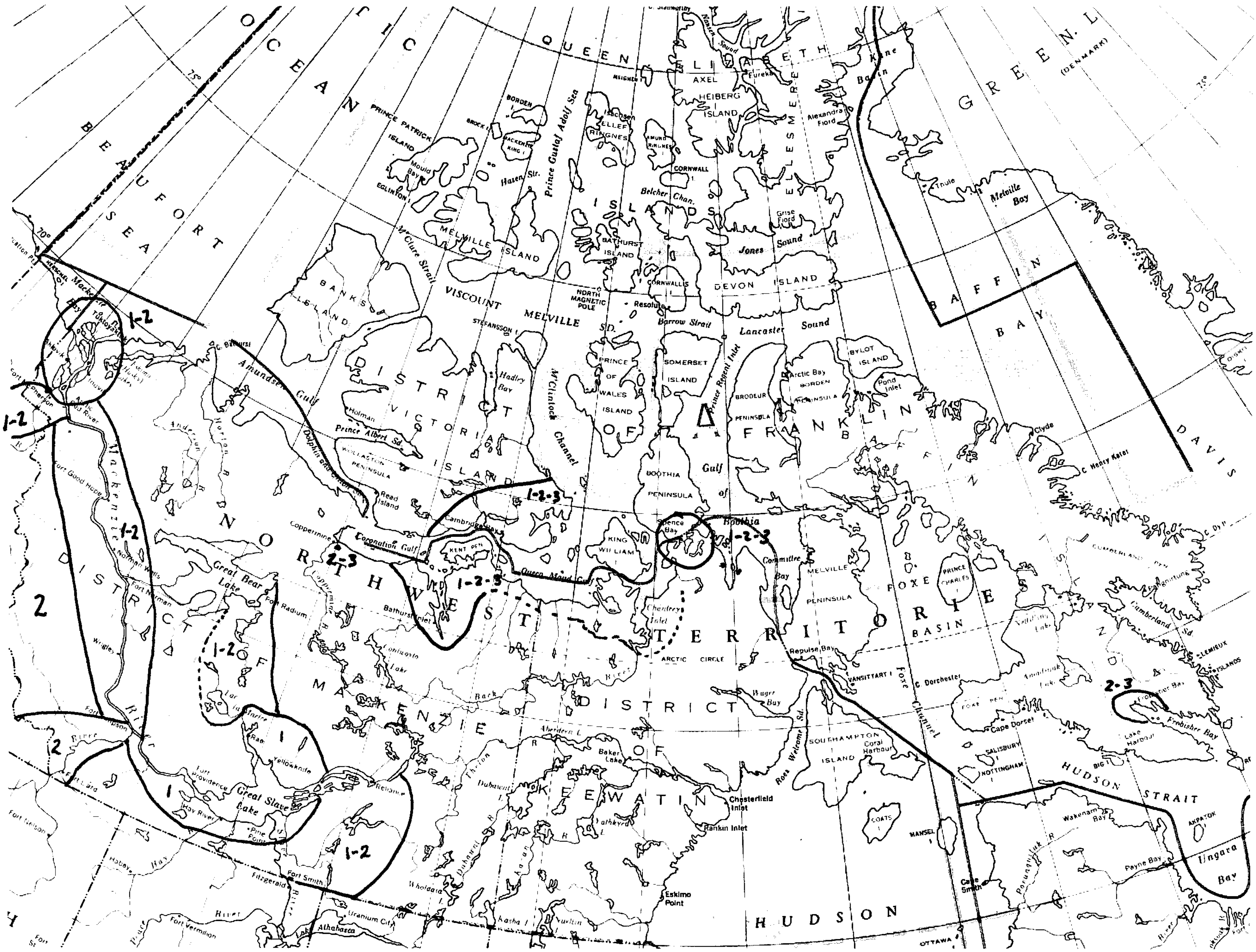

FIGURE 18: The fisheries development areas of the Northwest Territories.

Time Scale: 1. Immediate
2. Near Future
3. Long Range

CHAPTER VIII

RECOMMENDATIONS

1. The Inventory and Assessment method should be periodically reviewed and relevant changes made in the factors, survey techniques and methodology.
2. Field survey techniques should be simple and capable of measuring the factors of the method. The biological factors should be measured as they exist and not what they should be in relation to other biotic and abiotic factors.
3. The greatest effort during a field survey should be directed towards the collection of information on the fish population. Gill netting should be increased and seining and minnow trapping expanded to increase the small fish and minnow samples. Benthic sampling should not be increased and analysis confined to species identification, relative abundance and mean dry weight per depth zone. Plankton sampling is adequate and the analysis confined to species identification, relative abundance and total dry weight per acre.
4. New ageing methods should be determined for yellow pickerel. A study should be conducted to determine the spawning age of fish species throughout the Northwest

Territories. Stomach content analysis should be confined to gaining a general impression of fish species feeding preferences.

5. A greater effort should be directed towards angling. Catch per unit effort tables are exceptionally useful in determining the sports fishing potential of a lake.

6. The landscape factors are sufficient for the present. However, ranking of the factors may be possible and should be investigated.

7. There should be more communication between all government agencies respecting fisheries industrial development. The Territorial government should receive all fisheries biological reports and their opinions be considered during revision of the Fisheries Act and Regulations respecting the Northwest Territories. A greater co-operative effort by all government agencies involved could overcome northern social pressures and ensure the economic survival of fish stocks.

8. The quota within the control area should account for the variability in abundance of the commercial species. The relative abundance between the commercial species should be used as the percentage each species contributes to the quota catch. When any one species quota is reached the fishery should be closed.

9. The areas of fisheries development should be used as a guideline for the application of the Inventory and Assessment Method in the Northwest Territories (Fig. 18). The method should be initially applied in the No. 1 areas followed by No. 2 and then No. 3 areas. Due to the Transportation and Organization Factor influence these areas are subject to rapid change in development infrastructure.

10. The Northwest Territories should be divided into fisheries management zones. The zones should be delineated primarily on the species diversity and abundance of fish and secondarily on the intensity of sports, commercial and domestic fishery requirements. Areas such as around Yellowknife will be required for the sports fishing-tourist industry. Other areas such as Mackenzie River and Arctic communities may have substantial domestic fishing resources that could be used for sports and commercial industries.

11. The key to development lies with the management of the resources, not just the people. The opportunity exists to keep this unique part of Canada in harmony between wilderness and development. It is essential for governments to co-operate with each other and to plan the maximum beneficial use of fish resources. A basic

inventory and assessment of the fisheries potential in the Northwest Territories is the first requirement for planning the use of the resource.

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APPENDICES

A P P E N D I X   A

TABLE A-1: The commercially fished inland lakes and rivers in the Northwest Territories by year, distance to Hay River, landings (lbs.), and landed value ($).

1961			
TATHLINA	65	68,468	5,827
KAKISA	66	55,682	3,556
CHEDABUCTO	107	4,710	991
THUBAN	141	11,183	832
MACEWAN	142	1,884	277
JOHNSTON	155	1,470	118
McDONALD	172	47,928	3,572
KELLER	287	57,376	9,654
1962			
THUBAN	141	60,552	5,586
THEKULTHILI	190	117,348	12,994
GAGNON	195	43,644	5,975
NONACHO	209	2,281	324
FABER	218	2,398	-
KELLER	287	93,756	19,662
LAC STE. THERESE	317	1,756	549
1963			
TATHLINA	65	69,018	10,180
HIDDEN	136	4,151	374
THUBAN	141	29,744	2,284
ROSS	150	22,067	1,985
VICTORY	152	1,061	96
MOSHER	155	710	60
DESPERATION	161	4,262	384
GORDON	179	88,653	7,918
BASLER	212	6,299	567
GRANDIN	240	245,254	25,389
KELLER	287	48,708	9,890
HOTTAH	299	20,015	1,809
LAC STE. THERESE	317	47,687	6,613
NEULTIN	547	282,300	25,000 *

* Estimated

1964			
TATHLINA	65	24,609	3,673
PAULINE	117	2,354	188
DEFEAT	123	22,106	1,768
PLANTE	135	4,789	579
REID	135	393	35
SPARROW	139	12,286	983
BLAISDELL	151	1,450	131
VICTORY	152	7,779	700
MOSHER	155	2,721	226
DESPERATION	161	5,742	516
HELMER	162	8,806	705
GORDON	179	45,740	3,864
BASLER	212	12,222	1,100
INDIN	235	104	9
INGRAY	241	12,677	1,142
HOTTAH	299	763,632	67,666
NEULTIN	547	405,057	37,000 *
1965			
TATHLINA	65	4,284	784
KAKISA	66	2,766	830
THEKULTHILI	190	44,822	4,480
BASLER	212	7,086	814
WECHO	223	746	75
INGRAY	241	50,344	4,433
BEAVERLODGE	277	167	58
HOTTAH	299	365,021	36,520
CHARLIE	517	5,319	1,647
NEULTIN	547	183,794	16,710 *

* Estimated

1966

TATHLINA	65	718	251
KAKISA	66	160,017	29,721
CHEDABUCTO	107	7,630	1,653
PAULINE	117	3,707	593
HARDING	130	4,314	690
TREFIAK	149	5,969	2,089
SLEMON	164	15,049	1,813
McDONALD	172	17,213	2,593
THEKULTHILI	190	17,331	1,733
SPARKS	204	23,745	2,374
SADDLE	212	29,478	3,325
BASLER	212	1,336	122
MATTBERRY	223	35,559	3,727
ZINTO	230	11,669	1,181
INGRAY	241	39,857	4,117
ARSENO	256	2,579	235
MACKAY	271	24,477	4,895
MARGARET	272	21,851	3,430
LITTLE CRAPEAU	276	5,957	1,110
GRANT	281	45,220	3,714
HOTTAH	299	14,344	1,630
NEULTIN	547	149,560	13,596 *
McALESSE	578	15,100	6,638
MACKENZIE DELTA	783	62,338	5,612
HUSKY	-	13,365	1,337
LABRISH	-	9,638	841

1967

TATHLINA	65	37,381	7,534
KAKISA	66	71,882	11,023
ROCHER RIVER	106	1,248	122
CHEDABUCTO	107	10,381	1,653
DAVID	114	3,007	361
DUNCAN	126	2,959	715

* Estimated

1967 (Continued)

GULLION	127	641	128
HARDING	130	17,730	4,573
TREFIAK	149	12,985	5,014
YATSORE	184	34,755	3,476
MACKAY	271	57,276	10,309
MARGARET	272	40,787	5,105
LITTLE CRAPEAU	276	4,926	584
TURNER	376	6,105	1,319
NEULTIN	547	15,250	-
KITIGA	648	90,825	26,713
WELLINGTON BAY	652	53,716	8,057
BAKER	663	16,200	1,990
HAGALIK	-	1,725	104

1968

TATHLINA	65	19,958	3,174
KAKISA	66	34,703	4,271
FRANK	135	4,371	266
HIDDEN	136	1,275	344
TREFIAK	149	11,327	4,531
JONES (63° 04')	166	5,656	717
GRANDIN	240	19,145	3,244
KASBA	462	84,779	3,775
NEULTIN	547	191,964	17,451 *
WELLINGTON BAY	652	106,108	16,082
MERKLEY	655	11,315	1,258
TOASSIE	662	19,141	2,481
FERGUSON	662	2,755	344
HALOVIK RIVER	-	5,763	864
PALAYOK	-	14,250	2,137

* Estimated

1969			
TATHLINA	65	25,365	6,814
KAKISA	66	33,441	7,437
ROCHER RIVER	106	2,024	168
READE	141	3,622	1,436
MACEWAN	142	7,106	2,764
TREFIAK	149	5,059	1,717
WEDGE	153	10,007	2,473
GORDON	179	106,628	27,861
LAC LA MARTRE	192	245,218	47,450
NONACHO	209	118,812	39,849
HJALMAR	215	8,513	2,527
GRANDIN	240	161,353	23,050
KASBA	462	3,317	45
NEULTIN	547	66,228	6,020 *
RANKIN INLET	-	29,244	33,657
REPULSE BAY	-	4,613	-
WELLINGTON BAY	652	105,000	15,750
DINA RIVER	-	25,244	-
1970			
TATHLINA	65	43,122	15,703
KAKISA	66	32,397	10,304
ROCHER RIVER	106	4,656	2,232
GRAHAM	125	6,105	2,322
DUNCAN	126	460	334
PLANTE	135	6,748	2,071
THUBAN	141	21,985	5,489
TREFIAK	149	5,059	1,717
CHIPP	150	18,138	4,269
JOHNSON	155	306	102
JONES (63^{o} 04')	166	710	170
RUTLEDGE	171	5,366	1,497

* Estimated

1970 (Continued)

THISTLEWAITE	174	5,046	867
GORDON	179	37,828	8,932
TALTSON	187	69,172	13,869
LAC LA MARTRE	192	279,216	72,730
GAGNON	195	13,707	2,710
TRONKA CHUA	198	23,149	5,705
HJALMAR	208	99,034	30,615
NONACHO	209	308,921	86,580
GRANDIN	240	15,305	3,033
INGRAY	241	6,596	1,440
REBESCA	255	10,768	3,209
KELLER	287	6,417	2,186
HOTTAH	299	2,616	502
NORTH HENIK	599	5,621	1,315
MERKLEY	655	12,664	2,685
SURREY	656	8,493	2,316
BUFFET	661	2,519	579
TOASSIE	662	978	-
KAMINAK	685	115,273	31,705
RANKIN INLET	-	3,902	2,926
WELLINGTON BAY	652	12,959	8,219
DIANA RIVER	-	7,311	4,584
NAMELESS	-	77	18

<u>1971</u>

TATHLINA	65	33,065	10,169
KAKISA	66	38,134	12,095
DESKENATLATA	123	5,223	1,099
GRAHAM	125	18,239	2,680
DUNCAN	126	701	122
PLANTE	135	5,019	847
THUBAN	141	13,320	2,176
TREFIAK	149	5,039	1,717

* Estimated

1971 (Continued)

JOHNSON	155	305	102
JONES (63^{o} 04')	166	737	177
THISTLEWAITE	174	4,888	835
GORDON	179	33,649	7,982
McINNES	187	4,159	1,097
TALTSON	187	70,563	14,133
LAC LA MARTRE	192	205,449	53,368
GAGNON	195	22,348	5,363
TRONKA CHUA	198	23,391	5,567
SALKELD	202	31,352	7,939
HJALMAR	208	50,866	12,761
NONACHO	209	145,847	34,742
GRANDIN	240	15,122	3,033
INGRAY	241	6,775	1,580
REBESCA	255	9,858	2,621
BEAVERLODGE	277	25,641	6,423
HOTTAH	299	55,160	11,807
JONES (69^{o} 42')	656	632	153

1972

TATHLINA	65	49,351	13,648
KAKISA	66	48,581	13,620
TREFIAK	149	2,832	653
McDONALD	172	37,257	8,047
THEKULTHILI	190	177,426	38,675
LAC LA MARTRE	192	225,779	54,461
SPARKS	204	33,789	8,153
OTHER (Cambridge Bay, Rankin Inlet, etc.)		139,352	37,220

The 1972 figures are likely incomplete.

Source: Environment Canada, Fisheries Service, Economics Branch, Central Region Production and Landed Value Records.

1

PAYLOAD CALCULATIONS FOR VARIOUS TYPES OF SMALL AIRCRAFT BY TRIP DISTANCES

Model	Undercarriage	Gross Weight (lb.)	Empty Weight (lb.)	Disposable Weight (lb.)	Cruise Speed (mi./hr.)	Fuel Weight (lb./gal.)	Fuel Consumption	Fuel Reserve (lb.)	Pilot Weight (lb.)	Survival Equipment (lb.)	Take Off-Landing Allowance	EFFECTIVE PAYLOAD (LB.) 25 Miles One Way	50	75	100	150	200
Cessna 180 (180A)	Skis	2650	1745	904	120	7.2	14 g/hr.	76	175	50	10 min.	544	502	460	418	334	250
(180F)	Wheels	2650	1745	904	120	7.2	14 g/hr.	76	175	50	10 min.	544	502	460	418	334	250
(180H)	Floats	2820	1901	919	120	7.2	14 g/hr.	76	175	50	10 min.	559	517	475	433	349	265
Cessna 185 (A185)	Skis	3200	1798	1402	150	7.2	14 g/hr.	76	175	50	10 min.	1051	1017	983	950	882	816
	Wheels	3200	1798	1402	150	7.2	14 g/hr.	76	175	50	10 min.	1051	1017	983	950	882	816
	Floats	3300	2068	1232	150	7.2	14 g/hr.	76	175	50	10 min.	881	847	813	780	712	646

Model	Undercarriage	Gross Weight (lb.)	Empty Weight (lb.)	Disposable Weight (lb.)	Cruise Speed (mi./hr.)	Fuel Weight (lb./gal.)	Fuel Consumption	Fuel Reserve (lb.)	Pilot Weight (lb.)	Survival Equipment (lb.)	Take Off-Landing Allowance	EFFECTIVE PAYLOAD (LB.) Miles One Way: 25	50	75	100	150	200
Cessna 206 (U206)	Wheels	3300	1860	1440	150	7.2	16 g/hr.	86	175	50	10 min.	1071	1033	994	956	879	803
	Floats	3600	2144	1456	150	7.2	16 g/hr.	86	175	50	10 min.	1087	1049	1010	972	895	819
Norseman (VI) Noorduyn UC64A	Skis	7400	4727	2673	120	7.2	29 g/hr.	157	175	50	10 min.	2170	2081	1995	1909	1733	1560
	Floats	7540	4949	2594	120	7.2	29 g/hr.	157	175	50	10 min.	2091	2002	1916	1830	1654	1481
DHC2 MK II "Beaver"	Wheels	5100	3173	1927	115	7.2	15 g/hr.	81	175	50	10 min.	1556	1509	1462	1415	1321	1227
	Skis	5100	3173	1927	115	7.2	15 g/hr.	81	175	50	10 min.	1556	1509	1462	1415	1321	1227
	Floats	5090	3287	1803	115	7.2	15 g/hr.	81	175	50	10 min.	1432	1385	1338	1291	1197	1103

Model	Undercarriage	Gross Weight (lb.)	Empty Weight (lb.)	Disposable Weight (lb.)	Cruise Speed (mi./hr.)	Fuel Weight (lb./gal.)	Fuel Consumption	Fuel Reserve (lb.)	Pilot Weight (lb.)	Survival Equipment (lb.)	Take Off-Landing Allowance	EFFECTIVE PAYLOAD (LB.) Miles One Way 25	50	75	100	150	200
DHC2 MKlll "Turbo-Beaver"	Wheels	5100	2889	2211	130	8.02	40 lb./hr.	30	175	50	10 min.	1934	1919	1904	1888	1858	1828
	Floats	5090	3225	1865	130	8.02	40 lb./hr.	30	175	50	10 min.	1588	1573	1558	1542	1512	1482
	Skis	5100	3114	1986	130	8.02	40 lb./hr.	30	175	50	10 min.	1709	1694	1679	1663	1633	1603
DHC3 "Otter"	Wheels	8000	4900	3100	127	7.2	23 gal./hr.	124	175	50	10 min.	2658	2592	2527	2462	2331	2200
	Skis	8000	5185	2815	127	7.2	23 gal./hr.	124	175	50	10 min.	2373	2307	2242	2177	2046	1915
	Floats	7967	5322	2645	127	7.2	23 gal./hr.	124	175	50	10 min.	2203	2137	2072	2007	1876	1745

Model	Undercarriage	Gross Weight (lb.)	Empty Weight (lb.)	Disposable Weight (lb.)	Cruise Speed (mi./hr.)	Fuel Weight (lb./gal.)	Fuel Consumption	Fuel Reserve (lb.)	Pilot Weight (lb.)	Survival Equipment (lb.)	Take Off Landing Allowance	EFFECTIVE PAYLOAD (LB.) Miles One Way: 25	50	75	100	150	200
De Havilland "Twin Otter"	Wheels	11000	7000	4000	145	8.02	80 lb./hr.	60	350	50	10 min.	3499	3471	3444	3416	3361	3306
	Skis	11000	7600	3400	145	8.02	80 lb./hr.	60	350	50	10 min.	2899	2871	2844	2816	2761	2706
	Floats	11000	7800	3200	145	8.02	80 lb./hr.	60	350	50	10 min.	2699	2671	2644	2616	2561	2506
Beech C18 (D18, C45, 3N, 3NM)	Wheels	87500	5974	3126	145	7.2	30 gal./hr.	162	175	50	10 min.	2629	2553	2480	2404	2255	2106
	Skis	9100	6497	2603	145	7.2	30 gal./hr.	162	175	50	10 min.	2106	2030	1957	1881	1732	1583
	Floats	8750	6567	2183	145	7.2	30 gal./hr.	162	175	50	10 min.	1686	1610	1537	1461	1312	1163

Model	Gross Weight (lb.)	Empty Weight (lb.)	Disposable Weight (lb.)	Cruise Speed (mi./hr.)	Fuel Weight (lb./gal.)	Fuel Consumption	Fuel Reserve (lb.)	Pilot Weight (lb.)	Survival Equipment (lb.)	Take Off-Landing Allowance	EFFECTIVE PAYLOAD (LB.) Miles One Way 25	50	75	100	150	200
Consolidated PBY5A "Canso"	30500	19766	10734	90	7.2	46 g/hr.	248	350	50	10 min.	9851	9662	9477	9295	8928	8560
Douglas DC3	26900	18350	8550	125	7.2	46 g/hr.	248	350	50	10 min.	7713	7581	7449	7316	7051	6787

MODEL	UNDERCARRIAGE	RATE/MILE (ZONE M)	TRANSPORT COSTS FOR TRIP (DISTANCES ONE WAY VARIED) 25	50	75	100	150	200 (MILES)
Cessna 180	Skis	$0.55/mile (Gateway Aviation)	$27.50	$55.00	$82.50	$110.00	$165.00	$220.00
	Wheels	$0.55/mile	$27.50	$55.00	$82.50	$110.00	$165.00	$220.00
	Floats	$0.55/mile	$27.50	$55.00	$82.50	$110.00	$165.00	$220.00
Cessna 185	Skis	$0.70/mile (Carter Air Services)	$35.00	$70.00	$105.00	$140.00	$210.00	$280.00
	Wheels	$0.70/mile	$35.00	$70.00	$105.00	$140.00	$210.00	$280.00
	Floats	$0.70/mile	$35.00	$70.00	$105.00	$140.00	$210.00	$280.00
Cessna 206	Wheels	$0.60/mile (Parsons Airways Northern Ltd.)	$30.00	$60.00	$90.00	$120.00	$180.00	$240.00
	Floats	$0.60/mile	$30.00	$60.00	$90.00	$120.00	$180.00	$240.00
Norseman V	Skis	$0.90/mile (Parsons Airways Northern Ltd.)	$45.00	$90.00	$135.00	$180.00	$270.00	$360.00
	Floats	$0.90/mile	$45.00	$90.00	$135.00	$180.00	$270.00	$360.00
DHC2 "Beaver"	Wheels	$0.80/mile (Gateway Aviation)	$40.00	$80.00	$120.00	$160.00	$240.00	$320.00
	Skis	$0.80/mile	$40.00	$80.00	$120.00	$160.00	$240.00	$320.00
	Floats	$0.80/mile	$40.00	$80.00	$120.00	$160.00	$240.00	$320.00

TRANSPORT COSTS FOR TRIPS - DISTANCE ONE WAY VARIED)

MODEL	UNDERCARRIAGE	RATE/MILE (ZONE M)	25	50	75	100	120	200 (MILES)
DHC2 MK III	Wheels	$1.20/mile (Ptarmigan Airways Ltd.)	$60.00	$120.00	$180.00	$240.00	$360.00	$480.00
	Floats	$1.20/mile	$60.00	$120.00	$180.00	$240.00	$360.00	$480.00
	Skis	$1.20/mile	$60.00	$120.00	$180.00	$240.00	$360.00	$480.00
DHC 3 "Otter"	Wheels	$1.25/mile (Ilford-Riverton)	$62.50	$125.00	$187.50	$250.00	$375.00	$500.00
	Skis	$1.25/mile	$62.50	$125.00	$187.50	$250.00	$375.00	$500.00
	Floats	$1.25/mile	$62.50	$125.00	$187.50	$250.00	$375.00	$500.00
"Twin Otter"	Wheels	$1.65/mile (Gateway Aviation)	$82.50	$165.00	$247.00	$330.00	$495.00	$660.00
	Skis	$1.65/mile	$82.50	$165.00	$247.00	$330.00	$495.00	$660.00
	Floats	$1.65/mile	$82.50	$165.00	$247.00	$330.00	$495.00	$660.00
Beech C18	Wheels	$0.80/mile (Calm Air)	$40.00	$80.00	$120.00	$160.00	$240.00	$320.00
	Skis	$1.20/mile	$60.00	$120.00	$180.00	$240.00	$360.00	$480.00
	Floats	$1.20/mile	$60.00	$120.00	$180.00	$240.00	$360.00	$480.00
Consolidated PBY5A "CANSO"		$2.00/mile (Ilford-Riverton)	$100.00	$200.00	$300.00	$400.00	$600.00	$800.00
Douglas DC-3	Wheels	$1.75/mile (Northwest Territorial Airways)	$87.50	$175.00	$262.50	$350.00	$525.00	$700.00

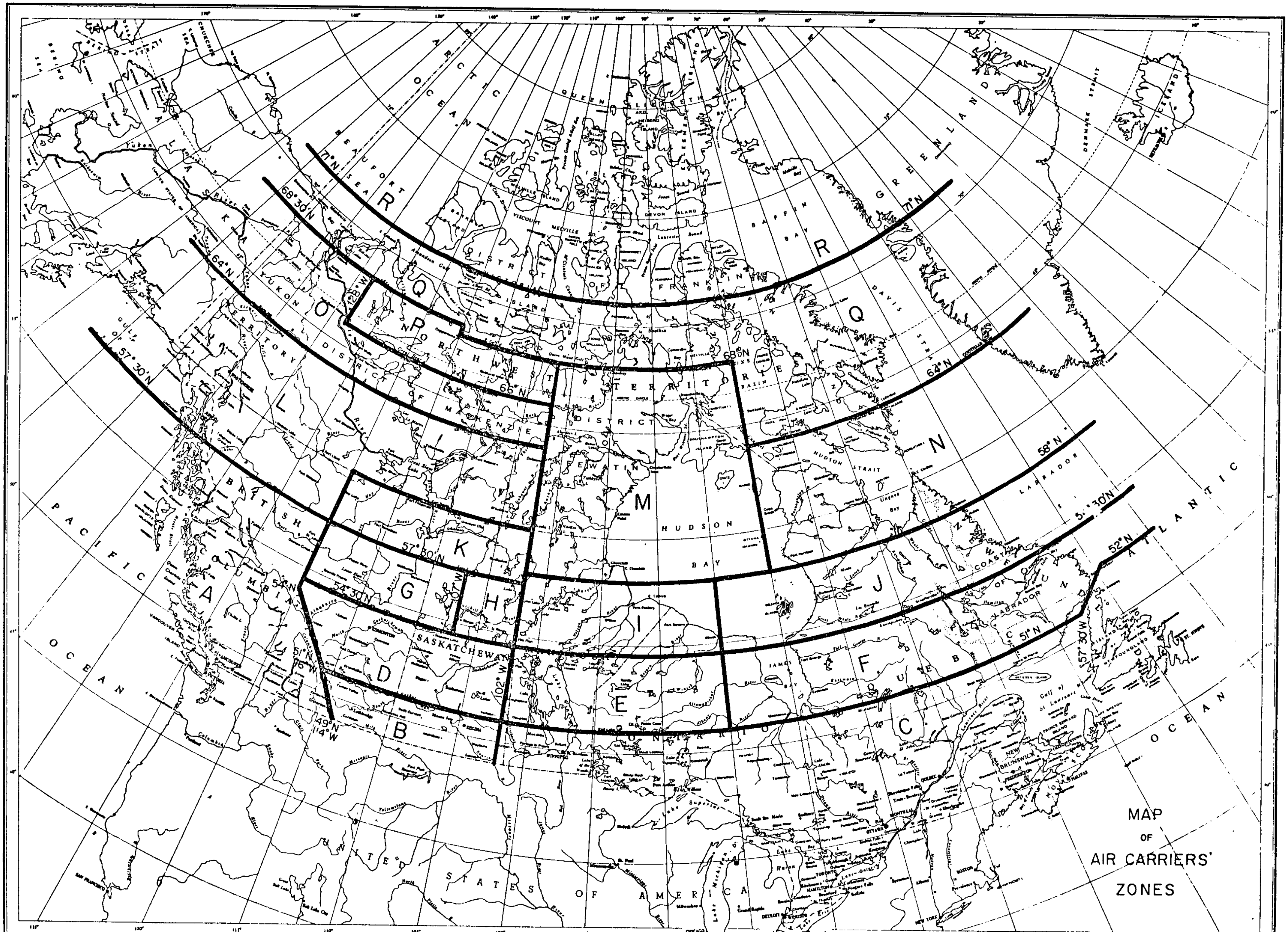
TRANSPORT COST PER LB. FISH = TRANSPORT COST/EFFECTIVE PAYLOAD
COST IN ¢/LB.

MODEL	UNDERCARRIAGE	25	50	75	100	150	200 miles one way
Cessna 180	Skis	5.05	10.96	17.93	26.31	49.40	88.00
	Wheels	5.05	10.96	17.93	26.31	49.40	88.00
	Floats	4.92	10.64	17.37	25.40	47.28	83.02
Cessna 185	Skis	3.33	6.88	10.68	14.74	23.81	34.31
	Wheels	3.33	6.88	10.68	14.74	23.81	34.31
	Floats	3.97	8.26	12.91	17.95	29.49	43.34
Cessna 206	Wheels	2.80	5.81	9.05	12.55	20.48	29.89
	Floats	2.76	5.72	8.91	12.34	20.11	29.30
Norseman V	Skis	2.07	4.32	6.77	9.43	15.58	23.08
	Floats	2.15	4.49	7.04	9.84	16.32	24.31
DHC2 "Beaver"	Wheels	2.57	5.30	8.21	11.31	18.17	26.08
	Skis	2.57	5.30	8.21	11.31	18.17	26.08
	Floats	2.79	5.78	8.97	12.39	20.05	29.01

TRANSPORT COST PER LB. FISH   TRANSPORT COST / EFFECTIVE PAYLOAD

COST IN ¢/LB.

MODEL	UNDERCARRIAGE	25	50	75	100	150	200 (Miles One Way)
DHC2 MK III Turbo-Beaver	Wheels	3.10	6.25	9.45	12.71	19.38	26.26
	Floats	3.78	7.63	11.55	15.56	23.81	32.39
	Skis	3.51	7.08	10.72	14.43	22.04	29.94
DHC 3 "Otter"	Wheels	2.35	4.82	7.42	10.15	16.09	22.73
	Skis	2.63	5.42	8.36	11.48	18.33	26.11
	Floats	2.84	5.85	9.05	12.46	19.99	28.65
"Twin Otter" DHC-6	Wheels	2.36	4.75	7.19	9.66	14.73	19.96
	Skis	2.85	5.75	8.70	11.72	18.23	24.39
	Floats	3.06	6.18	9.36	12.61	19.33	26.34
Beech C18	Wheels	1.52	3.13	4.84	6.66	10.64	15.19
	Skis	2.85	5.91	9.20	12.76	20.79	30.32
	Floats	3.56	7.45	11.71	16.43	27.44	41.27
Consolidated PBY5A		1.02	2.07	3.17	4.30	6.72	9.35
Douglas DC-3	Wheels	1.13	2.31	3.52	4.78	7.45	10.31


MAP
OF
AIR CARRIERS'
ZONES
A
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C
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N
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71°N
68°30'N
66°N
64°N
57°30'N
54°30'N
51°N
49°N
114°W
102°W
128°W
57°30'W
52°N
58°N
68°N
PACIFIC OCEAN
ATLANTIC OCEAN
ARCTIC OCEAN
HUDSON BAY
SASKATCHEWAN
ONTARIO
QUEBEC
UNITED STATES OF AMERICA
GREENLAND
BAFFIN BAY
DAVIS STRAIT
HUDSON STRAIT
LABRADOR
BEAUFORT SEA

APPENDIX C

GOVERNMENT OF THE NORTHWEST TERRITORIES

ORDINANCES AND REGULATIONS EFFECTING FISHERIES

1. Travel and Outdoor Recreation Ordinance

    271-68: The Outfitter's Regulations

    042-69: An expansion of 271-68 and cited as the Tourist Establishment Regulations

2. Public Health Ordinances

    375-64: The Eating or Drinking Place Regulations

    297-68: The Tourist Accommodation Health Regulations

3. Other Ordinances and Regulations

    The Business License Ordinance

    Ordinance to Provide for Labor Standards

    Northern Building Code

    Archeological Sites Regulations

    Small Vessel Regulations

    Fire Prevention Ordinance

    Forest Protection Ordinance

    Game Ordinance

APPENDIX D

TABLE II

TENTATIVE, NORTHERN ROAD PROGRAM, 1976-1985
(as proposed in 1965)

Second 10-year Plan

Location	Distance	Estimated Cost $
Fort Simpson - Wrigley	150	10,000,000
Wrigley - Norman Wells	180	11,000,000
Norman Wells - Arctic Red River	275	18,000,000
Arctic Red River - Inuvik *	80	5,000,000
Inuvik - Tuktoyaktuk	70	4,000,000
Arctic Red River - Fort McPherson *	25	1,500,000
Fort Smith - Talston River	60	3,000,000
Talston River - Fort Reliance	200	10,500,000
Fort Reliance - Wolverine Lake	90	5,000,000
Fort Smith - Uranium City	125	6,000,000
Northern Parks roads	160	8,000,000
Lateral (Resource) roads	N/A	20,000,000

* Moved forward to 1966-75 program.

1. Most Probable to Develop in the Immediate Future

Source: Ibid. Table 1.

TABLE I

STATUS, NEW CONSTRUCTION, NORTHERN ROAD PROGRAM, 1966-75

First 10-year Plan

Road	Distance (miles)	Cost to Date ($,000)	Status end 1970
Ross River-Carmacks	142	9,060	completed
Carmacks-Snag	120	---	not started
Dempster Highway (Chapman Lake-Fort McPherson)	200	2,122	15% completed
Canol Road - Y.T.	125	585	completed to minimum standards
Canol Road - N.W.T.	195	---	not started
Mackenzie Highway (Enterprise to Fort Simpson)	179	8,400	completed
Fort Simpson-Fort Liard and B.C. border	172	1,314	15% completed
Pine Point-Fort Smith	120	714	completed
Fort Smith-Fort Reliance	270	---	not started
Yellowknife - MacKay Lake	183	1,506	25% completed
MacKay Lake-Contwoyto Lake	150	---	not started
Ingraham Trail - Gordon Lake	35	---	not started
Pine Point - Fort Resolution		191	% completed
Arctic Red River-Inuvik		108	surveyed
Arctic Red River - Fort McPherson		111	surveyed

Source: Canada, Govt. of 1970. Arctic Transport. Proceedings of the Arctic Transportation Conference. Vol. 2. Ministry of Transport and Dept. of Indian Affairs and Northern Development, Yellowknife, Dec. 1970. Information Canada, Ottawa.

APPENDIX E

TABLE I: The water chemistry of Little Doctor Lake, July 6, 1971 (all figures in parts per million unless otherwise specified).

	Surface Time: 1300 hrs.	19 Meters Time: 1310 hrs.	25 Meters Time: 1320 hrs.
Temperature at sampling	13.0° C	5.4° C	4.5° C
Temperature at testing	23.8° C	23.8° C	23.6° C
Turbidity	1.7	0.8	0.7
Color	55.0	55.0	65.0
pH	7.7	7.8	7.6
Carbon: total organic	13.0	13.0	11.0
Carbon: total inorganic	14	15	15
Chloride: dissolved	0.8	0.9	0.9
Copper: dissolved	0.001	0.016	0.013
Fluoride: dissolved	0.05	0.05	0.05
Iron: dissolved	0.07	0.06	0.07
Lead: dissolved	0.004	0.004	0.004
Manganese: dissolved	0.010	0.010	0.010
Nitrogen: total kjeldahl	0.36	0.41	0.48
Nitrogen: Nitrate & Nitrite dissolved	0.07	0.11	0.11
Phosphate: dissolved, ortho	0.01	0.01	0.01
Phosphate: dissolved, inorganic	0.02	0.02	0.02
Phosphate: total	0.02	0.03	0.02
Potassium: dissolved	0.8	0.6	0.5
Specific conductance: umho/cm	147	155.0	155.0
Alkalinity: total	61.9	64.6	65.5
Hardness: total	72.3	75.1	75.0
Calcium: dissolved	20.5	22.1	22.0
Sulphate: dissolved	7.9	7.9	8.0
Silica: reactive	3.2	3.4	3.5
Sodium: dissolved	2.1	1.8	1.8
Zinc: dissolved	0.001	0.014	0.009
Mercury: total	.005	0.005	0.005

TABLE II: Maturity state by age class of fish captured by gill net in Little Doctor Lake, July, 1971.

No. of Annuli	Whitefish		Lake Trout		Northern Pike		Longnose Sucker	
	No. Fish	Maturity Code	No. Fish	Maturity Code	No. Fish	Maturity Code	No. Fish	Maturity Code
4							1	-
5	1	2					3	2x3
6	2	-					1	-
7	2	2			1	3	7	1x2 1x3 3x4 1x7 1x8
8					2	1x2 1x3	2	1x2 1x4
9	1	2	1	2			3	2x4 1x8
10	1	2	2	7	1	3	3	2x4 1x8
11	1	8	2	7			2	1x7 1x8
12	1	3	3	2x7 1x8				
13	1	2					1	1x8
14			1	7				

Maturity Code

Male		Female
1	Juvenile	6
2	Immature	7
3	Maturing	8
4	Ripe	9
5	Spent	10