ASSESSMENT OF THE IMPACT OF THE KEMANO II PROPOSAL ON THE FISH AND WILDLIFE RESOURCES OF THE NANIKA – KIDPRICE AND MORICE SYSTEMS

for
Habitat Protection Section
Fish and Wildlife Branch

based on field work partially funded by
B.C. Hydro and Power Authority
1979

Province of British Columbia
Ministry of Environment

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Dana: March 24/98

For your files.

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Preface

Several different consultants participated in the data collection and manuscript preparation for this report. The results of the 1974 field studies were collated into an interim data summary by Envirocon Limited personnel. Mr. J. R. Sutherland later incorporated the data from both the 1974 and 1975 field studies into a rough draft report, which was edited and partially rewritten by Ms. L. D. Bailey. The Fish and Wildlife Branch bears full responsibility for interpretation of the data, and for any conclusions or recommendations drawn from it.

This report provides a comprehensive summary of major findings. The raw data has been compiled into a separate set of Appendices. A limited number of copies of these Appendices are available, upon request, from the Fish and Wildlife Branch, Ministry of Environment, Parliament Buildings, Victoria, British Columbia.

Abstract

Kemano II is a proposed hydroelectric development involving the diversion of water from the Nanika-Kidprice Lakes and Morice River systems, located in the mid-western portion of British Columbia near Kitimat. The project would involve inundation of the Nanika-Kidprice system and severe flow reductions in the lower Nanika and Morice Rivers.

During 1974 and 1975, Fish and Wildlife Branch participated in field investigations in the area to assess the impact of Kemano II on fish and wildlife resources, with emphasis on limnology, spawning and rearing habitat, fish parasite infestation, sport fisheries, wildlife habitat, and recreation. Flooding would result in a loss of approximately 77 per cent of the existing fish spawning habitat and 80 per cent of rearing habitat in the Nanika-Kidprice system. The riparian area between the two lakes is the most heavily utilized wildlife habitat in the system, serving as a moose calving and concentration area for about 60 animals. Inundation would result in the loss of this habitat and pose potential migration problems. Dam construction would cause severe flow reductions in the Morice River, with probable adverse effects on the important steelhead fishery. Improved access to the areas could create excessive recreational pressures, with possible adverse effects on fish and wildlife populations. Population losses due to habitat and food supply destruction could eventually cause a decline in angling and hunting activity. Severe infestation by the fish tapeworm *Diphyllobothrium* exists in the Nanika-Kidprice system. Diversion of water from that system to Tahtsa Lake raises the possibility of parasite transfer to the Fraser River system.

Acknowledgements

Funding for the field portion of this study was provided by B. C. Hydro and Power Authority, whose support is gratefully acknowledged. Field work was conducted by K. Simpson, C. Morley, and F. Whitehead in 1974, and by J. Sutherland, C. Morley, N. Cunningham, and L. Harper in 1975.

Most of the information on wildlife was provided by Dr. D. Hatler, of the Fish and Wildlife Branch, Smithers office. The cooperation of Fisheries and Marine Service personnel, particularly T. Cleugh and B. Lawley, in providing valuable limnological data is gratefully acknowledged.

Various staff of the Fish and Wildlife Branch, Ministry of Environment, provided comments on the manuscript, specifically J. H. C. Walker (Chief of Habitat Protection), A. Tautz (Chief of Fisheries Research), M. Whately (Regional Fisheries Biologist, Smithers), and A. Edie (Regional Habitat Protection Biologist, Smithers). Their criticisms are appreciated.

Thanks are also extended to L. Collicott for typing the report and to the Engineering staff of the Fish and Wildlife Branch for drafting the figures.

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1 INTRODUCTION

1.1 PURPOSE OF REPORT

In 1974 and 1975, the Fish and Wildlife Branch conducted field studies on the fish and wildlife populations in the Nanika-Kidprice system which would be affected by the proposed Kemano II project. The field portion of these studies was funded by B. C. Hydro.

The purpose of this report is to describe, summarize, and evaluate the data obtained in the 1974-1975 studies and to assess the environmental impacts of the Kemano II project, as proposed by B. C. Hydro.

1.2 KEMANO I

The existing Kemano I hydroelectric development consists of a dam (Kenney Dam) at the outlet of Knewstubb Lake, which created a reservoir of Tahtsa, Ootsa, Whitesail, Eutsuk, Tetachuck, Natalkuz, and Knewstubb Lakes (Fig. 1). A hydraulic tunnel connects the west end of Tahtsa Lake to the Kemano River. This hydro development is owned and operated by the Aluminum Company of Canada Limited (Alcan), and provides power for the Alcan Plant in Kitimat. It was constructed from 1951 to 1956, and power generation commenced in 1957. The maximum generating capacity is 815 MW (Anon., 1972a).

1.3 PROPOSED HYDROELECTRIC DEVELOPMENT - KEMANO II

The Kemano II project, as originally proposed by B. C. Hydro, consists of a number of water storage and diversion schemes which would, if implemented:

- create a 47 m dam on the Nanika River at the outlet of Kidprice Lake, raising water levels in Nanika Lake by 10 m and in Kidprice Lake by 30 m

- create an 18 m dam on the Morice River at the outlet of Morice Lake, raising water levels in Morice Lake by 6 m

- divert water from Morice Lake to Nanika reservoir (Nanika and Kidprice Lakes) via a pumping station

- divert water from Nanika reservoir into Tahtsa Lake via a tunnel

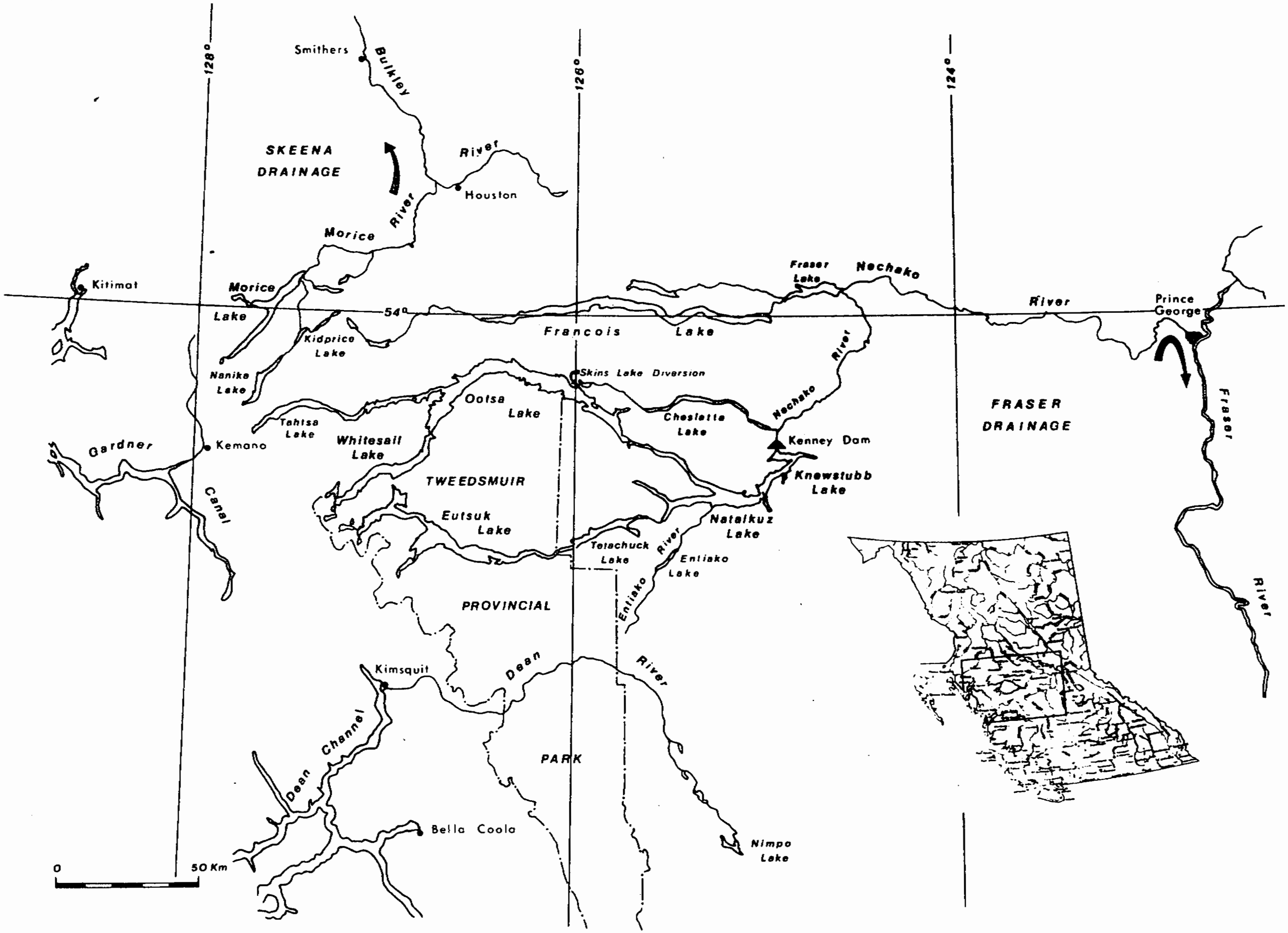


Fig. 1 Map of the areas which would be affected by Kemano II, as proposed by B. C. Hydro and Power Authority

- divert water from the Dean River into Tahtsa Lake via a system of dykes, dams, canals, and the Entiako River

- divert more water from Tahtsa Lake into Kemano River via a second hydraulic tunnel parallel to the present tunnel.

Details of the proposed Morice and Nanika diversions are shown in Fig. 2. Flows available for power generation were calculated by subtracting proposed average fish water release flows from average mean annual flows (Anon., 1972a) (Table 1).

Table 1 Summary of available water supply for Kemano II development (Anon., 1972a)

Diversion	Average Flow[1] (cfs)	Average Fish Water Release Flow (cfs)	Flow Available for Power (cfs)
Nechako	2030[2]	160	1870
Nanika	1045	83	962
Dean	719	70	649
Morice	1535	300	1235
TOTALS	5329	613	4716

[1] 1928-1958 flows

[2] Flow available at Kenney Dam after deducting an assumed average power flow to existing Kemano plant of 4600 cfs from the average flow of 6630 cfs

The hydrological effects of the Kemano II development would include:

- reduction of flow in the Nanika River below Kidprice Lake from 1063 cfs* (average) to 83 cfs (average)

- reduction of flow in the Morice River below Morice Lake from 2672 cfs* (average) to 300 cfs (average)

- reduction of flow in the Dean River from 719 cfs (average) to 70 cfs (average)

*1973 to 1976 flows

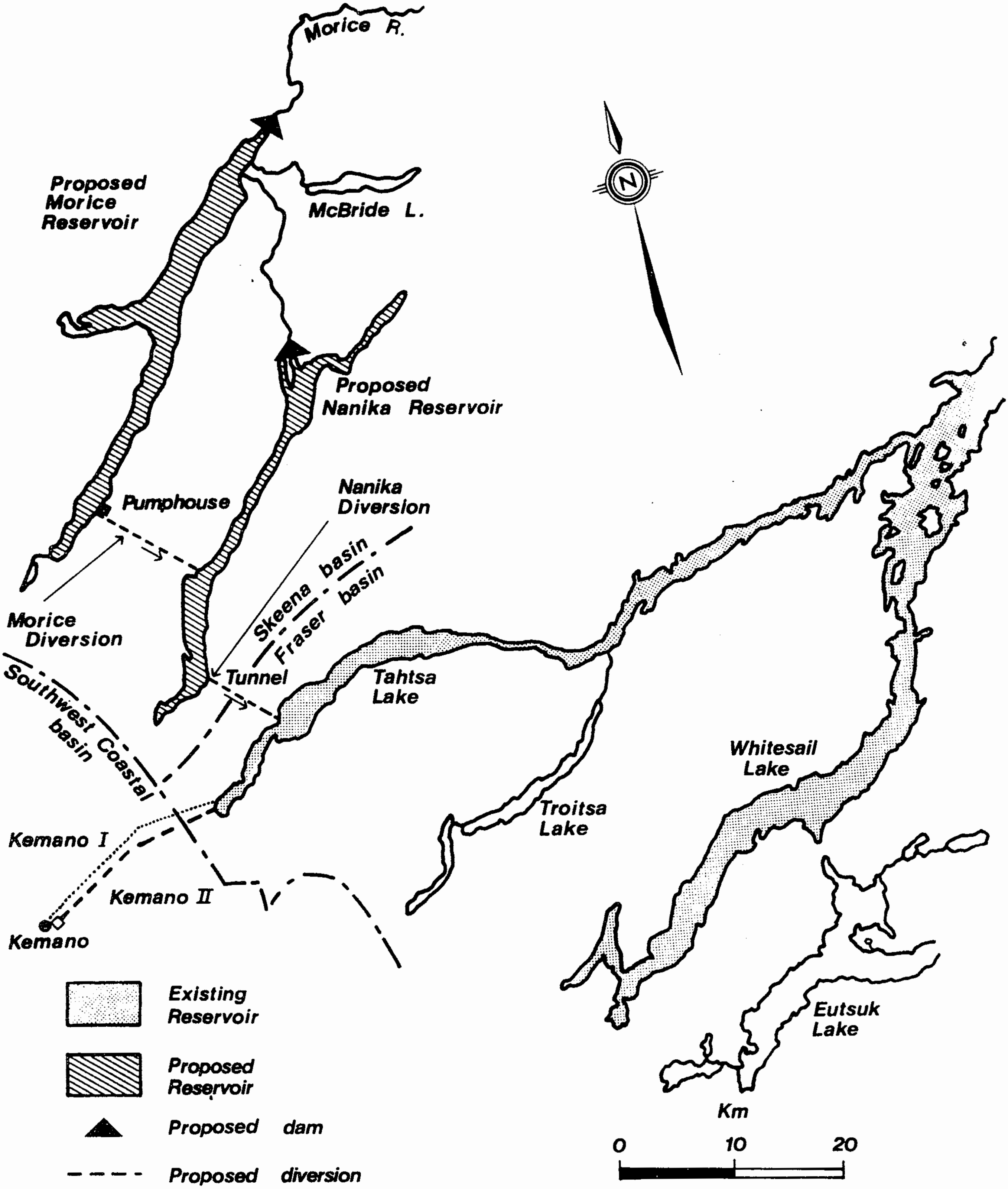


Fig. 2 Map showing existing and proposed reservoirs and the proposed Nanika and Morice dams and diversions (Anon., 1972a)

- further reduction of flow in the Nechako River to 160 cfs (average) from its original 6630 cfs (average)

- further increase of flow in the Kemano River by about 4892 cfs

- reduction of flows in the Bulkley-Skeena system and further reduction of flow in the Fraser River.

2 BACKGROUND

In 1974, B. C. Hydro and Power Authority funded a field study coordinated by the then Fisheries and Marine Service of Environment Canada, and which involved the Fisheries and Marine Service, the International Pacific Salmon Fisheries Commission, and the B. C. Fish and Wildlife Branch. The purpose of the study was to assess the implications of the Kemano II proposal for fish and wildlife in the Nanika, Morice, Nechako, and Dean systems.

During initial discussions of the Kemano II proposal with B. C. Hydro, the Fish and Wildlife Branch emphasized that the Dean River steelhead fishery was one of the finest in North America. The proposed Dean diversion was, therefore, unacceptable to the Branch. B. C. Hydro, for reasons of their own, subsequently decided to exclude the Dean diversion from the proposal.

The Fisheries and Marine Service studied the implications of the Kemano II proposal for chinook salmon in the Nechako River (Anon., 1979, Vol. 3) and for chinook, sockeye, coho, and pink salmon in the Nanika and Morice systems (Anon., 1979, Vol. 5). The Salmon Commission addressed the impact of Kemano II on sockeye salmon in the Nechako River (Anon., 1979, Vol. 2). The Fish and Wildlife Branch was to assess the potential impacts of the Kemano II proposal on the limnology, freshwater fisheries, wildlife, and recreation of the Nanika and Morice systems.

The Branch began studies of the Nanika-Kidprice system in 1974, with an emphasis on spawning and rearing habitat (Anon., 1975c). In 1975, further studies were conducted in the Nanika-Kidprice system to assess the problems related to the transfer of water from Morice Lake via the proposed Nanika-Kidprice reservoir to Tahtsa Lake, with an emphasis on parasites and limnology. Cursory observations were made on the Morice and Nechako systems during the 1974 and 1975 studies.

At the present time, B. C. Hydro is not actively considering the Kemano II proposal. However, Alcan is now interested in exercising additional options under the water licence they obtained in 1950. The Kemano II project, as modified by Alcan, involves the construction of a dam on the Nanika River below the outlet of Kidprice Lake, and the diversion of water from the Nanika reservoir to Tahtsa Lake via a tunnel. Their proposal also includes a second hydraulic tunnel from Tahtsa Lake into the Kemano River. The Alcan proposal differs from the one studied here in that it excludes the Morice dam and diversion.

The following report focuses on the potential impacts of the original B. C. Hydro proposal on the limnology, fisheries, wildlife, and recreation of the Nanika-Kidprice system. The potential impacts of that proposal on the Morice and, to a lesser extent, Nechako systems are discussed where the data base is adequate for assessment.

3 GEOGRAPHY

Nanika and Kidprice Lakes lie in a northeasterly trench in the eastern slope of the Coastal Mountains of British Columbia, at approximately 53°40' North Latitude and 127°30' West Longitude, at elevations 932 m and 908 m above mean sea level, respectively. Two mountain ranges, running transverse to the Coastal Mountains and rising to elevations of 1800 - 2400 m, enclose a drainage area of about 741 km^2 to the outlet of Kidprice Lake (Fig. 3). Annual rainfall may be as high as 180 cm in the area, and there is heavy snowpack in the winter. Alpine glaciation is active in the higher mountains, with most peaks of elevation greater than 2000 m having cirque glaciers or ice caps. The generally steep gradients of tributaries to Nanika and Kidprice Lakes, with their wildly fluctuating flows and heavy silt load, are characteristic of glacial run-off and snow melt.

Thirteen creeks run into Nanika Lake. Nanika Lake drains into Kidprice Lake via the upper Nanika River, which meanders through a low-lying area dotted with small ponds and sedge meadows. Four other creeks run into Kidprice Lake. Of the smaller lakes draining into Kidprice Lake, the most significant are Stepp and Anzac Lakes to the northeast and Spill Lake to the north. The continuation of the Nanika River, draining Kidprice Lake, flows into the northeastern end of Morice Lake. At the outlet of Kidprice Lake is an 18 m waterfall which prevents the upstream passage of fish (Fig. 4).

The shoreline of Nanika Lake is characterized by steep rocky bluffs and cliffs, often descending to considerable depth. The only extensive low gradient areas are at the mouth of Fenton Creek and in the outlet area where the upper Nanika River drains the lake. These low gradient areas support subalpine fir (*Abies lasiocarpa*), black spruce (*Picea mariana*), some whitebark pine (*Pinus albicaulis*), alder (*Alnus* spp.), and willow (*Salix* spp.). Some isolated low gradient areas occur at the mouths of Nikun Creek (III), Creek IX, and Creek XIV (Fig. 5). Even in these few low gradient areas, the beaches have gravel to about 4 - 6 m depth. Aquatic vegetation is very sparse.

The low-lying area between Nanika and Kidprice Lakes is poorly drained and extends for about 5 km, achieving a width of over 2 km (Area A, Fig. 6). In particular, where it opens into the shoreline at the southwestern end of Kidprice Lake, there is a relatively extensive development of beach and shallow littoral. Bergeland Creek flows from the south into this low-lying area, and

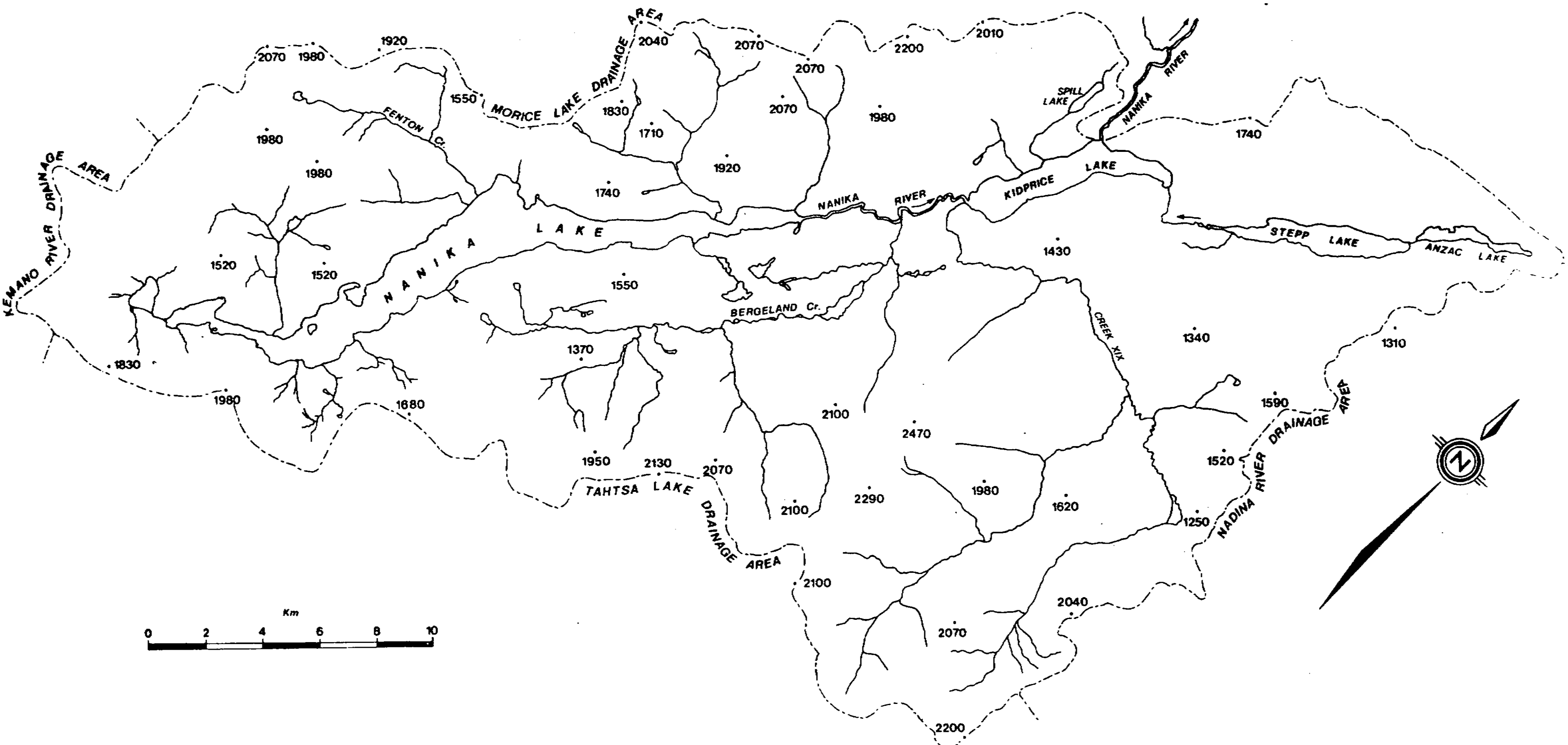


Fig. 3 Map of Nanika-Kidprice watershed

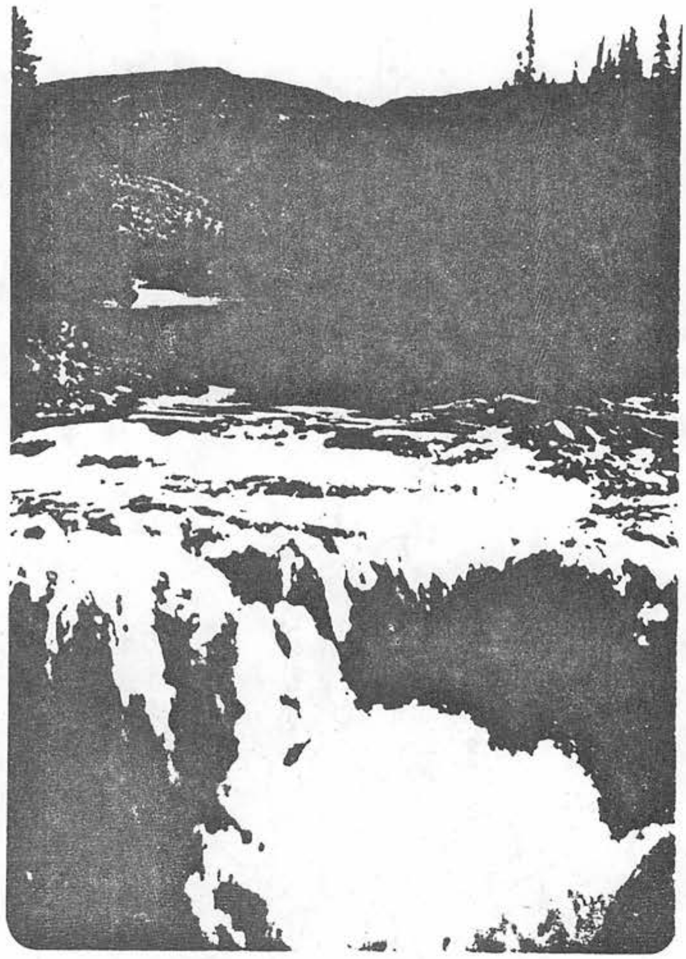


Fig. 4 Nanika Falls

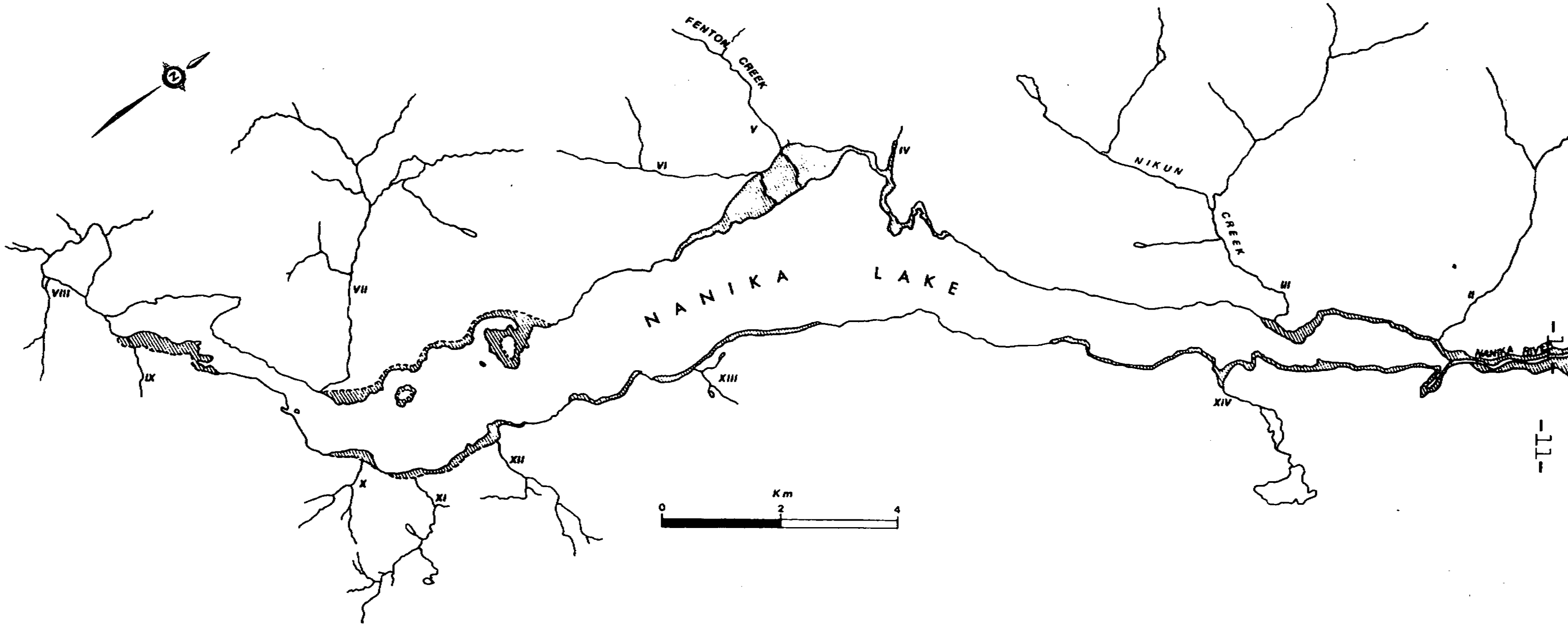


Fig. 5 Map of Nanika Lake and tributaries showing proposed flooded areas

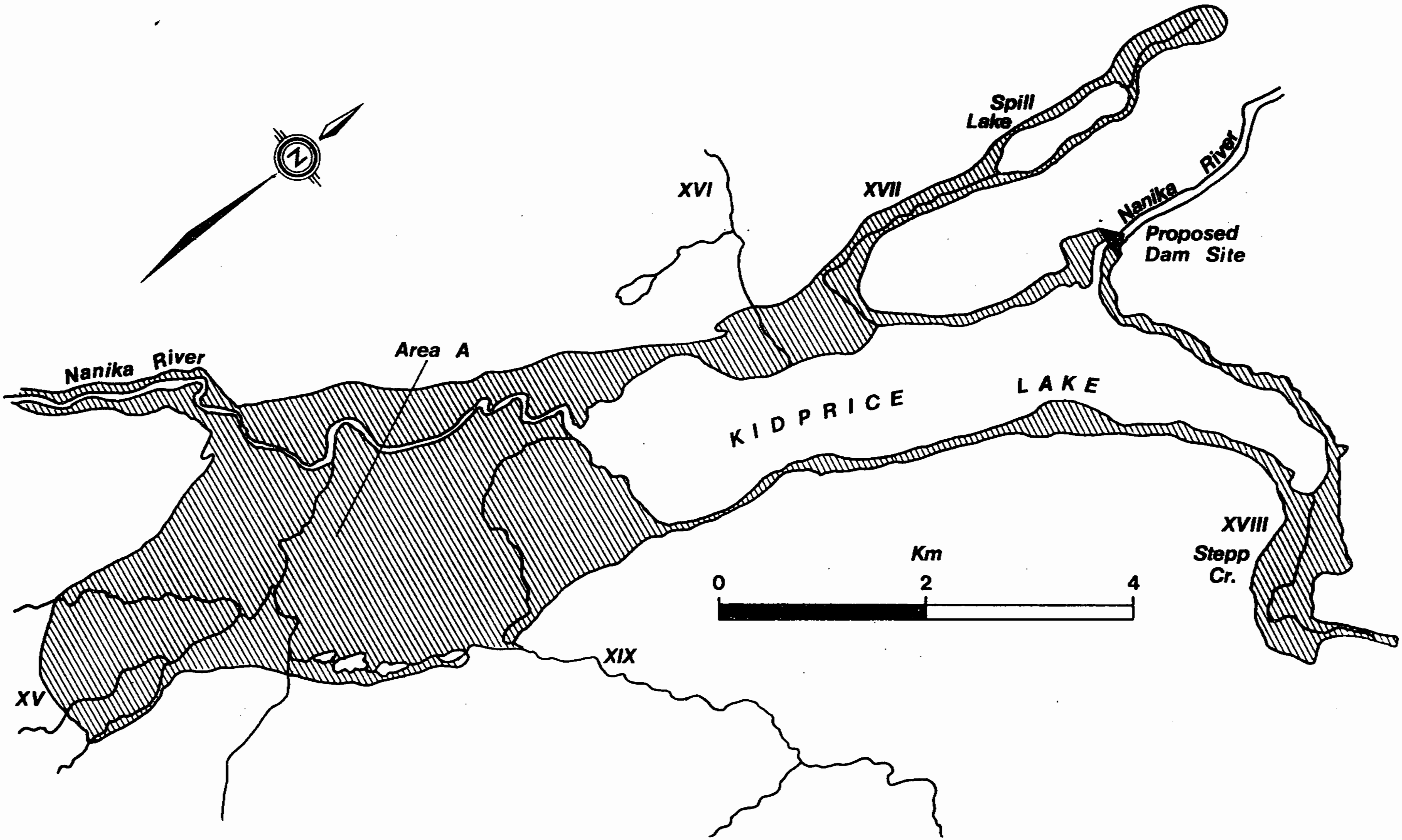


Fig. 6 Map of upper Nanika River, Kidprice Lake, and tributaries, showing proposed flooded areas

passes through it to join the upper Nanika River between the two lakes. An extensive system of small lakes and tributaries drains into Creek XIX, which also meanders through this area and thence into Kidprice Lake (Fig. 3). This riparian area is of key importance to the fish and wildlife of the Nanika-Kidprice system.

Kidprice Lake is about one-third the size of Nanika and about 24 m lower in elevation. While the northern, western, and southern shores slope more gently than the shores of Nanika Lake, the eastern shore of Kidprice is steep and characterized by rocky bluffs (Fig. 7). Shoreline vegetation is predominantly balsam fir, and includes spruce, lodgepole pine (P. contorta), whitebark pine, willow, alder, and northern black cottonwood (Populus trichocarpa). The low-lying areas are dotted with small ponds and sedge meadows. There is an extensive shallow area by the southern shore of Kidprice Lake and a smaller one at the outlet of Stepp Creek. Vegetation in the lake is sparse except for moderate growth in these shallow areas and around creek mouths. Representative aquatic macrophyte species in those areas include Carex, Elodea, and Potamogeton.

Stepp Lake drains into Kidprice Lake via Stepp Creek. The shoreline is bedrock in a few places, and there are few beaches, the most extensive one being at the northern end of the lake. Alders are quite abundant. Areas on both sides of the lake and along Stepp Creek have been burned at various times. Aquatic macrophytes are generally very sparse, although Potamogeton gramineus has been identified (Burns and Tredger, 1974).

Anzac Lake, draining into Stepp Lake via upper Stepp Creek, is the most northeasterly lake in the watershed. The shoreline is largely bedrock, although there is one sand beach. Alder and willow are abundant along the shoreline, with peaty brown soil and grassy meadow in a few places. Aquatic macrophytes, such as Nuphar, Sparganium, Potamogeton, Equisetum, and Najas species, are relatively abundant.

Morice Lake lies in a deep trench of the Tahtsa Range Mountains, approximately 7 km northwest of, and parallel to, Nanika and Kidprice Lakes. The lake has an area of 10360 hectares (Brett and Pritchard, 1946), and it is located at an elevation of 763 m above mean sea level (Fig. 8). About half way along Morice Lake, Atna Bay extends to the west for about 7.5 km. Morice Lake is deep, cold, and without islands in its main body, although there are several islands in the shallower water of Atna Bay. Like Nanika, Morice Lake is almost completely encircled by snow capped mountains, which drop steeply into its waters from elevations of 1200 to 1500 m.

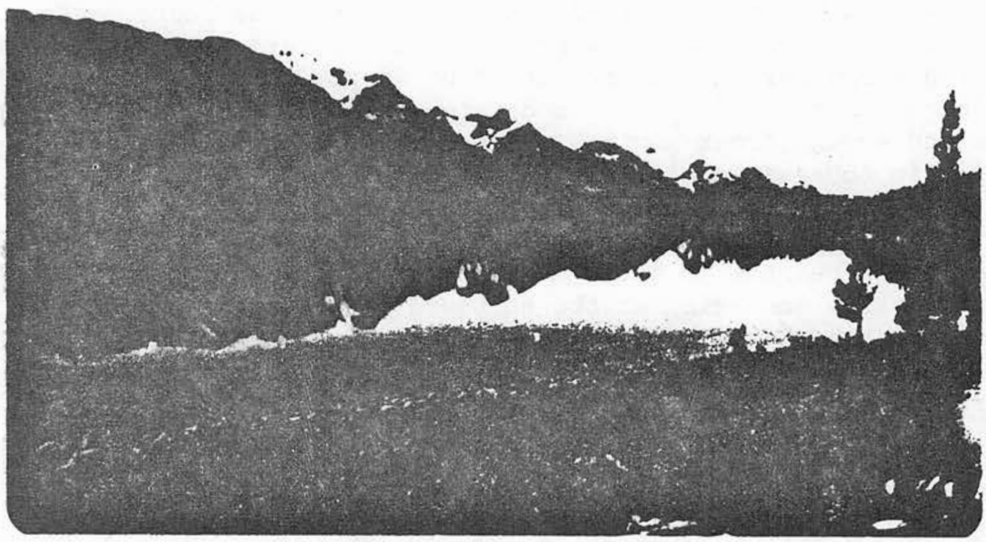


Fig. 7 Kidprice Lake looking southwest towards Nanika Lake. Note steep eastern shoreline, in comparison with more gently sloping shoreline in foreground

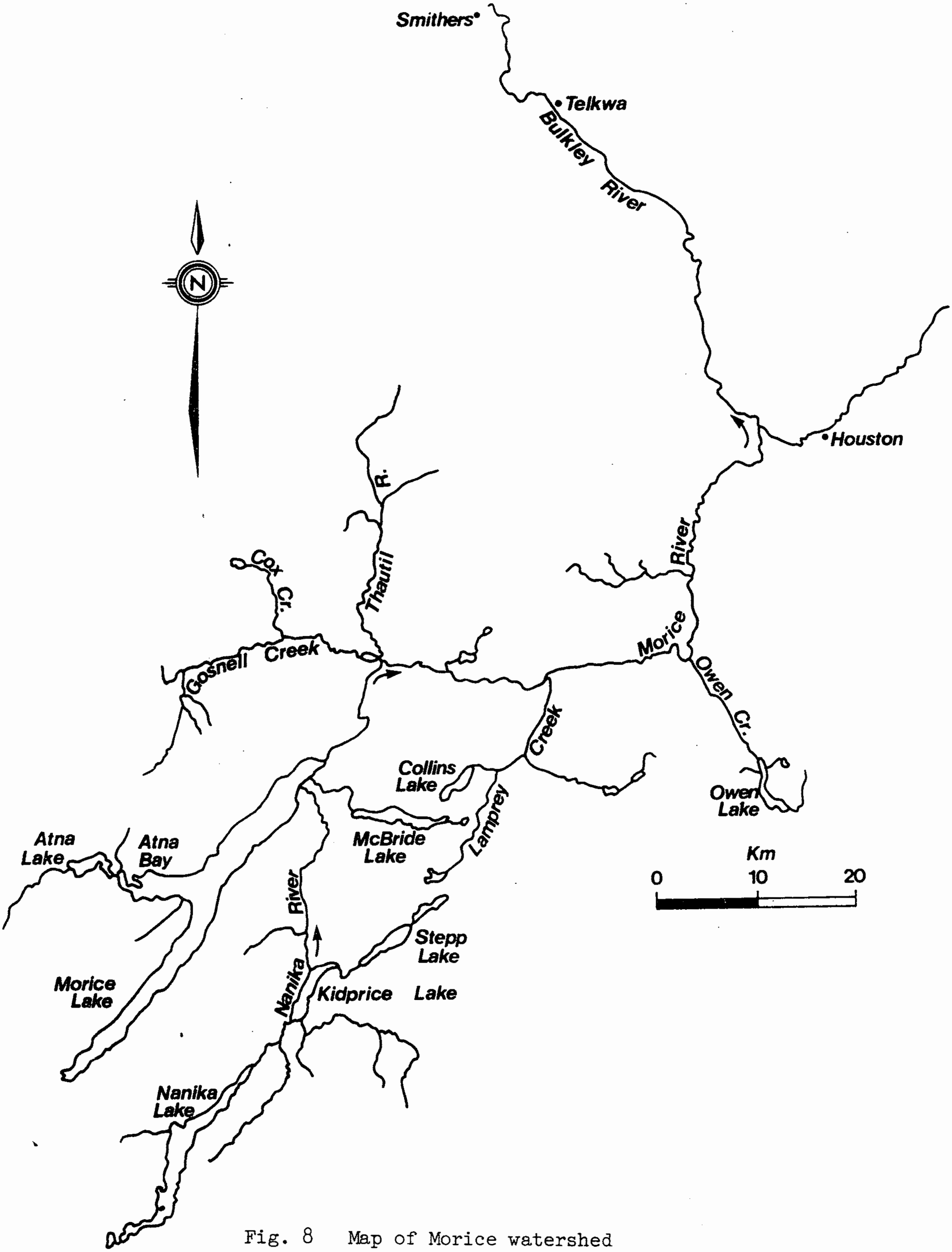


Fig. 8 Map of Morice watershed

There are thirty tributaries to Morice Lake (Fig. 9), many of which are short, steep glacial streams. The two main tributaries are the lower Nanika and Atna Rivers. The lower Nanika River flows from Nanika Falls at the outlet of Kidprice Lake to Morice Lake over a course of about 22.5 km, falling a total vertical distance of 120 m. The Atna River flows through Atna Lake, which discharges over falls into Atna Bay. McBride Lake flows into the north end of Morice Lake via McBride Creek. Morice Lake is drained at its northeastern end by the Morice River, which flows for about 80 km in a northeasterly direction to its confluence with the Bulkley River (Fig. 8). The major lake-headed tributaries are Owen and Lamprey Creeks.

The shoreline of Morice Lake is characteristically steep and rocky. Shoreline vegetation is dominated by spruce, with birch (Betula spp.) and willow found throughout the area. Poorly drained meadows are common along the river bottoms. Shallow areas with sand and gravel bottoms occur at the mouths of the lower Nanika River and McBride Creek, and at the outlet of Morice Lake. Aquatic vegetation is sparse.

Prior to Kemano I, the Nechako headwater lakes drained naturally to the east via the Nechako River to its confluence with the Fraser River near Prince George (Fig. 1). The major portion of the flow from the now-flooded lakes is to the west into Kemano River.

Tahtsa Lake lies at the western end of the Nechako system in the deep-sided trench of the Tahtsa mountains, immediately south of Nanika Lake. In its present flooded condition there is virtually no shoreline or eulittoral* development, and it is characterized by many steep rocky bluffs often descending into deep water.

*eulittoral - landward subdivision of the littoral zone of a body of water, usually the benthic zone that falls between the limits of fluctuation level in a body of water.

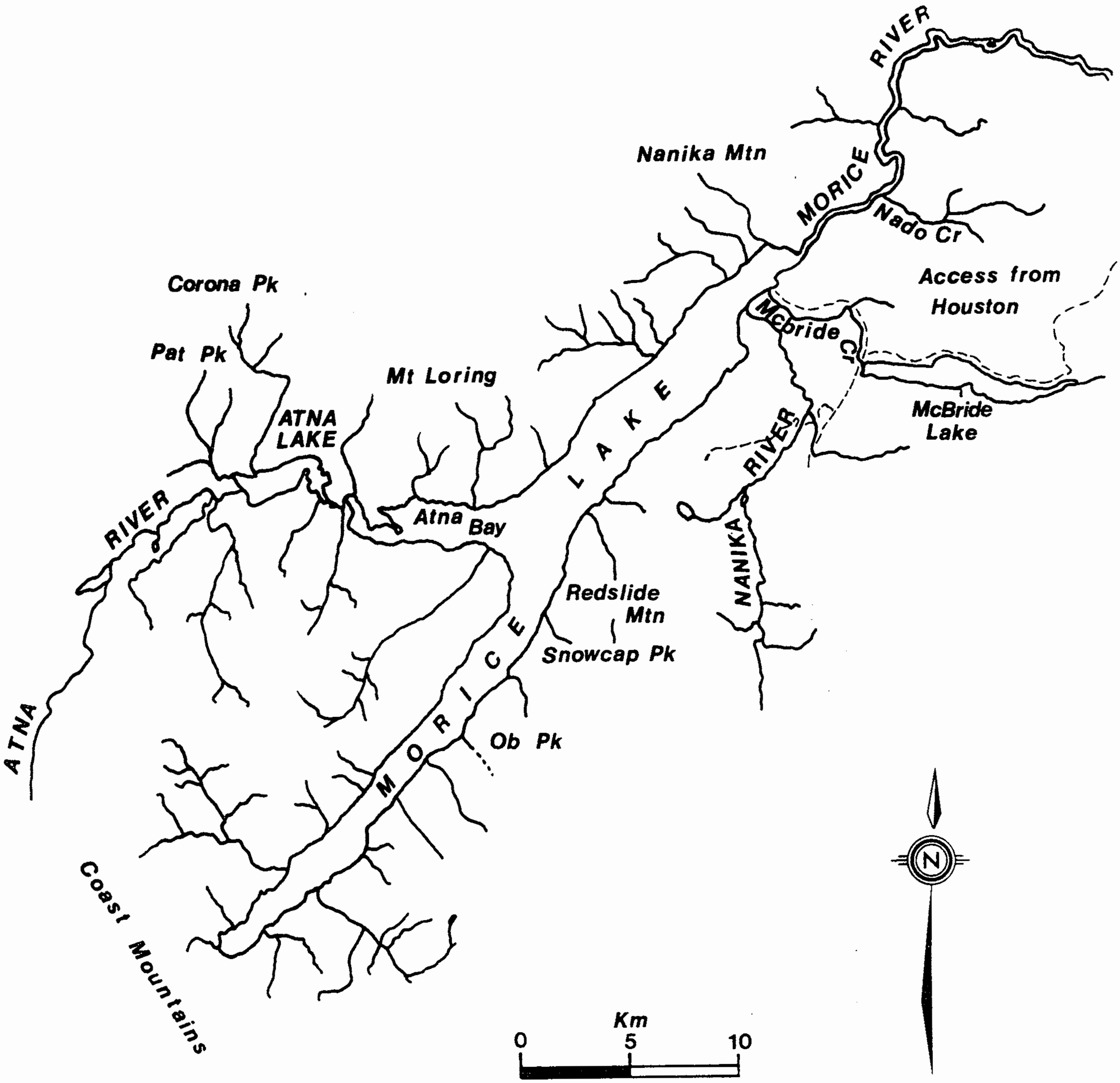


Fig. 9 Map of Morice Lake and tributaries

4 METHODS

4.1 LAKE STUDIES

Bathymetric data on Nanika, Kidprice, and Stepp Lakes were collected using a Furuno echo-sounder. Based on the preliminary echo-sounding data, 17, 4, and 2 stations were selected on these three lakes, respectively.

Flow data were obtained from the Inland Waters Directorate, Canada Department of Environment.

Temperatures in Nanika and Kidprice Lakes were measured with a thermistor. Temperatures were taken to a depth of 60 m at seven stations in Nanika Lake in August, 1975. Stations 5, 10, and 17, established in 1974, were utilized in 1975; however, four others were added. These latter four stations are designated on the bathymetry map (Fig. 10) by letter. Station U is located at the upwelling south of bathymetry Station 6, Station D at the deepest recorded point in the lake (222 m), Station P in the region of the proposed pipeline input, and Station T in the region of the proposed tunnel outlet. In Kidprice Lake, temperatures were measured from surface to bottom at four stations on two days at the end of July, eight days in August, and two days in late September, 1975.

Dissolved oxygen was measured at eight stations in Nanika Lake in late August 1975, and at four stations in Kidprice Lake from late July to late September 1975. Dissolved oxygen concentrations to 13 m were measured using a membrane probe. Since the length of the oxygen probe cable was only 13 m, water from below that depth was brought up with a sample bottle and analyzed either with the probe or with a Hach kit.

Water transparency readings were taken using a standard Secchi disc. Nutrient determinations were attempted in Nanika and Kidprice Lakes in 1974 using Hach kits, but concentrations proved to be below detectable limits. Chemical parameter measurements in Nanika and Kidprice Lakes and Bergeland Creek were later undertaken by the Fisheries and Marine Service. Samples were collected at 0.5 m depth with a Nansen water sampler in October and December, 1974 (Anon., 1979, Vol. 4).

Fisheries and Marine Service collected phytoplankton samples from two stations in Nanika Lake on July 31, 1974. The samples were collected at 0.5 m depth in 250 ml bottles and preserved in Lugol's solution for subsequent identification and enumeration (Anon., 1979, Vol. 4).

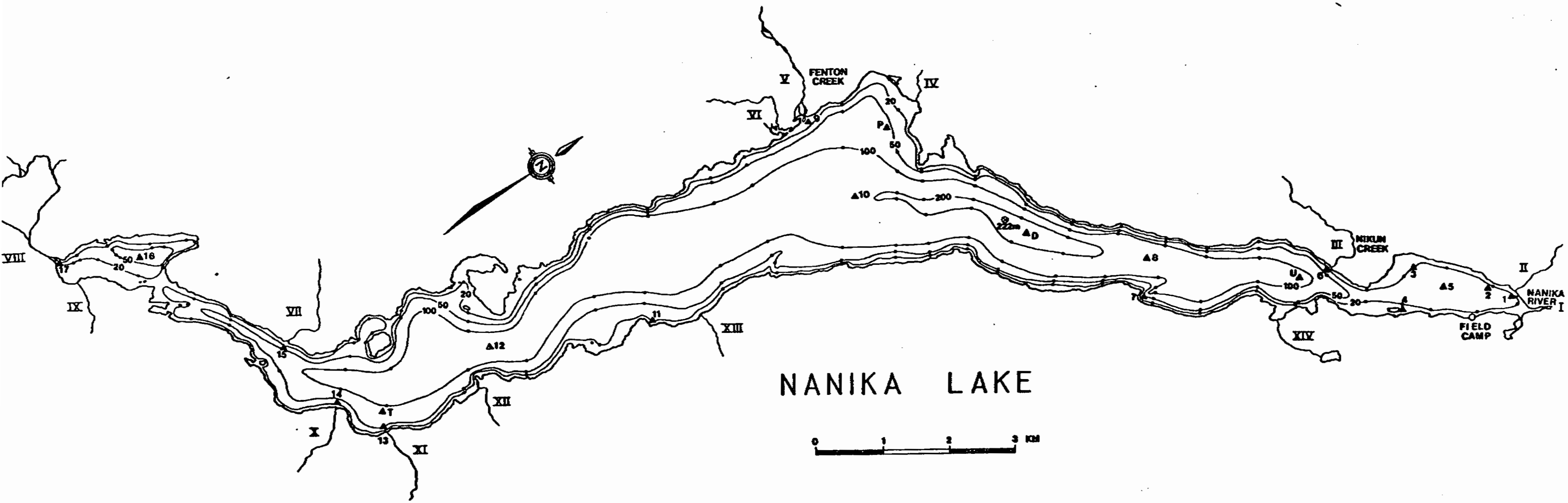


Fig. 10 Map showing bathymetry of Nanika Lake and location of sampling stations

Zooplankton were collected using a Wisconsin net with a mouth diameter of 12 cm, mesh size 80 microns. Hauls were made from 30 m to surface in Nanika Lake, and from 20 m to surface in Kidprice Lake. The samples were preserved in a 10 per cent Formalin solution for subsequent identification and enumeration.

Benthic organisms were sampled at selected littoral stations in Nanika, Kidprice, and Stepp Lakes with a 15 X 15 cm Ekman dredge, at depths of 5 and 25 m. The dredged organisms were screened and preserved in a 10 per cent Formalin solution for laboratory examination.

Fish were sampled in 1974 using gill nets of 1½, 2, 2½, and 3 in. stretched mesh, separately in the initial sets and in gangs thereafter. In the 1975 season, additional mesh sizes of 4 and 5 in. were used for deep netting. A total of 48 gill net sets were made during the two sampling seasons. Fork length, weight, sex, and degree of maturity were determined in the field.

In the 1974 season, scales were taken from a few fish and 10 fish were preserved for identification and enumeration of parasites. In the 1975 season, scales were taken from all fish sampled. The scale samples were sent to the Fisheries and Marine Service laboratory in Vancouver for analysis. Scales were pressed on plastic acetate cards and the resulting scale impressions read. All fish were routinely examined for the presence of *Diphyllobothrium* spp., and the degree of infection was estimated in the field by counting cysts or plerocercoids. Longnose suckers were examined for the presence of *Ligula intestinalis* in preserved specimens.

Tissue samples from the livers and kidneys were taken in the field in 1975 and frozen for later bacteriological and virus assays. However, it was not possible to ensure aseptic conditions in the field, and the tissues were found to be too contaminated to determine the presence of pathogenic bacteria. Stomach samples were preserved to determine diet.

4.2 STREAM STUDIES

Aerial and ground surveys of all tributaries to Nanika and Kidprice Lakes (Figs. 5 and 6) were carried out in the summer of 1974 in an attempt to gather information on the suitability of the streams as fish habitat; specifically, the locations of migration blockages, side channels, log jams, gravel beds, and large pools.

All streams were surveyed on foot for their entire length, unless the stream became torrential or a blockage to fish passage was observed which was clearly above the flood line of the proposed reservoir. For each 30 m stretch of stream, as determined by chain, an assessment was made of the 1) physical and biological aspects of the stream, particularly as they related to juvenile and adult habitat quality and spawning potential, and 2) surrounding vegetation and wildlife habitat.

The suitability of streams with respect to spawning, rearing, and adult salmonid habitat was classified as "good," "fair," or "poor" based on visual observations of physical stream characteristics. The presence and/or relative abundance of fry was also considered in rearing habitat classifications. Physical stream characteristics considered in the classification of spawning habitat included gravel cleanliness and size, as well as water depth and velocity. Rearing habitat classifications were based on the presence of suitable cover, undercut banks, and adequate water velocity. Streams draining ponds or lakes were given a higher rating due to a greater abundance of food organisms. Factors considered in the classification of adult habitat included water depth and the presence of undercut banks. Water velocity was not considered as important here as for spawning and rearing classifications.

It should be noted that the classifications are subjectively derived and do not necessarily indicate the relative use made of the stream by fish, as other factors may be involved. They thus can be said to reflect more the observed "capability" of the streams to support fish, rather than the level of present use by fish. Bergeland Creek, for example, was designated "good" under all three categories, although redd digging in July 1974 did not produce any alevins, and very few fry were observed. Neither were alevins found in redd digging in August 1975, upstream of the 1974 survey, and again few fry were seen.

Stream VIII (Fig. 5) was not completely surveyed because it proved to be a cascade flowing through a canyon and unsuitable for fish. Due to their size, the upper sections of Creek XIX and Bergeland Creek (Fig. 3) were surveyed by helicopter.

At least one station was selected on each stream, and measurements were made along 3 transects spaced 15 m apart. The stream widths and depths at three equally spaced points across the stream were measured for each transect. Surface velocities were measured by timing a float over a distance of 30.5 m, and stream flows were estimated from those measurements.

Other observations recorded included character of stream (torrential, meandering, etc.), type of substrate, amount and type of cover, nature of banks, a description of the surrounding vegetation and terrain, weather, and air and water temperatures.

During the stream surveys, juvenile fish were sampled at creek mouths and in adjacent lake shallows, using a 30 m beach seine, a hand seine, or by electrofishing. Subsamples were preserved in a 10 per cent Formalin solution for subsequent identification and length-weight measurements. Wherever spawning potential appeared high, the gravel was examined by digging for eggs or alevins.

4.3 WILDLIFE STUDIES

Data on wildlife were obtained in 1974 and 1975 from:

1. Aerial and ground wildlife habitat surveys conducted by D. Hatler (B. C. Fish and Wildlife Branch) et al. During these surveys, six days were spent on the ground and 20.5 hours in the air (7.75 hours in fixed-wing aircraft and 12.75 hours in helicopters). The fixed-wing flights were conducted at 150 m elevation and an air speed of 160 - 195 kph, and the helicopter flights at 60 - 90 m elevation and an air speed of 95 - 130 kph. The surveys were primarily random, with the exception of the Nanika-Kidprice Flats area, where a total count was attempted using a systematic "S" pattern. Emphasis was placed on the Nanika-Kidprice area, although portions of the entire study area (Nanika-Kidprice and Morice systems) were covered at least once.

2. Incidental sightings during fisheries and lake studies (mostly at ground level) in the Nanika-Kidprice Lakes area by B. C. Fish and Wildlife employees K. Simpson, C. Morley, and J. Sutherland. These observations took place primarily above the outlet of Kidprice Lake.

3. Incidental sightings during stream survey flights and ground observations by Department of Fisheries (Environment Canada) personnel, especially J. Mitchell, R. Coupe, and J. Jaques. Most of these observations took place in the Morice area.

5 RESULTS

5.1 NANIKA-KIDPRICE SYSTEM

The Nanika-Kidprice system, for the purpose of this report, is defined as all waters upstream of the proposed dam site at the outlet of Kidprice Lake, including Kidprice, Stepp, Anzac, and Spill Lakes, the upper Nanika River, Nanika Lake, and all associated tributaries.

5.1.1 LIMNOLOGY

a) Bathymetry

The maximum recorded depth of Nanika Lake is 222 m, and the mean depth is about 81 m (Fig. 10). The surface area of the lake is about 31 km^2 and its approximate volume is 25 X 10^8 m^3. Stage measurements in July and August, 1974 indicated a surface level fluctuation of approximately 0.5 m, but the normal yearly range of fluctuation is almost certainly greater than this. The lake is almost entirely steep sided, and shallow water areas of less than 3 m are few and not extensive.

The maximum recorded depth of Kidprice Lake is 47 m, and the mean depth is about 29 m (Fig. 11). The surface area of the lake is about 7 km^2 and its approximate volume is 3 X 10^8 m^3. There are more shallow water areas in Kidprice Lake than in Nanika, particularly at the northern and southwestern ends. Surface level fluctuations average about 1.2 m, and maximum mean levels occur in June.

Stepp Lake is quite shallow, with a maximum depth of 34 m and a mean depth of 17.1 m (Fig. 12). Stepp Lake has a more gently sloping shoreline than either Nanika or Kidprice Lakes. Its surface area is 4.7 km^2 and its volume is approximately 8 X 10^7 m^3.

Bathymetric data for Anzac and Spill Lakes were not collected. The greatest depth noted during a survey of Anzac Lake was 11.6 m (Burns and Tredger, 1974), and the depth of Spill Lake is reported to be less than 10 m (K. Simpson, pers. comm.).

b) Hydrology

A recording gauge was operated seasonally by the Aluminum Company of Canada at the outlet of Kidprice Lake between 1950 and 1962. Annual patterns of mean discharge for the years 1950 to 1962 are shown

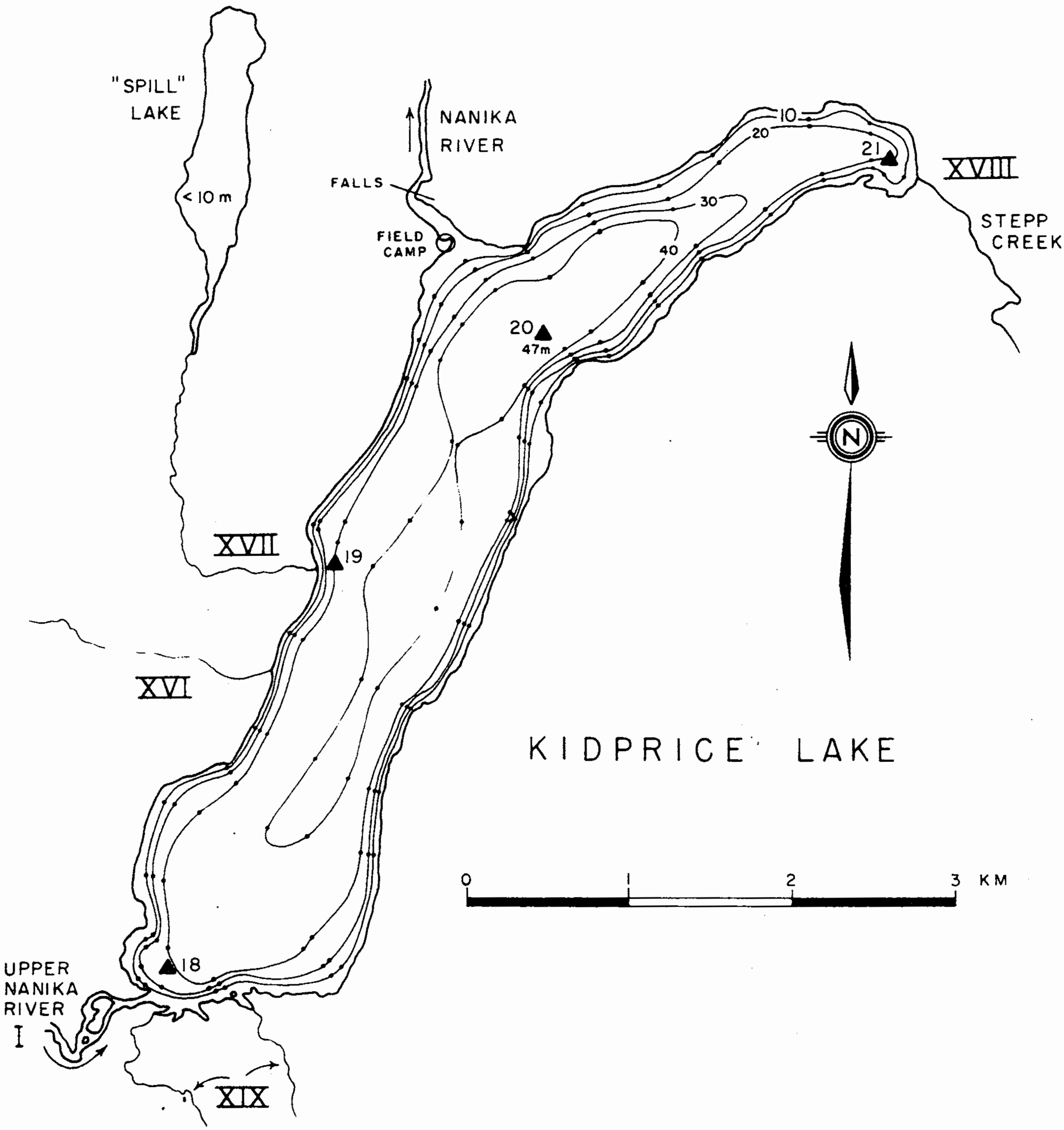


Fig. 11 Map showing bathymetry of Kidprice Lake and location of sampling stations

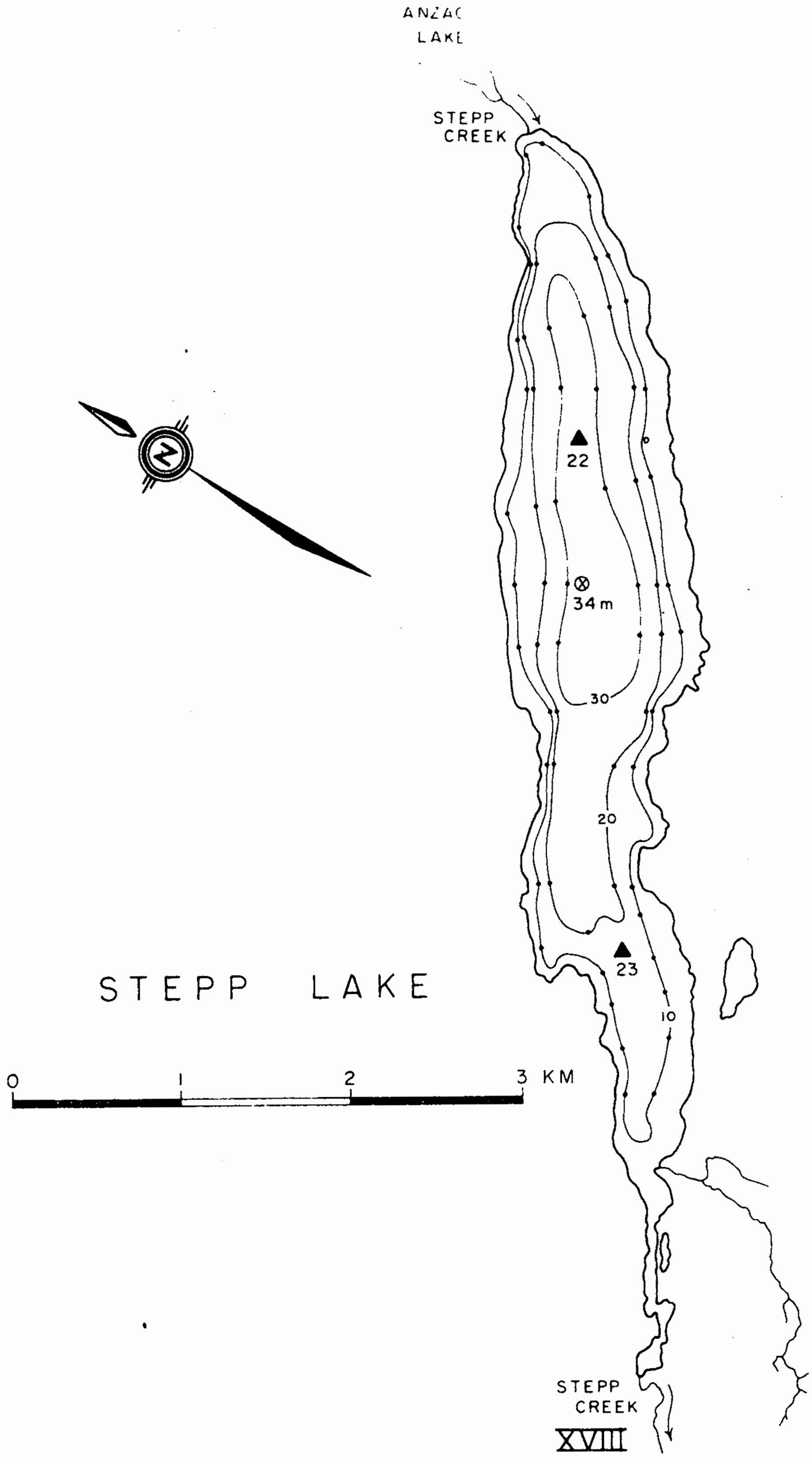


Fig. 12 Map showing bathymetry of Stepp Lake and location of sampling stations

in Fig. 13, and the averages of these means together with indicators of maximum and minimum recorded flows are shown in Fig. 14. The Inland Waters Directorate of the Department of the Environment has operated a discharge recording station at the outlet of Kidprice Lake since June 1972. Inland Waters data of mean monthly discharges for the period from July 1972 to December 1975, together with indicators of maximum and minimum flows, indicate that low flows from January to April range from 100 - 400 cfs and average about 250 cfs (Fig. 15). Spring freshets generally begin in April and reach peak flows by June, with mean summer flows (May, June, July) averaging about 2800 cfs. There is a slight decrease in flow in August and September and a subsequent increase during the late fall months, particularly in October when flows average about 1000 cfs. The average mean annual discharge at the outlet of Kidprice Lake was 1255 cfs from 1950 to 1962 and 1063 cfs from 1973 to 1976.

c) Temperature

The total temperature change in Nanika Lake measured from 0 to 60 m was in the range of 6° to 9°C, and varied from about 12°C at the surface to 4°C at 60 m (Figs. 16 and 17). The thermocline appears to occur in the 11 - 25 m zone, with a gradient of about 4°C in 5m. In the regions of the proposed pipeline input (Station P) and tunnel outlet (Station T), the epilimnion extended to a depth of 16 - 20 m during late August, 1975. The lowest recorded temperature at 60 m depth was 3.9°C at Station 10, August 23. Surface temperature did not exceed 12.8°C.

The lowest recorded temperature in Kidprice Lake in 1975 was 6.4°C at 42 m depth at Station 20, August 19. Temperatures from all four stations ranged from 9.5°C to 11.3°C at 10 m depth and from 8.8°C to 10.3°C at 20 m depth (Fig. 18).

Temperature data collected from Nanika and Kidprice Lakes in 1975 are provided in Appendix I.

d) Dissolved Oxygen and Water Transparency

As shown in the profiles of dissolved oxygen from Nanika Lake (Figs. 19 and 20) and Kidprice Lake (Fig. 21) in 1975, dissolved oxygen levels were generally high (10 - 11 ppm) in both lakes. Dissolved oxygen data collected from Nanika and Kidprice Lakes in 1975 are provided in Appendix II.

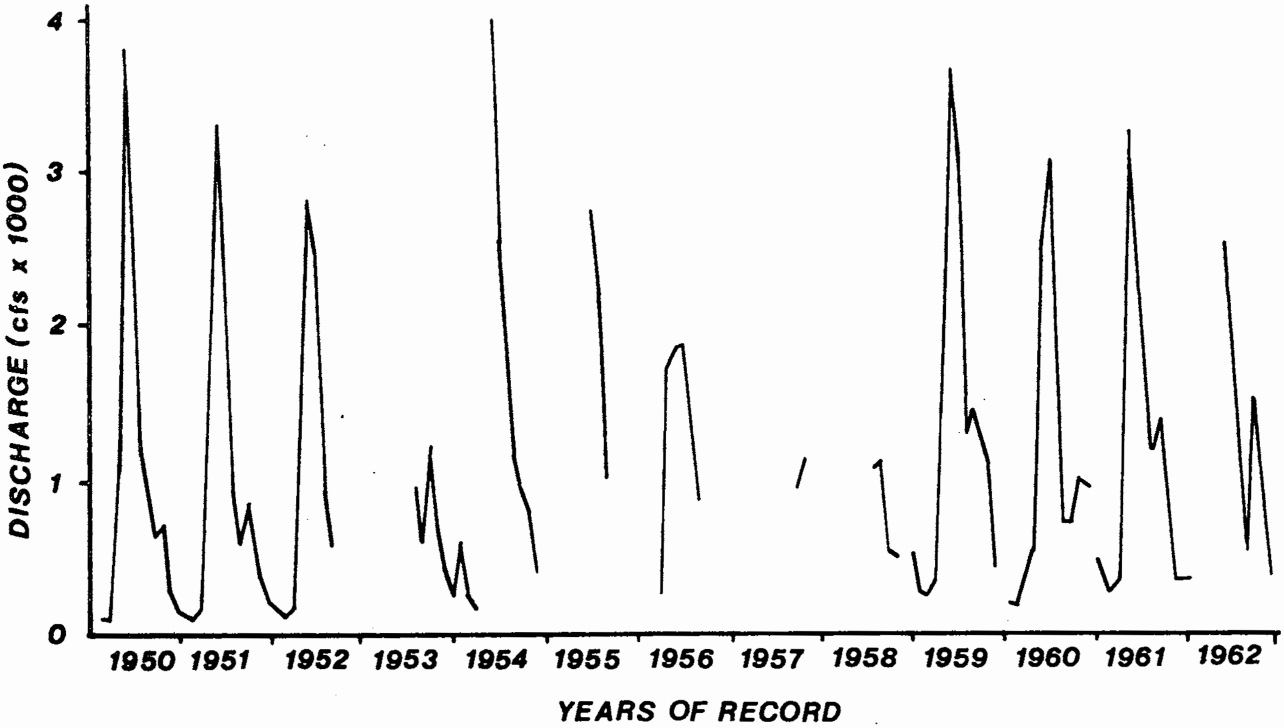


Fig. 13 Historical mean monthly discharges of the Nanika River at the outlet of Kidprice Lake, 1950 to 1962

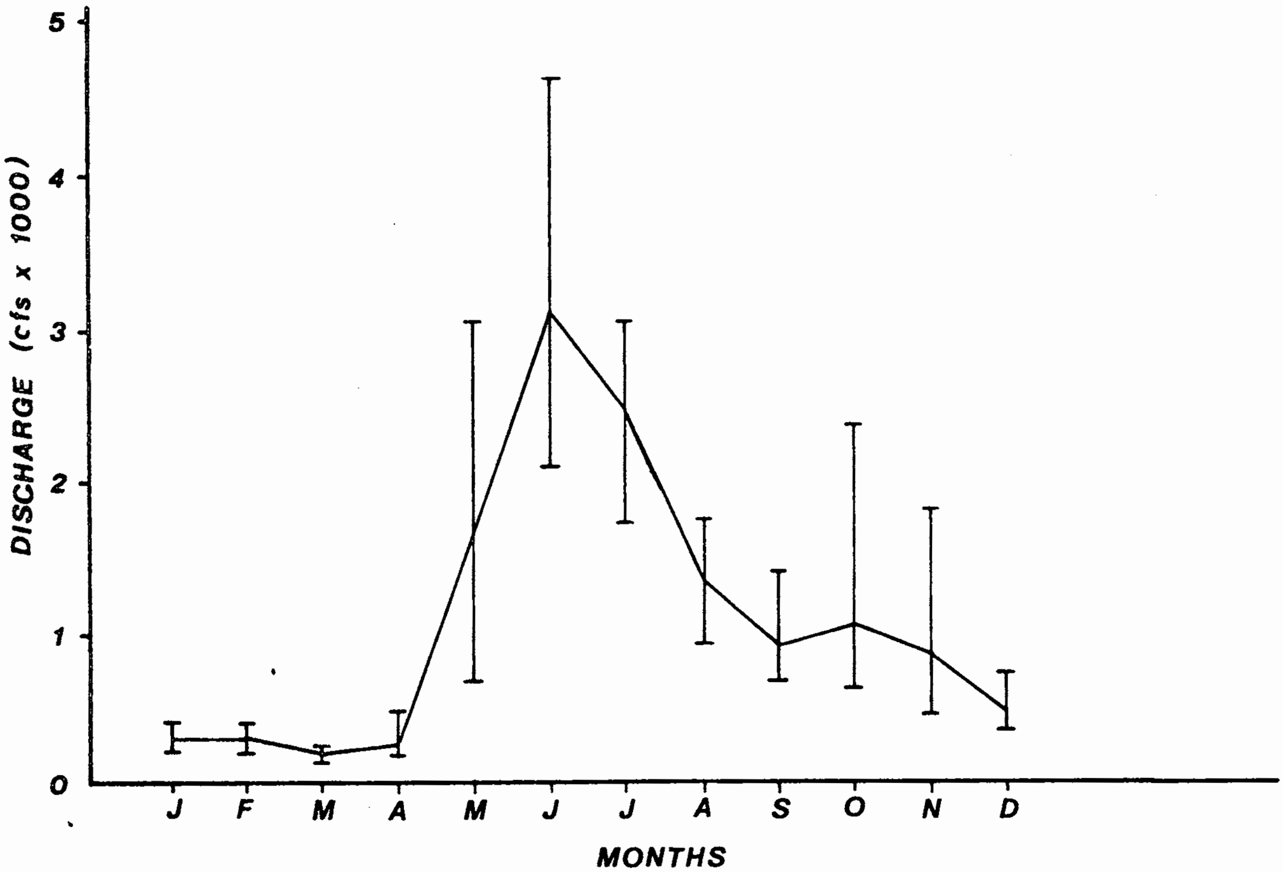


Fig. 14 Averages of mean monthly discharges and ranges of discharge in the Nanika River at the outlet of Kidprice Lake for the period 1950 to 1962

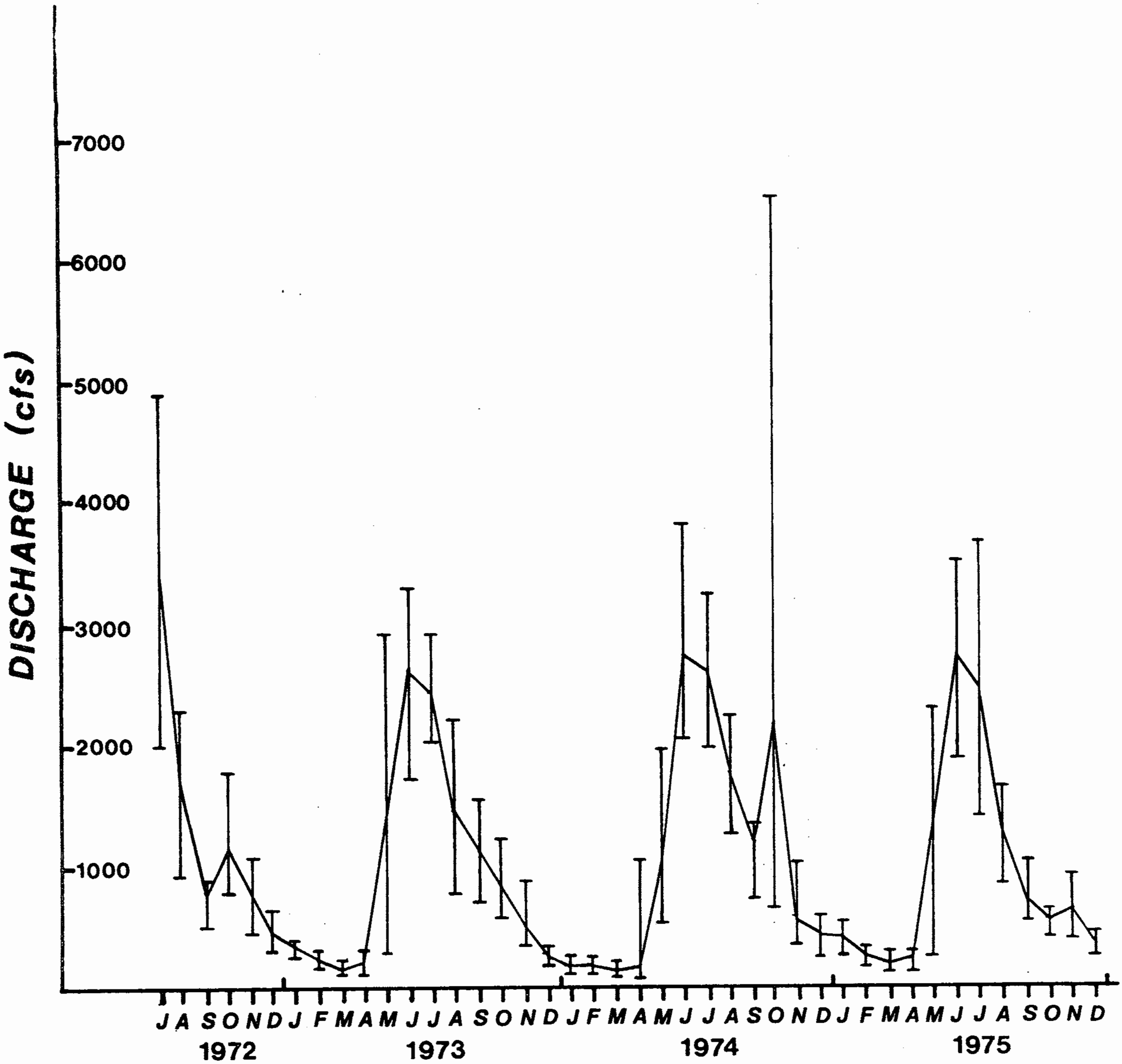


Fig. 15 Monthly mean discharges and ranges of discharge in the Nanika River at the outlet of Kidprice Lake for the period July 1972 to December 1975

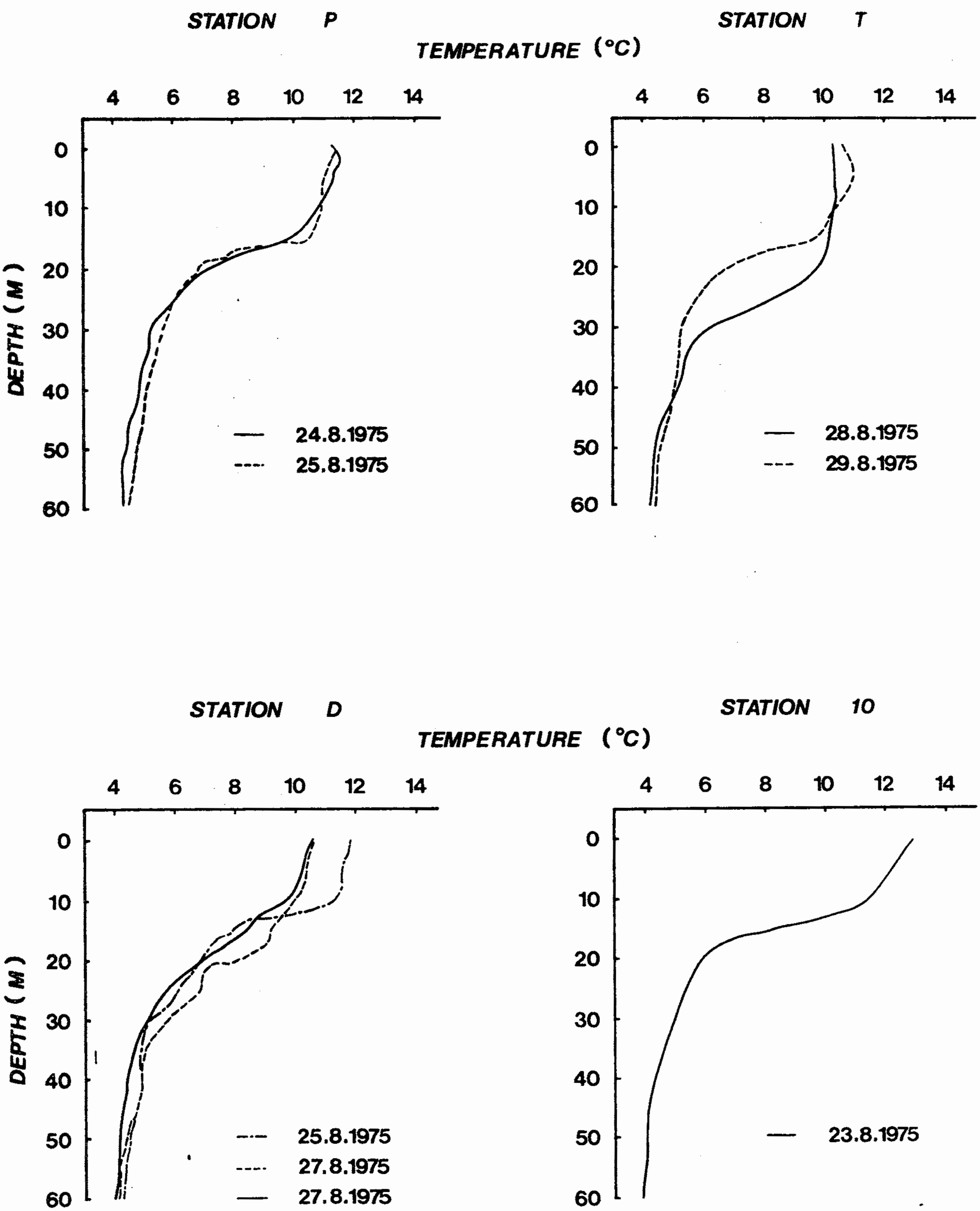


Fig. 16 Temperature profiles from Stations P, T, D, and 10 in Nanika Lake, 1975

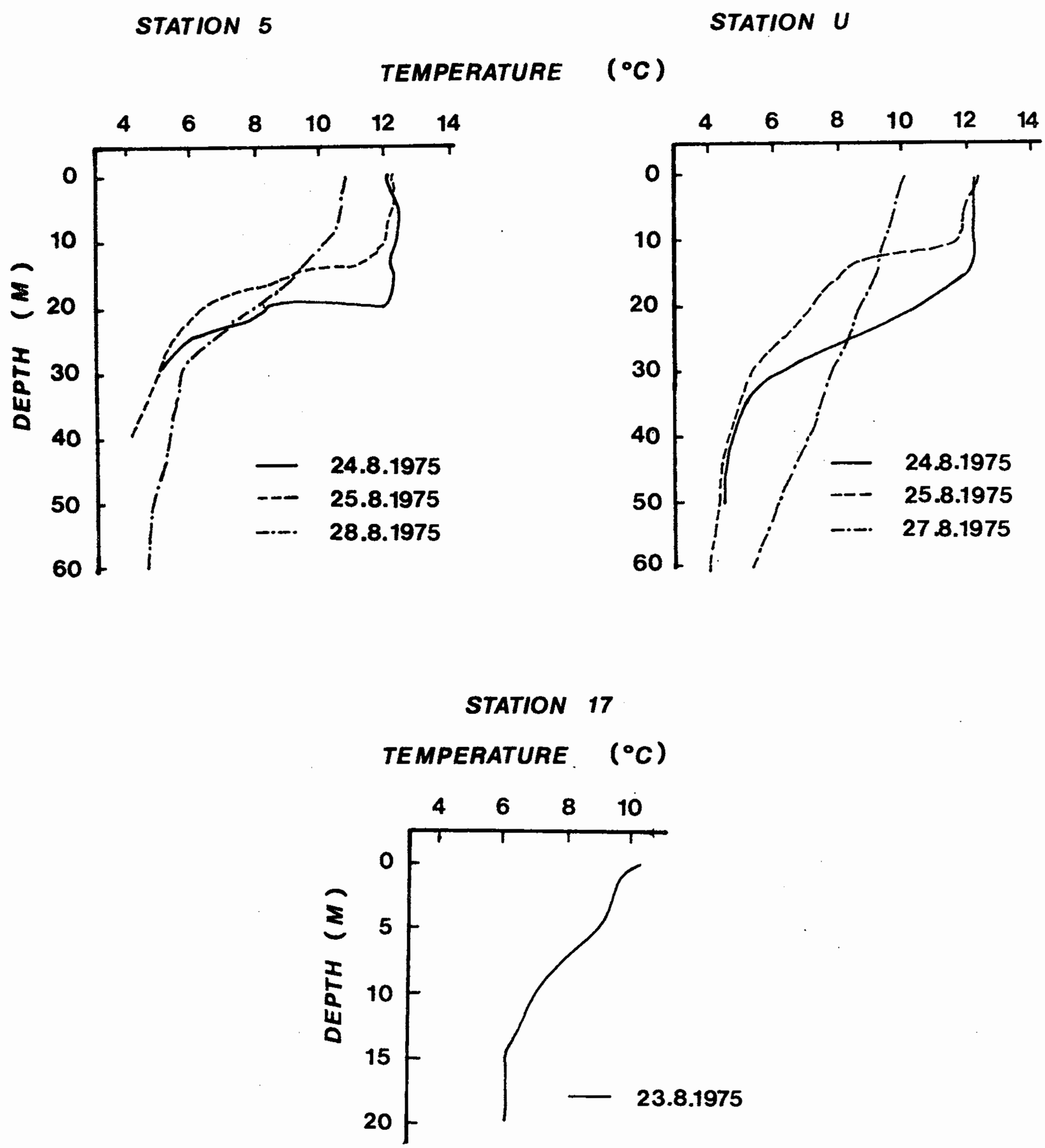


Fig. 17 Temperature profiles from Stations 5, U, and 17 in Nanika Lake, 1975

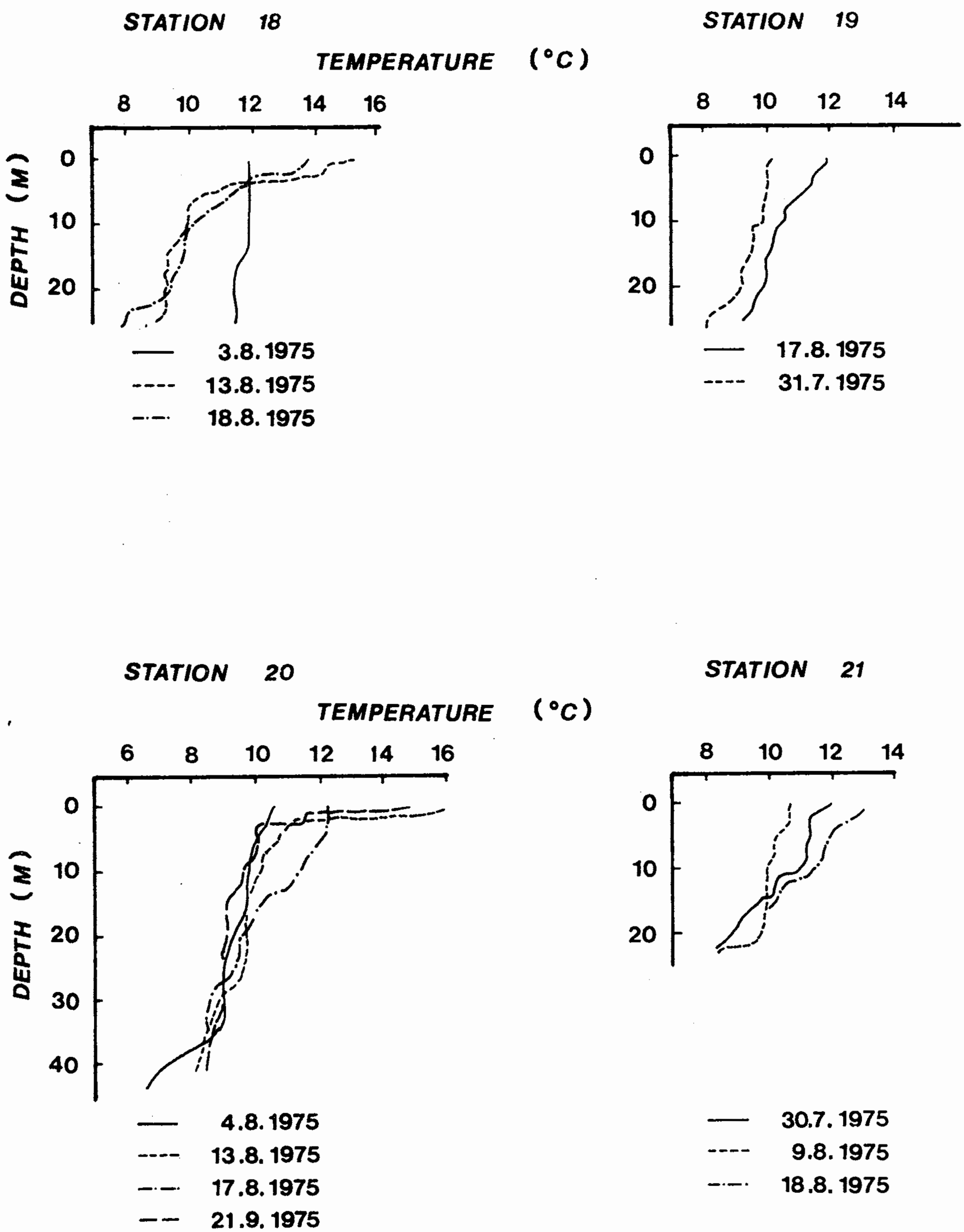


Fig. 18 Temperature profiles from Kidprice Lake, 1975

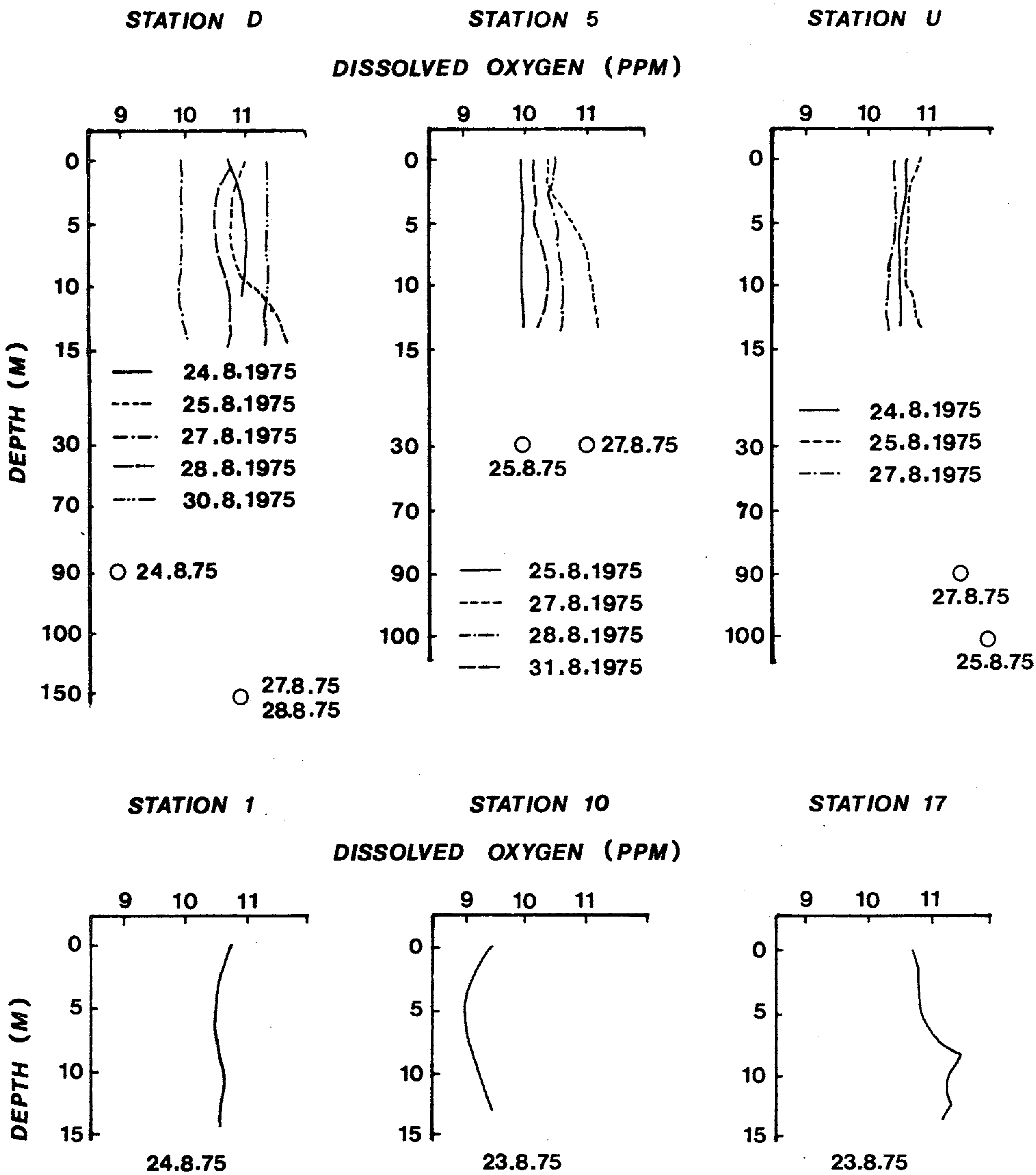


Fig. 19 Dissolved oxygen profiles from Stations D, 5, U, 1, 10, and 17 in Nanika Lake, 1975

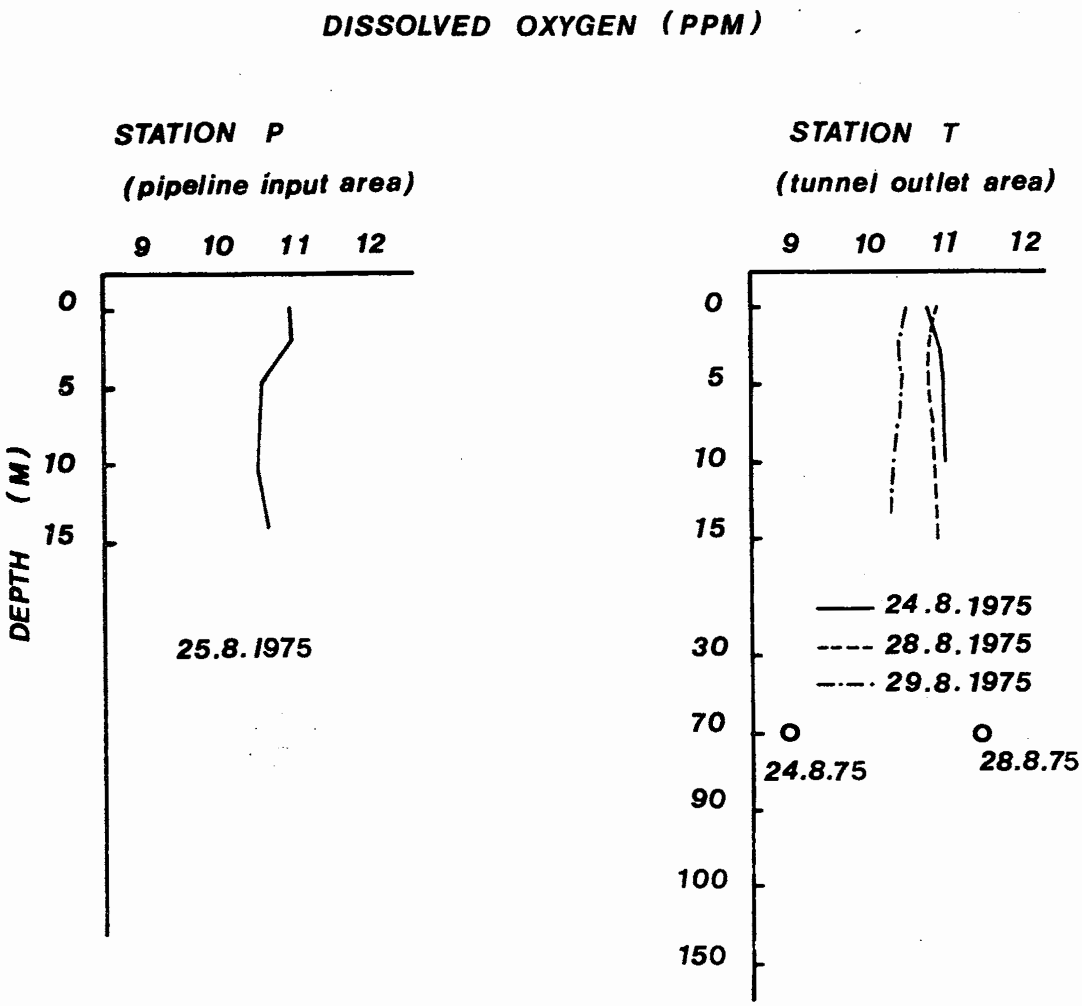


Fig. 20 Dissolved oxygen profiles from proposed pipeline input and tunnel outlet stations in Nanika Lake, 1975

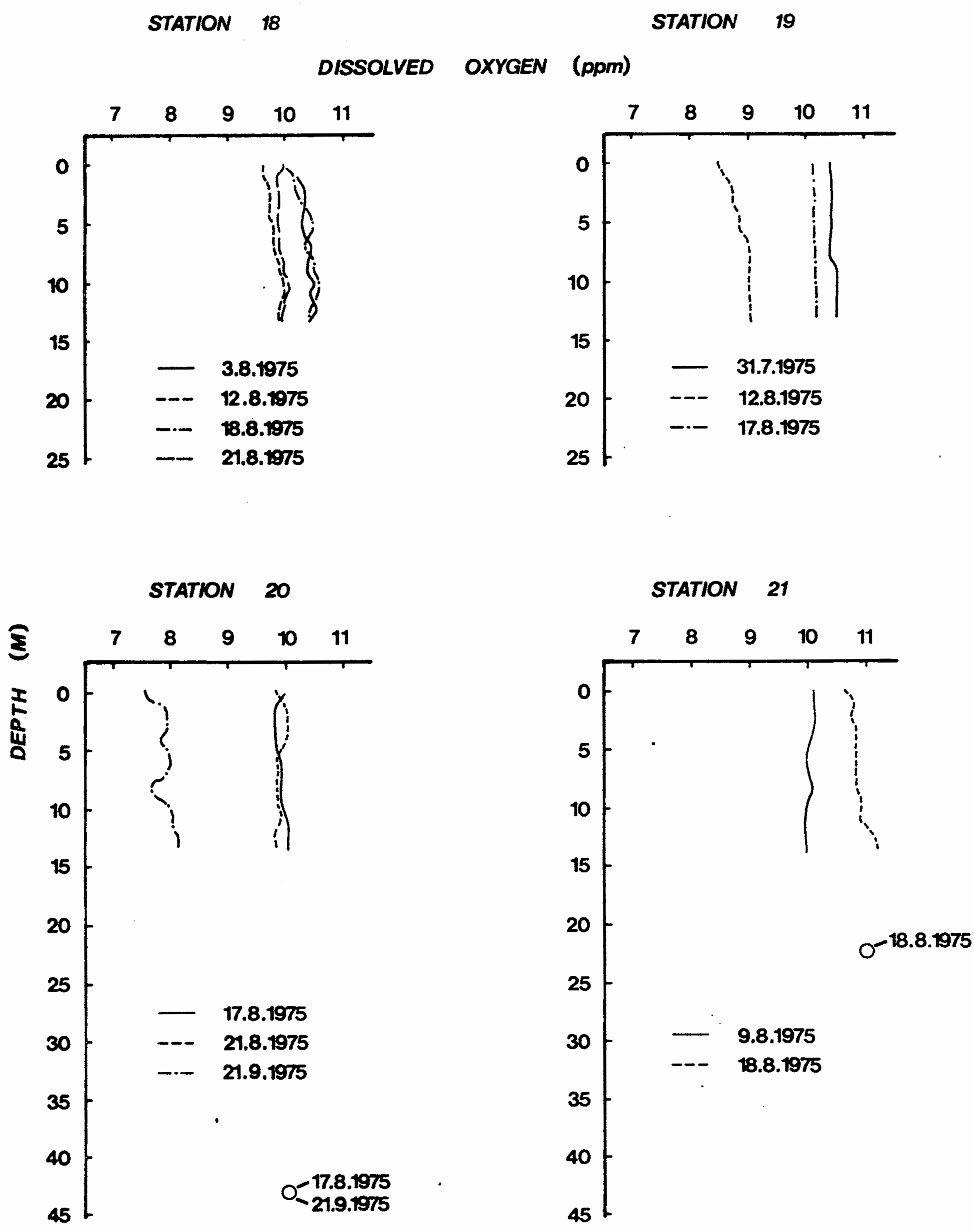


Fig. 21 Dissolved oxygen profiles from Kidprice Lake, 1975

Secchi depths in Nanika Lake (Table 2) were generally substantially greater than those in Kidprice Lake (Table 3), with the single exception of Station 17, due to the very heavy silt load entering from Creek VIII (Fig. 10). Secchi depths in Nanika Lake ranged from 4.0 m to 11.1 m in late August 1975, with the exception of Station 17. At all stations in Kidprice Lake, the trend was clearly increased water transparency with time from July to September, 1975. Secchi depths in Kidprice Lake ranged from 1.4 m in late July to 5.4 m in late September. Evidently the morphology and flow regime of Nanika Lake allows more effective settling of silt or its tributaries are less turbid, with its photosynthetic zone being consequently less restricted.

e) Water Chemistry

Measurements of TR (total residue or total dissolved solids) from 0.5 m depth in Nanika and Kidprice Lakes and Bergeland Creek (Table 4) ranged from 37 to 55 mg/l in October and from 15 to 19 mg/l in December (Anon., 1979, Vol. 4). Total residue averaged 41 mg/l from two stations in Nanika Lake and measured 41 mg/l in Kidprice Lake in October, and was 15 mg/l in Nanika and 19 mg/l in Kidprice in December. These very low concentrations indicate the extreme oligotrophic nature of the two lakes.

f) Phytoplankton and Zooplankton

The phytoplankton sampled from Nanika Lake on July 31, 1974 included Chysophyceae as the dominant plankters, with lesser percentages of Diatomeae, Cyanophyta, and Chlorophyta (Anon., 1979, Vol. 4).

Sampling of zooplankton in August and September 1975 showed that the dominant zooplankters in Nanika and Kidprice Lakes in early fall are cladocerans and copepods. The most abundant organisms are Diaptomus, Cyclops, Epischura, Daphnia, and Bosmina spp. Results of sampling the water column to 30 m depth in Nanika Lake and to 20 m depth in Kidprice Lake are summarized in Tables 5 and 6, respectively. The Nanika Lake data indicate that the number of organisms per liter is relatively high in the area of the proposed tunnel outlet (Station T, Fig. 10), the number decreasing towards the northeastern end of the lake along the direction of flow. It is not clear why this is so.

Table 2 Secchi depths, in meters, from Nanika Lake, 1975

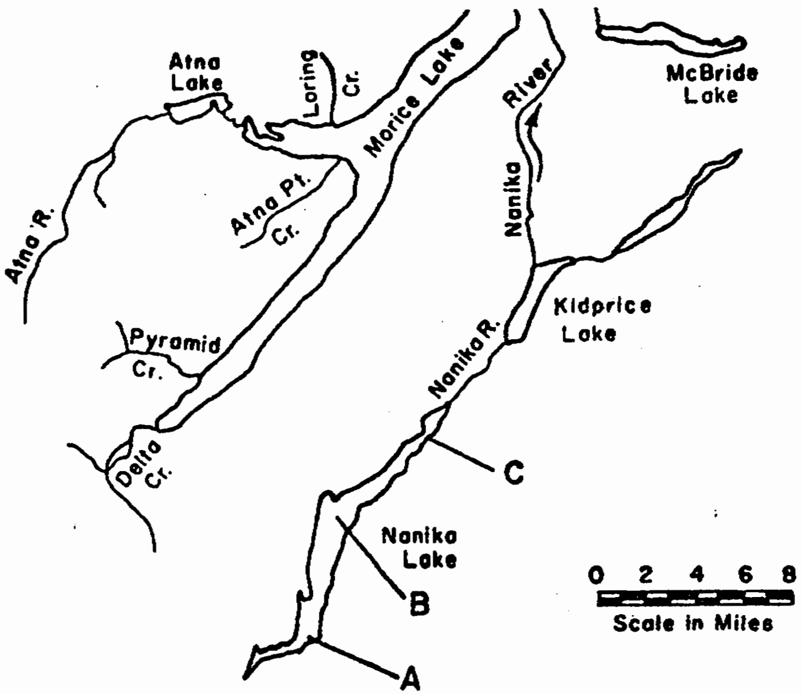
Station	1	5	U	10	D	P	T	9	17
23 Aug				8.5					1.4
24 Aug	5.5		7.5		5.0		5.1	4.0	
25 Aug		9.7	10.1		11.1	9.8			
27 Aug		10.4	10.6		8.5				
28 Aug		8.8			9.2		7.1		
29 Aug							8.2		
31 Aug		8.5							

Table 3 Secchi depths, in meters, from Kidprice Lake, 1975

Station	21	20	19	18
30 July	1.6			
31 July			1.4	
3 Aug				1.9
4 Aug		2.1		
9 Aug	2.2			
12 Aug	3.0		1.8	2.3
14 Aug		2.4		
17 Aug		2.9	2.5	
18 Aug	3.6			3.3
21 Sept		5.4		
23 Sept		5.3		

Table 4 Chemical analysis, Nanika and Kidprice Lakes and Bergeland Creek, 1974 (Anon., 1979, Vol. 4)

STATION	DEPTH m	TEMP °C	pH	Cu mg/l	Zn mg/l	Pb mg/l	TR mg/l	HARD. $CaCO_3$ mg/l	Na mg/l	K mg/l	Mg mg/l	Ca mg/l	Mn mg/l	Fe mg/l	Cl mg/l	SO_4 mg/l	Si mg/l	NH_3 mg/l	NO_2 mg/l	NO_3 mg/l	OP mg/l	TP mg/l
<u>OCTOBER 22</u>																						
KIDPRICE LK.	0.5	7	7.2	0.01	<.01	<.02	41	19	0.68	0.33	0.91	5.6	0.04	1.3	<1	6	1.48	-	<.005	<.01	-	0.065
BERGELAND CR.	0.5	2.3	7.3	0.01	<.01	<.02	55	-	0.70	-	0.96	11	<.03	0.25	<1	13	2.25	<.01	<.005	.014	-	0.016
NANIKA A	0.5	3.2	7.3	<.01	<.01	<.02	46	-	0.29	-	0.25	4.4	<.03	0.5	<1	<5	0.9	<.01	<.005	.018	-	0.02
NANIKA C	0.5	7	7.3	<.01	<.01	<.02	37	17	0.54	0.20	0.40	7.7	<.03	0.5	<1	<5	1.4	<.01	<.005	0.029	-	0.049
<u>DECEMBER 11</u>																						
KIDPRICE LK.	0.5	3.0	-	-	-	-	19	13	0.46	0.46	0.93	5.8	<.03	-	<1	<5	1.38	<.01	<.005	<.01	<.005	<.01
NANIKA C	0.5	3.0	-	-	-	-	15	15	0.33	0.12	0.33	5.5	<.03	-	<1	<5	1.21	<.01	<.005	<.01	<.005	<.01



* Map showing Nanika Lake sampling station locations

Table 5 Zooplankton abundance in Nanika Lake, 1975 (no. of organisms per liter)

Depth (m)	Abundant Organisms	Station 5			Station D (222 m Stn)		Station P Proposed input from Morice Lk 1.5 km NE of Stn 9		Station T Area of proposed tunnel outlet to Tahtsa Lk 0.8 km N of Stn 14	
		Aug 25	Aug 27	Aug 28	Aug 24	Aug 27	Aug 25	Aug 28	Aug 28	Aug 29
	Diaptomus spp.	0.09	0.14	0.08	0.19	0.21	0.16	0.18	0.40	0.39
	Cyclops spp.	0.08	0.10	0.09	0.52	0.96	0.98	0.64	1.75	1.05
	Epischura spp.	0.06	0.08	0.05	0.06	0.03	0.01	0.02	0.10	0.04
	Daphnia spp.	0.04	0.05	0.04	0.18	0.13	0.11	0.14	0.15	0.19
	Bosmina spp.	0.01	0.01	<0.01	0.04	0.05	0.04	0.02	0.03	0.07
0–30	TOTAL	0.28	0.38	0.26	0.99	1.38	1.30	1.00	2.43	1.74

Table 6 Zooplankton abundance in Kidprice Lake, 1975 (no. of organisms per liter)

Depth (m)	Abundant Organisms	Station 18 N of plume calm 30 m	Station 18 In plume turbulent 30 m	Station 18	Station 19	Station 20	Station 20	Station 20	Station 21	Station 21
		Aug 3	Aug 3	Aug 14	Aug 14	Aug 14	Sept 21	Sept 29	Aug 14	Aug 18
	Diaptomus spp.	0.13	0.05	0.06	0.09	0.05	0.06	0.04	0.44	0.07
	Cyclops spp.	0.05	0.02	0.03	0.04	0.05	0.04	0.05	0.13	0.09
	Epischura spp.	0.01	< 0.01	< 0.01	0.01	0.01	–	< 0.01	0.01	0.02
	Daphnia spp.	0.07	0.04	0.06	0.08	0.12	0.09	0.09	0.23	0.30
	Bosmina spp.	–	< 0.01	< 0.01	0.01	0.01	< 0.01	0.01	0.03	0.05
0-20	TOTAL	0.26	0.12	0.16	0.23	0.24	0.19	0.19	0.84	0.53

The average number of organisms per liter found in these samples is low (0.16 to 2.43/l). Similar results were obtained in samples taken by the Fisheries and Marine Service in 1974 (Anon., 1979, Vol. 4). The low standing crops of zooplankton are probably a reflection of the low nutrient levels and low primary productivity in the lakes.

The standing crop of zooplankton is lower in Kidprice Lake than in Nanika Lake, which is likely a reflection of the lower water transparency in Kidprice Lake (Tables 2 and 3). Factors such as shallow depth, flow, and silt input in Kidprice Lake do not allow the degree of settling observed in Nanika Lake. The higher zooplankton crop at Station 21 in Kidprice Lake (Fig. 11) may be a result of nutrient input from Stepp and Anzac Lakes and the presence of a shallow marginal area.

g) Benthos

Bottom fauna were sampled from Nanika, Kidprice, and Stepp Lakes in September, 1974. As would be expected at that time of year, bottom fauna were found to be quite sparse. Throughout the lakes, the benthos consists mainly of chironomids, sphaeriids, and oligochaetes, with the presence of some caddisflies, non-chironomid dipterans, and gastropods (Table 7). The data are provided in Appendix III. Per cent compositions of benthic organisms in Ekman samples from Nanika and Kidprice Lakes are shown in Figs. 22 and 23, respectively.

An examination of the gravel at 3 m depth in shallow areas of Kidprice Lake in August and September, 1975, showed a relative abundance of amphipods and gastropods existing among 2 - 8 cm cobbles. Rainbow trout (*Salmo gairdneri*) fry and fingerlings were observed feeding in the area. The abundance of these organisms in this zone and their scarcity in other sampled areas points to its importance as rearing habitat.

h) Aquatic Macrophytes

Rooted aquatic macrophytes are scarce in Nanika and Kidprice Lakes, both in species diversity and abundance. Extensive growths of *Carex* spp. and other marsh grasses in the several marshy areas near stream mouths, and a few areas supporting growths of *Elodea* spp., were observed in Kidprice Lake in a previous study (Morley and Whately, 1974).

Table 7 Benthic samples taken by Ekman dredge (no./m^2) from Nanika, Kidprice and Stepp Lakes, 1974

Lake	Nanika		Nanika		Nanika		Nanika		Kidprice		Kidprice		Stepp	
Station No.	1		9		11		17		18		21		23	
Depth (m)	5	25	5	25	5	25	5	25	5	25	5	25	5	25
Organism														
Oligochaetes	150		750	400		400		100	450					
Chironomids		350	350	200	100	200		300	100	50		50	100	
Sphaeriids			2150	50		50		200	50	150	50		50	100
Gastropods	200													
Caddisfly Case	50												50	
Diptera	50													
Totals	450	350	3250	650	100	650		600	600	200	50	50	200	100

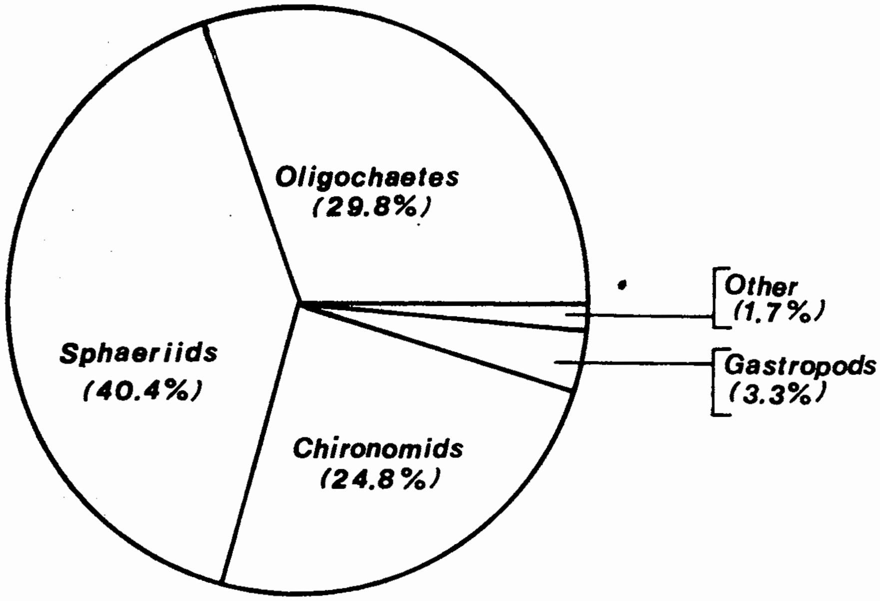


Fig. 22 Percentage composition by numbers of benthic organisms in Ekman dredge samples from Nanika Lake, 1974 (n=121)

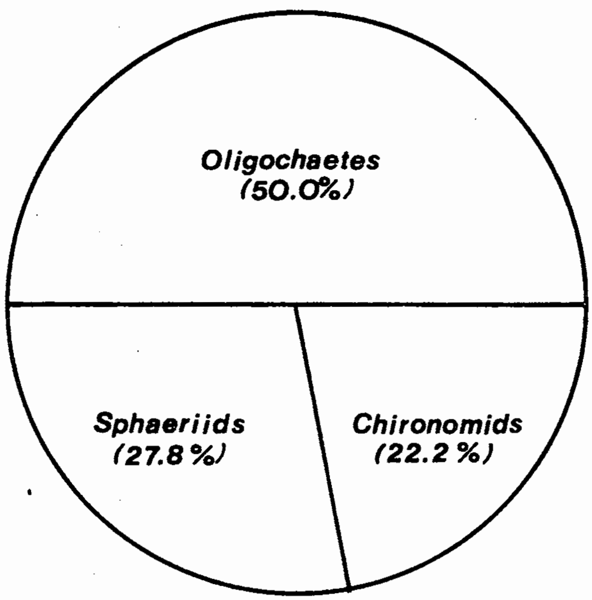


Fig. 23 Percentage composition by numbers of benthic organisms in Ekman dredge samples from Kidprice Lake, 1974 (n=18)

Two areas representing the greatest development of macrophytes in Kidprice Lake were studied in August, 1975. They included a shallow area south of Station 21 (Fig. 11) and a relatively extensive shallow area (less than 2 m) at the southern end of Kidprice Lake. Macrophyte species seen in these areas, in addition to Carex and Elodea spp., included Potamogeton and Hippuris spp., as well as some Ranunculus spp. in the eulittoral areas. Apart from these two areas, there are few aquatic plants in Kidprice Lake and even fewer in Nanika Lake. This is to be expected due to the steep shorelines of the lakes, together with low nutrient levels.

Burns and Tredger (1974) reported a sparse development of Potamogeton gramineus in Stepp Lake and a relatively large number of aquatic macrophytes in Anzac Lake, including P. gramineus, P. natans, and species of Equisetum, Najas, Nuphar, and Sparganium.

5.1.2 SPAWNING AND REARING AREAS

Descriptions of the tributary streams of Nanika, Kidprice, and Stepp Lakes are provided in Appendix IV, and a summary of stream data collected from those tributaries is given in Table 8.

A summary of catch data for juvenile fishes sampled by beach seining and redd digging in tributary streams of Nanika, Kidprice, and Stepp Lakes in 1974, and of Nanika and Kidprice Lakes in 1975, is provided in Appendix V.

Fish migration blockages exist on Streams IV, XII, and XIV within 300 m of their mouths, and log jams are numerous throughout the system, particularly on the longer, more meandering streams.

Fry were observed at the mouths of several streams, most notably upper Stepp Creek (about 300) and the upper Nanika River (about 80). The majority of the fry appeared to be rainbow trout, although some were probably Dolly Varden char (Salvelinus malma). Both species were caught in seine nets at stream mouths. Very few fry were observed in Bergeland Creek (Fig. 24) or in Creek XIX. The reasons for this fact are not clear, since observations indicated promising conditions for fry production.

Rainbow trout fry averaging from 2.5 to 5 cm in length were taken in the Nanika River near the outlet of Nanika Lake, in Kidprice Lake at the mouth of the upper Nanika River, and at the mouths of Stepp Creek and Stream XIV. A few larger fish (measuring from 7 to 11 cm) sampled from Nikun and Stepp Creeks were probably yearlings.

Table 8 Summary of Stream Survey Data[1] in the Tributaries to Nanika, Kidprice, and Stepp Lakes, 1974

Stream	Survey Date(s) 1974	Mean Width (ft.)	Mean Grad-ient	Main Substrate Type	Estimated Flow (CFS)	Water Temp. (°C)	Air Temp. (°C)	Passa-bility For Fish	Presence Of Fry	Spawning[3] Habitat Potential	Rearing[3] Habitat Potential	Adult[3] Habitat Potential
I Nanika River	July 22, Aug 7, Aug 14	103		boulder cobble some fines	1098	11.5	11.5	good	approx. 80 sighted	fair	good	good
II	July 19, Aug 29	20	steep	pebble cobble		5.0	14.5	fair		poor	poor	poor
III Nikun Creek	Aug 9	32.6	2-3%	pebble cobble boulder	151	9.5	16.5	good	7-10 sighted	poor	poor	poor
IV	Aug 15			boulder bedrock	1			poor for adults	approx. 35 sighted	poor	fair	poor
V Fenton Creek	Aug 6, Aug 13	20	2%	cobble pebble	176	6.8	18.0	good	12 sighted	poor	good in marshes	fair
VI	Aug 15	12-16		mud cobble	15	12.0	22.5	good	approx. 40 sighted	fair & good	good	fair
VII	July 24	20	2%	pebble	250	5.5	8.5	good		poor	poor	poor
VIII			steep	boulders	torrential			poor		poor	poor	poor
IX	Aug 20	10-15	steep	cobble		3.5	9.0	fair		poor	poor	poor
X	July 25	2-3	steep	boulders	22	3.0	9.5	fair		fair at mouth	poor,	fair
XI	July 24	10-15	2-3%	silt	53	5.5	8.5	fair		fair	fair	fair
XII	Aug 20			pebble	1	7.0	10.0	poor		poor	poor	poor
XIII	Aug 20			cobble	1-3			poor	3 sighted	fair	poor	poor
XIV	Aug 13	18-20		detritus algae	10			fair	approx. 75 sighted	good	poor	poor
XV[2] Bergeland Creek	July 17, July 20, Aug 8, Oct 7			pebble cobble sand	426	5.4	12.5	good	14 sighted	good	good	good
XVI	Oct 3	15		pebble cobble	30			fair		poor	poor	poor
XVII	Sept 28	9.3		silt pebble detritus	7	6.0	7.0	poor		poor	fair & good	fair & good
XVIII	Sept 20	8		pebble cobble algae	2	10.0	14.0	fair	approx. 300 sighted	poor	good	poor
XIX[2] Mystery River	Sept 30, Oct 7	20-25		mud detritus cobble gravel	137	4.0	5.0	fair	1 sighted	fair	fair	good
XX	Oct 5	6-8		mud sand pebble algae	1			poor		poor	good	poor

1 Some data on stream widths and substrate types taken from Mor[illegible]y and Whately (1974)

2 Survey by helicopter on October 7, 1974

3 [illegible]

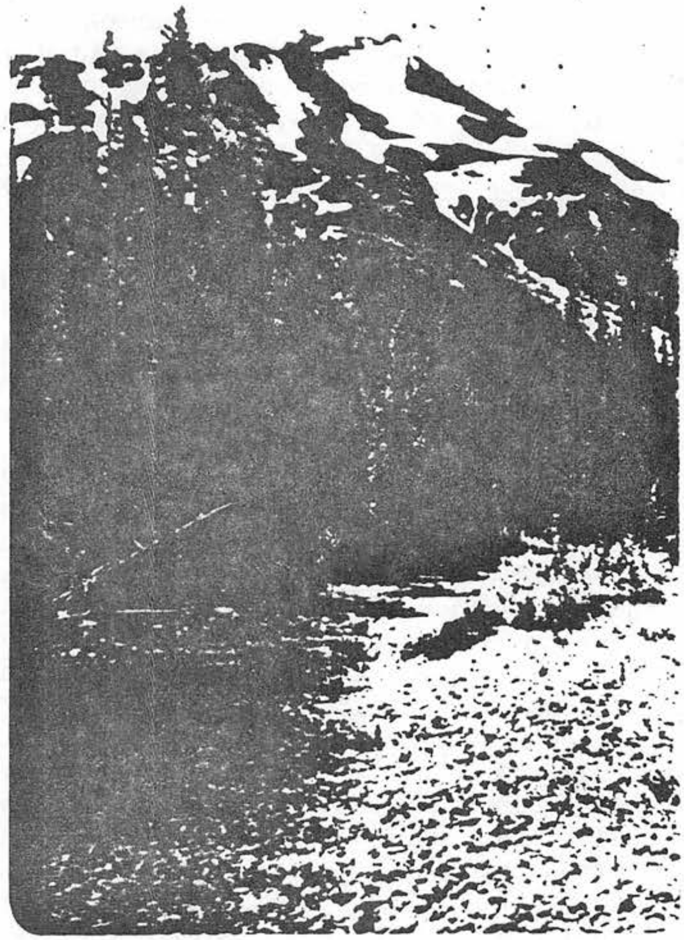


Fig. 24 Bergeland Creek

In addition to the streams where rainbow fry were found, considerable numbers of Dolly Varden fry were taken at the mouths of Nikun Creek, Fenton Creek, and Stream VII. From a sub-sample of 158 fish taken in 1974, 94 per cent were less than 4 cm long, although some measured up to 15 cm. The smaller fish represent the young of the 1973 fall spawners, while the larger fish were likely in their second summer.

Seining in shallow areas and near creek mouths yielded more Dolly Varden char juveniles than rainbow trout juveniles. Dolly Varden juveniles comprised 83.5 per cent of the total juvenile catch by seining from July to October, 1974, and 77.5 per cent of the total catch from July to September, 1975. No lake trout (S. namaycush) or longnose sucker (Catostomus catostomus) juveniles were taken from the study areas.

Redd digging for alevins indicated that the upper Nanika River, between Nanika and Kidprice Lakes, was the major spawning area for rainbow trout. Redds were examined weekly until the emergence of fry in August, 1974. The alevins were 1.5 to 2.5 cm in length, the largest having completely absorbed their yolk sacs.

Whether the streams in which Dolly Varden fry were found are also used for spawning could not be determined, since sampling did not extend through October when Dolly Varden char normally spawn. It was intended that actual rainbow trout spawning areas would be determined in the 1975 season by observing spawning activity. However, logistical problems prevented the field program from commencing until July of that year, when spawning had already occurred. Further investigations, such as looking for redds and fry and electroshocking, were conducted on Bergeland Creek, Fenton Creek, Streams VIII and XI, and on all tributaries of Kidprice Lake in 1975. These investigations confirmed that, in general, the upper Nanika River between Nanika and Kidprice Lakes is the main spawning area for both rainbow trout and Dolly Varden char in the system.

There could be a variety of reasons why most of the streams surveyed provided only limited potential as spawning areas. Bergeland Creek and Creek XIX are silty, particularly in the spring and early summer. These streams clear by late summer, with heavy deposits of silt being visible in the lower reaches. It is likely that heavy silt loads in the spring would prevent the circulation of oxygenated water through the gravels, rendering them unsuitable for spawning. In the upper reaches of Stream XIX there is a large system of pools and tributaries which may afford spawning potential. However, nothing is known of the water conditions in the spring, early summer, or winter. Flow regimes in the winter should be determined, since critically low flows could allow ice penetration of the gravels. A combination of heavy silt loads in the spring and ice penetration of gravels in the winter would prevent the gravels from being utilized by either spring spawners (rainbow trout) or fall spawners (Dolly Varden char).

Stream survey data and maps of the tributaries of Nanika, Kidprice, and Stepp Lakes are provided in Appendix VI. The stream surveys provided estimates of the amount of existing spawning and rearing habitat. The number of kilometers of stream which would be inundated as a result of dam construction were deduced from topographic maps, assuming increased lake levels of 10 m in Nanika Lake and 30 m in Kidprice Lake. Kilometers of spawning and rearing habitat flooded by those raised water levels and estimates of the amount of habitat remaining after flooding were derived from the above information (Table 9).

5.1.3 FISH POPULATION STUDIES

a) Gill Net Catch Data

Gill net catch data from Nanika, Kidprice, Spill, and Stepp Lakes in 1974, and from Nanika and Kidprice Lakes only in 1975, are provided in Appendix VII. The 1974 gill net catch data were obtained from Nanika Lake in July and August, Kidprice Lake in September and October, Spill Lake in September, and Stepp Lake in October. The 1975 gill net catch data were obtained from Nanika and Kidprice Lakes in August. For simplicity, all succeeding information regarding gill net catch data will be referred to by year and water body sampled only, not by month(s) of sample.

Fish species caught during the 1974-75 sampling programs in Nanika, Kidprice, and Stepp Lakes included rainbow trout, Dolly Varden char, and longnose sucker. No lake trout were caught in 1974 or 1975 despite extensive deep netting and deep angling in 1975, although two were reported from Nanika Lake in 1973 (Morley and Whately, 1974.

In 1973, 1974, and 1975, rainbow trout dominated the catch from Nanika Lake (Tables 10, 11, and 12). In Kidprice Lake in 1973, Dolly Varden char and longnose suckers were almost three times as abundant as rainbow trout (Table 10). In 1974, the two former species each represented almost 40 per cent of the total catch, and rainbows just over 20 per cent (Table 11). In 1975, about 50 per cent

Table 9 Kilometers of 1) existing spawning and rearing habitat, 2) spawning and rearing habitat lost by flooding, and 3) spawning and rearing habitat remaining after flooding *

Stream	1) Existing spawning habitat (km)	2) Spawning habitat lost by flooding (km)	3) Spawning habitat remaining after flooding (km)	1) Existing rearing habitat (km)	2) Rearing habitat lost by flooding (km)	3) Rearing habitat remaining after flooding (km)
Upper Nanika River (I)	2.41	2.41	0.00	5.73	5.73	0.00
II	0.03	0.03	0.00	0.03	0.03	0.00
Nikun Creek(III)	0.24	0.00	0.24	0.40	0.06	0.33
IV	0.00	-	-	0.40	0.40	0.00
Fenton Creek(V)	0.18	0.03	0.15	0.88	0.46	0.43
VI	0.15	0.15	0.00	0.97	0.94	0.03
VII	0.06	0.06	0.00	0.18	0.18	0.00
VIII	0.00	-	-	0.00	-	-
IX	0.06	0.06	0.00	0.14	0.11	0.03
X	0.00	-	-	0.24	0.08	0.17
XI	0.37	0.06	0.30	0.43	0.09	0.33
XII	0.03	0.03	0.00	0.03	0.03	0.00
XIII	0.00	-	-	0.00	-	-
XIV	0.00	-	-	0.55	0.33	0.21
Bergeland Ck(XV)	4.57	3.05	1.52	7.32	4.88	2.44
XVI	0.75	0.72	0.03	0.64	0.61	0.03
XVII	0.51	0.51	0.00	2.24	2.24	0.00
Stepp Ck(XVIII)	0.27	0.27	0.00	0.98	0.98	0.00
Mystery River(XIX)	+	0.27	+	+	0.85	+
XX	0.00	-	-	0.30	0.13	0.17
TOTAL	9.63	7.65	2.24	21.46	18.13	4.17

* Kilometers of existing habitat represent <u>potential use</u> by fish, rather than observed use.

+ Mystery River (XIX) was surveyed to flood level only, therefore, kilometers of existing or remaining habitat cannot be determined.

of the gill net catch from Kidprice Lake was comprised of Dolly Varden char, with 40 per cent rainbow trout and 10 per cent longnose suckers (Table 12). In August 1975, only two longnose suckers were caught in Kidprice Lake, while in September 1975 these fish represented about one third of the catch. Sampling in Spill Lake in 1974 yielded almost 90 per cent rainbow trout and about 10 per cent Dolly Varden char (Table 11). Sampling in Stepp Lake in 1974 yielded about 60 per cent longnose suckers, with rainbow trout the second most abundant species (Table 11).

Table 10 Percentage composition of total gill net catches from Nanika and Kidprice Lakes, 1973 (Morley and Whately, 1974)

Species	Nanika Lk September		Kidprice Lk September		Total Catch	
	No.	%	No.	%	No.	%
Rainbow trout	118	92.9	22	15.0	140	51.1
Dolly Varden	2	1.6	61	41.5	63	23.0
Longnose sucker	5	3.9	64	43.5	69	25.2
Lake trout	2	1.6			2	0.7
TOTAL CATCH	127		147		274	

Table 11 Percentage composition of total gill net catches from Nanika, Kidprice, Spill and Stepp Lakes, 1974

Species	Nanika Lk July-Aug		Kidprice Lk Sept-Oct		Spill Lk September		Stepp Lk October		Total Catch	
	No.	%	No.	%	No.	%	No.	%	No.	%
Rainbow trout	296	72.2	19	23.2	16	88.9	39	35.1	370	59.6
Dolly Varden	60	14.6	32	39.0	2	11.1	4	3.6	98	15.8
Longnose sucker	54	13.2	31	37.8	0	0.0	68	61.3	153	24.6
TOTAL CATCH	410		82		18		111		621	

Table 12 Percentage composition of total gill net catches from Nanika and Kidprice Lakes, 1975

Species	Nanika Lk August		Kidprice Lk Aug - Sept		Total Catch	
	No.	%	No.	%	No.	%
Rainbow trout	55	91.7	54	39.7	109	55.6
Dolly Varden	5	8.3	69	50.7	74	37.8
Longnose sucker	0	0.0	13	9.6	13	6.6
TOTAL CATCH	60		136		196	

Catch per unit effort (CPUE) values for each lake sampled in 1974 and 1975 are calculated as the number of fish caught per gill net hour. Total catch and CPUE values from Nanika, Kidprice, Spill, and Stepp Lakes in 1974 are given in Table 13, and from Nanika and Kidprice Lakes in 1975 in Table 14. CPUE for rainbow trout, Dolly Varden char, and longnose sucker from the above four lakes in 1974 was 1.92 fish per gill net hour. CPUE for those three species from Nanika and Kidprice Lakes only was 2.96 fish per gill net hour in 1974 and 1.26 fish per gill net hour in 1975.

Table 13. Total catch and catch per unit effort (CPUE)* for total gill net catches from Nanika, Kidprice, Spill, and Stepp Lakes, 1974.

Location	Rainbow Trout		Dolly Varden		Longnose Sucker		Totals	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
Nanika Lake 189 gill net hrs.	296	1.57	60	0.32	54	0.29	410	2.17
Kidprice Lake 104 gill net hrs.	19	0.18	32	0.31	31	0.30	82	0.79
Spill Lake 3 gill net hrs.	16	5.33	2	0.67	0	0.00	18	6.00
Stepp Lake 27 gill net hrs.	39	1.44	4	0.15	68	2.52	111	4.11
TOTALS 323 gill net hrs.	370	1.15	98	0.30	153	0.47	621	1.92

Table 14. Total catch and catch per unit effort (CPUE)* for total gill net catches from Nanika and Kidprice Lakes, 1975.

Location	Rainbow Trout		Dolly Varden		Longnose Sucker		Totals	
	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
Nanika Lake 48 gill net hrs.	55	1.15	5	0.10	0	0.00	60	1.25
Kidprice Lake 108 gill net hrs.	54	0.50	69	0.64	13	0.12	136	1.26
TOTALS 156 gill net hrs.	109	0.70	74	0.47	13	0.83	196	1.26

* CPUE = number of fish caught per gill net hour.

b) Length and Age Distribution

As reported by Morley and Whately in 1973, rainbow trout sampled from Nanika Lake in 1974 and 1975 were consistently within a narrow size range. Mean length was 34.1 cm in 1974 and 33.6 cm in 1975. The majority of trout were between 30 and 40 cm, and the largest fish was 47.7 cm from the 1975 sample. This narrow size range could be a function of gear selectivity. The length range of rainbow trout in Kidprice Lake was relatively broad (14 - 38 cm) in the 1973, 1974, and 1975 field seasons, with the majority of fish between 16 and 34 cm. Mean length was 27.9 cm in 1974 and 25.9 cm in 1975. Kidprice Lake appears to have proportionally more habitat offering at least minimal cover for young fish, due to the presence of a greater amount of shallow area and a greater abundance of aquatic macrophytes. This could contribute to the wider size range of fish from the lake, if predation is proven to be a major source of mortality. The majority of trout caught in Stepp Lake (95 per cent) were under 30 cm in length.

Length distributions of Dolly Varden char sampled from Nanika and Kidprice Lakes in 1974 were very similar, ranging from 14 to 27 cm. Mean length was 20.0 cm from Nanika and 18.7 cm from Kidprice. The length range for the 1975 Dolly Varden catch from Kidprice Lake was 15.9 to 33.3 cm, and mean length was 20.2 cm. The mean length of the five char sampled from Nanika Lake in 1975 was 24.2 cm.

Length frequency histograms for rainbow trout, Dolly Varden char, and longnose sucker sampled during 1974 and 1975 are included in Appendix VII.

Age has been plotted against fork length for rainbow trout sampled from Nanika and Kidprice Lakes in 1974 and 1975, and for Dolly Varden char sampled from Kidprice Lake in 1975. Those graphs are also included in Appendix VII.

Mean lengths within age groups for rainbow trout from the 1975 catches (Fig. 25) suggest that mean length and growth rate are lower in Kidprice Lake than in Nanika Lake. This may be associated with lower zooplankton production in Kidprice compared to Nanika.

Comparative data on age length relationships in rainbow trout and Dolly Varden char from other lakes in British Columbia and Alberta are given in Tables 15 and 16, respectively. Table 16 would suggest that the sampled Kidprice Lake Dolly Varden population has

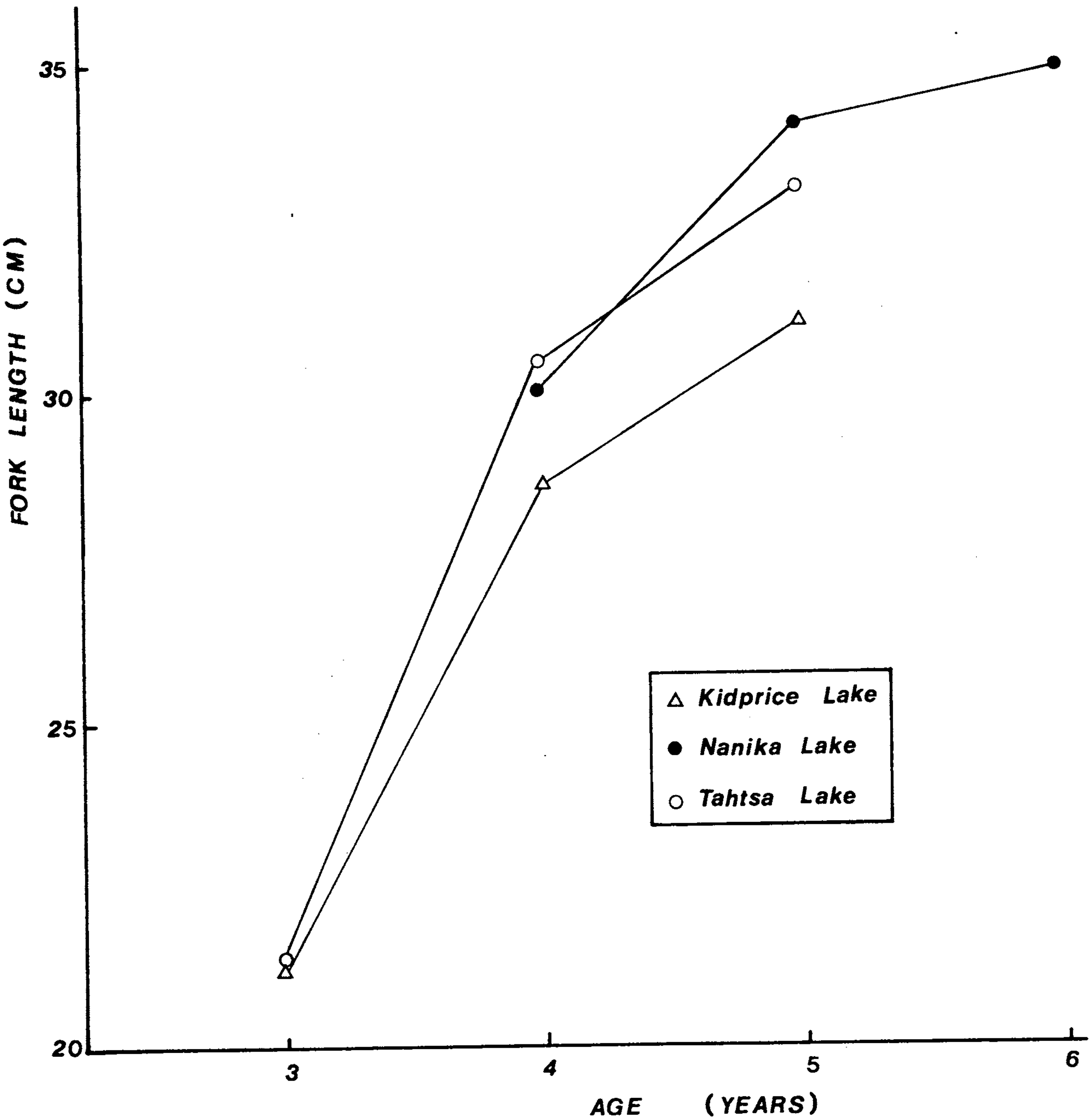


Fig. 25 The relationship of mean length and age for rainbow trout from Nanika, Kidprice, and Tahtsa Lakes, 1975

Table 15 Comparative growth rates for rainbow trout from other lakes in British Columbia and Alberta

Location	Fork Length Measure	Age 1	2	3	4	5	6	7
Pyramid Lk, Alta*	FL cm	6.1	13.5	19.0	23.6	29.5	37.6	45.5
Kootenay Lk, B.C.*	FL cm	6.2	12.5	28.9	44.5	59.8	78.5	-
L. Okanagan, B.C.	FL cm	6.5	12.0	29.0	43.5	51.5	59.0	71.0
Buttle Lk, B.C.	FL cm	-	25.4	26.7	29.2	31.5	-	-
Nanika Lake	FL cm	-	-	-	30.0	34.0	34.0	-
Kidprice Lake	FL cm	-	-	21.3	28.6	30.5	-	-
Tahtsa Lake	FL cm	-	-	21.4	30.4	33.0	-	-

Table 16 Comparative growth rates for Dolly Varden char from other locations in British Columbia and Alberta

Location	Fork Length Measure	Age 1	2	3	4	5	6	7	8	9
Bow R., Alta*	FL cm	16.5	21.1	24.6	26.9	32.0	33.5	-	-	-
Jasper Nat. Pk.*	FL cm	-	20.0	25.0	33.0	41.0	50.0	56.0	-	-
			23.0	30.0	40.0	46.0	54.0	62.0	-	-
Upper Campbell Lake, B.C.*	FL cm	23.1	23.9	29.0	-	-	-	-	-	-
Kidprice Lk., B.C.	FL cm	-	-	17.3	19.3	21.2	24.3	26.0	31.7	-

* Data from Scott and Crossman (1973)

a low growth rate in comparison with other lakes. Scott and Crossman (1973) noted that inland, high altitude, and northern populations of Dolly Varden are often stunted in growth, and may not exceed 30 cm.

c) Length-Weight Relationships

The length-weight relationship in fishes can be described by the equation:

$$W = aL^b$$

where W = Weight,
L = Length,
and b = Growth Exponent.

The growth exponent, b, is a measure of the relative robustness of fish. Were b is equal to 3, comparative weight per unit length (isometric growth) is indicated, while values of greater or less than 3 indicate greater or less weight per unit length, respectively (allometric growth) (Ricker, 1958). The value of b may reflect differences in species, individuals, or environmental conditions.

The coefficients a and b in the exponential form of the length-weight relationship are obtained from the equation:

$$\log W = \log a + b \log L.$$

Values of a and b calculated for various species are given in Table 17.

Table 17 Computed values of the growth coefficient b

Species	Lake	Year	Log W = b log L + log a
Longnose sucker	Nanika, Kidprice, and Stepp	1974	Log W = 3.2 log L - 2.18
Dolly Varden	Nanika, Kidprice, and Stepp	1974	Log W = 2.6 log L - 1.43
Rainbow trout	Nanika, Kidprice, Spill, and Stepp	1974	Log W = 2.8 log L - 1.68
Rainbow trout	Nanika and Kidprice	1975	Log W = 2.93 log L - 1.88
Rainbow trout	Nanika	1975	Log W = 2.43 log L - 1.10
Rainbow trout	Kidprice	1975	Log W = 2.72 log L - 1.60
Rainbow trout	Tahtsa	1975	Log W = 2.63 log L - 1.41

There is no significant difference in the length-weight relationships of the rainbow trout, Dolly Varden char, and longnose sucker populations sampled from Nanika, Kidprice, and Stepp Lakes in 1974 (Fig. 26 to 28). Nor is there any significant difference in the length-weight relationships of male and female rainbow trout sampled from Nanika and Kidprice Lakes in 1975 (Figs. 29 and 30, respectively).

d) Stomach Contents

The food items in the diet of adult trout from Nanika, Kidprice, and Stepp Lakes included aquatic and terrestrial insects, gastropods, zooplankton (mainly Daphnia spp.), gammarid amphipods, and fish. In Nanika Lake, where the largest number of fish were sampled, invertebrates, particularly gastropods and insects, were the major food organisms (Fig. 31). Twelve orders of insects were represented, among which Diptera, Hymenoptera, and Coleoptera were most abundant both in terms of numbers and frequency of occurrence. Fish were found in approximately 28 per cent of the samples from the three lakes (Fig. 31), but the species were not identified due to the degree of digestion.

The predominantly invertebrate diet of trout in this system may be contributing to the observed decrease in growth rate in older trout (Fig. 25). Larkin et al. (1956) noted a decline in growth rate with increasing length in rainbow trout from relatively unproductive lakes where forage fish were not available. Although some fish were found in stomach samples, it appears that prey fishes are limited in the Nanika-Kidprice system.

The stomach content samples from Dolly Varden char contained the same major invertebrate groups found in samples from rainbow trout. In Nanika Lake, which was sampled in July and August, eggs were the most numerous food organisms, and in Kidprice Lake, sampled in September and October, cladocerans were most numerous (Fig. 32). The large number of eggs found in stomach samples from Nanika Lake was probably a function of the time of sampling, as rainbow trout eggs are still in the gravel during those months. Amphipods, molluscs (mainly pelecypods), and insects were found in low numbers in the char samples from both lakes (Fig. 33).

Dolly Varden char, like rainbow trout, feed primarily on plankton and benthic organisms in the Nanika-Kidprice system, and some competition for food may occur. It was noted that the percentage of empty stomachs in Dolly Varden samples (Fig. 33) was greater than

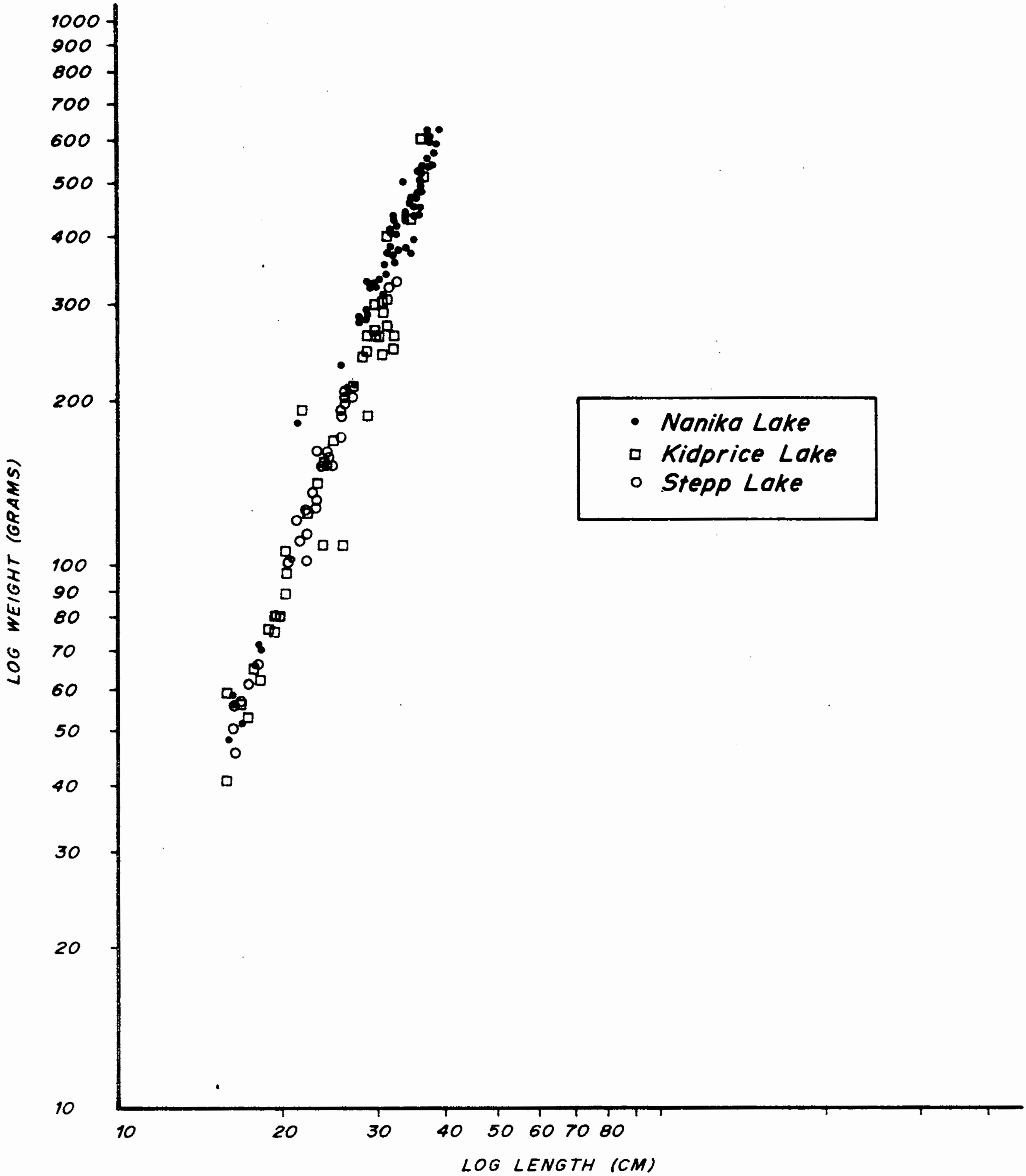


Fig. 26 The relationship of length and weight for rainbow trout from Nanika, Kidprice, and Stepp Lakes, 1974

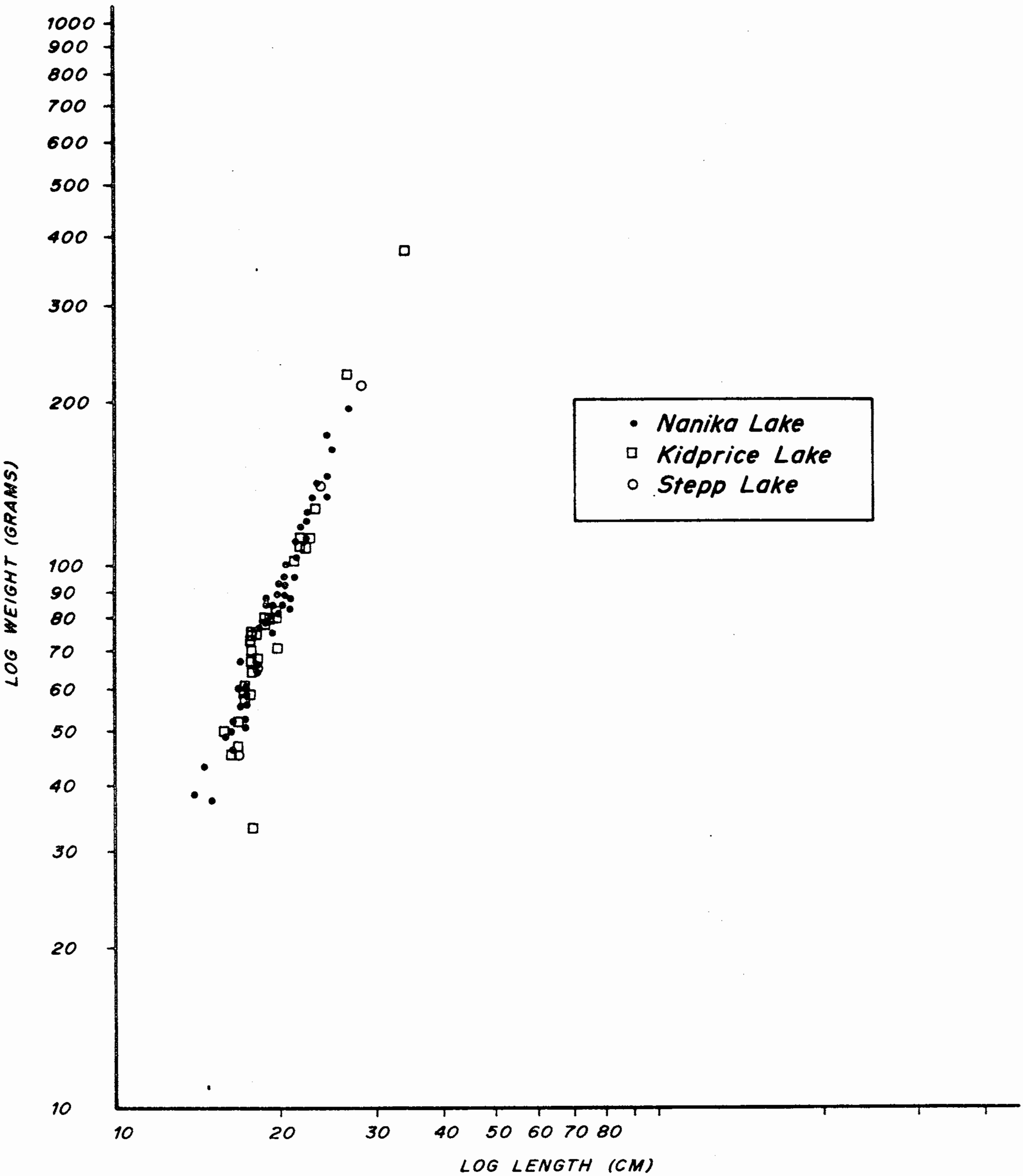


Fig. 27 The relationship of length and weight for Dolly Varden from Nanika, Kidprice, and Stepp Lakes, 1974

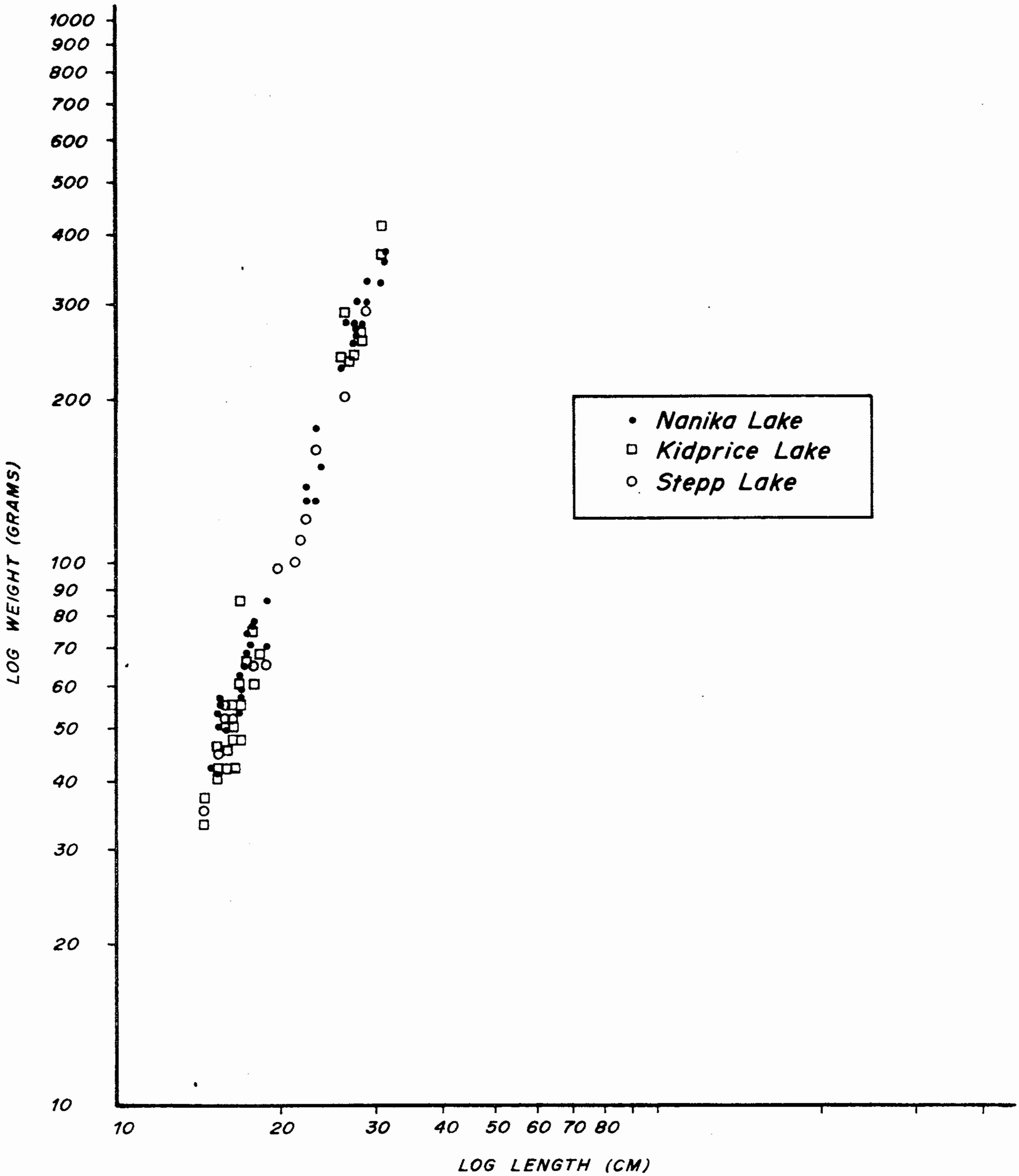


Fig. 28 The relationship of length and weight for longnose sucker from Nanika, Kidprice, and Stepp Lakes, 1974

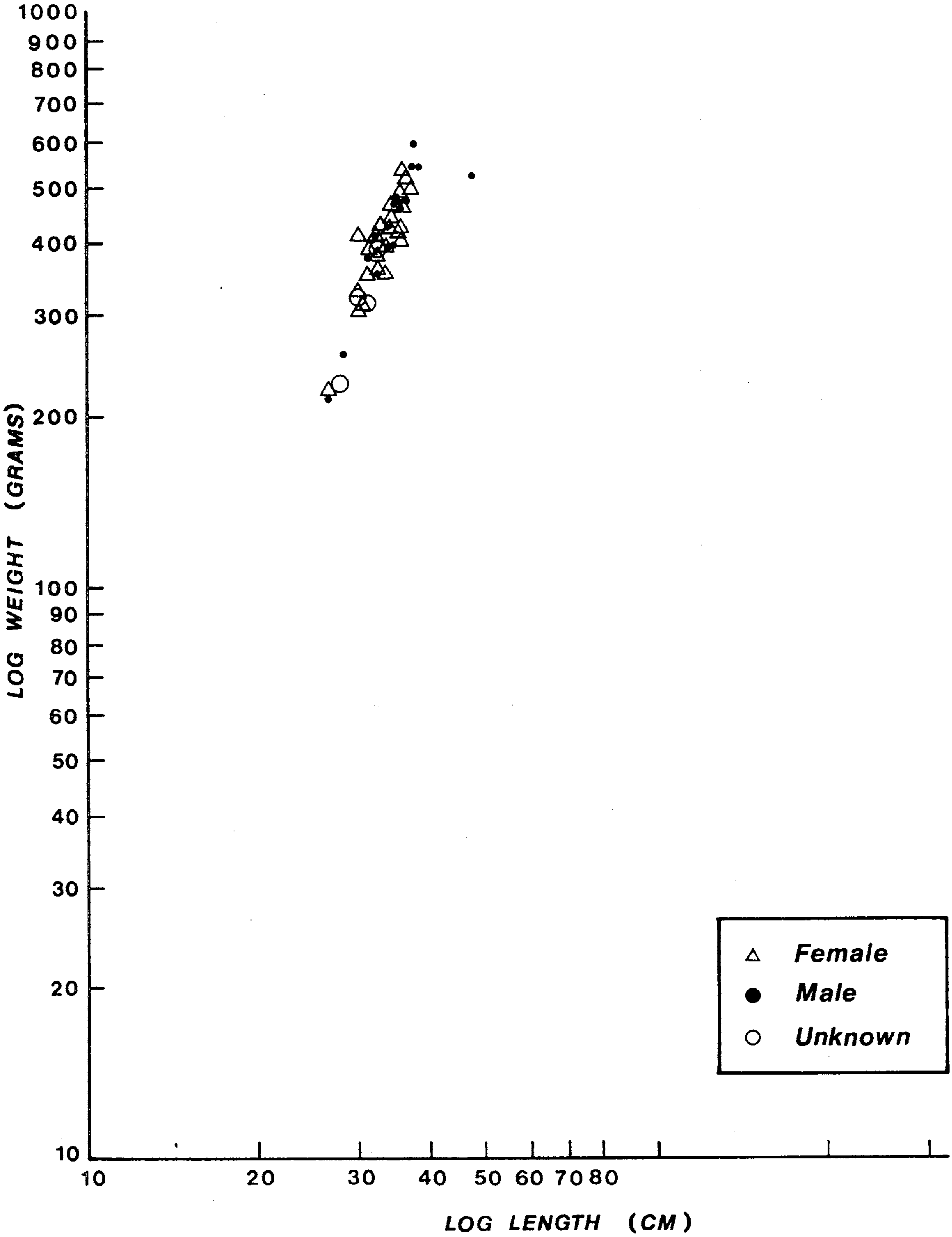


Fig. 29 The relationship of length and weight for male and female rainbow trout from Nanika Lake, 1975

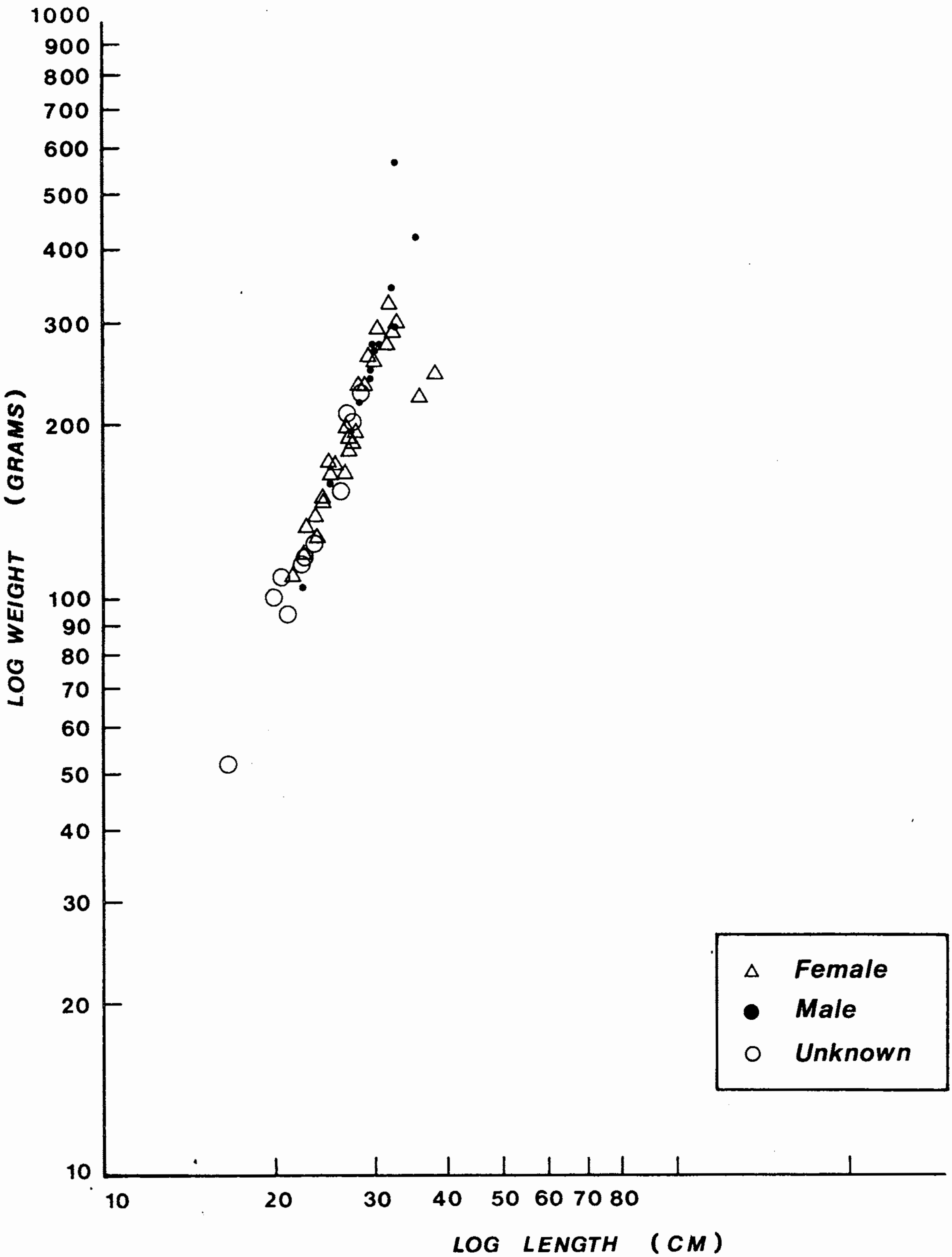


Fig. 30 The relationship of length and weight for male and female rainbow trout from Kidprice Lake, 1975

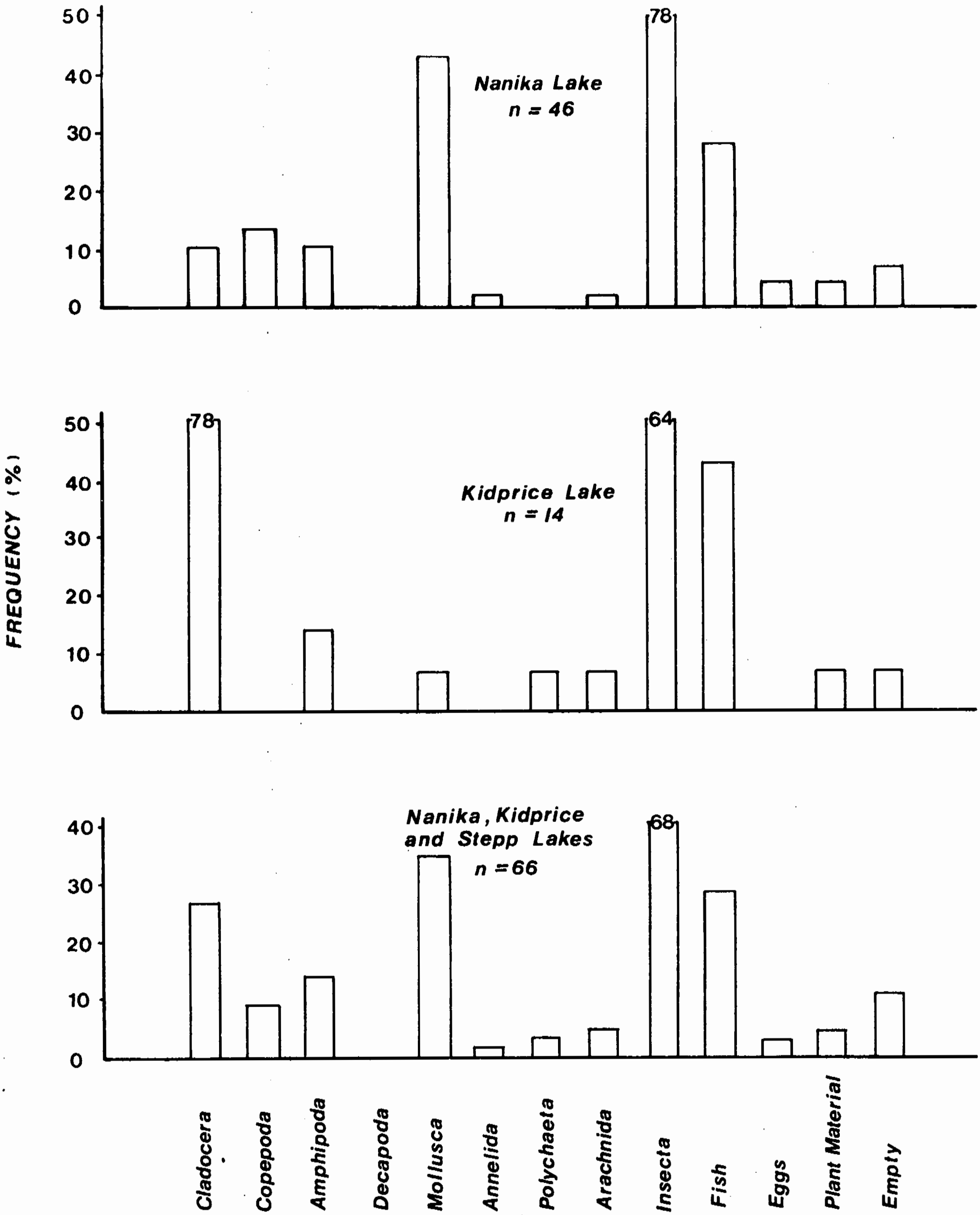


Fig. 31 Frequency of occurrence of food organisms in rainbow trout stomach samples from Nanika, Kidprice, and Stepp Lakes, 1974

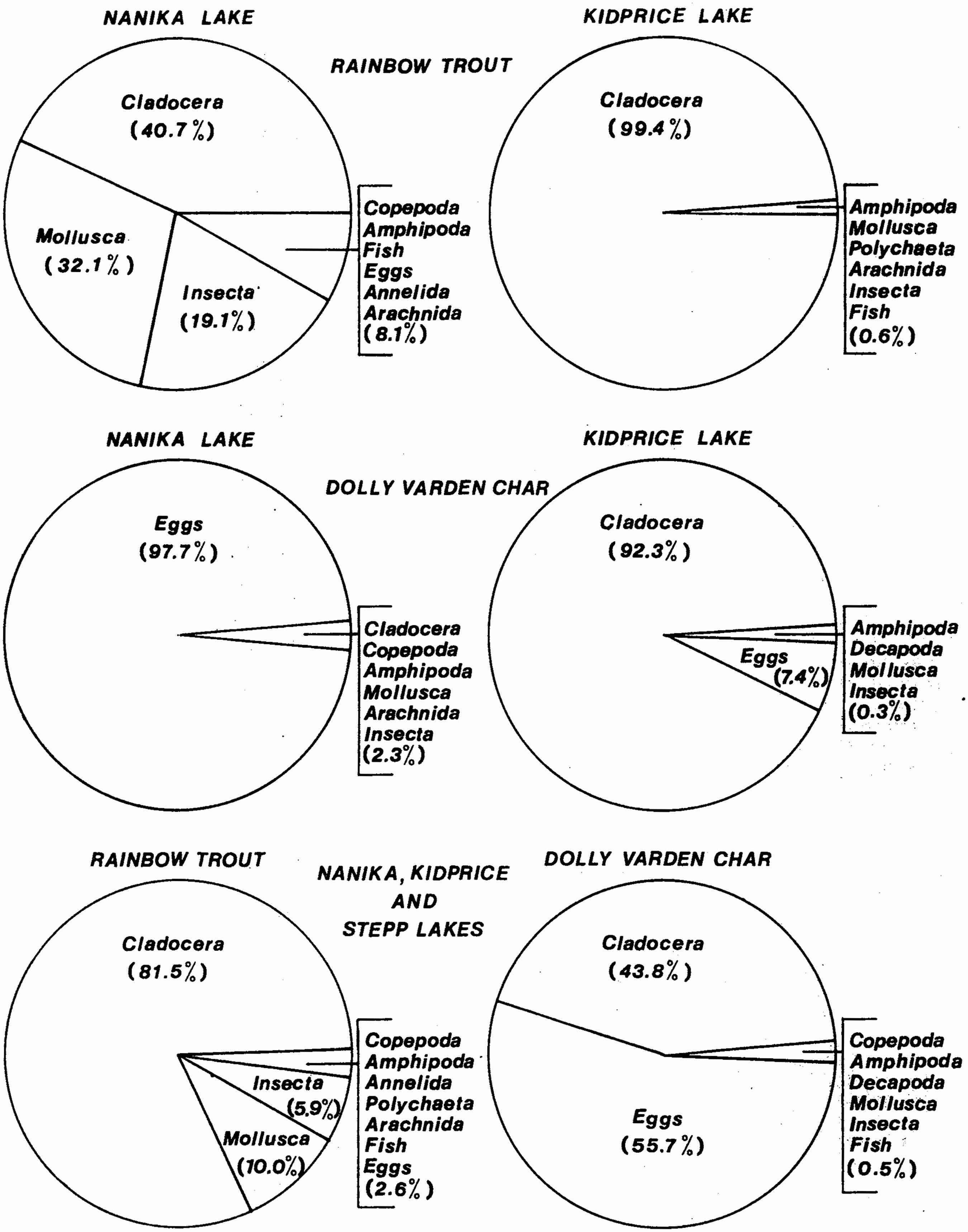


Fig. 32 Percentage composition by numbers of food organisms in rainbow trout and Dolly Varden stomach samples from Nanika, Kidprice, and Stepp Lakes, 1974

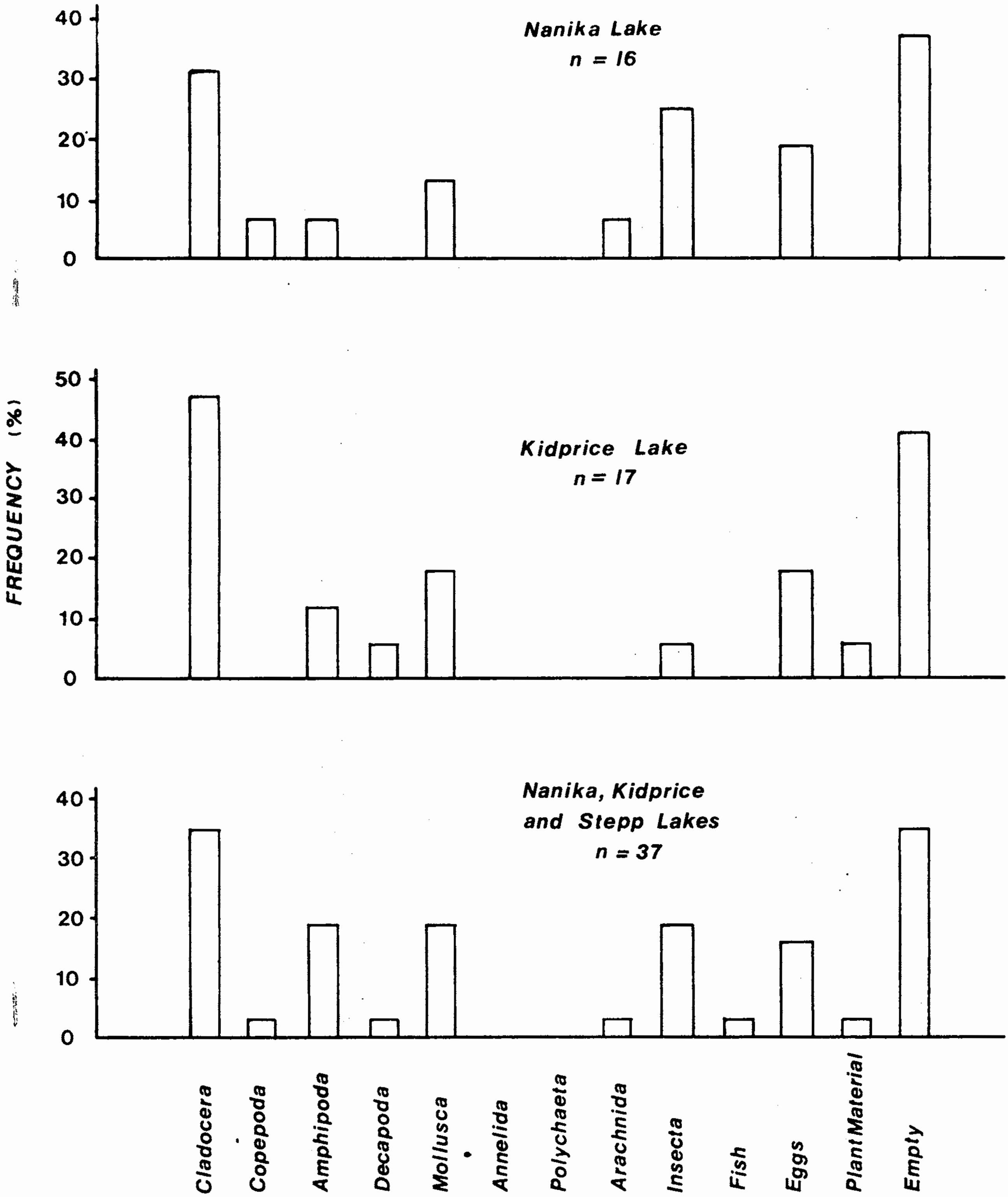


Fig. 33 Frequency of occurrence of food organisms in Dolly Varden stomach samples from Nanika, Kidprice, and Stepp Lakes, 1974

that observed in the rainbow trout samples (Fig. 31), and that their stomach capacity rarely exceeded 30 per cent. This is probably a function of sampling conducted prior to or after spawning (Dolly Varden are fall spawners).

Food items in the stomachs of longnose suckers sampled from Nanika Lake in 1974 and Kidprice Lake in 1975 included amphipods, cladocerans, copepods, molluscs, and insects. Amphipods (Gammarus spp.) were found in 75 per cent of the longnose sucker stomachs from Nanika Lake, and cladocerans (Daphnia spp.) and amphipods (Gammarus spp.) in 60 per cent of the stomachs from Kidprice Lake.

The results of stomach content analyses from rainbow trout, Dolly Varden char, and longnose sucker sampled from the Nanika-Kidprice system in 1974 and 1975 are presented in Appendix VIII.

One of the gill net samples from Kidprice Lake in 1975 was comprised of 10 rainbow trout, 16 Dolly Varden char, and 11 longnose sucker. All of these fish were analyzed for stomach contents to address the question of interspecific food competition. The data suggest significant diet overlap in rainbow trout, Dolly Varden char, and longnose sucker. In particular, the longnose sucker stomachs contained amphipods (Gammarus spp.), which were also observed to be taken in considerable numbers by juvenile trout.

The types of food available in the lakes, as revealed in the benthic samples (Figs. 22 and 23), are predominatly oligochaetes, sphaeriids, chironomids, and gastropods. Although these organisms were represented in the diet of rainbow trout and Dolly Varden char, it appears that zooplankton and insects (at least in the summer) are the major invertebrates consumed by those species. Suckers, on the other hand, may utilize benthic invertebrates to a greater extent.

e) Sex and Maturity

The sex and state of maturity of the three fish species were determined in the field by the examination of gonads. The state of maturity of Dolly Varden char and longnose suckers from the 1974 gill net catches is shown in Tables 18 and 19, respectively. Age at maturity is generally 3 to 5 years for rainbow trout, 3 to 6 years for Dolly Varden char, and 5 to 7 years for longnose sucker (Scott and Crossman, 1973).

In all three field seasons, sampling was conducted in the summer and fall, therefore little can be learned of the reproductive potential of rainbow trout, since they are spring spawners. It was

Table 18 State of maturity of Dolly Varden from Nanika, Kidprice, and Stepp Lakes, 1974 (n=78)

	No. of Fish	Per cent	Mean Length (cm)	Length Range (cm)
MALES	36			
Immature	13	16.7	19.6	16.5 - 27.0
Mature	23	29.5	22.4	15.0 - 34.5
FEMALES	42			
Immature	26	33.3	19.1	16.0 - 24.5
Mature	16	20.5	19.1	14.5 - 24.0

Table 19 State of maturity of Longnose sucker from Nanika, Kidprice, and Stepp Lakes, 1974 (n=111)

	No. of Fish	Per cent	Mean Length (cm)	Length Range (cm)
MALES	51			
Immature	23	20.7	16.8	14.5 - 26.5
Mature	28	25.2	17.4	15.0 - 26.5
FEMALES	60			
Immature	38	34.2	19.4	15.5 - 31.0
Mature	22	19.8	26.0	15.5 - 31.5

intended that particular emphasis be placed on spring spawning studies in 1975, but funds for the study were not available until late July. A large proportion of the trout sampled were designated immature, but it is probable that many of these fish had spawned in previous years or may have spawned the following year. Unless the gonads are extensively developed, it is difficult to determine the degree of maturity. Although residual eggs were noted in some fish, indicating they had spawned, those eggs were not always present.

Unlike rainbow trout, Dolly Varden char are fall spawners. Observations of sexual condition showed that 50 per cent of the char sampled in 1974 were in spawning condition (Table 18). In 1975, all Dolly Varden caught in Kidprice Lake during early August were immature, while in late September about 50 per cent of both males and females were mature. Five Dolly Varden caught in Nanika Lake in late August 1975 were all mature.

Of the 111 longnose suckers for which sex and sexual condition were recorded in 1974, approximately 45 per cent contained developing gonads and were described as mature (Table 19).

5.1.4 FISH PARASITES

a) General Observations

Field sampling of rainbow trout and Dolly Varden char in the Nanika-Kidprice system in 1974 indicated an extremely high incidence of parasitism, especially by the tapeworm *Diphyllobothrium*. Table 20 shows the intensity of parasitism in 10 selected fish from the 1974 Nanika Lake gill net catches.

In the 1975 field study, all gill net catches were routinely examined for the presence of *Diphyllobothrium* spp. (Appendix VII). Frequency of infection by this parasite was higher in rainbow trout (83.3 per cent) than in Dolly Varden char (26.5 per cent) from Kidprice Lake. The intensity of infection was also higher in rainbow trout from Kidprice Lake. The highest number of cysts counted in any one Dolly Varden was 20, while 14.8 per cent of the rainbows contained more than 20 cysts. Since individual levels of infection are a function of exposure time, a good comparison is between the four to five year old fish from the two lakes. In Nanika Lake, 94.6 per cent of four and five year trout were infected, compared to 89.7 per cent of the same age groups in Kidprice Lake. In these same age groups, 24.3 per cent of rainbow trout from Nanika Lake and 3.4 per cent from Kidprice Lake

Table 20 Intensity of parasitism in rainbow trout, Dolly Varden char, and longnose sucker from Nanika Lake, 1974

	Rainbow trout			Dolly Varden		Longnose Suckers				
Parasites	1	2	3	4	5	6	7	8	9	10
COPEPODA										
Salmincola sp.	7	2								
CESTODA										
Diphyllobothrium sp.	>125	>100	>50	17	>25					
Eubothrium sp.	> 10	> 50	>10	1						
Ligula intestinalis						1				
ACANTHOCEPHALA							1	1	1	
TREMATODA										
Crepisdostonum farionus	> 50	>25	>40							
NEMOTODA										
Philonema sp.	2	2	20		4					
Unidentified				1	1					
MYXOSPORIDEA										
Myxidium spores		+								
Myxobolus neurobius spores		+		+	+					
Myxosoma spores										

* Numbers in the top row refer to fish sample numbers

\+ Indicates the presence of spores

contained more than 50 cysts. No six year old fish were found to have escaped infection. Histograms of per cent of trout infected with Diphyllobothrium in age groups from the 1975 Nanika and Kidprice Lakes samples are presented in Fig. 34.

Statistical analyses on the level of Diphyllobothrium infection in male and female rainbow trout, in age groups, sampled from Nanika and Kidprice Lakes in 1975 are given in Appendix IX.

There is no clear trend of differences in average levels of infection between sexes, and the differences are generally not significant. Nor is there a trend in average infection level within age groups between lakes, the differences again not being signficant.

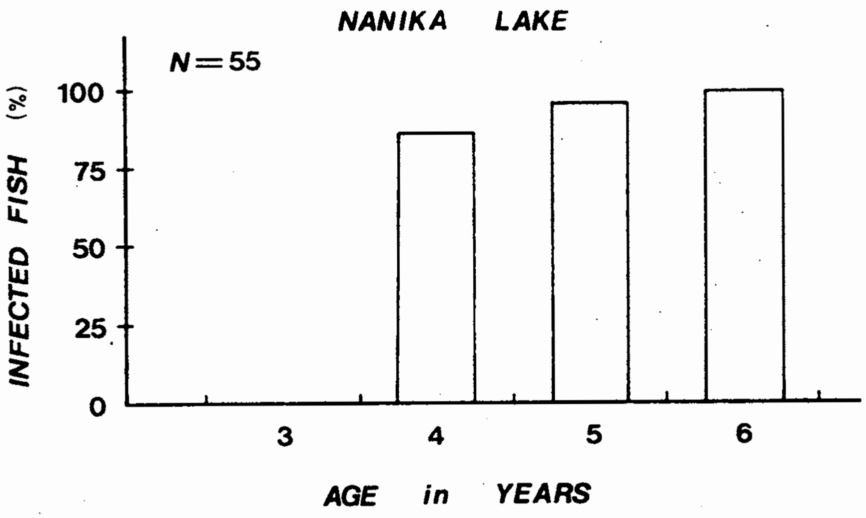
Histograms of average Diphyllobothrium counts in various age groups of rainbow trout from Nanika and Kidprice Lakes are presented in Fig. 35. Since individual infection counts of greater than 50 were recorded in the field simply as greater than 50, averages were calculated by conservatively assessing these as 50. The percentage of fish having counts greater than 50 is also shown in Fig. 35.

Mean lengths in age groups against Diphyllobothrium infection in rainbow trout from Nanika Lake are shown in Table 21 and from Kidprice Lake in Table 22. It can be seen that there is a general trend of greater infection with increased age and of greater infection with increased length. It is suggested that greater infection with increased length may be due to a greater food intake in larger fish, the greater food intake resulting in a greater intake of infective organisms.

Longnose suckers appeared to be free from infection by Diphyllobothrium, but were heavily infected by another tapeworm (Ligula intestinalis). Infection by Ligula intestinalis was found in 36.4 per cent of the longnose suckers sampled from Kidprice Lake in 1975 (Appendix VII), with the weight of the parasite being as much as 22 per cent of the body weight of the fish.

Other fish parasites in the Nanika-Kidprice system were not investigated routinely, but substantial infection by Philonema and Eubothrium spp. was noted.

Infection by Diphyllobothrium spp. is also found in salmonids in the Nanika River below Nanika Falls and in Morice Lake, although intensities of infection appear to be lower than in Kidprice Lake.



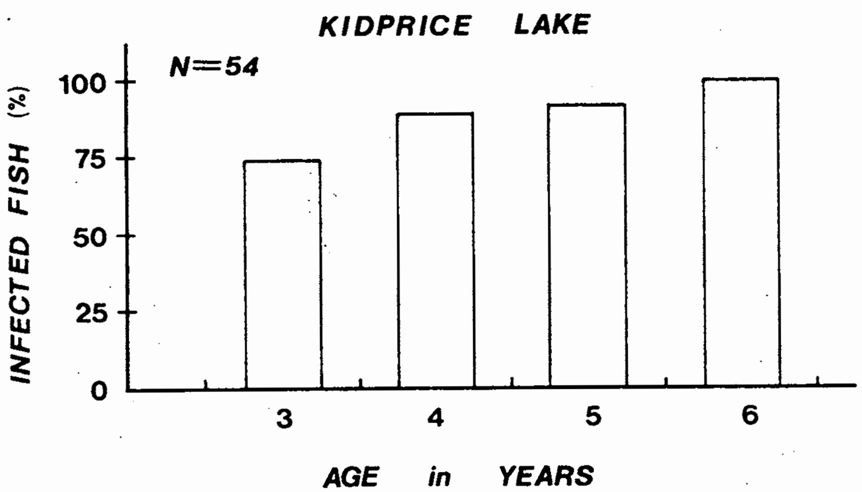


Fig. 34 Histograms of per cent of rainbow trout infected with Diphyllobothrium in age groups from Nanika and Kidprice Lakes, 1975

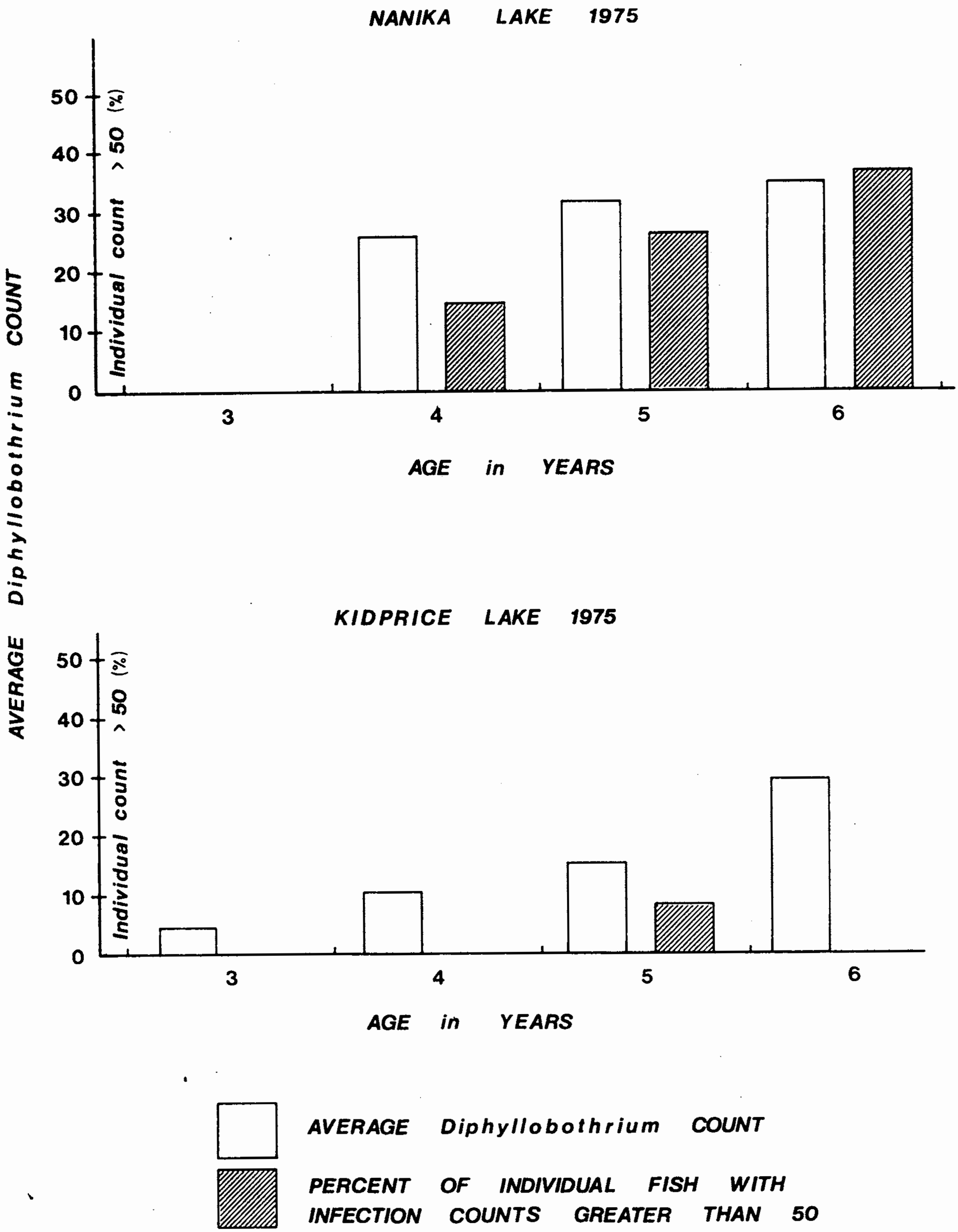


Fig. 35 Histograms of average Diphyllobothrium count in age groups for rainbow trout from Nanika and Kidprice Lakes, 1975

Table 21 Mean fork length, age, and Diphyllobothrium infection in rainbow trout from Nanika Lake, 1975

Diphyllo-bothrium	AGE 3 Mean Length cm	N	4 Mean Length cm	N	5 Mean Length cm	N	6 Mean Length cm	N
0			28.2	1	27.7	1		
1 - 10			26.7	2	31.4	4	32.7	2
11 - 20			32.2	1	32.9	6	33.2	4
21 - 30					34.5	4	33.8	1
31 - 40					34.4	5	32.6	1
41 - 50			32.3	2	36.7	2	35.9	2
> 50			31.8	1	35.7	8	35.47	7
TOTAL			30.0	7	34.0	30	34.81	17

Table 22 Mean fork length, age, and Diphyllobothrium infection in rainbow trout from Kidprice Lake, 1975

Diphyllo-bothrium	AGE 3 Mean Length cm	N	4 Mean Length cm	N	5 Mean Length cm	N	6 Mean Length cm	N
0	17.89	6	27.01	2	26.90	1		
1 - 10	21.95	15	28.04	9	31.02	5		
11 - 20	25.35	2	28.53	4	30.50	2		
21 - 30	23.50	1			27.20	1	29.70	1
31 - 40			32.60	2	38.60	1	29.10	1
41 - 50								
> 50					32.30	1		
TOTAL	21.3	24	28.6	17	31.01	11	29.4	2

It is not known whether Diphyllobothrium spp. infection in Morice Lake is a result of introduction through the Nanika River or whether it appeared independently, but the presence of gulls, copepod hosts, and salmonids will likely ensure the maintenance of the parasite.

b) Diphyllobothrium Life Cycle

The typical life cycle of Diphyllobothrium spp. involves three hosts, although in at least one species (D. norvegicum) a fourth host is probably necessary (Vik, 1964). A piscivore is the definitive host to the adult tapeworm, the eggs being shed in the feces. In water, the eggs develop into free swimming coracidia. Copepods, typically Cyclops or Diaptomus species, ingest the coracidia, which pass through the stomach wall of the copepod and encyst in the tissue of the body cavity, where the procercoid develops. When the crustacean is eaten by a host fish and digested, the procercoid passes through the wall of the alimentary tract of the fish and develops into the plerocercoid, which may encyst in the caecal wall, mesentary, or other abdominal tissue. With continuing growth, the plerocercoid may eventually break free from the cyst and become free living in the body cavity of the fish. When the fish is eaten by the primary host, the plerocercoids are released from the cyst or muscle tissue, and development into the adult cestode follows within the intestine of the host.

A number of animals have been cited as primary hosts to Diphyllobothrium spp. Most reports cite avian piscivores, predominately gulls: herring gulls (Thomas, 1946; Vik, 1964), the glaucous gull in Alaska (Hilliard, 1960), ring-billed gulls (Alexander, 1960), Bonaparte's gull (Vik, 1964), and the California gull (Matthias, 1963; Post, 1971). Becker and Brunson (1967) found that the most frequently recorded avian host in North America was the herring gull. Post (1971) has cited the American merganser and the white pelican as hosts. Among terrestrial mammals, bears have been cited in Wyoming (Post, 1971), Alaska (Rausch, 1954; Rausch and Hilliard, 1970), and British Columbia (Northcote, 1957). Humans have been cited as hosts in Alaska (Hitchcock, 1951) and in British Columbia (Margolis et al., 1973), and there are reports of human hosts from other continents (Vik, 1964; Baer, 1969). Experimental infection has been demonstrated in rats (Vik, 1964), cats (Post, 1971), and the golden hampster (Vik, 1964). Among marine mammals, infection has been reported in sea lions (Baer, 1969) and seals (Rausch, 1969; Vik, 1964).

Infection by Diphyllobothrium spp. is not necessarily fatal to fish, but it is known to cause visceral adhesions which may prevent spawning due to the blockage of ducts. Visceral adhesions may influence the survival of fish in other ways, although little is known of the physiological relationship between plerocercoid and fish. Severe mortality in rainbow trout related to *Diphyllobothrium* infection levels comparable to those found in Nanika and Kidprice Lakes was noted in three Washington lakes (Becker and Brunson, 1967).

In British Columbia, *Diphyllobothrium* infection has been reported in rainbow trout, Dolly Varden char, cutthroat trout (*S. clarki*), lake trout, sockeye salmon (*Oncorhynchus nerka*), kokanee, coho salmon (*O. kisutch*), and mountain whitefish (*Prosopium williamsoni*) (Bangham and Adams, 1954), although the levels of infection or species of *Diphyllobothrium* were not reported. Distribution of *Diphyllobothrium* in British Columbia by host species and by drainage is shown in Table 23. Plerocercoids have been found in the flesh of salmon in British Columbia (Northcote, 1957). Plerocercoids of at least one species of *Diphyllobothrium* (*D. latum*) may normally move freely in the body cavity of the host (Vik, 1964).

In the Nanika-Kidprice system, the primary hosts to adult tapeworms are not definitely known. Black bear (*Ursus americanus*) and grizzly bear (*U. arctos horribilis*) are present in the area, and it is possible that otters may be implicated. Mew gulls (*Larus canus*), which migrate to the freshwater lakes of northwestern British Columbia to nest, are abundant during the summer. Further study would be required to determine whether or not mew gulls are primary hosts. *Cyclops* spp. and *Diaptomus* spp., known secondary hosts, are the dominant copepods in the system.

5.1.5 SPORT FISHERY

Fishing pressure in Nanika Lake is reportedly light (Morley and Whately, 1974). A summary of creel census data collected at Nanika Lake in July, August, and September 1974 is given in Table 24. Angling records are incomplete since, due to the inaccessibility of the area and a lack of personnel to undertake an extensive survey, not every angler was interviewed. The catch per unit effort in Nanika Lake was calculated from the available data to be 1.8 fish per rod hour.

Table 23 Distribution of Diphyllobothrium in British Columbia by host species and by drainage (Bangham and Adams, 1954)

	DRAINAGE			
Species	Columbia	Fraser	Skeena	Coastal Streams
Mountain Whitefish	Grave Lake Wood Lake	Mabel Lake Shuswap Lake Dragon Lake		
Coho salmon			Nanika River*	Port John
Sockeye salmon			Lakelse Lake	Prudhomme Lake Port John
Kokanee	Christina Lake Goat Lake	Redfish Creek Takla Lake Shuswap Lake		
Cutthroat trout	Kiakho Lake		Lakelse Lake	Prudhomme Lake Rainbow Lake
Rainbow trout	Jewel Lake Okanagan Lake Swalwell Lake Wood Lake	Sugar Lake Face Lake Pinanton Lake Paul Lake Hihium Lake Ridge Lake Shuswap Lake Dragon Lake	Kidprice Lake* Nanika Lake* Nanika River* Morice Lake*	
Dolly Varden			Kidprice Lake* Nanika Lake* Nanika River*	Prudhomme Lake Rainbow Lake

* data from present study

Also one record for rainbow trout in Peace River drainage (Azouzetta Lake)

Table 24 Sport fishing effort and catch in Nanika Lake, 1974

Date	No. of Anglers	Rod Hours	No. of Fish
July 7	6	10.3	13
July 27	3	6.5	7
July 29	2	2	17
July 31	1	2	4
August 1	1	2	15
August 2	1	5	15
August 3	4	10	13
August 15	2	4	7
August 17	6	11	4
Sept 10	2	1.5	1
TOTALS	28	54.3	96

Fish per rod hour - 1.8

Sport angling data for Kidprice Lake is limited. Interviews with anglers in 1974 indicated a catch per unit effort of approximately 4 fish per rod hour. Fishing pressure is also reported to be light in Kidprice Lake (Morley and Whately, 1974).

5.1.6 WILDLIFE

The information on wildlife in the Nanika-Kidprice system as well as the Morice River system is based primarily on aerial and ground surveys made by Dr. D. F. Hatler of the Fish and Wildlife Branch, Ministry of Environment, and associates. Additional data consists of cursory observations made by federal and provincial personnel conducting fisheries investigations in the areas. Summaries of the wildlife observations made in the Nanika-Kidprice and Morice areas in 1974 and 1975 are provided in Appendix X.

The objectives of the periodic surveys were to identify areas of intensive wildlife use, to document seasonal distribution of the pertinent species, and to attempt to estimate the numbers of animals in the study areas. Hatler has emphasized that animal populations are dynamic, and since there are no comparable data from other years, the population figures obtained from this study may not be representative of all years. Consequently, the intention of this report is to provide an assessment of the study areas on the basis of their capabilities to support various wildlife species, rather than attempt to estimate population sizes.

For convenience of reference, the entire study area has been split into 13 blocks (Fig. 36). Most observations reported for a given block will have been made within a short distance of a designated waterway, since most of the observers' activities were concentrated in those areas.

a) Moose

It was intended that moose (Alces alces) distribution in the Nanika-Kidprice system would be documented on a monthly basis throughout the year, from July 1974 to June 1975. However, several flight cancellations (usually caused by weather) resulted in missing November, March, and a six week period between early May and mid June. General seasonal use patterns are nevertheless inferable from the surveys made (Table 25).

Moose and fresh sign seen during the aerial survey flights are listed in Table 26. Sign was observed in most areas surveyed from July 1974 through June 1975, including the subalpine meadows along the steep montane slopes west of Nanika Lake. However, it is evident that the habitats most heavily used are the river valley bottoms.

In early July 1974, two moose were seen in the Kidprice Lake area (Block 5) and sixteen moose were sighted in the Nanika-Kidprice Flats area (Block 6).

In October 1974, moose were still dispersed throughout the Nanika-Kidprice area. During that month, moose were seen at four locations high on the slopes (above snowline) west of Stepp Lake (Block 5), and four different animals were observed near the head-waters of Bergeland Creek (Block 8). Fresh sign was abundant at Spill Lake (just west of Kidprice Lake in Block 5), all along Bergeland Creek (Block 8), and in the high meadows of Creek XIX (Block 9).

By mid December, snow depths of one meter or more prevailed throughout the area (Blocks 4 - 9), and the only signs of moose were five sets of tracks at the north end of Spill Lake.

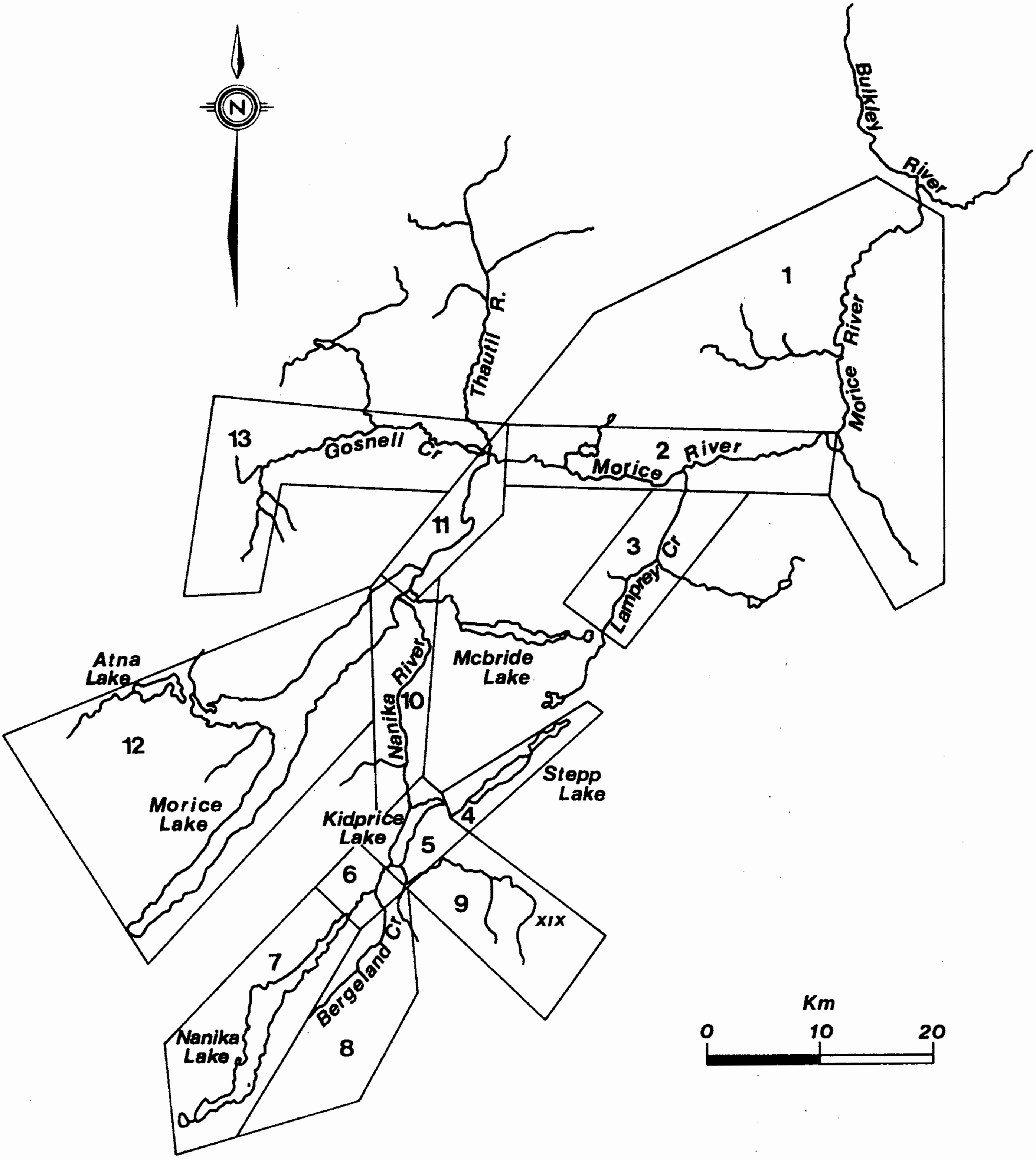


Fig. 36 Wildlife survey map. Numbers in blocks refer to block numbers in text

Table 25 List of specific wildlife surveys conducted in Kemano II area, July 1974-June 1975

Survey No.	Date	Mode	Time Spent[a]	Observers[b]	Purpose
1.	8/VII/74	Beaver Aircraft	1½ hrs	Hatler, Walker Simpson, C. Morley	Reconnaisance of Nanika-Kidprice Lakes area
2.	27-29/VII/ 74	Ground	2 days	Hatler, Morrell, Shepherd	Explore Nanika Lake area for wildlife values
3.	4-8/X/74	Ground	4 days	Hatler, A. Dorst	Ground assessments of Kidprice Lake area for bear and waterfowl capability
4.	17/XII/74	Beaver Aircraft	2¼ hrs	Hatler, Bustard, Chambers	Determine early-winter distribution of animals in Morice-Nanika area
5.	15/I/75	helicopter Bell 206B	2½ hrs	Hatler, Spalding, Whately	Same, plus explore areas to east (Nameless Creek) to look for wintering animals
6.	28/II/75	helicopter Bell 206B	2 hrs	Hatler, Bustard, Hodson	Late winter distribution
7.	2/IV/75	Beaver Aircraft	2 hrs	Hodson, Bustard, Allan	Early spring distribution
8.	1/V/75	Beaver Aircraft	2 hrs	Hatler, Bustard, Remington, Hodson	Late spring distribution
9.	11/VI/75	helicopter Bell G38-1	2½ hrs	Hatler, Hodson	Moose counts-distribution; look for bear use areas
10.	17/VI/75	helicopter Bell 206B	2 hrs[c]	Hatler, Mitchell, Tetreau	Summer distribution; Recon Gosnell Creek
11.	30/VI/75	helicopter Bell 206B	3 3/4 hrs	Hatler, Hodson	Summer distribution; look for bears

a flying times usually include ferry time to and from Smithers (45 min, or more)

b Observers: All B.C. Fish and Wildlife Branch except Morrell and Shepherd (B.C. Provincial Museum), Mitchell and Tetreau (Environment Canada) and Dorst (LGL Consulting Ltd.)

c one-half of the flying time (one hr) paid for by Environment Canada

Table 26 Aerial counts of moose in the area to be affected by the Kemano II Hydro Development, July 1974 - June 1975

Date	Block 1 Lower Morice	Block 2 Central Morice	Block 3 Lamprey Creek	Block 4 Stepp Lake	Block 5 Kidprice Lake	Block 6 Nan-Kid Flats	Block 7 Nanika Lake	Block 8 Berge-land Ck	Block 9 Name-less Ck	Block 10 Lower Nan. R.	Block 11 Upper Morice	Block 12 Morice Lake	Block 13 Gosnell Creek
July 8	X	X	X	-	2	16	-	-	X	X	X	X	X
Oct 24	X	X	X	4	*	*	X	4	*	X	X	X	X
Dec 17	21	5	10	-	*	-	-	-	-	2	-	X	X
Jan 15	20	4	22	-	-	-	X	-	-	-	-	X	X
Feb 28	5	2	4	-	-	-	X	X	X	X	X	-	-
Apr 2	*	*	*	-	-	-	X	-	X	*	*	X	X
May 1	1	X	*	-	-	-	X	X	X	-	*	X	X
Jun 11	X	X	X	6	4	15	2	X	X	X	-	X	X
Jun 17	X	2	3	3	*	9	*	2	X	-	X	X	20

The numbers in the body of the table are the number of animals seen in the blocks indicated (Fig 36); X indicates the block was not surveyed on the date indicated; an asterisk (*) indicates that no animals were seen, but fresh sign was present; a dash (-) indicates the area was surveyed, but no animals or sign were seen.

No moose or sign were observed in Blocks 4 - 9 from January through early May, 1975.

Return of moose to the Nanika-Kidprice area was first detected in mid June 1975, at which time six animals were observed along the south end of Stepp Lake (Block 4), four were seen near Spill Lake (Block 5), and an additional fifteen were counted at the north end of the Nanika-Kidprice Flats (Block 6). No moose and little sign were seen up Bergeland Creek (Block 8) or in the southern half of Nanika-Kidprice Flats (Block 6), suggesting that the animals had only recently moved in from the north. The single exceptional sighting was of a female and new born calf at Fenton Creek (west side of Nanika Lake in Block 7). Possibly this female had wintered, undetected, somewhere in that vicinity. Six days later (June 17) the moose were less concentrated, having dispersed over the entire Nanika-Kidprice Flats (Block 6) and part way up Bergeland Creek (Block 8). Most bulls had moved to the higher summer ranges while cows, especially those with calves, had remained primarily in the wetter lowlands.

Moose were sighted from July through September, 1975 in the riparian area between Nanika and Kidprice Lakes, as well as on the west side and outlet of Kidprice Lake. Moose sign was observed at Fenton Creek, along the west side of Kidprice Lake, and by Stream IX.

LeResche and Rausch (1974) experimented with counts of known numbers of moose in one square mile enclosures and showed that the most experienced observers under optimum viewing conditions saw 68 per cent of the moose present, while less experienced observers and/or less than excellent viewing conditions resulted in the observation of a smaller percentage of animals. Poor conditions pertained to snow cover being patchy or absent, thus moose in the Nanika-Kidprice area were observed only under what are considered to be poor conditions. The best that the most experienced Alaskan observers did under such conditions was 40 per cent.

The largest count in the Nanika-Kidprice area (Blocks 4 - 8) was made on June 11, 1975, when 25 adult moose were seen. Assuming maximum observer competency and experience, the estimated summer population in the Nanika-Kidprice area would be approximately 60 animals. The animals were somewhat concentrated on that date, thus this figure may be inflated. However, counts can vary significantly even within a few hours on the same day. It had been previously established that moose activity in the summer is greatest in the very early morning hours (before 0600), but the intense, low-angle light at that time makes counts difficult and unreliable. On June 11, two counts made in the Nanika-Kidprice Flats produced the following results:

	Males	Females	Calves
0720 - 0740	4	10	1
0845 - 0905	4	4	1

Within just over an hour, 60 per cent of the adult females seen on the first flight had disappeared, probably to tend calves in brushier areas. All animals seen during both counts were in open meadows.

The extensive riparian meadows in the Nanika-Kidprice Flats-lower Bergeland Creek area (Block 6, Fig. 36) serve as a locally important moose calving area, and apparently also as a concentration area in the spring prior to their dispersal into adjacent valleys and uplands. The Nanika-Kidprice and Morice systems occupy approximately 20 per cent of the area in management unit 6-9, and Nanika Kidprice Flats and the Gosnell Creek drainage are the most productive summer moose areas in the southern half of that management unit. Together they contribute 25 per cent or more of the locally important wintering population along the Morice River.

b) Other Ungulates

Ten caribou (Rangifer tarandus) were sighted on Sibola Peak (east of Nanika Lake) in May 1975, and there are known populations in the mountains to the south.

Healthy populations of mountain goats (Oreamnos americanus) occupy the alpine slopes and ridges surrounding Nanika Lake. There is a small population (about 9 animals) on a low mountain above Creek XIX at the southwest end of Kidprice Lake.

Goats occasionally move into valley bottoms. Tracks were seen in September 1973 on the shoreline of Nanika Lake (Morley and Whately, 1974), and tracks and droppings were seen on a gravel bar in Bergeland Creek in October 1974. In 1975, one goat was sighted on the west side of Kidprice Lake in May, and two goats were seen on the west side of Nanika Lake in August.

The B. C. Land Inventory ratings of ungulate capability in the Nanika-Kidprice system (Anon., 1971) are given in Table 27. Moose, caribou, and mountain goat are listed as indicator species in the area.

Table 27 B.C. Land Inventory ratings of ungulate capability in the Nanika-Kidprice system (Anon., 1971, Map 93E)

Area	Capability Rating	Ungulate Indicator Species	Limiting Factors for Ungulate Production
Nanika Lake (northeast end)	3	moose, caribou	Q
Nanika Lake (other than northeast end)		moose, caribou, mountain goat	Q,R
Nanika Lake (southwest corner)	3 (10%) 4 (90%) 5	moose caribou mountain goat	Q Q,R
Nanika River	3	moose, caribou	Q
Kidprice Lake	3	moose, caribou	Q

Q = snow depth

R = soil depth (restriction of the rooting zone)

Capability Rating = capability of land to support ungulates

1 very high

2 high

3 moderate to high

4 moderate to low

5,6,7 little or none

Mule deer (Odocoileus hemionus hemionus) tracks were seen twice in the Nanika-Kidprice area in 1974, once near Kidprice Lake and once in the Bergeland Creek area, but they appear to be uncommon in the area.

c) Black Bear

Black bears are common throughout the timbered areas of the Nanika-Kidprice system. This is good bear country, with riparian meadows to provide early spring foods, alpine snow slide areas to provide plant food in late spring and early summer, and numerous species of berry-producing plants at all elevations from valley bottom to timberline, which provide the main food upon which interior bears fatten in summer and fall.

Fresh tracks of at least two different black bears were seen within two miles of the outlet of Kidprice Lake in October, 1974. Observations of black bears in August 1975 included a sighting in the Bergeland Creek area and tracks on the beach at the south end of Kidprice Lake.

d) Grizzly Bear

In the Nanika-Kidprice area, only a single grizzly bear sighting was reported during the study period, in the pass at the head of Nanika Lake in July 1974. Other sightings have been reported in recent previous years. Hiker Peter Goruk encountered a sow and cub along the upper Nanika River, pilot Emil Mesich saw single bears, at different times, along the Nanika Lake shore (once at the mouth), and a sow with two cubs once entered the Alcan camp at the mouth of Kidprice Lake.

Several attempts were made during this study to census grizzlies in the Nanika-Kidprice area. Early morning and late evening flights covering lowland meadows and alpine slide areas in the spring failed to produce a single sighting. The technology for reliably counting grizzly bears in interior, forested areas does not exist. However, the bears are in the area, as indicated by a number of track sightings throughout the study period, including tracks observed at the north and south ends of Kidprice Lake in August and September, 1975.

The Nanika-Kidprice area supports good grizzly habitat due to its lowland spring feeding areas, abundant berries, and remoteness and inaccessibility.

e) Other Mammals

Wolves (Canis lupus) occur seasonally in the Nanika-Kidprice area. A wolverine (Gulo luscus) was seen in the Nanika-Kidprice area during one survey flight, and wolverine, marten (Martes americana), and river otter (Lutra canadensis) tracks were commonly seen in the area. Five otters were sighted at Fenton Creek in September 1975.

Old sign indicates that beaver (Castor canadensis) have occupied most of the waterbodies in the Nanika-Kidprice area. Morley and Whately (1974) indicated that the riparian areas between the lakes were heavily utilized by beavers in 1973. An old dam extends several hundred feet along the meadows around Spill Lake, and there was an active colony on Stepp Lake in 1974. There are presently few active beaver colonies in the Nanika-Kidprice area. It is probable that heavy snow in the area makes it only marginal for beaver habitat. Heavy snow forces the ice of lakes and ponds down, causing the displacement of water up into the beaver lodge and forcing the animals out of their quarters at a time of year when there are few alternative sites.

f) Birds

Of the three delta areas on the perimeter of Nanika Lake surveyed in September 1973, all had been used by waterfowl (mainly Canada geese (Branta canadensis)) for moulting and nesting (Morley and Whately, 1974). Observations in October 1974 (LGL Limited, 1974) indicated Nanika Lake was used by breeding gulls and waterfowl and appears to be used as a moulting area by a small number of Canada geese. Numerous small lakes and ponds northeast of Nanika Lake may provide habitat for breeding waterfowl (LGL Limited, 1974).

Observations of numbers and species of water birds made on Kidprice Lake in October 1974 (LGL Limited, 1974) are given in Table 28. In August 1975, Canada geese were seen near Kidprice Lake and Fenton Creek, and sign was found at the south end of Kidprice Lake and near the outlet of Nanika Lake. Mew gulls were commonly seen on Kidprice and Nanika Lakes, as well as between Fenton Creek and Stream X, in August and September, 1975.

Observations of numbers and species of water birds made on Spill Lake in 1974 (LGL Limited, 1974) indicated it may provide suitable breeding habitat for water birds.

Table 28 Water Birds Sighted on Kidprice Lake, October 4 to 8, 1974 (LGL Limited, 1974)

Species	Date			
	October			
	4	6	7	8
Common loon	0	0	1	1
Arctic loon	0	3	0	0
Western grebe	0	0	18	0
Red-necked grebe	12	4 - 11	26+	0
Horned grebe	0	2	1	0
Canada goose	0	0	18	0
Common goldeneye	0	0	0	1
Goldeneye species	1 (female)	0	1 (female)	0
Mallard	0	0	2	0
Herring gull	0	0	1	0
Gull species	0	0	6	0

Bald eagles (Haliaetus leucocephalus) were sighted twice in the Nanika-Kidprice area in 1975, once above Nanika Falls in August and once near Spill Creek in September. There was a sighting of five grouse (species unknown) in the heavy forest between Kidprice and Spill Lakes in August, 1975.

5.1.7 RECREATION

Access to Nanika Lake is limited to float plane or hiking in via a 13 km pass from southwest Morice Lake. There are no permanent residences in the area, but a number of beaches and camp areas are located around Nanika Lake. The lake is suitable for small boating. Morley and Whately (1974) indicated that a considerable number of people (primarily residents of the Smithers area) hike in to Anzac Lake, pick up their canoes and supplies which have been flown in, then canoe Stepp, Kidprice, and Nanika Lakes.

Kidprice Lake is accessible by plane or by hiking in from Morice Lake via the Nanika River. Local residents travel by snowmobile via Lamprey Creek to Anzac, Stepp, and Kidprice Lakes in the winter. There is some small boat use of Kidprice Lake, including canoeing, as indicated above. There are no permanent residences in the area.

The B. C. Land Inventory classifications of the recreational capability of lands in the Nanika-Kidprice system (Anon., 1972b) are given in Table 29. As indicated in the table, angling is the most popular recreational activity, supplemented by camping, canoeing, and scenic viewing.

Due to the abundance of wildlife in the Nanika-Kidprice area, big game hunting is also an important recreational activity. Moose is the main animal hunted, with less emphasis on mountain goat and bear.

5.2 MORICE SYSTEM

The Morice system, for the purpose of this report, is defined as the waters below the outlet of Kidprice Lake, including the lower Nanika River, Morice, McBride, and Atna Lakes, the Morice River, and all associated tributaries.

Table 29 B.C. Land Inventory classifications of the recreational capability of lands in the Nanika-Kidprice system (Anon., 1972b, Map 93E)

Area	B.C.L.I. Classification	Type of Recreation Available	Comments
Nanika Lake (approx. 2 miles of shoreline)	2	Angling, camping, scenic viewing	High capability for outdoor recreation
Remainder of Nanika Lake and the area between Nanika and Kidprice Lakes	4 (50%)	Angling, scenic viewing, observing wetland wildlife	Moderate to low recreational capability
Kidprice Lake	6 (60%)	Angling, observing wildlife, boating	Moderately low to low capability
	5 (40%)	Family lodging use, angling, observing wildlife	

5.2.1 LIMNOLOGY

Morice Lake reaches depths of 60 m over most of its area. Depths of 150 m have been recorded in the centre and in the south arm. The maximum depth of Morice Lake is believed to be between 236 and 300 m, and its mean depth is 100 m (Brett and Pritchard, 1946).

A discharge recording station has been operated on the Morice River by the Inland Waters Directorate of the Canada Department of the Environment since September, 1961. Data obtained at Morice Gauging Station No. 08ED002 indicate the average mean annual discharge at the outlet of Morice Lake from 1962 to 1972 was 2777 cfs, and from 1973 to 1976 inclusive was 2672 cfs. The mean low flow (January through April) in the Morice River from 1962 to 1972 was 802 cfs, and the mean summer flow (May through July) for the same years was 5315 cfs.

Summer surface temperatures in Morice Lake approximate 14°C, and temperatures at 60 m rarely rise above 5°C. The maximum surface temperature recorded in the lake in 1974 was 12.7°C in August, and a trend of warmer temperatures towards the northeastern end of the lake was noted (Anon., 1979, Vol. 4).

Maximum temperatures of about 13°C (min. 10°C) occur in the lower Nanika River below Nanika Falls in September and decline to about 6°C in October (Anon., 1975a).

In October 1975, the water temperature in the Atna River was 4.5°C, and the water transparency was sufficient to observe the river bottom (depths of 0.5 to 1.5 m) most of the time. Water transparency in Atna Lake at that time was low (Secchi depth - 1.8 m).

Dissolved oxygen levels in Morice Lake were high (90 - 100% saturation) in samples taken to 50 m depth in July, September, December 1974, and May 1975 (Anon., 1979, Vol. 4). Water transparencies ranged from 2.0 m in July 1974 to 9.75 m in September 1974 (Anon., 1979, Vol. 4).

A survey of the chemical parameters of Morice Lake was conducted at 0.5 m depth at three stations on a monthly basis throughout the summer and winter months of 1974 and 1975 (Anon., 1979, Vol. 4). The mean total residue (or total dissolved solids) value in 1975 was 40.3 mg/l (Anon., 1979, Vol. 4). This low level indicates the oligotrophic nature of the lake.

Very low phytoplankton abundance and a low number of species and total abundance of zooplankton were found in Morice Lake in the summer months of 1974 and 1975 (Anon., 1979, Vol. 4). The lake is silted, and it supports a sparse amount of aquatic vegetation (Brett and Pritchard, 1946).

5.2.2 SPAWNING AND REARING AREAS

In the Morice River, from about 1.5 to 4.8 km downstream from Morice Lake, there is an estimated 22,300 m^2 of excellent spawning gravel (from 5 to 13 cm in diameter), with ridges perpendicular to the direction of flow (Pinsent and Chudyk, 1973).

From a population viewpoint, the Morice and Bulkley River steelhead runs should be considered as one, since about 90 per cent of the steelhead which ascend the Bulkley River spawn at the head of the Morice River (Pinsent and Chudyk, 1973). Pinsent and Chudyk (1973) found that the Morice system steelhead utilize spawning gravels in both the Morice River and its tributaries (Fig. 8). The total Morice-Bulkley system steelhead population prior to angling pressure is currently estimated to be about 1500-3000 fish (M. Whately, pers. comm.).

Data (Anon., 1975a) indicate that the major spawning area for chinook salmon (O. tshawytscha) is the upper 2 km of the Morice River, with minor areas in the Morice River 10 to 11 km below the outlet of Morice Lake. Other spawning areas occur just upstream of Gosnell Creek and in the lower Nanika River upstream of Glacier Creek (Fig. 8). Juvenile chinook salmon migrate from the Morice River to Morice Lake to rear(Anon., 1975a).

Coho salmon spawning grounds are generally in the smaller tributaries of Morice Lake and the Morice River. Juvenile and spawning adult coho have been observed in Owen Creek (Pinsent, 1969). Two adult coho were caught in the lower Nanika River below Nanika Falls in 1975, and five coho were seen in the Atna River 2 to 3 km above Atna Lake in November 1974 (Anon., 1975a). Juvenile coho were observed in McBride Creek (Anon., 1975a), and McBride Lake provides rearing habitat for juvenile coho (Burns and Grosjean, 1974).

Major sockeye salmon spawning grounds are located at the south end of Morice Lake and in the lower Nanika River for 2 km below Nanika Falls (Anon., 1979, Vol. 5).

Little is known of the spawning areas utilized by resident sport fish in the Morice system. The spawning gravels from about 1.5 to 2.5 km below Nanika Falls have been estimated to represent 80 per cent of the total spawning area in the lower Nanika River (Anon., 1975b). It is thought that rainbow trout and possibly Dolly Varden char may utilize these spawning areas, and they may both spawn in McBride Creek. The majority of the tributaries to

Morice Lake are steep and glacial, and are probably too silty for spawning utilization by rainbow trout. Atna Falls may present an impassable barrier to rainbow trout and Dolly Varden char. Observations of silt load in the Atna River indicate the river is probably unsuitable for rainbow trout spring spawning. In summary, the lower Nanika River, possibly McBride Creek, and the shallow section of Morice Lake near the outlet seem likely to be the major spawning grounds for rainbow trout and Dolly Varden char.

An adult cutthroat trout population exists in McBride Lake (Burns and Grosjean, 1974), and cutthroat trout probably utilize gravels in McBride Creek for spawning.

Lake trout likely utilize beach gravels in Morice Lake, but their spawning areas are not known.

In the Morice River, resident Dolly Varden char and mountain whitefish increase in numbers on the spawning grounds concurrent with the arrival of chinook salmon in the fall (Taylor and Seredick, 1968b). Taylor and Seredick (1968b) found that this is likely due to feeding patterns, since the stomachs contained large numbers of eggs. They reported the presence of Dolly Varden fry high up in small tributary streams. Mountain whitefish spawn in late fall or early winter, but little is known of their spawning behaviour (Scott and Crossman, 1973).

5.2.3 SPORT FISHERY

Morice Lake supports populations of Pacific salmons, rainbow trout, steelhead, lake trout, cutthroat trout, Dolly Varden char, pygmy whitefish (*P. coulteri*), lake whitefish (*Coregonus clupeaformis*), longnose sucker, and cottids (Anon., 1975a).

Catch data were collected from Morice Lake from 1961 to 1967, omitting 1963 (Taylor, 1968). The average catch per unit effort over the six year period was 0.36 fish per hour, with rainbow and steelhead trout the most abundant species caught (Taylor, 1968). Trolling catch data were collected from Morice Lake in 1975 (Appendix VII). These catches were comprised mainly of rainbow trout, with one Dolly Varden char caught off the mouth of the lower Nanika River.

The lower Nanika River, below Nanika Falls (Fig. 37), supports a sport fishery for resident rainbow trout and Dolly Varden char. Angling in the Nanika River below Nanika Falls in 1975 produced rainbow trout, Dolly Varden char, and coho salmon (Appendix VII).

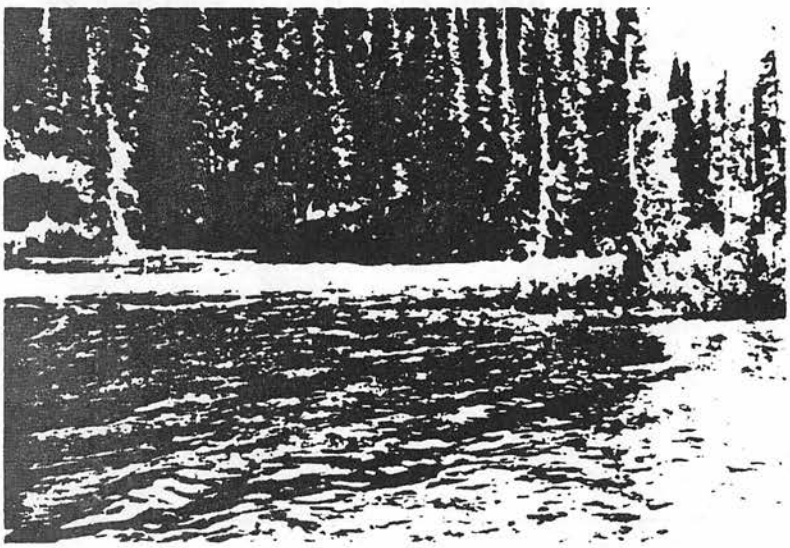


Fig. 37 Pool in the lower Nanika River, below Nanika Falls

The sport fishing success was about six fish per rod hour (Table 30). Angling success in the lower Nanika River may be due to very light fishing pressure at present. Other fish populations in the lower Nanika River and tributaries include cutthroat and steelhead trout, chinook salmon, mountain whitefish, and longnose sucker (Carswell, 1979).

Table 30 Sport fishing effort and catch in Nanika River below Nanika Falls, 1975

Date	No. of Anglers	Rod Hours	No. of Fish
July 30	1	1	5
Aug 15	1	2	11
Sept 20	1	1	7
Sept 27	1	1.5	10
Sept 28	1	1	6
Totals	5	6.5	39

Fish per rod hour - 6.0

McBride Lake supports a sport fishery for cutthroat trout, lake trout, lake whitefish, and mountain whitefish (Burns and Grosjean, 1974). Other populations in McBride Lake include ling (*Lota lota*), peamouth chub (*Mylocheilus caurinus*), and longnose sucker (Burns and Grosjean, 1974).

The Morice and Bulkley Rivers support runs of steelhead trout and coho, sockeye, chinook, pink (*O. gorbuscha*), and chum (*O. keta*) salmon. There are also resident game fish populations of rainbow trout, Dolly Varden char, cutthroat trout, and mountain whitefish.

Chinook and coho salmon, and especially steelhead trout, are the main species sought in the sport fishery (Pinsent and Chudyk, 1973). Steelhead bound for the Morice River are subjected to intense sport and Indian fisheries along the length of the Bulkley River prior to becoming available to anglers on the Morice (Whately *et al.*, 1978). Steelhead begin to appear in the Morice sport fishery in the latter part of August, and the fishery continues until freeze-up, which may occur any time after November 1 (Whately et al., 1978).

The sport fishery of the Morice River is provincially significant. In terms of reported steelhead caught and released in British Columbia, the Morice River ranked among the top eleven steelhead streams in the province from 1970 through 1978 (Anon., 1970).

Angler catch statistics from the Morice and Bulkley Rivers for the years 1970 through 1978 (Anon., 1970) are summarized in Table 31. The mean reported catch per day for the years 1970 through 1978 was 0.457 from the Morice River and 0.342 from the Bulkley River. The mean reported catch per angler over the same eight year period was 1.991 from the Morice and 1.921 from the Bulkley. The results of 1976 and 1977 creel surveys on the Morice River (Whately et al., 1978) are given in Table 32.

5.2.4 MORICE RIVER STEELHEAD

Steelhead were not included in the 1974 or 1975 field studies. However, the Morice River supports a significant steelhead population. Information on that population is summarized here from various internal Fish and Wildlife studies conducted over the past five to ten years.

Whately et al. (1978) reported that two main stocks of steelhead spawn in the Morice River system, one averaging about 1.7 kg which spends four years in fresh water and one year in salt water, and another averaging about 4.1 kg, which spends four years in fresh water and two to three years in salt water. Pinsent and Chudyk (1973) suggested that the first stock may have a lower rate of interception by commercial nets at the mouth of the Skeena River, and consequently better escapement, due to their smaller size.

Pinsent and Chudyk (1973) indicated that steelhead smolts generally migrate to the sea in July. They found that returning steelhead enter the system in late August, with the major influx occurring in October. Small numbers were recorded during December and on into late March. Taylor and Seredick (1968b) found that Morice steelhead may overwinter before spawning, with periods of up to 11 months of freshwater residence being known.

Morice River steelhead spawn during late May and June (Whately et al., 1978). Pinsent and Chudyk (1973) found that average data collected on the redd sites at the appropriate time

Table 31 Angler catch statistics from the Morice and Bulkley Rivers, 1970 - 1978 (Anon., 1970)

River	Year	Number of Anglers		Number of Angler Days		Number of Fish Angled		Catch Per Day*	Catch Per Angler**
		Rep	Est	Rep	Est	Rep	Est		
Morice	1970-71	325	1211	1130	4242	612	2007	0.542	1.883
	1971-72	390	1146	1673	4851	922	2535	0.551	2.364
	1972-73	324	1064	1309	4340	788	2463	0.602	2.432
	1973-74	280	1050	1389	5476	502	1891	0.361	1.793
	1974-75	279	804	1551	4344	429	1208	0.277	1.538
	1975-76	257	875	1286	4447	652	2179	0.507	2.537
	1976-77	241	764	987	3087	339	1148	0.343	1.407
	1977-78	302	892	1256	3836	597	1582	0.475	1.977
Bulkley	1970-71	393	1376	1839	7232	682	2622	0.371	1.735
	1971-72	397	1140	2008	6000	912	2702	0.454	2.297
	1972-73	314	1070	1735	6215	838	2864	0.483	2.669
	1973-74	302	1153	1714	6841	579	2298	0.348	1.917
	1974-75	331	922	2361	6476	634	1175	0.268	1.915
	1975-76	285	950	1900	6505	514	1795	0.270	1.803
	1976-77	319	993	1797	5856	539	1809	0.300	1.690
	1977-78	341	1021	1901	6248	458	1499	0.241	1.343

Rep = Reported
Est = Estimated

*The sum of steelhead killed and released per day (Rep)
**The sum of steelhead killed and released per angler (Rep)

Table 32 Morice River steelhead angler harvest and catch per unit effort from 1976 and 1977 creel surveys (Whately, et al., 1978)

Category	Number Anglers	Number Angler Trips	Number Angler Days	Kills	Releases	Catch per Day	Catch per Angler
a) Creel Survey 1976							
Local Residents	-	582	650	130	42	0.26	-
Other B.C. Residents	-	719	959	117	51	0.18	-
Other Canadian	-	105	142	15	1	0.11	-
Non-Canadians	-	97	220	17	21	0.17	-
Total	-	1503	1971	279	115	0.20[1]	-
b) Creel Survey 1977							
Local Residents	284	668	704	162	117	0.40	0.98
Other B.C. Residents	372	568	845	171	15	0.26	0.50
Other Canadians	58	77	80	6	2	0.10	0.14
Non-Canadians	55	114	204	77	77	0.75	2.80
Total	769	1427	1833	416	211	0.34[1]	0.82[1]

[1] Average C.U.E. for all residence categories combined

of spawning were as follows: pH 7.3, total dissolved oxygen 12 ppm, water velocity 4.5 - 5 cfs, stream gradient less than 1%, gravel 5 - 13 cm, water temperature 5.5° - 6.7°C, water visibility 100%, and water depth 0.6 - 2.4 m. They also found the critical temperature initiating spawning in Skeena drainage steelhead to be about 6°C.

5.2.5 WILDLIFE

a) Ungulates

Aerial surveys were conducted from December 1974 to June 1975 in Blocks 1 - 3 and 10 - 13, Fig. 36, to document moose distribution in the Morice system. Aerial counts are given in Table 26, and a list of observations made in the area is included in Appendix X.

In mid December, the only moose seen in Block 10, Fig. 36, were a cow and calf along the lower Nanika River near Morice Lake, although tracks indicated the presence of other animals. It is likely that at least some of these had come from the Spill Lake area.

A few moose (less than ten) remained in the lower Nanika River-Morice Lake area (Block 10) through the winter of 1975 (from January to early May). During this period, abundant moose sign and numbers of moose were observed along the Morice River, especially from its confluence with Thautil River downstream and along Lamprey Creek (Table 26, Fig. 36).

Sporadic visits to the area did not enable certain identification of the winter range of the Nanika-Kidprice moose (Section 5.1.6(a)). However, it appears that some, perhaps most, of the moose move north along Stepp Lake to Lamprey Creek and the central Morice River areas (Blocks 2 and 3), and a few individuals probably move down the Nanika River to the Morice system. Some movement may also occur out through the large valley of Creek XIX to the Nadina system.

Eighteen adult moose were seen on a June 17, 1975 survey of the Gosnell Creek drainage (Block 13), a known moose-producing area. The moose were well dispersed, providing a population estimate of about 45 animals based on the assumptions and manipulations employed in the Nanika-Kidprice estimate. As previously indicated, the Gosnell Creek and Nanika-Kidprice Flats areas are the two most productive summer moose areas in the southern half of management unit 6-9, and together they probably contribute 25 per cent or more of the locally important wintering population along the Morice River.

Healthy populations of mountain goats occupy the slopes and ridges surrounding Morice Lake. Six mountain goats were seen near the confluence of Gosnell Creek and the Morice River in September, 1974, and two goats were seen at Morice Lake near Atna Bay in May, 1975.

Mule deer summer, in small numbers, at several locations in the Morice system, up to the lower Nanika River (Block 10). From May to October, 1974, and in June, 1975, small numbers of mule deer were sighted at several locations in the Morice system.

The B. C. Land Inventory ratings of ungulate capability in the Morice system (Anon., 1971) are given in Table 33. Moose, caribou, mountain goat, and deer are listed as indicator species.

b) Other Mammals

Black bears are common throughout the timbered areas of the Morice system, as well as the Nanika-Kidprice system. The comments regarding black bear food supply in the Nanika-Kidprice system (Section 5.1.6(c)) also apply to the Morice system. Black bear sightings along the Morice River and around Morice Lake were common in 1974 and 1975. Tracks were sighted on the beach at Atna Lake in October 1975. It is likely that the Morice River system, with its runs of salmon supplementing the fall berry diet, supports as many black bears as can be expected for this area of British Columbia.

Grizzly bears were sighted on three occasions in 1974 and 1975, and tracks were observed on several occasions. Good lowland spring feeding areas and abundant berries make the Morice area good grizzly habitat. The lower Nanika River, where the grizzlies come in the fall to feed on spawning sockeye salmon, is particularly important. Most of the Morice system below the lake is lowland forest and is utilized primarily by black bears.

Wolves and coyotes (*C. latrans*) were seen in the Morice area on several occasions, and four lynx (*Lynx canadensis*) were sighted between June and August, 1974.

Furbearers (mink (*Mustela vison*), wolverine, river otter, marten, and beaver) abound in the Morice area, especially along the river. Sightings in 1974 included one wolverine on the upper Morice River, two otters in Morice Lake near McBride Creek, and three martens in the Morice Lake area. Beavers were sighted in Collins Lake, McBride Creek, and between Collins and McBride Lakes between July and October 1974, and several beaver dams and a couple of lodges were observed on McBride Creek in October 1974.

Table 33 B.C. Land Inventory ratings of ungulate capability in the Morice system (Anon., 1971, Map 93L)

Area	Capability Rating	Ungulate Indicator Species	Limiting Factor for Ungulate Production
Lower Nanika River	3	moose	Q
Morice Lake (southwest end)	3	moose	Q
Morice Lake	4	moose, caribou, mountain goat	Q,R
Morice River	3	moose, caribou, deer	Q,R

Q = snow depth

R = soil depth (restriction of the rooting zone)

Capability Rating

3 moderate to high
4 moderate to low

c) Birds

Observations of numbers and species of water birds were made in September 1974 (LGL Limited, 1974) on Morice Lake (Table 34) as well as on Collins and McBride Lakes and a small unnamed lake (Table 35). In addition to those sightings, ten trumpeter swans (Olor buccinator) were seen at the mouth of the lower Nanika River in April, 1975 (Hatler, pers. comm.).

Morice Lake occasionally provides breeding habitat for mergansers (Mergus spp.) and for at least one pair of Canada geese, although in general the area does not appear to offer attractive habitat for breeding water birds. The lake is used by migrating water birds such as loons (Gaviidae) and grebes (Podicipedidae). However, the available data do not suggest that Morice Lake is of major importance to these birds during fall migration (LGL Limited, 1974).

The Morice River does not appear to be heavily used by migrating or staging water birds, although geese may occasionally use the gravel bars along the river (LGL Limited, 1974). The Morice River appears to provide nesting habitat for mergansers only (LGL Limited, 1974).

Observations of raptors were made in the Morice area from May through September, 1974. Many bald eagles were observed around Morice Lake and the Morice and lower Nanika Rivers in August, 1974, and several were seen in the upper Morice River-Gosnell Creek area in September, 1974. Other raptors seen in the Morice area included great horned owls (Bubo virginianus), osprey (Pandion haliaetus), sharp-shinned (Accipiter gentilis) and rough-legged (Buteo lagopus) hawks, golden eagles (Aquila chrysaetos), and a falcon (species unknown). Several grouse (various species) were sighted in the Morice area from July through September, 1974.

5.2.6 RECREATION

The B. C. Land Inventory ratings of the recreational capability of the Morice system (Anon., 1972b) are given in Table 36. As seen from the table, recreation potential is relatively high in the Morice drainage.

Morice Lake is easily accessible by 84 km of road from Houston. There are camping facilities at the edge of the lake near its outlet. Angling, camping, and scenic viewing are the most popular recreational activities. Water sports and shore-based recreation are generally limited due to the cold water temperature and steep shoreline of the lake.

Table 34 Numbers and species of water birds sighted on Morice Lake, September 30, 1974 (LGL Limited, 1974)

Species	Number
Common loon	18
Arctic loon	1
Red-throated loon	33
Loon species	2
Western grebe	1
Red-necked grebe	113
Grebe species	3
Canada goose	30
Goldeneye species	5
White-winged scoter	6
Surf scoter	37
Scoter species	13
Common merganser	3
Duck species	40
Gull species (possibly herring)	8

Table 35 Numbers and species of water birds sighted on Collins, McBride, and a small unnamed lake, September 29 and 30, 1974 (LGL Limited, 1974)

Species	Date	
	September 29	September 30
	Collins Lake	
Common loon	2	2
Red-necked grebe	1	10
Surf scoter	1	0
	McBride Lake	
Common loon	0	1
Western grebe	0	10 (2 feeding)
Red-necked grebe	6	43
Horned grebe	0	1
Grebe species	1	0
Mallard	15	0
Canvasback	46	0
Ring-necked duck	6	0
Goldeneye species	1	0
White-winged scoter	0	) 92 (mostly surf)
Surf scoter	0	)
Scoter species	0	4
	Small Unnamed Lake	
White-winged scoter	4	4 (all feeding)
Surf scoter	4	5

Table 36 B. C. Land Inventory ratings of the recreational capability of the Morice system (Anon., 1972b, Map 93L)

AREA	B.C.L.I. CLASSIFICATION	TYPE OF RECREATION AVAILABLE	COMMENTS
Nanika River	4 -	Angling, canoeing, camping	Moderate capability
	2 -	Angling, canoeing, scenic viewing	High capability
Morice Lake	3 (30%) -	Camping, scenic viewing, angling	Moderately high capability
	5 (50%) -	Boating, family beach recreation scenic viewing, angling	Moderately low capability (low water temperatures discourage water sports)
Morice Lake	4 and 3 (20%)	Family lodging, angling, scenic viewing, boating	Moderately high to moderate capability
Morice River Upper Morice River	3	Angling, boating, family lodging	Moderately high capability
Conflux of the Thautil-Morice Rivers	2	Angling, camping, boating	High capability
Remainder of the Morice River	3	Angling, boating, camping, family lodging	Moderately high capability

Steelhead angling is a major attraction of the Morice River. Pinsent and Chudyk (1973) have indicated that the high recreational value of the Morice-Bulkley system sport fishery is dependent upon the fact that it is easily accessible by main provincial routes while retaining much of its wilderness appeal. It has many miles of fishable shoreline which are easily accessible, many anglers can be accommodated without over-crowding, and there is good production within the system of other species of game fish in addition to steelhead. Another attraction of the Morice River is its navigability. Canoeing, kayaking, and other types of boating are popular activities on the river.

Big game hunting is also an important recreational activity in the Morice area. The estimated number of hunter days spent by B. C. residents in the Morice area in 1976 and 1977 (Anon., 1976), as well as the estimated economic value of those recreational days (Quadra Economic Consultants Ltd., 1976), are given in Table 37. Per cent kills in the Morice area were calculated using total kill figures for management unit 6-9 and the Morice area (Anon., 1976). The percentages were then divided into the reported and estimated hunter days in the management unit (Anon., 1976) to obtain reported and estimated hunter day values for the Morice area. Economic values for each hunter day by species (Quadra Economic Consultants Ltd., 1976) were multiplied by the estimated number of hunter days in the Morice area, by species, to obtain recreational values for the area. The recreational value of moose in the Morice area was estimated to be $31,787 in 1976 and $48,252 in 1977 (Table 37). No mountain goat were harvested in the area in 1976, and the recreational value of those harvested in 1977 was $1,369 (Table 37). The total recreational value of moose and mountain goat in the Morice area in 1976 and 1977 was $81, 408. This figure excludes the economic benefits derived from the undetermined hunter days spent in the area by non-residents. Of the total number of grizzly bears that were harvested in management unit 6-9 in 1977-78 (six) and 1978-79 (three), 33 per cent were taken in the Morice area both years (Anon., 1977).

5.3 NECHAKO SYSTEM

Fish species caught during a limited gill net sampling program in Tahtsa Lake in October, 1975 (Appendix VII) included rainbow trout, kokanee salmon, mountain whitefish, and squawfish (Ptychocheilus oregonensis).

Approximately half of the gill net catches from Tahtsa Lake were comprised of rainbow trout, with mountain whitefish and kokanee each comprising about 20 per cent of the catches (Table 38). Catch per unit effort was calculated to be 1.06 fish per gill net hour (Table 38).

Table 37 Estimated hunter days (Anon., 1976), and estimated recreational values (Quadra Economic Consultants Ltd., 1976) of wildlife resources, Morice area, 1976 and 1977

Species	Year	Total kill M.U.6-9	Total kill Morice area	Per cent kill Morice area	Per cent effort Morice area[1]	Rep. hunter days M.U.6-9	Rep. hunter days Morice[2]	Est. hunter days M.U.6-9	Est. hunter days Morice[2]	Current dollar value Morice[3]
Moose	1976	109	13	12	12	2912	349	9960	1195	31,787
	1977	85	17	20	20	2245	449	9072	1814	48,252
Black Bear	1976	27	10	37	37	328	121	1038	384	*
	1977	15	5	33	33	212	71	1313	437	*
Mt. Goat	1977	18	4	22	22	217	48	332	73	1,369

1. Per cent <u>kill</u> reported in Morice area assumed to be <u>proportional</u> to per cent <u>effort</u> in Morice area.

2. Reported and estimated hunter days in Morice area assumed to be the same percentage of management unit 6-9 as the per cent kill in the area.

3. The value per hunter day is estimated to be $26.60 for moose and $18.75 for mountain goat. The estimate values are in 1976 dollars and were derived by increasing the values established in 1970-71 at a rate equal to the general rate of inflation up to 1976 (Quadra Economic Consultants Ltd., 1976).

* No value per hunter day was estimated for black bear (Quadra Economic Consultants Ltd., 1976).

Table 38 Total catch, percentage composition, and catch per unit effort (CPUE)* for total gill net catches from Tahtsa Lake, 1975

Species	October		
	No.	%	CPUE
Rainbow trout	20	55.6	0.59
Mountain whitefish	8	22.2	0.23
Kokanee	7	19.4	0.21
Squawfish	1	2.8	0.03
TOTAL	36	100.0	1.06

*CPUE is calculated as the number of fish caught per gill net hour. Nets were set for a total of 34 hours in Tahtsa Lake

The relationship of mean length and age for rainbow trout from the 1975 gill net catches (Fig. 25) suggests that the mean length and growth rate of three and four year old trout are higher in Tahtsa Lake than in Kidprice Lake, and are similar between four year old trout from Tahtsa and Nanika Lakes.

Much of the recreational potential of Tahtsa Lake has been lost as a result of Kemano I. In its present flooded condition there is virtually no beach, and consequently few places to land a boat during the frequent storms on the lake. In addition, many of the shallower areas (0 - 20 m) of the lake are characterized by large numbers of dead trees, which project from the lake surface or reach to just below the surface and pose a considerable danger to navigation.

6 ENVIRONMENTAL IMPACTS OF KEMANO II

For the purpose of discussing the environmental impacts of the Kemano II proposal, the Nanika-Kidprice system is defined as all waters above the outlet of Kidprice Lake, including Kidprice, Nanika, Stepp, Anzac, and Spill Lakes, and all associated tributaries. The Morice system is defined as all waters downstream of the outlet, including the lower Nanika River, Morice, McBride, and Atna Lakes, the Morice River, and all associated tributaries.

6.1 NANIKA-KIDPRICE SYSTEM

A 47 meter rockfill dam is proposed for approximately .8 km below the outlet of Kidprice Lake (Anon., 1972a). This dam (Nanika dam) would create a single impoundment reaching from the outlet of Kidprice to the present southern end of Nanika Lake, including Stepp Lake to the northeast and Spill Lake to the northwest. The total proposed flooded area of approximately 2,024 hectares is depicted in Figs. 5 and 6.

6.1.1 EFFECTS ON PRODUCTIVITY

An initial post-impoundment rise in productivity generally occurs in recently flooded reservoirs, due to the leaching of nutrients from newly inundated vegetation along the shoreline (Rawson, 1958). This phenonmenon would not likely occur in the Nanika basin, since the shoreline of the lake is characterized by steep beaches, cliffs, and rocky bluffs. However, inundation of the low-lying area between Nanika and Kidprice Lakes would in all probability result in some initial temporary increase in productivity in Kidprice Lake.

The number of benthic organisms in Nanika and Kidprice Lakes would be reduced as a result of increased water depths. Benthic organisms might re-establish in the flooded areas after the new littoral zone stabilized. However, colonization of any shallow marginal areas by benthic organisms would be adversely affected by operational drawdowns of the reservoir, which would expose benthic organisms to dehydration. Only the more mobile or physiologically tolerant organisms would survive. The net effect of initial impoundment would likely be an immediate and drastic decline in the abundance of littoral benthic invertebrates. Although these organisms were not represented in high numbers in the diets of adult rainbow trout and Dolly Varden char, they appeared to be important food for juveniles, as evidenced by observations of rainbow fry feeding on benthic invertebrates in the shallow areas of Kidprice Lake.

6.1.2 EFFECTS ON SPAWNING AND REARING AREAS

Under proposed impoundment conditions, a total 27.9 km of stream would be inundated. The upper Nanika River, 7.5 km in length, would be inundated by 6 to 30 m of water, and Streams XVII and XVIII (Stepp Creek), each 2.7 km in length, would also be totally inundated. Spawning gravels in those three streams and in the lower reaches of all tributaries to Nanika and Kidprice Lakes would be lost.

It is unlikely that sufficient areas of potential spawning habitat exist above the proposed flood level to replace the gravels which would be lost in the upper Nanika River. Suitable remaining habitat would be restricted to Nikun Creek (III), Fenton Creek (V), Creek XI, Bergeland Creek (XV), and Creek XIX (Table 9). However, indications are that Bergeland Creek and Creek XIX may be unsuitable for spring spawners due to high silt loads in spring and early summer. Nothing is known of the winter regimes in these creeks, so their suitability for fall spawners is not known.

There is no potential spawning habitat above existing fish migration blockages in Creeks IV, XII, and XIV, and inundation of these creeks above the blockages would not result in the development of any additional spawning habitat.

Of the existing rearing habitat in the system, 4.9 km in Bergeland Creek, 5.7 km in the upper Nanika River, and 2.2 km in Stream XVII would be eliminated (Table 9). Existing marginal shallow areas, such as those in Kidprice Lake which support macrophytic growth and provide cover for young fish, would also be inundated. The steep and rocky nature of the new shoreline would preclude any extensive littoral development.

Post-impoundment rearing habitat would be restricted to the upper reaches of Nikun Creek (III), Fenton Creek (V), Creeks XI and XIV, Bergeland Creek (XV), and Creeks XIX and XX (Table 9). Towards the northern end of the impoundment, a significant area of shallow littoral can be expected to develop around the present Spill Lake area. However, fish rearing areas must be productive of food organisms, and problems associated with reservoir drawdown would adversely affect the colonization of such areas by benthic invertebrates.

In summary, the construction of Nanika dam would result in the loss of approximately 77 per cent of the existing spawning habitat (7.38 of 9.63 km) and 80 per cent of the existing rearing habitat (17.28 of 21.46 km) in the tributaries of the Nanika-Kidprice system (these figures exclude "Mystery River" (XIX)). There would be a 69 per cent total habitat loss (spawning, rearing, and adult habitats combined) (Table 39).

6.1.3 EFFECTS ON FISH POPULATIONS

Post-impoundment conditions in Nanika Lake would provide even less habitat for pelagic or benthic organisms than presently exists. As a result, the present moderate sport fishery can be expected to decline to a lower level following impoundment.

The initial temporary rise in productivity expected to occur in Kidprice Lake may result in increased fish growth shortly after impoundment. However, the loss of spawning and rearing habitat in the system would probably result in an eventual decline in fish populations.

6.1.4 EFFECTS ON WILDLIFE

The complex of flat meadows, pools, and streams which presently exists between Nanika and Kidprice Lakes (Fig. 38) is of central importance to the wildlife in the area. This relatively extensive riparian habitat would be submerged under 6 to 30 m of water as a result of the Nanika dam construction, leaving the system with little wildlife potential. Although limited redistribution of the species in the area can be expected, their numbers would be adversely affected as a result of habitat and food supply losses.

Moose would be most affected by the inundation of Nanika-Kidprice Flats. These lowlands serve as a locally important moose calving area, and as a concentration area in spring prior to the dispersal of the animals into adjacent valleys and uplands. If proposed logging takes place in the Gosnell Creek area in the near future, with attendant problems of access and habitat loss, the Nanika-Kidprice Flats would be the only undisturbed calving area in the region.

In addition to adversely affecting habitat and food supply, flooding of the lakes could result in migration problems for moose and caribou. Although the location of these routes is presently unknown,

Table 39. Kilometers of total nabitat* 1) existing, 2) lost by flooding, and 3) remaining after flooding**

Stream	1) Total existing habitat (km)	2) Total habitat lost by flooding (km)	3) Total habitat remaining after flooding (km)
Upper Nanika River			
I	6.94	6.94	0.00
II	0.06	0.06	0.00
Nikun Creek (III)	0.52	0.08	0.44
IV	0.40	0.40	0.00
Fenton Creek (V)	1.10	0.43	0.67
VI	1.01	0.91	0.10
VII	0.24	0.00	0.24
VIII	0.00	-	0.00
IX	0.18	0.15	0.03
X	0.27	0.21	0.06
XI	0.43	0.09	0.34
XII	0.06	0.06	0.00
XIII	0.00	-	0.00
XIV	0.55	0.30	0.25
Bergeland Ck. (XV)	8.54	3.05	5.49
XVI	0.94	0.85	0.09
XVII	2.44	2.44	0.00
Stepp Creek (XVIII)	1.13	1.33	0.00
Mystery River (XIX)	+	-	+
XX	0.30	0.09	0.21
TOTAL	25.11	17.39	7.92

* Total habitat is defined as spawning, rearing, and adult habitat combined.

** Kilometers of existing habitat represent potential use by fish, rather than observed use.

+ Mystery River (XIX) was surveyed to flood level only, therefore, kilometers of existing or remaining habitat cannot be determined.

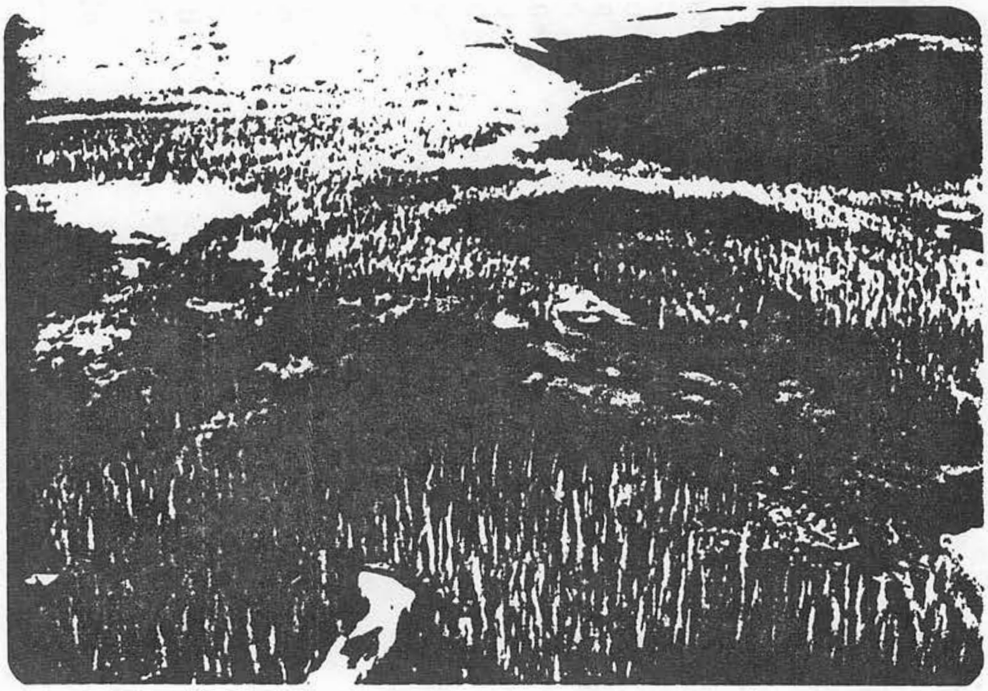


Fig. 38 Lowlands between Nanika and Kidprice Lakes

flooding of the valley bottom would impede migration from one mountain range to another. Any standing timber and debris left in the reservoir would substantially increase the barrier effect of the reservoir, increasing the losses of migrating animals. Drawdowns in winter could result in ice fracture, which would also strand migrating animals.

The Nanika-Kidprice system supports moderate numbers of black bears and an above-average density of grizzly bears. The effect of the proposal on bears is not known.

Inundation of the riparian habitat in the Nanika-Kidprice system would affect waterfowl in those areas. Flooding of the upper Nanika River could also affect raptors, particularly species such as bald eagles, which feed extensively on salmonids.

6.1.5 EFFECTS ON ANGLING, HUNTING, AND GENERAL RECREATION

A moderate sport fishery presently exists in the Nanika-Kidprice system, although it is somewhat restricted due to the difficulty of access to the area. Sport angling effort in the Nanika-Kidprice impoundment would probably increase slightly in the first few years after flooding, as a result of the increased ease of access associated with dam construction. However, effort would probably taper off as fish populations declined from the present moderate level.

Increased access and the accompanying construction activity on the Nanika River could also result in increased hunting activity, especially illegal hunting activity, with attendant pressures on wildlife populations. However, hunting success could eventually decline due to habitat and food supply losses. There is a concern that the Kidprice mountain goat population would be jeopardized despite a hunting closure there. Poachers would only have a short climb to reach the population, which is too small to absorb much hunting pressure.

Recreational activity in the Nanika-Kidprice area presently focuses around the wilderness experience which the region offers. Increased access to the area could result in excessive recreational pressure and a subsequent decline in the quality of the wilderness experience. One of the primary attractions to the area is scenic viewing, particularly of Nanika Falls (Fig. 4). This 18 m waterfall, located at the outlet of Kidprice Lake, would be obliterated by Nanika dam. It is difficult to assess the recreational value of this type of scenic attraction, but there is little question that its destruction would represent a very great loss in terms of the aesthetic appeal of the area.

6.2 MORICE SYSTEM

An 18 m concrete gravity dam is proposed for the outlet of Morice Lake (Anon., 1972a). The dam would raise water levels in Morice Lake by 6 m and flood an area of approximately 405 hectares.

6.2.1 EFFECTS ON PRODUCTIVITY

An initial post-impoundment rise in productivity is not expected to occur in Morice Lake as a result of dam construction. The shoreline is characterized by steep, rocky cliffs, and flooding would result in little inundation of nutrient rich forested areas. Effects on benthic organisms in the lake would be similar to those described for the Nanika-Kidprice system.

Reduced flows in the lower Nanika River due to the presence of the Nanika dam could result in temperature increases in the river. The net effect of such temperature increases is difficult to assess, and may even be beneficial if they resulted in an increase in primary productivity.

Construction of the Morice dam at the outlet of Morice Lake would cause severe flow reductions in the Morice River. On the basis of Inland Waters flow data, the average mean annual discharge at the outlet of Morice Lake for the years 1973 to 1976 inclusive was 2672 cfs. Assuming an average release flow of 300 cfs for fish (Table 1), the present average annual flow in the Morice River would be reduced by approximately 89 per cent.

Temperatures in the Morice River could rise due to the lower thermal capacity of its decreased water volume, increased water temperatures behind the dam, and the reduced shading effect of stream-side vegetation.

Construction of Nanika dam at the outlet of Kidprice Lake would cause severe flow reductions in the lower Nanika River. On the basis of Inland Waters flow data, the average mean annual discharge at the outlet of Kidprice Lake from 1973 to 1976 inclusive was approximately 1063 cfs. Assuming an average release flow of 83 cfs for fish (Table 1), the present average annual flow in the lower Nanika River would be reduced by approximately 92 per cent.

Since the lower Nanika is one of the major tributaries of Morice Lake, flow reduction in the river would cause proportionate reductions throughout the Morice system. On the basis of Inland Waters data, the average mean discharge for the years 1973 to 1976 inclusive was 1063 cfs at the outlet of Kidprice Lake and 2672 cfs at the outlet of Morice Lake. Based on these figures, the Nanika River presently contributes 40 per cent of the flow to the Morice River. Using the 1973 to 1976 flow data and assuming an average fish release flow of 83 cfs to the lower Nanika River (Table 1), the present average annual flow in the Morice River would be reduced by approximately 63 per cent as a result of Nanika dam construction.

Reduced flows in the Morice and lower Nanika Rivers would alter the basic productivity of aquatic food chains. Terrestrial insect drift and nutrient input would decline as the wetted areas of the rivers receded beyond the influence of streamside vegetation. Scouring and transport of gravels, caused by period high discharges, could have negative effects on stream invertebrates.

6.2.2 EFFECTS ON SPAWNING AND REARING AREAS

Raised water levels in Morice Lake would cause the loss of beach spawning areas, affecting resident fish such as lake trout and whitefish. Re-establishment of beach spawning areas would occur only partially, or not at all, due to fluctuations associated with reservoir drawdowns.

Raised water levels in Morice Lake would also inundate the lower reaches of the few tributaries presently suitable for resident sport fish spawning and rearing. The amount of stream flooded by the dam would be 1.30 km in the lower Nanika River, 2.98 km in the Atna River, and 1.56 km in McBride Creek. Remaining spawning gravels and rearing habitat would be limited due to the high gradients of the streams.

The Morice dam would also prevent the passage of anadromous fish species, specifically coho, chinook, and sockeye salmon (Anon., 1979, Vol. 5) and steelhead (C. Morley, pers. comm.) between the Morice River and Morice Lake. The provision of fish ladders would mitigate, but not likely overcome, this problem. While spawning adults may be induced to ascend a fish ladder, the situation for juveniles migrating from lake tributaries to the river may be different, since the net effect of the dam and the diversion of water from the south-western end of the lake could be a reversal of flow in the lake. Juvenile steelhead passing through Morice Lake could be forced to migrate against the current in order to find the exit at the outlet of the lake.

Reduced flows in the Morice River resulting from construction of Morice and/or Nanika dam could affect steelhead spawning. Flows may not be adequate to meet oxygen demands for egg incubation, to remove waste products, or to prevent ice from penetrating the redds. However, the greatest effect of reduced flows would probably be a decrease in the amount of rearing habitat for steelhead. Rearing habitat for the estimated 1500-3000 steelhead reported to spawn in the Morice River, the majority of which spend four years in fresh water prior to migration (Whately et al., 1978), could be a critical factor.

The Fish and Wildlife Branch is very concerned that the proposed average fish release flow of 300 cfs to the Morice River (Table 1) may not be adequate for spawning and rearing. Because Morice River steelhead spawn during late May and June (Whately et al., 1978), maintenance of sufficient flows for redd digging and spawning are especially critical at that time of year. If the Morice dam is constructed, more acceptable minimum flows may have to be guaranteed, depending on a detailed assessment of fish requirements.

The Nanika River below Nanika Falls provides important spawning and rearing habitat for rainbow trout and Dolly Varden char. Water storage during spring months could delay spawning, since freshets, which induce spawning migration (Hayes, 1953), would be eliminated. Post-impoundment reduction in flow could affect spawning conditions in the river. Flow may not be sufficient to allow access to spawning grounds, and water velocity may not be adequate to support redd building behaviour (Bovee, 1978).

The Fish and Wildlife Branch is also very concerned that the proposed average fish release flow of 83 cfs to the lower Nanika River (Table 1) may not be adequate for spawning and rearing needs. If Nanika dam is constructed, more acceptable minimum flows may have to be guaranteed, following an in-depth assessment of site specific flow requirements.

6.2.3 EFFECTS ON ANGLING, HUNTING, AND GENERAL RECREATION

The provincially significant sport fishery of the Morice River could be severely impacted by dam construction. Spawning and rearing habitat losses resulting from flow reductions could lead to significant impacts on the steelhead in the Morice-Bulkley system. Similar impacts could occur in the lower Nanika River, which presently supports a modest sport fishery for rainbow trout and Dolly Varden char.

The Nanika-Kidprice moose population winters in the Morice River-Lamprey Creek area, and Gosnell Creek is a calving area. Reduced or altered flows in the system could cause successional changes in riparian vegetation along the streams, with an adverse effect on food supplies. The flooding of Morice Lake could cause migration problems. Effects of the dams on black and grizzly bears, which exist in moderate numbers in the area, are not known. Reduced flows in the lower Nanika and Morice Rivers could affect food supplies of some raptor species.

Additional access could cause an increase in angling, hunting, and other recreational activities in the area, possibly resulting in a decline in the quality of those activities. However, angling and hunting activity would probably eventually decline due to habitat and food supply losses.

6.3 NECHAKO SYSTEM

6.3.1 EFFECTS OF DIVERSION OF WATER FROM NANIKA TO TAHTSA LAKE

As seen in Fig. 1, the Skeena and Fraser watersheds, contiguous in the study area, are historically separate. The proposed diversion of water from Nanika to Tahtsa Lake would result in the introduction of chemical and biological components of the Skeena system into the Fraser system. The Fish and Wildlife Branch considers this to be an extremely important consideration, from an ecological point of view, in any proposed diversion. Of particular concern to the Branch would be the introduction of certain stages in the life cycle of the fish tapeworm *Diphyllobothrium* from the Nanika-Kidprice to Nechako system.

Water diverted from Nanika to Tahtsa Lake at an average rate in excess of 2000 cfs would necessarily carry both coracidia and infected copepods into the Tahtsa reservoir, creating local densities of infective organisms comparable to those presently found in Nanika Lake. Copepod host species (*Diaptomus* and *Cyclops*) of *Diphyllobothrium* are abundant in Tahtsa Lake and have been noted in abundance in other lakes of the Nechako drainage (Table 40). Infection by *Diphyllobothrium* was not found in samples of rainbow trout, kokanee, and mountain whitefish taken from Tahtsa Lake in 1975. All of these species are susceptible to infection (Bangham and Adams, 1954). However, the sampling program in Tahtsa Lake was too limited (36 fish) to conclude that the parasite is absent from the lake, and a much more extensive sampling program should be undertaken to confirm the presence

Table 40 Dominant crustaceans in plankton samples from Tahtsa Lake and other lakes of the Fraser watershed (Lyons and Larkin, 1951)

Tahtsa Lake	Whitesail Lake	Sinclair Lake	Ootsa Lake	Ootsa Lake	Intata Lake	Natalkuz Lake	Eutsuk Lake	Tetachuck Lake	Euchu Lake
Aug 29	Aug 9	Aug 2	July 31	Aug 6	July 27	July 24	Aug 18	Aug 19	July 22
Diaptomus*	Daphnia*	Bosmina*	Daphnia*	Daphnia*	Cyclops	Daphnia	Diaptomus*	Daphnia	Cyclops
Bosmina	Cyclops*	Cyclops	Cyclops*	Cyclops*	Daphnia	Cyclops	Daphnia	Diaptomus	Diaptomus
Cyclops	Bosmina	Daphnia	Diaptomus	Bosmina*	Bosmina	Bosmina	Bosmina	Bosmina	Bosmina
Daphnia	Diaptomus		Bosmina	Diaptomus			Leptodora	Cyclops	Daphnia
								Leptodora	Leptodora

* indicate abundant forms

or absence of infection. It is not known to what extent significant levels of infection would spread through the Nechako drainage system or into the Gardner Canal via Kemano Power Station.

There is no known method for the eradication of Diphyllobothrium. One could speculate that the artificial introduction of significant numbers of alternative aquatic non-host organisms might reduce infection levels by offering alternative diet.

High levels of infection by another tapeworm (Ligula intestinalis) exist in longnose sucker in the Nanika-Kidprice system. No infection by L. intestinalis was found in the mountain whitefish sample from Tahtsa Lake. This fish is a notable host in which the parasite often grows to a large size, causing distension of the body cavity. Effects on mortality are not known, but the physical size of the parasite would likely affect the ability of the fish to escape natural predators. Introduction of water from Nanika Lake may cause infection of mountain whitefish in Tahtsa Lake by this parasite.

7 CONCLUSIONS

1. The proposed diversion of water from Nanika to Tahtsa Lake would result in the introduction of chemical and biological components of the Skeena system into the Fraser system. The probability of such an introduction is of great concern to the Fish and Wildlife Branch, because of the potential for parasite and disease transfer from one river system to another.

2. Construction of the proposed Nanika dam would cause severe flow reductions in the lower Nanika River, with proportionate reductions throughout the Morice system. Construction of the Morice dam at the outlet of Morice Lake, as originally proposed, would cause further flow reductions in the Morice River. The Morice River supports a significant sport fishery for steelhead. Reduced flows could adversely affect steelhead spawning, as well as reduce the amount of rearing habitat. The Fish and Wildlife Branch is very concerned that the proposed release flows for fish may not be adequate for steelhead spawning and rearing. If the proposed dams are constructed, the Branch recommends that a detailed assessment of fish flow requirements be conducted, and acceptable minimum flows for fish be guaranteed.

3. Construction of the proposed Nanika dam would result in the loss of 69 per cent of the total existing rainbow trout and Dolly Varden char habitat in the Nanika-Kidprice system. This includes a loss of approximately 77 per cent of the existing rainbow and char <u>spawning</u> habitat, 80 per cent of the existing <u>rearing</u> habitat, and 50 per cent of the existing resident <u>adult</u> habitat in the Nanika-Kidprice system. It is unlikely that a sufficient amount of spawning habitat exists above the proposed flood level to replace the habitat which would be lost.

4. Construction of the proposed Nanika dam would cause inundation of the riparian area between Nanika and Kidprice Lakes. This riparian area is of central importance to the wildlife in the Nanika-Kidprice area, serving as a moose calving and concentration area. Inundation of these lowlands would leave the system with little wildlife potential.

5. Increased access to the Nanika-Kidprice and Morice systems, as a result of dam construction, could cause excessive pressures on remaining fish and wildlife populations.

6. Nanika Falls, one of the primary scenic attractions in the area, would be obliterated by construction of the proposed Nanika dam.

7. The presently popular recreational experience of flying into the Nanika-Kidprice area and canoeing the lakes in the system would be diminished due to the loss of the wilderness appeal of the area.

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