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Preliminary Results of a Fisheries Study of Two Freshwater Lake Systems on the Tuktoyaktuk Peninsula, Northwest Territories

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PRELIMINARY RESULTS OF A FISHERIES STUDY OF TWO FRESHWATER LAKE SYSTEMS ON THE TUKTOYAKTUK PENINSULA, NORTHWEST TERRITORIES

by

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ABSTRACT

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In 1981, the Department of Fisheries and Oceans commenced a two-year study of two lake systems draining into Tuktoyaktuk Harbour on the southern Beaufort Sea coast. The purpose of the study was to determine the significance of these lake systems as fish habitat, especially for anadromous coregonids. This report presents preliminary data gathered during summer, 1981. A final report is to be produced following completion of the study in 1982.

Migrations of anadromous broad whitefish, Coregonus nasus (Pallas), lake whitefish, C. clupeaformis (Mitchill), and least cisco, C. sardinella (Valenciennes) were documented in both streams. Fish movements within the streams were monitored using two-way counting fences. The fence on Mayogiak Creek was operated from 14 June to 13 August while that on Freshwater Creek was run between 16 June and 1 September. At the fence sites data were collected describing the numbers of migrant fish, diurnal and seasonal timing of migrations, length-frequency distribution, age and growth, sex and maturity, and food habits.

Brief surveys were conducted on three lakes in each watershed to gather information on lake morphometry, water chemistry, benthic invertebrates, zooplankton, and to assess the importance of these waterbodies as fish habitat.

Key words: fishery surveys; migrations; anadromous species; whitefish, broad; whitefish, lake; cisco, least; Beaufort Sea; overwintering; feeding; Mackenzie estuary; industrial development.

RESUME

Bond, W.A., and R.N. Erickson. 1982. Preliminary results of a fisheries study of two freshwater lake systems on the Tuktoyaktuk Peninsula, Northwest Territories. Can. Data Rep. Fish. Aquat. Sci. 348: vi + 62 p.

En 1981, le ministère des Pêches et Océans entreprit une étude biennale sur deux bassins hydrographiques qui s'écoulent dans le Tuktoyaktuk Harbour, sur la côte sud de la Beaufort Sea. L'étude servira à définir l'importance de ces bassins hydrographiques en tant qu'habitat pour les poissons, notamment les corégones anadromes. Ce rapport énonce les données préliminaires recueillies pendant l'été 1981. Un rapport définitif paraîtra en 1982, lorsque l'étude sera terminée.

On a relevé des données sur la migration des corégones anadromes, soit le corégone tschir, Coregonus nasus (Pallas), le grand corégone, C. clupeaformis (Mitchill), et le cisco sardinelle, C. sardinella (Valenciennes), dans chacun des deux ruisseaux à l'aide de barrières de comptage à deux sens. La barrière du Mayogiak Creek servit du 14 juin au 13 août et celle du Freshwater Creek, du 16 juin au 1er septembre. Les données recueillies portaient sur le nombre de poissons migrateurs, l'heure et la date de leur migration, la durée et la fréquence de leurs mouvements, l'âge et la croissance des poissons, leur sexe, leur degré de maturité ainsi que leurs habitudes alimentaires.

On a effectué de courtes études sur trois lacs dans chaque bassin hydrographique pour obtenir des renseignements sur la morphométrie et l'hydrochimie des lacs, les invertébrés benthiques, le zooplancton, et l'utilisation des lacs par les poissons.

Mots-clés: études sur la pêche; migrations; espèces anadromes; corégone tschir; corégone, grand; cisco sardinelle; Beaufort Sea; hivernant(e); alimentation; estuaire du Mackenzie; aménagement industriel.

INTRODUCTION

The fish fauna of the southern Beaufort Sea coast is dominated during the summer months by anadromous coregonids, believed to be of Mackenzie River origin (Mann 1974; Craig and Mann 1974; Percy 1975; Kendel et al. 1975; Galbraith and Hunter 1975; Lawrence et al. In prep.). The nearshore area of the Tuktoyaktuk Peninsula (Fig. 1) appears to serve as a migration corridor through which these fish can gain access to important feeding, rearing, and overwintering sites located some distance from the Mackenzie itself. For some species these critical areas involve coastal bays and lagoons; this appears to be the case for Arctic cisco, Coregonus autumnalis (Pallas), and inconnu, Stenodus leucichthys (Güldenstadt). Recent studies, however, indicate that certain species of anadromous coregonid fishes migrate out of coastal waters to enter freshwater lakes located on the peninsula (Fallis et al. In prep.; Lawrence et al. In prep.). These lakes may play a major role in the maintenance of the broad whitefish, Coregonus nasus (Pallas), lake whitefish, C. clupeaformis (Mitchill), and least cisco, C. sardinella (Valenciennes), populations of the Mackenzie River.

Near the hamlet of Tuktoyaktuk (Fig. 1), the search for oil has produced a dramatic increase in the level of industrial activity in recent years and this activity is likely to increase substantially in the future. Such activities, occurring in nearshore areas, have the potential to impede the progress of fish migrations along the coastal margin and to prohibit access to areas critical to the life histories of these fish. The possibility of salinity changes as a result of major hydroelectric developments in the upper reaches of the Mackenzie watershed is also cause for concern. The effect of these activities on these important fish populations could be negative and long-term. If such negative impacts are to be minimized, it is necessary to define, more precisely than is presently possible, the details of what appear to be highly complex life history patterns. Such improved definition is the main objective of studies now being conducted in the vicinity of Tuktoyaktuk by the Department of Fisheries and Oceans.

This report presents preliminary results gathered during the first year of a two-year study, initiated in 1981, to determine the significance as fish habitat of the lake systems associated with Freshwater and Mayogiak creeks, two streams draining off the Tuktoyaktuk Peninsula into Tuktoyaktuk Harbour.

MATERIALS AND METHODS

COUNTING FENCE OPERATIONS

Two-way fish counting fences similar to those described by Fallis et al. (In prep.) were installed in Mayogiak and Freshwater creeks in mid-June, 1981, in order to monitor fish movements between Tuktoyaktuk Harbour and the lake systems of the two watersheds. Traps and fence wings were constructed of 2.54 x 2.54 cm welded wire fabric. After the first few weeks, this was covered with 0.63 cm plastic mesh to prevent gilling of smaller fish. Trapped fish were dipnetted, identified to species, and passed through the fence in the direction in which they were travelling. During periods of heavy migration, the traps were opened to permit free passage of fish, and counts and identifications were made by an observer stationed atop the trap.

Fork lengths (±1.0 mm) were obtained from as many migrant fish as possible. No fish were intentionally sacrificed during the counting fence operations; however, fish that died as a result of being gilled in the wire mesh, or for other reasons, were subjected to complete biological analysis as described below.

Mayogiak Creek

Before entering Tuktoyaktuk Harbour, Mayogiak Creek broadens into a shallow lake. The 1981 counting fence was situated approximately 1.5 km upstream of this lake (Fig. 2). At this location water levels were affected by tidal movements but the water never became salty to the taste. Mayogiak Creek was still frozen into the substrate on 7 June but was ice-free by 13 June. A functional counting fence was in place by 1800 h on 14 June. The initial fence location was very narrow, preventing side by side placement of the traps; as a consequence, the traps were set in tandem. On 29 June the traps were relocated approximately 150 m upstream. This second location was wide enough to permit the traps to be placed side by side and provided the additional advantage of a slightly higher elevation, thus reducing the effect of backflooding as a result of tidal movements.

A field camp was maintained at the Mayogiak Creek fence site from 13 June until 4 July. During this initial period trap checks were usually made every two or three hours between noon and 0200 h. Continuous monitoring was conducted at times of heavy fish movements. After 4 July the field camp was dismantled and personnel commuted between Tuktoyaktuk and the fence site on a five day per week basis until 13 August, with traps being checked four or five times daily. The traps were left open on weekends to permit free passage of fish. From 24 June on, water temperature and water level were recorded at each trap check. Temperatures were taken with a pocket thermometer while water levels were obtained from a metre stick anchored in the stream just below the first fence site.

Apart from the counting fence, fish movements were monitored on three occasions (1-2 July, 3-4 July, and 6-7 July) using hoopnets which were placed in the stream connecting lakes 1 and 2 (Fig. 2). The hoopnets employed had a 63.5 cm diameter and were constructed of #35 Delta nylon netting with 3.2 mm square openings. On each occasion two hoopnets were set, one to catch fish moving in each direction, and the nets were left for twenty-four hours. Fish were then counted and released.

Freshwater Creek

The Freshwater Creek counting fence was located approximately 8.5 km upstream from Tuktoyaktuk Harbour and about 0.5 km below the stream's outfall from the first major lake of the system (Fig. 3). At the original fence site the stream averaged about 8 m in width and 25 cm in depth while current velocity (estimated 30 August) ranged from about 0.6 to 0.8 $m \cdot s^{-1}$. Ice-out occurred on 13 June and fence installation was complete by 1500 h on 16 June. From that date a two-way fence was operated discontinuously until 13 August but, thereafter, only a downstream trap was functional.

During the course of the summer, the Freshwater fence experienced considerable down time as plant material, originating in the lakes, combined with strong current to complicate the operation. As a result of these conditions the fence required almost continuous cleaning and repairs, and on three occasions the structure had to be removed from the stream and relocated further downstream.

As a concession to the strong current, and in an effort to minimize mortalities among migrant fish, the traps were left open when not attended. Furthermore, since fish held in the traps could not withstand the current for long, most trap monitoring involved enumeration and identification of fish from above as they passed through.

Problems associated with fence operations

As indicated above, several problems were encountered during the counting fence operations on Mayogiak and Freshwater creeks. Since these problems and our success or failure in dealing with them were important in determining the results obtained, they are discussed in this report.

Tidal movements resulted in daily water level fluctuations at the Mayogiak Creek site ranging from 7 cm on 8 August to 86 cm on 7 July (Fig. 4). Occasionally, high water flooded the site reducing the flow through the traps and rendering them ineffective. At the lower site, this occurred at a gauge reading of approximately 70 cm while at the upper site the traps became ineffective at gauge readings greater than 85 cm. During the study, readings greater than 70 cm were obtained on 14 days while readings of more than 85 cm occurred six times. It is possible that some fish were able to pass around the fence at very high water levels; however, no flooding occurred during the time of most intense fish movement (prior to 27 June) and it is felt that few fish were missed as a result of flooding.

Fallis et al. (In prep.) reported that they were able to distinguish, with a high degree of accuracy, between broad whitefish, lake whitefish, and least cisco in Kukjuktuk Creek by viewing the fish from above as they passed through a trap. This method was used at Mayogiak Creek on only four days during the present study (22-25 June). At this operation, water in the trap was usually quite shallow and the gentle flow left the water surface undisturbed so that the fish could be viewed quite easily. Despite these advantages, identification to species was still difficult, probably because Mayogiak Creek fish were much smaller than those in Kukjuktuk Creek runs. It is felt, however, that this method produced acceptable results at Mayogiak Creek. At Freshwater Creek, on the other hand, where this technique was used more extensively, especially during June and July, results are considered to be less favourable. Turbulence in the traps made identification of the fish very difficult, the result being an overestimation of the number of broad whitefish and an underestimation of the number of lake whitefish and least cisco.

A problem commonly encountered when upstream and downstream runs are proceeding simultaneously is that some upstream fish inevitably get carried into the downstream trap where they are counted as downstream fish. During the present study this problem was minimized, although not completely overcome, by blocking the entrance to the downstream trap while the upstream trap was being cleared.

No problems were encountered at Mayogiak Creek as a result of current or organic material in the water. Current was a constant problem, however, at Freshwater Creek and in early July this problem was compounded by large quantities of plant material which were carried downstream from the lakes. The combination of these factors resulted in considerable down time and, no doubt, an underestimation of the number of migrant fish. Between 27 June and 18 August the fence was out of the water for a total of 14 days (26% of the time) and it was operated at less than 100% efficiency for much of the time that it was in the stream.

LAKE SURVEYS

Lake surveys, conducted on three lakes in each watershed (Fig. 2 and 3) between 22 July and 5 August provided information on lake morphometry, water chemistry, zooplankton, macrobenthos, and fish.

Bathymetry and morphometry

Outline maps for each lake were prepared by enlargement of tracings taken from 1:50 000 scale topographic maps (Canada Department of Energy, Mines and Resources, Surveys and Mapping Branch, Maps 107C/8E and 107C/8W).

Depth soundings of each lake were obtained using a Furuno FG 200 A Mk. 3 battery-powered recording echo sounder. Graphical depth profiles were produced along predetermined transects which were run at constant speed using a 5 m aluminum boat powered by a 20 HP engine. The data obtained were used to construct bathymetric maps of each lake.

Surface areas and shoreline lengths for each lake were measured directly from the outline maps using a Hewlett-Packard 9100 B calculator coupled with a Hewlett-Packard 9107 A digitizer (precision of ±1.0%). According to Franzin and McFarlane (1976) the estimated cartographic error involved in this method (through changes in scale and drafting error) is approximately 5%. They also estimated that depth measurements were subject to an error of approximately ±5%. The three error terms yield an error of about ±10% on the volume calculations. In the present study depth measurements and, therefore, volume calculations were probably subject to greater percentage errors than this because of the shallowness of the lakes. An attempt will be made in 1982 to assess this error. Morphometric parameters for each lake were calculated according to the procedures described by Hutchinson (1957).

At each lake a general description of shoreline vegetation was obtained and the nature of the substrate near the water's edge was described according to the classification of Cowardin et al. (1979); i.e., mud (clay-silt) - particles less than 0.074 mm in diameter; sand - 0.074 to 2 mm; gravel - 2 mm to 7.6 cm; cobble - 7.6 to 25.4 cm; stone - 25.4 to 61.0 cm.

Physico-Chemical

Near the deepest point of each lake, water temperature was measured at the surface and at 1 m intervals throughout the water column by means of a model 33 YSI meter, and the Secchi disc transparency was determined. Water samples were also taken at 1 m intervals using a 2 L van Dorn water bottle. Samples for analysis of dissolved oxygen were preserved in the field. Dissolved oxygen, pH, and conductivity were determined within twenty-four hours at the field laboratory in Tuktoyaktuk.

Biological

The benthic macroinvertebrate fauna was sampled at two locations in each lake (only one location in Mayogiak Lake 1) using an improved Ekman-type grab (Burton and Flannagan 1973). Dredge samples were placed in plastic bags in the field and fixed in 10% formalin. The preserved samples were later washed through a 505 µm Nitex screen. In the laboratory the animals were picked from the samples, identified to the lowest possible taxon using keys provided by Edmondson (1959), Merritt and Cummins (1978), Usinger (1971), and Pennak (1978), and enumerated. The wet weight of each taxon (±0.01 g) was then determined on a Mettler PL 1200 balance. Mollusc shells were included in the wet weights. In order to obtain an estimate of the proportion of Mollusc weight contributed by the shells, 50 *Valvata* and 10 *Lymnaea* were removed from the shells and weighed separately. Shells were found to contribute 74% of the total weight of *Valvata* and 54% in the case of *Lymnaea*.

A small (20 cm opening) Wisconsin-style plankton net constructed of 73 µm Nitex was used to sample the zooplankton in each lake. Usually two vertical hauls of the net were made at the deepest location and the samples were fixed in 5% formalin. These samples were subjected only to a qualitative evaluation to identify the species present.

Fish in the lakes were sampled by gillnets and seines. Seine hauls were usually made at two locations in each lake. The seines used were 6.1 m long and constructed of 6.4 mm nylon mesh. In each case the length of shoreline seined was recorded and captured fish were preserved in 10% formalin. The gillnets used were Swedish survey nets, 60 m long by 1.8 m deep and consisted of equal lengths of 10, 19, 33, 45, 55, and 60 mm multifilament nylon mesh (bar measure). These nets were set on the bottom at two locations in each lake (one location in Mayogiak Lake 1) and were fished for approximately two hours each. Upon lifting the nets, fish were separated according to mesh size and subjected to complete biological analysis. In each case fork length (±1.0 mm) and body weight (usually ±10 g) were recorded. Scales, otoliths, and pectoral fins were retained for age determination. Sex and maturity were determined by gonadal examination. The degree of gonadal development was described according to the following scale:

Female	Male	
1	6	Immature
2	7	Maturing
3	8	Mature
4	9	Ripe
5	10	Spent
0		Sex Indistinguishable

The stomach of each fish was removed and preserved in 10% formalin. Stomach content analysis was conducted using the volumetric point system described by Thompson (1959). Mollusc shells were included in the volume estimates. Because no partial food points were assigned, this system tends to overestimate the contribution of small animals occurring in small numbers. However, the method is rapid and appears to provide an acceptable description of the stomach contents. Results of the stomach content analysis were also expressed in terms of numbers of food organisms present and their frequency of occurrence.

Broad whitefish, lake whitefish, and least cisco were aged using scales. Several scales from each fish were mounted between two glass slides and the annuli were interpreted from the image produced by a microprojector. The assigned scale age was equal to the number of completed annuli except for fish captured in June and early July which had not yet laid down their new annulus. In such cases the fish were credited with an additional annulus.

Although scales are a favoured method for aging many fish species, the results obtained have been called into question in recent years. In cases where scale ages have been compared with those determined from other body structures, such as otoliths or fin-rays, the scale ages have often been found to underestimate fish age, especially in the older age groups. Studies comparing the results of various aging techniques for the anadromous coregonid fishes of the southern Beaufort Sea area are few. Where comparisons have been made it has been observed that there can be major discrepancies between results obtained through different aging techniques. Mann (1974) compared scale ages and otolith ages for least cisco and reported that, while results agreed closely among younger age groups, scales tended to underestimate the age of older fish. Craig and Mann (1974) reported similar results in the case of Arctic cisco. It seems likely further studies will identify the existence of a similar problem in the case of other anadromous coregonids.

Knowledge of the age structure of a fish population is fundamental to its proper management. There is an urgent need to establish the usefulness and reliability of various aging techniques for the fishes of the southern Beaufort Sea. By comparing the results obtained from scales, otoliths, and pectoral fins of broad whitefish, lake whitefish, and least cisco, this study hopes to make a contribution in this regard. To date, preliminary results from least cisco otoliths have been obtained and are presented in this report. The otoliths, where necessary, were ground by hand on a carborundum and cleared using a 3:1 mixture of benzyl benzoate and methyl salicylate. Growth zones were then identified by viewing the otolith through a dissecting microscope. Results of the fin-ray analysis and the otolith analysis for the other two species are not yet available.

RESULTS

MAYOGIAK CREEK COUNTING FENCE

A total of 31 200 fish were counted through the upstream trap at Mayogiak Creek between 14 June and 13 August 1981 (Table 1). Broad whitefish (88.2% of the total), least cisco (9.5%), and lake whitefish (2.1%) accounted for most of the migrants while small numbers of northern pike, Esox lucius Linnaeus, starry flounder, Platichthys stellatus (Pallas), and ninespine stickleback, Pungitius pungitius (Linnaeus), were also captured. During the same period 3 692 fish were taken in the downstream trap, some of which are known to have been upstream fish that had inadvertently entered the downstream trap. As in the upstream run, broad whitefish also dominated the downstream catch, accounting for 78.3% of the total (Table 1). Details for the migrations of the three coregonid species are provided in the following sections.

Broad whitefish

Timing of migrations: Upstream movement of broad whitefish began shortly after ice-out and continued throughout the study period (Fig. 5, Appendix 1). The most intense period of upstream migration occurred between 21 and 27 June when 52.5% of the run passed the fence. The main peak in the upstream run occurred during the period in which stream water temperature was increasing from near 0°C to near 10°C. A decrease in the number of upstream migrants between 25 June and 1 July coincided with a period of cold weather during which the daily maximum water temperature decreased from 14° to 9°C. After 1 July, daily counts fluctuated, producing a series of smaller peaks through the remainder of the fence operation.

Only 2 892 broad whitefish were captured in the downstream trap, these fish occurring as a number of small peaks displaying no apparent trends (Fig. 5). Most of the peaks in the downstream graph coincided with peaks in upstream movement and probably consisted, in part, of upstream fish. In actuality, therefore, the number of downstream migrants was probably closer to 2 000.

Size and age of migrants: Fork lengths were obtained for 5 035 broad whitefish captured in the upstream trap and for 2 186 captured in the downstream trap. Length-frequency distributions obtained in the measured samples (Tables 2 and 3) were applied to the total counts recorded in each of the indicated time periods to produce a theoretical overall length-frequency description of the upstream and downstream migrations (Fig. 6).

Broad whitefish in the upstream run ranged from 31 to 450 mm in fork length with two peaks occurring in the length-frequency distribution (Fig. 6). The majority of upstream fish (56.9%) were between 175 and 249 mm long while individuals in the 50 to 99 mm range represented 14.9% of the total.

The length-frequency distribution of upstream migrants varied during the course of the study (Table 2). Those captured during the first three days of the run (14-16 June) had a modal fork length in the 300 to 324 mm range. As the upstream run proceeded, the modal length of the fish decreased steadily and by the last time period (27 July to 13 August), 43.3% of all fish captured were between 50 and 74 mm.

The length-frequency distribution of broad whitefish in the downstream run differed considerably from that exhibited by upstream fish (Fig. 6). Downstream fish ranged from 69 to 490 mm but the majority (61.8%) had fork lengths between 250 and 374 mm. The smaller peak, occurring between 175 and 249 mm is believed to consist mostly of upstream fish that had gotten into the downstream trap.

As in the upstream run, the modal fork length of broad whitefish moving downstream also decreased as the run progressed (Table 3). This decrease, however, was not as pronounced as that observed among upstream fish. The modal length interval of downstream migrants decreased from 350-374 mm during the period 14-30 June to 250-274 mm between 1-13 August.

It is not entirely clear whether the large fish observed in the downstream run simply represent the return of the larger upstream migrants. In some instances this may be, and probably is, the case. Fallis et al. (In prep.) noted that the largest upstream migrants in Kukjuktuk Creek had begun to return downstream within three to four weeks and that downstream movements continued to occur throughout the summer. However, our results indicate downstream movement of larger broad whitefish during the first few days of fence operations (Table 3). In fact, between 14 and 16 June, downstream fish outnumbered upstream migrants by 128 to 73, suggesting strongly that some large broad whitefish had overwintered in lakes of the Mayogiak system.

Because our fence operation was terminated on 13 August it is not possible to say what proportion of the smaller broad whitefish (<250 mm) returned downstream. Only small numbers of such fish had been taken at the downstream trap by 13 August, many of which were, undoubtedly, upstream fish that had entered the downstream trap accidentally. At Kukjuktuk Creek, Fallis et al. (In prep.) found that large numbers of small broad whitefish remained upstream after freeze-up, indicating the existence of major overwintering areas within that watershed. The results of the present study suggest that lakes of the Mayogiak watershed may also be of importance in this regard.

Scale ages were determined for 260 broad whitefish captured at the Mayogiak Creek counting fence in 1981. Age and growth data for these fish are summarized in Table 4 and the length-frequency distributions for fish of each age group are shown in Table 5. These data are not meant to be representative of the age structure of the broad whitefish migration in this tributary. However, they do place fairly reliable limits on the size ranges to be expected in age groups 0 to 3 inclusive, and, in conjunction with age and growth data provided by other studies in the vicinity of Tuktoyaktuk (Fallis et al. In prep.; Bond 1982), provide a means of applying age criteria to the length-frequency distributions indicated in Tables 2 and 3 and in Fig. 6.

Clearly these data indicate that the major part of the upstream migration consisted of age 2 and age 3 fish and that there was a gradual decrease in the age of the migrants as the run progressed. The first young-of-the-year (53 mm) was captured on 16 July and during the period 27 July to 13 August most fish moving upstream (43.6%) were less than 75 mm in fork length and believed to belong to the 1981 year class.

The largest broad whitefish captured during the study could have been as old as 13 years, the maximum scale age reported for this species in Tuktoyaktuk Harbour (Bond 1982). However, most of the fish taken during the early stages of the upstream migration, and during the downstream run (250 - 374 mm) were likely age 4 to age 7 inclusive.

Sex and maturity of migrants: No sexually mature broad whitefish were identified during the present study. In fact, most fish were juveniles that could not be sexed in the field. Of 57 fish for which sex was determined, 31 (54.4%) were males (Table 4).

Food habits of migrants: Food habits were evaluated for 89 broad whitefish captured at the Mayogiak Creek fence site. Seventy-six were upstream migrants while 13 were captured in the downstream trap. Results of the analysis indicated little difference between the stomach contents of "upstream" and "downstream" fish (Table 6). As will be seen later, the stomach contents of broad whitefish taken at the fence site differed considerably from those of fish captured in lakes of the Mayogiak system.

Of the 89 fish examined only nine (10.1%) had empty stomachs although, based on the percentage of total food points assigned, the "average" stomach was only 37.5% full. Immature Diptera, mainly Chironomidae, dominated the stomach contents both in terms of numbers and in terms of volume (Table 6).

Least cisco

Timing of migrations: A total of 1 972 least cisco were counted through the upstream trap, of which 65.9% passed the fence between 23 and 27 June (Fig. 7, Appendix 1). Upstream movement peaked on 23 June, the same day as was the case for broad whitefish. The only other active period of upstream movement occurred between 10 and 14 July, during which time 28.9% of the run was counted.

Few least cisco were taken at the downstream trap prior to mid-July. After that date downstream activity was generally greater, although somewhat irregular (Fig. 7). Of 566 cisco taken in the downstream trap 455 (80.4%) were captured between 15 July and 13 August.

Size and age of migrants: The length-frequency distributions for 624 least cisco from the upstream migration (Table 7) and 431 cisco captured from the downstream run (Table 8) were applied to the total counts recorded in each of the indicated time periods in order to create length-frequency descriptions of the overall migrations (Fig. 8).

The overall length-frequency patterns predicted from the measured samples were virtually identical in the upstream and downstream runs (Fig. 8). In both cases the length-frequency distribution was distinctly bimodal with strong modes occurring between 100 and 174 mm and between 250 and 324 mm. Since gear selectivity was not a factor in determining length-frequency in this case, the observed pattern is considered to reflect a real situation, perhaps a weak year class.

Least cisco from the upstream run ranged in fork length from 52 to 390 mm while fish taken from the downstream trap varied from 87 to 403 mm. The early part of the upstream run was dominated by large fish (275-324 mm) but the size of the fish in the run became smaller as the migration progressed (Table 7). Between 6 and 13 August, most least cisco taken in the upstream trap (88.0%) were less than 100 mm in fork length. A similar pattern was also observed in the downstream run (Table 8).

During 1980, Bond (1982) reported a large migration of small least cisco (35-55 mm) entering Tuktoyaktuk Harbour in mid-July. That migration had peaked and apparently moved past Tuktoyaktuk Harbour by late July or early August and it was suggested that Mayogiak Creek may serve as a rearing area for these small fish. The results of the present study, however, show no indication of upstream movement of least cisco in that size range.

Scale ages were determined for 103 least cisco captured at the Mayogiak Creek counting fence in 1981. Table 9 summarizes the age and growth data for these fish while the length-frequency distributions for fish in each age group are given in Table 10. These data do not necessarily represent a random sample of the Mayogiak Creek least cisco run but are useful in attempting to interpret the length-frequency distributions indicated in Tables 7 and 8 and in Fig. 8.

Judging from the results of Table 9 and 10 and from the length-frequency distribution indicated in Fig. 8, most least cisco in the Mayogiak Creek run were either age 1 or 2 or age 5 to 7. The gap in the length-frequency distribution, alluded to earlier, seems to reflect a paucity of age 3 (mainly) and age 4 individuals. The maximum scale age observed in this study was nine years.

Preliminary results comparing scale ages with otolith ages indicate fairly close agreement among younger age classes but suggest the possibility of wide discrepancies in fish age 5 or older (Fig. 9). In almost all cases where results obtained by the two methods did not agree, the otolith age was greater than the scale age. These results emphasize the need for more definitive study in this area.

Sex and maturity of migrants: Sex and maturity were identified in 40 Mayogiak Creek least cisco, of which 31 (77.5%) were females (Table 9). The youngest mature males observed were age 4 while the youngest mature females were age 5. Bond (1982) placed the age of first spawning for Tuktoyaktuk Harbour least cisco at five years.

Food habits of migrants: The stomachs of 12 upstream least cisco were examined and 10 (83.3%) contained some food. The "average" stomach was judged to be about one-third full (Table 11). Immature Diptera occurred in virtually all stomachs containing food, contributing 65.9% of the diet in terms of numbers and 28.4% in terms of volume. The stomach of only one downstream fish was examined. This individual contained virtually no Diptera but had gorged itself on Cladocera.

Lake whitefish

Timing of migrations: Lake whitefish was the least abundant of the three anadromous species with only 658 being counted through the upstream trap. The pattern of movement was very similar to that exhibited by least cisco (Fig. 10, Appendix 1). Most of the upstream run (53.8%) occurred between 22 and 26 June and upstream movement had virtually ceased by 15 July.

By 13 August, 222 lake whitefish had passed through the downstream trap. The largest daily downstream movement occurred on 23 July when 38 fish were taken.

Size and age of migrants: Lake whitefish measured during the upstream migration (n=122) ranged in fork length from 148 to 397 mm with the majority (50.8%) being 150 to 224 mm (Table 12). Unfortunately, few fish were measured during the peak of the migration (22-26 June); however, samples taken at other times suggest that the largest fish tended to move upstream first. Between 14 and 21 June when 36 of 39 upstream fish were measured, fork lengths varied from 182 to 377 mm with 77.8% of the fish being 200 to 324 mm inclusive (modal length interval 250-274 mm). From 6 to 14 July, 52 of 222 upstream migrants were measured. These fish ranged from 148 to 397 mm with 69.2% being 150 to 224 mm inclusive (modal length interval 175-199 mm). Fork lengths of fish captured after 15 July ranged from 155 to 342 mm, the majority (56.3%) being less than 200 mm (modal length interval 150-174 mm).

By 13 August, when the fence operation was terminated, few small lake whitefish had returned downstream. Fish in the downstream run ranged in fork length from 148 to 462 mm but 92.8% of the sample exceeded 224 mm and 87.7% of the total were between 225 and 399 mm (modal length interval 300-324 mm) (Table 12).

Scale ages were assigned to only 29 lake whitefish during the present study, with ages ranging from 2 to 10 years (Table 13). Length-frequency distributions for individual age groups are presented in Table 14. Bond (1982) reported a maximum scale age of 16 years for lake whitefish in Tuktoyaktuk Harbour.

Sex and maturity of migrants: Sex and maturity were assessed for only 13 lake whitefish during the present study, of which 11 were females. Only one fish, a seven-year-old female, appeared to be capable of spawning in 1981 (Table 13).

Food habits of migrants: The stomachs of eight upstream and two downstream lake whitefish were examined for food habits (Table 15). Downstream fish had a larger volume of stomach contents (85.0% of the total possible food points assigned) than did upstream fish (23.8%). The identifiable food in the stomachs of upstream fish consisted entirely of insects, of which immature Diptera (especially Chironomidae) were the most abundant. Diptera were also abundant in the stomachs of the two downstream fish but the major food item was the amphipod, (Gammarus lacustris), which comprised 36.3% of the food in terms of numbers and 26.5% of the estimated food volume. It is assumed that the Gammarus, as well as the gastropod mollusc Lymnaea palustris were obtained in upstream lakes, where they are known to occur.

MAYOGIAK WATERSHED LAKE SURVEYS

Three lakes in the Mayogiak watershed (Fig. 2) were surveyed between 29 July and 5 August 1981. Sampling sites, shoreline vegetation, and the nature of the substrate at inshore locations are shown in Fig. 11, 12, and 13. Bathymetric maps of the three lakes are provided in Fig. 14, 15, and 16.

Limnology

Morphometric characteristics of the three lakes surveyed are summarized in Table 16 while the physical and chemical properties are shown in Table 17.

Lake 1 was the smallest of the three lakes, having a maximum length of 1.1 km, a maximum width of 0.3 km, and a surface area of just 23.6 ha. The estimated volume of 55 000 m^3 gave this lake a mean depth of 0.2 m. The shoreline development factor was calculated to be 1.5. Lake 1 differs from the other two lakes examined in that the shoreline has receded considerably since its formation, and even since 1960 (most recent NTS maps), the lake has undergone considerable reduction in size (Fig. 11) to the point where it is now little more than a marsh. The stream from Lake 2, which once entered Lake 1 at its northeast corner, now bypasses it completely, flowing directly into the outlet stream (Fig. 11). Specific conductance values for water samples from Lake 1 (763-781 $\mu S \cdot cm^{-1}$) were considerably higher than those found in the other two lakes (144-147 $\mu S \cdot cm^{-1}$).

Lake 2 has a surface area of 73.4 ha and an estimated volume of 5.44 x 10^5 m^3, giving it a mean depth of 0.7 m. The maximum depth recorded during the sounding process was 1 m although the actual maximum depth is known to be at least 2 m (Table 17). The shoreline development factor for this lake was 1.3. Clean sand and cobbles made up the substrate in most nearshore areas and the shore of the lake was lined with willows.

Water temperatures in Lake 2 on 31 July 1981 ranged from 15.0° to 16.0°C. Specific conductance (144-145 $\mu S \cdot cm^{-1}$) and dissolved oxygen (10.4 $mg \cdot L^{-1}$) were constant throughout the water column. Lake water was slightly alkaline with pH ranging from 8.15 at the surface to 8.80 at the bottom (2 m). A Secchi disc reading of 1.9 m was obtained.

Lake 3 was the largest and deepest of the three lakes surveyed. Shoreline vegetation (willows) and nearshore substrate (clean sand and cobbles) were similar to that of Lake 2. The surface area of Lake 3 is 331.4 ha and the estimated volume of 27.57 x 10^5 m^3 give it a mean depth of 0.8 m. The maximum depth recorded on the sounder was 1 m although a hole, having a depth of 3 m, was located (Table 17).

On 5 August 1981, water temperatures ranged from 10.5° to 11.0°C. Specific conductance (145-147 $\mu S \cdot cm^{-1}$), dissolved oxygen (11.0-12.0 $mg \cdot L^{-1}$), and pH (7.90-7.91) were also constant throughout the water column. Secchi disc transparency was 0.7 m.

Biology

Plankton: The plankton samples obtained from the lakes contained only small numbers of animals. Zooplankton identified included three species of Calanoid copepods, two species of Cyclopoid copepods, and four species of Cladocera (Table 18).

Benthos: Only one benthic sample was obtained from Lake 1 and this contained a single oligochaete. In Lakes 2 and 3 the benthic fauna was dominated by molluscs and chironomid larvae (Table 19). The pelecypod mollusc, *Sphaerium* sp., was the most abundant form in both lakes although apparently more numerous in Lake 2 ($789 \cdot m^{-2}$) than in Lake 3 ($65 \cdot m^{-2}$). The gastropod, *Valvata sincera helicoidea*, had densities of 258 and 43 $individuals \cdot m^{-2}$ in Lakes 2 and 3, respectively. Densities for chironomid larvae were $287 \cdot m^{-2}$ in Lake 2 and $65 \cdot m^{-2}$ in Lake 3. *Gammarus lacustris* was also taken in both lakes and appeared to be slightly more abundant in Lake 3 ($43 \cdot m^{-2}$) than in Lake 2 ($29 \cdot m^{-2}$).

Fish: Thirty-six fish were captured in gillnets from the three Mayogiak lakes, of which 34 (94.4%) were broad whitefish. Most of the broad whitefish were taken in Lake 2 (n=19) and Lake 3 (n=13). Lake whitefish (n=1) and least cisco (n=1) were captured in Lake 1 but were not taken in the other two lakes. Both species, however, as well as northern pike (n=2) were captured in hoopnets set in the stream between Lakes 1 and 2 (Fig. 11). Only three fish were captured in seines during the lake surveys; two least cisco (between 100 and 150 mm fork length) were seined from Lake 1 and a single ninespine stickleback was taken in Lake 3.

Catch and size data for fish captured by gillnets in each lake are given in Tables 20, 21, and 22. Length-frequency and age-frequency distributions for broad whitefish appear in Tables 23 and 24, respectively. Broad whitefish captured in the Mayogiak Lakes ranged in fork length from 151 to 353 mm although only two fish exceeded 300 mm. Scale ages for these fish varied from one to four years but the majority were either age 2 (n=11) or age 3 (n=18). These results coincide with those of the counting fence operation alluded to earlier as the majority of upstream migrant broad whitefish belonged to age groups 2 and 3. All 34 broad whitefish captured in the Mayogiak Lakes were sexually immature. Of 14 fish for which the sex could be identified, 11 were males.

Broad whitefish captured in the lakes had consumed a greater variety and a greater volume of food (Table 25) than had those sampled at the fence site (Table 6). Whitefish taken from the lakes had fed primarily on immature Diptera, Mollusca, Amphipoda, and Notostraca. The latter two groups would appear, on the basis of stomach contents, to be more abundant in the lakes than suggested by the results of the benthic samples taken (Table 19).

The relative importance of the major dietary items varied from lake to lake. Immature Diptera, for example, accounted for 83.0% of the food in terms of numbers for fish captured in Lake 1, but only 34.6% in Lake 2 and 14.7% in Lake 3. The corresponding values in the case of food volume were 33.3, 18.0, and 3.7%, respectively. Lake 1 fish contained no Mollusca, Amphipoda, or Notostraca; however, these food items were dominant in the stomachs of fish taken from the other two lakes (Table 25). Lawrence et al. (In prep.) also reported that the diet of broad whitefish in lakes of Richard's Island and the Tuktoyaktuk Peninsula was dominated by Gastropoda, Pelecypoda, Diptera (Chironomidae), Notostraca, and Amphipoda.

FRESHWATER CREEK COUNTING FENCE

The upstream trap at Freshwater Creek was operated from 16 June until 13 August 1981, during which time 44 194 fish were enumerated (Table 26). This number is known to be an underestimation of the actual number of fish that moved upstream. In the first place, it is known that upstream movements commenced on 13 June, immediately the stream became ice-free. Large numbers of fish were observed passing the fence site on 14 and 15 June before installation of the fence was complete. Also contributing to the underestimation was the fact that the fence, as mentioned earlier, spent 26% of the sampling period undergoing maintenance on the stream bank, and was operated at less than 100% efficiency for much of the time it was in the stream. The great majority of upstream migrants were broad whitefish although they may not have made up 97.1% of the total as indicated in Table 26. Difficulties in identification were encountered owing to the depth and turbulence of water moving through the trap. The result of this problem, we believe, was an overestimation in the case of broad whitefish and an underestimation in the case of lake whitefish and least cisco. One northern pike and two ninespine stickleback were also taken in the upstream trap.

A total of 23 406 fish were counted through the downstream trap of which broad whitefish (83.7%), lake whitefish (12.5%), and least cisco (3.8%) were the most numerous. Six pike, one lake trout, Salvelinus namaycush (Walbaum), and twelve pond smelt, Hypomesus olidus (Pallas), were also captured (Table 26). Because more fish were actually handled during the downstream phase of the operation, identifications in this case were more reliable than during the upstream run. The underestimation of numbers of downstream fish was probably less severe than in the case of upstream fish simply because little downstream activity occurred prior to mid-July. During the last half of August, the entire operation was devoted to monitoring the downstream run.

Broad whitefish

Timing of migrations: Broad whitefish in upstream migration began to pass the fence site on 14 June, very shortly after break-up. Chunks of ice were drifting downstream on that date and stream water temperature was approximately 3°C. Fish were first noticed in the stream at 1000 h and upstream movement continued without letup until 2200 h at which time it appeared that the migration had subsided. A few lake whitefish were also noted in the run but most fish were broad whitefish. Broad whitefish (and lake whitefish) continued to move upstream throughout 15 June while the traps were being installed. Periodic checks, made between 0300 and 0545 h on 16 June, indicated a concerted upstream movement continuing. At that time, numerous fish were passing through the traps even though the wings of the fence were not yet in place. For example, 35 broad whitefish were counted through the trap in one two-minute period and a later four-minute count totalled 144 fish. Between 0515 and 0545 h, 75 broad whitefish were counted through the trap as movement subsided. Fence installation was complete by 1400 h on 16 June but no fish movement was detected until after 2000 h. A total of 2 694 broad whitefish were then enumerated between 2000 h on 16 June and 0400 h on 17 June. After this initial burst, migratory activity decreased and few fish were captured between 17 and 22 June (Fig. 17, Appendix 2).

The heaviest part of the upstream migration occurred between 23 and 26 June, during which period 28 693 fish passed the fence. Another peak occurred on 5 July when 7 233 fish were counted (Fig. 17). Upstream movements were concentrated in the evening and early morning hours as most movement occurred between 1800 and 0600 h. After 5 July, upstream migrations were reduced considerably although small numbers of fish continued to move upstream through 13 August.

Very little downstream movement of broad whitefish was evident until the end of July (Fig. 17) but downstream activity increased greatly in early August. The fence was converted to a one-way (downstream) operation on 19 August in consideration of this fact. Downstream movement peaked between 23 and 25 August and then decreased abruptly.

Size and age of migrants: Broad whitefish measured during the upstream migration (n=865) ranged in fork length from 51 to 590 mm with the majority (50.6%) being in the 150 to 199 mm size range (Table 27). It was fish of this size that dominated the very heavy migration of 23 to 26 June (Fig. 17). As was the case in Mayogiak Creek, the largest broad whitefish moved upstream first and the size of upstream migrants decreased as the run progressed (Table 27). Small fish (57-73 mm), believed to be young-of-the-year, were first taken on 30 July and between 1 and 13 August; 19.5% of all fish measured were 50 to 74 mm in length.

Broad whitefish in the downstream run varied from 69 to 563 mm in fork length but, in contrast to those in the upstream run, the majority (74.8%) were large fish in the 325 to 449 mm range (Table 28). By 1 September, only 34 broad whitefish shorter than 250 mm had been measured at the downstream trap and there was no indication of a downstream run of fish of this size. It is possible that such a downstream run occurred after fence operations were terminated. On the other hand it is possible that no such run occurred as was observed in Kukjuktuk Creek by Fallis et al. (In prep.). The possibility exists that lakes of the Freshwater Creek drainage provide important overwintering sites for large numbers of small broad whitefish.

Age and growth data for broad whitefish taken in the Freshwater Creek system are summarized in Table 29 while Table 30 gives the length-frequency distributions for fish of each age group. Scale ages for broad whitefish ranged up to 13 years but it is clear that most fish taking part in the upstream migration were two- and three-year-olds. Fish of this age would account for most of the individuals between 150 and 199 mm which, as mentioned previously, dominated the upstream run. Although none was aged, small fish (57-73 mm) taken between 30 July and 13 August are believed to be young-of-the-year. It is evident that the downstream migration contained few broad whitefish younger than age 4.

Concerning the mean fork lengths indicated in Table 29 for broad whitefish of age groups 1, 2 and 3, it should be remembered that most of the fish sampled were not drawn randomly from the run but were fence mortalities. Most of these mortalities resulted from fish becoming gilled in the 2.54 x 2.54 cm fence material.

The fish most susceptible to this fate were those within the approximate size range of 150 to 224 mm. Fish smaller than 150 mm were small enough to pass through the mesh while fish greater than 224 mm were simply too large to be gilled. The effect of this is that our sample of age 1 fish probably consisted of only the very largest fish in that age group while only the smallest three-year-olds were taken.

Sex and maturity of migrants: No sexually mature broad whitefish were identified from the Freshwater Creek system during the present study. Of 113 fish for which sex was determined 51 (45.1%) were males (Table 29).

Food habits of migrants: Broad whitefish captured during migrations in Freshwater Creek had little food in their stomachs. This was true for both upstream and downstream migrants. A total of 227 stomachs were examined from upstream broad whitefish of which only 25 (11.0%) contained food. In the case of downstream migrants only 23.1% of 39 fish examined had food in their stomachs. Most of the stomachs that contained food (or appeared to contain food) were retained for more detailed laboratory analysis. Immature Diptera, mainly Chironomidae, were the most common food. Other food items included Plecoptera and Ephemeroptera nymphs, Coleptera, Gastropoda, Pelecypoda, Cladocera, Acarina, and Nematoda (Table 31).

Least cisco

Timing of migrations: A total of 1 167 least cisco were counted at the upstream trap of the Freshwater Creek counting fence (Table 26). This is believed to be an underestimation of the actual number of migrant cisco, as mentioned earlier. The largest daily counts of upstream migrants were made on 21 June (n=250), 11 July (n=170), 15 to 18 July (n=418), and 7 to 13 August (n=230) (Appendix 2).

Little downstream movement of least cisco was observed prior to 7 August. Of 878 fish taken at the downstream trap, 839 (95.6%) were captured between 7 and 30 August with peak activity occurring on 24 August (Fig. 18, Appendix 2).

Size and age of migrants: Least cisco measured during the upstream migration (n=218) ranged in fork length from 48 to 420 mm, but the length-frequency distribution varied throughout the course of the run (Table 32). Fish measured in the early stages of the migation (16-25 June) were large individuals, having a modal size range of 300 to 324 mm. During the middle phase of the run (26 June-31 July), the modal size interval was 200 to 224 mm, while in the latter stages (1-13 August) most upstream migrants were young-of-the-year in the 50 to 74 mm size range.

Fork lengths of downstream fish (n=80) varied from 107 to 345 mm, but the majority (66.3%) were large individuals in the 275 to 349 mm range (Table 33).

Based on 101 determinations, scale ages for least cisco from the Freshwater Creek system ranged from 0 (young-of-the-year) to 8. Age and growth data for these fish are summarized in Table 34 while the length-frequency distributions for fish in each age group are presented in Table 35. As indicated earlier, these fish probably do not represent a random sample from the run because of the fortuitous manner in which they were obtained.

Preliminary results comparing scale ages with otoliths ages for Freshwater Creek least cisco indicate close agreement among younger age groups but suggest the possibility of wide discrepancies in fish age 5 and older (Fig. 9).

Sex and maturity of migrants: The youngest mature male observed during the study was age 3 (Table 34). All of the least cisco considered to be sexually mature were taken in the downstream trap during August. Mature females at this time were observed to have eggs averaging approximately 1 mm in diameter. Of 52 fish for which sex was determined, 20 (38.5%) were males.

Food habit of migrants: The stomachs of least cisco captured at the Freshwater Creek fence site seldom contained food, and those with food usually contained only small quantities. Examinations were made of 40 upstream migrants of which 33 (82.5%) were empty. Stomachs of 30 downstream least cisco were examined with 19 (63.3%) being empty. Only nine least cisco stomachs were analyzed in the laboratory. These contained Diptera larvae, Plecoptera nymphs, and Cladocera (Table 36).

Lake whitefish

Timing of migrations: The difficulty encountered in identifying fish to species as they passed through the upstream trap is emphasized by the fact that only 92 lake whitefish were counted moving upstream (Appendix 2). Most of these were observed during the first three weeks of the fence operation. Many lake whitefish in the upstream run were undoubtedly identified as broad whitefish.

A total of 2 926 lake whitefish were counted moving downstream. All but eight of these were observed between 30 July and 1 September with the peak of the migration (n=846) occurring on 10 and 11 August (Fig. 18, Appendix 2).

Size and age of migrants: Lake whitefish measured during the upstream migration (n=90) ranged in fork length from 151 to 435 mm (Table 37). The data, although scanty, seem to suggest that the largest individuals moved upstream first.

In the downstream run lake whitefish (n=219) exhibited fork lengths ranging from 170 to 455 mm with most fish (68.5%) being between 325 and 424 mm (Table 37).

Scale ages, determined for 86 lake whitefish from the Freshwater Creek watershed (includes 16 fish from lakes) ranged from 3 to 11 years. Age and growth data for these fish are summarized in Table 38 while length-frequency distributions within age groups are given in Table 39.

Sex and maturity of migrants: None of the fish examined during the present study had gonadal development sufficient to indicate that they would spawn in 1981. However, one fish, captured 23 August (395 mm fork length), had well developed nuptial tubercles, structures usually found on spawning coregonids (especially males). Of 55 lake whitefish for which sex was determined, 22 (44.0%) were males (Table 38).

Food habits of migrants: Lake whitefish captured during migrations in Freshwater Creek usually had little or no food in their stomachs. Overall, the stomachs of 24 upstream and 39 downstream fish were examined of which 22 (91.7%) and 32 (82.1%), respectively, were empty. Laboratory analyses were performed on only six fish. Two upstream fish had consumed small quantities of larval Chironomidae, Gastropoda, and Nematoda. Downstream fish (n=3) had more food in their stomachs on average than the upstream fish, the most common items being Gastopoda and Notostraca (Table 40).

FRESHWATER WATERSHED LAKE SURVEYS

Three lakes in the Freshwater Creek drainage system (Fig. 3) were surveyed between 24 and 27 July 1981. The locations of sampling sites, shoreline vegetation, and the nature of the substrate at inshore locations are shown in Fig. 19, 20, and 21. Bathymetric maps of the three lakes are shown in Fig. 22, 23, and 24.

Limnology

Morphometric characteristics of the three lakes surveyed are summarized in Table 41 while the physical and chemical properties are indicated in Table 42.

Lake 1 had a maximum length of 4.0 km, a maximum width of 2.3 km, and a surface area of 560.2 ha. Its estimated volume was 43.56 x 10^5 m^3 and its mean depth was 0.8 m. The maximum depth of this lake was at least 2.25 m (Table 42) although 1.5 m was the greatest depth recorded on the sounder. The shoreline development factor was 1.7. The sediment in most areas of the lake appeared to consist of silt and sand with some areas of clean gravel. Willows lined the entire circumference of the lake.

Water temperature in Lake 1 on 27 July, 1981 ranged from 17.5° to 18.5°C. Specific conductance (162-163 $\mu S \cdot cm^{-1}$) and dissolved oxygen (10.6-10.8 $mg \cdot L^{-1}$) were constant throughout the water column. Lake water was slightly alkaline with pH ranging from 7.35 at the surface to 8.25. The Secchi disc transparency was 2.25 m.

Lake 2, with a maximum length of 6.4 km, a maximum width of 2.4 km and a surface area of 817.3 ha, was the largest of the three lakes surveyed in the Freshwater system. This lake had an estimated volume of 52.5 x $10^5 m^3$ and a mean depth of 0.6 m. Maximum depth recorded by the sounder was 1.0 m although a depth of 2.0 m was located during the survey (Table 42). Shoreline vegetation (willows) was similar to Lake 1 but the substrate in nearshore areas seemed to have more sandy areas except in the north basin where silt predominated. The shoreline development factor was 1.6.

Water temperatures on 25 July 1981, ranged from 17.5° to 18.5°C. Specific conductance was the same at the surface as at the bottom (156 $\mu S \cdot cm^{-1}$) while dissolved oxygen (10.2-10.4 $mg \cdot L^{-1}$) also varied little throughout the water column. pH values ranged from 7.95 to 8.05 and the Secchi disc transparency was 1.3 m.

Lake 3 was the smallest of the three lakes surveyed in the Freshwater system, having a maximum length of 2.0 km, a maximum width of 1.9 km, and a surface area of 180.7 ha. It was also the deepest lake investigated, with a maximum depth of 5.0 m and a mean depth of 1.2 m. The estimated volume of Lake 3 was 22.38 x 10^5 m^3. Inshore substrates along the north shore of the lake were mainly sand and cobbles while silts were found along the south shoreline. The shoreline development factor was 1.6.

Water temperature in Lake 3 ranged from 17.0° to 18.0°C. Specific conductance was 209 $\mu S \cdot cm^{-1}$) at the water surface but varied from 163 to 167 $\mu S \cdot cm^{-1}$) throughout the water column. Dissolved oxygen values obtained ranged from 10.1 to 11.1 $mg \cdot L^{-1}$ while pH varied from 8.46 to 8.60. The Secchi disc transparency was 3.8 m.

Biology

Plankton: Zooplankton identified from lakes of the Freshwater Creek system included three species of Calanoid copepods, two species of Cyclopoid copepods, and five species of Cladocera (Table 43).

Benthos: The benthic fauna of the three lakes was dominated by molluscs, annelids, chironomid larvae and amphipods (Table 44). Overall, the density of benthic organisms was considerably greater in Lake 2 ($931 \cdot m^{-2}$) and Lake 3 ($1066 \cdot m^{-2}$) than in Lake 1 ($201 \cdot m^{-2}$). *Valvata sincera helicoidea* was the single most abundant species, its density increasing from $43 \cdot m^{-2}$ in Lake 1 to $301 \cdot m^{-2}$ and $441 \cdot m^{-2}$ in Lakes 2 and 3, respectively. *Sphaerium* sp., although not found in Lake 1, was abundant in both Lakes 2 ($258 \cdot m^{-2}$) and 3 ($280 \cdot m^{-2}$).

Fish: Eighty-two fish were captured in gillnets from the three lakes, of which 60 (73.2%) were broad whitefish. Lake whitefish (18.3%), least cisco (6.1%), and northern pike (2.4%) made up the remainder of the catch. Broad whitefish was the only species taken in all three lakes. Lake whitefish were captured in Lakes 1 and 2, least cisco in Lakes 2 and 3, and northern pike only in Lake 3. Seines produced only a single ninespine stickleback in Lake 3.

Catch and size data for fish captured by gillnets in each lake are given in Tables 45, 46, and 47. Broad whitefish captured in lakes of the Freshwater system ranged in fork length from 191 to 573 mm although the majority (66.7%) were 325 to 449 mm long (Table 48). Scale ages for these fish varied from two to 13 years but most (86.4%) were 4 to 9, inclusive (Table 49). Broad whitefish taken by gillnets in lakes of the Freshwater Creek drainage were, therefore, larger and older than those captured in Mayogiak Lakes where few fish exceeded 300 mm or age 3.

Lake whitefish from Freshwater lakes (n=15) had fork lengths ranging from 266 to 412 mm (Table 50) and scale ages ranging from 4 to 11 years (Table 51).

As was the case in the Mayogiak system, stomachs of broad whitefish captured in lakes of the Freshwater Creek watershed contained a greater variety and quantity of food (Table 52) than did those sampled at the fence site (Table 31). Broad whitefish from lakes had fed predominantly on Valvata sincera helicoidea, which dominated the food in all three lakes in terms of both numbers and volume. Sphaerium sp. was the second most important food item over all while immature Diptera, Lymnaea palustris, Amphipoda, and Trichoptera larvae were also common in the food. The diet of lake whitefish (Table 53) was similar to that of broad whitefish.

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Table 1. Number of fish passed through the Mayogiak Creek counting fence, 1981.

Species	Number of Fish	
	Upstream Trap	Downstream Trap
Broad whitefish	27 514	2 892
Lake whitefish	658	222
Least cisco	2 972	566
Northern pike	9	4
Starry flounder	12	8
Ninespine stickleback	35	0
Total	31 200	3 692

Table 2. Length-frequency distribution for broad whitefish measured during different segments of the upstream migration in Mayogiak Creek, 1981.

Fork Length (mm)	14-20 June		21-30 June		1-15 July		16-24 July		27 July-13 August		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
25-49									6	0.3	6	0.1
50-74					2	0.2	12	1.4	809	43.3	823	16.3
75-99			1	0.2	22	1.7	24	2.9	527	28.2	574	11.4
100-124			5	1.0	88	6.6	160	19.1	183	9.8	436	8.7
125-149			9	1.8	159	11.9	261	31.2	180	9.6	609	12.1
150-174	15	3.0	31	6.2	175	13.1	161	19.2	96	5.1	478	9.5
175-199	66	13.3	139	27.9	384	28.8	125	14.9	35	1.9	749	14.9
200-224	140	28.2	153	30.7	308	23.1	69	8.2	16	0.9	686	13.6
225-249	92	18.6	90	18.1	128	9.6	17	2.0	6	0.3	333	6.6
250-274	37	7.5	33	6.6	40	3.0	8	1.0	8	0.4	126	2.5
275-299	28	5.7	16	3.2	14	1.1	1	0.1	2	0.1	61	1.2
300-324	40	8.1	11	2.2	5	0.4					56	1.1
325-349	35	7.1	6	1.2	4	0.3					45	0.9
350-374	20	4.0	3	0.6	2	0.2					25	0.5
375-399	10	2.0			2	0.2					12	0.2
400-424	4	0.8	1	0.2	1	0.1					6	0.1
425-449	9	1.8									9	0.2
450-474					1	0.1					1	< 0.1
475-499												
Total	496 (75.3)[1]		498 (3.3)		1 335 (24.0)		838 (86.1)		1 868 (34.4)		5 035 (18.3)	

[1] Number of measured fish as a percentage of the total number counted during the designated time period.

Table 3. Length-frequency distribution for broad whitefish measured during different segments of the downstream migration in Mayogiak Creek, 1981.

Fork Length (mm)	14-30 June		1-15 July		16-31 July		1-13 August		Total	
	N	%	N	%	N	%	N	%	N	%
50-74					2	0.3			2	0.1
75-99			3	0.4	2	0.3			5	0.2
100-124			7	0.9	11	1.7			18	0.8
125-149			11	1.4	27	4.2	1	0.3	39	1.8
150-174	6	1.4	30	3.7	26	4.0	1	0.3	63	2.9
175-199	20	4.5	106	13.2	25	3.8	6	2.1	157	7.2
200-224	41	9.3	105	13.1	28	4.3	1	0.3	175	8.0
225-249	25	5.7	65	8.1	27	4.2	12	4.1	129	5.9
250-274	33	7.5	43	5.4	92	14.2	75	25.7	243	11.1
275-299	39	8.8	40	5.0	129	19.8	74	25.3	282	12.9
300-324	44	10.0	73	9.1	119	18.3	72	24.7	308	14.1
325-349	73	16.5	121	15.1	61	9.4	25	8.6	280	12.8
350-374	84	19.0	97	12.1	52	8.0	14	4.8	247	11.3
375-399	41	9.3	45	5.6	26	4.0	7	2.4	119	5.4
400-424	16	3.6	23	2.9	4	0.6	2	0.7	45	2.1
425-449	12	2.7	26	3.2	7	1.1	2	0.7	47	2.2
450-474	8	1.8	7	0.9	8	1.2			23	1.1
475-499					4	0.6			4	0.2
Total	442 (50.8)[1]		802 (83.3)		650 (87.8)		292 (91.5)		2 186 (75.6)	

[1] Number of measured fish as a percentage of the total number counted during the designated time period.

Table 4. Mean fork length (mm), mean weight (g), maturity, sex ratio, and condition factor by age group for broad whitefish captured from Mayogiak Creek, 1981.

Scale Age (Yr.)	Number	Fork Length			Weight			Condition factor	Males		Females		Number Sex Unknown
		Mean	SD	Range	Mean	SD	Range		Number	% Mature	Number	% Mature	
0	13	71	12.4	52 - 92	4	1.9	2 - 7	0.99					13
1	74	123	18.5	89 - 162	17	8.8	6 - 45	0.92					74
2	69	176	23.5	121 - 230	57	28.3	17 - 155	1.05	8	0	8	0	53
3	92	194	25.7	152 - 304	82	56.6	40 - 450	1.11	18	0	15	0	59
4	4	274	32.4	229 - 305	269	118.1	110 - 395	1.31	1	0	1	0	2
5	5	285	61.9	188 - 354	305	179.0	60 - 550	1.31	2	0	2	0	1
6	2	339	39.6	311 - 367	565	304.1	350 - 780	1.45	2	0			
7	1	385			700						1	0	
Total	260								31	0	26	0	202

Table 5. Length-frequency distribution by age group for broad whitefish captured from Mayogiak Creek, 1981.

Fork Length (mm)	Scale Age (yr)								Total
	0	1	2	3	4	5	6	7	
50 - 74	11								11
75 - 99	5	7							12
100 - 124		40	2						42
125 - 149		28	6						34
150 - 174		6	23	17					46
175 - 199			27	47		1			75
200 - 224			8	18					26
225 - 249			3	8	1				12
250 - 274					1				1
275 - 299				1	1	2			4
300 - 324				1	1	1	1		4
325 - 349									
350 - 374						1	1		2
375 - 399								1	1
Total	16	81	69	92	4	5	2	1	270

Table 6. Food habits of broad whitefish captured at the Mayogiak Creek fence site, 1981. Results are expressed as frequency of occurrence (FO), percentage composition by number (% N), and estimated percentage composition by volume (% Vol.).

Food Item	Upstream			Downstream		
	FO	% N	% Vol.	FO	% N	% Vol.
Diptera						
Chironomidae						
Unid. larvae	89.9	97.2	53.8	90.9	88.5	32.3
Unid. pupae	2.9	0.1	0.5	9.1	0.3	1.5
Ceratopogonidae larvae	4.3	0.1	0.8	18.2	9.5	12.3
Unid. larvae	2.9	<0.1	1.2	18.2	0.9	4.6
Unid. pupae	29.0	2.0	3.3	9.1	0.6	3.1
Trichoptera larvae				9.1	0.3	7.7
Coleoptera	7.2	0.1	0.5			
Nematoda	15.9	0.4	0.8			
Unid. Animal matter	37.7		14.1	54.6		23.1
Unid. Plant material, debris, mud	53.6		24.9	45.5		15.4
Number stomachs examined		76			13	
Number stomachs empty (%)		7 (9.2)			2 (15.4)	
Total food points assigned (%)		602 (39.6)			65 (25.0)	
Total food points unassigned (%)		918 (60.4)			195 (75.0)	

Table 7. Length-frequency distribution for least cisco measured during different segments of the upstream migration in Mayogiak Creek, 1981.

Fork Length (mm)	14 June-9 July		10 July-5 August		6-13 August		Total	
	N	%	N	%	N	%	N	%
50-74			1	0.3	39	78.0	40	6.4
75-99			137	36.0	5	10.0	142	22.8
100-124			125	32.8			125	20.0
125-149	2	1.0	52	13.7			54	8.7
150-174			22	5.8	2	4.0	24	3.9
175-199	1	0.5	21	5.5	1	2.0	23	3.7
200-224	6	3.1	11	2.9	1	2.0	18	2.9
225-249	11	5.7	2	0.5			13	2.1
250-274	32	16.6	6	1.6			38	6.1
275-299	48	24.9	3	0.8	1	2.0	52	8.3
300-324	69	35.8			1	2.0	70	11.2
325-349	17	8.8	1	0.3			18	2.9
350-374	5	2.6					5	0.8
375-399	2	1.0					2	0.3
400-424								
Total	193 (10.0)[1]		381 (41.5)		50 (43.9)		624 (21.0)	

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[1] Number of measured fish as a percentage of the total number counted during the designated time period.

Table 8. Length-frequency distribution for least cisco measured during different segments of the downstream migration in Mayogiak Creek, 1981.

Fork Length (mm)	14 June-9 July		10-23 July		24 July-5 August		6-13 August		Total	
	N	%	N	%	N	%	N	%	N	%
50-74										
75-99			2	1.1					2	0.5
100-124			5	2.7	3	3.2	4	4.4	12	2.8
125-149			6	3.2	20	21.1	28	30.8	54	12.5
150-174	1	1.8	4	2.1	20	21.1	18	19.8	43	10.0
175-199	1	1.8	2	1.1	13	13.7	9	9.9	25	5.8
200-224	2	3.6	5	2.7	3	3.2	2	2.2	12	2.8
225-249	3	5.4	12	6.4	1	1.1	4	4.4	20	4.6
250-274	11	19.6	17	9.0	11	11.6	9	9.9	48	11.1
275-299	13	23.2	58	30.7	12	12.6	9	9.9	92	21.4
300-324	17	30.4	40	21.2	8	8.4	8	8.8	73	16.9
325-349	7	12.5	25	13.2	3	3.2			35	8.1
350-374	1	1.8	9	4.8	1	1.1			11	2.6
375-399			3	1.6					3	0.7
400-424			1	0.5					1	0.2
Total	56 (71.8)[1]		189 (89.6)		95 (57.6)		91 (81.3)		431 (76.1)	

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[1] Number of measured fish as a percentage of the total number counted during the designated time period.

Table 9. Mean fork length (mm), mean weight (g), maturity, sex ratio, and condition factor by age group for least cisco captured from Mayogiak Creek[1], 1981.

Scale Age (yr)	Number	Fork length			Weight			Condition factor	Males		Females		Number Sex Unknown
		Mean	SD	Range	Mean	SD	Range		Number	% Mature	Number	% Mature	
0	1	68			2			0.64					1
1	45	104	18.7	78 - 153	9	3.4	3 - 18	0.77					45
2	7	149	26.8	102 - 184	26	15.3	6 - 50	0.79					7
3	9	178	27.8	140 - 217	50	24.7	20 - 100	0.88			1	0	8
4	5	232	19.5	201 - 253	137	60.4	60 - 225	1.10	2	50	2	0	1
5	10	265	24.0	246 - 321	189	49.9	140 - 310	1.02	3	33	6	17	1
6	12	292	17.3	258 - 322	225	41.0	150 - 300	0.91	4	75	8	13	
7	12	295	20.7	255 - 323	244	70.5	150 - 375	0.95			12	42	
8	1	345			375			0.91			1	0	
9	1	319			220			0.68			1	0	
Total	103								9	56	31	23	63

[1] Includes one fish captured in Mayogiak Lake #1

Table 10. Length-frequency distribution by age group for least cisco captured from Mayogiak Creek[1], 1981.

Fork Length (mm)	Scale Age (yrs.)										Total
	0	1	2	3	4	5	6	7	8	9	
50 - 74	1	1									2
75 - 99		20									20
100 - 124		19	1								20
125 - 149		3	2	3							8
150 - 174		2	3								5
175 - 199			1	3							4
200 - 224				2	2						4
225 - 249					3	3					6
250 - 274					1	4	2	2			9
275 - 299						2	7	4			13
300 - 324						1	3	6		1	11
325 - 349									1		1
Total	1	45	7	8	6	10	12	12	1	1	103

[1] Includes one fish captured in Mayogiak Lake #1.

Table 11. Food habits of least cisco captured at the Mayogiak Creek fence site, 1981. Results are expressed as frequency of occurrence (FO), percentage composition by number (% N), and estimated percentage composition by volume (% Vol.).

Food Item	Upstream			Downstream		
	FO	% N	% Vol.	FO	% N	% Vol.
Diptera						
Chironomidae						
Unid. larvae	90.0	38.7	9.9			
Orthocladinae pupae	30.0	0.9	2.5			
Culicidae larvae	10.0	0.1	1.2			
Ceratopogonidae larvae	20.0	0.4	3.7			
Unid. larvae	10.0	0.1	1.2			
Unid. pupae	50.0	25.7	9.9	100.0	0.2	5.3
Coleoptera	10.0	0.4	2.5			
Crustacea						
Cladocera	20.0	33.4	4.9	100.0	99.8	95.0
Nematoda	10.0	0.4	1.2			
Unid. Animal matter	100.0		63.0			
Number stomachs examined		12			1[1]	
Number stomachs empty (%)		2 (16.7)			0	
Total food points assigned (%)		81 (33.8)			20 (100.0)	
Total food points unassigned (%)		159 (66.2)			0 (0 0)	

[1] The stomach of this fish contained >6500 Cladocera

Table 12. Length-frequency distribution for lake whitefish captured at the counting fence on Mayogiak Creek, 1981.

Fork Length (mm)	Upstream Trap N	Upstream Trap %	Downstream Trap N	Downstream Trap %
100-124				
125-149	1	0.8	1	0.5
150-174	24	19.7	4	2.1
175-199	18	14.8	6	3.1
200-224	20	16.4	3	1.5
225-249	9	7.4	18	9.2
250-274	17	13.9	23	11.8
275-299	14	11.5	20	10.3
300-324	10	8.2	41	21.0
325-349	4	4.1	22	11.3
350-374	3	2.5	26	13.3
375-399	2	1.6	21	10.8
400-424			7	3.6
425-449			2	1.0
450-474			1	0.5
Total	122 (18.5)[1]		195 (87.8)	

[1] Number of fish measured as a percentage of the total number counted.

Table 13. Mean fork length (mm), mean weight (g), maturity, sex ratio, and condition factor by age group for lake whitefish captured from Mayogiak Creek, 1981.

Scale Age (yr)	Number	Fork Length			Weight			Condition factor	Males		Females		Number Sex Unknown
		Mean	SD	Range	Mean	SD	Range		Number	% Mature	Number	% Mature	
0													
1													
2	1	154			42			1.15					1
3	12	171	10.3	155 - 196	56	12.3	40 - 80	1.14					12
4	1	212			100			1.05					1
5													
6	2	278	21.2	263 - 293	295	77.8	240 - 350	1.37			1	0	1
7	9	292	25.2	248 - 320	298	87.3	150 - 400	1.20	1	0	7	14	1
8													
9	3	362	21.5	338 - 380	533	104.1	450 - 650	1.13	1	0	2	0	
10	1	382			500			0.90			1	0	
Total	29								2	0	11	9	16

Table 14. Length-frequency distribution by age group for lake whitefish captured from Mayogiak Creek, 1981.

Fork Length (mm)	Scale Age (yr) 0	1	2	3	4	5	6	7	8	9	10	Total
150 - 174			1	9								10
175 - 199				3								3
200 - 224					1							1
225 - 249								1				1
250 - 274							1	1				2
275 - 299							1	2				3
300 - 324								5				5
325 - 349										1		1
350 - 374										1		1
375 - 399										1	1	2
Total			1	12	1		2	9		3	1	29

Table 15. Food habits of lake whitefish captured at the Mayogiak Creek fence site, 1981. Results are expressed as frequency of occurrence (FO), percentage composition by number (% N), and estimated percentage composition by volume (% Vol.).

Food Item	Upstream FO	Upstream % N	Upstream % Vol.	Downstream FO	Downstream % N	Downstream % Vol.
Diptera						
Chironomidae						
Unid. larvae	66.7	90.9	18.4	100.0	28.4	5.9
Unid. pupae	16.7	0.8	2.6	50.0	0.5	2.9
Ceratopogonidae larvae	16.7	0.8	2.6	50.0	20.9	5.9
Unid. pupae	50.0	4.1	7.9	100.0	1.0	2.9
Trichoptera larvae				50.0	6.5	11.8
Coleoptera	16.7	0.8	5.3	50.0	1.5	8.8
Hemiptera						
Corixidae	16.7	0.8	2.6			
Mollusca						
Lymnaea palustris				50.0	2.0	8.8
Amphipoda						
Gammarus lacustris				50.0	36.3	26.5
Acarina				50.0	3.0	5.9
Nematoda	16.7	1.7	2.6			
Unid. Animal matter	83.3		26.3	100.0		17.7
Unid. Plant material, debris, mud	50.0		31.6	50.0		2.9
Number stomachs examined		8			2	
Number stomachs empty (%)		2 (25.0)			0 (100.0)	
Total food points assigned (%)		38 (23.8)			34 (85.0)	
Total food points unassigned (%)		122 (76.3)			6 (15.0)	

Table 16. Morphometry of three lakes in the Mayogiak Creek watershed, 1981.

Lake	Location	A (ha)	L (km)	W (km)	Z (m)	$\bar{Z}$ (m)	V (x1000 m^3)	SL (km)	D
Lake 1	69°24'N; 132°55'W	23.6	1.1	0.3	0.5	0.2	55	2.6	1.5
Lake 2	69°24'N; 132°52'W	73.4	1.2	1.0	1.0	0.7	544	3.8	1.3
Lake 3	69°23'N; 132°51'W	331.4	3.5	1.7	1.0	0.8	2757	9.8	1.5

Abbreviations:

A: Surface area of lake
L: Maximum length
W: Maximum width
Z: Maximum depth
$\bar{Z}$: Mean depth (V/A)
V: Volume
SL: Shoreline length
D: Shoreline development factor

Table 17. Physical and chemical data from three lakes in the Mayogiak Creek watershed, 1981.

Lake	Date (D/M/Y)	Secchi (m)	Depth (m)	Temp(°C) Field	Temp(°C) Lab	pH	D.O. (mg·L^{-1})	Spec. Cond. (umho·cm^{-1})
Lake 1	29/7/81	0.8	0(S)[1]	18.0	20.1	7.45	8.9	781
			1(B)[2]	18.0	18.9	8.15	8.9	763
Lake 2	31/7/81	1.9	0(S)	15.0	16.9	8.15	10.4	144
			1	16.0	16.8	8.70	10.4	144
			2(B)	15.5	16.9	8.80	10.4	145
Lake 3	5/8/81	0.7	0(S)	10.5	20.8	7.91	11.0	147
			1	11.0	20.5	7.91	11.0	145
			2	10.5	20.5	7.91	12.0	146
			3(B)	10.5	20.5	7.90	11.0	146

[1] Surface

[2] Bottom

Table 18. Zooplankton identified from lakes in the Mayogiak Creek watershed, 1981

Species	Lake 1	Lake 2	Lake 3
Copepoda			
Calanoida			
Eurytemora sp.			+
Diaptomus pribilofensis		+	+
Heterocope septentrionalis		+	
Diaptomid nauplii	+		
Cyclopoida			
Cyclops bicuspidatus	+		+
Cyclops vernalis	+		+
Cyclopoid copepodids	+		+
Cyclopoid nauplii	+	+	+
Cladocera			
Daphnia galeata	+		+
Ceriodaphnia quadrangula	+	+	
Bosmina longirostris	+	+	+
Chydorus sphaericus	+	+	+

Table 19. Species composition, biomass, and density of benthic invertebrates in lakes of the Mayogiak Creek watershed, 1981.

Taxa	Lake 1			Lake 2			Lake 3		
	% Number	% Wet Wt.	Density (No./m^2)	% Number	% Wet Wt.	Density (No./m^2)	% Number	% Wet Wt.	Density (No./m^2)
Diptera									
Chironomidae									
Chironominae				14.3	6.7	215	16.7	+	43
Orthocladinae							8.3	+	22
Tanypodinae				4.8	+	72			
Mollusca									
Valvatidae									
Valvata sincera helicoidea				17.1	16.7	258	16.7	33.3	43
Sphaeriidae									
Sphaerium sp.				52.4	63.3	789	25.0	66.7	65
Annelida									
Oligochaeta	100.0	100.0	43	7.6	10.0	115	16.7	+	43
Hirudinea				1.0	3.3	14			
Crustacea									
Amphipoda									
Gammarus lacustris				1.9	+	29	16.7	+	43
Nematoda				1.0	+	14			
Total			43			1,506			260
Number Dredge Hauls Taken			1			3			2
Total Number Animals Counted			1			105			12
Total Wet Weight (g)			< 0.01			0.30			0.03

Table 20. Catch and size data for fish captured in Swedish gillnets from Lake 1, Mayogiak Creek watershed, 29 July 1981.

Species	Mean Length (mm)	Mean Weight (g)		Mesh Size (mm)						Total	C/E[1]
				10	19	33	45	55	60		
Broad whitefish	189	90	N		2					2	1.0
			%		100.0					50.0	
Lake whitefish	329	460	N			1				1	0.5
			%			100.0				25.0	
Least cisco	215	90	N		1					1	0.5
			%		100.0					25.0	
Total					3	1				4	1.0

Catch-per-unit-effort expressed as number of fish per gang per hour.

Table 21. Catch and size data for fish captured in Swedish gillnets from Lake 2, Mayogiak Creek watershed, 31 July 1981.

Species	Mean Length (mm)	Mean Weight (g)		Mesh Size (mm)						Total	C/E[1]
				10	19	33	45	55	60		
Broad whitefish	234	203	N		13	6				19	4.8
			%		68.4	31.6				100.0	
Total					13	6				19	4.8

[1]Catch-per-unit-effort expressed as number of fish per gang per hour.

Table 22. Catch and size data for fish captured in Swedish gillnets from Lake 3, Mayogiak Creek watershed, 5 August 1981.

Species	Mean Length (mm)	Mean Weight (g)		Mesh Size (mm)						Total	C/E[1]
				10	19	33	45	55	60		
Broad whitefish	256	284	N	1	4	8				13	3.3
			%	7.7	30.8	61.5				100.0	
Total				1	4	8				13	3.3

[1]Catch-per-unit-effort expressed as number of fish per gang per hour.

Table 23. Length-frequency distribution for broad whitefish captured by Swedish gillnets from lakes in the Mayogiak Creek watershed, 29 July to 5 August 1981.

Fork Length (mm)	Lake 1		Lake 2		Lake 3		Total	
	N	%	N	%	N	%	N	%
150-174	1	50.0	1	5.3	1	7.7	3	8.8
175-199			4	21.1			4	11.8
200-224			5	26.3	1	7.7	6	17.7
225-249	1	50.0	2	10.5	3	23.1	6	17.7
250-274			3	15.8	4	30.8	7	20.6
275-299			3	15.8	3	23.1	6	17.7
300-324								
325-349					1	7.7	1	2.9
350-374			1	5.3			1	2.9
Total	2		19		13		34	

Table 24. Age-frequency distribution for broad whitefish captured by Swedish gillnets from lakes in the Mayogiak Creek watershed, 29 July to 5 August 1981.

Scale Age (yr)	Lake 1		Lake 2		Lake 3		Total	
	N	%	N	%	N	%	N	%
1	1	50.0			1	7.7	2	5.9
2	1	50.0	8	42.1	2	15.4	11	32.4
3			11	57.9	7	53.8	18	52.9
4					3	23.1	3	8.8
Total	2		19		13		34	

Table 25. Food habits of broad whitefish captured in lakes of the Mayogiak Creek watershed, 1981. Results are expressed as frequency of occurrence (FO), percentage composition by number (% N), and estimated percentage composition by volume (% Vol.).

Food Item	LAKE 1			LAKE 2			LAKE 3		
	FO	% N	% Vol.	FO	% N	% Vol.	FO	% N	% Vol.
Diptera									
Chironomidae									
Orthocladinae larvae				5.6	0.4	1.0			
Unid. larvae	100.0	44.7	10.0	77.8	20.3	9.3	27.3	14.5	3.1
Unid. pupae				44.4	11.2	3.1			
Empididae larvae	50.0	17.0	10.0	5.6	0.1	0.5			
Unid. larvae	100.0	21.3	13.3	27.8	1.2	3.1			
Unid. pupae				16.7	1.4	1.0	9.1	0.2	0.6
Trichoptera									
Limnephilidae larvae				22.2	0.7	4.6	18.2	0.6	1.8
Unid. adult				5.6	0.1	1.0			
Plectoptera				22.2	1.1	0.5			
Ephemeroptera				5.6	0.1	0.5			
Mollusca									
Valvata sincera helicoidea				22.2	0.5	1.6	45.5	29.9	3.1
Lymnaea palustris				22.2	0.8	2.1	18.2	1.1	1.8
Sphaeriidae				66.7	13.2	7.2	81.8	14.0	2.4
Amphipoda									
Gammarus lacustris				61.1	15.8	13.9	45.5	37.7	61.0
Crustacea									
Notostraca									
Lepidurus sp.				11.1	3.4	26.8	36.4	0.8	4.3
Cladocera	100.0	14.9	6.7	22.2	27.6	6.2			
Ostracoda				16.7	1.5	1.0	18.2	1.3	1.2
Nematoda	50.0	2.1	3.3	16.7	0.6	0.5			
Unid. Animal matter	100.0		56.7	77.8		13.4	72.7		11.0
Plant material, debris, mud				5.6		2.6	36.4		9.8
Number stomachs examined		2			19			13	
Number stomachs empty (%)		0 (0.0)			1 (5.3)			2 (15.4)	
Total food points assigned (%)		30 (75.0)			194 (51.1)			164 (63.1)	
Total food points unassigned (%)		10 (25.0)			186 (49.0)			96 (36.9)	

Table 26. Number of fish passed through the Freshwater Creek counting fence 1981[1].

Species	Number of Fish		
	Upstream Trap	Downstream Trap	
		16 June-13 Aug.	19 Aug.-1 Sept.
Broad whitefish	42 932	6 111	13 472
Lake whitefish	92	2 010	916
Least cisco	1 167	311	567
Northern pike	1	6	
Lake trout	0	1	
Ninespine stickleback	2	0	
Pond smelt	0	12	
Total	44 194	23 406	

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[1] Both upstream and downstream traps operated until 13 August but only downstream trap functional from 19 August to 1 September.

Table 27. Length-frequency distribution for broad whitefish measured during different segments of the upstream migration in Freshwater Creek, 1981.

Fork Length (mm)	16-23 June		24 June-4 July		5-31 July		1-13 August		Total	
	N	%	N	%	N	%	N	%	N	%
50-74					9	7.3	50	19.5	59	6.8
75-99					1	0.8	23	9.0	24	2.8
100-124			1	0.3			2	0.8	3	0.4
125-149			2	0.6	3	2.4	9	3.5	14	1.6
150-174	3	2.1	37	10.7	53	43.1	94	36.7	187	21.6
175-199	2	1.4	167	48.4	44	35.8	38	14.8	251	29.0
200-224			67	19.4	4	3.3	14	5.5	85	9.8
225-249	4	2.8	31	9.0	3	2.4	13	5.1	51	5.9
250-274	2	1.4	21	6.1	1	0.8	6	2.3	30	3.5
275-299	3	2.1	11	3.2	3	2.4	4	1.6	21	2.4
300-324	14	9.9	5	1.5	1	0.8	1	0.4	21	2.4
325-349	47	33.3	3	0.9	1	0.8	1	0.4	52	6.0
350-374	28	19.9							28	3.2
375-399	17	12.1							17	2.0
400-424	12	8.5					1	0.4	13	1.5
425-449	7	5.0							7	0.8
450-474	1	0.7							1	0.1
475-499										
500-524										
525-549										
550-574										
575-599	1	0.7							1	0.1
Total	141 (3.7)[1]		345 (1.2)		123 (1.3)		256 (34.9)		865 (1.9)	

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[1] Number of measured fish as a percentage of the total number counted during the designated time period.

Table 28. Length-frequency distribution for broad whitefish measured during downstream migration in Freshwater Creek, 1981.

Fork Length (mm)	16 June-31 July		1-13 August		19 August 1 September		Total	
	N	%	N	%	N	%	N	%
50-74			1	0.4			1	0.2
75-99								
100-124								
125-149								
150-174	3	3.2					3	0.5
175-199	4	4.3	2	0.8			6	1.1
200-224	4	4.3	3	1.2	5	2.1	12	2.1
225-249			1	0.4	11	4.7	12	2.1
250-274	3	3.2	2	0.8	7	3.0	12	2.1
275-299	4	4.3	1	0.4	11	4.7	16	2.8
300-324	5	5.4	10	4.2	12	5.1	27	4.8
325-349	15	16.1	33	13.7	17	7.3	65	11.4
350-374	18	19.4	63	26.1	32	13.7	113	19.9
375-399	14	15.1	46	19.1	26	11.1	86	15.1
400-424	7	7.5	38	15.8	37	15.8	82	14.4
425-449	5	5.4	31	12.9	43	18.4	79	13.9
450-474	3	3.2	7	2.9	31	13.3	41	7.2
475-499	3	3.2	3	1.2	2	0.9	8	1.4
500-524	2	2.2					2	0.4
525-549	2	2.2					2	0.4
550-574	1	1.1					1	0.2
Total	93 (8.3)[1]		241 (4.8)		234 (1.7)		568 (2.9)	

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[1] Number of measured fish as a percentage of the total number counted during the designated time period.

Table 29. Mean fork length (mm), mean weight (g), maturity, sex ratio, and condition factor by age group for broad whitefish from the Freshwater Creek watershed[1], 1981.

Scale Age (yr)	Number	Fork Length			Weight			Condition factor	Males		Females		Number Sex Unknown
		Mean	SD	Range	Mean	SD	Range		Number	% Mature	Number	% Mature	
0													
1	91	164	9.3	134 - 184	50	10.5	30 - 70	1.12			1	0	90
2	60	185	21.6	135 - 252	73	30.2	20 - 210	1.15	2	0	8	0	50
3	98	191	21.7	164 - 291	82	39.3	50 - 300	1.18	5	0	6	0	87
4	17	313	38.3	257 - 357	396	145.4	125 - 620	1.29	12	0	2	0	3
5	28	345	31.9	284 - 405	578	200.6	280 -1120	1.41	12	0	16	0	
6	9	360	26.0	331 - 415	655	211.5	410 -1120	1.41	6	0	3	0	
7	12	420	27.4	376 - 462	1112	279.2	710 -1610	1.50	5	0	7	0	
8	14	422	37.6	376 - 500	1229	437.5	775 -2415	1.63	6	0	8	0	
9	9	427	22.1	390 - 461	1147	255.2	810 -1555	1.47	2	0	7	0	
10	4	388	42.8	334 - 433	785	339.6	425 -1235	1.35			4	0	
11													
12													
13	1	573			3175				1	0			
Total	343								51	0	62	0	230

[1] Age groups 4-13 include 53 fish gillnetted during the lake surveys.

Table 30. Length-frequency distribution by age group for broad whitefish from the Freshwater Creek watershed[1], 1981.

Fork Length (mm)	Scale Age (yr)												
	0	1	2	3	4	5	6	7	8	9	10	13	Total
125 - 149		3	1										4
150 - 174		76	18	12									106
175 - 199		12	27	67									106
200 - 224			13	13									26
225 - 249			2	4	1								7
250 - 274			1	4	3								8
275 - 299				2	2	2							6
300 - 324					2	5							7
325 - 349					6	9	4				1		20
350 - 374					3	6	3						12
375 - 399						4	1	3	4	1	1		14
400 - 424						2	1	4	6	2			15
425 - 449								4		4	2		10
450 - 474								1	2	2			5
475 - 499									1				1
500 - 524									1				1
525 - 549													
550 - 574												1	1
Total		91	62	102	17	28	9	12	14	9	4	1	349

[1] Includes 59 fish gillnetted during the lake surveys.

Table 31. Food habits of broad whitefish captured at the Freshwater Creek fence site, 1981. Results are expressed as frequency of occurrence (FO), percentage composition by number (% N), and estimated percentage composition by volume (% Vol.).

Food Item	Upstream			Downstream		
	FO	% N	% Vol.	FO	% N	% Vol.
Diptera						
Chironomidae						
Orthocladinae larvae	40.9	41.9	9.4	20.0	2.3	2.1
Unid. larvae	31.8	16.5	7.5	40.0	9.9	6.4
Unid. pupae	4.5	0.3	0.6			
Ceratopogonidae larvae	13.6	1.2	0.6			
Simuliidae larvae	9.1	7.5	6.3			
Unid. larvae	22.7	3.6	2.5			
Unid. pupae	9.1	0.6	0.6			
Unid. adult	9.1	0.9	3.1			
Plecoptera						
Nemouridae	18.2	9.6	12.5	20.0	1.5	4.3
Ephemeroptera	4.5	3.6	3.8			
Coleoptera	4.5	0.3	1.3			
Mollusca						
Valvata sincera helicoidea	9.1	0.9	1.3	20.0	0.8	2.1
Lymnaea palustris				20.0	0.8	6.4
Sphaeriidae	18.2	1.8	1.9	60.0	84.0	19.1
Crustacea						
Cladocera	13.6	8.1	5.0			
Acarina	9.1	0.9	0.6	20.0	0.8	2.1
Nematoda	9.1	2.4	0.6			
Unid. Animal matter	77.3		17.5	80.0		57.4
Unid. Plant material, debris, mud	18.2		25.0			
Number stomachs examined		31			6	
Number stomachs empty (%)		9 (29.0)			1 (16.7)	
Total food points assigned (%)		160 (25.8)			47 (39.2)	
Total food points unassigned (%)		460 (74.2)			73 (60.8)	

Table 32. Length-frequency distribution for least cisco measured during different segments of the upstream migration in Freshwater Creek, 1981.

Fork Length (mm)	16-25 June N	16-25 June %	26 June-31 July N	26 June-31 July %	1-13 August N	1-13 August %	Total N	Total %
25-49					2	1.7	2	0.9
50-74			1	1.7	80	69.6	81	37.2
75-99					3	2.6	3	1.4
100-124								
125-149								
150-174			1	1.7			1	0.5
175-199			17	29.3	11	9.6	28	12.8
200-224			30	51.7	12	10.4	42	19.3
225-249			3	5.2	1	0.9	4	1.8
250-274	1	2.2					1	0.5
275-299	11	24.4	3	5.2	1	0.9	15	6.9
300-324	21	46.7	3	5.2	1	0.9	25	11.6
325-349	10	22.2			3	2.6	13	6.0
350-374	1	2.2			1	0.9	2	0.9
375-399								
400-424	1	2.2					1	0.5
Total	45 (16.3)[1]		58 (8.9)		115 (47.7)		218 (18.7)	

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[1] Number of measured fish as a percentage of the total number counted during the designated time period.

Table 33. Length-frequency distribution for least cisco measured during the downstream migration in Freshwater Creek, 1981.

Fork Length (mm)	June N	June %	July N	July %	August N	August %	Total N	Total %
25-49								
50-74								
75-99								
100-124					1	1.4	1	1.3
125-149								
150-174					1	1.4	1	1.3
175-199					1	1.4	1	1.3
200-224					7	9.9	7	8.8
225-249					11	15.5	11	13.8
250-274			2	33.3	4	5.6	6	7.5
275-299			2	33.3	12	16.9	14	17.5
300-324	2	66.7	1	16.7	24	33.8	27	33.8
325-349	1	33.3	1	16.7	10	14.1	12	15.0
350-374								
375-399								
Total	3		6		71		80	

Table 34. Mean fork length (mm), mean weight (g), maturity, sex ratio, and condition factor by age group for least cisco from the Freshwater Creek watershed[1], 1981.

Scale Age (yr)	Number	Fork Length			Weight			Condition factor	Males		Females		Number Sex Unknown
		Mean	SD	Range	Mean	SD	Range		Number	% Mature	Number	% Mature	
0	3	63	2.7	60 - 64	2	0.0	2	0.80	0	0	0	0	3
1													
2	19	196	25.1	107 - 234	65	15.4	55 - 100	0.87	1	0	2	0	16
3	39	209	15.7	179 - 242	80	21.8	50 - 130	0.87	13	0	8	13	18
4	17	233	23.3	193 - 281	123	44.1	50 - 210	0.97	2	0	4	50	11
5	9	284	26.8	240 - 312	233	76.6	110 - 300	1.02	2	50	6	33	1
6	5	316	23.0	291 - 350	312	21.7	280 - 330	1.00	2	50	3	0	0
7	3	322	16.7	303 - 335	316	96.2	207 - 390	1.00	0	0	3	33	0
8	6	316	11.0	300 - 327	296	38.0	245 - 340	0.94	0	0	6	0	0
Total	101								20	10	32	19	49

[1] Includes four fish gillnetted during the lake surveys.

Table 35. Length-frequency distribution by age group for least cisco from the Freshwater Creek watershed[1], 1981.

Fork Length (mm)	Scale Age (yr)									Total
	0	1	2	3	4	5	6	7	8	
50 - 74	3									3
75 - 99										
100 - 124			1							1
125 - 149										
150 - 174										
175 - 199			10	10	1					21
200 - 224			7	22	6					35
225 - 249			1	7	7	2				17
250 - 274					2					2
275 - 299					1	4	1			6
300 - 324						3	3	1	4	11
325 - 350							1	2	2	5
Total	3		19	39	17	9	5	3	6	101

[1] Includes four fish gillnetted during the lake surveys.

Table 36. Food habits of least cisco captured at the Freshwater Creek fence site, 1981. Results are expressed as frequency of occurrence (FO), percentage composition by number (% N), and estimated percentage composition by volume (% V.).

Food Item	Upstream			Downstream		
	FO	% N	% Vol.	FO	% N	% Vol.
Diptera						
Chironomidae larvae	100.0	94.9	14.3			
Unid. larvae	20.0	1.7	4.8			
Plecoptera	20.0	3.4	9.5			
Crustacea						
Cladocera				100.0	100.0	6.7
Unid. Animal matter	100.0		71.4	100.0		93.3
Number stomachs examined		7			2	
Number stomachs empty (%)		2 (28.6)			0 (0.0)	
Total food points assigned (%)		21 (15.0)			15 (37.5)	
Total food points unassigned (%)		119 (85.0)			25 (62.5)	

Table 37. Length-frequency distribution for lake whitefish captured at the counting fence on Freshwater Creek, 1981.

Fork Length (mm)	Upstream Trap 16-23 June N	%	25 June-12 August N	%	Total N	%	Downstream Trap N	%
150-174			10	17.2	10	11.1	1	0.5
175-199			16	27.6	16	17.8	2	0.9
200-224	1	3.1	15	25.9	16	17.8	6	2.7
225-249			5	8.6	5	5.6	8	3.7
250-274			5	8.6	5	5.6	6	2.7
275-299	5	15.6	2	3.4	7	7.8	10	4.6
300-324	8	25.0	1	1.7	9	10.0	19	8.7
325-349	10	31.3	2	3.4	12	13.3	35	16.0
350-374	4	12.5	1	1.7	5	5.6	42	19.2
375-399							40	18.3
400-424	2	6.3	1	1.7	3	3.3	33	15.1
425-449	2	6.3			2	2.2	16	7.3
450-474							1	0.5
Total	32		58		90		219	

Table 38. Mean fork length (mm), mean weight (g), maturity, sex ratio, condition factor by age group for lake whitefish from the Freshwater Creek watershed[1], 1981.

Scale Age (yr)	Number	Fork Length Mean	SD	Range	Weight Mean	SD	Range	Condition factor	Males Number	% Mature	Females Number	% Mature	Number Sex Unknown
0													
1													
2													
3	17	184	15.5	161 - 214	70	18.2	40 - 105	1.14					17
4	13	235	33.9	200 - 303	161	91.2	80 - 355	1.23	2	0	1	0	10
5	4	280	32.6	252 - 309	273	118.6	160 - 375	1.24	1	0	1	0	2
6	7	298	28.1	266 - 340	336	81.3	245 - 420	1.27	4	0	3	0	
7	16	335	24.6	275 - 366	512	120.8	250 - 740	1.36	7	0	9	0	
8	12	365	28.3	307 - 396	683	168.0	385 - 900	1.41	3	0	8	0	1
9	10	390	30.2	344 - 437	831	262.8	680 -1305	1.41	3	0	6	0	1
10	5	397	13.1	375 - 406	960	115.6	820 -1130	1.53	2	0	3	0	
11	2	420	11.3	412 - 428	1190	28.3	1170 -1210	1.61			2	0	
Total	86								22	0	33	0	31

[1] Includes 16 fish gillnetted during the lake surveys.

Table 39. Length-frequency distribution by age group for lake whitefish from the Freshwater Creek watershed[1], 1981.

Fork Length (mm)	Scale Age (yr) 0	1	2	3	4	5	6	7	8	9	10	11	Total
50 - 74													
75 - 99													
100 - 124													
125 - 149													
150 - 174				5									5
175 - 199				9									9
200 - 224				3	7								10
225 - 249					2								2
250 - 274					2	2	2						6
275 - 299					1		2	1					4
300 - 324					1	2	2	5					10
325 - 349							1	6	2	1			10
350 - 374								4	4	1			9
375 - 399									6	5	2		13
400 - 424										1	3	1	5
425 - 449										2		1	3
Total				17	13	4	7	16	12	10	5	2	86

[1] Includes 16 fish gillnetted during the lake surveys.

Table 40. Food habits of lake whitefish captured at the Freshwater Creek fence site, 1981. Results are expressed as frequency of occurrence (FO), percentage composition by number (% N), and estimated percentage composition by volume (% Vol.).

Food Item	Upstream FO	% N	% Vol.	Downstream FO	% N	% Vol.
Diptera						
Chironomidae larvae	100.0	42.9	16.7			
Trichoptera larvae				33.3	0.5	3.6
Mollusca						
Valvata sincera helicoidea	50.0	28.6	16.7	100.0	89.6	32.1
Sphaeriidae				33.3	1.9	3.6
Crustacea						
Notostraca						
Lepidurus sp.				33.3	1.4	28.6
Acarina				100.0	6.6	3.6
Nematoda	50.0	28.6	16.7			
Unid. Animal matter	50.0		50.0			
Unid. Plant material, debris, mud				100.0		25.0
Number stomachs examined		3			3	
Number stomachs empty (%)		1 (33.3)			0 (0.0)	
Total food points assigned (%)		6 (10.0)			28 (46.7)	
Total food points unassigned (%)		54 (90.0)			32 (53.3)	

Table 41. Morphometry of three lakes in the Freshwater Creek watershed, 1981.

Lake	Location	Parameters							
		A (ha)	L (km)	W (km)	Z (m)	$\bar{Z}$ (m)	V ($\times 1000\ m^3$)	SL (ha)	D
Lake 1	69°26'N; 132°49'W	560.2	4.0	2.3	1.5	0.8	4356	14.3	1.7
Lake 2	69°24'N; 132°46'W	817.3	6.4	2.4	1.0	0.6	5250	16.7	1.6
Lake 3	69°27'N; 132°37'W	180.7	2.0	1.9	5.0	1.2	2238	7.6	1.6

Abbreviations:			
A:	Surface area of lake	$\bar{Z}$:	Mean depth (V/A)
L:	Maximum length	V:	Volume
W:	Maximum width	SL:	Shoreline length
Z:	Maximum depth	D:	Shoreline development factor

Table 42. Physical and chemical data from three lakes in the Freshwater Creek watershed, 1981.

Lake	Date (D/M/Y)	Secchi (m)	Depth (m)	Temp(°C)		pH	D.O. ($mg \cdot L^{-1}$)	Spec. Cond. ($umho \cdot cm^{-1}$)
				Field	Lab			
Lake 1	25/7/81	2.25	0(S)[1]	18.0	21.1	7.35	10.6	163
			1	18.5	21.9	8.25	10.8	162
			2	17.5	21.5	8.13	10.8	162
Lake 2	25/7/81	1.3	0(S)	18.0	21.5	7.95	10.0	156
			1	18.5	ND	ND	10.4	ND
			2(B)[2]	17.5	21.3	8.05	10.2	156
Lake 3	27/7/81	3.8	0(S)	17.0	18.9	8.46	10.3	209
			1	18.0	18.9	8.59	11.1	163
			2	17.0	ND	ND	ND	ND
			3	17.0	18.9	8.50	10.1	163
			4	17.0	ND	ND	ND	ND
			5(B)	17.0	18.9	8.60	10.2	167

[1] Surface
[2] Bottom

Table 43. Zooplankton identified from lakes in the Freshwater Creek watershed, 1981.

Species	Lake 1	Lake 2	Lake 3
Copepoda			
Calanoida			
Eurytemora sp.		+	+
Epischura sp.		+	
Diaptomus pribilofensis		+	
Diaptomid copepodids	+	+	+
Cyclopoida			
	+	+	+
			+
Cyclopoid copepodids	+	+	+
Cyclopoid nauplii	+	+	+
Cladocera			
Daphnia longiremis	+	+	
Daphnia galeata	+	+	
Bosmina longirostris	+	+	+
Eubosmina longispina	+	+	
Holopedium gibberum	+		

Table 44. Species composition, biomass, and density of benthic invertebrates in lakes of the Freshwater Creek watershed, 1981.

Taxa	Lake 1			Lake 2			Lake 3		
	% Number	% Wet Wt.	Density (No./m^2)	% Number	% Wet Wt.	Density (No./m^2)	% Number	% Wet Wt.	Density (No./m^2)
Diptera									
Chironomidae									
Chironominae	7.1	+	14	15.4	6.5	143	11.1	8.3	118
Orthocladinae							2.0	+	22
Tanypodinae									
Unidentified							1.0	+	11
Empididae				1.5	+	14			
Plecoptera	7.1	+	14						
Trichoptera									
Limnephilidae							1.0	13.9	11
Mollusca									
Valvatidae									
Valvata sincera helicoidea	21.4	20.0	43	32.3	32.3	301	41.4	33.3	441
Lymnaeidae									
Lymnaea palustris							1.0	11.1	11
Sphaeriidae									
Sphaerium sp.				27.7	38.7	258	26.3	22.2	280
Annelida									
Oligochaeta	37.5	40.0	72	20.0	19.4	186	10.1	2.8	107
Crustacea									
Amphipoda									
Gammarus lacustris	14.3	40.0	29	3.1	3.2	29	6.1	8.3	65
Cladocera	14.3	+	29						
Total			201			931			1,066
Number Dredge Hauls Taken			3			3			4
Number Animals Counted			14			65			99
Total Wet Weight (g)			0.05			0.31			0.36

Table 45. Catch and size data for fish captured in Swedish gillnets from Lake 1, Freshwater Creek watershed, 27 July 1981.

Species	Mean Length (mm)	Mean Weight (g)		Mesh Size (mm)						Total	C/E[1]
				10	19	33	45	55	60		
Broad whitefish	341	616	N	3	3	3	2	3		14	3.5
			%	21.4	21.4	21.4	14.3	21.4		53.9	
Lake whitefish	322	518	N		3	6	2	1		12	3.0
			%		25.0	50.0	16.7	8.3		46.2	
Total				3	6	9	4	4		26	6.5

[1] Catch-per-unit-effort expressed as number of fish per gang per hour.

Table 46. Catch and size data for fish captured in Swedish gillnets from Lake 2, Freshwater Creek watershed, 27 July 1981.

Species	Mean Length (mm)	Mean Weight (g)		Mesh Size (mm)						Total	C/E[1]
				10	19	33	45	55	60		
Broad whitefish	385	935	N	2	7	11	8	10		38	9.7
			%	5.3	18.4	29.0	21.1	26.3		84.4	
Lake whitefish	402	1,003	N		1	1	1			3	0.8
			%		33.3	33.3	33.3			6.7	
Least cisco	250	191	N	2	2					4	1.0
			%	50.0	50.0					8.9	
Total				4	10	12	9	10		45	11.5

[1] Catch-per-unit-effort expressed as number of fish per gang per hour.

Table 47. Catch and size data for fish captured in Swedish gillnets from Lake 3, Freshwater Creek watershed, 27 July 1981.

Species	Mean Length (mm)	Mean Weight (g)		Mesh Size (mm)						Total	C/E[1]
				10	19	33	45	55	60		
Broad whitefish	384	1,166	N		1	3	4			8	2.0
			%		12.5	37.5	50.0			72.7	
Least cisco	118	8	N	1						1	0.3
			%	100.0						9.1	
Northern pike	297	215	N	1	1					2	0.5
			%	50.0	50.0					18.2	
Total				2	2	3	4			11	2.8

[1] Catch-per-unit-effort expressed as number of fish per gang per hour.

Table 48. Length-frequency distribution for broad whitefish captured by Swedish gillnets from lakes in the Freshwater Creek watershed, 24-27 July 1981.

Fork Length	Lake 1		Lake 2		Lake 3		Total	
(mm)	N	%	N	%	N	%	N	%
175-199					1	12.5	1	1.7
200-224			1	2.6			1	1.7
225-249	1	7.1	1	2.6			2	3.3
250-274	1	7.1	2	5.3	1	12.5	4	6.7
275-299	1	7.1	1	2.6			2	3.3
300-324	2	14.3					2	3.3
325-349	4	28.6	4	10.5	1	12.5	9	15.0
350-374	1	7.1	5	13.2			6	10.0
375-399	1	7.1	4	10.5	1	12.5	6	10.0
400-424	3	21.4	9	23.7			12	20.0
425-449			6	15.8	1	12.5	7	11.7
450-474			4	10.5	1	12.5	5	8.3
475-499					1	12.5	1	1.7
500-524					1	12.5	1	1.7
525-549								
550-574			1	2.6			1	1.7
Total	14		38		8		60	

Table 49. Age-frequency distribution for broad whitefish captured by Swedish gillnets from lakes in the Freshwater Creek watershed, 24-27 July 1981.

Scale Age	Lake 1		Lake 2		Lake 3		Total	
(yr)	N	%	N	%	N	%	N	%
2			2	5.3			2	3.4
3	1	7.7	1	2.6	2	25.0	4	6.8
4	1	7.7	6	15.8			7	11.9
5	5	38.5	4	10.5	2	25.0	11	18.6
6	2	15.4	5	13.2			7	11.9
7			6	15.8	2	25.0	8	13.6
8	4	30.8	6	15.8	2	25.0	12	20.3
9			6	15.8			6	10.2
10			1	2.6			1	1.7
11								
12								
13			1	2.6			1	1.7
Total	13		38		8		59	

Table 50. Length-frequency distribution for lake whitefish captured by Swedish gillnets from lakes in the Freshwater Creek watershed, 24-27 July 1981.

Fork Length (mm)	Lake 1		Lake 2		Lake 3		Total	
	N	%	N	%	N	%	N	%
250-274	3	25.0					3	20.0
275-299	1	8.3					1	6.7
300-324	3	25.0					3	20.0
325-349	2	16.7					2	13.3
350-374	1	8.3					1	6.7
375-399	1	8.3	1	33.3			2	13.3
400-424	1	8.3	2	66.7			3	20.0
Total	12		3				15	

Table 51. Age-frequency distribution for lake whitefish captured by Swedish gillnets from lakes in the Freshwater Creek watershed, 24-27 July 1981.

Scale Age (yr)	Lake 1		Lake 2		Lake 3		Total	
	N	%	N	%	N	%	N	%
4	1	7.7					1	6.3
5								
6	2	15.4					2	12.5
7	6	46.2					6	37.5
8	2	15.4					2	12.5
9	1	7.7					1	6.3
10			3	100.0			3	18.8
11	1	7.7					1	6.3
Total	13		3				16	

Table 52. Food habits of broad whitefish captured in lakes of the Freshwater Creek watershed, 1981. Results are expressed as frequency of occurrence (FO), percentage composition by number (% N), and estimated percentage composition by volume (% Vol.).

Food Item	LAKE 1			LAKE 2			LAKE 3		
	FO	% N	% Vol.	FO	% N	% Vol.	FO	% N	% Vol.
Diptera									
Chironomidae larvae	64.3	12.3	3.5	87.1	4.9	1.5	42.9	4.9	3.5
Simuliidae adults				6.5	0.1	0.6			
Empididae larvae				6.5	0.5	0.9			
Unid. larvae	78.6	2.7	1.4	51.6	1.4	1.2	42.9	2.4	2.6
Unid. pupae	28.6	3.3	1.4	6.5	0.1	0.6	14.3	0.1	0.9
Unid. adults	7.1	0.1	0.7						
Trichoptera									
Limnephilidae				6.5	0.2	1.2	57.1	2.2	6.1
Unid. larvae	14.3	1.6	2.8	6.5	0.1	0.9	14.3	0.1	0.9
Plecoptera	14.3	0.5	0.7	6.5	1.6	0.9			
Mollusca									
Valvata sincera helicoidea	71.4	55.6	24.5	90.3	50.5	22.5	100.0	79.0	26.3
Lymnaea palustris	14.3	1.0	1.4	22.6	1.1	4.8	28.6	2.0	6.1
Sphaeriidae	57.1	21.0	9.8	90.3	36.8	16.5	71.4	8.1	3.5
Crustacea									
Amphipoda									
Gammarus lacustris	28.6	1.1	3.5	48.4	2.1	5.1	28.6	1.0	1.8
Notostraca									
Lepidurus sp.	7.1	0.1	0.7	16.1	0.1	1.2			
Oligochaeta							14.3	0.1	0.9
Acarina	7.1	0.8	0.7	3.2	<0.1	0.3	28.6	0.1	0.9
Nematoda				9.7	0.6	0.3	14.3	0.1	0.9
Unid. Animal matter				45.2		0.9			
Plant material, debris, mud	92.9		49.0	100.0		40.5	100.0		45.6
Number stomachs examined		14			38			8	
Number stomachs empty (%)		0 (0.0)			7 (18.4)			1 (12.5)	
Total food points assigned (%)		143 (51.1)			333 (43.8)			114 (71.3)	
Total food points unassigned (%)		137 (48.9)			427 (56.2)			46 (28.8)	

Table 53. Food habits of lake whitefish captured in lakes of the Freshwater Creek watershed, 1981. Results are expressed as frequency of occurrence (FO), percentage composition by number (% N), and estimated percentage composition by volume (% Vol.).

Food Item	LAKE 1			LAKE 2			LAKE 3		
	FO	% N	% Vol.	FO	% N	% Vol.	FO	% N	% Vol.
Diptera									
Chironomidae									
Chironominae larvae	54.6	0.5	0.6	33.3	0.2	2.4		NO DATA	
Unid. larvae	63.6	4.7	1.8						
Unid. pupae									
Tanypodinae larvae	36.4	2.1	1.2						
Culicidae adult				33.3	0.2	2.4			
Unid. larvae	18.2	0.2	0.6	33.3	0.6	2.4			
Trichoptera									
Limnephilidae larvae	27.3	1.7	3.0	66.7	11.1	11.9			
Unid larvae				33.3	0.4	2.4			
Unid. adult	9.1	0.1	1.2						
Plecoptera	9.1	0.2	0.6	33.3	0.4	2.4			
Emphemeroptera									
Baetidae	9.1	0.7	1.2						
Mollusca									
Valvata sincera helicoidea	100.0	55.1	33.1	100.0	69.7	19.1		NO DATA	
Lymnaea palustris	63.6	1.2	1.8	66.7	4.8	16.7			
Sphaeriidae	36.4	4.6	1.8	66.7	8.0	4.8			
Crustacea									
Amphipoda									
Gammarus lacustris	18.2	0.2	1.2	33.3	1.5	7.1			
Notostraca									
Lepidurus sp.	18.2	0.1	2.4						
Cladocera	27.3	1.3	1.8						
Ostracoda	27.3	23.8	1.2	33.3	1.5	2.4			
Nematoda	36.4	0.9	1.8						
Acarina	100.0	3.0	0.6	33.3	1.9	2.4			
Unid. Plant material, debris, mud	100.0		44.4	100.0		23.8			
Number stomachs examined		12			3			NO DATA	
Number stomachs empty (%)		1 (8.3)			0 (0.0)				
Total food points assigned (%)		169 (70.4)			42 (70.0)				
Total food points unassigned (%)		71 (29.6)			18 (30.0				

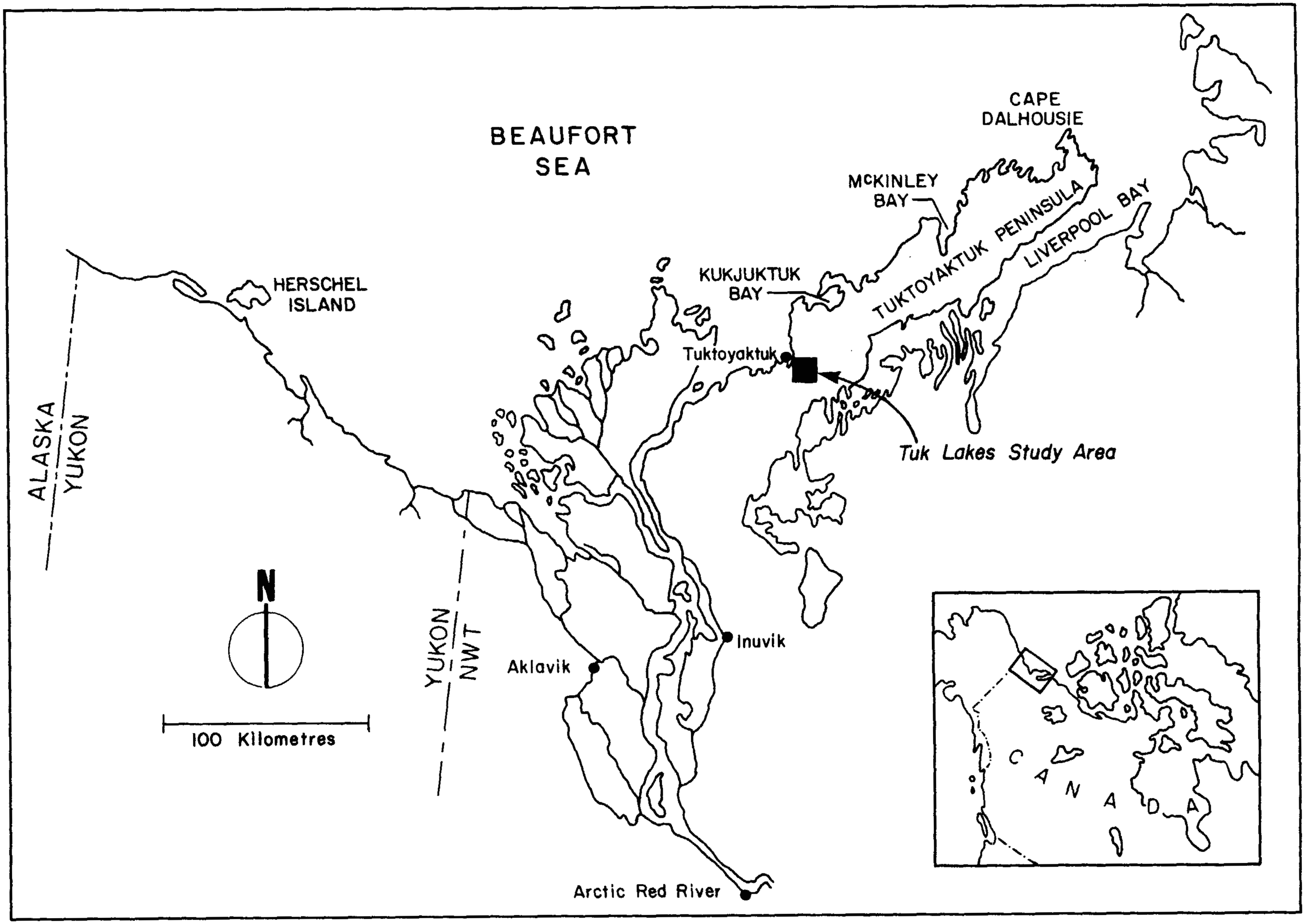

Fig. 1. The Mackenzie Delta and southern Beaufort Sea showing the location of the study area.

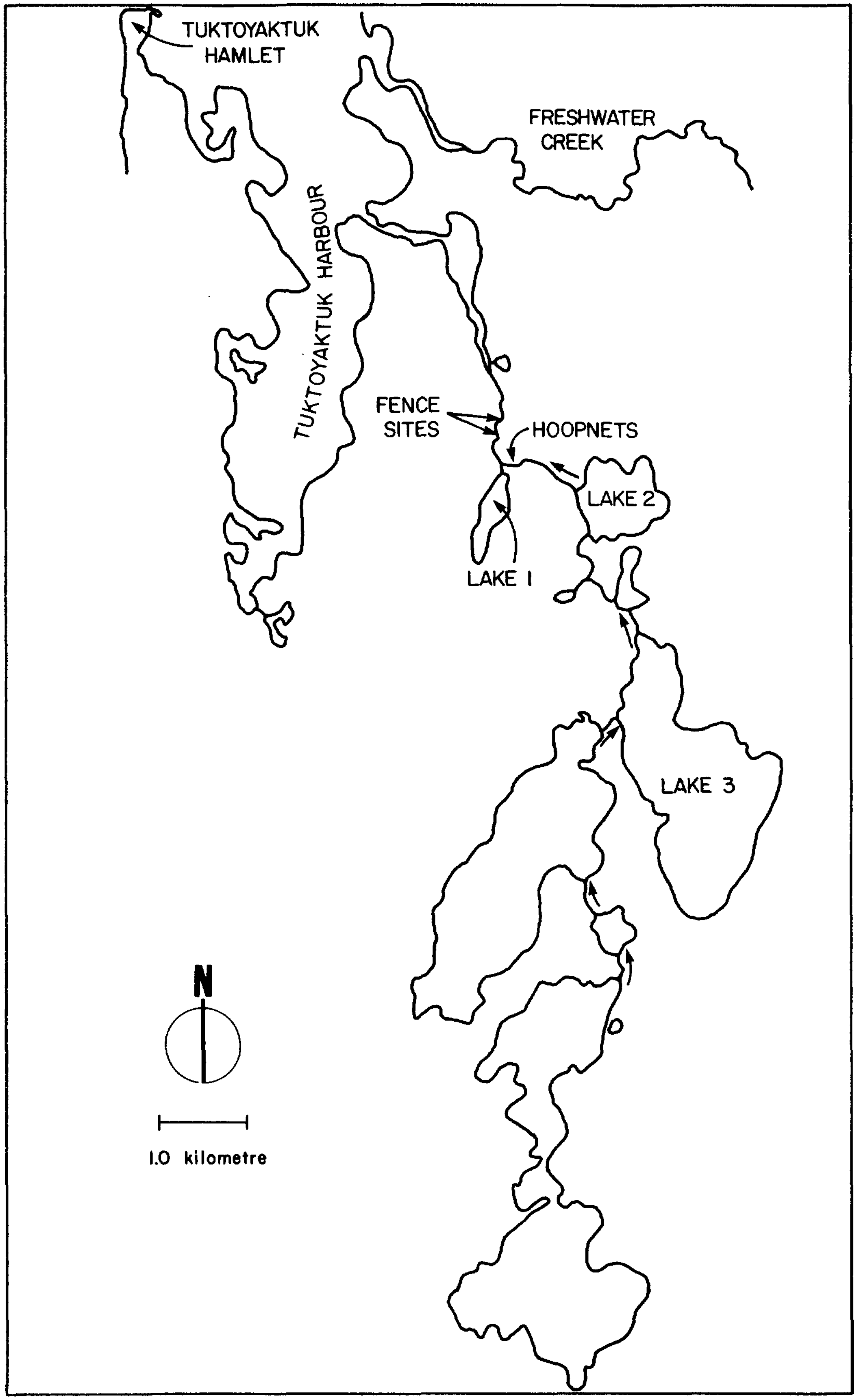

Fig. 2. The Mayogiak Creek watershed indicating the location of the counting fence and the lakes surveyed in 1981.

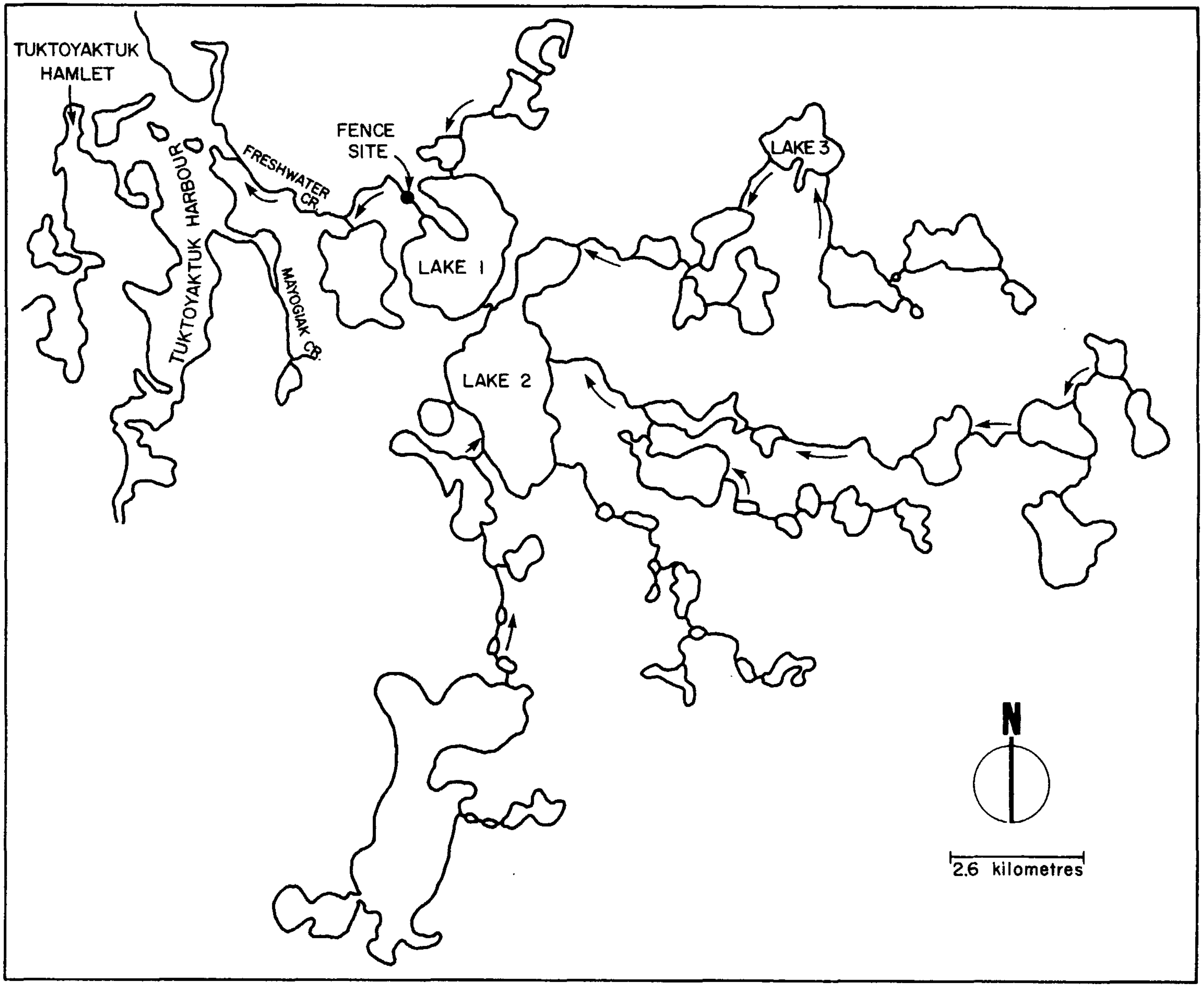

Fig. 3. The Freshwater Creek watershed indicating the location of the counting fence and the lakes surveyed in 1981.

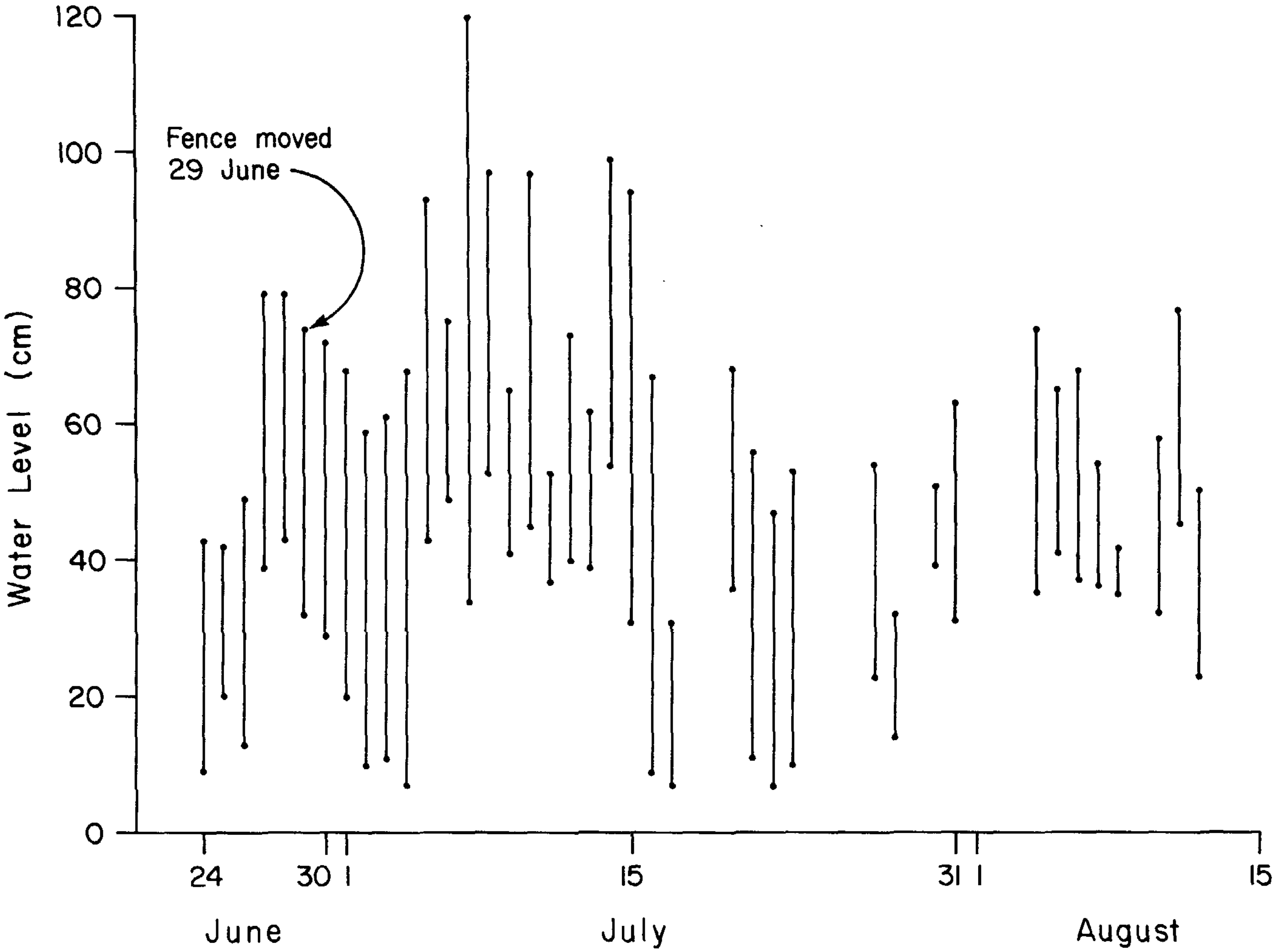

Fig. 4. Observed daily water level fluctuations at the Mayogiak Creek fence site, 1981.

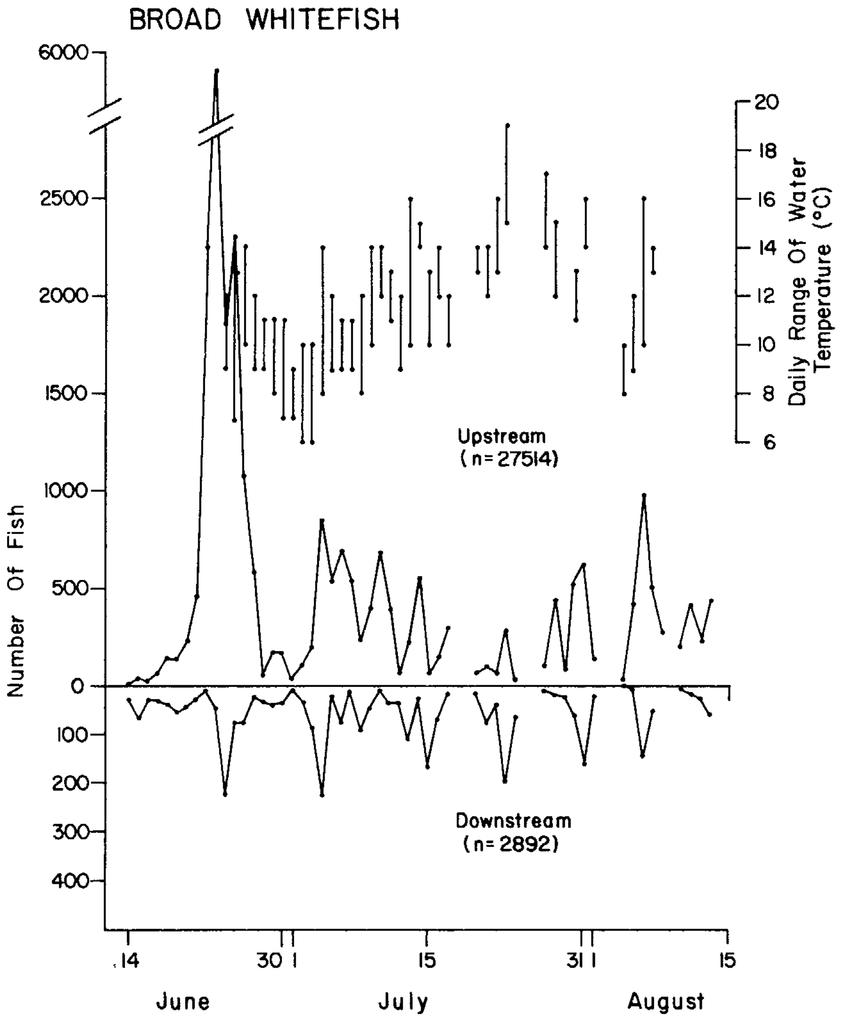

Fig. 5. Number of broad whitefish captured per day in upstream and downstream traps at Mayogiak Creek, 1981.

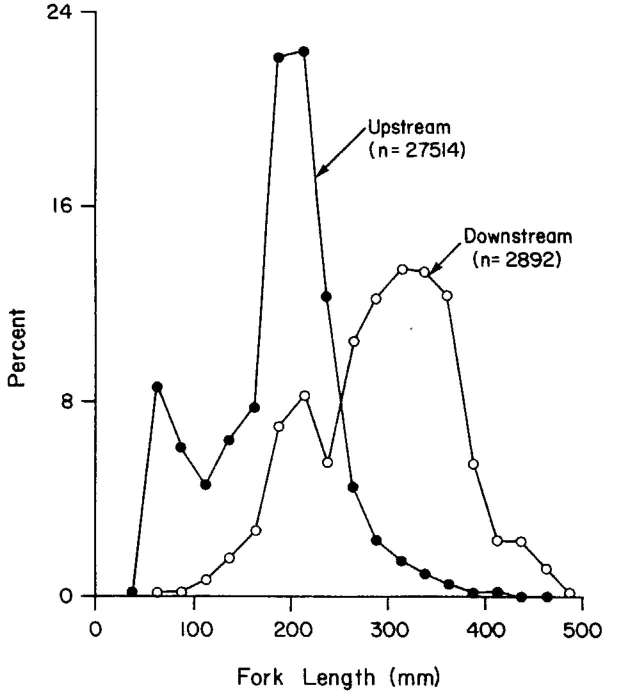

Fig. 6. Theoretical length-frequency distribution for broad whitefish in upstream and downstream runs, Mayogiak Creek, 1981.

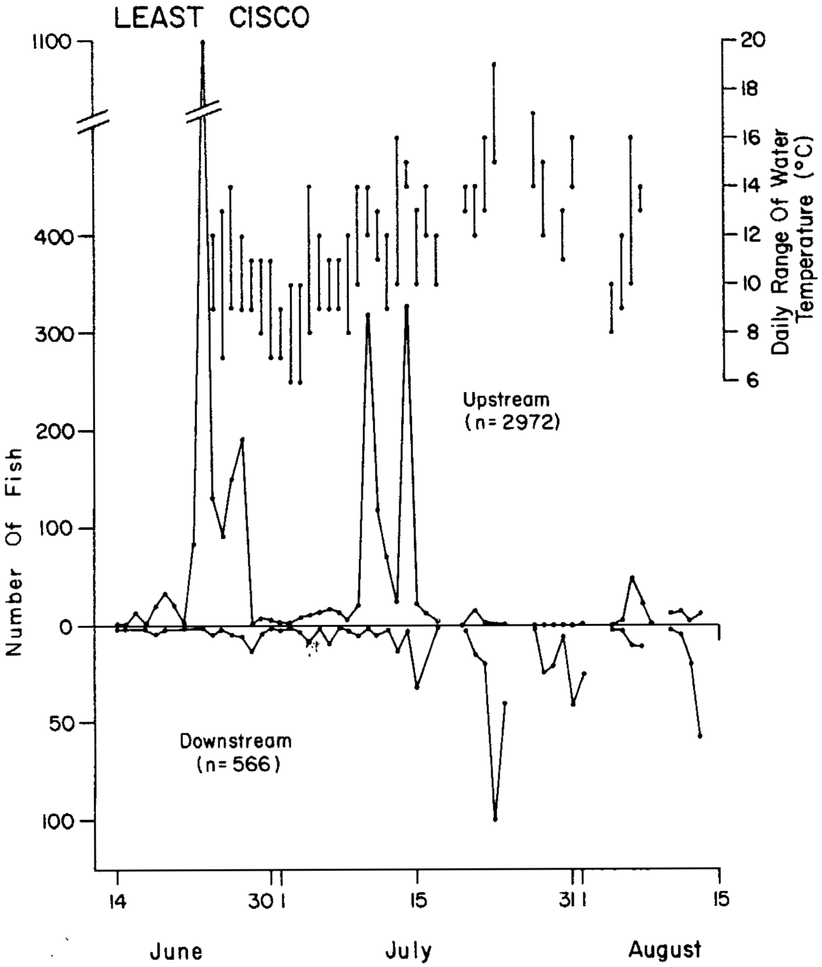

Fig. 7. Number of least cisco captured per day in upstream and downstream traps at Mayogiak Creek, 1981.

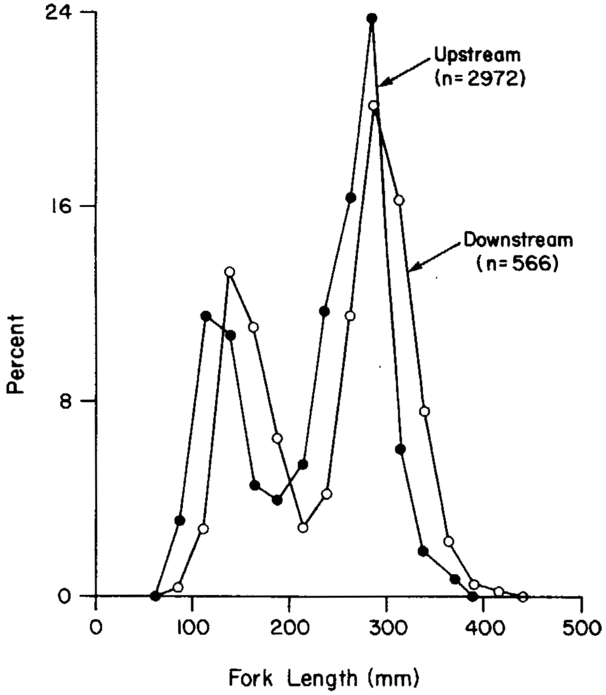

Fig. 8. Theoretical length-frequency distribution for least cisco in upstream and downstream runs, Mayogiak Creek, 1981.

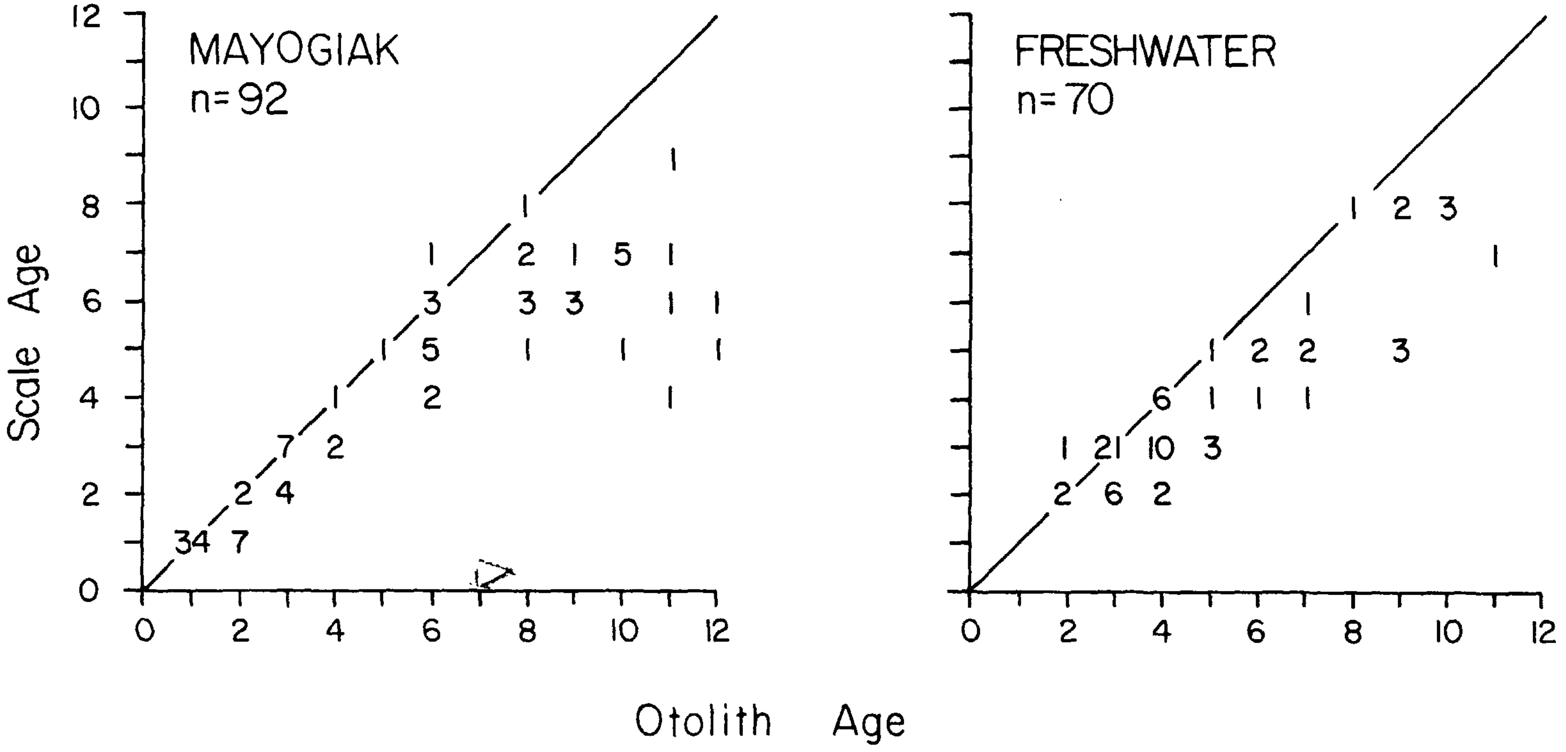

Fig. 9. Comparison of fin-ray, scale age pairs for least cisco from Mayogiak and Freshwater creeks, 1981. The numbers represent pairs of ages falling in each age group. The diagonal line represents cases where scale age - otolith age.

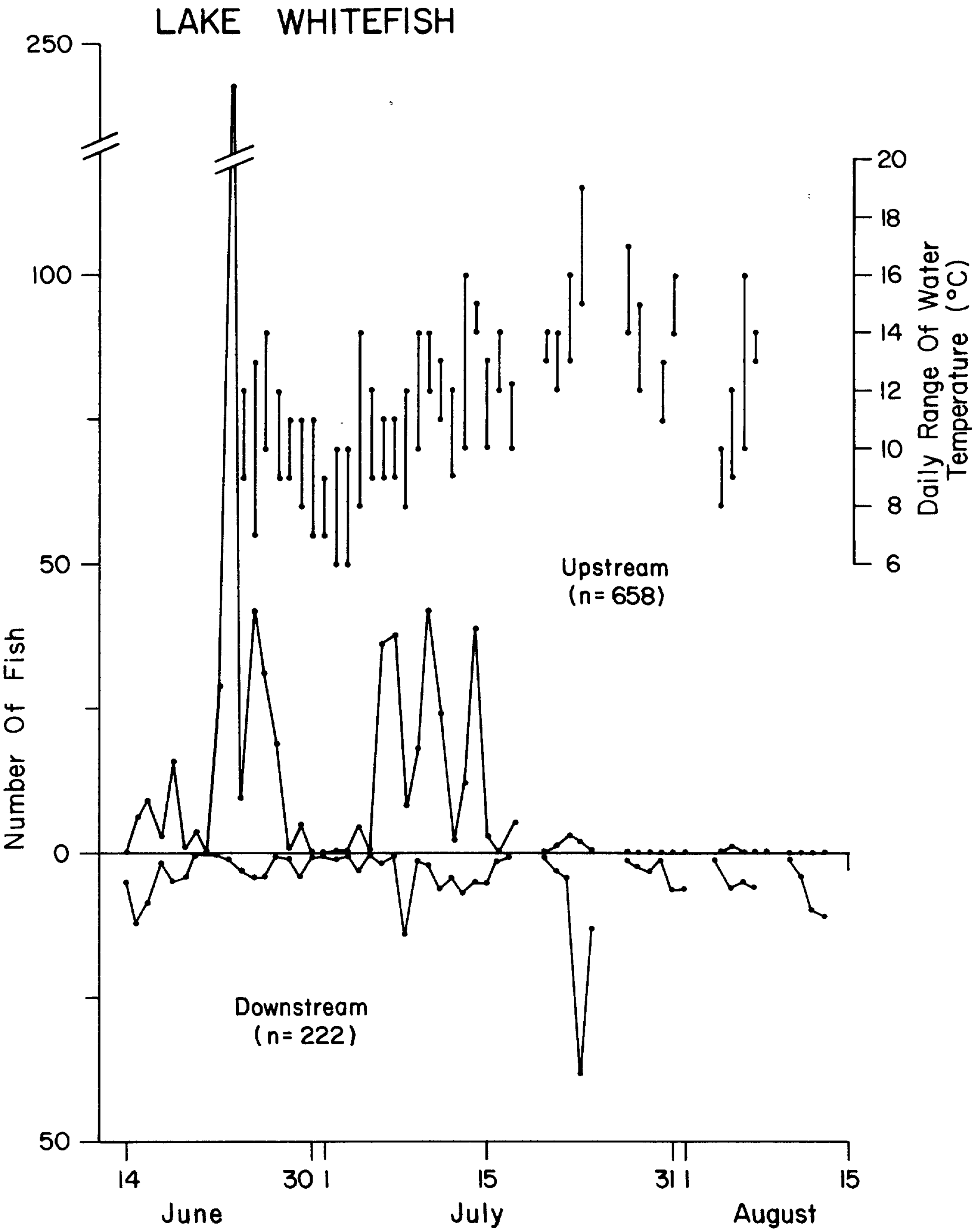

Fig. 10. Number of lake whitefish captured per day in upstream and downstream traps at Mayogiak Creek, 1981.

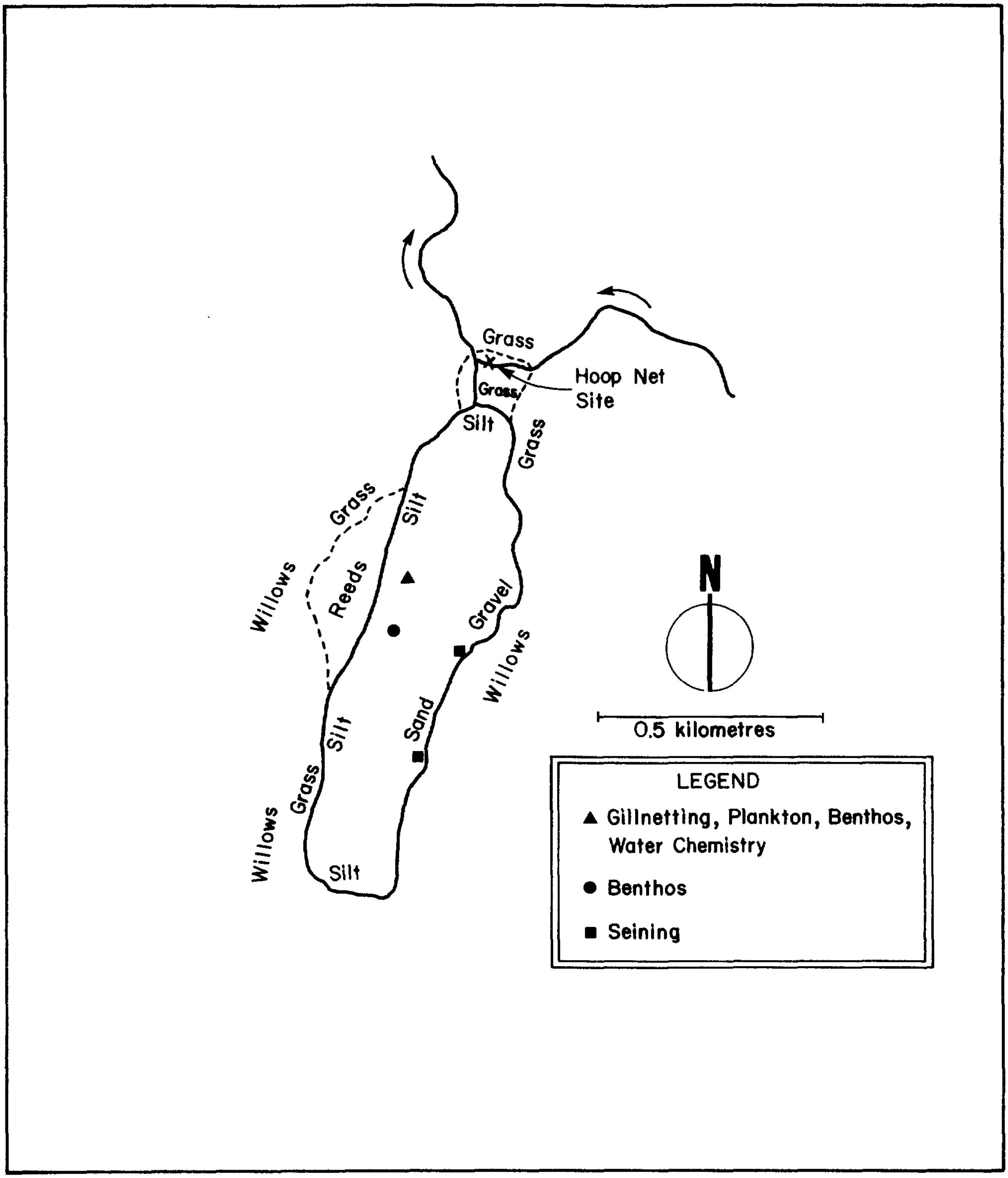

Fig. 11. Mayogiak Lake 1 indicating 1981 sampling locations, shoreline vegetation, and nearshore substrate types.

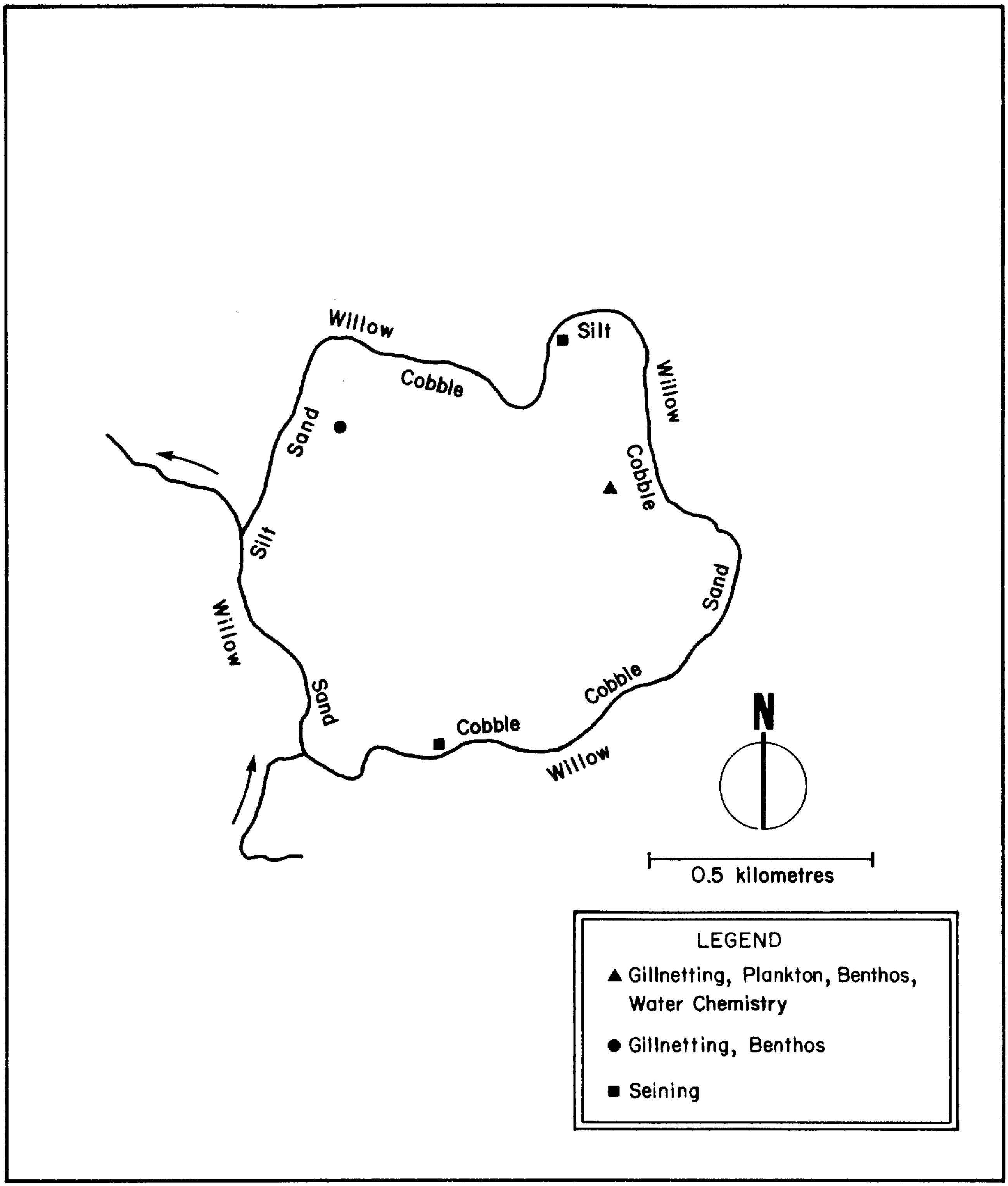

Fig. 12. Mayogiak Lake 2 indicating 1981 sampling locations, shoreline vegetation, and nearshore substrate types.

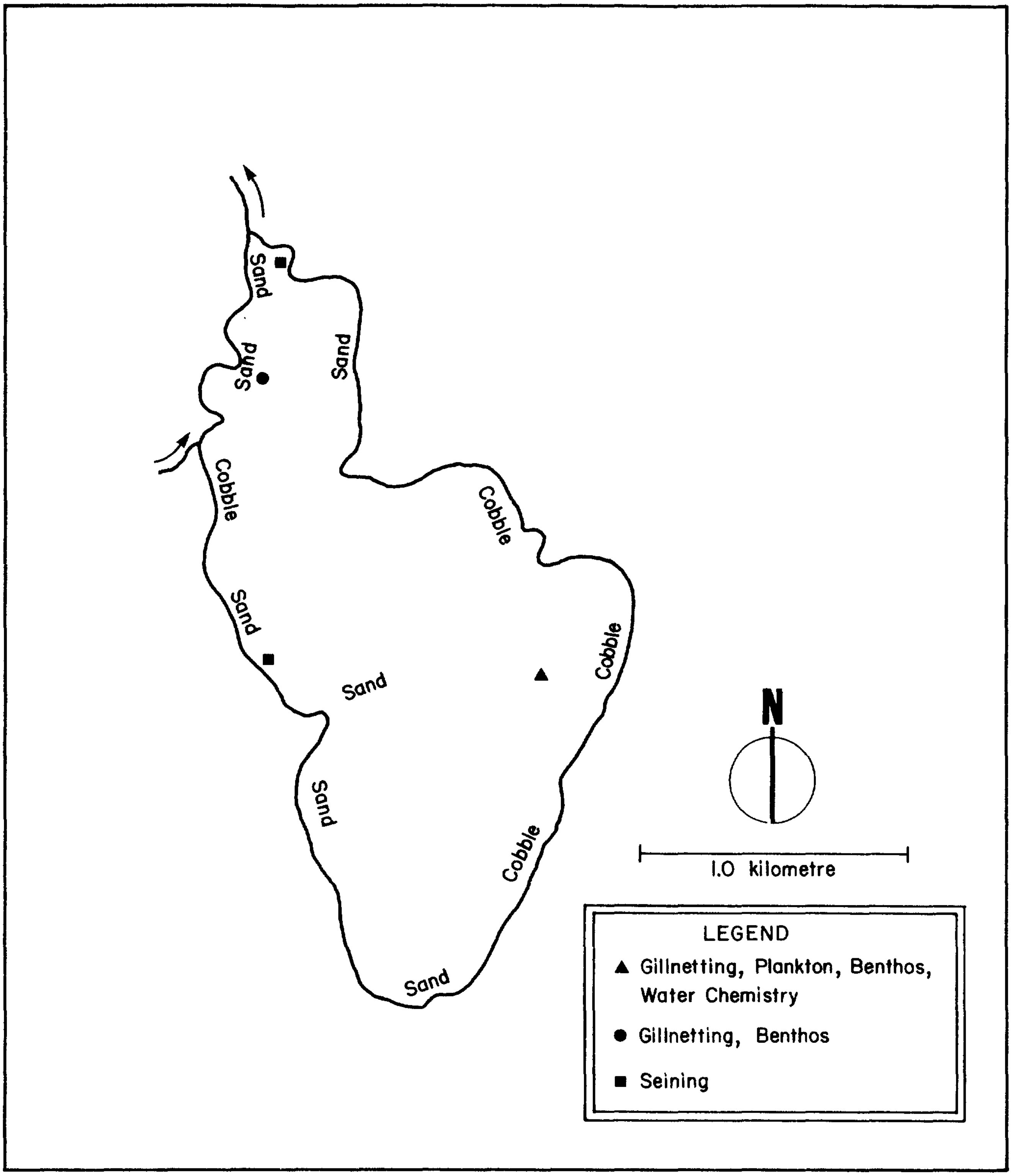

Fig. 13. Mayogiak Lake 3 indicating 1981 sampling locations and nearshore substrate types.

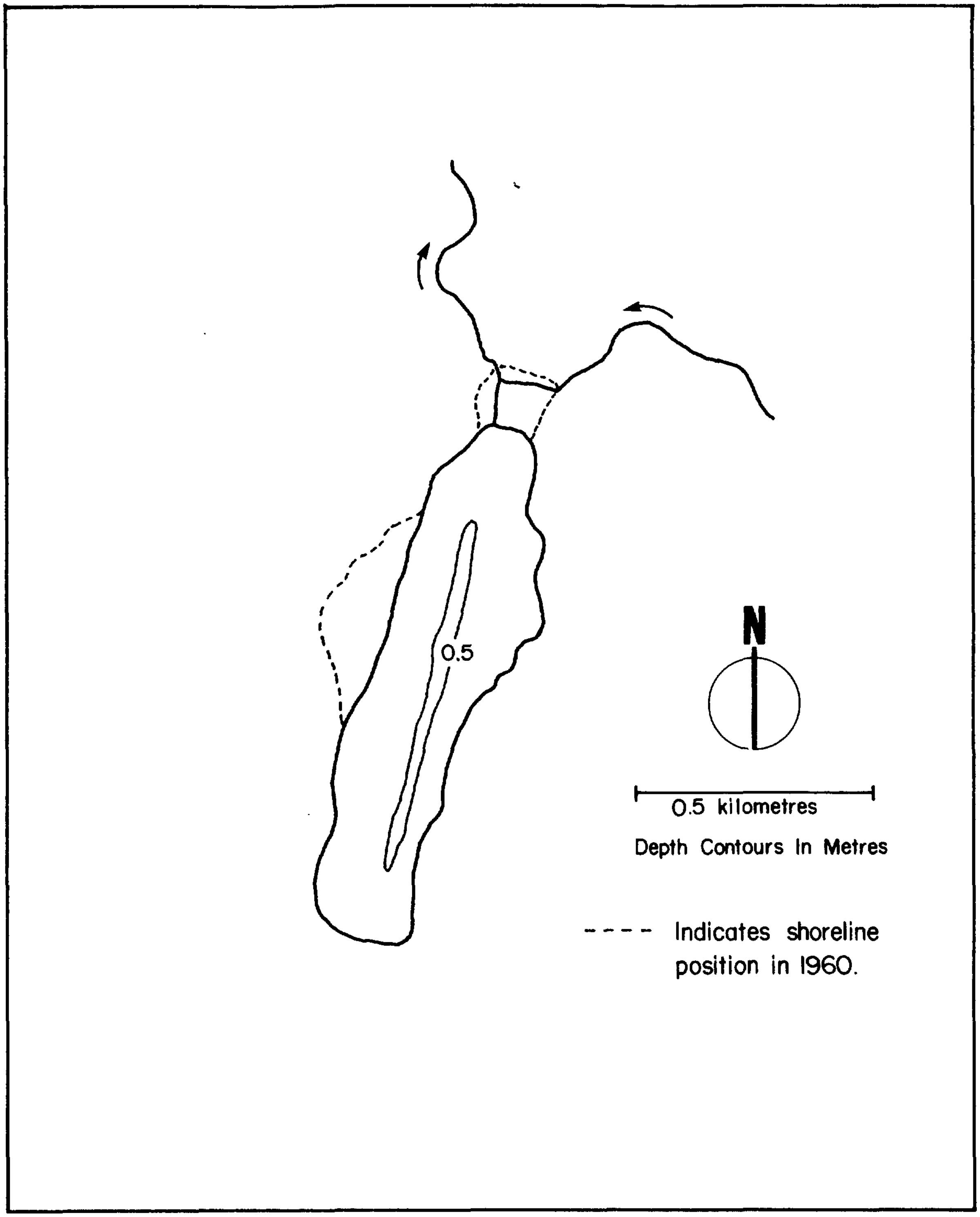

Fig. 14. Bathymetric map of Mayogiak Lake 1.

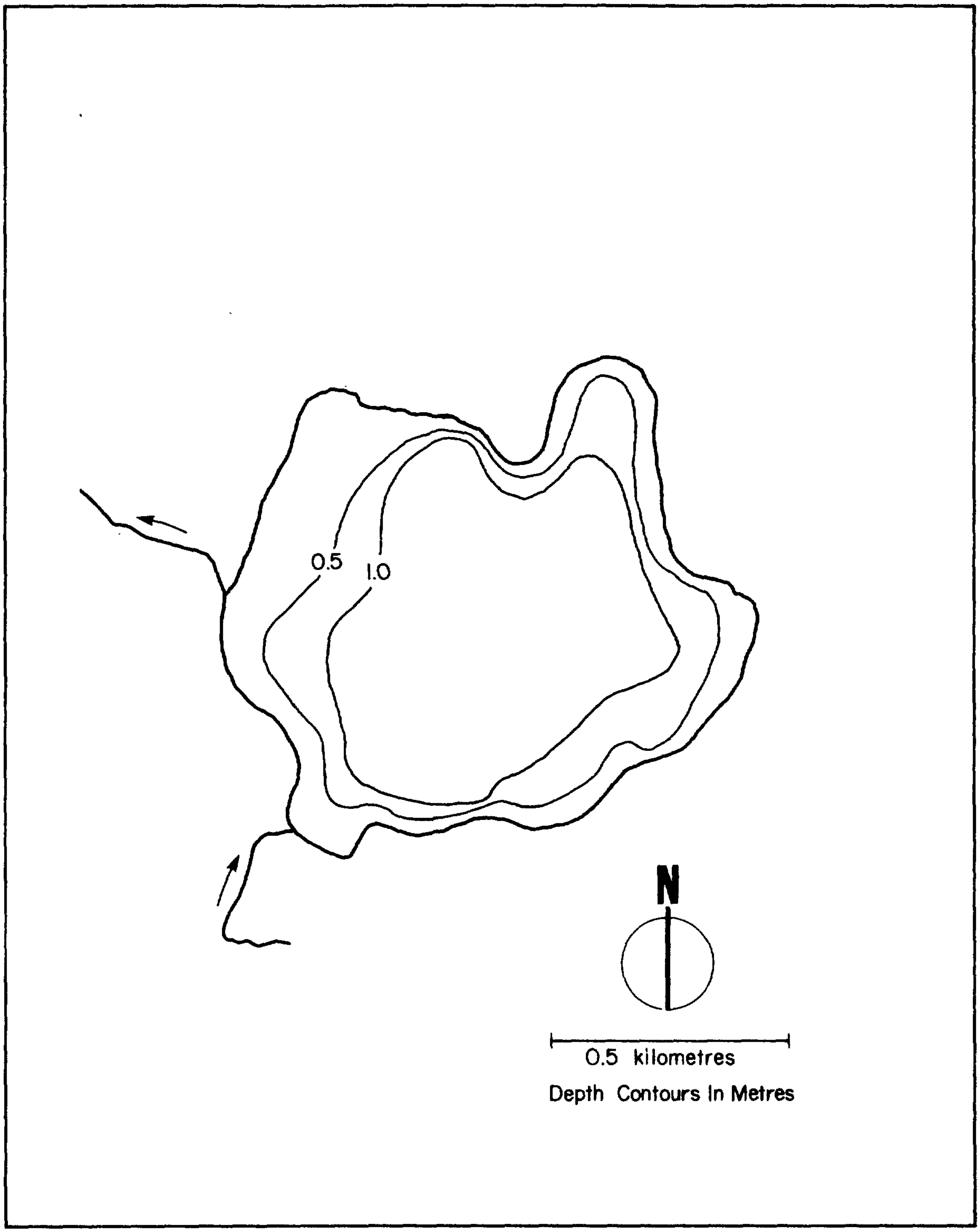

Fig. 15. Bathymetric map of Mayogiak Lake 2.

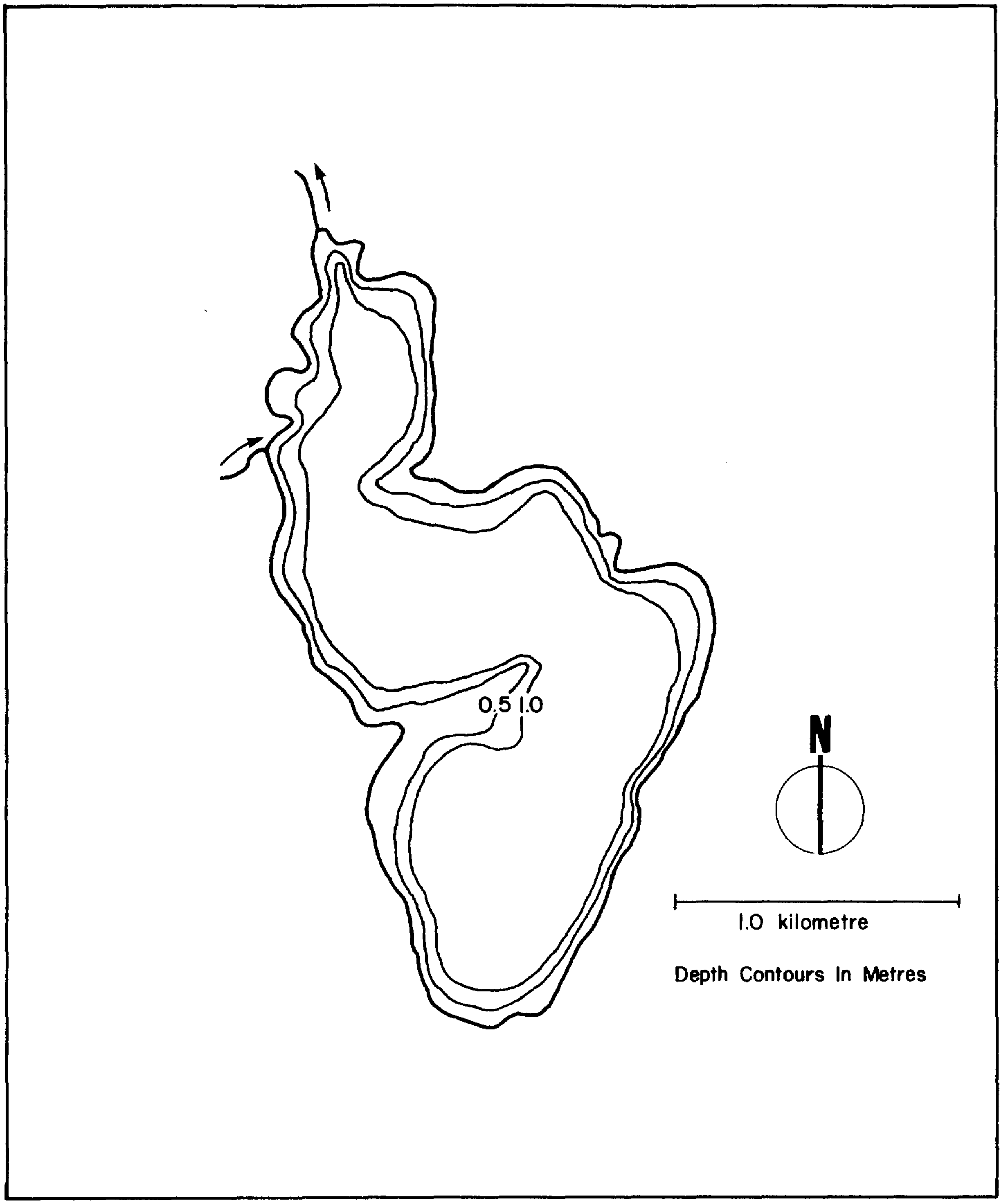

Fig. 16. Bathymetric map of Mayogiak Lake 3.

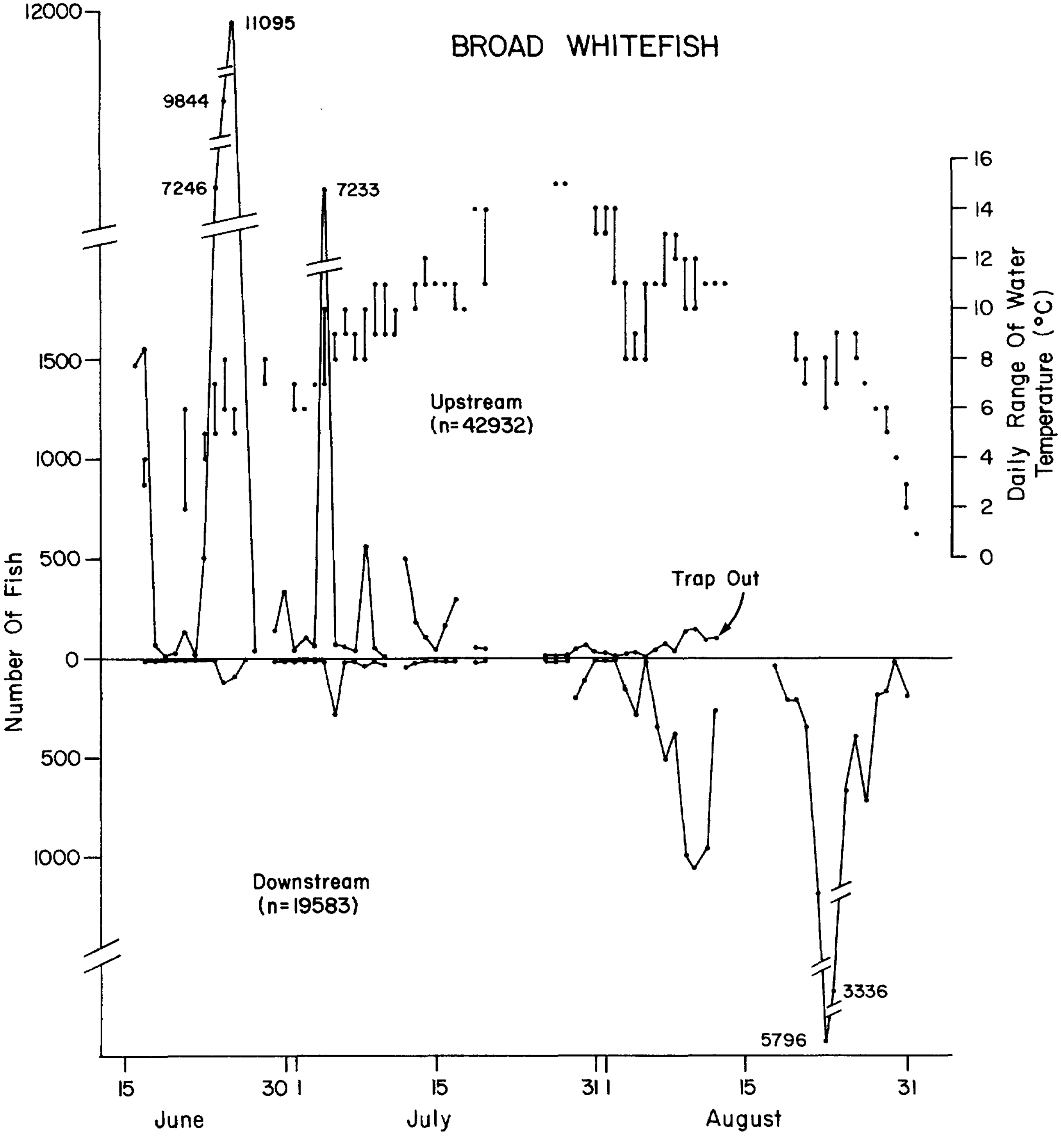

Fig. 17. Number of broad whitefish captured per day in upstream and downstream traps at Freshwater Creek, 1981.

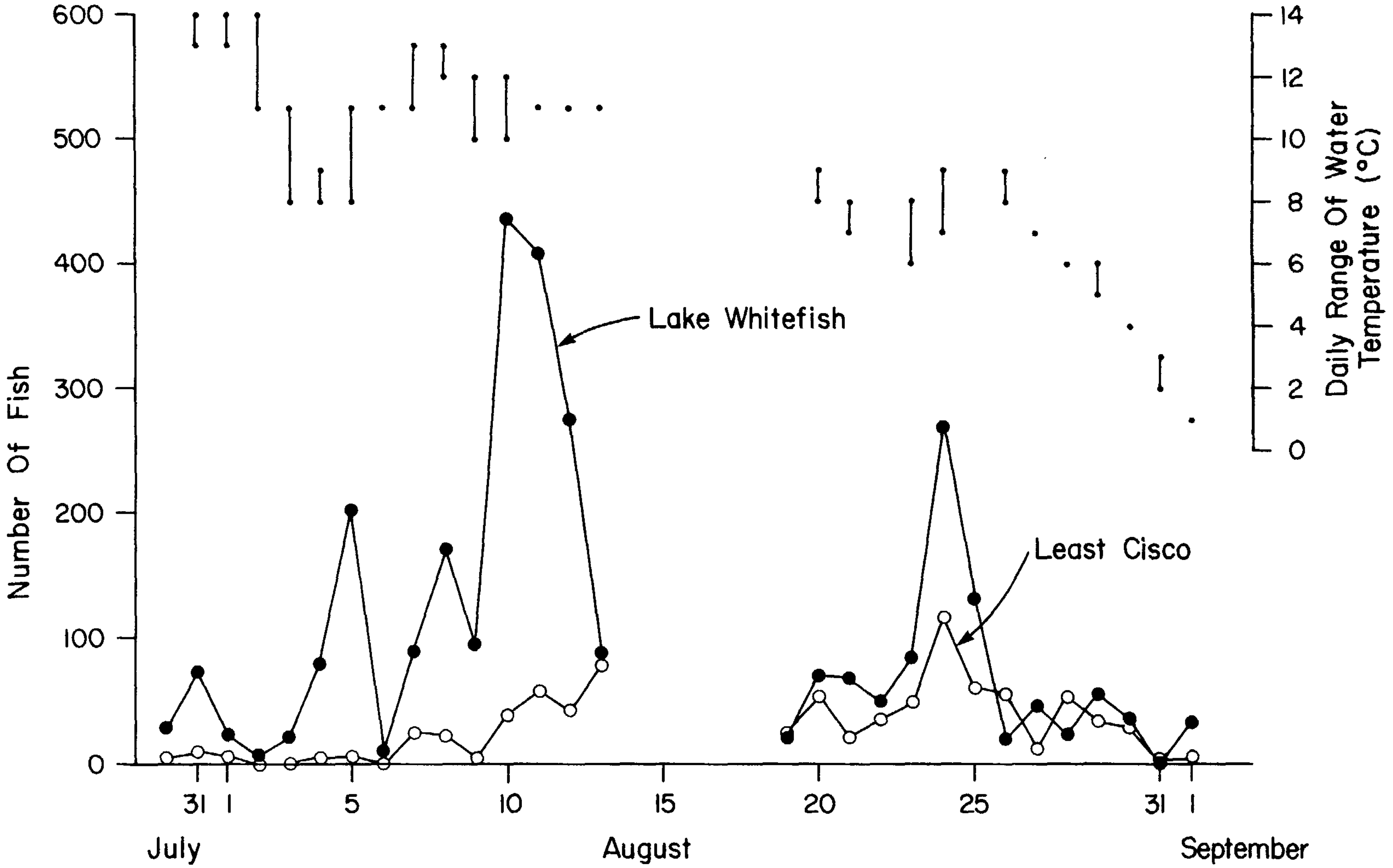

Fig. 18. Number of lake whitefish and least cisco captured per day in the downstream trap, Freshwater Creek, 30 July to 1 September 1981.

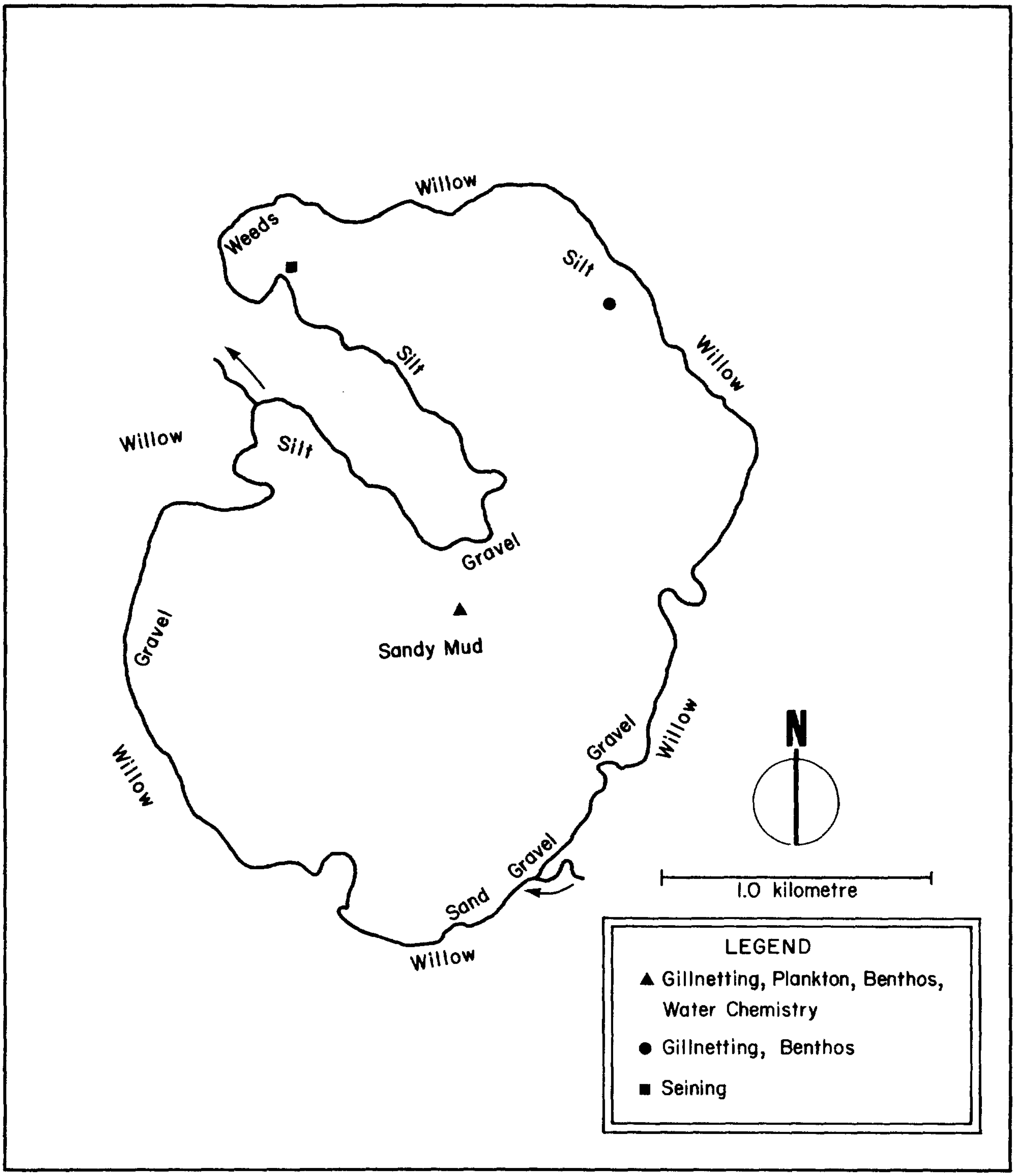

Fig. 19. Freshwater Lake 1 indicating 1981 sampling locations, shoreline vegetation, and nearshore substrate types.

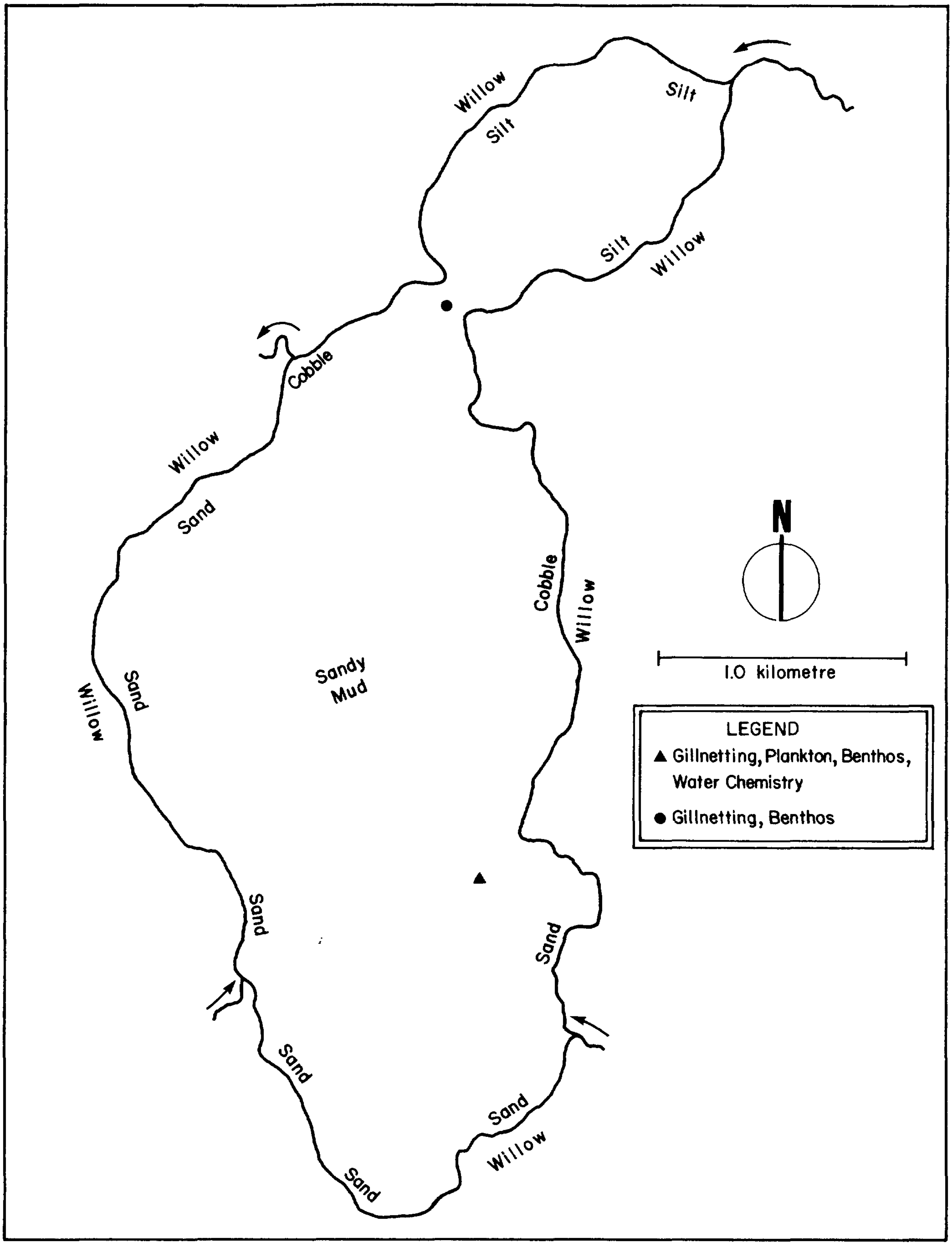

Fig. 20. Freshwater Lake 2 indicating 1981 sampling locations, shoreline vegetation, and nearshore substrate types.

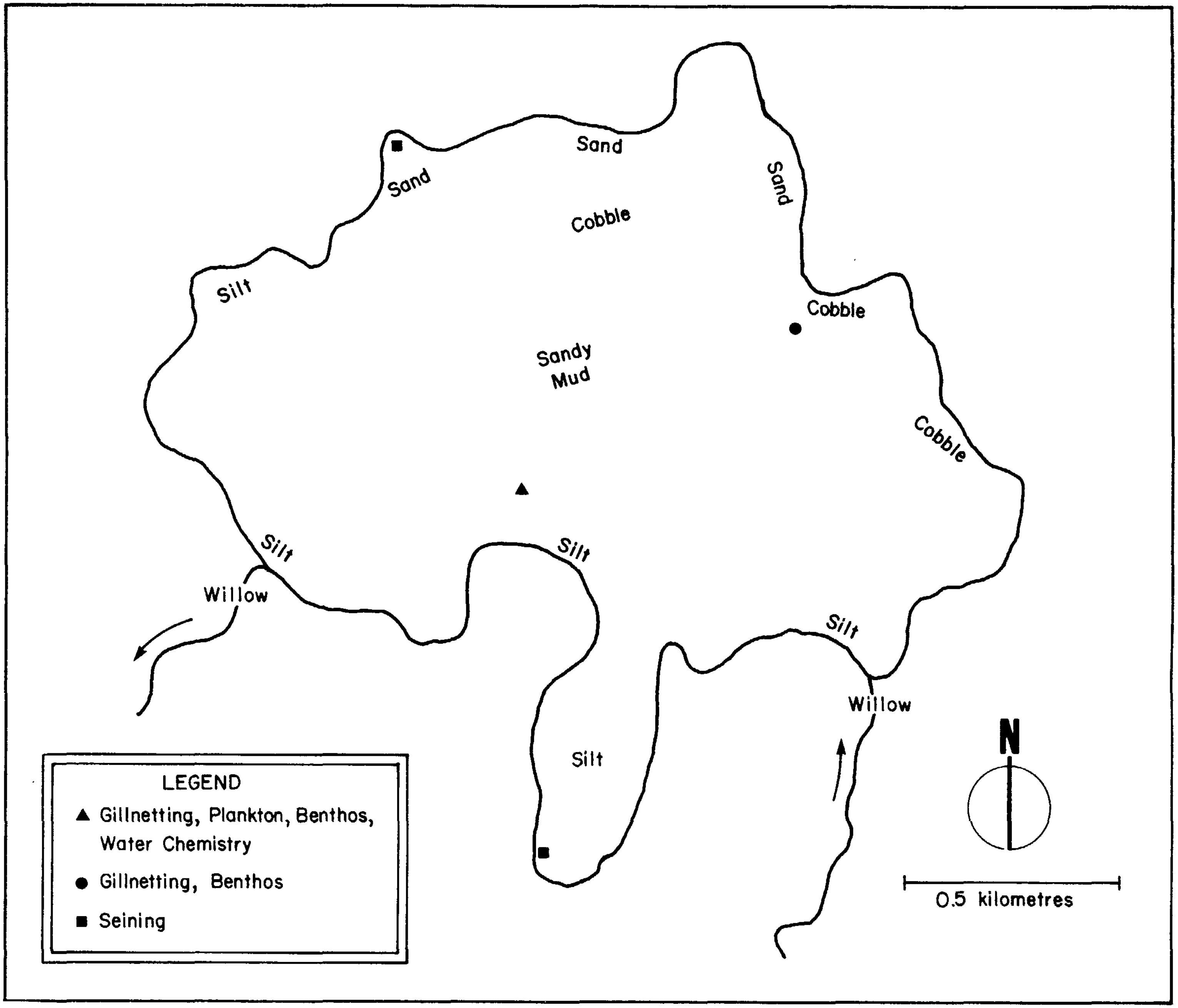

Fig. 21. Freshwater Lake 3 indicating 1981 sampling locations and nearshore substrate types.

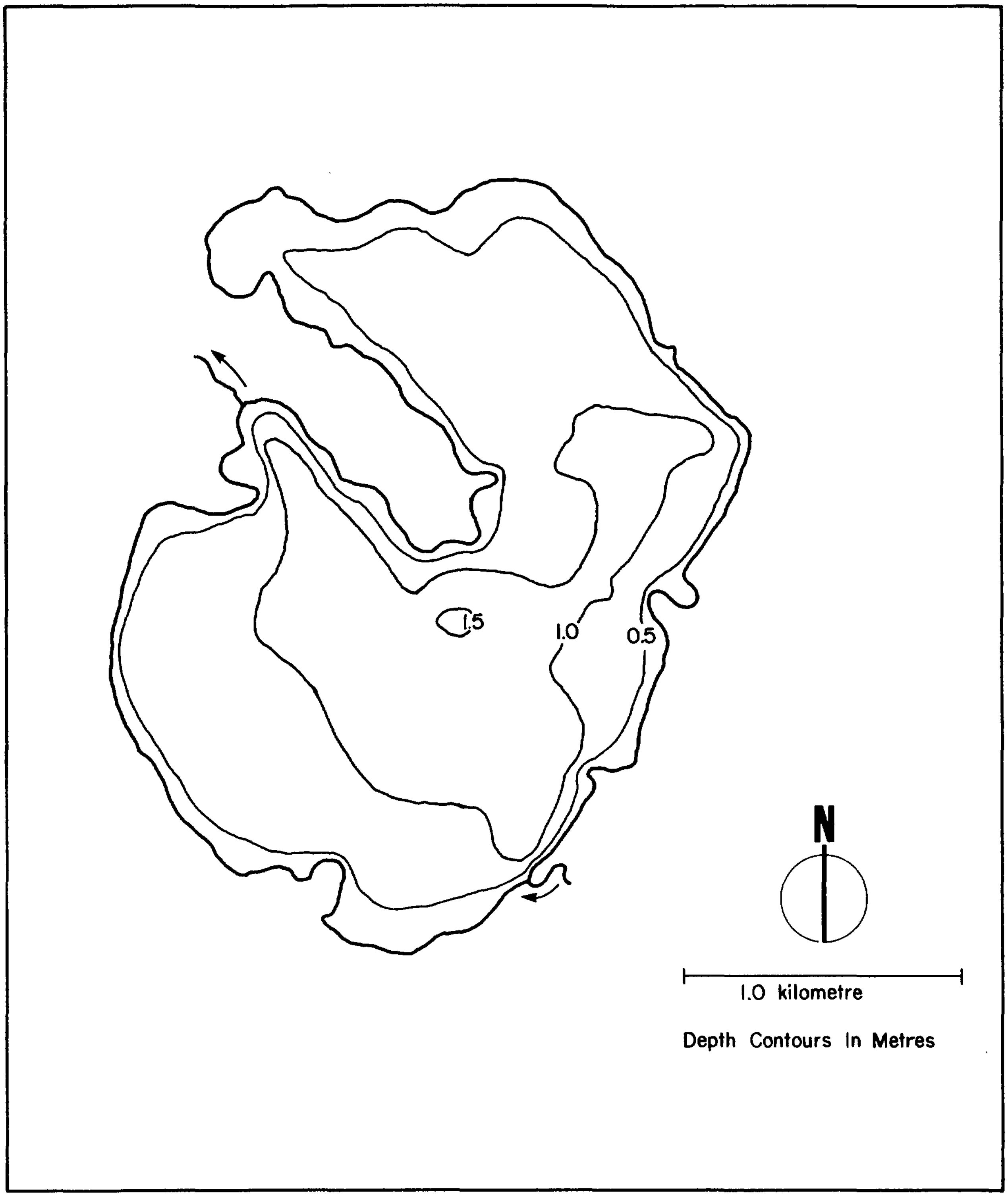

Fig. 22. Bathymetric map of Freshwater Lake 1.

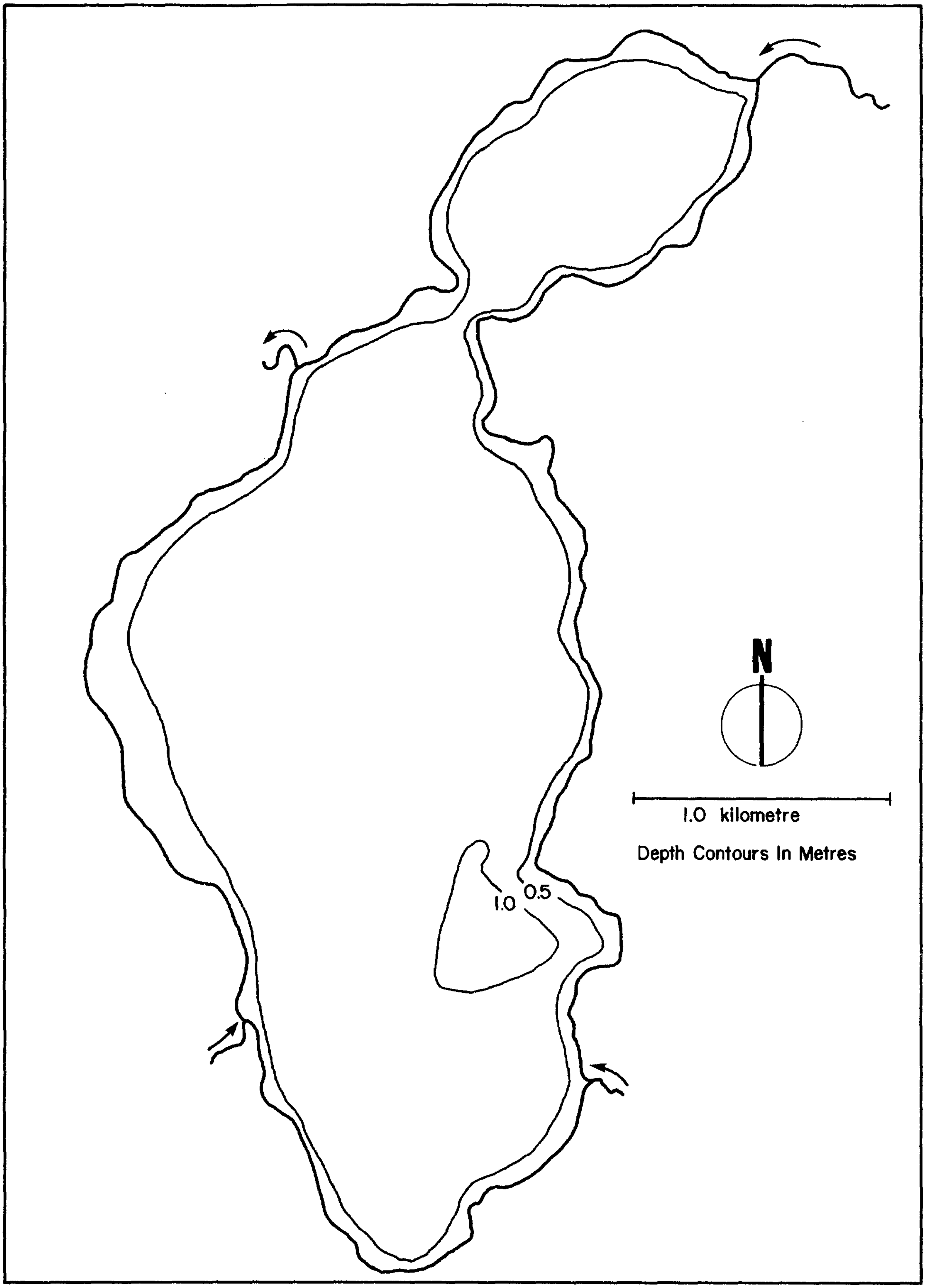

Fig. 23. Bathymetric map of Freshwater Lake 2.

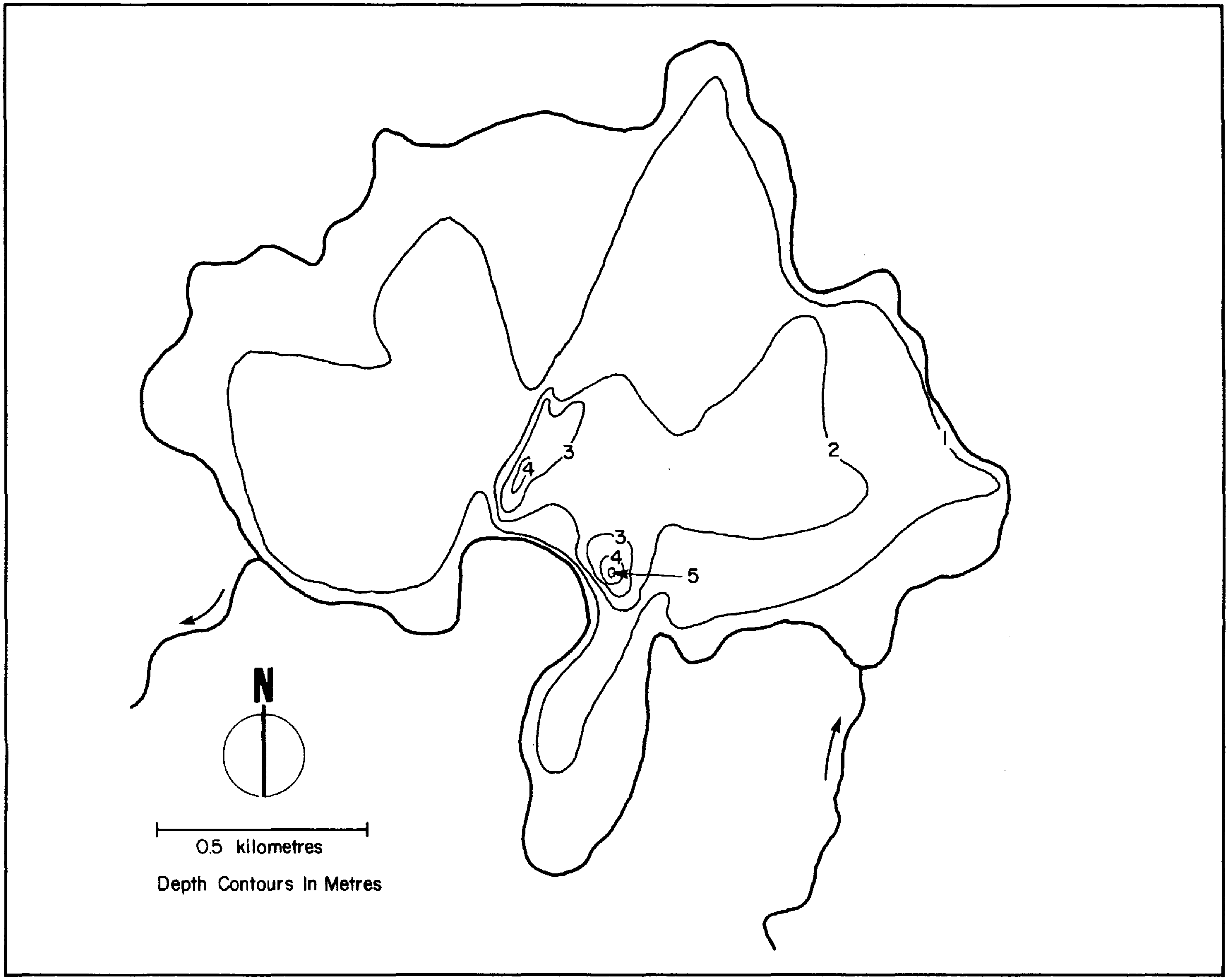

Fig. 24. Bathymetric map of Freshwater Lake 3.

Appendix 1. Daily fence counts for broad whitefish (BWF), lake whitefish (LWF), and least cisco (LC) at Mayogiak Creek, 1981.

	Number of Fish					
	Upstream			Downstream		
Date	BWF	LWF	LC	BWF	LWF	LC
14 June	3		2	29	5	
15 June	45	6		68	12	
16 June	25	9	14	31	8	
17 June	68	3	2	32	2	
18 June	140	16	19	37	5	4
19 June	140	1	32	54	4	1
20 June	238	4	18	44		2
21 June	463		3	29		1
22 June	2256	29	83	4		
23 June	5917	243	1098	43	1	
24 June	1856	9	130	224	3	5
25 June	2303	42	92	75	4	2
26 June	1076	31	149	72	3	6
27 June	585	19	190	23		6
28 June	46	1	4	33	1	14
29 June	174	5	7	40	4	4
30 June	209		5	32		
1 July	37		3	3		1
2 July	115		1	33	1	
3 July	197	1	8	84		4
4 July	854	5	11	227	3	8
5 July	534		13	24		2
6 July	694	36	16	78	2	10
7 July	537	38	13	4		
8 July	237	8	7	90	14	3
9 July	397	18	19	47	1	5
10 July	684	42	319	6	2	
11 July	385	24	119	34	6	6
12 July	57	2	70	33	4	3
13 July	227	12	24	106	7	13
14 July	557	39	327	24	5	3
15 July	60	3	22	170	5	32
16 July	135		12	67	1	16
17 July	304	5	4	13		1
18 July	ND	ND	ND	ND	ND	ND
19 July	ND	ND	ND	ND	ND	ND
20 July	64		1	15		3
21 July	88	1	16	77	3	16
22 July	66	3	2	36	4	19
23 July	283	2		194	38	99
24 July	33			69	13	41
25 July	ND	ND	ND	ND	ND	ND
26 July	ND	ND	ND	ND	ND	ND
27 July	109			7		1
28 July	453			20	2	25
29 July	87			25	3	21
30 July	528			59	1	7
31 July	632			158	6	42
1 Aug.	128			24	6	25
2 Aug.	ND	ND	ND	ND	ND	ND
3 Aug.	ND	ND	ND	ND	ND	ND
4 Aug.	34					
5 Aug.	418	1	3	3	6	3
6 Aug.	989		49	138	5	11
7 Aug.	489		22	53	6	12
8 Aug.	270			ND	ND	ND
9 Aug.	ND	ND	ND	ND	ND	ND
10 Aug.	204		12	3	1	2
11 Aug.	424		13	17	4	5
12 Aug.	222		5	22	10	20
13 Aug.	438		13	59	11	62
Total	27514	658	2972	2892	222	566

Appendix 2. Daily fence counts for broad whitefish (BWF), lake whitefish (LWF), and least cisco (LC) at Freshwater Creek, 1981.

	Number of Fish					
	Upstream			Downstream		
Date	BWF	LWF	LC	BWF	LWF	LC
14 June	ND	ND	ND	ND	ND	ND
15 June	ND	ND	ND	ND	ND	ND
16 June	1473	2				
17 June	1553	5				
18 June	70	5	3			
19 June	9	2		5		
20 June	28	19	7	8	8	2
21 June	137	2	250	4		
22 June	25		7	7		
23 June	508	1	7	4		
24 June	7246			6		
25 June	9844	9	3	121		
26 June	11095			98		
27 June	ND	ND	ND			
28 June	38	10	2	ND	ND	ND
29 June	ND	ND	ND	ND	ND	ND
30 June	134	9	6	1		
1 July	333	4	4	5		
2 July	47	7	3	3		
3 July	95	5	2	1		
4 July	67			1		
5 July	7233			16		
6 July	69			292		4
7 July	59					
8 July	36			3		
9 July	563		2	37		
10 July	44		4	8		2
11 July	3	1	170	37		
12 July	ND	ND	ND	ND	ND	ND
13 July	496			56		
14 July	203		4	23		1
15 July	112		91	3		1
16 July	44		30	7		
17 July	161		107			
18 July	284		190	10		
19 July	ND	ND	ND	ND	ND	ND
20 July	39	3	8	11		
21 July	33	4	12			
22 July	ND	ND	ND	ND	ND	ND
23 July	ND	ND	ND	ND	ND	ND
24 July	ND	ND	ND	ND	ND	ND
25 July	ND	ND	ND	ND	ND	ND
26 July	ND	ND	ND	ND	ND	ND
27 July	6					
28 July	5		2			
29 July	9		4			
30 July	31		2	216	27	3
31 July	67	2	6	122	73	8
1 Aug.	26		3	17	22	4
2 Aug.	23	1	6		3	
3 Aug.	2			17	22	
4 Aug.	12	1		167	80	3
5 Aug.	25	3		290	204	4
6 Aug.	2			11	1	1
7 Aug.	33		19	349	91	26
8 Aug.	76	2	27	510	172	23
9 Aug.	37	3	14	383	97	7
10 Aug.	142		32	991	438	41
11 Aug.	151	1	51	1053	408	60
12 Aug.	98	1	34	950	276	43
13 Aug.	106		53	268	88	78
14 Aug.	ND	ND	ND	ND	ND	ND
15 Aug.	ND	ND	ND	ND	ND	ND
16 Aug.	ND	ND	ND	ND	ND	ND
17 Aug.	ND	ND	ND	ND	ND	ND
18 Aug.	ND	ND	ND	ND	ND	ND
19 Aug.			2	45	21	25
20 Aug.		Trap removed		218	73	55
21 Aug.				220	69	23
22 Aug.				358	51	36
23 Aug.				1192	85	49
24 Aug.				5796	269	121
25 Aug.				3336	130	62
26 Aug.				670	20	53
27 Aug.				379	47	14
28 Aug.				721	23	54
29 Aug.				188	56	34
30 Aug.				164	37	35
31 Aug.				3		
1 Sept.				182	35	6
Total	42932	92	1167	19853	2926	878