Coregonid Migration Studies at Kukjuktuk Creek, a Coastal Drainage on the Tuktoyaktuk Peninsula, Northwest Territories

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ABSTRACT

Chang-Kue, K.T.J., and E.F. Jessop. 1992. *Coregonid migration studies at Kukjuktuk Creek, a coastal drainage on the Tuktoyaktuk Peninsula, Northwest Territories.* Can. Tech. Rep. Fish. Aquat. Sci. 1811: ix + 112 p.

A total of over 1 350 000 fishes comprising broad whitefish (94.1%), least cisco (3.9%) and lake whitefish (2.0%) were enumerated in upstream and downstream runs during 1978 and 1979 at Kukjuktuk Creek. This study was the first to establish that migration behaviour, migration corridors and spatially separated habitats, located in coastal drainages, constitute important components in the early life history stages of some Mackenzie Delta coregonid populations.

Upstream runs involved immature fish proceeding to nursery, feeding and overwintering habitats in headwater lakes. About 88% of the broad whitefish upstream run in 1979 were 0+ and 1+ year old fish; most of this group may remain in lakes for up to four years before switching to complex annual migrations between lakes and coastal waters. After foraging in lakes for 21-45 days, many immature fish (age 4-8 years) return downstream to coastal waters although others may remain to overwinter in lakes that year. Large, mature broad whitefish were among the earliest downstream migrants after a phase of residency in lakes. Stream migratory behaviour appeared to cease with onset of sexual maturity (age 7-8 years); older broad whitefish, prevalent in the Mackenzie River, were infrequent in the upstream run. Tagged downstream migrants were recaptured each fall at coastal sites (Whitefish Station and Tuktoyaktuk Harbour). Lake and broad whitefish were recaptured in subsequent years among spawning runs in the Mackenzie Delta, Arctic Red River and in the lower Mackenzie River near Fort Good Hope.

Least cisco and lake whitefish used the watershed for similar purposes although the youngest least cisco (0-3 years) and lake whitefish (0-5 years) were relatively absent in stream migrations.

Key words: migrations; tagging; anadromous species; broad whitefish; lake whitefish; least cisco; Beaufort Sea; Mackenzie Delta; life history; overwintering; feeding; nursery grounds; fish habitat; tundra lakes; coastal waters.

RÉSUMÉ

Chang-Kue, K.T.J., and E.F. Jessop. 1992. Coregonid migration studies at Kukjuktuk Creek, a coastal drainage on the Tuktoyaktuk Peninsula, Northwest Territories. Can. Tech. Rep. Fish. Aquat. Sci. 181: ix + 112 p.

Un total de plus de 1 350 000 poissons comprenant du corégone tschir (94,1 p. 100), du cisco sardinelle (3,9 p. 100) et du corégone de lac (2,0 p. 100) ont été dénombrés en 1978 et 1979 dans des tronçons d'amont et d'aval du ruisseau Kukjuktuk. La présente étude a été la première à établir que le comportement migratoire, les corridors de migration et des habitats géographiquement distincts, situés dans des cours d'eau littoraux, constituent des composantes importantes dans les premières étapes de vie de certaines populations de corégonidés du delta du Mackenzie.

Le tronçon d'amont renfermait du poisson immature partis à la recherche de sites d'alevinage, de fourrage et d'hivernage dans les lacs d'amont. Environ 88 p. 100 des corégones tschirs du tronçon d'amont étaient âgés de 0+ et de 1+ ans en 1979; il se peut que la plus grande partie de ce groupe ait séjourné dans des lacs pendant une période atteignant quatre années avant d'entreprendre des migrations annuelles complexes entre lacs et eaux littorales. Après avoir fourragé dans des lacs pendant 21 à 45 jours, nombre de poissons immatures (âgés de 4 à 8 ans) sont redescendu vers la côte, même si les autres ont pu rester pour passer l'hiver dans des lacs cette année-là. De gros corégones tschirs matures ont été parmi les premiers à migrer vers l'aval après un séjour dans des lacs. La migration dans des cours d'eau a semblé cesser au moment de la maturité sexuelle (à l'âge de 7 à 8 ans); les corégones tschirs plus vieux, abondants dans le Mackenzie, étaient rares dans le tronçon d'amont. Les migrants vers l'aval étiquetés ont été recapturés chaque automne dans des sites littoraux (station de Whitefish et port de Tuktoyaktuk). Des corégones de lacs et tschirs ont été recapturés des années ultérieures dans des sections de frai du delta du Mackenzie, de la rivière Arctic Red et du cours inférieur du Mackenzie près de Fort Good Hope.

Des ciscos sardinelles et des corégones de lac ont utilisé le bassin hydrographique à des fins semblables même si les plus jeunes ciscos sardinelles (0-3 ans) et corégones de lac (0-5 ans) étaient relativement absents dans les migrations dans des cours d'eau.

Mots clés: migrations; ètiquetage; espèce anadrome; corégone tschir; corégone de lac; cisco sardinelle; mer de Beaufort; delta du Mackenzie; vie; hivernage; fourrage; sites d'alevinage; habitat du poisson; lacs de toundra; eaux littorales.

INTRODUCTION

In the decade prior to this study, several investigations were made to determine the life histories of coregonid fish species in the Mackenzie River (Hatfield et al. 1972a, 1972b; Stein et al. 1973a, 1973b, 1973c; Jessop et al. 1974; Jessop and Lilley 1975; Percy 1975). While broad whitefish, lake whitefish, least cisco, Arctic cisco and inconnu were known to inhabit coastal waters (Bray 1975; Galbraith and Fraser 1974; Galbraith and Hunter 1975; Jones and den Beste 1977), it was thought that the inconnu, lake whitefish and broad whitefish were more confined to estuarine and freshwater habitats in the Mackenzie Delta and the lower Mackenzie River. Recapture information on coregonids tagged in 1972-1974 by the Department of Fisheries and Oceans (DFO) provided initial clues that the East Channel and proximal coastline of the Tuktoyaktuk Peninsula (Fig.1) constituted a part of broad whitefish summer habitat. Tagging data also suggested that migrations for Mackenzie Delta lake whitefish and least cisco extended along the coast at least to Tuktoyaktuk Harbour (Jessop et al. 1974). While the presence of lake resident populations of least cisco and lake whitefish were reported for some lake systems in the region (Mann 1974; deGraff and Machniak 1977), any linkages among lake, coastal and Mackenzie Delta populations were speculative. It was surmised that the freshwater drainages of the north coastal region of Tuktoyaktuk Peninsula had an important role in providing feeding, spawning and overwintering habitats for distinct coastal coregonid populations.

Despite the fluctuations in economic forecasting for this region, there is always some proposed level of industrial development especially with regard to the hydrocarbon reserves that lie beneath the Beaufort Sea. Any proposed exploration and development plans offer the potential for impacts on fish and fish habitats as well as disturbance to fish migrations. The escalating offshore exploration activities of Dome Petroleum, Esso Resources and Gulf Canada by 1978 prompted an initiative by DFO to conduct life history studies on fish populations in the southern Beaufort Sea coastal area, specifically along the north shoreline of the Tuktoyaktuk Peninsula and Richards Island.

The purpose of this study was to investigate the nature and extent of fish migrations in coastal streams. A two-way counting fence was used to enumerate and examine the fish fauna utilizing a representative drainage on Tuktoyaktuk Peninsula. Fish were tagged to determine the movement and dispersal patterns of fish entering or leaving this drainage. This report presents the results of a two-year (1978-1979) study at Kukjuktuk Creek on the Tuktoyaktuk Peninsula and provides an assessment of its significance to fish populations in the region. The study was one of an initial set of inter-related investigations carried out by DFO to expand our knowledge of the biology and life history of the fishes in the area (Bond 1982; Lawrence et al. 1984; B.W. Fallis, Department of Fisheries and Oceans, 501 University Cres., Winnipeg, personal communication). Additional investigations by DFO on fishes in Tuktoyaktuk Harbour and tributary creeks were conducted by Bond and Erickson (1982, 1985), Hopky and Ratynski (1983) and Ratynski (1983).

DESCRIPTION OF STUDY AREA

The north side of the Tuktoyaktuk Peninsula has a highly indented coastline characterized by numerous embayments, inlets and lagoons. The largest embayment is Kukjuktuk Bay (N69°40', W132°30') located approximately 26 km east of Tuktoyaktuk Harbour (Fig. 1). The major drainage into Kukjuktuk Bay encompasses an area of 280 km^2 and, like most of the adjacent systems, consists of a network of lakes and interconnecting streams draining towards the north shore of the Peninsula (Fig. 2). Kukjuktuk Creek is a single-channel, tundra creek that varies from 2 to 6 m in width. Its shallow, gravel-bottomed reaches are interrupted by occasional scour channels, 1.0 to 1.5 m deep, and a few wide, silt-bottomed pools. The water is yellow-brown in colour with very little suspended sediment. Although the normal tidal range of 0.5 m measured at Tuktoyaktuk is quite narrow (Burns 1973), water levels in the lower reaches of the creek can rise substantially due to coastal storm surges.

The study area is part of the physiographic region designated as the Pleistocene Coastal Plain (Mackay 1963). This area of fluvial and deltaic deposits is covered by tundra along the coast with scrub tundra farther inland. The terrain is characterized by numerous lake systems, flats, low hills and isolated pingoes.

The annual precipitation in the area is low, averaging 130 mm at Tuktoyaktuk (Burns 1973). Mean daily temperatures at Tuktoyaktuk vary from a low of -29.2°C in February to a high of 10.3°C in July (Burns 1973).

Mean date of complete freeze-over of coastal waters in the vicinity of Kukjuktuk Bay is October 15 while the mean date clear of ice is June 30 (Burns 1973). Salinity in the estuarine waters of the Mackenzie Delta may vary both temporally and spatially; in Kugmallit Bay the salinity of the water can range, on an annual basis, from 0 to at least 31.4‰ (Barber 1968). A major influence on salinities along the coastal shelf area is the warm, silt laden discharge of the Mackenzie River. Satellite photographs clearly show Mackenzie River waters flowing in a northeasterly direction along the Tuktoyaktuk Peninsula coastline. This freshwater plume, a result of interactions with the cold saline seawater, prevailing winds, and the earth's rotational Coriolis effect, creates an extended freshwater/estuarine environment along this coast in summer and winter.

MATERIALS AND METHODS

COUNTING FENCE OPERATIONS

Fence location

A two-way fish counting fence was installed in Kukjuktuk Creek during the open water season of 1978 and 1979. In 1978, the fence was located approximately 2.5 km upstream from Kukjuktuk Bay (Fig. 2). The fence was in operation from 16 June until 11 September 1978. Flooding of the fence by high tides during a prolonged coastal storm in late August hindered the counting operation for the rest of the season.

The counting fence was relocated in 1979 to a site five kilometers upstream from the coast (Fig.2), well above any historic high tide marks. At this site Kukjuktuk Creek was 4 m wide and 0.5-0.7 m deep, with a flat, gravel bottom and even flow. This fence was in operation from breakup to freezeup (13 June to 29 September 1979).

Fence construction

The fence was constructed to form a temporary barrier to allow counting and sampling of migrating fish. The trap design and fence installation were similar in both years, except as noted. Each trap box (1.2 x 2.4 x 1.2 m deep) was framed with spruce lumber and covered with welded wire-mesh fencing material (2.54 cm mesh size). Upstream and downstream traps were secured side by side and located in mid-stream. The upstream and downstream lead wings, funnelling fish into the appropriate trap, were constructed of the same metal wire fencing. The wings were supported on the downsteam sides by steel fence stakes driven into the substrate. Wire mesh skirting along each trap bottom and wings was secured and anchored to the creek bottom with gravel-filled sandbags.

In 1979, a supplementary plastic mesh (0.63 cm square mesh size) was fastened to the upstream side of the fence and to the inside of the traps to facilitate entrapment of fry or yearlings as well as minimizing injury to fish. Another important modification was the inclusion of an adjustable rear doorway in the back of each trap to allow the direct passage of fish during peak migrations.

Fence operation

The fence crew, residing at the main base camp at Kukjuktuk Bay, commuted daily to the fence site in 1978. The traps were monitored 24 hours a day during peak upstream fish runs; however, the traps were only scheduled, at most, for twice daily checks for the remainder of the season. This situation was problematic as commuting to the fence, by boat or on foot, was influenced at times by the tides and storm surges. Delays in accessability resulted in lost time for processing fish through the fence. Several fence washouts, occurring between shifts, were also not attended to immediately.

The problems encountered in 1978 were minimized or avoided in 1979. A full-time fence crew was based in a separate field camp at the fence site. This permitted continuous (24 hours/day, 7 days/week) monitoring of the fence from breakup until freeze-up. Depending on the migration rate, traps were checked up to several times an hour by a 2-3 person crew to prevent crowding of fish in the traps. Fish were taken out of each trap, identified and allowed to continue their migration in the appropriate direction. Subsamples were taken for dissection or examined to collect length data. The traps and fence were scrubbed frequently to remove debris that could accumulate and cause washouts. The wings were dismantled on only one occasion for 16 hours on 16-17 June during a major surge of candle ice and lake macrophytes resulting from breakup in the lakes.

The downstream trap was closed for 2-3 weeks during the initial peak upstream runs each year and was opened as soon as downstream migrations began in mid-July. During periods when large surges of upstream migrants were being put through, it was necessary to close the downstream trap briefly to avoid the premature recapture of some upstream migrants falling back temporarily because of crowded conditions above the fence. In late July 1979, major surges of downstream migrants led to instances of severe crowding above the fence. The upstream trap was therefore closed for 1-5 hours on several occasions to allow the crew to process the buildup of downstream migrants that would have impeded the upstream run still in progress.

PHYSICAL AND CHEMICAL DATA

A stream gauge station was situated approximately 50 m upstream from the 1979 fence site. Stream velocity and discharge were measured at 1000 hr each day using a Gurley Price current meter (No. 622 type AA) and a wading rod. A minimum of 5 velocity readings at 0.6 of total depth were made across a designated stream transect.

Temperature and conductivity readings were made with a YSI temperature-conductivity meter in 1978. A Wekslar seven-day recording thermograph was used to record water temperatures at the fence site in 1979 while fence site air temperatures were recorded daily with a Taylor maximum-minimum thermometer.

A depth integrating water sampler was used to obtain sample volumes of 300-500 mL in both years. The total hardness and alkalinity were recorded for one sample using a Hach field test kit (Model AI-36B). A Fisher Accumet 150 pH meter was used to measure the pH. Another sample was filtered for suspended solids. Suspended carbon, suspended nitrogen and total suspended solids were later determined by the Analytical Chemistry Unit at the Freshwater Institute, Winnipeg. An additional daily water sample was retained for a conductivity reading in our field lab in Tuktoyaktuk during 1979.

FISH SAMPLING

Fish were identified by species and counted (fish count data) as they were dipnetted out of each trap and allowed to proceed in their direction of travel. The species keys and descriptions in McPhail and Lindsey (1970), Scott and Crossman (1973) and Hart (1973) were used for species identification. During the peak of upstream runs by the large size classes in June and July 1979, the hinged rear door of the upstream trap was opened to minimize handling of fish. Fence personnel became proficient in counting and identifying the three coregonid species as they emerged through the door to proceed over a white-painted plywood board set 20-30 cm below the water surface. Any previously-tagged fish passing through the trap was intercepted with a dipnet and examined for recapture data. During intense periods of activity however, some tagged fish escaped the dipnet or were passed through without examination.

Subsamples of each coregonid species were taken daily for length frequency analysis (live sample data). A fork length measurement ($\pm$1 mm) was taken for each fish and scales were collected for ageing from the area below the dorsal fin and above the lateral line. The frequency of live sampling was curtailed during the earliest part of the upstream run when tagging took precedence; however, during peak migrations, counting took precedence as fish were quickly passed through to avoid crowding and unnatural migration delays. Between 24 July and 21 August 1979, actual counts were not always possible on 18 days because of large influxes of small size classes (<200 mm fork length) of upstream migrants. After determining the average number of fish taken in a dipnetful, an estimated count was made as fish were dipnetted out of the upstream trap during peak runs. A comparison of estimated counts against actual counts over an eight hour shift on 31 August showed an accuracy of 97% $\pm$ 20%.

Periodically, subsamples of fish were sacrificed to obtain more detailed biological information (dead sample data). Fork length (±1 mm) and weight (±25 g) were recorded for each fish. Weights for juveniles were determined with an electronic balance accurate to ±1 g. Gonads were examined for determination of sex and maturity. The degree of gonad maturity was assigned according to the following scale:

Female	Male	Maturity
0	0	unknown
1	6	immature
2	7	maturing
3	8	mature
4	9	ripe
5	10	spent

Scales were used in determining ages of coregonid fishes. Several scales from each specimen were cleaned and mounted between two glass slides and the annuli interpreted from the magnified image projected in a Leitz Trichinoscope. All dead sample fish were aged. A selected sample of tagged and live sample fish was also aged and included in length-frequency by age group summaries.

Fork length data were grouped into 25 mm length intervals for analysis. The length-frequency distribution of each week's total fork length data (live sample + dead sample + tagged fish + recaptured fish) was used as a representative subsample to calculate the length-frequency distribution of the week's total upstream or downstream run. The summation of each week's calculated distribution produced the season's overall length-frequency distribution for the upstream and downstream runs. It was necessary to divide and process broad whitefish data into two groups i.e., fish equal to or smaller than 200 mm fork length and fish greater than 200 mm fork length when it became obvious in 1979 that an overwhelmingly large proportion of small fish would have overshadowed the distribution pattern of large fish. Consequently, the length-frequency distributions are depicted and discussed separately for each group. To allow some measure of comparison to the 1979 data, the 1978 data were also divided into these two size groups. These two size groups are designated as <200 mm fish and >200 mm fish in this report.

Length-weight and age data were analysed for graphic and tabular presentation using the University of Manitoba's Amdahl 5850 computer. The Statistical Analysis Sysyem (SAS 1982) was used to generate length, weight, age, sex and maturity summaries. Length-weight relationships were described by the equation:

$$\log_{10} W = a + b\,(\log_{10} L)$$

where
- W = weight (g)
- L = fork length (mm)
- a = y-intercept
- b = slope of the regression line

Condition factor (K) was calculated using the formula:

$$K = \frac{W \times 10^5}{L^3}$$

where
- W = weight (g)
- L = fork length (mm)

FISH TAGGING

Numerous coregonid fishes were marked and released in both years of the study. A Dennison (Mark II) tagging gun was used to insert numbered Floy™ anchor tags (Type FD-68b) in the area beside the dorsal fin and secured between the pterygiophores. Tagging of fish smaller than 250 mm fork length was avoided. Subsamples of fish from both the upsteam and downstream run were tagged in 1978 whereas in 1979, most of the tagging was done on the upstream run. The fork length and tag number was recorded for each fish (tagged fish data) and a scale sample retained for ageing. Tagged fish recaptured in the traps were examined to record the fork length and tag number before release (recaptured fish data). Additional recapture information was obtained from DFO personnel involved in concurrent lake and coastal surveys and from subsistence fishermen located in communities and traditional fishing campsites along the coast and in the Mackenzie Delta. Posters offering a cash reward for the return of tags and capture information were displayed in coastal and Mackenzie Delta communities.

In addition to fishes tagged at the fence, coregonids captured at the river mouth were tagged by the coastal survey crew between 27 June and 27 July 1979 (Mr. B. Fallis, Department of Fisheries and Oceans, Winnipeg, unpublished data). These fish were expected to arrive as upstream migrants at the counting fence.

For any specified time period, the sum of the fishes individually recorded in the fish count sample, live sample, dead sample, tagged sample and recaptured sample is referred to as the total number or total enumerated in this report.

RESULTS AND DISCUSSION

PHYSICAL AND CHEMICAL DATA

Water chemistry data from Kukjuktuk Creek are summarized in Appendix 1. Stream temperatures during 1978 ranged from 0.9 to 17.3°C. The recording thermometer in 1979 showed that the daily maximum water temperature was usually reached near midnight each day. The warmest stream temperature recorded in 1979 was 23°C on 22 and 24 July; by this time the difference between each day's maximum and minimum water temperatures was as wide as 10 degrees (Fig.3). Stream discharge in 1979 (Fig. 3) ranged from a high of 0.41 $m^3 \cdot sec^{-1}$ on 1 July to a low of 0.03 $m^3 \cdot sec^{-1}$ on 15 September when a brief cold spell dropped stream temperatures temporarily to near zero. Otherwise, water flow was relatively stable as discharge diminished gradually over the season without any other peak flow events. Freeze-up began on 29 September and the stream was completely frozen to the bottom by 2 October 1979.

Conductivity of the creek waters ranged from 66 to 155 $\mu S \cdot cm^{-1}$ and pH ranged from 6.8 to 8.8 in 1978 (Table A1.1). Total suspended solid readings averaged 11 $mg \cdot L^{-1}$, ranging from 2 to 82 $mg \cdot L^{-1}$. In 1979, conductivity ranged from 75 to 230 $\mu S \cdot cm^{-1}$ and ph ranged from 6.9 to 7.8 (Table A1.2). Total suspended solid readings, averaging 7 $mg \cdot L^{-1}$, ranged from 1 to 85 $mg \cdot L^{-1}$. Most of the high readings for total suspended solids corresponded to obvious high turbidity events caused by the activity of numerous migrants crowded in upstream reaches and in a wide shallow pool located 100 m upstream.

FISH SPECIES AND NUMBERS

Ten fish species, representing six families, were recorded moving through the Kukjuktuk Creek fence in 1978 and 1979 (Table 1). In the first year of fence operation, 86 384 fish were enumerated in the upstream trap and 33 720 in the downstream trap (Table 2). The totals were significantly higher the following year when 1 118 096 fish were passed through the upstream trap and 112 062 through the downstream trap. The 1979 results reflected the ability of the modified fence to capture fry and small juveniles that had been able to pass through the larger mesh of the 1978 counting fence.

Three coregonid species dominated the catch in 1978 and 1979. Broad whitefish, Coregonus nasus (Pallas), was the most numerous species in both upstream and downstream traps (Table 2) followed by least cisco, Coregonus sardinella Valenciennes, and lake whitefish, Coregonus clupeaformis (Mitchill). The overall ratio of the three species in 1978 was approximately 8:2:1 while the inclusion of the small size classes in 1979 changed the ratio to 74:2:1. Expressed as a percentage, broad whitefish made up 74% of the total catch in 1978 and 96% in 1979. Other species, only incidental in their occurrence, included starry flounder, Platichthys stellatus (Pallas), northern pike, Esox lucius Linnaeus, Arctic charr, Salvelinus alpinus (Linnaeus), rainbow smelt, Osmerus mordax dentex, and fourhorn sculpin, Myoxcephalus quadricornis (Linnaeus).

The downstream count in 1979 did not include schools of juvenile pond smelt, Hypomesus olidus (Pallas), and ninespine stickleback, Pungitius pungitius (Linnaeus), that were small enough to drift downstream through the counting fence between 29 August and 30 September. An accurate count of these two species was not possible. No upstream migration of these two species were recorded in the creek despite intensive monitoring efforts. Resident populations of these species have been reported in the tundra lakes in the drainages of Tuktoyaktuk Peninsula by Lawrence et al. (1984).

TAGGED FISH RELEASED

In 1978, 3 299 upstream migrants and 1 070 downstream migrants were tagged; the 1979 totals were 4 209 upstream and 201 downstream fish tagged (Table 3). For both years broad whitefish made up 60.6% of the total tagged followed by least cisco (24.8%) and lake whitefish (14.7%). The tag colours served only to provide instant identification on fishes tagged at the counting fence. Recapture data came primarily from subsistence fishermen returning tags to community-based Northwest Territories game officers and to Department of Fisheries and Oceans fishery officers. Inaccurate recapture dates were suspected for many tag returns; therefore, only the month of recapture was noted unless actual dates of recapture were verified. Original data (release date) on tagged fish released at the mouth of Kukjuktuk Creek plus the date and location of any recaptures of tagged fish in the headwater lakes by the bay and lake survey crew (Mr. Bruce Fallis, Department of Fisheries and Oceans, Winnipeg, personal communication) contributed to the migration analysis. All fish recapture data are discussed in the appropriate fish species sections of this report.

FISH LIFE HISTORIES

The fish counting fence on Kukjuktuk Creek provided the first unique opportunity to collect a full season's data on the fish fauna in a coastal drainage in the southern Beaufort Sea area. The following sections provide descriptions of upstream and downstream fish migrations that were more complex than previously realized. The biological data collected and the recapture information on tagged fish contributed to our interpretation of these migrations. Although two years of data were collected, the second season's total enumeration data are considered more complete and comprehensive.

Broad whitefish

Magnitude and timing of migrations: The total count of broad whitefish caught per week in the upstream and downstream traps in 1978 and 1979 are summarized in Fig. 4 and 5 respectively. Daily totals are included in Appendix 2.

The total number of broad whitefish enumerated in the upstream and downstream trap in 1978 was 65 209 and 23 291, respectively while the upstream and downstream migration in 1979 totalled 1 097 481 and 85 503, respectively (Table 2). The downstream total in 1978 comprised only 37% of the upstream total, thus fewer fish came downstream than went upstream. This observation suggests that there was either a high mortality rate amongst the migrants going into the lakes or that other factors were contributing to a large proportion remaining in the lakes to overwinter that year. It was also possible that data were lost during fence washouts and flooding in 1978. However, the observations made during the 1979 season, when no data was lost to washouts, indicate that, indeed, fewer fish returned downstream in the fall than the numbers counted going upstream in the spring and early summer.

Upstream migrations in this small tundra stream were continuous from ice breakup to freeze-up (Appendix 2). The 1979 data provided the best chronicle of migration timing. As the fence was being installed on the day ice broke away off the streambed (14 June), a small school of lake and broad whitefish appeared from downstream. The upstream migration escalated on 18 June, two days after the occurrence of a sudden surge of ice, water and lake macrophytes resulting from ice breakup in the lakes upstream. Upstream movements and numbers increased as discharge and water temperatures increased. Migrants numbered several hundreds a day by 20 June 1979 when stream temperatures reached 9°C. When maximum water temperatures reached 20 to 23°C during 14-26 July, the daily broad whitefish total ranged from 2 912 to 23 000 (Table A2.2). The peak run of the <200 mm group of fish, occurring on 8-16 August, contributed to estimated daily totals ranging from 22 196 to 343 388. Maximum stream temperatures during this period varied from 19 to 22°C. Temperatures began to drop noticeably on 17 August (Fig. 3) by which time 94% of the upstream migrants had already passed through. Stream temperatures declined at a steady pace, reaching 0°C on 29 September 1979. Freeze-up on 2 October marked the end of the short streamflow period of 16 weeks in 1979.

Figure 4 and 5 illustrate, on a weekly basis, the magnitude of the broad whitefish migrations as the season progressed. In 1978, the peak upstream migration occurred during the week of 29 June to 5 July when 55% of the total upstream run passed the fence (Fig. 4). In 1979, when the broad whitefish were separated into two size classes, the peak upstream migration for the >200 mm fish also occurred between 29 June and 5 July 1979 when 40% of the season's total upstream run passed through (Fig. 5). Peak migration for the <200 mm fish occurred during 3-16 August when 57% of the total sample of this size group was counted.

Downstream migrations of fish in both years began in mid-July, about three weeks later than the start of the upstream run. Migration activity did not cease until freeze-up. In 1978, the peak weekly downstream migration (66% of the total) occurred during the week of 17 to 23 August 1978 (Fig. 4). In 1979, the peak downstream migration of the >200 mm size group occurred in two waves (Fig. 5); 39% came down between 20 and 26 July 1979 and 34% between 3 and 16 August 1979 when stream temperatures were highest (Fig. 3). The downstream migration for the <200 mm fish peaked several weeks later than the larger fish when 69% of that size group came downstream just prior to freeze-up on 21-27 September 1979 (Fig. 5). Some difficulty was encountered in 1979 when both upstream and downstream migrations were occurring simultaneously. As a result, the daily total (Table A2.2) on some days was inordinately low when the upstream trap was shut down so that downstream migrants, that had accumulated above the fence, could all be processed first.

Numbers, size and age of migrants - for the season: In 1978, fork lengths were taken from 3 505 of the broad whitefish upstream migrants and 1 992 of the downstream migrants while fork lengths were recorded in 1979 from 9 212 upstream fish and 5 744 downstream fish (Appendix 3). Data records show that the size range of upstream migrants was 50 to 567 mm in 1978 and 50 to 553 mm in 1979; downstream fish ranged from 87 to 552 mm in 1978 and from 62 to 557 mm in 1979. The season's overall length-frequency distribution for the upstream and downstream migration in 1978 and 1979 are shown in Figures 6 and 7, respectively. The age and length data for all sampled broad whitefish in 1978 are presented in Table 4. Table 5, which includes additional age data from live sampled and tagged fish, is a summary of the length-frequency distribution by age group. The same summaries for 1979 are in Tables 6 and 7.

The 1978 season's length-frequency distributions displayed unimodal length frequency peaks in each size group of fish for both upstream and downstream migrants (Fig. 6). For upstream migrants <200 mm, the dominant length interval was 126-150 mm. This was also the case for the downstream run. The distribution of fish >200 mm showed a predominance of 351-375 mm fish in the upstream run; however, the next size class, 376-400 mm, dominated the downstream run.

Broad whitefish sampled from Kukjuktuk Creek in 1978 represented all age groups from young-of-year (y-o-y) to age 15 years (Table 4 and 5). Using length as an indication of age, the length-frequency distribution for the whole season (Fig. 6) show that the >200 mm group of migrants in 1978 had a strong representation of 5 to 8 year old fish. The <200 mm group of fish, which made up a small proportion (7.6%) of all broad whitefish enumerated in 1978, consisted mostly of 1 year old fish.

Fence modifications in 1979 resulted in a dramatic change in the catch of small size classes of broad whitefish. The 1979 total number of <200 mm fish made up 88% of the total broad whitefish enumerated that year compared to the 7.7% attained in 1978. The overall length-frequency distribution data for 1979 (Fig. 7) was more likely an accurate representation of the broad whitefish migration patterns in Kukjuktuk Creek. For fish <200 mm, the distribution was unimodal for upstream migrants. The majority of the upstream fish were in the 51-75 mm size interval whereas most downstream fish were in the 176-200 mm size interval. The distribution for upstream fish >200 mm was unimodal at the 376-400 mm length interval. The downstream distribution appeared to be bimodal with the main peak at 376-400 mm and a smaller peak at the 276-300 mm length interval.

The ages of broad whitefish in 1979 ranged from 0+ to 13 years (Table 6 and 7). The majority of the <200 mm fish migrating upstream in 1979 included not only age 1+ fish as seen in 1978, but a significantly greater proportion of age 0+ fish. Specifically, 87.8% of the total broad whitefish enumerated in the upstream run in 1979 were smaller than 150 mm fork length, representing mostly 0+ and 1+ fish. This data confirmed that these small size ranges were not adequately sampled in 1978. The 376-400 mm length interval in the upstream migrants (Fig. 7) represented 7-8 year old fish. Downstream migration for fish <200 mm was composed largely of 1 and 2 year olds while the distribution of downstream migrants >200 mm show a predominance of 7-8 year old fish.

Upstream migrants outnumbered downstream migrants in 1978 at a ratio of 5.6:1 for <200 mm fish and 2.7:1 for >200 mm fish. In the following year, the upstream to downstream ratio for <200 mm fish was 88.1; however, for the >200 mm, more fish were enumerated in the dowstream run resulting in a ratio of 0.9:1. The concerted upstream migration pattern of the <200 mm fish and the subsequent small proportion of these fish among the migrants returning to the coast before freeze-up was a strong indication that the lakes in Kukjuktuk drainage provide major nursery habitat for y-o-y and yearlings originating from spawning grounds located elsewhere. Residency in the lakes showed that coastal watersheds could provide an alternative to the coastal bays or Mackenzie Delta estuarine sites that were previously thought to be the only overwintering areas for coastal whitefish populations.

The small proportion of broad whitefish migrants between 201 and 275 mm fork length (Fig. 6 and 7) suggests that juvenile fish have a tendency to reside in the lakes for 3-5 years before undertaking stream migratory behaviour. Immature fish become more prominent in migrations when they reach the 276-300 mm and 301-325 mm length classes (age 4-6 years). Excluding fish smaller than 200 mm, the largest group of stream migrants in 1979 were between 276 and 425 mm fork length, representing ages 4-10 years. The dominance of the 351-375 mm and 376-400 mm length classes (age 6-8 years) in stream migrations indicates that annual migrations between summer foraging areas in the lakes and coastal overwintering sites become an important feature at this particular stage of their life cycle.

Downstream migrants in 1979 included fish in the largest size intervals recorded (451-475, 476-500, 501-525, 526-550, 551-575 mm). It became obvious that migrants seen in the first two weeks of the downstream run included fish larger than any seen in the upstream run. These fish provided the first indication that the watershed contained fish that were either lake residents or were previous upstream migrants that had overwintered. The presence of the largest size intervals among the earliest of downstream migrants was also the first indication that a group of broad whitefish was bypassing a full summer of foraging in the lakes and was, instead, commencing a specific migration to other destinations. Our data suggested, at this stage, that many broad whitefish had established residency in the lakes for one or more years before migrating out of the lakes again. Attainment of maturity and the need to migrate towards spawning areas located outside the drainage seemed a likely reason for this behaviour.

Numbers, size and age of migrants - biweekly: The predominant size/age group of broad whitefish migrants in Kukjuktuk Creek during 1978 and 1979 changed as the season progressed (Fig. 8). In general, the dominant modal length interval in each biweekly period indicated that the largest fish were the first to migrate in mid-June, followed by a progression of smaller members of the migrant population in succeeding weeks. Data for the 1979 upstream run showed that the largest size fish (401-575 mm) were among the first to appear in the first 2 weeks after ice breakup; however, the dominant length intervals were the 376-400 mm (48%) and the 401-425 mm (26%) fish. As time progressed the smaller size intervals appeared: the 301-325 mm fish by mid-July, the 251-300 mm fish by late July and the 201-225 mm fish by late September. Downstream migrants >200 mm showed a similar decrease in modal fork length over the season although the peaks were not as distinct.

The <200 mm broad whitefish did not appear in the upstream migration until early July 1979 while the first downstream migrants showed up in the last week of July (Fig. 5 and 8). The peak period for the young-of-year upstream migrants occurred between 20 July and 16 August when an estimated 456 068 fish in the 51-75 mm length interval were enumerated. Towards the end of the season, when migrations were expected to end, upstream migration of 76-100 mm fish still continued until freeze-up. There was a notable increase in the downstream run of 176-200 mm fish just prior to freeze-up (Fig. 8). Many of these late migrants became trapped in ice as the stream froze to the bottom between 29 September and 2 October 1979. This particular mortality factor was also observed in June 1978 at another coastal drainage, Canyanek Creek, where the junior author observed large numbers of small least cisco, pond smelt and burbot frozen in the creek ice from the previous winter.

The upstream run of fry and small juveniles seen in 1979 was not unique to Kukjuktuk Creek. Overnight hoopnets set in August 1979 in three similar coastal creeks east of Kukjuktuk Bay by Lawrence et al. (1984) produced catches of 500 to 8000 y-o-y in the 51-75 mm length class. Coastal seining surveys by the same authors showed that y-o-y broad whitefish, while absent in the spring, appeared primarily at Kugmallit Bay locations by late July 1979. The mean fork length reported was 49 mm (N = 19, range: 33-63 mm).

The origin of the significant numbers of y-o-y broad whitefish was most likely the Mackenzie River. Known or suspected spawning sites for broad whitefish are located in the mainstem Mackenzie River and major tributaries like the Peel and Arctic Red River (Stein et al. 1973a; Chang-Kue and Jessop 1983). The possibility of these y-o-y originating in adjacent Tuktoyaktuk Peninsula coastal streams seemed remote as no downstream movement out of other coastal lake-river systems were seen by Lawrence et al. (1984) during their 1978-1980 coastal surveys in the region. The 24-hour/day monitoring at the 1979 fence recorded 462 240 upstream migrants versus only 580 downstream migrants in the 1-75 mm size range. Some of the small fish showing up in the downstream trap during the peak upstream run may have included upstream migrants drifting back downstream because of crowding or handling stress. If it is assumed that these fish had originated from a possible lake resident population, then the relatively small numbers seem to suggest that this coastal drainage made a minor contribution to the overall coastal runs of y-o-y and juveniles.

A comparison of the overall length-frequency distributions of >200 mm fish provided indirect evidence linking the coastal broad whitefish to the Mackenzie Delta broad whitefish. Figure 9 compares Kukjuktuk Creek 1979 data with that of a large sample (N = 882) taken throughout the Delta and Arctic Red River area in 1972 by Stein et al. (1973c). The juxtaposition, using only fish greater than 200 mm fork length to allow an equivalent level of comparison, is informative. The length-frequency distribution in the Delta was skewed towards large fish ranging from 440 to 560 mm fork length, comprising 73.6% of the fish in the >200 mm size group. The Delta population of broad whitefish was always characterized by a predominance of mature fish on spawning runs that begin in late July each year (Stein et al. 1973a; Jessop et al. 1974; Jessop and Lilley 1975). Extensive fishing by Stein et al. (1973c) with survey gillnet gangs in the Delta channels and main stem river showed that most broad whitefish in the 200-440 mm size range were immature. Only a small sample (N = 42) of fish smaller than 200 mm were captured. In addition, beach seining in the main channels confirmed that broad whitefish fry and small juveniles were scarce in comparison to the other coregonid species. It was concluded that the y-o-y and immature broad whitefish inhabited Delta lakes and secondary channels that had not received the same intensity of sampling (Stein et al. 1973a, 1973c; Jessop et al. 1974).

Data on the y-o-y and the upstream and downstream length-frequency distribution of >200 mm fish from Kukjuktuk Creek indicate that the "missing" length classes of the Mackenzie Delta occur in the coastal streams of the Tuktoyaktuk Peninsula (Fig. 9). Broad whitefish in the 200 to 450 mm range were dominant among the creek migrants, comprising 99.5% of the upstream run and 98.4 % of the downstream run of fish >200 mm in 1979.

Length-frequency data of broad whitefish taken in the East Channel region of the Mackenzie Delta in 1980 by Chang-Kue and Jessop (1992) provided data for a similar comparison (Fig. 10). The distribution of the 1980 Delta sample (N = 569) was similar to the 1972 data (Fig. 9) with respect to displaying the same skew towards the large size classes. Extensive sampling effort in 1980 with survey gillnets and beach seines confirmed again that broad whitefish fry and juveniles were absent in the Delta channels although juveniles of the other four coregonids were encountered (Chang-Kue and Jessop 1992). This complementary distribution of length classes between these two areas indicates that the majority of broad whitefish found in the Mackenzie Delta channels are the large, maturing or mature adults, whereas the young-of-year, juveniles, and sub-adults are found mainly in the coastal drainages or nearshore waters.

Growth, sex and maturity: Broad whitefish in Kukjuktuk Creek grew rapidly in fork length up to age 4 (Fig. 11), reaching a mean fork length of 307 ± 29 mm (1978 data). The growth curve for the 1978 fish (N = 2 310) was similar to the 1979 fish (N = 525). In most cases there was no significant difference in growth between males and females of the same age in each migratory group of fish (Table A4.1, A4.2, A5.1 and A5.2). Since it was hypothesized that coastal broad whitefish originate from the Mackenzie Delta population, the 1979 growth curve was compared to the curves obtained from previous DFO surveys in the outer Delta (Percy 1975), the mid-Delta area (Stein et al. 1973c) and the Arctic Red River area (Stein et al. 1973c). Kukjuktuk Creek's curve was intermediate among the 3 curves at least to age 8 after which older fish in the Mackenzie Delta and Arctic Red River area showed a tendency to be larger in fork length (Fig. 12). Broad whitefish originating from other nursery and foraging areas may contribute to the spawning fish passing through the Aklavik and Arctic Red River area; consequently, the growth curve of fish sampled there may reflect the inclusion of fish with different growth rates.

Sex, maturity and age were determined from 309 and 288 broad whitefish in 1978 and 1979 respectively (Table 8). Almost all of the sample in 1978 were immature except for a 7 year and a 12 year old female. Sexually maturing males and females were seen in 5% and 7% of the fish examined in 1979. In total, 16 fish were considered mature with the majority (10 fish) occurring in the early downstream migrants. The minimum age at maturity for both males and females was 7 years, corresponding to fish at mean length 377 ± 22 mm (Table 6). While fish larger than 350 mm comprised 54% of the upstream run, this same group made up a larger percentage (67%) of the downstream run (Fig. 7) whose destinations were surmised to be either overwintering or spawning areas. Supporting evidence was sought from mark and recapture data (see: Tagging data).

As described previously, the downstream run also had a greater proportion of large fish when compared to the upstream run (Fig. 7). These large fish, seen among the earliest downstream migrants, were in prime condition in terms of weight and fat reserves and were thought to constitute part of the earliest spawning migrants seen each August in the Mackenzie Delta. Maturity data for the earliest downstream migrants were incomplete since few of these fish were sacrificed for dissection during the busy July period when counting and tagging took precedence. There was an opportunity to specifically determine what proportion of the largest size classes were mature during a return visit to the site on 25-26 July 1985 when early downstream migrants, delayed by 2 weeks of cold weather, were collected by the authors for a Western Arctic fish collection (Reist 1987). Of 50 fish examined (fork length range: 332-509 mm), 16 fish were >450 mm. Gonad examination showed that 3 of 9 males and 6 of 7 females were mature; thus 50% of these large downstream migrants were mature.

Summer use of Kukjuktuk Creek by post-spawning fish from the Mackenzie River was not evident. Since most spawning fish examined by Stein et al. (1973c) were larger than 450 mm, the possible return of large post-spawning fish to coastal creeks for summer feeding was expected. Such large broad whitefish, however, were a minority among Kukjuktuk Creek upstream migrants as only 315 of 67 819 upstream migrants in 1979 were larger than 450 mm. In addition, no spent gonads were observed among the large fish dissected in 1978 and 1979 at Kukjuktuk Creek. The behaviour of the larger and older post-spawning fish in terms of their foraging migrations is yet to be determined.

The 1980 study in the Mackenzie Delta also established that the minimum age at maturity for broad whitefish, determined from spawning fish sampled in November (Table 9), was 7 years. This age corresponded to fish at mean fork length 355 ± 30 mm (Chang-Kue and Jessop 1992) . Fish larger than 350 mm made up 97% of all broad whitefish (>200 mm) taken in 1980 in the Delta and only 4 fish smaller than 200 mm were encountered. These observations indicate further that the Mackenzie Delta channels function mainly as migratory corridors between spawning habitats in the Mackenzie River and nursery, feeding and overwintering habitats located in suitable Delta lakes or in coastal watersheds.

The overall length-weight relationship for broad whitefish in Kukjuktuk Creek in 1979 (pooled upstream and downstream sample; N = 1379, range 57-557 mm) is described by the equation:

$$\log_{10} W = 3.226 (\log_{10} L) - 5.461$$

$$SD_b = 0.025$$

Separate calculations for male and female broad whitefish from the upstream and downstream runs for each year produced different values for slopes and intercepts (Table 10). Analysis of covariance between males and females showed a significant difference ($P<0.05$) between the intercepts of the regressions in 1978 and between the slopes ($P<0.05$) of the regressions in 1979 for downstream fish. Analysis between males or between females in upstream and downstream runs also produced several cases of significant difference between the intercepts or the slopes. There was only one case, upstream versus downstream males in 1979, where a significant difference existed for both slope and intercept. What was most obvious in 1979 was the greater robustness of downstream migrants.

The condition factors (K) by age data for downstream migrants were higher than the readings for upstream migrants. In 1979 the range of mean K factors for age 7 and older fish (N = 46) in the upstream migration was 1.15 to 1.30 (Table A4.3). The age 7 and older downstream migrants (N = 102) had a mean K factor range of 1.40 to 1.50 (Table A4.4). Most fall downstream migrants were obviously heavier in appearance than upstream migrants and dissections confirmed that these broad whitefish had accumulated significant amounts of body fat.

Tagging data - migrations within Kukjuktuk drainage: By the end of the counting fence operations in October 1979, a total of 5 316 broad whitefish had been tagged and released over the two years; 4 267 were upstream and 1 049 were downstream migrants (Table 3). Recaptures at the fence in 1978 were either tagged upstream migrants returning through the downstream trap or tagged downstream migrants returning upstream before freeze-up. Recaptures in 1979 involved fish in several categories:

- fish tagged in 1978, returning upstream to feed after overwintering outside the drainage,
- fish tagged in 1978, returning downstream after a year's residency in the lakes,
- fish tagged as upstream migrants in 1979, returning downstream after one summer of feeding in the lakes,
- fish tagged as downstream migrants in 1979, returning upstream in 1979,
- fish tagged in 1979 at Kukjuktuk Creek mouth prior to their upstream migration.

Forty broad whitefish tagged at the mouth of Kukjuktuk Creek in late June and early July 1979 were recaptured in the watershed. Thirty-three of these fish, examined as they passed through the upstream trap, took 2-21 days to reach the counting fence (Table 11). Most fish (85.5%) took less than 12 days. Fifteen of the 33 were recaptured again in the downstream trap 21-70 days later, showing that the foraging period in the headwaters averaged 30 days. Eighteen of this group of 33 did not return downstream indicating, as did the season's total enumerations, that a proportion of upstream migrants did not return downstream before freeze up. The numbers show, assuming no mortality, that up to 45% of upstream migrants from this selected group of tagged fish may have remained and overwintered in the lakes that winter. Seven fish that escaped inspection in the upstream run returned through the downstream trap after spending 25-45 days in the drainage.

Nineteen tagged broad whitefish from the fence site were recaptured in 1979 at several lake and stream locations in the drainage (Table 12). Two fish tagged as upstream migrants in 1978 were recorded and released as they returned upstream in late June 1979. Both fish were likely part of the downstream run that had escaped detection in 1978. One was recaptured 31 days later in Lake 10 while the other fish was taken seven days later in Lake 12 (Fig. 2). Another three upstream migrants from 1978 were also recaptured in Lakes 10 and 11. Since these were their first recapture record, these three fish were possible examples of fish that had overwintered in the lakes. The remaining 14 fish were upstream migrants in 1979. Six were recaptured in Lakes 10, 11 and 12; one fish showed that it took as little as five days for migrants to reach Lake 10, the fourth upstream lake in one chain of lakes (Fig. 2). The other eight fish were caught, recorded and released from hoopnets set in the creeks connecting lakes 7 to 8, 8 to 10 and 10 to 11 (Fig. 2, Loc. KL090, KL091 and KL092, respectively). Finally, seven of the latter re-released fish were recaptured as downstream migrants between 21 July and 12 August 1979.

Tagged upstream migrants that returned downstream later in the same season indicated that that broad whitefish stayed in the lakes for as long as 75 days in 1978 and 100 days in 1979 (Table 13). Of 186 upstream migrants exhibiting this behaviour in 1978, the majority (67%) spent 36-55 days in the lakes before returning to the coast. Of 1 694 upstream migrants exhibiting this behaviour in 1979, the majority (67%) stayed for a shorter duration of 26-40 days before returning downstream.

Tag returns within the same year also provided an estimate of what proportion of fish took up residency in the lakes (Table 13). Of 1 845 upstream migrants tagged at the fence in 1978, only 186 returned, indicating that 90% remained in the lakes that winter. This estimate's accuracy was doubtful because tagged fish in the downstream run may have escaped enumeration during times when the fence was not fully operational in 1978. The 1979 data showed that of 2 422 tagged upstream migrants, 1 694 returned to the coast; this result gave an estimate of retention in the headwaters of 30%, without considering tag loss or natural mortality.

A total of 198 broad whitefish (11% of the original 1 845 upstream migrants tagged in 1978) that had overwintered in the Kukjuktuk Lakes returned downstream after spending 336-425 days in the drainage (Table 14). Evidence of some degree of migration fidelity to Kukjuktuk Creek was obtained from the sample of 882 broad whitefish that were tagged going downstream in 1978. In the following year 88 fish returned as upstream migrants, indicating a migration fidelity of at least 10% to Kukjuktuk Creek between two consecutive years.

Only four broad whitefish downstream migrants were recaptured as upstream migrants within the same season (Table 15). The short time span (≤15 days) between release and recapture suggests that these fish were simply upstream migrants that had dropped downstream temporarily past the fence before returning upstream.

Several factors may affect the return by fish to the same stream in consecutive years. Removal from the migratory population may arise from subsistence harvesting along the coast and the Mackenzie River. Mortality from spawning and post-spawning activities may also take its toll. Juvenile and immature fish may suffer mortality if an overwintering site proves to be only marginal as the winter progresses. In addition, the presence of several similar coastal drainages both east and west of Kukjuktuk Creek provides alternate foraging sites for the immature migrants each year. A high tendency for homing to one particular foraging watershed would be disadvantageous to the year-to-year survival of the immature segment of the population. Changes in annual precipitation, watershed runoff or streamflow may diminish overwintering conditions or limit access to lakes.

<u>Tagging data - migrations outside Kukjuktuk drainage</u>: A total of 183 tagged broad whitefish from Kukjuktuk Creek were recaptured at distant locations. Most recaptures came from the subsistence fishery, all of which are located west of the Kukjuktuk drainage. As a result, recapture location data reflect known traditional fishing sites in the vicinity of seasonal hunting and fishing camps.

During a two-year study at Freshwater Creek, another coastal system that flows into Tuktoyaktuk Harbour (Fig. 13, Loc. FW100), Bond and Erickson (1985) recaptured seven broad whitefish that had been released at Kukjuktuk Creek. The first fish, recaptured on 9 September 1981, had been tagged as an upstream migrant at Kukjuktuk Creek on 1 August 1978 (359 mm, age 6 yr). The other six, tagged in 1979, were caught at the Freshwater Creek counting fence either as upstream migrants in June 1982 or downstream migrants in late September 1982.

Subsistence fishermen at two coastal sites were the main source of coastal recaptures of Kukjuktuk Creek broad whitefish. The most intense fishery occurs at the west entrance of Tuktoyaktuk Harbour (Fig. 13, Loc. TH100) where 145 recaptures were reported between 1978 and 1984. Some fish were caught as early as June although the majority were taken in August and September each year when the annual fall runs of whitefish are harvested by residents of Tuktoyaktuk. Summer residents at East Whitefish Station (Loc. EW100) were the source of 14 tag returns taken during the months of July and August in 1978, 1979, 1980 and 1982. Some of the tag recaptures in 1978 and 1979 showed that migration of broad whitefish from Kukjuktuk Creek to these two coastal sites was accomplished within a week.

Tag returns in the Mackenzie Delta and the lower Mackenzie River totalled 14. The first tag return in the Mackenzie Delta occurred in 1978 when a downstream migrant, released on 9 August 1978 at Kukjuktuk Creek (449 mm, age 8 yr), was recaptured about 130 km upstream in the Arctic Red River in September/October 1978 (Fig. 13, Loc. AR101). Six additional fish were taken in the Arctic Red River mouth (Loc. AR100) between 1980-1982, two as early as 21 July and the rest as late as 20 October.

Five of the above group of 14 recaptured fish were taken in the Delta: two in the East Channel, two in the Middle Channel, and one in the West Channel. One of the East Channel fish, taken at Lucas Point (Fig. 13, Loc. EC102) on 3 August 1979, was originally tagged as an upstream fish at Kukjuktuk Creek on 2 July 1978 (424 mm, age 7 yr); it had been recorded returning to the creek on 30 June 1979 before coming back downstream on 25 July 1979. Its recapture showed that migration into the Delta was accomplished within 9 days. The second East Channel fish, recaptured on 1 November 1980 (Loc. EC100), had been tagged as an upstream fish on 21 June 1979 and recaptured once before as a downstream migrant on 27 July 1979. The one West Channel fish, recaptured on 12 September 1980 at location WC100, was originally tagged going upstream at Kukjuktuk Creek on 2 July 1978 (416 mm, age 7 yr). The first Middle Channel fish was recaptured in August 1979 at Horseshoe Bend (Loc. MC100), a known pre-spawning aggregation site; this fish was originally tagged on 20 June 1979 and had been recorded coming downstream on 25 July 1979. The second Middle Channel fish, taken in the first week of July 1983 at location MC101, was also an upstream fish tagged on 20 June 1979 and recorded coming downstream on 20 July 1979.

The most distant recapture location for broad whitefish was recorded in 1982 when two fish were taken in the Mackenzie River near Fort Good Hope (Fig. 13). The first fish, released at Kukjuktuk Creek on 1 July 1978 (362 mm, age 6 yr), was recaptured 4 years later at the Ramparts Rapids (Loc. FG101) on 20 September 1982. The second fish, tagged as a downstream migrant on 18 June 1978 was recaptured on 20 September 1982 at location FG100. Both sites were identified by local residents as areas in the main stem Mackenzie River where pre-spawning aggregations of whitefish occur annually (Chang-Kue and Jessop 1983).

Three broad whitefish from the upstream runs at Kukjuktuk Creek were recaptured at the mouth of the Peel River, the first major west side tributary to the Mackenzie River (Loc. PR100). The first fish, released on 21 June 1979, had been recaptured once before coming downstream at Kukjuktuk Creek on 26 July 1979 before its final recapture in September/October 1981. Another fish recaptured at the same site in September 1984 was originally released on 6 August 1978 (375 mm, age 8 yr) and recaptured once before as an upstream fish the next year on 2 July 1979. The third fish, released on 23 June 1979, was recaptured on 7 September 1982 at the same site.

The preceding tagged fish data provided enough information to establish not only a positive link between the Mackenzie River and the southern Beaufort Sea coastal area, but also a link between coastal streams. As discussed in the previous section, tagged broad whitefish returning to Kukjuktuk Creek indicated an estimate of 10% fidelity to the stream. This low value suggested that fish could utilize alternate but similar drainages to fulfill their summer feeding requirements. Bond and Erickson (1982, 1985) studied similar seasonal coregonid migrations in two other coastal creeks flowing into Tuktoyaktuk Harbour and their observation of Kukjuktuk tagged fish among the upstream and downstream migrations at Freshwater Creek in 1981 and 1982 confirmed an exchange of broad whitefish between coastal drainages.

Tagged broad whitefish leaving Kukjuktuk Creek reached two possible overwintering areas at Tuktoyaktuk and East Whitefish Station within a week. Each site is located at the entrance of the two largest coastal embayments between Kukjuktuk Creek and the Mackenzie Delta viz., Tuktoyaktuk Harbour and Whitefish Bay. These two bays and the deep waters of the lower East Channel between Tununuk Point and Kugmallit Bay appear to offer suitable overwintering habitat for the juvenile and non-spawning adult broad whitefish that leave the coastal drainages after a summer of foraging in the lakes.

The ages of all tagged Kukjuktuk broad whitefish at the time of recapture in the Mackenzie River were older than the minimum age of maturity (7 years). The one tagged fish, providing evidence in 1978 that downstream migrants can reach spawning areas later that fall, was 8 years old. Other fish recaptured at various sites in the Mackenzie system ranged in age from 8 to 14 years at the time of recapture.

We do not have any data to dismiss the possibility that migrations of broad whitefish from Kukjuktuk Creek may also proceed along the coast east of Kukjuktuk Creek. The coastal surveys of Lawrence et al. (1984) showed that other drainages east and west of Kukjuktuk Creek supported similar migratory whitefish populations and it is expected that some interchange of immature fish between Kukjuktuk Creek and the streams further east also occurs for the summer feeding migrations. Less sheltered coastal bays and greater distance from a major river offering spawning and overwintering habitats suggest that the most favourable migration direction for spawning fish and for overwintering juveniles emerging from coastal streams in the late summer and fall is westwards towards the Mackenzie Delta.

Overwintering: The broad whitefish movements within Kukjuktuk Creek indicated the presence of overwintering habitat in the upstream lake system. Overwintering areas for the group of juvenile coastal migrants that apparently forego inland lakes are believed to be selected coastal sites in Kugmallit Bay (Percy 1975, Lawrence et al. 1984) and Tuktoyaktuk Harbour (Bond 1982). Post-spawning broad whitefish in the Mackenzie River appear to return to the lower Delta channels to overwinter (Stein et al. 1973a, 1973b; Jessop et al 1974). The lower reach of the East Channel from Tununuk Point to Kugmallit Bay is an ideal area since constant winter flows and a deep sub-ice channel (up to 30 m deep) ensure suitable conditions for winter refuge for fish from both delta and coastal areas.

Lake whitefish

Magnitude and timing of migrations: The total run of lake whitefish in 1978 consisted of 7 070 upstream and 3 476 downstream migrants while the 1979 run consisted of 6 575 upstream and 9 393 downstream fish (Table 2). The weekly total number of lake whitefish caught in the upstream and downstream traps in 1978 and 1979 are summarized in Fig. 14 and 15, respectively. Daily totals are included in Appendix 2.

Upstream migrations of lake whitefish began immediately after ice break-up in both years and continued throughout the summer into the fall. The daily numbers of upstream migrants in 1978 began to increase after 28 June, reaching a high of 1 449 fish on 3 July (Table A2.1). The most intense upstream migrations occurred during the week of 29 June to 5 July when 72% and of the total upstream migrants came through (Fig. 14). This upstream migration rate diminished after that week and had essentially ended by 9 August just as the downstream migration began to increase, starting from a few fish per day to a peak of 1002 fish on 19 August (Table A2.1). The peak weekly downstream migration of lake whitefish occured during 17 to 23 August, when the majority (72%) of the season's downstream migrants passed the fence. Lake whitefish downstream migrations had essentially ceased by the last week of August 1978 (Fig. 14).

Upstream migration in 1979 began on 18 June with the daily totals increasing to a peak of 900 lake whitefish on 30 June (Table A2.2). The most intense week of migration occurred during 22 June to 5 July when 77% of the total upstream run came through (Fig. 15). Daily maximum water temperatures reached 17°C by 30 June. During this period the stream discharge reached the highest levels (0.37 to 0.41 $m \cdot sec^{-1}$). As discharge decreased, the number of upstream migrants decreased, dropping to less than six per day by 20 July. The end date of this upstream run was two weeks earlier than the previous year with the daily total remaining at less than six fish per day until freezeup in late September 1979. The downstream lake whitefish run in 1979 began to escalate on 17 July, three days before the upstream run ended. Major peaks occurred on 24 July and on 9 August when 827 and 538 fish were enumerated in the downstream trap; the peak weekly total occurred on 20-26 July when 34% of the run came through (Fig. 15). Although this downstream run peaked earlier than the previous year, it was more protracted over the following three weeks during which an additional 49% of the total run came down.

Numbers,size and age of migrants - for the season: During 1978, fork lengths were taken from 527 of the upstream migrants and 214 of the downstream migrants (Table A3.3). In 1979, 1 280 and 1 167 fish were measured from the upstream and downstream runs, respectively (Table A3.4). Data records show that the size range of upstream migrants was 153-450 mm in 1978 and 98-487 mm in 1979. Downstream migrants ranged from 228 to 447 mm in 1978 and from 59 to 560 mm in 1979.

The resulting overall length-frequency distributions of the migrations in 1978 and 1979 are shown in Fig. 16 and 17, respectively. Unlike the broad whitefish, lake whitefish in the <200 mm size group did not occur in overwhelming numbers. The relatively sparse number seen in 1978 (N=15 or 0.14% of all lake whitefish) was also observed in 1979 (N=530 or 3.4% of all the total migrants). For fish >200 mm, a total of 7 043 lake whitefish was taken in the upstream trap in 1978 and 3 476 in the downstream trap. In 1979, 6 444 lake whitefish passed upstream; however, a greater number, 8 953, came downstream. This difference in the upstream to downstream ratio between the consecutive years may reflect some undetermined pattern or natural variation; however, the loss of data during fence flooding may have resulted in an inaccurate count in 1978. The 1979 downstream count immediately suggested the presence of lake whitefish that had spent one or more years in the lakes prior to leaving the lakes in 1979.

The 1978 length-frequency distribution for the upstream run of lake whitefish displayed a unimodal distribution that peaked at the 376-400 mm length interval (Fig. 16). The downstream run was also unimodal with the peak encompassing both 376-400 mm and 401-425 mm fish. Most of the upstream migrants (96%) were in the 301-425 mm size group while 93% of the downstream fish were in a larger (351-450 mm) size range. These distributions also indicated that the downstream run had larger fish in the 426-500 mm size range not seen in the upstream run. Lake whitefish smaller than 275 mm contributed only 1.4% of the total upstream run.

The overall length-frequency distributions for the 1979 upstream and downstream runs also showed unimodal peaks at the 376-400 mm length interval (Fig.17). Upstream migrants in the 301-425 mm size group comprised 90% of the total run while 92% of the downstream run were 326-450 mm fish. Lake whitefish smaller than 275 mm contributed 4% of the total upstream run. In contrast to 1978, a greater number of downstream migrants in the 350-450 length group in 1979 showed that lake whitefish, presumed to be lake residents from previous years, were contributing significantly to the downstream run. This observation indicated that upstream lakes in the Kukjuktuk drainage provided habitat for both seasonal and long term resident population of lake whitefish, similar to the situation for the broad whitefish.

The ages of lake whitefish in Kukjuktuk Creek in 1978 ranged from 2 to 15 years (Tables 16 and 17). Using length as an indication of age, the length-frequency distribution for the 1978 season (Fig. 16) indicate that lake whitefish migrants were mostly 7-14 year old fish with ages 10-13 dominant. Young-of-year and small juveniles were virtually absent. Age data from 1979 confirmed the presence of 1-2 year old juveniles (Tables 18 and 19) although some of the unaged small fish (51-100 mm size class) counted in the traps (Fig. 17) most likely included 0+ fish. The length-frequency distribution for the 1979 season show that 7-13 year old fish were involved in the upstream and downstream migrations with ages 8-13 dominant (Fig. 17). For both years, lake whitefish y-o-y and immature fish up to age 5-6 years constituted a minor proportion of the migrations.

Numbers and size of migrants - biweekly: Biweekly length-frequency data for lake whitefish show that the modal size interval in each time period shifted gradually from the largest to the smaller size classes as the season progressed (Fig. 18). The modal length interval in the 1978 upstream run began with the 376-400 mm fish during the first (15-28 June) and second (29 June-

12 July) biweekly period. As the migration rate began to decrease during the 13-26 July period, the mode dropped to the 351-375 mm size interval. By the end of the upstream run in August, all the smaller length intervals appeared, with the 251-275 mm length interval being dominant. The modal length interval in the downstream run was 376-400 mm during the start (27 July - 9 August) and the main period of migration (10-23 August) although the 401-425 mm group was almost similar in magnitude. By the last week of August, the lake whitefish migration had essentially ended.

The 1979 fence operation allowed an additional four weeks of observations that carried through into September (Fig. 18). The largest lake whitefish were among the first to appear during 15-28 June 1979 when the 376-400 mm and 401-425 mm length intervals comprised 65% of the upstream run for that period. During the following biweekly period these two size groups only made up 30.7% of upstream migrants as the smaller size intervals (301-325, 326-350 and 351-375 mm) began to appear, contributing 59%. By 13-26 July the smaller size intervals below 250 mm appeared as well, contributing to the run for the rest of the season.

There was no obvious change in the modal length intervals with time periods for the 1979 downstream run (Fig. 18). The 376-400 mm length interval dominated each biweekly period until 20 September. The smaller length interval below 275 mm appeared during the 10-23 August period and, by the last biweekly period, the run was comprised of mainly 101-125 mm and 126-150 mm fish. Compared to the broad whitefish, the lake whitefish had a shorter migration season which lasted only 4-5 weeks. In addition, any stepwise change in modal length classes with time was not as distinct as that displayed by broad whitefish.

The preceding data showed that young-of-year and juvenile whitefish, unlike the broad whitefish, did not migrate in significant numbers into Kukjuktuk Creek. Most of the small fish seen in 1979 were taken in the downstream trap and most likely originated from a resident population. The coastal surveys by Lawrence et al. (1984) found that lake whitefish in the southern Beaufort coastal area were between 1 and 16 years old with a notable scarcity of young-of-year. Bond and Erickson (1985) also reported that relatively small numbers of lake whitefish younger than age 4 years were seen migrating up Freshwater Creek. Assuming that lake whitefish migrants originated in the Mackenzie River, such observations suggested that nursery areas for lake whitefish were located closer to the Delta, particularly the extensive network of Delta lakes and channels as concluded in previous studies (Stein et al. 1973a, 1973c).

Additional data collected in the Delta since 1979 reaffirmed the greater importance of the Delta to the early life history stages of lake whitefish. After emerging from upstream spawning sites in the Mackenzie River, lake whitefish y-o-y are found in the Delta channels throughout the rest of the open water period. Lake whitefish in the 20 to 160 mm size group was the second most abundant, after least cisco, of the coregonid fry/juveniles caught in beach seines in the East Channel area (Chang-Kue and Jessop 1992). Taylor et al. (1982) estimated that lake whitefish was the third most abundant (8.2%) among four species of coregonid y-o-y found in Delta lakes that are connected to the main Delta channels during the full, open water period. In contrast, their estimate for 0+ broad whitefish was only 0.2% while least cisco and Arctic cisco contributed 77.5% and 14.2%, respectively.

Coastal bays adjacent to the Delta appear to be important summer feeding habitats for the next older group of juvenile lake whitefish. Hopky and Ratynski (1983) reported that juvenile lake whitefish in the 150 to 250 mm length group comprised over 90% of lake whitefish taken in trapnets in Tuktoyaktuk Harbour in 1981. After a period of coastal feeding and overwintering near the Mackenzie estuarine areas for 3-5 years, it appears that the lake whitefish enter another life history stage that involve migrations to more distant points and into tundra lakes for a wider spectrum of feeding and overwintering habitats. Lake whitefish larger than 225 mm fork length, representing fish age 4 years and older, comprised 98% of the upstream and 95% of the downstream run at Kukjuktuk Creek in 1979. Bond and Erickson (1985) also observed this situation at Freshwater Creek where the majority of lake whitefish migrants (89% of upstream and 98% of downstream) were between 225 and 449 mm fork length.

Growth, sex and maturity: The observed growth rate for lake whitefish from Kukjuktuk Creek (Fig. 19) was similar for both years, showing a gradual, even growth in length after the first year. These curves were similar to that of coastal fishes sampled in 1978-1980 by Lawrence et al. (1984). The 1979 curve for Kukjuktuk Creek matched the one for lake whitefish migrants seen in Freshwater Creek (Bond and Erickson 1985). Kukjuktuk fish show similar growth rate to outer Delta whitefish (Percy 1975) (Fig. 20); however, lake whitefish taken in the Delta and Arctic Red River have a faster growth rate. It is believed that other stocks of lake whitefish, originating from different summer foraging areas, contribute to the major spawning runs seen in the upper Delta.

Out of a sample of 179 lake whitefish sexed and aged in 1978, only one mature fish, a 12 year old female, was seen (Table 20). The female to male sex ratio was 1: 0.9. The following year 11 (9%) mature males and 17 (17%) mature females were identified among 227 fish; of these fish 5 males and 4 females were upstream migrants. The female to male sex ratio was 1: 1.3. Maturity data for the early run of large downstream migrants were incomplete since few fish were sacrificed for dissections during the busy July period. Although the presence of a self-sustaining lake resident population in the Kukjuktuk drainage was not unlikely, it was not known if any of the upstream migrating lake whitefish spawn in the Kukjuktuk drainage. The minimum age at maturity for Kukjuktuk Creek lake whitefish was 8 years and 7 years for males and females, respectively.

Gillnet surveys in the east side Mackenzie Delta in 1980 showed an age at maturity of 10 years for both sexes (Chang-Kue and Jessop 1992). An early winter survey in the Peel River, Arctic Red River and Delta channels in November 1980, when ripe gonads could be examined, indicated the age at maturity was 10 years for both sexes (Table 21). A fall survey in 1981 in the upper Delta established that spawning migrants were mainly 8-15 year old with minimun age at maturity of 7 and 8 for male and females, respectively (Chang-Kue and Jessop 1992).

In terms of fork length at age 10 years, the data at Kukjuktuk Creek indicate that lake whitefish may achieve first maturity at 350 mm. The strongest biweekly downstream component observed in 1978 and 1979 were fish greater than 376 mm fork length; in 1979 these fish accounted for 67% of the total downstream run by 6 September 1979 (Fig. 18). Although maturity data were lacking, the size range and downstream timing of the largest size classes suggest that the lake whitefish downstream migrants were likely contributors to the annual spawning migrations in the Mackenzie Delta.

The length-weight relationship for lake whitefish in Kukjuktuk Creek in 1979 (pooled upstream and downstream fish; N=479, range 73-461 mm) was described by the equation:

$$\log_{10} W = 3.354(\log_{10} L) - 5.793$$

$$SD_b = 0.034$$

Separate calculations for male and female lake whitefish from the upstream and downstream runs for each year produced different values for slopes and intercepts (Table 22). Analysis of covariance between males and females show significant difference ($P<0.05$) between the intercepts for the 1978 upstream run and between the slopes for the downstream run in 1979. Analysis between males and between females in the upstream vs downstream runs produced several cases of significant differences between intercepts for 1978 fish and between slopes for 1978 and 1979 fish. The results suggest that the small sample of downstream fish in 1978 were in poorer condition than upstream fish with regard to size and weight. The data collected in 1979 showed that the downstream females were in significantly better condition than the upstream females with regard to weight. Dissections of these downstream migrants showed extensive fat reserves in the body cavity, providing tangible evidence that these immature and sub-adult fishes had foraged successfully during their stay in the lakes.

Tagging data - migrations within Kukjuktuk drainage: Two lake whitefish, tagged at the creek mouth in 1979, were recaptured in the drainage. The first, tagged on 8 July 1979, passed through the upstream trap 5 days later but did not return downstream. The second fish escaped upstream detection; however, it had spent 33 days in the drainage when recaptured in the downstream trap on 3 August 1979 (Table 11).

In the two summers spent at Kukjuktuk Creek, a total of 1 287 lake whitefish were tagged and released at the fence sites; 1 218 were upstream migrants and only 69 were downstream fish (Table 3). The lake survey crew recaptured only two of the tagged whitefish in the lakes (Table 12). Both were caught on 10 July 1979, 14-22 days after tagging, in lake 12, the second upstream lake in the system (Fig. 2).

Tagged upstream migrants that returned downstream later in the same season indicated that lake whitefish stayed in the lakes for as long as 65 days in 1978 and 100 days in 1979 (Table 13). Of 70 upstream migrants exhibiting this behaviour in 1978, the majority (64%) spent 36-50 days in the watershed before returning to the coast. Of 504 upstream migrants exhibiting this behaviour in 1979, the majority (75%) stayed 26-50 days before leaving the watershed.

Tag returns within the same year provided an estimate of the percentage of upstream lake whitefish migrants that stayed to overwinter in the lakes (Table 13). In 1978, only 70 of 387 tagged upstream migrants returned downstream, suggesting that 82% of the run stayed to overwinter. However, the 1979 tag data showed that 504 of 826 tagged upstream migrants returned downstream, indicating 29% of this group stayed to overwinter. The length-frequency distribution data suggested that the downstream run included large fish that had overwintered in the system from previous years. Tag recaptures verified this observation since 40 of the upstream whitefish, tagged in 1978, were recaptured only for the first time coming downstream in 1979 after spending 361-415 days in the headwaters. (Table 14).

From the small sample of lake whitefish that was tagged going downstream in 1978 (N=24), five returned upstream in 1979 (Table 14), indicating a migration fidelity of 21% to Kukjuktuk Creek between two consecutive years.

Four lake whitefish downstream migrants in 1979 returned upstream within 15 days. The short time span between release and recapture suggested that these fish were only upstream migrants that had dropped downstream temporarily past the fence before returning upstream.

<u>Tagging data - migrations outside Kukjuktuk drainage</u>: A total of 36 tagged lake whitefish from the Kukjuktuk Creek fence were recaptured by subsistence fishermen.

In 1978, two fish were recaptured in Tuktoyaktuk Harbour (Fig. 13, Loc. TH100) in July and September; both had been tagged in the upstream run earlier in the summer. A third fish, released on 19 August 1978 at the downstream trap (401 mm fork length), was recaptured in October/November at Tununuk Point (Loc. EC101) in the Mackenzie Delta's East Channel. This fish provided the first recapture evidence linking coastal lake whitefish with Mackenzie Delta lake whitefish.

The largest number of tag returns came in 1979 when 24 lake whitefish were recaptured. Twenty-one were taken in Tuktoyaktuk Harbour by local fishermen in July and August; these fish were age 9-14 years and ranged from 315 to 428 mm in fork length. Five of these were tagged in 1978 and the rest were tagged in 1979 in the upstream run. Most of the fish had also been recorded coming through the downstream trap between 20 July and 20 August 1979.

Subsistence fishermen at East Whitefish Station (Loc. EW100) returned two tags in 1979. One fish, released at the fence on 3 July 1978 (390 mm fork length), was recaptured on 8 September 1979. The second fish had a multiple recapture history. It was among the first group of fish that appeared at ice breakup at the counting fence site where it was tagged and released on 14 June 1979 (406 mm fork length), the day before the fence was completed. After drifting downstream on release, this fish returned through the upstream trap two weeks later on 1 July. After foraging in the lakes for a month, it returned downstream on 30 July 1979 and was recaptured 7 days later at East Whitefish Station (Loc. EW100), located about 65 km west of Kukjuktuk Creek.

The last fish recaptured in 1979 was taken in the East Channel near Inuvik (Loc EC100) on 14 November 1979. Since this fish had been tagged in the upstream run on 19 June 1979 (404 mm fork length), it provided further evidence that lake whitefish, migrating out of Kukjuktuk Creek, reach the Mackenzie Delta by the fall of the same season.

Three tag returns in 1980 came from fish recaptured in Tuktoyaktuk Harbour between early July and early September. All had been tagged when moving upstream on Kukjuktuk Creek in June 1979 and recaptured and released again as they returned downstream on 23, 29 July and 8 September 1979. Three other tagged lake whitefish were recaptured at East Whitefish Station in August 1980. One fish was tagged 29 June 1978 (410 mm) as a downstream migrant and recaptured going downstream on 23 July 1979 before its final recapture. The other 2 fish (407 and 410 mm) were tagged among the upstream and downstream migrants in June 1979 at the fence.

A single tag return in 1981 came from one fish recaptured in the Mackenzie River. This fish, first tagged in the upstream trap on 26 June 1979 and measuring 369 mm, came downstream a month later on 24 July 1979 before it was recaptured two years later at Arctic Red River (Loc. AR102) in September/October 1981. The presence of ripe and spent lake whitefish at Arctic Red River led Stein et al. (1973c) to conclude that spawning areas were located in several backeddies on both banks of the main stem Mackenzie River around the town of Arctic Red River. On 8-9 October 1983, we visited the area and caught 97 spawning lake whitefish in a gillnet set overnight at a backeddy known locally as Nazon's Eddy, located on the east bank of the Mackenzie River and across from Arctic Red River. A subsample of 27 fish (420-510 mm fork length) consisted of 26 males and one female all of which had gonads in ripe condition (unpublished data).

Finally, two tag returns in 1982 were also taken in the Mackenzie system. The first fish, recaptured on 8-9 October 1982 at a site upstream on the Arctic Red River (Fig. 13; loc AR101), was first tagged as an upstream migrant (395 mm , age 13 years) at Kukjuktuk Creek on 22 June 1978. This fish came downstream on 18 August 1978 and was again recorded as a downstream migrant on 21 July 1979 before its final recapture at a time and location consistent with lake whitefish in the middle of a spawning run in the Arctic Red River. The second fish, recaptured in the East Channel (Loc. EC101), was an upstream migrant (404 mm) at Kukjuktuk Creek tagged on 16 June 1979 and recorded coming downstream on 31 July 1979. Its location and recapture date, 26 October 1982, suggested that this fish was overwintering in the East Channel, a most probable downstream destination for post-spawning fish.

Overwintering: Lake whitefish movements within Kukjuktuk Creek indicate that overwintering habitat exists in the upstream lake system. Overwintering areas for the immature coastal migrants that forego inland lakes are believed to be selected coastal sites in Kugmallit Bay (Percy 1975; Lawrence et al. 1984) and Tuktoyaktuk Harbour (Bond 1982). Post spawning lake whitefish in the Mackenzie River appear to return to the lower Delta channels to overwinter (Stein et al. 1973a, 1973c; Jessop et al. 1974). Coastal overwintering sites east of Kukjuktuk Creek are unknown.

The lower reach of the Mackenzie Delta's East Channel from Tununuk Point to Kugmallit Bay is thought to be the optimum overwintering area in the region since constant winter flows and a deep subice channel ensures suitable conditions. Chang-Kue and Jessop (1992) report that catch-per-unit-of-effort peaks in July, August and September in the East Channel suggested discrete groups of lake whitefish moving into the area. Mature fish comprised part of the July and August catches after which mainly immature and non-spawning fish were prevalent, suggesting that mature fish had continued upstream towards spawning areas. The sources of these immature and non-spawning adult fish are most likely the downstream migrants coming from coastal drainages like Kukjuktuk Creek and from east side Delta tributaries such as Pete's Creek and Holmes Creek.

Least cisco

Two forms of least cisco occur in the Mackenzie River and southern Beaufort Sea area. The most common is the anadromous form seen in the fall on spawning runs in the lower Mackenzie River and Delta (Hatfield et al. 1971a, Stein et al. 1973c, Jessop et al. 1974, Percy 1975, Chang-Kue and Jessop 1992). This migratory form is easily distinguishable from the other Mackenzie coregonid species by it protruding lower jaw, scales that slough off easily on handling and relatively small size. A non-migratory form of least cisco that inhabits freshwater lakes can be identified externally by its less protruding lower jaw, resulting in a terminal mouth. It also has scales that, in comparison, are not readily lost in handling and it has a darker pigmentation in the dorsal area and ventral fins. Lawrence et al. (1984) encountered these two forms during their three-year coastal and lake surveys in the Richards Island and Tuktoyaktuk Peninsula area. They reported that the lake spawning variety, believed to migrate within their home freshwater drainage, was not caught at any of their coastal sampling sites.

During 1978 and through the early part of the 1979 season, only the familiar anadromous form of least cisco was identified in both upstream and downstream migrations at Kukjuktuk Creek. A few lake resident form of least cisco were detected in the upstream run in mid-August 1979, when the reduced numbers of stream migrants allowed closer examination of fishes. Pyloric caecae counts and lateral line scale counts confirmed our identification. Although a few more were seen mainly in the upstream run, it was not known if many others had been missed during the earlier peak periods of upstream and downstream migrations. All least cisco data were combined for analysis in this report with the understanding that the majority of the sample consisted of the anadromous type.

Magnitude and timing of migration: The total run of least cisco in 1978 consisted of 14 102 upstream and 6 951 downstream migrants while the 1979 run had 14 037 upstream and 17 164 downstream migrants (Table 2). The weekly total numbers of least cisco caught in the upstream and downstream traps in 1978 and 1979 are summarized in Fig. 21 and 22, respectively. Daily totals are listed in Appendix 2.

The upstream migration of least cisco in 1978 began on 28 June, ten days later than the other coregonid runs (Table A2.1). Peaks in the daily totals occurred on 3 July and 17 July when 433 and 2 011 least cisco passed through. The most intense upstream migration occurred during the week of 13-19 July, when 50% of the season's upstream run came up (Fig. 21). The run slowed down over the next two weeks when an additional 28% of the total migrants came through. Like broad whitefish, the least cisco upstream migration was still in progress when the fence operation ceased in mid-September. The downstream run commenced on 20 June, matching the other species in timing. Daily totals increased gradually to a peak of 2 002 fish on 20 August. This number contributed to the peak weekly downstream total during the week of 17-23 August, when 71% of the total run came down (Fig.21). After a total of 921 on 21 August, migration activity dropped abruptly to an average of 17 fish per day over the remaining 3 weeks.

The least cisco upstream migration in 1979 also began a few days later than the broad and lake whitefish runs (Table A2.2). As stream temperatures increased so too did the daily total, reaching the maximum recorded run of 1 050 and 1 305 cisco on 14 and 15 July, respectively, when the maximum temperature reached 21°C. The main run occurred over three consecutive weekly periods, beginning on 29 June, when 21%, 19% and 36% of the season's migrants came up (Fig. 22). The upstream run then declined rapidly by 20 July, as it did in 1978, reaching a daily count of only 44 fish by 22 July 1979, the day when the warmest stream temperature of 23°C was reached. The least cisco peak differed this year from the other coregonid species by occurring later than the lake whitefish peak (30 June) and earlier than the >200 mm broad whitefish (21 July). The upstream migration continued at an average rate of 33 fish/day for the rest of the season.

The least cisco downstream migration in 1979 began on 17 July and escalated as rapidly as the upstream run's decline. Peak downstream totals showed two main waves of fish: one on 25 July (1 120 fish) when stream temperatures were the warmest and another on 10 August (1 510 fish) when temperatures rose to 21°C again after falling to 13°C the previous week during a cold spell. The peak downstream weekly total occurred during the week of 20-26 July when 36% of the total run came down (Fig. 22). The downstream run was protracted over the following 3 weeks when an additional 44% of the total run came down.

Numbers, size and age of migrants - for the season: During 1978, the fork length of 1 693 upstream and 571 downstream least cisco migrants were recorded (Table A3.5). The sample in 1979 was 2 988 upstream and 1 903 downstream fish (Table A3.6). Data records show that the size range for upstream migrants was 25-415 mm in 1978 and 60-425 mm in 1979. Downstream migrants ranged from 175 to 404 in 1978 and from 64 to 432 in 1979.

The overall length-frequency distribution of the upstream and downstream migrations for each year are shown in Fig. 23 and 24. Like broad whitefish, the data for the least cisco was separated into two groups to examine if significant migration patterns occurred with the smaller (<200 mm) fishes. As with lake whitefish, these small fish did not overwhelm the total run and represented only a small proportion (0.8%) of all least cisco seen in 1978 (Fig. 23). Similarly, the <200 mm fish comprised only 4% of all least cisco in 1979 despite the closer surveillance at the traps (Fig.24).

The 1978 overall length-frequency distributions for least cisco were unimodal for both upstream and downstream runs (Fig. 23). Fish at length intervals 276-300 and 301-325 mm contributed to 30% and 28% of the total upstream run; the same length intervals comprised 29% and 34% of the total downstream run. Upstream migrants were mostly (79.5%) fish larger than 275 mm; similarly 84.6% of the downstream fish were larger than 275 mm.

In 1979, the only noteworthy feature among the smaller sized migrants (<200 mm) was the dominance of 76-100 mm fish in the downstream run (Fig. 24). The 276-300, 301-325 and 326-350 mm size intervals contributed to most of the fish in both the upstream (63%) and the downstream (57%) runs. Least cisco differed from the other coregonids in not having a disproportionate number of the fish in the larger size classes in its downstream run.

The age of least cisco in Kukjuktuk Creek in 1978 ranged from 2 to 10 years (Tables 23 and 24) although a small group of live sampled upstream migrants smaller than 100 mm fork length (Fig. 23) most likely included 0+ and 1 year old fish. The sample of downstream migrants aged in 1979 included 1 to 11 year old fish (Tables 25 and 26). Using length as an indicator of age, the length-frequency distribution for 1978 (Fig. 23) indicate that migrants were mostly 4 to 9 years old with ages 5 to 7 years dominant. Age derived from the 1979 length distribution (Fig. 24) also confirmed the relative absence of least cisco less than 3 years old. Migrants were mostly 3 to 8 years old with ages 4 to 7 years dominant. The 76-100 mm and 100-125 mm length classes in the 1979 downstream run suggested that some 0+ to 2 year old fish had their origins in the lakes and not from outside drainages.

Numbers and size of migrants - biweekly: When the calculated length-frequency distribution for least cisco was separated into biweekly periods (Fig. 25), the modal length interval showed slight variations over time. The largest individuals, especially the 326-350 mm fish, were the first to migrate upstream in early July 1978. By 13-26 July the 276-300 mm length interval dominated the run while the 301-325 mm length interval was a close second. Although the distribution began to include smaller fishes (76-150 mm) by 10-23 August, the dominant size interval class reverted to the 301-325 mm group and remained so for the rest of the season. The downstream run's distribution pattern for each period essentially mirrored that of the upstream run.

Similar observations were made in 1979. A group of large fish, dominated by the 326-350 mm length interval, comprised the first batch of least cisco upstream migrants in late June (Fig. 25). During the next two periods, which included the time when migration rates were highest, the 301-325 mm length interval was dominant. These were replaced by 276-300 mm fish during 13 to 26 July. By 10-23 August, the trend toward smaller length intervals was reversed as the slower-paced upstream run was dominated by 301-325 mm fish for the rest of the season. The downstream run for 3 periods during 13 July - 23 August was dominated by smaller fish (276-300 mm). By September 1979, there was a strong representation of small fish in the 76-100 mm and 101-125 mm length intervals. These size ranges of downstream migrants, with their presumed origins in the headwaters, had not been observed in 1978.

The least cisco in Kukjuktuk Creek were similar to the lake whitefish with respect to the small numbers of young-of-year and age 1-2 year old juveniles in the upstream run, suggesting that this coastal drainage was not a prime nursery area for least cisco. Previous studies in the Delta concluded that the large numbers of least cisco that migrate annually into the Mackenzie Delta come from summer feeding grounds in the outer Delta and coastal areas (Stein et al. 1972a, 1972c; Jessop et al. 1974; Percy 1975; Mann 1975). After emerging from spawning sites in the Mackenzie system, the y-o-y least cisco inhabit the channel and lakes of the

Mackenzie Delta during the spring flood. Least cisco are the most abundant of the coregonid species found in the Delta channels and the presence of juvenile fish in the earlier surveys led to the conclusion that main channels functioned as nursery areas (Jessop et al. 1974). More recent work in the lower east Delta in 1980 showed that least cisco, most of which were y-o-y, constituted 43% of the total coregonid beach seine catch (Chang-Kue and Jessop 1992). Taylor et al. (1982) reported the presence of least cisco in several representative Delta lakes of the type that have access channels to main Delta channels in the ice-free period. Their estimates in 1981 showed that least cisco comprised 72% of the total summer population of 0+ and 1 year old coregonids.

The presence of least cisco y-o-y later in the summer along the coastal zone indicates that least cisco may have an active migratory component to the coast as well. Although absent in spring and early summer surveys, least cisco y-o-y became abundant in mid-summer seine surveys conducted by Lawrence et al. (1984) along the Richards Island and the Kugmallit Bay coastline. Bond (1982) also observed a large migration of y-o-y (65-94 mm range) entering Tuktoyaktuk Harbour in 1980 in mid-July; their subsequent decline in catch-per-unit effort suggested a dispersal further along the coast and possibly up coastal streams. The first appearance of 0+ and 1+ fish (51-100 mm interval) at Kukjuktuk Creek in mid-August of each year corroborates these observations; however, the numbers of fish that were less than 100 mm fork length made up a minor proportion (0.14%) of the total upstream run. On the other hand, the high proportion of this size group in the least cisco upstream migrants enumerated by Bond and Erickson (1985) at Freshwater Creek in 1982 suggests that coastal drainages closer to the Delta may have an important role as nursery areas for the y-o-y fish. Few of these upstream migrants returned to the coast by the end of the season.

Numerous factors such as spawning success, incubation success, Mackenzie River seasonal discharge patterns and year-to-year variations in prevailing winds and temperature conditions may influence the migration success of least cisco along the Beaufort Sea coast. This success perhaps may be measured by the numbers of y-o-y making upstream migrations in more distant streams in any given year. It could be surmised that streams closer to the Mackenzie Delta offer the safest refuge for young-of-the-year. After residing in lakes for for 1-3 years, least cisco may return to the coast to join a coastal migratory group of fish that possess the strength and energy reserves to range further along the coast and use additional streams, such as Kukjuktuk Creek, for feeding and overwintering.

Growth, sex and maturity: The growth rate for least cisco from Kukjuktuk Creek (Fig. 26) was similar for 1978 and 1979. Fish grow rapidly in fork length up to age 4 years, reaching an average size of 262 ± 25.5 mm (1979 data) before continuing at a moderate growth rate for age 4 to 10 years. There were several instances where the average size between the sexes was significantly different at some ages (Table 23, 25, A4.9, A4.11 and A4.12). In all cases, females were larger than males. Compared to earlier Mackenzie Delta fish data (Fig. 27), the Kukjuktuk Creek least cisco demonstrated a faster growth rate than those collected in the Aklavik/west Delta area, the Arctic Red River area (Stein et al. (1972c) and the outer Delta (Percy 1975). Coastal collections taken closer in time to this study include Tuktoyaktuk Harbour (Bond 1982), Freshwater Creek (Bond and Erickson 1982) and the coastal stations in the Richards Island/Tuktoyaktuk Peninsula (Lawrence et al. 1984). Inspection of the growth curves from these areas showed that all three lie between the Arctic Red River and Kukjuktuk Creek curves shown in Fig. 27. The Kukjuktuk Creek fish growth curve was almost identical to the growth curve for the lake resident form of least cisco collected in the Tuktoyaktuk Peninsula lakes by Lawrence et al. (1984). In general, Lawrence et al. (1984) found that the lake-caught least cisco were significantly larger than those caught on the coast in 1978 and 1980; however, no similar significance difference in growth was found in his 1979 survey data.

The growth curve for Kukjuktuk least cisco may be difficult to interpret since it may be a composite of two types of least cisco the ratio of which is unknown. An interesting aspect from this least cisco study, however, was the observation that the lake resident form of least cisco was not fully confined to the lakes and that a coastal migratory component existed. In subsequent Tuktoyaktuk Peninsula stream studies, Bond and Erickson (1982, 1985) also encountered both forms in their counting fence operations at two streams draining into Tuktoyaktuk Harbour, viz. Mayogiak and Freshwater Creek.

The preceding growth comparisons all involved scale aged fish so that the inherent discrepancies associated with otolith and scale age for the same fish were avoided. Both Mann (1974) and Bond and Erickson (1985) found that ages from both structures agreed for the younger age groups; however, scale ages may underestimate age for the older fish especially after age 4 years.

From a total sample of 333 least cisco sexed and aged in 1978, 43% of the females and 36% of the males were mature (Table 27). The female to male sex ratio was 1:0.7 . The age at maturity for both sexes was 5 years. In the following year, the youngest mature male and female were age 4 years among a total sample of 316 fish. With a female to male sex ratio of 1:0.6, 32% of the female and 26% of the males were mature. In concurrent coastal studies, the youngest mature least cisco was age 5 years along the coast (Lawrence et al. 1984), 5-6 years for Tuktoyaktuk Harbour and 4 years for the stream migrants in Freshwater Creek (Bond and Erickson 1985). Age 5 years was the minimum age of maturity reported for migratory least cisco in the earlier Delta surveys (Stein et al. 1973c; Percy 1975). In the East Channel area, mature males ranged in age from 4 to 8 years and females from 5 to 8 years (Chang-Kue and Jessop 1992).

While the two least cisco forms were seen in both the upstream and downstream traps during late August and September, it became apparent that mature and ripe females of the lake resident form were only observed in the upstream run while mature/ripe females in the downstream run were the anadromous variety. Since the upstream run of ripe lake type least cisco in the fall indicated that spawning was occurring in the lake system, it was likely that some of these fish had come down from the lakes earlier in the season and were returning upstream after a summer of feeding in the Mackenzie estuary, along the coast, or in some other drainage. Some tagging data, discussed in a section that follows, may support this speculation. While migrations of the lake-resident type of least cisco may have involved only Kukjuktuk's resident population, we cannot dismiss the possibility that migrations of the lake-resident types may occur between adjacent drainages.

The length-weight relationship for least cisco in Kukjuktuk Creek in 1979 (pooled upstream and downstream fish: N=576, range 75-392 mm fork length) was described by the equation:

$$\mathrm{Log}_{10}\,W = 3.207(\log_{10} L) - 5.52$$

$$SD_b = 0.063$$

Separate calculations for male and female least cisco for the upstream and downstream runs for each year produced different values for slopes and intercepts (Table 28). Analysis of covariance between males and females showed significant difference between intercepts and slopes in all cases. Analysis between males and between females in the upstream and downstream runs showed instances of significant differences between the slopes and intercepts for females in 1978 and between intercepts for males in 1978. The significance and interpretation of the data is not clear because of the unknown mix of the two forms of least cisco that occurred at Kukjuktuk Creek.

Tagging data - migrations within Kukjuktuk drainage: A total of 2 023 upstream migrants and 153 downstream least cisco migrants were tagged and released at Kukjuktuk Creek in 1978 and 1979 (Table 3). Five fish were also tagged in the estuary between 25 June and 10 July 1979. Potential recapture sites during the study were the fence sites, Kukjuktuk Bay and the upstream lakes sampled by the lake survey crew.

Three least cisco tagged in 1979 at the mouth of Kukjuktuk Creek were recaptured (Table 11). All were recaptured at the upstream trap 4-19 days after release. The lake survey crew, using survey gillnets and stream hoopnets, recaptured only four of the upstream migrants released at the fence site (Table 12). One fish was taken in Lake 10 and another in the stream connecting lake 10 and 11 (Fig. 2, Loc KL092) ten days after release. The other two were recaptured in Lake 18 on 17 September 1979, 24-25 days after release. No least cisco tagged in 1978 were recaptured in the lake surveys.

Tagged upstream migrants that returned downstream later in the same season indicated that least cisco may spend up to 95 days in the lake system before leaving the watershed (Table 13). The distribution of 5-day time intervals spent in the headwaters seemed to indicate 2 modes each year. Of 145 upstream migrants exhibiting this behaviour in 1978, 41% stayed up to 15 days and 38% stayed from 26 to 40 days. Of 282 upstream migrants exhibiting this behaviour in 1979, 37% stayed less than 15 days and 35% stayed for 21-35 days. One explanation for the short stay demonstrated by some fish each year was handling stress. Least cisco did not recover from the tagging procedure as well as broad and lake whitefish. Many tagged fish returned downstream in an apparent weak condition and appeared unable to continue upstream, especially during peak migrations when crowding in the reach above the fence occurred. These fish made up the bulk of the recorded downstream migrants. The peak length of time spent on the one season's feeding foray by least cisco was shorter than the lake and broad whitefish by about 15 days in 1978 and 5 days in 1979.

The recaptures, in 1979, of tagged fish from 1978 showed that least cisco could survive the stress of the tagging procedure (Table 14). The first-time recapture of 51 fish in the downstream trap in 1979 indicated that some of the 1978 upstream migrants had overwintered for one winter before returning to the coast. Some of these even spent their second summer of feeding in the lakes before returning downstream 386-400 days after their release at the upstream trap in 1978.

Another set of tag returns involved the recapture, in the upstream trap for the first time, of a group of least cisco that was tagged in the downstream run in 1978 (Table 14). The return of 16 least cisco out of 143 released showed that there was a migration fidelity of 11% for Kukjuktuk Creek between two consecutive years.

A final set of tag returns showed that some least cisco tagged going downstream did indeed return upstream later in the summer (Table 15). Eleven of 143 least cisco tagged in 1978 returned upstream after spending from 5 to 31 days either in the lower reaches of Kukjuktuk Creek or in adjacent coastal waters. Data records show that these fish had been tagged in late July or mid-August and were recaptured returning in August or mid-September, respectively. Ranging in age from 4 to 8 years, these ciscoes averaged 315 mm in fork length (range: 267 to 355 mm). Only one of 10 downstream migrants tagged in 1979 (312 mm fork length) returned upstream after 48 days. While the records did not distinguish what particular form of least cisco were tagged in either year, it is possible that these individuals may have been the lake resident type of least cisco that had gone to the coast on a summer feeding migration. Mature spawning least cisco seen in the upstream run in late August 1979 were only the lake resident type. Data records show that the fork lengths of 9 of these 12 fall returnees were greater than 301 mm, consistent with the 301-325 mm size interval of least cisco that reappeared in mid-August in both 1978 and 1979 (Fig. 25).

Tagging data - migrations outside Kukjuktuk drainage: Only two least cisco from Kukjuktuk Creek have been recaptured by the subsistence fishery in Tuktoyaktuk Harbour. Both fish, tagged in 1978, were recaptured in July 1979.

A single least cisco recaptured on 25 July 1978 by a domestic fisherman at East Whitefish Station (Fig. 13, Loc. EW100) did not originate from Kukjuktuk Creek. Records show that this fish was tagged and released on 28 June 1978 at the outflow of a headwater lake in Canyanek Creek (Fig. 13), another coastal drainage west of Tuktoyaktuk Harbour (M. Lawrence, unpublished data). It is thought that the migratory path of this fish may be representative of least cisco from other coastal drainages. The low recapture rate of least cisco may reflect a high mortality rate among tagged fish returning to the coast. The most likely reason, however, is the use of large mesh gillnets by subsistence fishermen to catch the larger coregonid species; consequently, few least cisco are taken in the local fishery.

There has been no record of recaptures in the Delta to provide direct evidence that some of the least cisco migrations in the Delta originate from the coastal populations; however, the eventual destination of mature individuals of the anadromous form of least cisco from Tuktoyaktuk Peninsula streams is believed to be the Mackenzie River. Females in an advanced state of maturity were observed in the downstream run at Kukjuktuk Creek in mid-August and none were seen going upstream. It seems likely that these mature fish were spawning least cisco moving toward the Delta.

Fish in the 276-350 mm length group dominated the downstream migrants at Kukjuktuk Creek from mid-July to mid-August (Fig. 25). Chang-Kue and Jessop (1992) observed that gillnet catch-per-unit-of-effort for least cisco in the East Channel locations in 1980 increased by a factor of 2 to 23 times in September after a period of low catches in July and August. This timing of an influx of least cisco into the Mackenzie Delta seemed to follow the timing of mature least cisco leaving coastal streams as observed at Kukjuktuk Creek. Almost all (97%) of the least cisco captured in the upper Delta in September-October 1981 were 251-325 mm in fork length with the 276-300 mm length interval accounting for 62% of the sample. The percentage of least cisco with maturing gonads was greatest during the month of August in the lower East Channel and it was thought that these fall migrants eventually reach sites in the upper Delta and lower Mackenzie River. Almost all of the least cisco encountered in the upper Delta in September and October 1981 by Chang-Kue and Jessop (1992) were mature, spawning fish.

Overwintering: The tagging program established that least cisco overwintered in lakes of the Kukjuktuk drainage. Immature least cisco leaving Kukjuktuk Creek were most likely migrating to overwintering areas on the coast. Least cisco have been taken under the ice in coastal areas near Hendrickson Island (Percy 1975) and Tibjak Point (Galbraith and Hunter 1975). Under-ice catches in sheltered coastal bays have also been made at Mallik Bay (Percy 1975) and at Tuktoyaktuk Harbour (Bond 1982). The lower East Channel of the Delta would also offer suitable overwintering conditions because of the constant winter flows and deep sub-ice channel. The high proportion of immature fish accompanying the presence of mature fish into this area in September provided evidence for Chang-Kue and Jessop (1992) to conclude that the lower section of East Channel, from Tununuk Point to Kugmallit Bay, is a significant overwintering area for least cisco. Although no data are available, it appears likely that post-spawning least cisco return downstream in the late fall to use the same overwintering sites as the non-spawning members of the population.

SUMMARY

Kukjuktuk Creek has an important role in the life cycle of broad whitefish, least cisco and lake whitefish populations. The most obvious function appears to be its use as a migratory corridor between coastal waters and inland tundra lakes. While each species displays its own unique upstream and downstream migration pattern over the short streamflow period, the overall purposes are similar. Upstream migration activity appears to be related to specific age groups proceeding to areas within the network of lakes offering nursery, summer feeding and overwintering habitats. Downstream migrations involve a return of a large group of immature fish to overwintering areas outside the lakes while another group, consisting of mature fish, migrate further to spawning grounds. Except for the appearance of some mature lake resident form of least cisco among fall upstream migrants, there is no evidence of any major spawning migrations going up Kukjuktuk Creek.

Kukjuktuk Creek coregonids appear to originate from the populations of broad whitefish, lake whitefish and least cisco in the Mackenzie Delta. Schools of these species are most prominent during annual spawning migrations in the lower Mackenzie River and its major tributaries. While the size and age composition of these mature fish were well documented in earlier Delta studies, data on the fry and immature segments of the populations were lacking until we began to study the coastal fishes. The large numbers of migrants in Kukjuktuk Creek as well as data on migration timing, length-frequency, age composition and tagging collectively provided evidence to link coregonid populations in this coastal drainage with those in the lower Mackenzie River. This study revealed the important role of distant habitats, migration routes and migration behaviour to the non-spawning segments of some Mackenzie Delta coregonid populations.

BROAD WHITEFISH

Broad whitefish is by far the most important stream migratory fish species, comprising 94.2% of the total migratory fish count over the two-year study. By early June the oldest and largest upstream migrants appear to have migrated under the ice to the mouth of Kukjuktuk Creek from overwintering areas located in the outer Delta and coastal bays. These fish are among the first upstream migrants at stream ice-out. As the summer proceeds, progressively smaller size ranges of immature and juvenile broad whitefish arrive on their way to the upstream network of lakes. After foraging in the lakes during the short summer season, many leave the lakes and migrate down the stream to return to the coast by late summer; some fish however, may skip this return migration and stay the winter in the lakes. A similar but less pronounced change in size range with time occurs in the downstream run.

Fish smaller than 200 mm, representing mainly 0+ and 1 year old fish, may comprise up to 88% of the upstream run. After being flushed from the spawning grounds into Kugmallit Bay by the spring freshet, y-o-y broad whitefish appear in Kukjuktuk Creek by mid-July from which time they dominate the upstream run until late August. The Mackenzie Delta channels do not appear to be important nursery habitat for this species since fry and yearlings are virtually absent; some fry, however, do inhabit Delta lakes in the summer. The yearlings that accompany the y-o-y fish at Kukjuktuk Creek are most likely the proportion of the previous year's fry that used such alternate nursery habitats before appearing in coastal streams in their second year. The retention of these fry and yearling fish in the Kukjuktuk lakes at the end of the streamflow period indicate that this coastal drainage is a significant nursery and overwintering habitat for broad whitefish.

Broad whitefish fry appear to take up residency in the lakes for up to 5 years although some migrate out as early as age 2 years. Excluding fish smaller than 200 mm, the largest group of stream migrants are 4 to 10 year old fish (276-425 mm), suggesting that after age 3 or 4, broad whitefish behaviour include annual migrations between overwintering sites in the nearshore coastal areas and summer feeding areas in the lakes. Coastal overwintering sites for immature Kukjuktuk Creek broad whitefish include Tuktoyaktuk Harbour, Whitefish Bay and the East Channel of the Mackenzie Delta. Broad whitefish at the age of first maturity (7-8 years) are among the earliest downstream migrants undertaking the more distant migrations to spawning areas in the Mackenzie River. The latter group also include some adult fish that were residents in the lakes for one or more years before leaving the system on a spawning migration.

The migration behaviour of mature broad whitefish from a coastal drainage appears to be as follows. After one or more seasons of feeding in the lakes, mature broad whitefish migrate out of the lakes in mid-July. They migrate westwards along the nearshore zone towards the Mackenzie Delta, bypassing overwintering bays used by immature fish and reaching the lower East Channel in about a week. Sites well upstream in the East Channel may be reached within two weeks as migrants proceed through this main access channel into the Delta; such fishes are among the earliest groups of migrants going through the main Delta Channels during August and September. The large numbers seen in September and October in major channel backeddies, such as Horseshoe Bend in the Middle Channel, are thought to represent mature fish holding in pre-spawning aggregation sites before spawning. While some broad whitefish may pause in the Delta, others may proceed further upstream toward more distant aggregation and spawning sites. By late October or early November, broad whitefish may be in the vicinity of their spawning grounds in the mainstem Mackenzie or major tributaries. The Arctic Red River, Peel River and the main stem Mackenzie River at Fort Good Hope and Ramparts Rapids are known migration destinations of spawning fish from Kukjuktuk Creek.

LAKE WHITEFISH

Lake whitefish is the third most abundant species (1.9%) in the migrations at Kukjuktuk Creek. Upstream migrations begin at the same time as broad whitefish but are shorter in duration, lasting only 4-5 weeks. In marked contrast to the broad whitefish, only older juveniles and adult fish from age 7 to 14 years (301-475 mm) are prominent in the upstream run. The largest fish are the first to appear, followed by smaller length classes as the season progresses. A proportion of each season's run spend one summer in the lakes while the rest take up lake residency for at least one year. The return migration of such residents to the coast in subsequent years can create a larger downstream run. The downstream run begins as the upstream run ends. Immature migrants overwinter in coastal bays and outer Delta areas such as the lower East

Channel while the mature fish migrate into the Delta where they contribute to spawning runs in the lower Mackenzie River and Arctic Red River.

Coastal drainages are not as important to lake whitefish young-of-year and juveniles up to age 6 (<275 mm fork length) since they amount to less than 4% of the upstream count of lake whitefish. Nursery habitats and foraging areas for fry and small juveniles (20-160 mm) are located in Mackenzie Delta lakes and main Delta channels. Yearlings and juveniles (150-250 mm) are common in large adjacent coastal bays such as Tuktoyaktuk Harbour where both summer feeding and suitable overwintering conditions occur.

LEAST CISCO

Least cisco is the second most abundant species (3.9%) in the migrations at Kukjuktuk Creek. Both the anadromous and lake-resident variety of least cisco are present in the upstream and downstream migrations.

Upstream migration of least cisco begin 5-10 days later than the other coregonids with the majority of the run lasting 4-5 weeks. Like lake whitefish, only older juveniles and adult fish from age 4 to 9 (200-425 mm) are involved in the migrations. The largest fish migrate first, followed by the smaller length classes as the season progresses. Some upstream migrants stay only one season in the lakes while others take up residency and may return as downstream migrants the following year. Downstream migration also begins as the upstream run ends. Juvenile least cisco return to overwintering areas in adjacent coastal bays and the lower East Channel of the Mackenzie Delta. Many downstream migrants, in obvious mature spawning condition, most likely contribute to the fall spawning migrations in the Mackenzie Delta. A small concurrent upstream migration of mature lake-resident type cisco also occurs in August at Kukjuktuk Creek.

Least cisco are similar to lake whitefish with respect to the limited use of Kukjuktuk Creek by y-o-y and small juveniles up to age 3 years (< 200 mm fork length). Delta lakes and main channel areas in the lower Delta are prime nursery areas for y-o-y and yearling cisco although y-o-y do appear in coastal waters by mid-summer. These small fish then appear to dominate the upstream run of least cisco during August and September in some streams, such as Freshwater Creek, which are characterized by their close proximity to the Mackenzie Delta.

COASTAL DRAINAGES

Kukjuktuk Creek proved to be a suitable choice for a fish fence operation to determine the role of a southern Beaufort Sea freshwater system in the life history of coastal coregonids. Kukjuktuk Creek, which provides a stream corridor to habitats in the network of accessible headwater lakes and ponds, probably represents the general situation occurring in several other Tuktoyaktuk Peninsula drainages between Whitefish Bay in the west and McKinley Bay in the east.

The tagging data on the return migration between 1978 and 1979 show that migration fidelity to Kukjuktuk Creek varied: 10% for broad whitefish, 21% for lake whitefish and 11% for least cisco. The availability of adjacent drainages probably contributes to the low percentages and can be viewed as an important advantage by allowing the distribution of migratory members of each species over a wide area encompassing several watersheds. A coastal population will not be seriously compromised if migration opportunities become altered by natural events such as climatic variations or physical barriers brought on by coastal or watershed erosional processes.

The migration strategy of using distant habitats adds further advantages for a fish species. Access to the networks of lakes and ponds on Tuktoyaktuk Peninsula significantly increases the area of feeding habitats. While the network of Delta lakes may seem more accessible, the annual flooding in the numerous delta lakes by the turbid Mackenzie River spring freshet may render them less productive in comparison to the peninsula lakes because of low light penetration and siltation. Lakes in the tundra watersheds may therefore have an advantage with respect to primary production. However, investigations by Fee et al. (1988) found that differences in phytoplankton productivity were not significant during their study to support such a conclusion. The lack of additional mid-season flood events of the type experienced in the Delta may be a factor providing some advantage to tundra lakes. The relative stable conditions may support optimum foraging conditions over the short summer for the smallest planktivorous whitefish as well as the older, benthivorous whitefish. Competition with other coregonid species is minimized for the fry and small juvenile broad whitefish by their apparent greater ability to inhabit tundra lakes within their first year.

The presence of overwintering habitats in the deeper lakes of the Tuktoyaktuk Peninsula increases the probability for fish survival. Optimum growth may be realized for the early year classes of fish since no energy is expended in annual long distance migrations. These same lakes also appear to provide alternate overwintering areas for the older juveniles and sub-adults that do not return to coastal overwintering sites. Such partitioning of the population over several sites ensures better survival over the winter and a greater chance for population members to prevail should a catastrophic event occur in one area or along a narrow stream migration corridor.

The lack of predators in key habitats would ensure better survival for coregonid populations. Although tundra lakes do harbour predatory fish such as burbot and northern pike, it is thought that their population density may be considerably less than those in the Delta lakes and secondary channels where pike are most conspicuous. Taylor et al. (1982) believed that these two predators may be the major limiting factor to the production of small coregonids in Delta lakes. They estimated that pike consumed from 4 to 54 times more fish biomass than what actually escaped from Delta lakes into the main Delta channels at the end of the growing season.

While all these factors may contribute to the integrity and survival of coastal coregonid populations, the migration corridors linking habitats may make the coastal broad whitefish population extremely vulnerable with respect to impacts by industrial developments. The most sensitive link in the life history use patterns of fish in the Kukjuktuk drainage is the creek itself. Any blockage of a small, seemingly minor tundra streams as a result of a road or pipeline crossings may disrupt several life history stages of fish, as no alternate route is available for the migrations. The routing of such linear facilities along the peninsula to McKinley Bay, a possible scenario for regional hydrocarbon development, may compound the possible impacts since several drainages will have to be crossed. On a larger scale, the reduction or timing of the Mackenzie River discharge pattern as a result of a major or cumulative series of hydroelectric developments in the upper Mackenzie drainage may disrupt the timing and extent of the coastal freshwater migratory corridor. Access along the coastline would be limited, thereby reducing opportunities to use coastal drainages by the non-reproductive segments of broad whitefish, lake whitefish and least cisco populations.

We have no appreciation of the variations in the number of migrants or migration timing since our interpretations and conclusions were based on a small time window of only two years on Kukjuktuk Creek. The data on retention of fish in the system may be influenced greatly by a variety of events occurring in the headwater lakes. Variations in summer rainfall, run-off and resulting inter-lake creek flows may isolate fish in certain lakes and prevent an exit to the coast for that year. Mortality due to entrapment in shallow foraging lakes or in shallow creeks may be significant in certain years. Although there is a strong behavioural component in the migrations, such natural variations in the regional climatic and physical environment might have a major influence on migration into a particular watershed and the degree of fish interchange among several watersheds.

RECOMMENDATIONS

There is still a need to acquire additional knowledge on coastal fish populations and their habitats even though our current understanding of the habitat types located over a wide geographic area has been enhanced. Although subsequent studies at other coastal streams have reaffirmed our conclusions on migrations and coastal watersheds, there are still many aspects of coastal fish populations that have not been addressed. Lawrence et al. (1984) provided a series of recommendations for further research to address the variety of data gaps on fish species, populations and habitat use in other areas of the southern Beaufort Sea. The underlying aim was to collect information on a large scale to address industrial development projects affecting many habitats and many drainages.

On a smaller scale, it would be more prudent to direct any further research towards the entire Kukjuktuk drainage and to approach it as a representative coastal system in a long term scientific study. Aspects such as fish utilization patterns in its lakes, winter survival plus natural variations in climate, streamflow, fish migration and population structure are unknown. The annual fall migrations of coregonids, especially the broad whitefish, are historically harvested by a succession of subsistence fishermen from Tuktoyaktuk to Fort Good Hope. With the current downtrend on hydrocarbon exploration and development, the emphasis on data needed to facilitate assessment of industrial development impacts has shifted towards data needed to address aspects of subsistence harvests and a potential commercial fishery.

Any research effort in this Southern Beaufort region must incorporate both a harvest and a fish status component. There is a need to document accurately the annual coastal and Delta subsistence harvests in terms of effort and comprehensive catch data on species taken, maturity, age and length composition. The fish status component should be a concurrent program aimed at monitoring the migrant populations at Kukjuktuk Creek and at least one other coastal stream. Ongoing and long term information on the status of the coastal fish in relation to environmental influences and fish harvests will contribute to the formulation of fish management strategies in the region.

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Table 1. List of fish species captured at Kukjuktuk Creek in 1978 and 1979.

Family and scientific name	Common name	Code
Salmonidae		
Coregonus clupeaformis (Mitchill)	Lake whitefish	LKWT
Coregonus nasus (Pallas)	Broad whitefish	BDWT
Coregonus sardinella Valenciennes	Least cisco	LSCS
Salvelinus alpinus (Linnaeus)	Arctic char	CHAR
Osmeridae		
Hypomesus olidus (Pallas)	Pond smelt	PDSM
Osmerus mordax dentex	Rainbow smelt	RNSM
Esocidae		
Esox lucius Linnaeus	Northern pike	NRPK
Cottidae		
Myoxocephalus quadricornis (Linnaeus)	Fourhorn sculpin	FHSC
Gasterosteidae		
Pungitius pungitius (Linnaeus)	Ninespine stickleback	NSSB
Pleuronectidae		
Platichthys stellatus (Pallas)	Starry flounder	STFL

Table 2. Total number of each fish species counted at the Kukjuktuk Creek counting fence in 1978 and 1979.

Species	Number of Fish			
	1978		1979	
	Upstream Trap	Downstream Trap	Upstream Trap	Downstream Trap
Broad whitefish	65 209	23 291	1 097 481	85 503
Lake whitefish	7 070	3 476	6 575	9 393
Least cisco	14 102	6 951	14 037	17 164
Starry flounder	1	2	3	0
Northern pike	0	0	0	1
Arctic char	0	0	1	0
Ninespine stickleback	0	0	0	a
Pond smelt	0	0	0	a
Rainbow smelt	1	0	0	0
Fourhorn sculpin	1	0	0	0
TOTAL	86 384	33 720	1 118 097	112 061

[a] no accurate count - too small for capture in traps

Table 3. Total numbers of broad whitefish, lake whitefish and least cisco tagged and released at the Kukjuktuk Creek upstream and downstream trap in 1978 and 1979.

	Long Yellow Tags				Short Yellow Tags				Long Green Tags				Long Orange Tags				Light Blue Tags				Total				Total	
	1978		1979		1978		1979		1978		1979		1978		1979		1978		1979		1978		1979			
	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D	U	D
Broad whitefish	209	0	426	0	1636	0	1700	0	0	821	0	167	0	61	295	0	0	0	0	0	1845	882	2422	167	4267	1049
Lake whitefish	14	0	264	1	354	3	389	0	0	42	0	23	0	0	178	0	19	0	0	0	387	45	831	24	1218	69
Least cisco	335	0	3	0	732	0	197	0	0	136	557	10	0	7	199	0	0	0	0	0	1067	143	956	10	2023	153
Total	558	0	693	1	2722	3	2286	0	0	999	558	200	0	68	672	0	19	0	0	0	3299	1070	4209	201	7508	1271

U = Upstream trap; D = Downstream trap.

Table 4. Mean fork length and mean condition factor (K) by sex for each age group of all broad whitefish sampled from the upstream and downstream run at Kukjuktuk Creek in 1978.

Scale Age (yr)	Males					Females					Sex Unknown				Combined				
	N	Mean[a]	S.D.	Range	K	N	Mean	S.D.	Range	K	N	Mean	S.D.	Range	N	Mean	S.D.	Range	t-test
0+											22	77	10.8	61- 92	22	77	10.8	61- 92	
1	5	144	29.8	93-172	0.91	10	173	26.1	133-217	1.07	86	130	29.3	81-243	101	135	31.7	81-243	1.940
2	8	217	32.5	173-276	1.18	14	209	34.6	161-283	1.07	40	233	32.4	151-236	62	232	35.9	151-236	0.535
3	12	260	50.1	162-328	1.24	14	252	21.1	215-237	1.12	159	284	25.8	213-378	185	280	29.2	162-378	0.545
4	16	304	27.0	245-344	1.18	12	282	29.3	232-321	1.14	134	309	28.6	194-376	162	307	29.3	194-376	2.058
5	13	339	20.5	300-380	1.22	19	334	19.2	282-372	1.17	203	340	25.1	268-418	235	340	24.4	268-418	0.704
6	36	354	19.2	302-402	1.21	28	356	23.7	307-409	1.26	395	363	27.4	247-445	459	362	26.8	247-445	0.373
7	22	374	33.5	332-474	1.27	32	376	22.4	340-443	1.28	585	378	24.1	271-506	639	378	24.4	271-506	0.263
8	25	396	25.1	316-442	1.33	17	392	21.9	357-440	1.30	272	392	26.3	283-475	314	393	26.0	283-475	0.533
9	8	420	21.7	398-461	1.36	7	413	28.5	371-445	1.38	63	412	31.1	337-490	78	413	30.0	337-490	0.540
10	5	445	34.8	395-484	1.47	1	417		417	1.48	24	408	35.4	346-473	30	414	36.9	346-484	
11	2	422	55.9	382-461	1.36	2	419	36.8	393-445	1.21	8	465	35.7	412-509	12	450	41.3	382-509	0.063
12						1	474		474	1.34	4	375	20.3	351-393	5	395	47.5	351-474	
13											4	410	40.3	376-468	4	409	40.3	376-468	
15											2	513	55.9	473-552	2	512	55.9	473-552	
Total	152	343	70.8	93-484		157	326	75.8	133-474		2001	347	71.1	61-552	2310	345	71.5	61-552	

[a]Fork length (mm).

Table 5. Length-frequency distribution by age group for all broad whitefish sampled from the upstream and downstream run at Kukjuktuk Creek in 1978.

Fork Length (mm)	Scale Age (yr)															Total
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	15	
51-75	11															11
76-100	11	14														25
101-125	1	40														41
126-150		53														53
151-175		35	9	1												45
176-200		6	10	1												17
201-225		8	32	8												48
226-250		4	15	18	7		1									45
251-275			18	54	19	1	3	1								96
276-300			7	69	37	8	8		1							130
301-325				40	65	59	20	9	1							194
326-350				3	30	91	106	46	12	1	1					290
351-375				1	6	59	185	270	70	6	4		2			603
376-400				1	2	18	119	232	118	24	6	2	2	3		527
401-425						1	12	76	90	24	9	2				214
426-450							4	10	19	16	3	1				53
451-475								4	7	5	6	5	1	1	1	30
476-500								2		4	1					7
501-525								1				2				3
526-550																0
551-575															1	1
Total	23	160	91	196	166	237	458	651	318	80	30	12	5	4	2	2433

Note: Some additional ages from live sample or tagged fish data are included.

Table 6. Mean fork length and mean condition factor (K) by sex for each age group of all broad whitefish sampled from the upstream and downstream run at Kukjuktuk Creek in 1979.

Scale Age (yr)	Males					Females					Sex Unknown				Combined					t-test
	N	Mean[a]	S.D.	Range	K	N	Mean	S.D.	Range	K	N	Mean	S.D.	Range	N	Mean	S.D.	Range	K	
0+											15	68	10.3	50- 84	15	68	10.3	50- 84		
1	2	149	38.2	122-176	1.00						235	107	17.8	78-183	237	108	18.3	78-183	1.16	
2	11	214	42.5	154-259	1.16	4	179	64.5	130-274	0.78					15	205	49.4	130-274	1.06	1.237
3	13	275	15.5	246-297	1.27	6	279	23.8	241-300	1.22					19	276	17.9	241-300	1.24	0.376
4	24	298	22.5	262-334	1.24	7	293	19.2	275-320	1.24					31	297	21.5	262-334	1.24	0.537
5	28	326	23.9	281-365	1.23	6	319	13.2	300-335	1.27					34	325	22.4	281-365	1.24	0.630
6	31	357	28.5	283-430	1.28	10	366	22.0	330-393	1.35					41	359	27.1	283-430	1.29	0.983
7	27	380	19.7	347-435	1.32	18	374	25.6	312-403	1.36					45	377	22.2	312-435	1.34	0.961
8	30	398	26.9	355-472	1.36	14	412	33.2	369-468	1.41	2	415	7.8	409-420	46	403	23.9	355-472	1.38	1.502
9	17	423	29.5	366-460	1.41	18	434	21.0	401-463	1.44					35	429	25.7	366-463	1.43	1.219
10	3	435	10.8	423-443	1.35	12	447	33.9	376-504	1.45					15	444	30.7	376-504	1.43	0.561
11	2	471	29.7	450-492	1.51	2	512	4.9	508-515	1.36					4	491	29.1	450-515	1.43	1.903
12	1	535		535	1.42	2	456	62.9	411-500	1.39					3	482	63.9	411-535	1.40	
Total	139	348	66.4	122-535		99	330	74.2	130-515		252	110	33.3	78-420	540	246	136.5	50-535		

[a]Fork length (mm).

Table 7. Length-frequency distribution by age group for all broad whitefish sampled from the upstream and downstream run at Kukjuktuk Creek in 1979.

Fork Length (mm)	Scale Age (yr)														Total
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
26-50	8														8
51-75	7														7
76-100		102													102
101-125		102													102
126-150		28	1												29
151-175		3	5												8
176-200		2	2												4
201-225			5	1	2										8
226-250			3	8	13	13	1								38
251-275				10	22	24	1	1							58
276-300				1	16	34	26								77
301-325					7	25	31	2						1	66
326-350						6	10	14							30
351-375					1		16	41	10	2					70
376-400							4	36	53	12	2				107
401-425								5	22	18	11		1		57
426-450							1	1	7	12	9	2			32
451-475									4	9	4				17
476-500											1	1	1		3
501-525											1	2			3
526-550													1		1
Total	15	237	16	20	61	102	90	100	96	53	28	5	3	1	827

Note: Some additional ages from live sample or tagged fish data are included.

Table 8. Age specific sex ratio and maturity for broad whitefish sampled at Kukjuktuk Creek in 1978 and 1979.

Scale Age (yr)	Female N	Female %	Female % Mature	Male N	Male %	Male % Mature	F/M Ratio	Sexed Fish N	Sexed Fish (%)	Unsexed Fish N	Total N	Total (%)
1978 Fish												
0	0	-	-	0	-	-	-	0		22	22	(5.0)
1	10	67	0	5	33	0	2.0	15	(4.8)	83	98	(22.3)
2	14	64	0	8	36	0	1.8	22	(7.1)	11	33	(7.5)
3	14	54	0	12	46	0	1.2	26	(8.4)	5	31	(7.0)
4	12	43	0	16	57	0	0.8	28	(9.1)	6	34	(7.7)
5	19	59	0	13	41	0	1.5	32	(10.4)	0	32	(7.3)
6	28	44	0	36	56	0	0.8	64	(20.7)	2	66	(15.0)
7	32	59	3	22	41	0	1.5	54	(17.5)	0	54	(12.3)
8	17	40	0	25	60	0	0.7	42	(13.6)	2	44	(10.0)
9	7	47	0	8	53	0	0.9	15	(4.9)	0	15	(3.4)
10	1	17	0	5	83	0	0.2	6	(1.9)	0	6	(1.4)
11	2	50	0	2	50	0	1.0	4	(1.3)	0	4	(0.9)
12	1	100	100	0	0	0	-	1	(0.3)	0	1	(0.2)
Total	157	51	1	152	49	0	1.0	309	(100)	131	440	(100)
1979 Fish												
0	0	-	-	0	-	-	-	0		15	15	(2.8)
1	0	-	-	2	100	0	0	2	(0.7)	235	237	(43.6)
2	4	27	0	11	73	0	0.4	15	(5.2)	0	15	(2.8)
3	6	32	0	13	68	0	0.5	19	(6.6)	1	20	(3.7)
4	7	23	0	24	77	0	0.3	31	(10.8)	0	31	(5.7)
5	6	18	0	28	82	0	0.2	34	(11.8)	0	34	(6.3)
6	10	24	0	31	76	0	0.3	41	(14.2)	0	41	(7.5)
7	18	40	6	27	60	11	0.7	45	(15.6)	1	46	(8.5)
8	14	32	7	30	67	7	0.5	44	(15.3)	2	46	(8.5)
9	18	51	6	17	49	12	1.1	35	(12.2)	0	35	(6.5)
10	12	80	8	3	20	33	4.0	15	(5.2)	0	15	(2.8)
11	2	50	50	2	50	0	1.0	4	(1.4)	0	4	(0.7)
12	2	66	100	1	34	100	2.0	3	(1.0)	0	3	(0.6)
Total	99	34	7	189	66	5	0.5	288	(100)	254	542	(100)

Table 9. Age specific sex ratio and maturity for broad whitefish taken in the lower Mackenzie Delta (June- August 1980) and from a winter sample (November 1980) in the Delta, Peel River and Arctic Red River.

Scale Age (yr)	Female			Male			F/M Ratio	Total	
	N	%	% Mature	N	%	% Mature		N	%
June - August 1980 Fish									
0	0	-	-	0	-	-	-	0	
1	0	-	-	0	-	-	-	0	
2	0	-	-	0	-	-	-	0	
3	1	50	0	1	50	0	1.0	2	(0.4)
4	0	-	-	0	-	-	-	0	
5	1	100	0	0	0	0	0	1	(0.2)
6	0	0	0	2	100	0	-	2	(0.4)
7	7	54	71	6	46	33	1.2	13	(2.3)
8	7	35	71	13	65	23	0.5	20	(3.5)
9	40	41	57	58	59	40	0.7	98	(17.4)
10	75	39	71	116	61	56	0.6	191	(33.9)
11	43	42	79	60	58	67	0.7	103	(18.3)
12	33	46	82	38	54	82	0.9	71	(12.6)
13	21	53	91	19	47	63	1.1	40	(7.0)
14	11	65	91	6	35	100	1.8	17	(3.0)
15	1	20	100	4	80	50	0.3	5	(0.8)
16	0	-	-	0	-	-	-	0	
17	0	0	0	1	100	100	-	1	(0.2)
Total	240	43	75	324	57	57	0.7	564	(100)
November 1980 Fish									
0	0	-	-	0	-	-	-	0	
1	0	-	-	0	-	-	-	0	
2	0	-	-	0	-	-	-	0	
3	0	-	-	0	-	-	-	0	
4	0	-	-	0	-	-	-	0	
5	0	-	-	0	-	-	-	0	
6	0	-	-	0	-	-	-	0	
7	0	0	0	1	100	100	-	1	(2.0)
8	2	40	100	3	60	67	0.7	5	(10.2)
9	10	53	90	9	47	89	1.1	19	(38.8)
10	2	29	100	5	71	100	0.4	7	(14.3)
11	7	87	100	1	13	100	7.0	8	(16.3)
12	5	100	100	0	0	0	-	5	(10.2)
13	3	100	100	0	0	0	-	3	(6.2)
14	1	100	100	0	0	0	-	1	(2.0)
Total	30	61	97	15	34	80	1.6	49	(100)

Data from Chang-Kue and Jessop (1992)

Table 10. Length-weight relationships for broad whitefish from Kukjuktuk Creek in 1978 and 1979.

Group		N	Length Range (mm)	Y-Intercept (a)	Slope (b)	SD_b	Analysis of Covariance							
							Intercept				Slope			
							M vs F	M vs M	F vs F	All vs All	M vs F	M vs M	F vs F	All vs All
1978														
Upstream	M[a]	100	93 - 442	-5.754	3.328	0.109		▲O						
	F	108	161 - 445	-5.569	3.256	0.086			▲O					
	All	347	61 - 490	-5.457	3.212	0.027				▲O				
Downstream	M	53	153 - 484	-5.550	3.268	0.112	▲							
	F	49	133 - 474	-5.811	3.364	0.123								
	All	144	87 - 484	-5.509	3.249	0.050								
Upstream + Downstream	All	491	61 - 490	-5.480	3.226	0.026								
1979														
Upstream	M	201	117 - 440	-5.215	3.125	0.077		▲O				▲O		
	F	76	108 - 411	-5.387	3.195	0.098							▲O	
	All	1083	57 - 444	-5.384	3.192	0.029								▲O
Downstream	M	121	154 - 557	-5.509	3.250	0.075					▲			
	F	98	129 - 515	-5.813	3.369	0.108								
	All	296	59 - 557	-5.773	3.354	0.049								
Upstream + Downstream	All	1379	57 - 557	-5.461	3.226	0.025								

[a]M = Male; F = Female; All = Male + Female + Unsexed fish.
▲Significant difference at 5% level.
OSignificant difference at 1% level.

Table 11. Dates of tagging and recapture, location of recapture, and elapsed time between release and recapture for fish tagged at the mouth of Kukjuktuk Creek in 1979.

			Recapture Data			
			at Upstream Trap		at Downstream Trap	
Species	Tag Number	Tagging Date at Creek Mouth[a]	Date	Elapsed time (days)	Date	Elapsed time (days)
Broad whitefish	LB 01597	21 June/79	12 July/79	21	3 Aug./79	22
	LB 01603	21 June/79	2 July/79	11	24 July/79	22
	LB 01618	21 June/79	30 June/79	9	21 July/79	21
	LB 01621	21 June/79	1 July/79	10	11 Aug./79	41
	LB 01625	21 June/79	1 July/79	10	1 Aug./79	31
	LB 01631	21 June/79	7 July/79	16	11 Aug./79	35
	LB 01647	21 June/79	1 July/79	10	30 July/79	29
	LB 01652	21 June/79	27 June/79	6	25 July/79	28
	LB 01707	26 June/79	4 July/79	8	9 Aug./79	36
	LB 01708	26 June/79	3 July/79	7	25 July/79	22
	LB 01710	26 June/79	2 July/79	6	2 Aug./79	31
	LB 01711	26 June/79	1 July/79	5	25 July/79	24
	LB 01724	26 June/79	2 July/79	6	23 July/79	21
	LB 01796	8 July/79	13 July/79	5	11 Aug./79	29
	LB 01800	9 July/79	16 July/79	7	24 Sept./79	70
	LB 01628	21 June/79	12 July/79	21		
	LB 01643	21 June/79	12 July/79	21		
	LB 01661	23 June/79	30 June/79	7		
	LB 01669	24 June/79	1 July/79	7		
	LB 01679	24 June/79	30 June/79	6		
	LB 01688	24 June/79	2 July/79	8		
	LB 01696	24 June/79	1 July/79	7		
	LB 01700	26 June/79	4 July/79	8		
	LB 01705	26 June/79	5 July/79	9		
	LB 01718	26 June/79	1 July/79	5		
	LB 01719	26 June/79	1 July/79	5		
	LB 01720	26 June/79	4 July/79	8		
	LB 01726	26 June/79	4 July/79	8		
	LB 01753	1 July/79	12 July/79	11		
	LB 01757	1 July/79	5 July/79	4		
	LB 01758	1 July/79	4 July/79	3		
	LB 01771	6 July/79	8 July/79	2		
	LB 01776	7 July/79	14 July/79	7		
	LB 01648	21 June/79			1 Aug./79	41
	LB 01664	23 June/79			4 Aug./79	42
	LB 01699	26 June.79			24 July/79	28
	LB 01704	26 June/79			22 July/79	26
	LB 01712	26 June/79			10 Aug./79	45
	LB 01727	26 June/79			28 July/79	32
	LB 01794	8 July/79			12 Aug./79	35
Lake whitefish	LB 01730	1 July/79			3 Aug./79	33
	LB 01797	8 July/79	13 July/79	5		
Least cisco	LB 01624	21 June/79	25 June/79	4		
	LB 01626	21 June/79	10 July/79	19		
	LB 01668	25 June/79	1 July/79	6		

[a]B. Fallis, personal communication.

Table 12. Dates of tagging and recapture, location of recapture, and elapsed time between release and recapture for fish tagged at the counting fence and recaptured in the headwaters of Kukjuktuk Creek.

	Tagging Data			Recapture Data[b]					
				First Recapture			Second Recapture		
Species	Tag Number	Location[a]	Date	Location	Date	Elapsed time (days)	Location	Date	Elapsed time (days)
Broad whitefish	LY 42446	UT	30 July/78	UT	2 July/79	337	LAKE10	3 Aug./79	31
	LY 43535	UT	13 Aug./78	LAKE10	3 Aug./79	355			
	LY 43870	UT	18 June/79	KL092	29 June/79	11	DT	27 July/79	28
	LY 44264	UT	19 June/79	KL091	30 June/79	11	DT	22 July/79	22
	LY 44445	UT	19 June/79	KL090	1 July/79	12	DT	11 Aug./79	41
	SY 00778	UT	2 July/78	LAKE11	29 June/79	362			
	SY 01378	UT	8 July/78	LAKE10	3 Aug./79	391			
	SY 01934	UT	14 July/78	UT	24 June/79	345	LAKE12	1 July/79	7
	SY 03447	UT	20 June/79	KL092	29 June/79	9	DT	21 July/79	22
	SY 03465	UT	20 June/79	KL092	29 June/79	9	DT	21 July/79	22
	SY 03470	UT	29 June/79	KL092	29 June/79	9	DT	1 Aug./79	33
	SY 03546	UT	21 June/79	LAKE11	29 June/79	8			
	SY 03771	UT	21 June/79	KL091	30 June/79	9			
	SY 03774	UT	21 June/79	LAKE10	29 June/79	8			
	SY 03804	UT	21 June/79	LAKE11	29 June/79	8			
	SY 04058	UT	23 June/79	KL092	29 June/79	6	DT	12 Aug./79	44
	SY 04224	UT	24 June/79	LAKE10	29 June/79	5			
	SY 04474	UT	25 June/79	LAKE12	1 July/79	6			
	SY 05420	UT	3 July/79	LAKE10	3 Aug./79	30			
Lake whitefish	LY 44233	UT	18 June/79	LAKE12	10 July/79	22			
	SY 04652	UT	26 June/79	LAKE12	10 July/79	14			
Least cisco	LG 07619	UT	23 Aug./79	LAKE18	17 Sept./79	25			
	LG 07725	UT	24 Aug./79	LAKE18	17 Sept/79	24			
	LY 44347	UT	19 June/79	KL092	29 June/79	10			
	LY 44500	UT	19 June/79	LAKE10	29 June/79	10			

[a]UT = upstream trap; DT = downstream trap; KL = location in Kukjuktuk drainage (see Fig.2)

[b] = Headwater lake and creek recapture data from Mr. B. Fallis, personal communication.

Table 13. Time spent in Kukjuktuk Creek headwaters in one season by broad whitefish, lake whitefish and least cisco tagged at Kukjuktuk Creek in 1978 and 1979.

Time Interval (days)	Broad Whitefish				Lake Whitefish				Least Cisco			
	[a]U('78)-D('78)		U('79)-D('79)		U('78)-D('78)		U('79)-D('79)		U('73)-D('78)		U('79)-D('79)	
	N	%	N	%	N	%	N	%	N	%	N	%
0 - 5	16	8.6	2	0.1	2	2.9	0	0	17	11.7	46	16.3
6 - 10	5	2.7	2	0.1	0	0	3	0.6	27	18.6	43	15.2
11 - 15	3	1.6	7	0.4	4	5.7	3	0.6	15	10.3	16	5.7
16 - 20	5	2.7	52	3.1	1	1.4	11	2.2	9	6.2	20	7.1
21 - 25	4	2.2	168	9.9	0	0	15	3.0	6	4.1	22	7.8
26 - 30	14	7.5	364	21.5	2	2.9	50	9.9	13	9.0	50	17.8
31 - 35	10	5.4	539	31.8	3	4.3	124	24.6	24	16.6	26	9.2
36 - 40	27	14.5	226	13.3	12	17.1	98	19.4	18	12.4	10	3.5
41 - 45	38	20.5	124	7.3	14	20.0	67	13.3	11	7.6	6	2.1
46 - 50	43	23.1	95	5.6	18	25.6	41	8.1	3	2.1	4	1.4
51 - 55	17	9.1	46	2.7	6	8.6	32	6.3	2	1.4	2	0.7
56 - 60	1	0.5	13	0.8	6	8.6	8	1.6			5	1.8
61 - 65	2	1.1	8	0.5	2	2.9	3	0.6			4	1.4
66 - 70	0	0	15	0.9			6	1.2			7	2.5
71 - 75	1	0.5	1	0.1			9	1.8			9	3.2
76 - 80			10	0.5			10	2.0			2	0.7
81 - 85			6	0.4			7	1.4			3	1.1
86 - 90			12	0.7			10	2.0			6	2.1
91 - 95			3	0.2			6	1.2			1	0.4
96 - 100			1	0.1			1	0.2				
Total	186	100	1694	100	70	100	504	100	145	100	282	100

[a]U = Upstream trap; D = Downstream trap; U('78)-D('78) = Released at upstream trap in 1978 and later recaptured the same year at downstream trap.

Table 14. Time interval between 1978 release date and 1979 recapture date for broad whitefish, lake whitefish and least cisco tagged at Kukjuktuk Creek in 1978.

Time Interval	UP (1973) - DN (1979)[a]						Time Interval	DN (1978)- UP (1979)					
(days)	BDWT		LKWT		LSCS		(days)	BDWT		LKWT		LSCS	
	N	%	N	%	N	%		N	%	N	%	N	%
316 - 320					2	3.9	281 - 285	1	1.1				
321 - 325					1	2.0	286 - 290	0	0				
326 - 330					0	0	291 - 295	5	5.7			1	6.3
331 - 335					0	0	296 - 300	3	3.4	1	20.0	1	6.3
336 - 340	1	0.5			1	2.0	301 - 305	9	10.2	1	20.0	1	6.3
341 - 345	0	0			0	0	306 - 310	8	9.1	0	0	2	12.4
346 - 350	1	0.5			1	2.0	311 - 315	0	0	0	0	0	
351 - 355	1	0.5			3	5.9	316 - 320	6	6.8	0	0	4	25.0
356 - 360	1	0.5			4	7.8	321 - 325	11	12.5	2	40.0	0	
361 - 365	6	3.0	2	5.0	0	0	326 - 330	16	18.2	0	0	3	18.7
366 - 370	6	3.0	0	0	4	7.8	331 - 335	8	9.1	0	0	0	
371 - 375	8	4.0	2	5.0	4	7.8	336 - 340	7	8.0	0	0	2	12.4
376 - 380	26	13.1	3	7.5	5	9.8	341 - 345	5	5.7	0	0	0	
381 - 385	42	21.2	10	25.0	3	5.9	346 - 350	3	3.4	1	20.0	1	6.3
386 - 390	47	23.7	6	15.0	7	13.6	351 - 355	5	5.7			0	
391 - 395	18	9.2	8	20.0	5	9.8	356 - 360	1	1.1			1	6.3
396 - 400	18	9.2	6	15.0	3	5.9							
401 - 405	10	5.1	2	5.0	0	0							
406 - 410	8	4.0	0	0	2	3.9							
411 - 415	3	1.5	1	2.5	1	2.0							
416 - 420	0	0			1	2.0							
421 - 425	2	1.0			0	0							
426 - 430					2	3.9							
431 - 435					1	2.0							
436 - 440					1	2.0							
Total	198	100	40	100	51	100		88	100	5	100	16	100

[a]UP = Upstream trap; DN = Downstream trap; UP (1978) - DN (1979) = released at upstream trap in 1978 and only recaptured the next year at downstream trap.

Table 15. Time spent in coastal waters or in creek below counting fence by broad whitefish, lake whitefish and least cisco tagged and recaptured within the same year at Kukjuktuk Creek in 1978 and 1979.

Time Interval (year)	DN (1978) - UP (1978)[a]						DN (1979) - UP (1979)					
	BDWT		LKWT		LSCS		BDWT		LKWT		LSCS	
	N	%	N	%	N	%	N	%	N	%	N	%
0 - 5	1	33.3			1	9.0						
6 - 10	1	33.3			2	18.2	1	100	2	50		
11 - 15	1	33.3			2	18.2			2	50		
16 - 20					0	0						
21 - 25					2	18.2						
26 - 30					2	18.2						
31 - 35					2	18.2						
36 - 40												
41 - 45												
46 - 50											1	50
51 - 55												
56 - 60												
Total	3	100	0	0	11	100	1	100	4	100	1	100

[a]UP = Upstream trap; DN = Downstream trap; DN (1978) - UP (1978) = released at downstream in 1978 and recaptured the same year at upstream trap.

Table 16. Mean fork length and mean condition factor (K) by sex for each age group of all lake whitefish sampled from the upstream and downstream run at Kukjuktuk Creek in 1978.

Scale Age (yr)	Males					Females					Sex Unknown				Combined				
	N	Mean[a]	S.D.	Range	K	N	Mean	S.D.	Range	K	N	Mean	S.D.	Range	N	Mean	S.D.	Range	t-test
0+																			
1																			
2											1	153		153	1	153		153	
3						1	187		187	1.04					1	187		187	
4											1	165		165	1	165		165	
5	1	200		200	0.96	1	207		207	1.16	3	283	58.0	248-350	5	251	59.9	200-350	
6	2	257	17.0	245-269	1.07						3	222	17.9	212-243	5	236	24.4	212-269	
7	4	265	46.1	228-330	1.22	1	231		231	1.05	4	348	45.8	298-398	9	298	62.6	228-398	
8	5	354	48.5	314-415	1.20	1	321		321	1.15	5	316	42.0	251-367	11	334	45.2	251-415	
9	13	327	25.1	292-365	1.14	9	339	35.6	275-385	1.21	20	341	34.6	252-391	42	336	32.1	252-391	0.930
10	16	350	26.9	309-392	1.21	22	345	30.8	292-395	1.22	72	366	26.5	303-432	110	360	28.7	292-432	0.520
11	15	361	32.4	310-422	1.29	23	369	27.9	310-427	1.31	80	377	26.9	316-432	118	373	28.1	310-432	0.811
12	17	391	26.2	341-429	1.27	20	389	27.1	330-431	1.30	80	389	19.0	341-441	117	390	21.5	330-441	0.227
13	6	393	22.7	362-420	1.28	10	400	21.9	372-447	1.26	44	392	20.9	341-435	60	399	21.1	341-447	0.611
14	6	402	23.6	375-438	1.34	6	395	34.1	344-430	1.25	23	399	25.7	329-450	35	399	26.2	329-450	0.413
15											6	397	19.2	374-428	6	397	19.2	374-428	
Total	85	356	48.4	200-438		94	365	45.5	187-447		342	375	38.2	153-450	521	370	41.9	153-450	

[a]Fork length (mm).

Table 17. Length-frequency distribution by age group for all lake whitefish sampled from the upstream and downstream run at Kukjuktuk Creek in 1978.

Fork Length (mm)	Scale Age (yr)																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
151-175			1		1												2
176-200				1		1											2
201-225						1	2										3
226-250						1	2	3		1							7
251-275						1	1	1	1	2							6
276-300								1		3	2						6
301-325								1	6	12	13	6					38
326-350						1		1	1	9	27	24	4	1	2		70
351-375								2	1	12	32	32	26	14	3	1	123
376-400									1	4	31	39	51	21	14	3	164
401-425									1		3	17	33	21	11	1	87
426-450											2	2	4	3	5	1	17
Total	0	0	1	1	1	5	5	9	11	43	110	120	118	60	35	6	525

Note: Some additional ages from live sample or tagged fish data are included.

Table 18. Mean fork length and mean condition factor (K) by sex for each age group of all lake whitefish sampled from the upstream and downstream run at Kukjuktuk Creek in 1979.

Scale Age (yr)	Males					Females					Sex Unknown				Combined					t-test
	N	Mean[a]	S.D.	Range	K	N	Mean	S.D.	Range	K	N	Mean	S.D.	Range	N	Mean	S.D.	Range	K	
0+																				
1	2	119	3.5	116-121	0.78	1	116		116	0.77	31	114	11.3	92-144	34	114	10.8	92-144	0.83	
2	14	160	19.9	118-195	0.98	6	155	20.0	129-183	0.98	3	153	21.0	132-174	23	158	19.4	118-195	1.01	0.514
3	4	183	5.5	175-187	1.03	3	171	36.8	147-213	0.76	1	180		180	8	178	20.9	147-213	0.96	0.664
4	4	228	21.6	205-257	1.14	5	241	19.1	220-272	1.20	1	233		233	10	235	19.0	205-272	1.18	0.959
5	6	264	14.7	249-288	1.22	2	246	8.5	240-252	1.07					8	260	15.3	240-288	1.18	1.591
6	3	279	41.9	241-324	1.22	5	291	21.0	269-316	1.24					8	287	28.1	241-324	1.23	0.554
7	17	313	22.3	275-352	1.26	8	307	28.4	263-346	1.22	1	311		311	26	311	23.5	263-352	1.25	0.575
8	12	356	38.8	298-441	1.25	6	356	20.1	320-375	1.29					18	356	33.1	298-441	1.27	0
9	20	342	35.1	268-416	1.30	13	366	24.5	324-395	1.30					33	352	33.2	268-416	1.30	2.140[b]
10	14	377	16.3	353-405	1.35	18	385	23.0	315-408	1.37	2	312		312	34	377	25.8	312-408	1.35	1.102
11	10	394	15.9	371-428	1.36	11	401	23.4	350-433	1.43	1	450		450	22	400	22.5	350-450	1.40	0.793
12	12	424	17.9	393-444	1.33	11	424	27.4	353-451	1.37	1	440		440	24	424	22.1	353-451	1.35	0
13	9	419	26.4	376-461	1.36	10	423	14.7	395-444	1.36	1	458		458	20	423	21.6	376-461	1.37	0.414
14	1	422		422	1.34	1	432		432	1.29					2	427	7.1	422-432	1.32	
Total	128	324	88.6	116-461		100	347	84.9	116-451		42	159	98.4	92-458	270	307	109.5	92-461		

[a]Fork length (mm).

[b]Significant difference between means for males and females ($P < 0.05$).

Table 19. Length-frequency distribution by age group for all lake whitefish sampled from the upstream and downstream run at Kukjuktuk Creek in 1979.

Fork Length (mm)	Scale Age (yr)															Total
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
76-100		1														1
101-125		29	1													30
126-150		4	7	1												12
151-175			11	2												13
176-200			4	4												8
201-225				1	3											4
226-250					5	2	1									8
251-275					3	6	5	2		1						17
276-300					1	1	10	15	3	1						31
301-325						1	9	17	14	9	7					57
326-350								12	14	21	6	2				55
351-375								1	8	15	18	5	3	1		51
376-400								2	3	13	29	18	7	5	1	78
401-425										2	5	10	12	11	1	41
426-450									1			6	15	7	1	30
451-475													1	3		4
Total	0	34	23	8	12	10	25	49	43	62	65	41	38	27	3	440

Note: Some additional ages from live sample or tagged fish data are included.

Table 20. Age specific sex ratio and maturity for lake whitefish sampled at Kukjuktuk Creek in 1978 and 1979.

Scale Age (yr)	Female N	Female %	Female % Mature	Male N	Male %	Male % Mature	F/M Ratio	Sexed Fish N	Sexed Fish (%)	Unsexed Fish N	Total N	Total (%)
1978 Fish												
0	0	-	-	0	-	-	-	0		0	0	
1	0	-	-	0	-	-	-	0		0	0	
2	0	-	-	0	-	-	-	0		1	1	(0.5)
3	1	100	0	0	0	0	-	1	(0.6)	0	1	(0.5)
4	0	-	-	0	-	-	-	0		1	1	(0.5)
5	1	50	0	1	50	0	1.0	2	(1.1)	0	2	(1.1)
6	0	0	0	2	100	0	0	2	(1.1)	3	5	(2.7)
7	1	20	0	4	80	0	0.3	5	(2.8)	0	5	(2.7)
8	1	17	0	5	83	0	0.2	6	(3.4)	0	6	(3.2)
9	9	41	0	13	59	0	0.7	22	(12.3)	0	22	(11.8)
10	22	58	0	16	42	0	1.4	38	(21.2)	2	40	(21.4)
11	23	61	0	15	39	0	1.5	38	(21.2)	0	38	(20.3)
12	20	54	5	17	46	0	1.2	37	(20.7)	1	38	(20.3)
13	10	63	0	6	37	0	1.7	16	(8.9)	0	16	(8.6)
14	6	50	0	6	50	0	1.0	12	(6.7)	0	12	(6.4)
Total	94	53	1	85	47	0	1.1	179	(100)	8	187	(100)
1979 Fish												
0	0	-	-	0	-	-	-	0		0	0	
1	1	33	0	2	67	0	0.5	3	(1.3)	31	34	(12.5)
2	5	26	0	14	74	0	0.4	19	(8.4)	4	23	(8.5)
3	3	43	0	4	57	0	0.8	7	(3.1)	1	8	(3.0)
4	5	56	0	4	44	0	1.3	9	(4.0)	1	10	(3.7)
5	2	25	0	6	75	0	0.3	8	(3.5)	0	8	(3.0)
6	5	63	0	3	37	0	1.7	8	(3.5)	1	9	(3.3)
7	8	32	13	17	68	0	0.5	25	(11.0)	1	26	(9.6)
8	6	33	0	12	67	8	0.5	18	(7.9)	0	18	(6.6)
9	13	39	8	20	61	0	0.7	33	(14.5)	0	33	(12.2)
10	18	56	28	14	44	14	1.3	32	(14.1)	2	34	(12.5)
11	11	52	9	10	48	30	1.1	21	(9.3)	1	22	(8.1)
12	11	48	46	12	52	33	0.9	23	(10.1)	1	24	(8.9)
13	10	53	40	9	47	11	1.1	19	(8.4)	1	20	(7.4)
14	1	50	0	1	50	0	1.0	2	(0.9)	0	2	(0.7)
Total	99	44	17	128	56	9	0.8	227	(100)	44	271	(100)

Table 21. Age specific sex ratio and maturity for lake whitefish taken in the lower Mackenzie Delta (June-August 1980) and from a winter sample (November 1980) in the Delta, Peel River and Arctic Red River.

Scale Age (yr)	Female N	Female %	Female % Mature	Male N	Male %	Male % Mature	F/M Ratio	Total N	Total %
June - August 1980									
0	0	-	-	0	-	-	-	0	
1	0	-	-	0	-	-	-	0	
2	0	-	-	0	-	-	-	0	
3	14	74	0	5	26	0	2.8	19	(4.4)
4	8	38	0	13	62	0	0.6	21	(4.8)
5	7	58	0	5	42	0	1.4	12	(2.8)
6	7	54	0	6	46	0	1.2	13	(3.0)
7	3	30	0	7	70	0	0.4	10	(2.3)
8	11	35	0	20	65	0	0.6	31	(7.1)
9	23	49	0	24	51	0	1.0	47	(10.8)
10	31	53	10	27	47	4	1.1	58	(13.3)
11	23	41	39	33	59	21	0.7	56	(12.8)
12	30	45	37	36	55	44	0.8	66	(15.1)
13	33	57	52	25	43	64	1.3	58	(13.3)
14	21	68	52	10	32	50	2.1	31	(7.1)
15	11	79	27	3	21	0	3.7	14	(3.2)
Total	222	51	24	214	49	21	1.0	436	(100)
November 1980									
0									
1									
2									
3									
4									
5									
6									
7									
8	1	100	0	0	0	0	-	1	(2.9)
9	0	0	0	1	100	0	-	1	(2.9)
10	2	40	100	3	60	100	0.7	5	(14.2)
11	3	43	100	4	57	100	0.8	7	(20.0)
12	3	43	100	4	57	100	0.8	7	(20.0)
13	1	100	100	0	0	0	-	1	(2.9)
14	4	80	100	1	20	100	4.0	5	(14.2)
15	2	40	100	3	60	100	0.7	5	(14.2)
16	0	0	0	1	100	100	-	1	(2.9)
17	0	-	-	0	-	-	-	0	
18	0	-	-	2	100	100	-	2	(5.8)
Total	16	46	94	19	54	95	0.8	35	(100)

Data from Chang-Kue and Jessop (1992)

Table 22. Length-weight relationships for lake whitefish from Kukjuktuk Creek in 1978 and 1979.

Group		N	Length Range (mm)	Y-Intercept (a)	Slope (b)	SD_b	Analysis of Covariance							
							Intercept				Slope			
							M vs F	M vs M	F vs F	All vs All	M vs F	M vs M	F vs F	All vs All
1978														
Upstream	M[a]	62	200 - 438	-5.849	3.364	0.186	▲	▲○				▲		
	F	74	187 - 421	-5.643	3.288	0.146			▲○				▲	
	All	195	153 - 439	-5.708	3.313	0.090				▲○				▲○
Downstream	M	24	228 - 429	-4.872	3.001	0.288								
	F	21	362 - 447	-3.444	2.453	1.038								
	All	45	228 - 447	-4.716	2.941	0.304								
Upstream + Downstream	All	240	153 - 447	-5.729	3.324	0.089								
1979														
Upstream	M	60	116 - 444	-5.883	3.390	0.100								
	F	39	116 - 428	-5.676	3.306	0.149							▲	
	All	296	101 - 453	-5.623	3.284	0.051								▲○
Downstream	M	77	118 - 461	-5.771	3.347	0.073					▲			
	F	70	129 - 451	-6.066	3.463	0.095								
	All	183	73 - 461	-5.908	3.402	0.044								
Upstream + Downstream	All	479	73 - 461	-5.793	3.354	0.034								

[a]M = Male; F = Female; All = Male + Female + Unsexed fish.
▲ Significant difference at 5% level.
○ Significant difference at 1% level.

Table 23. Mean fork length and mean condition factor (K) by sex for each age group of all least cisco sampled from the upstream and downstream run at Kukjuktuk Creek in 1978.

Scale Age (yr)	Males					Females					Sex Unknown				Combined				
	N	Mean[a]	S.D.	Range	K	N	Mean	S.D.	Range	K	N	Mean	S.D.	Range	N	Mean	S.D.	Range	t-test
0+																			
1																			
2											1	108		108	1	108		108	
3	12	201	11.2	183-219	0.90	8	198	12.4	175-208	0.84	1	172		172	21	199	12.8	172-219	0.563
4	24	227	15.0	190-259	0.91	8	229	21.5	196-272	0.99	16	263	14.9	236-285	48	239	23.0	190-285	0.293
5	35	260	22.4	210-347	1.00	24	263	23.0	192-316	0.99	129	273	18.6	218-362	188	269	20.6	192-362	0.499
6	38	293	15.7	262-325	1.05	53	297	17.9	253-333	1.05	300	295	17.8	230-393	391	295	17.6	230-393	1.105
7	22	300	24.4	257-351	1.10	50	319	13.7	293-351	1.02	134	317	20.3	254-380	206	316	20.1	254-380	4.218[b]
8	6	336	16.5	316-361	1.07	37	347	20.3	312-387	1.01	112	339	21.7	217-402	155	341	21.4	217-402	1.258
9						16	368	17.0	343-394	1.04	27	364	19.5	321-415	43	366	18.5	321-415	
10											1	385		385	1	385		385	
Total	137	268	39.7	183-361		196	307	44.5	175-394		721	304	32.3	108-415	1054	300	37.9	108-415	

[a] Fork length (mm).

[b] Significant difference between means for males and females ($P < 0.05$).

Table 24. Length-frequency distribution by age group for all least cisco sampled from the upstream and downstream run at Kukjuktuk Creek in 1978.

Fork Length (mm)	Scale Age (yr)											
	0	1	2	3	4	5	6	7	8	9	10	Total
101-125			1									1
126-150												0
151-175			1	2								3
176-200				8	2	1						11
201-225				12	16	4			1			33
226-250					29	29	3	1				62
251-275					12	105	49	7				173
276-300					3	59	221	35	1			319
301-325						4	124	116	37	2		283
326-350						2	10	48	79	7		146
351-375						1	1	7	38	21		68
376-400							2	1	7	14	1	25
401-425									1	1		2
Total	0	0	2	22	62	205	410	215	164	45	1	1126

Note: Some additional ages from live sample or tagged fish data are included.

Table 25. Mean fork length and mean condition factor (K) by sex for each age group of all least cisco sampled from the upstream and downstream run at Kukjuktuk Creek in 1979.

Scale Age (yr)	Males					Females					Sex Unknown				Combined					t-test
	N	Mean[a]	S.D.	Range	K	N	Mean	S.D.	Range	K	N	Mean	S.D.	Range	N	Mean	S.D.	Range	K	
0+																				
1	1	132		132	0.74						4	95	12.2	77-103	5	103	19.6	77-132	0.76	
2	3	178	8.5	170-187	0.83	5	153	36.9	121-212	0.98	4	143	34.9	114-189	12	156	32.2	114-212	0.91	3.549[b]
3	18	225	25.6	163-274	0.95	15	221	16.1	197-264	1.04	3	147	12.2	136-160	36	217	29.9	136-274	0.97	0.524
4	18	256	23.0	214-295	1.12	30	266	26.6	193-305	1.03					48	262	25.5	193-305	1.06	1.324
5	35	281	22.6	227-330	1.03	30	287	22.3	243-335	1.10	1	286		286	66	284	22.3	227-335	1.06	1.074
6	24	301	17.0	270-330	1.09	43	303	17.6	260-342	1.04	1	340		340	68	303	17.8	260-342	1.06	0.451
7	15	310	22.5	269-341	1.09	36	317	13.2	285-343	1.03					51	315	16.6	269-343	1.05	1.389
8	1	332		332	0.82	22	338	22.4	292-383	1.01					23	338	21.9	292-383	1.00	
9	1	372		372	1.26	14	354	12.8	323-366	1.02					15	355	13.1	323-372	1.04	
10						4	365	19.5	337-380	1.03					4	365	19.5	337-380	1.03	
11	1	345		345	1.24										1	345		345	1.24	
Total	117	274	42.0	132-372		199	297	45.9	121-383		13	155	76.8	77-340	329	283	54.0	77-383		

[a]Fork length (mm).

[b]Significant difference between means for males and females ($P < 0.05$).

Table 26. Length-frequency distribution by age group for all least cisco sampled from the upstream and downstream run at Kukjuktuk Creek in 1979.

Fork Length (mm)	Scale Age (yr)												Total
	0	1	2	3	4	5	6	7	8	9	10	11	
76-100		2											2
101-125		2											2
126-150		1	4										5
151-175			3	3									6
176-200			2	3									5
201-225			2	13	3								18
226-250			1	6	5	1							13
251-275				7	14	7	1						29
276-300			1	9	29	22	10	3	1				75
301-325				1	17	65	33	19	3				138
326-350					3	45	44	26	9	2		1	130
351-375						6	15	22	16	8	2		69
376-400							1	4	4	6	2		17
401-425									1	1			2
Total	0	5	13	42	71	146	104	74	34	17	4	1	511

Note: Some additional ages from live sample or tagged fish data are included.

Table 27. Age specific sex ratio and maturity for least cisco sampled at Kukjuktuk Creek in 1978 and 1979.

Scale Age (yr)	Female N	Female %	Female % Mature	Male N	Male %	Male % Mature	F/M Ratio	Sexed Fish N	Sexed Fish (%)	Unsexed Fish N	Total N	Total (%)
1978 Fish												
0	0	-	-	0	-	-	-	0		0	0	
1	0	-	-	0	-	-	-	0		0	0	
2	0	-	-	0	-	-	-	0		1	1	(0.3)
3	8	40	0	12	60	0	0.7	20	(6.1)	1	21	(6.2)
4	8	25	0	24	75	0	0.3	32	(9.6)	0	32	(9.5)
5	24	41	4	35	59	2.8	0.7	59	(17.7)	2	61	(18.0)
6	53	58	23	38	42	29.0	1.4	91	(27.3)	1	92	(27.2)
7	50	69	20	22	31	27.3	2.3	72	(21.6)	0	72	(21.3)
8	37	86	24	6	14	33.0	6.2	43	(12.9)	0	43	(12.7)
9	16	100	56	0	0	0	-	16	(4.8)	0	16	(4.8)
Total	196	59	43	137	41	36.0	1.4	333	(100)	5	338	(100)
1979 Fish												
0	0	-	-	0	-	-	-	0		0	0	
1	0	0	0	1	100	0	-	1	(0.3)	4	5	(1.5)
2	5	63	0	3	37	0	1.7	8	(2.5)	4	12	(3.6)
3	15	45	0	18	55	0	0.8	33	(10.4)	3	36	(10.9)
4	30	62	7	18	38	11	1.7	48	(15.3)	0	48	(14.6)
5	30	46	27	35	54	29	0.9	65	(20.6)	1	66	(20.1)
6	43	64	30	24	36	38	1.8	67	(21.2)	1	68	(20.7)
7	36	71	58	15	29	47	2.4	51	(16.1)	0	51	(15.5)
8	22	96	59	1	4	100	22.0	23	(7.3)	0	23	(7.0)
9	14	93	36	1	7	100	14.0	15	(4.7)	0	15	(4.6)
10	4	100	50	0	0	0	-	4	(1.3)	0	4	(1.2)
11	0	0	0	1	100	0	-	1	(0.3)	0	1	(0.3)
Total	199	63	32	117	37	26	1.7	316	(100)	13	329	(100)

Table 28. Length-weight relationships for least cisco from Kukjuktuk Creek in 1978 and 1979.

Group		N	Length Range (mm)	Y-Intercept (a)	Slope (b)	SD_b	Analysis of Covariance: Intercept M vs F	Intercept M vs M	Intercept F vs F	Intercept All vs All	Slope M vs F	Slope M vs M	Slope F vs F	Slope All vs All
1978														
Upstream	M[a]	95	183 - 361	-6.088	3.445	0.228	▲				▲			
	F	128	184 - 389	-5.371	3.144	0.240			▲○				▲	
	All	232	86 - 389	-5.534	3.212	0.127				▲○				
Downstream	M	44	190 - 342	-5.852	3.356	0.473								
	F	69	175 - 394	-6.168	3.484	0.311								
	All	115	175 - 394	-6.035	3.430	0.249								
Upstream + Downstream	All	347	86 - 394	-5.606	3.246	0.117								
1979														
Upstream	M	88	178 - 372	-6.173	3.485	0.244	▲○	▲○			▲○			
	F	149	121 - 384	-5.275	3.116	0.177								
	All	442	78 - 392	-5.431	3.178	0.088								
Downstream	M	44	132 - 345	-5.816	3.346	0.316								
	F	80	127 - 380	-5.249	3.108	0.219								
	All	134	75 - 380	-5.609	3.255	0.099								
Upstream + Downstream	All	576	75 - 392	-5.502	3.207	0.063								

[a]M = Male; F = Female; All = Male + Female + Unsexed fish.
▲Significant difference at 5% level.
○Significant difference at 1% level.

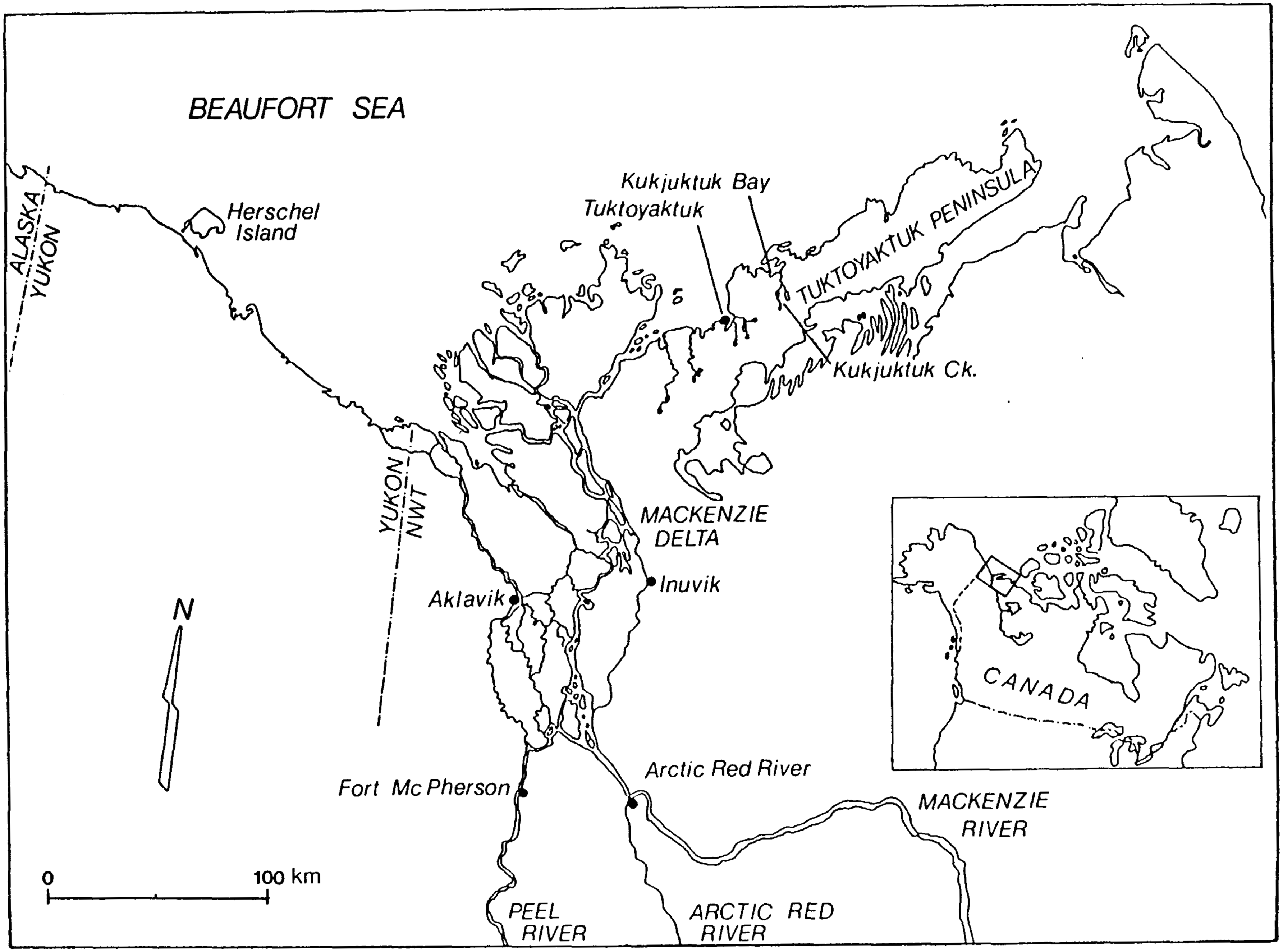


Fig. 1. Map of the Mackenzie Delta and Beaufort Sea coastal area showing the location of Kukjuktuk Creek on the Tuktoyaktuk Peninsula.

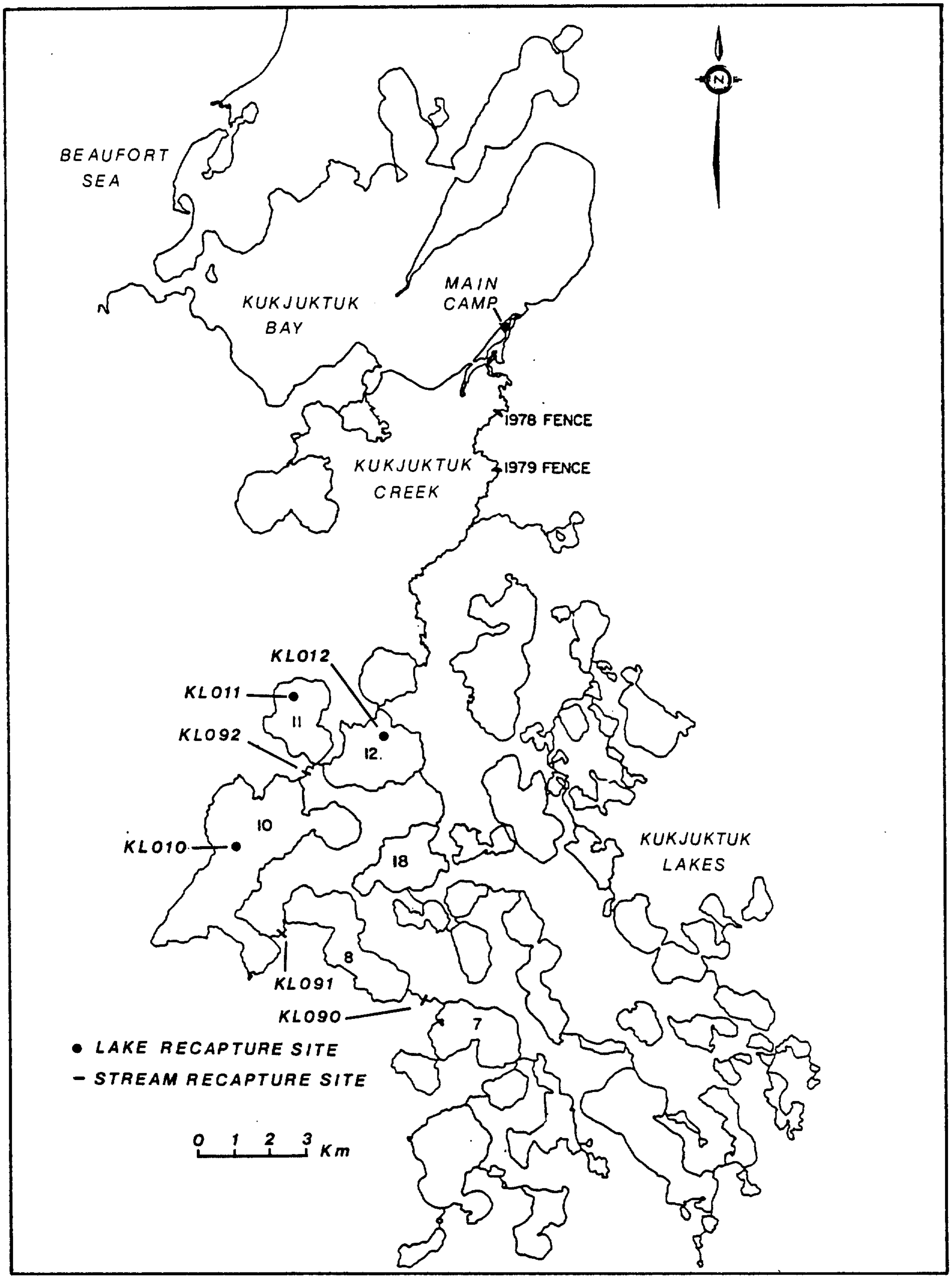


Fig. 2. The Kukjuktuk Creek drainage showing the counting fence locations (1978 and 1979) and the identification code for selected lakes and creeks.

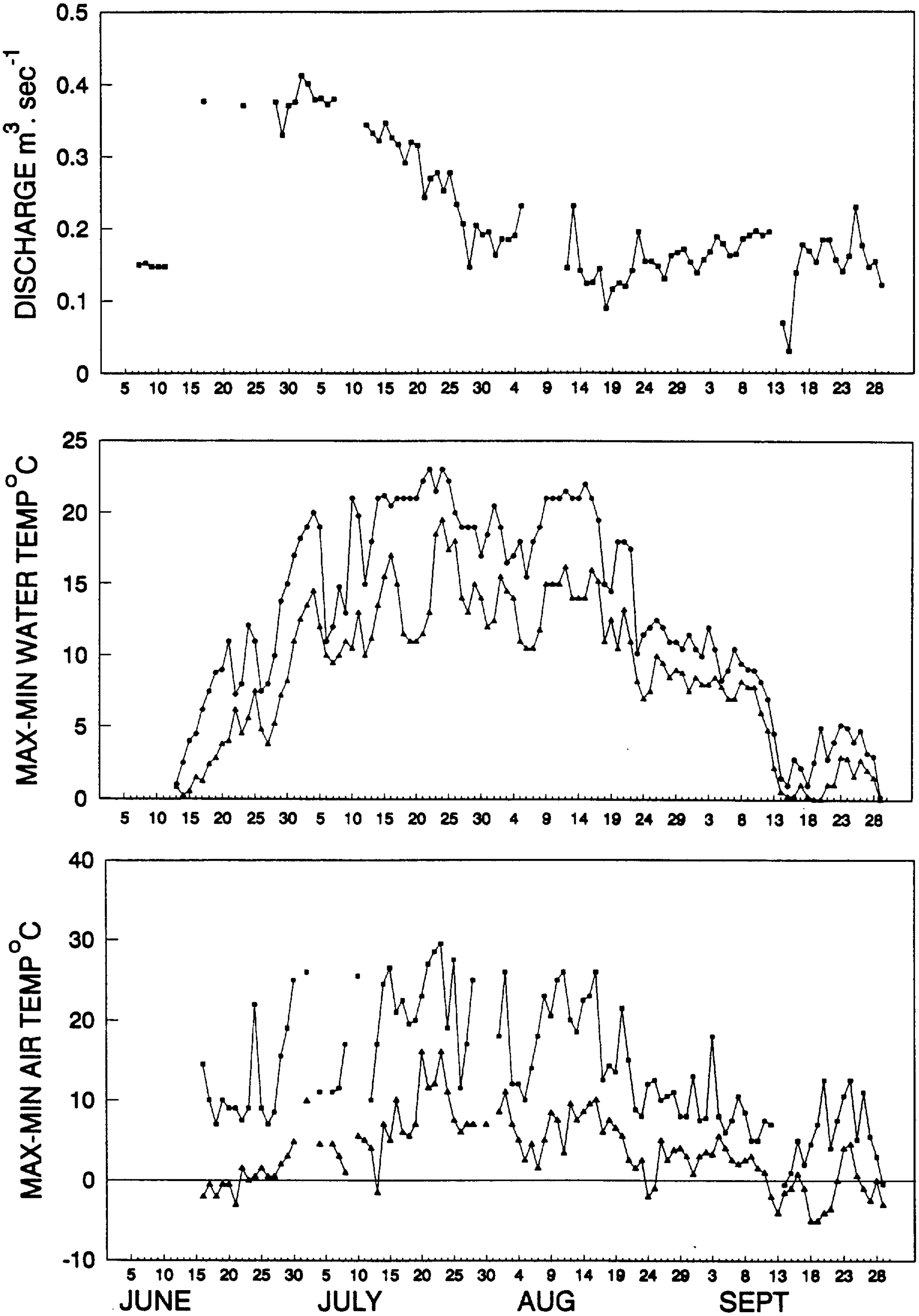


Fig. 3. Stream discharge, daily water temperature range and air temperatures recorded at Kukjuktuk Creek, 1979.

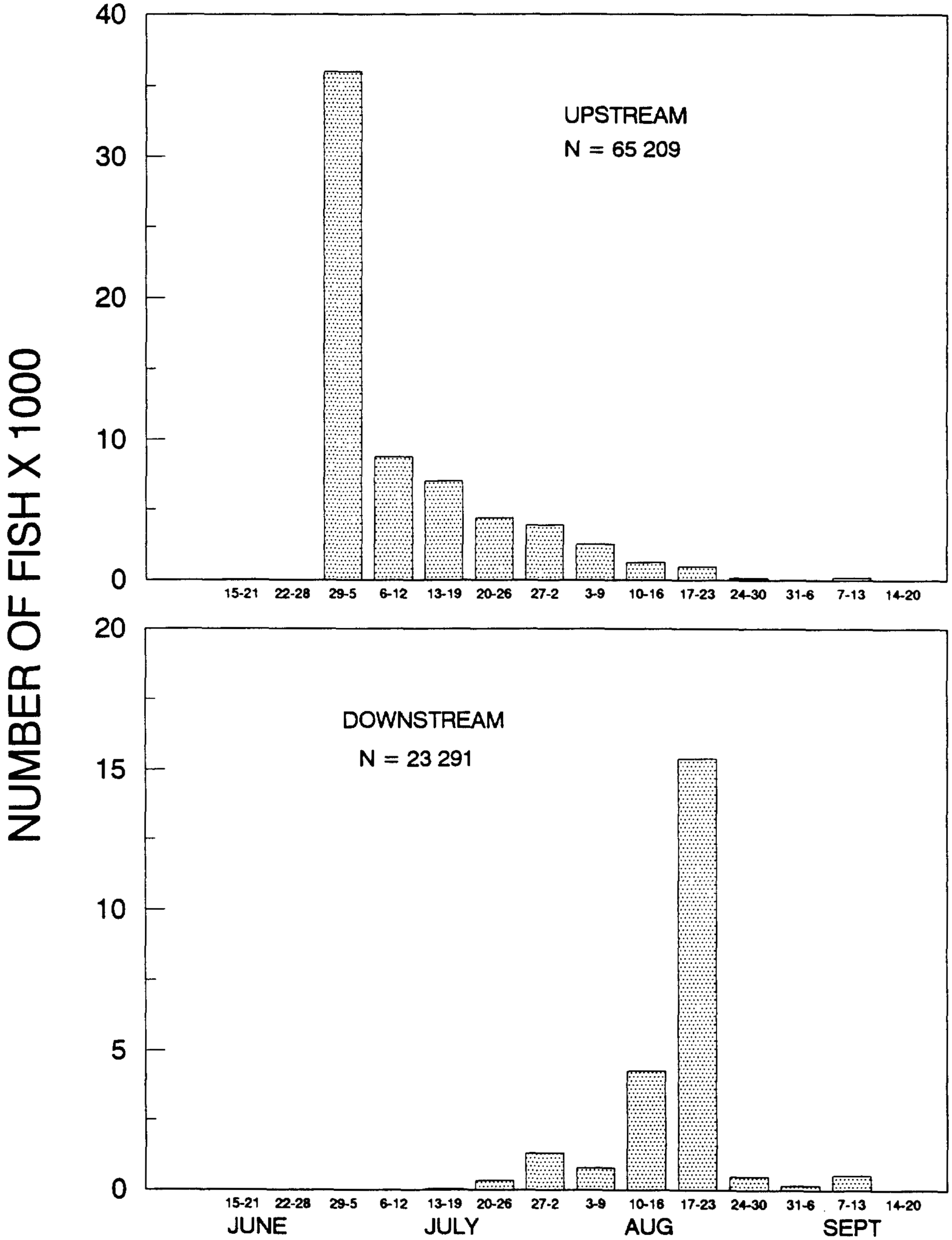


Fig. 4. Total number of broad whitefish per week moving through the upstream and downstream trap at Kukjuktuk Creek, 1978.

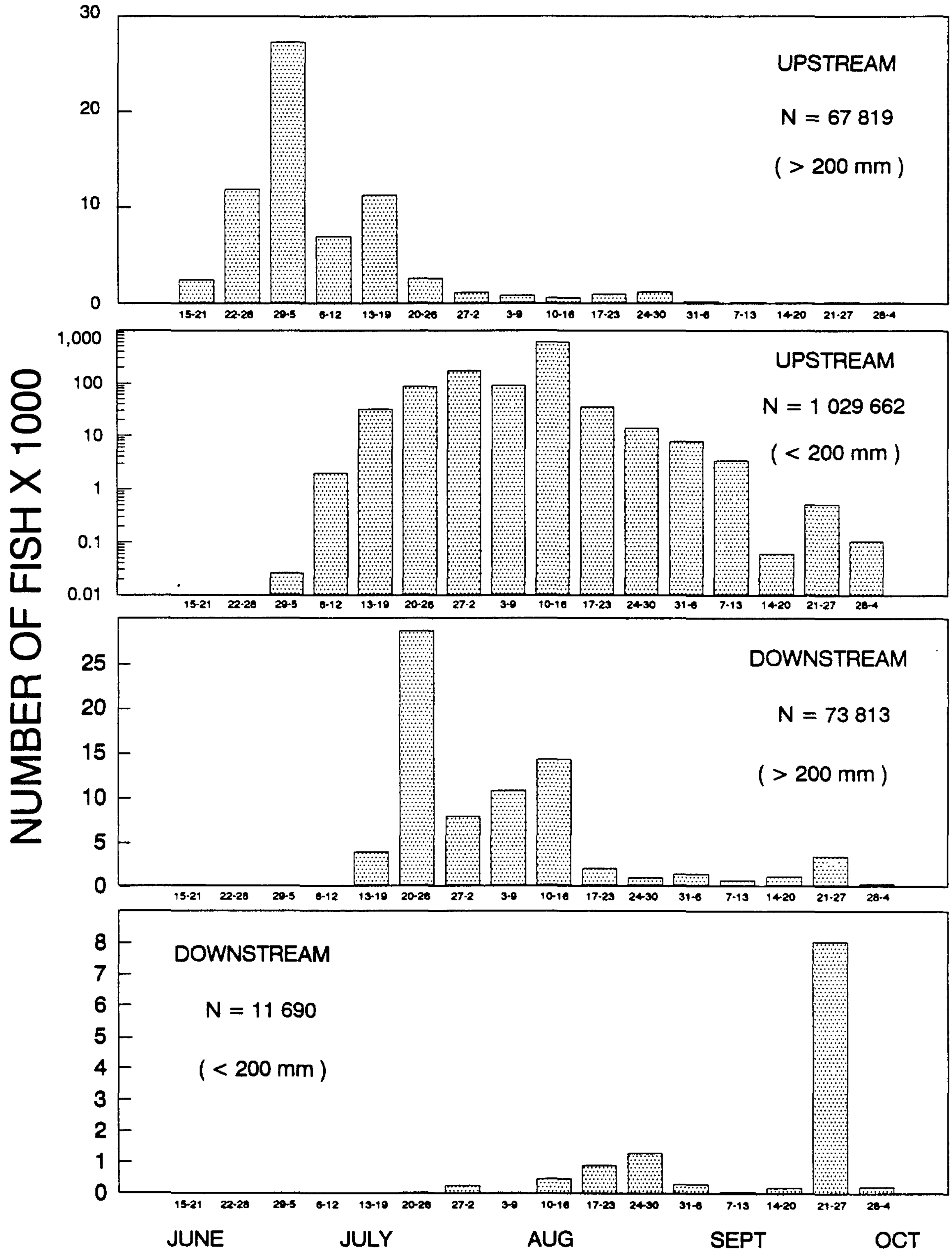


Fig. 5. Total number of broad whitefish per week moving through the upstream and downstream trap at Kukjuktuk Creek, 1979.

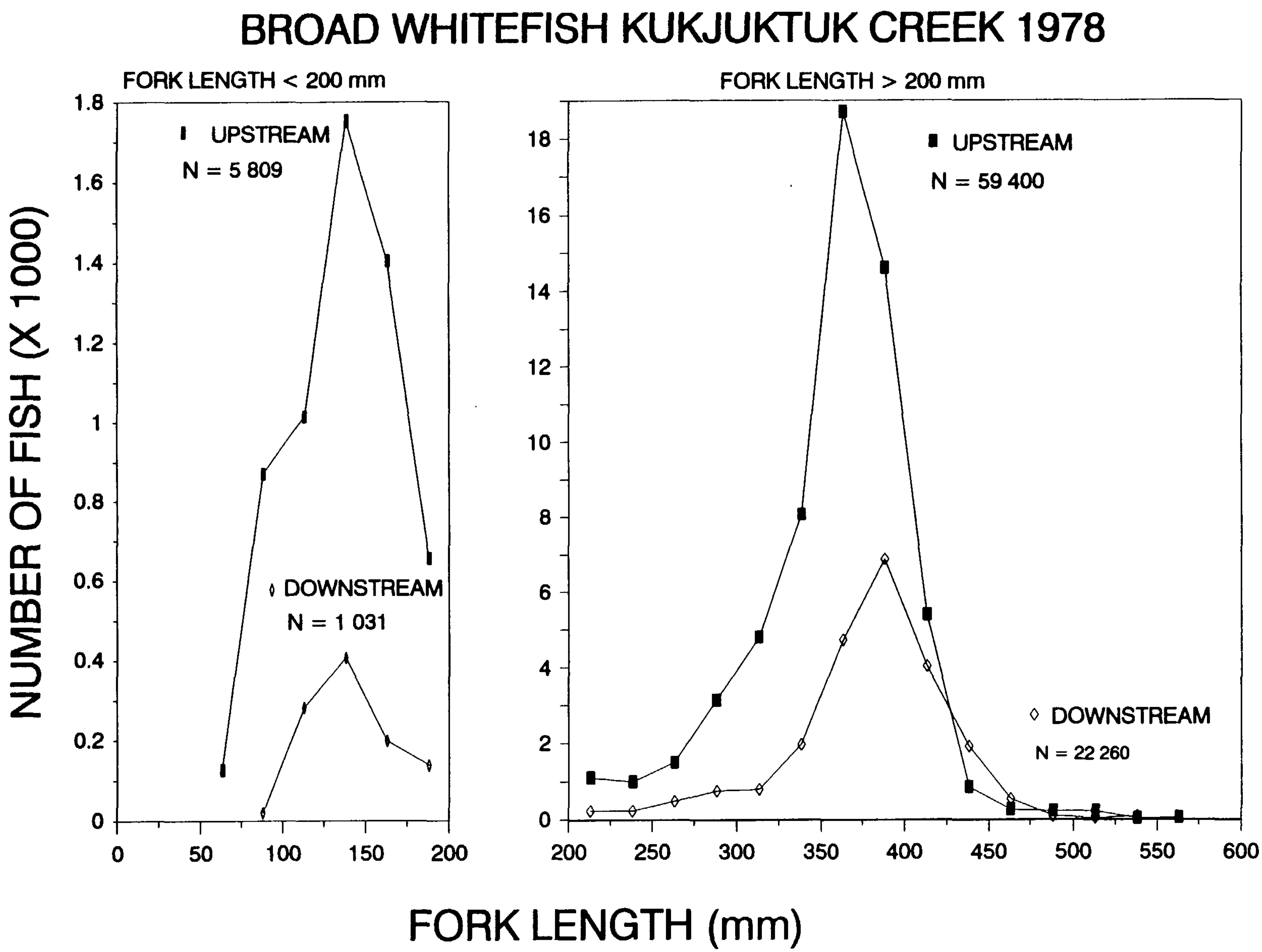


Fig. 6. The estimated overall length-frequency distribution for broad whitefish in the upstream and downstream migrations in Kukjuktuk Creek in 1978.

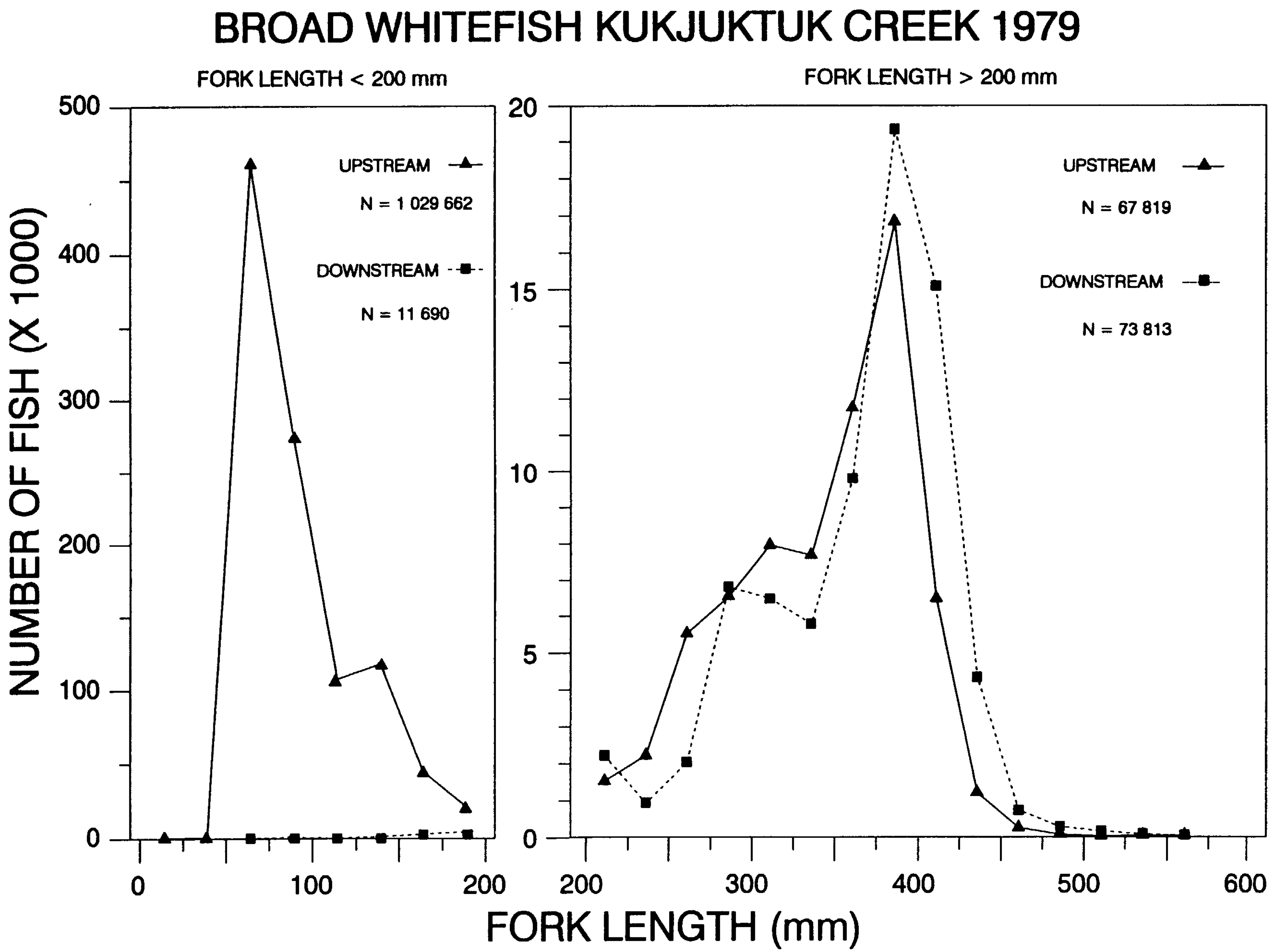


Fig. 7. The estimated overall length-frequency distribution for broad whitefish in the upstream and downstream migrations in Kukjuktuk Creek in 1979.

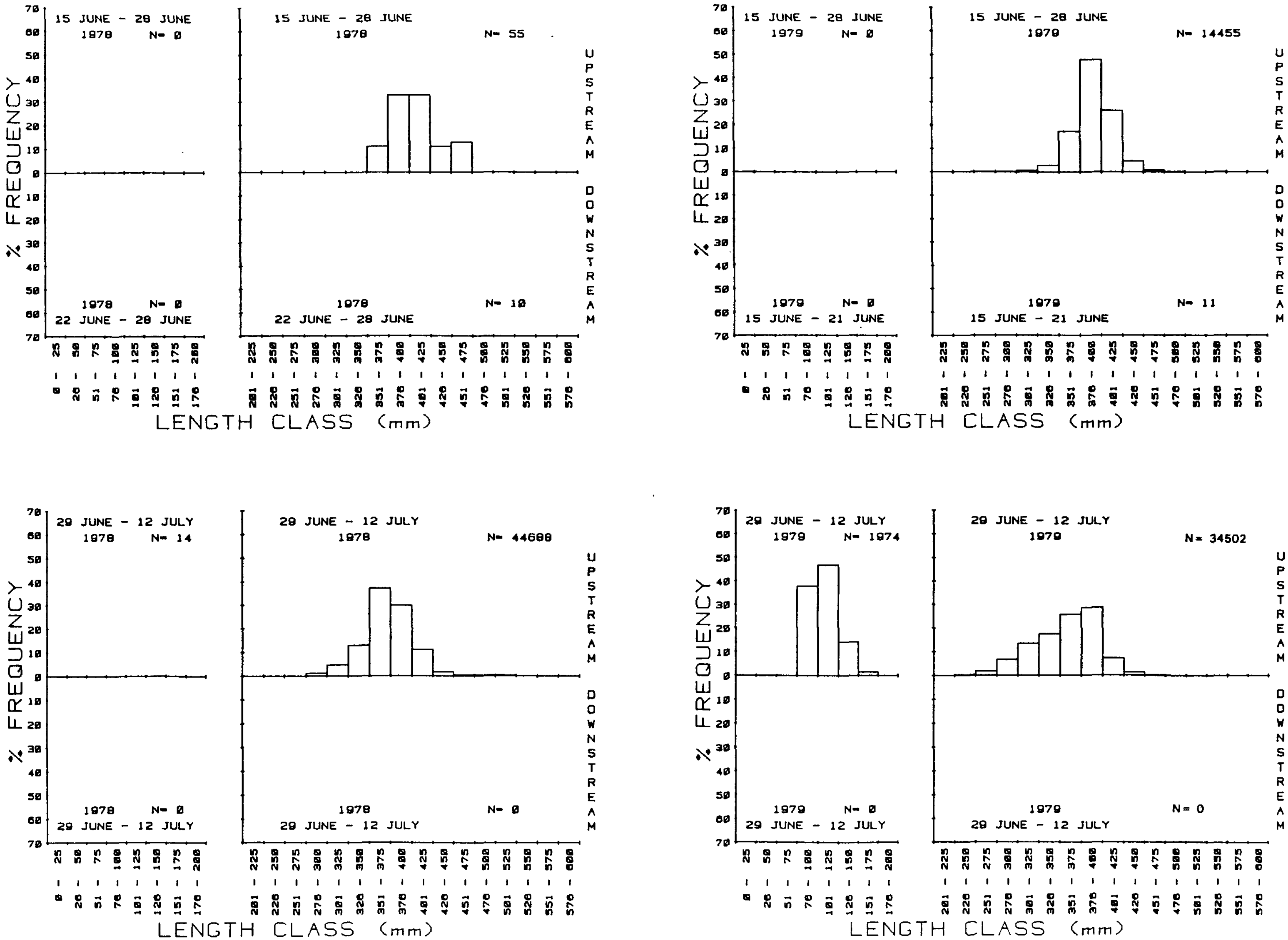


Fig. 8. Length frequency distribution per biweekly period for broad whitefish migrations in Kukjuktuk Creek in 1978 and 1979.

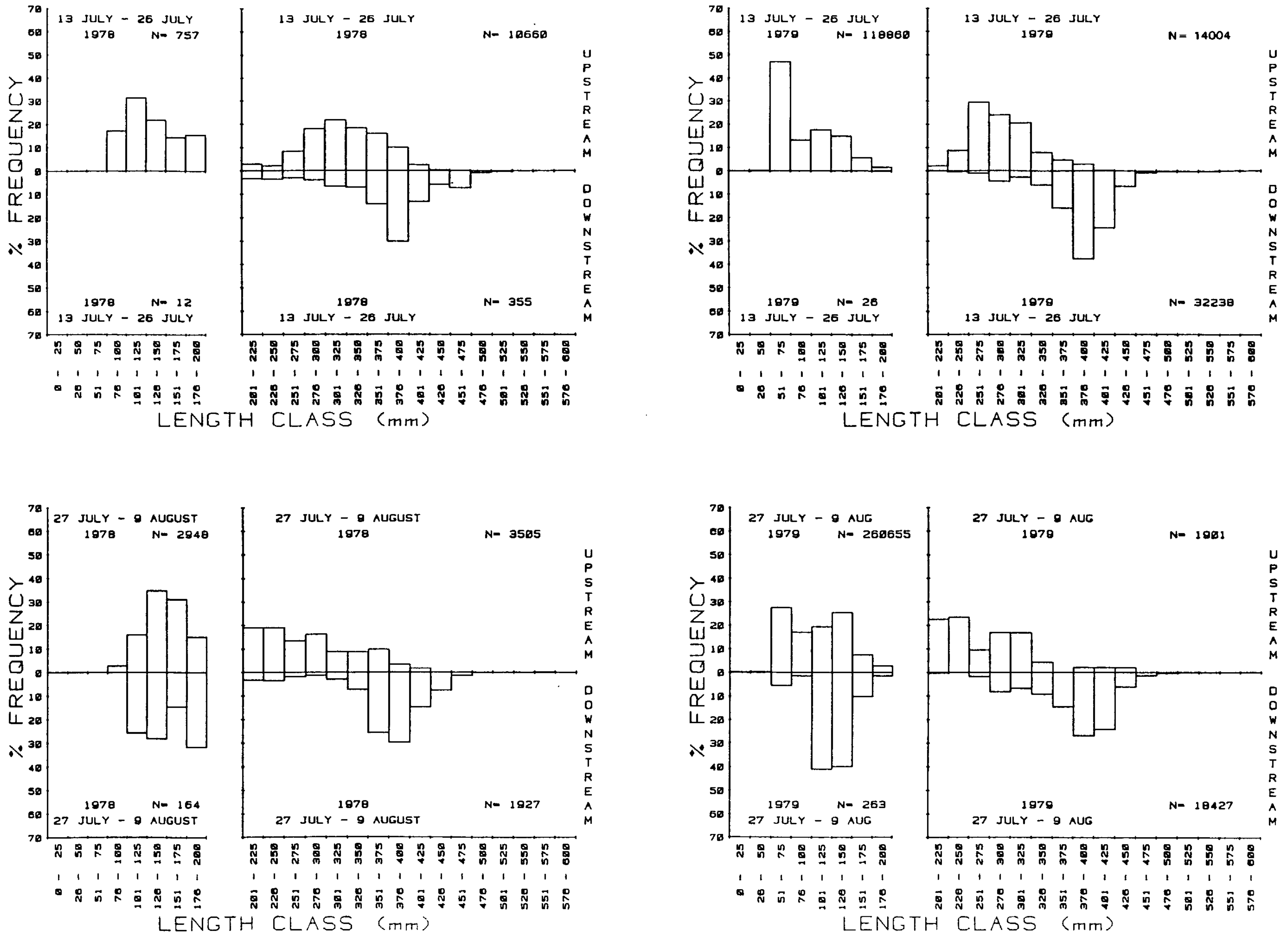

13 JULY - 26 JULY
1978 N= 757
13 JULY - 26 JULY
1978 N= 10660
1978 N= 12
13 JULY - 26 JULY
1978 N= 355
13 JULY - 26 JULY
13 JULY - 26 JULY
1979 N= 110060
13 JULY - 26 JULY
1979 N= 14004
1979 N= 26
13 JULY - 26 JULY
1979 N= 32238
13 JULY - 26 JULY
27 JULY - 9 AUGUST
1978 N= 2948
27 JULY - 9 AUGUST
1978 N= 3505
1978 N= 164
27 JULY - 9 AUGUST
1978 N= 1927
27 JULY - 9 AUGUST
27 JULY - 9 AUG
1979 N= 260655
27 JULY - 9 AUG
1979 N= 1901
1979 N= 263
27 JULY - 9 AUG
1979 N= 18427
27 JULY - 9 AUG
% FREQUENCY
LENGTH CLASS (mm)
UPSTREAM
DOWNSTREAM

Fig. 8. Cont.

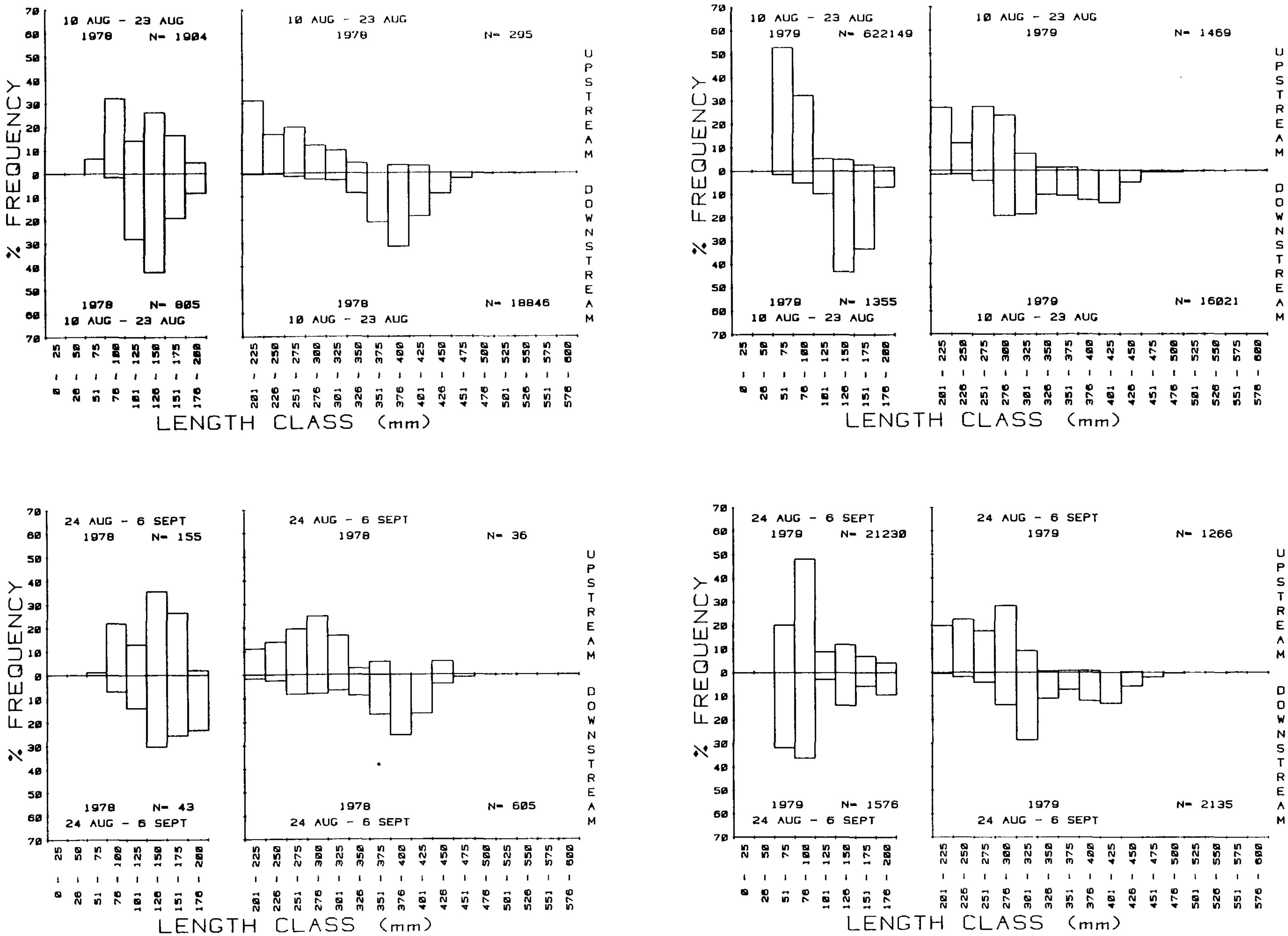

10 AUG - 23 AUG
1978 N= 1904
10 AUG - 23 AUG
1978 N= 295
1978 N= 805
10 AUG - 23 AUG
1978 N= 18846
10 AUG - 23 AUG
10 AUG - 23 AUG
1979 N= 622149
10 AUG - 23 AUG
1979 N= 1469
1979 N= 1355
10 AUG - 23 AUG
1979 N= 16021
10 AUG - 23 AUG
24 AUG - 6 SEPT
1978 N= 155
24 AUG - 6 SEPT
1978 N= 36
1978 N= 43
24 AUG - 6 SEPT
1978 N= 605
24 AUG - 6 SEPT
24 AUG - 6 SEPT
1979 N= 21230
24 AUG - 6 SEPT
1979 N= 1266
1979 N= 1576
24 AUG - 6 SEPT
1979 N= 2135
24 AUG - 6 SEPT
% FREQUENCY
LENGTH CLASS (mm)
UPSTREAM
DOWNSTREAM

Fig. 8. Cont.

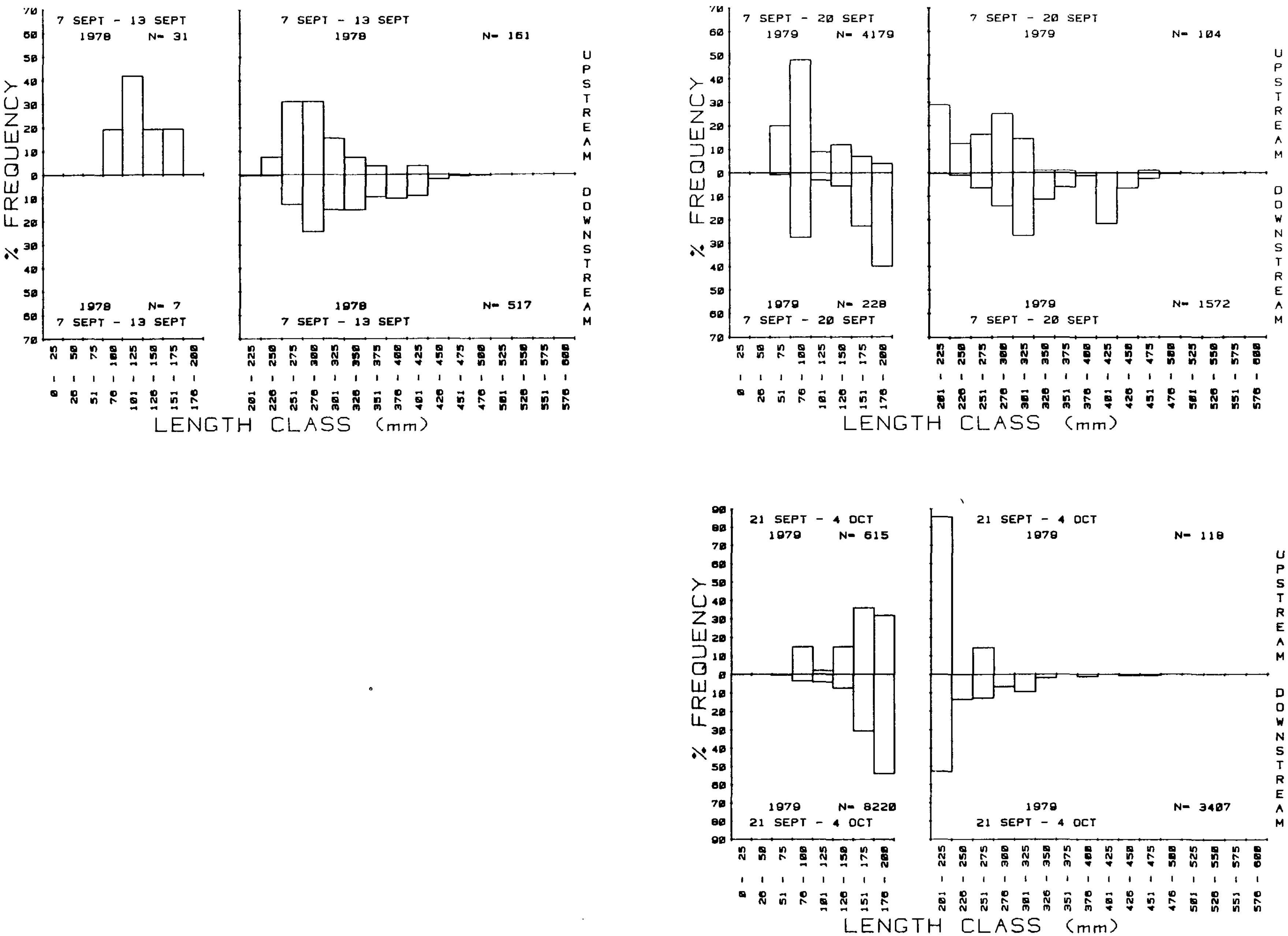

7 SEPT - 13 SEPT
1978 N= 31
7 SEPT - 13 SEPT
1978 N= 161
1978 N= 7
7 SEPT - 13 SEPT
1978 N= 517
7 SEPT - 13 SEPT
% FREQUENCY
UPSTREAM
DOWNSTREAM
LENGTH CLASS (mm)
7 SEPT - 20 SEPT
1979 N= 4179
7 SEPT - 20 SEPT
1979 N= 104
1979 N= 228
7 SEPT - 20 SEPT
1979 N= 1572
7 SEPT - 20 SEPT
% FREQUENCY
UPSTREAM
DOWNSTREAM
LENGTH CLASS (mm)
21 SEPT - 4 OCT
1979 N= 615
21 SEPT - 4 OCT
1979 N= 118
1979 N= 8220
21 SEPT - 4 OCT
1979 N= 3407
21 SEPT - 4 OCT
% FREQUENCY
UPSTREAM
DOWNSTREAM
LENGTH CLASS (mm)

Fig. 8. Cont.

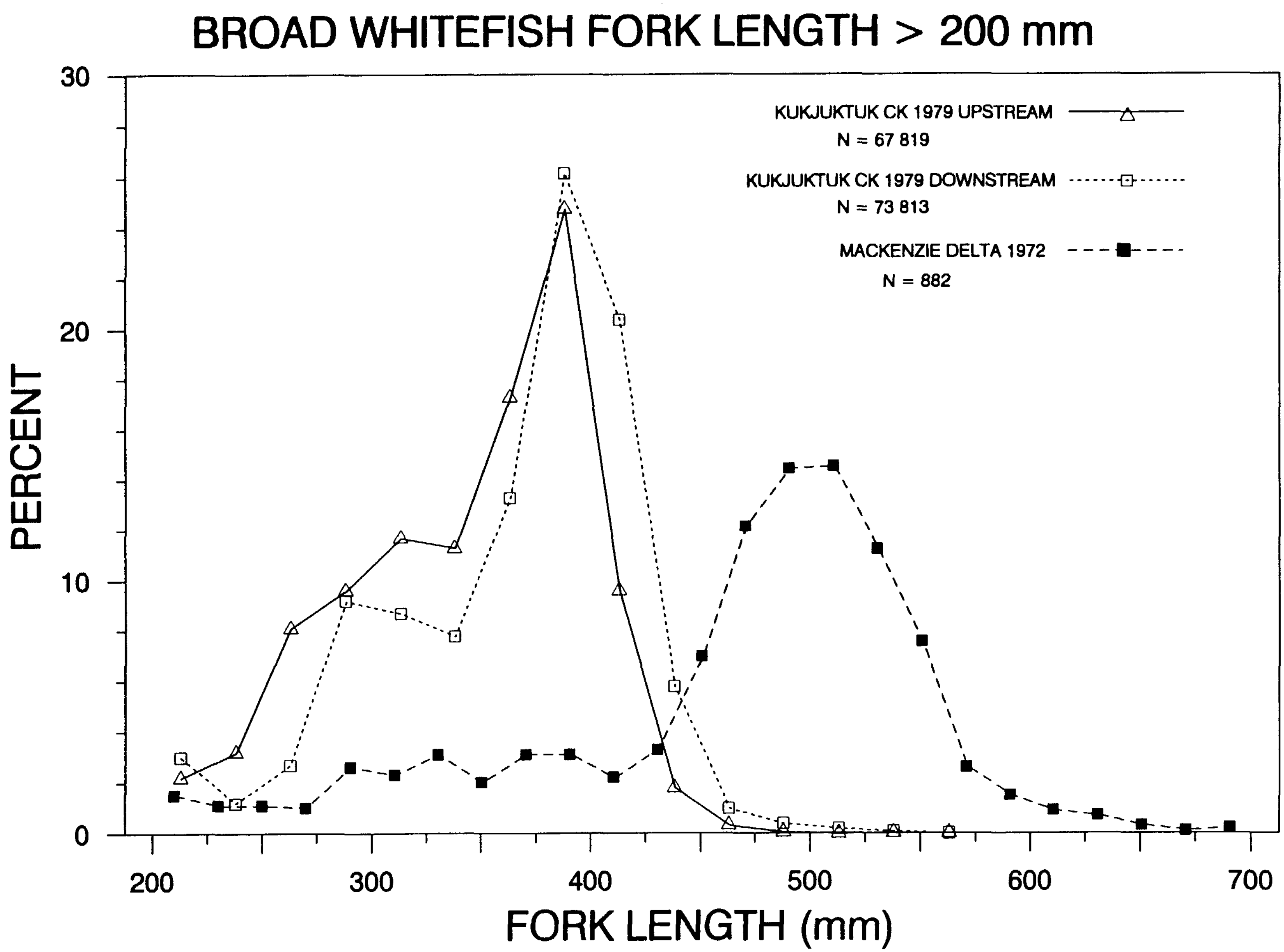


Fig. 9. Comparison of the upstream and downstream length-frequency distribution of Kukjuktuk Creek broad whitefish in 1979 with the distribution observed in the Mackenzie Delta in 1972.

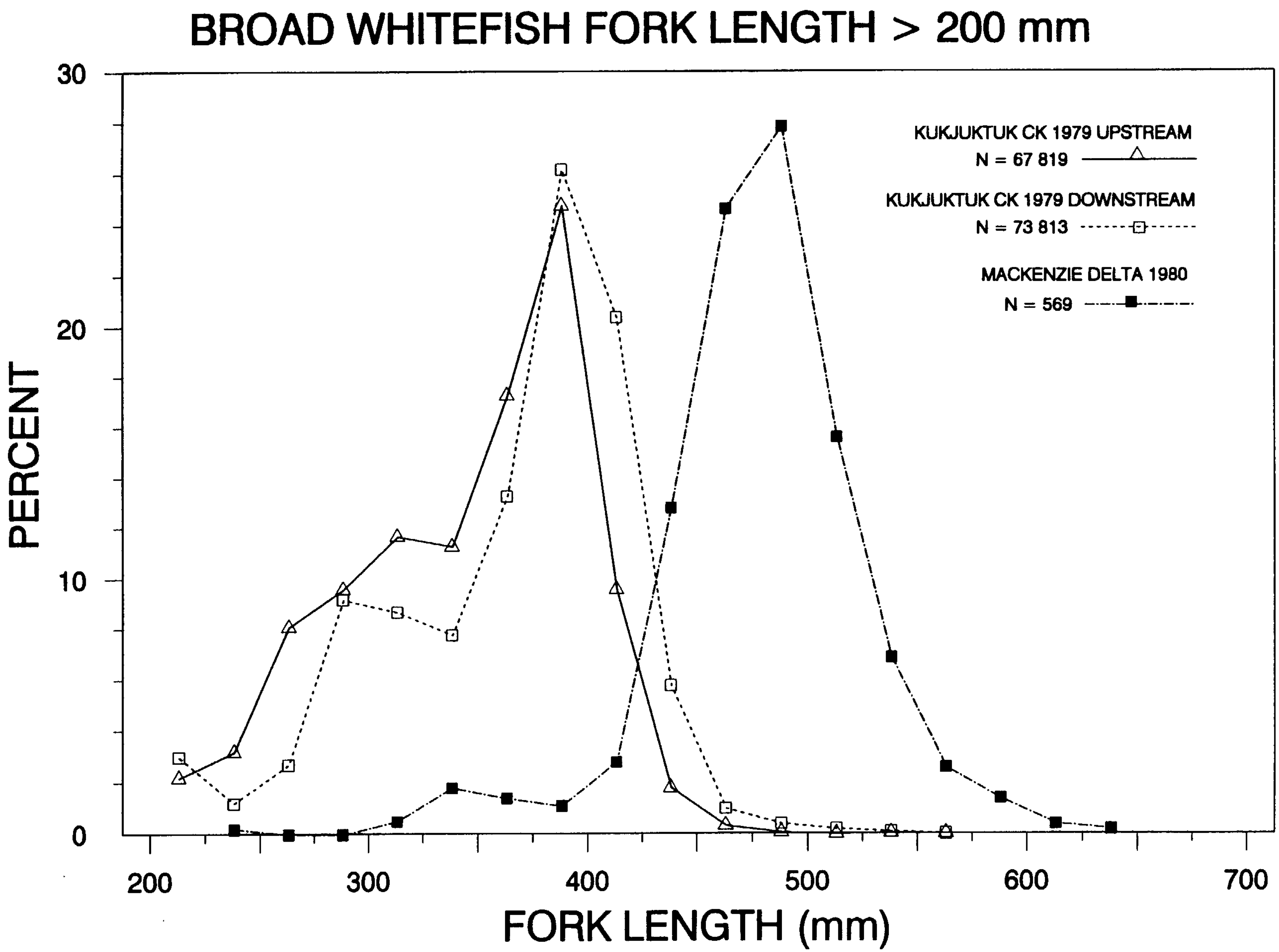
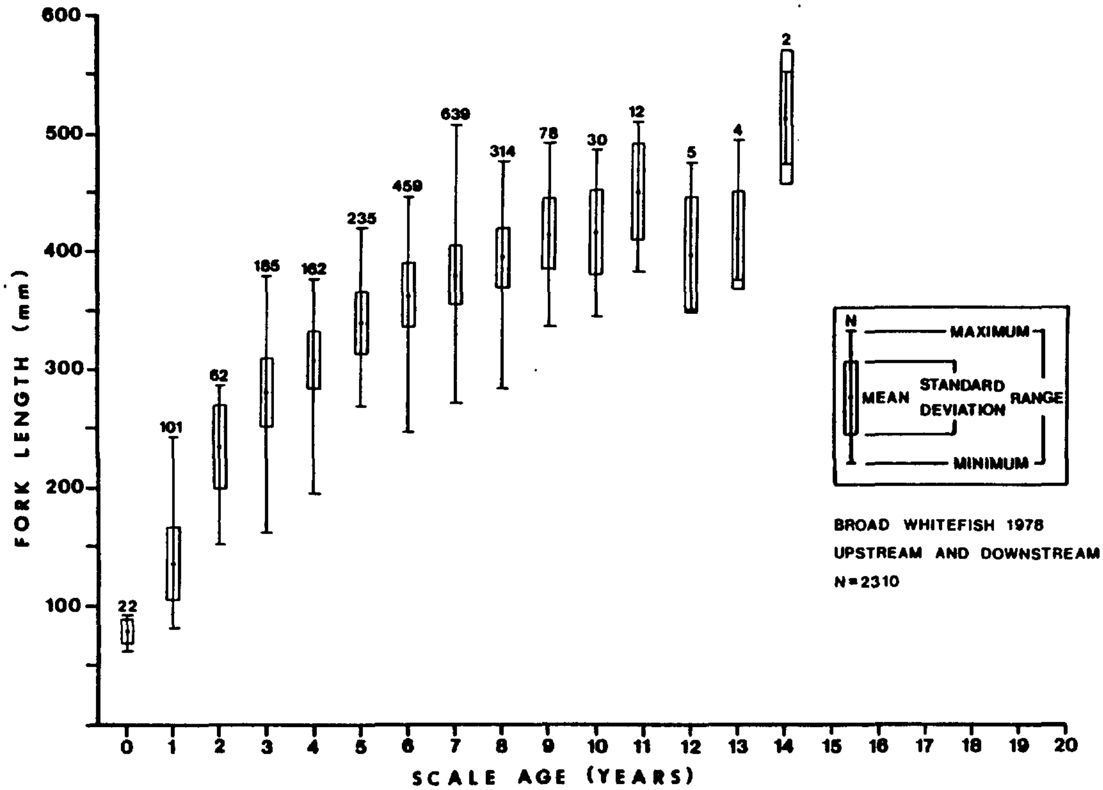


Fig. 10. Comparison of the upstream and downstream length-frequency distribution of Kukjuktuk Creek broad whitefish in 1979 with the distribution observed in the Mackenzie Delta in 1980.



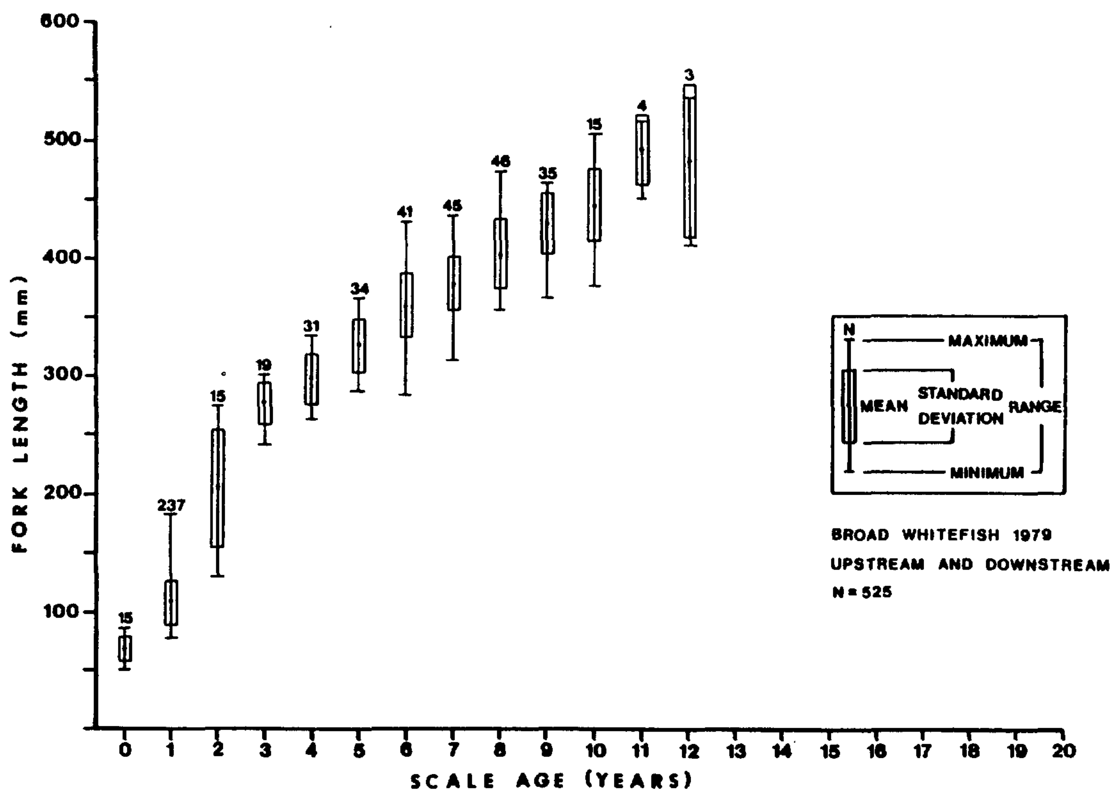


Fig. 11. Growth in fork length for broad whitefish from Kukjuktuk Creek in 1978 and 1979.

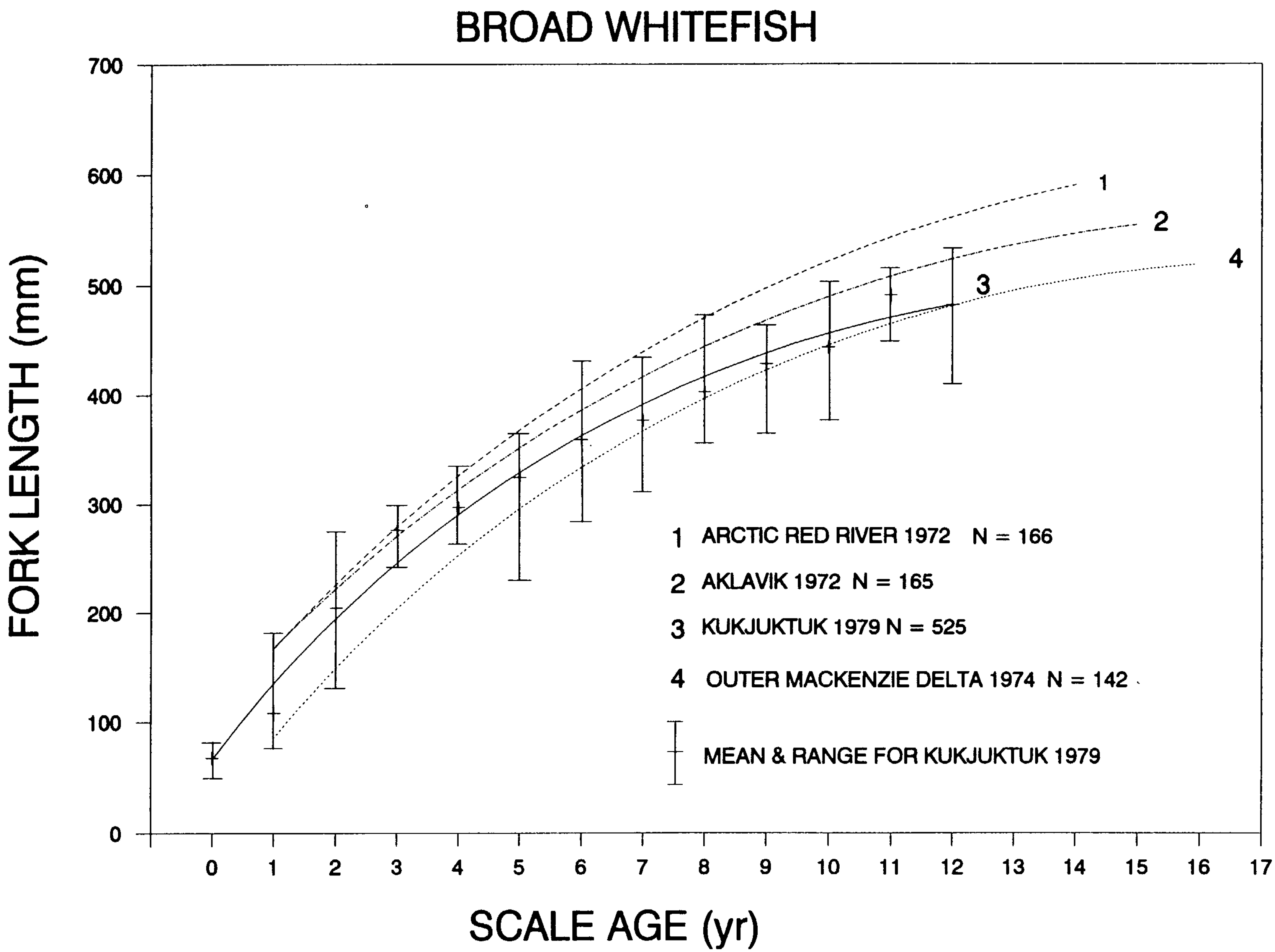


Fig. 12. Comparison of the growth rate for Kukjuktuk Creek broad whitefish with those from three other areas in the Mackenzie Delta: 1. Arctic Red River/upper Delta (Stein et al. 1973c); 2. Aklavik/middle Delta (Stein et al. 1973c); 4. Outer Delta (Percy, 1975).

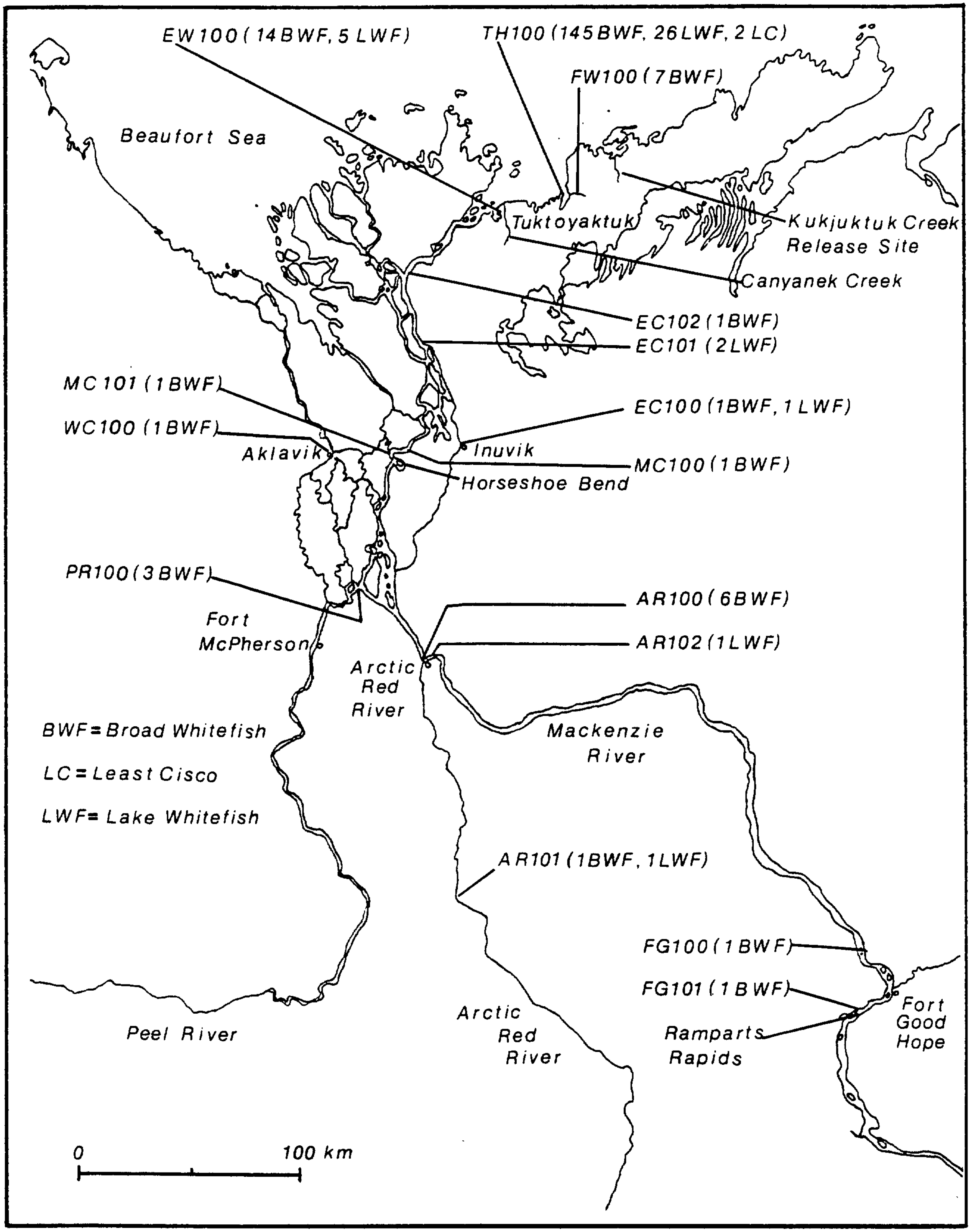


Fig. 13. Numbers taken and locations on the coast and lower Mackenzie River where tagged fish from Kukjuktuk Creek were recaptured from 1978 to 1984.

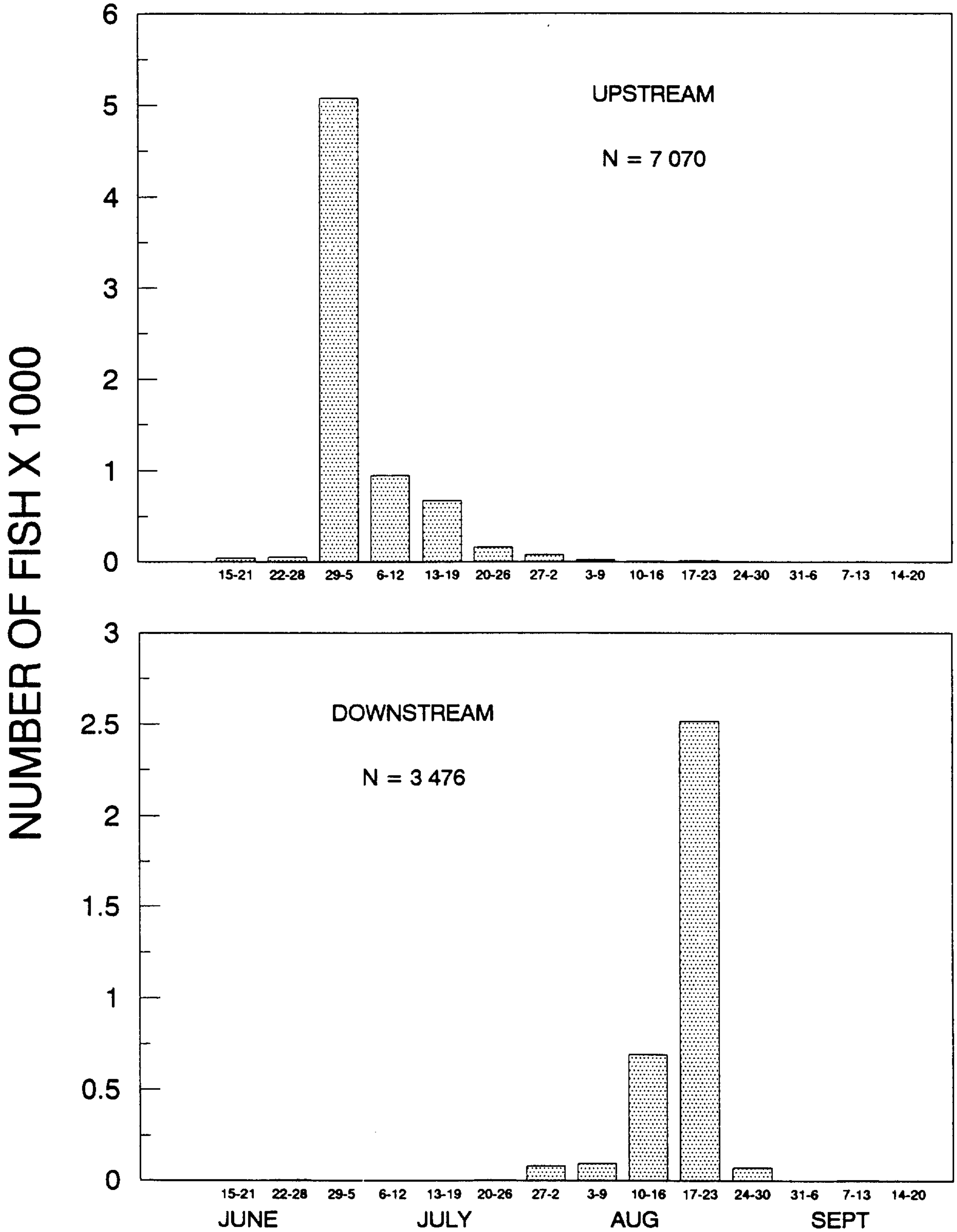


Fig. 14. Total number of lake whitefish per week moving through the upstream and downstream trap at Kukjuktuk Creek, 1978.

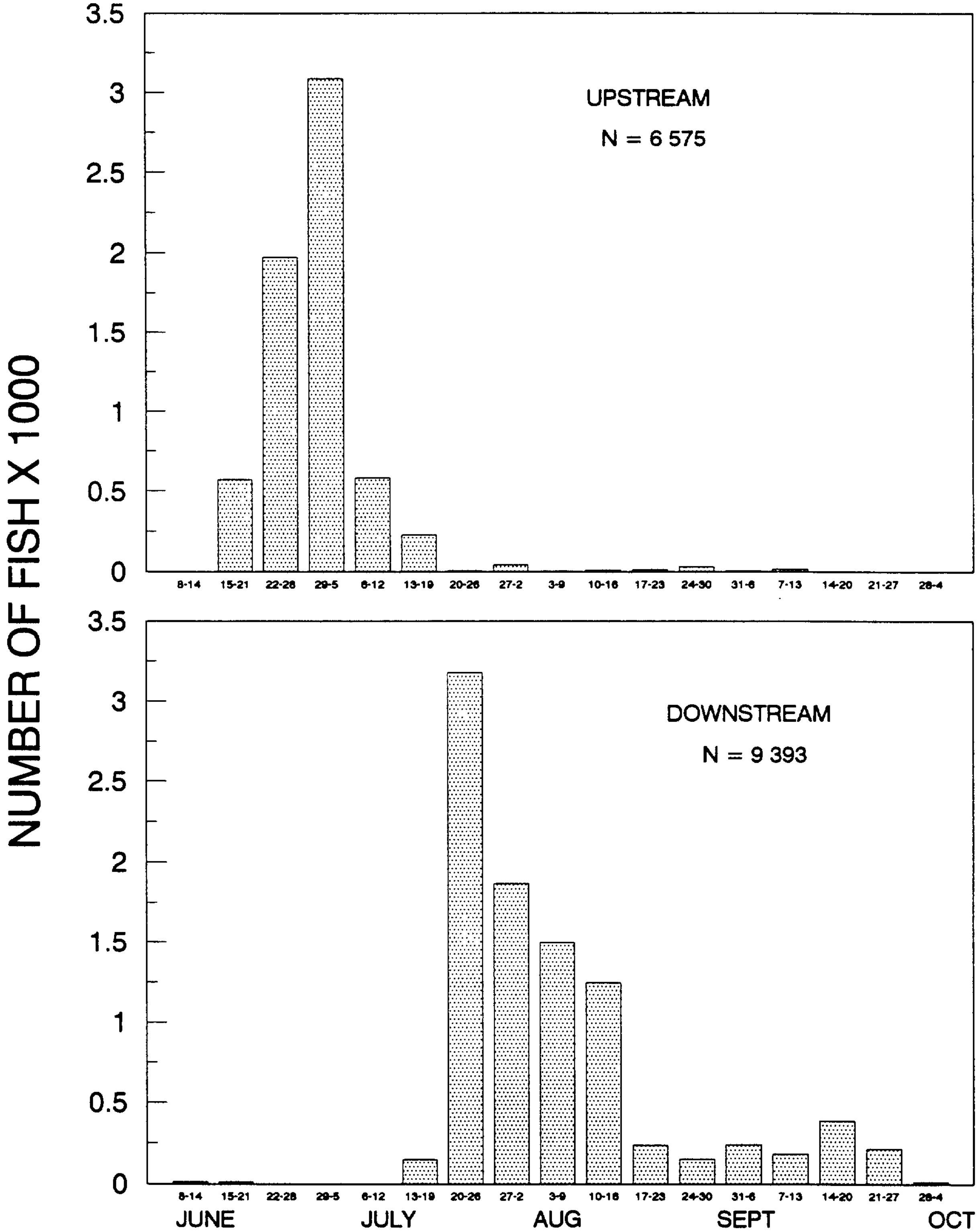


Fig. 15. Total number of lake whitefish per week moving through the upstream and downstream trap at Kukjuktuk Creek, 1979.

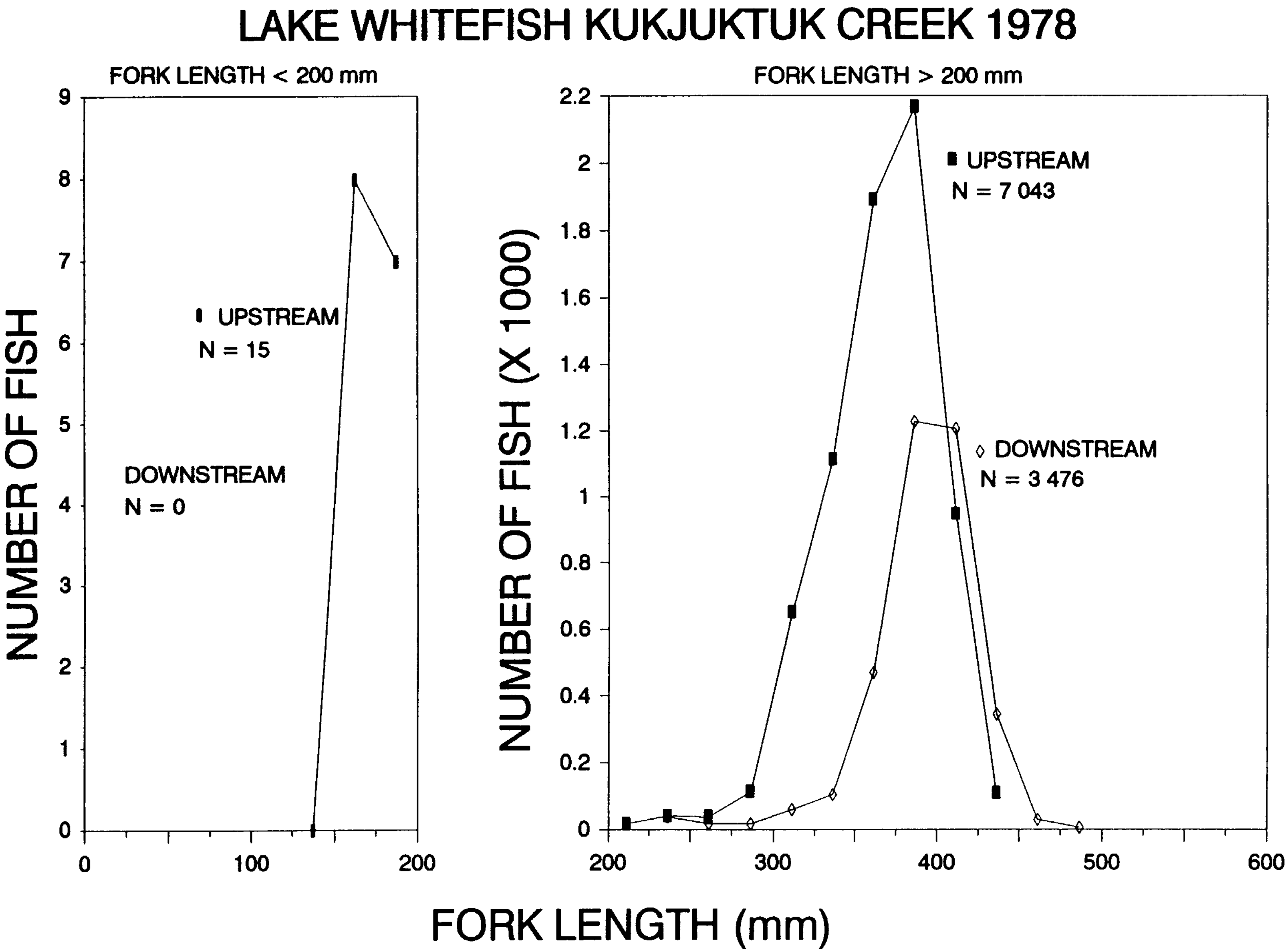


Fig. 16. The estimated overall length-frequency distribution for lake whitefish in the upstream and downstream migrations in Kukjuktuk Creek in 1978.

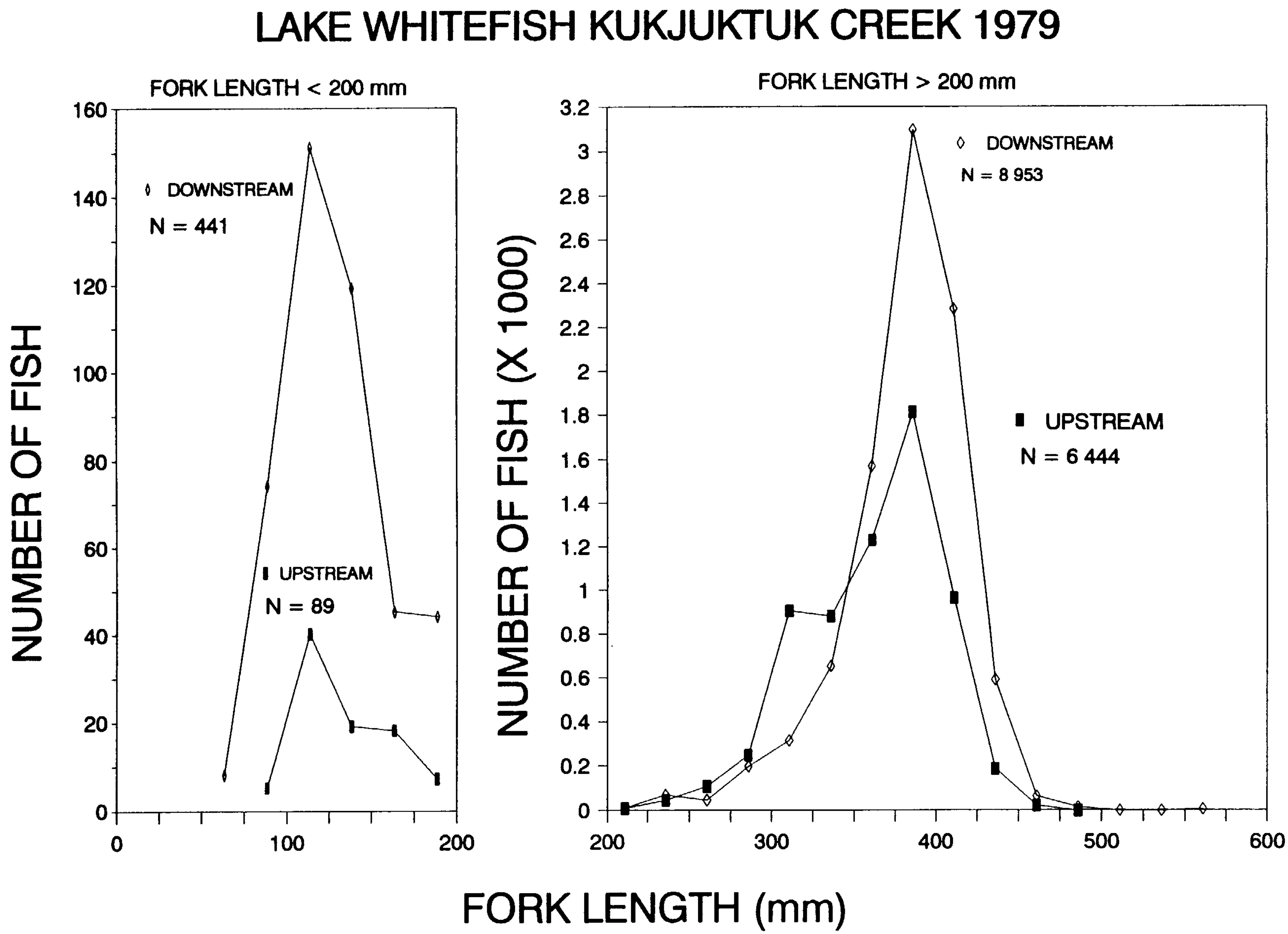


Fig. 17. The estimated overall length-frequency distribution for lake whitefish in the upstream and downstream migrations in Kukjuktuk Creek in 1979.

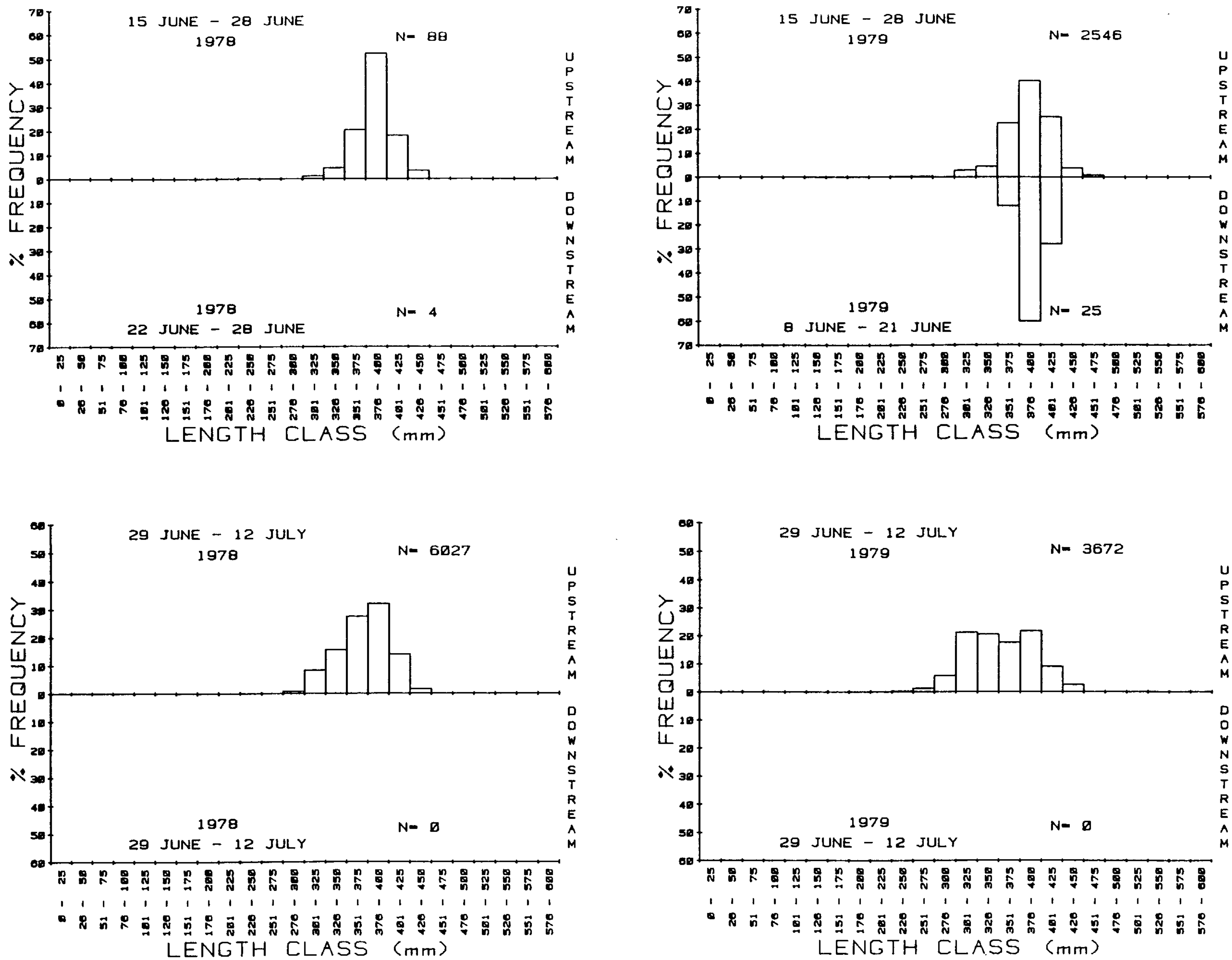


Fig. 18. Length frequency distribution per biweekly period for lake whitefish migrations in Kukjuktuk Creek in 1978 and 1979.

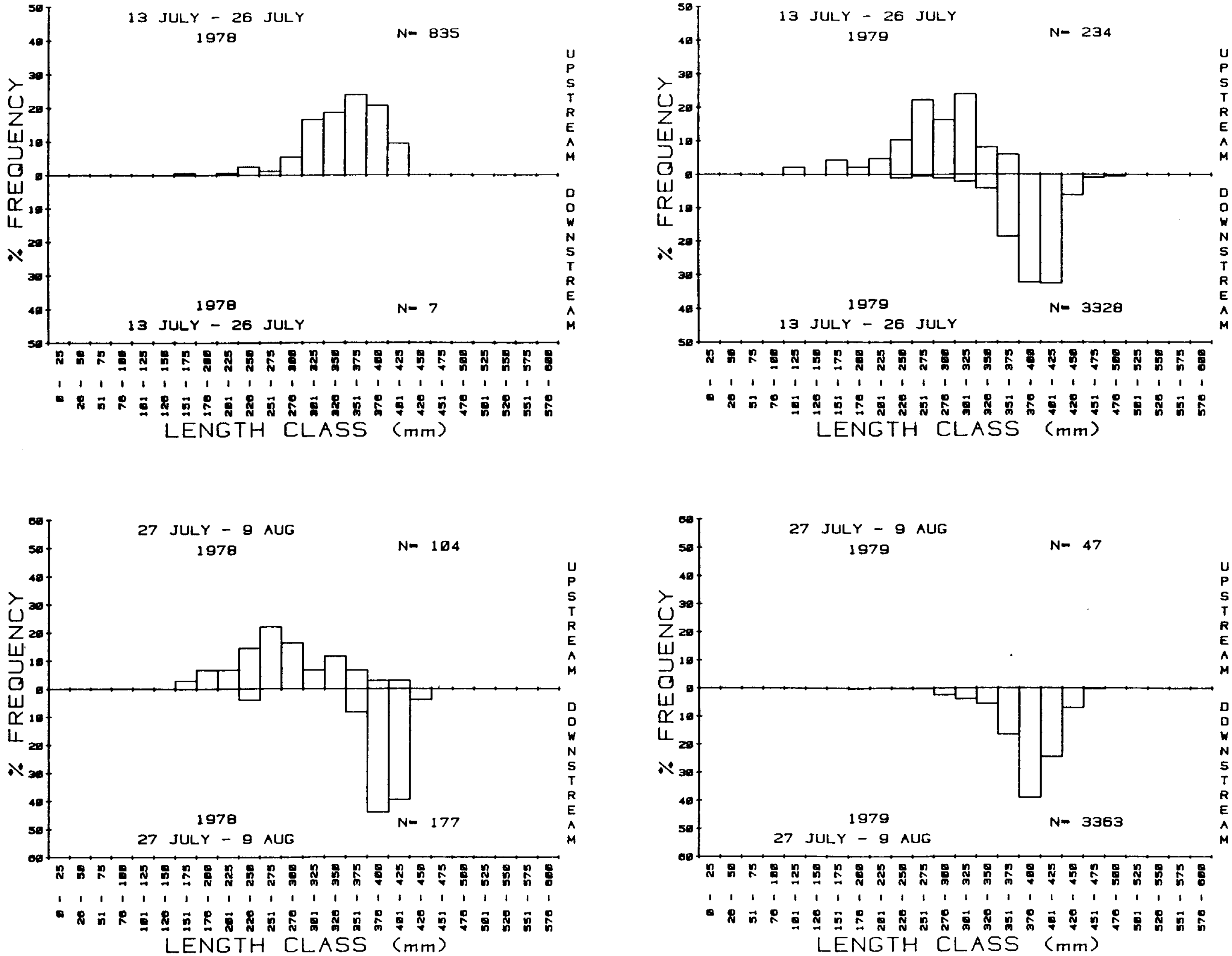
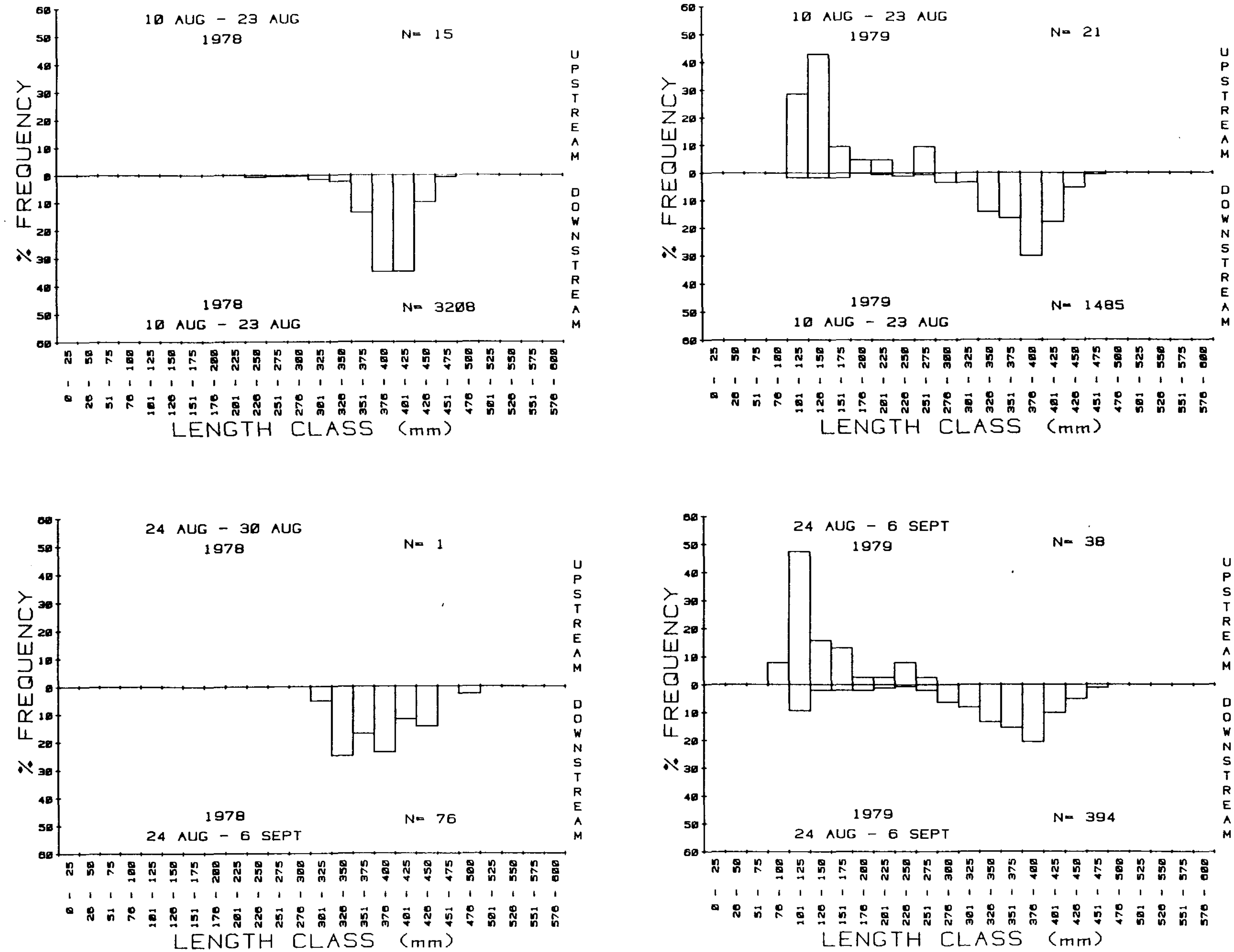
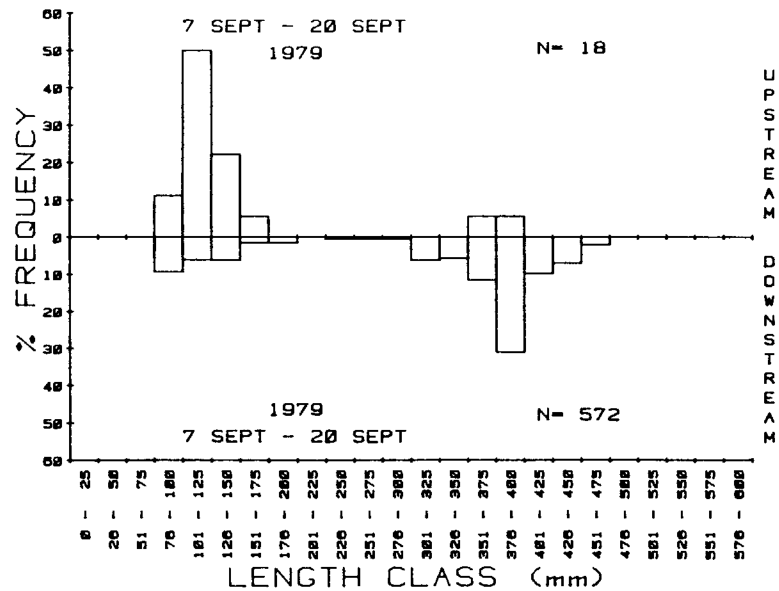

13 JULY - 26 JULY
1978
N= 835
1978
13 JULY - 26 JULY
N= 7
13 JULY - 26 JULY
1979
N= 234
1979
13 JULY - 26 JULY
N= 3328
27 JULY - 9 AUG
1978
N= 104
1978
27 JULY - 9 AUG
N= 177
27 JULY - 9 AUG
1979
N= 47
1979
27 JULY - 9 AUG
N= 3363
% FREQUENCY
LENGTH CLASS (mm)
UPSTREAM
DOWNSTREAM

Fig. 18. Cont.



10 AUG - 23 AUG
1978
N= 15
1978
N= 3208
10 AUG - 23 AUG
10 AUG - 23 AUG
1979
N= 21
1979
N= 1485
10 AUG - 23 AUG
24 AUG - 30 AUG
1978
N= 1
1978
N= 76
24 AUG - 6 SEPT
24 AUG - 6 SEPT
1979
N= 38
1979
N= 394
24 AUG - 6 SEPT
% FREQUENCY
UPSTREAM
DOWNSTREAM
LENGTH CLASS (mm)

Fig. 18. Cont.


7 SEPT - 20 SEPT
1979
N= 18
UPSTREAM
DOWNSTREAM
1979
7 SEPT - 20 SEPT
N= 572
% FREQUENCY
LENGTH CLASS (mm)

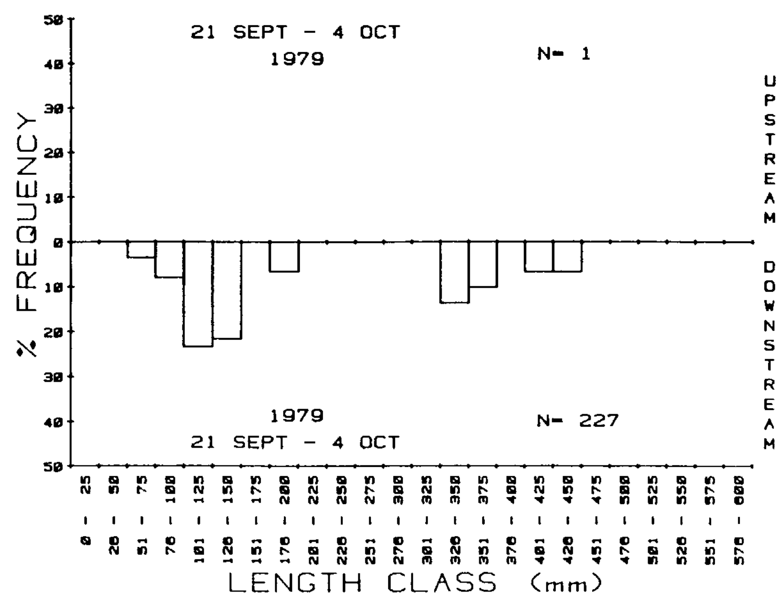
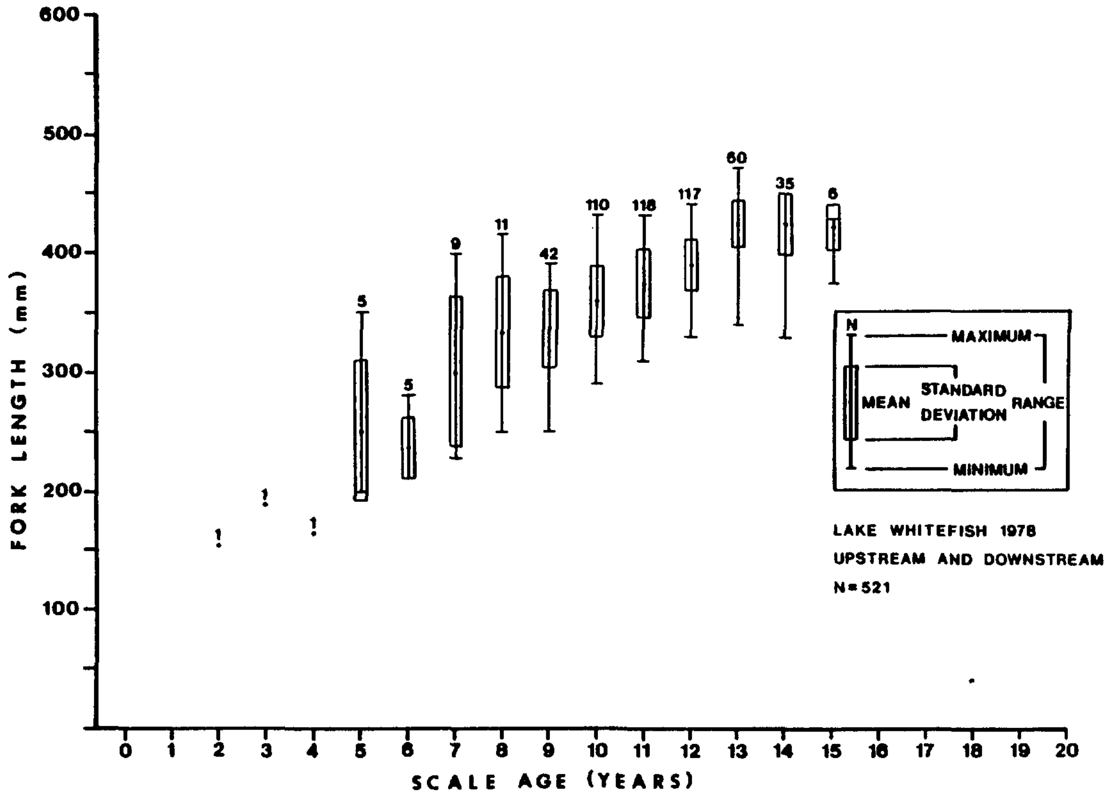

21 SEPT - 4 OCT
1979
N= 1
UPSTREAM
DOWNSTREAM
1979
21 SEPT - 4 OCT
N= 227
% FREQUENCY
LENGTH CLASS (mm)

Fig. 18. Cont.



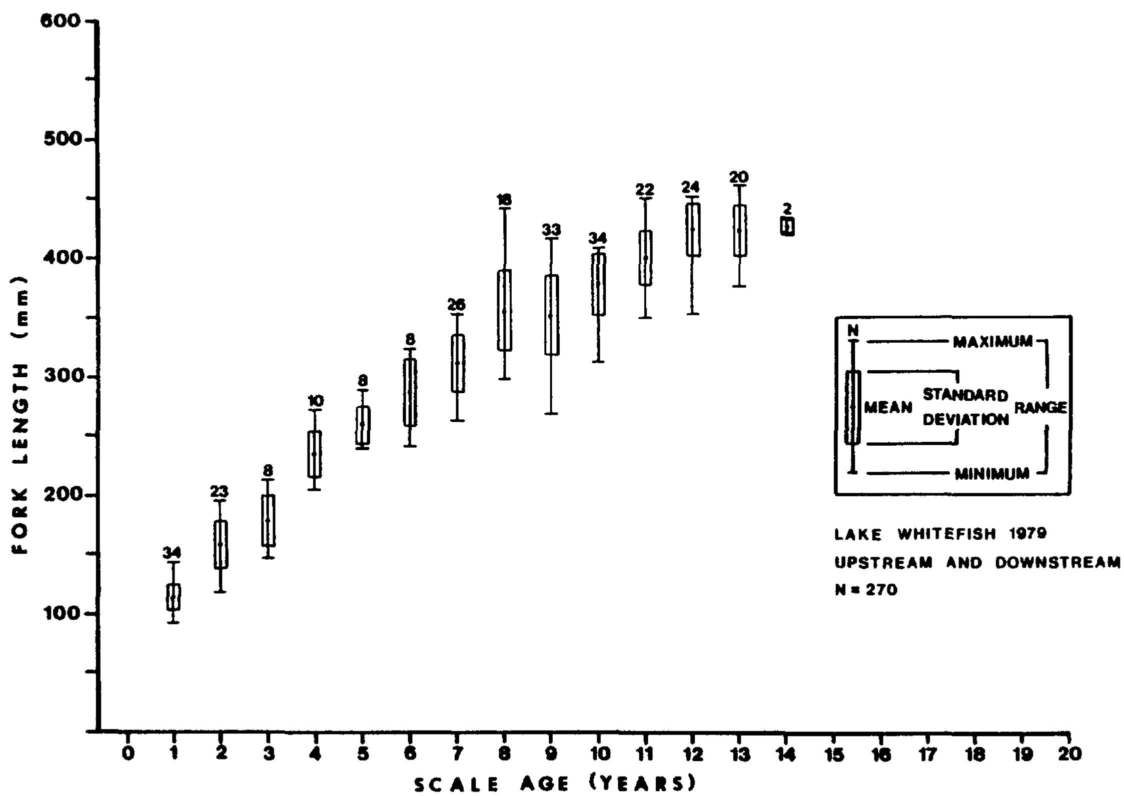


Fig. 19. Growth in fork length for lake whitefish from Kukjuktuk Creek in 1978 and 1979.

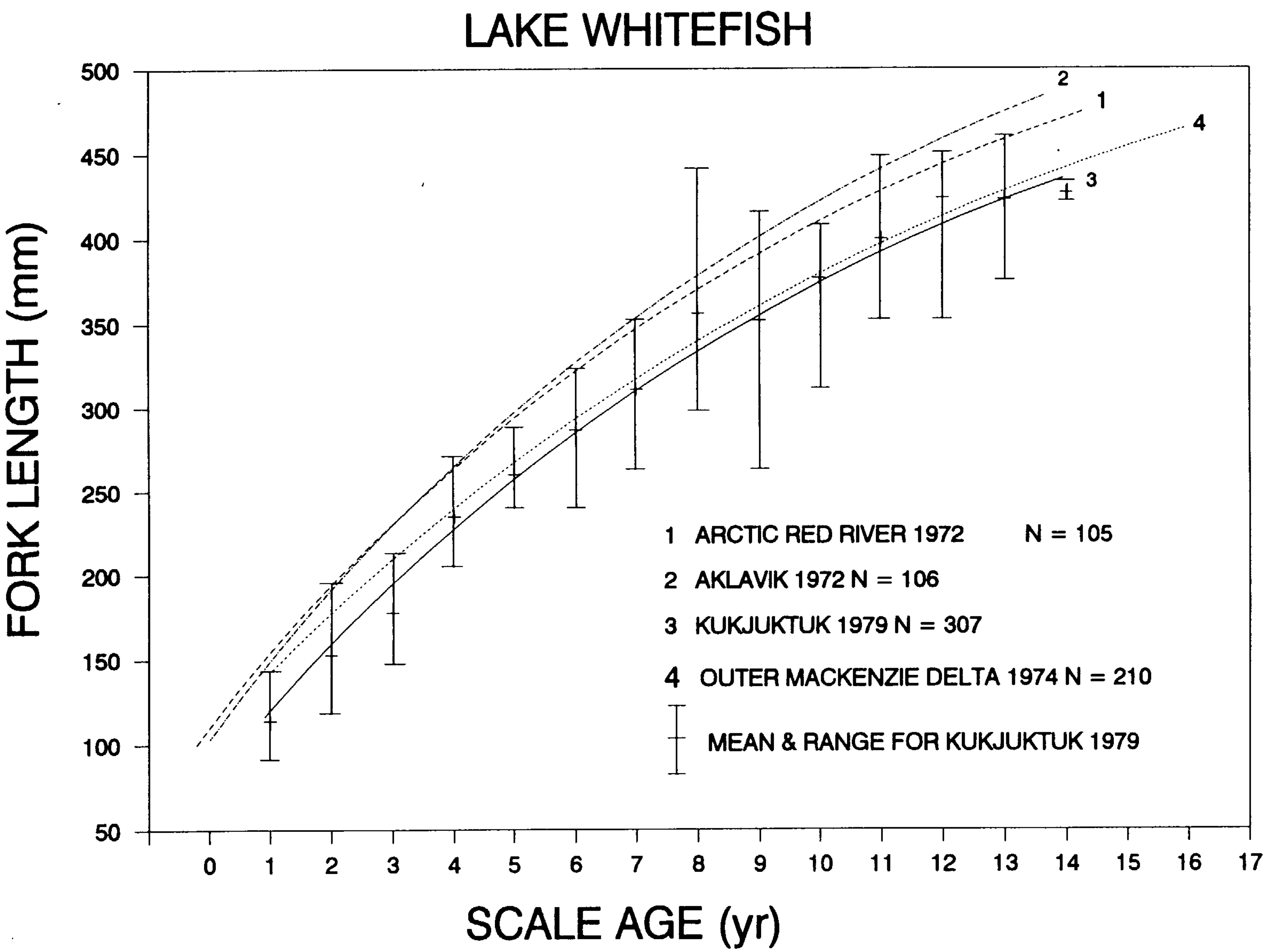


Fig. 20. Comparison of the growth rate for Kukjuktuk Creek lake whitefish with those from three other areas in the Mackenzie Delta: 1. Arctic Red River/upper Delta (Stein et al. 1973c); 2. Aklavik/middle Delta (Stein et al. 1973c); 4. Outer Delta (Percy, 1975).

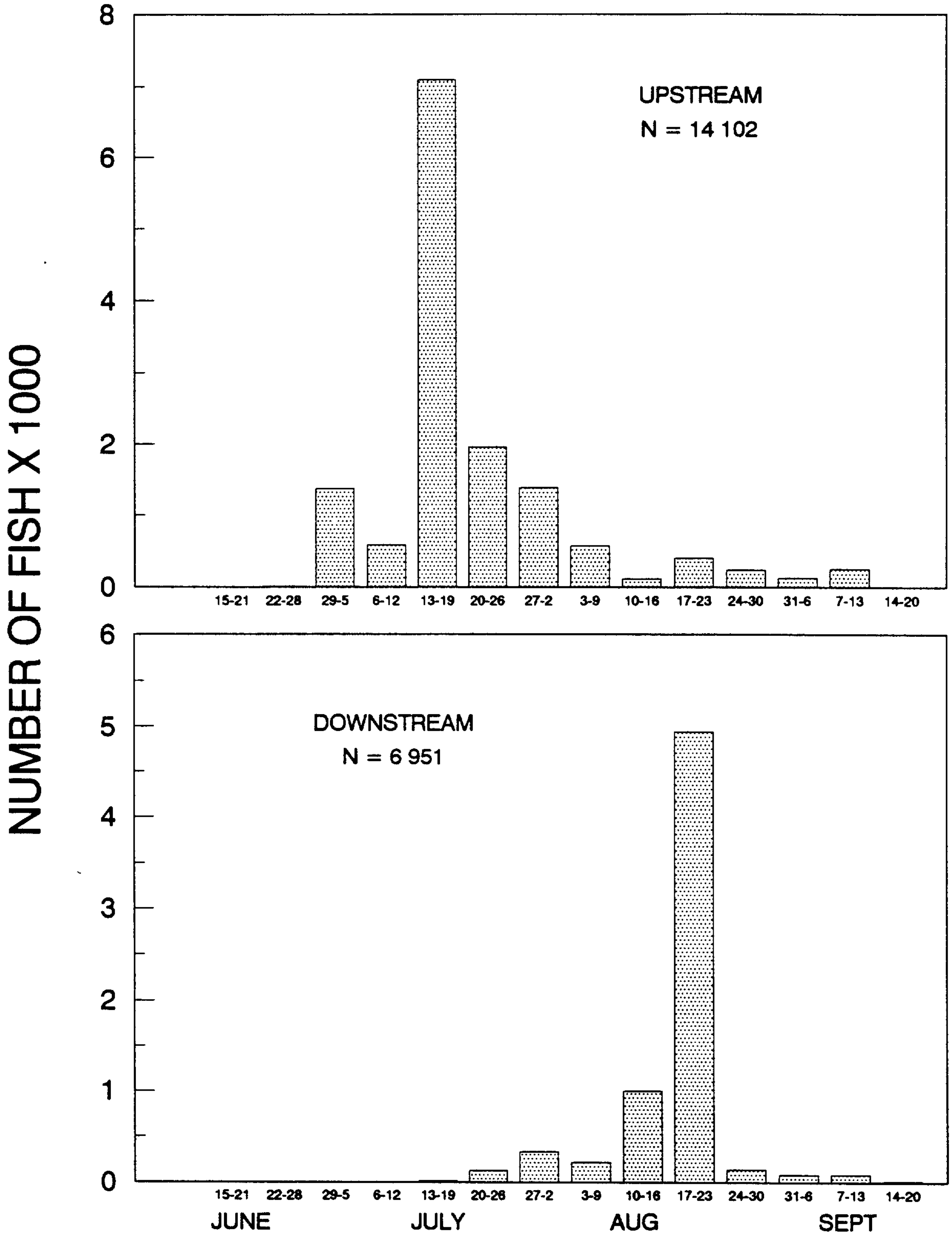


Fig. 21. Total number of least cisco per week moving through the upstream and downstream trap at Kukjuktuk Creek, 1978.

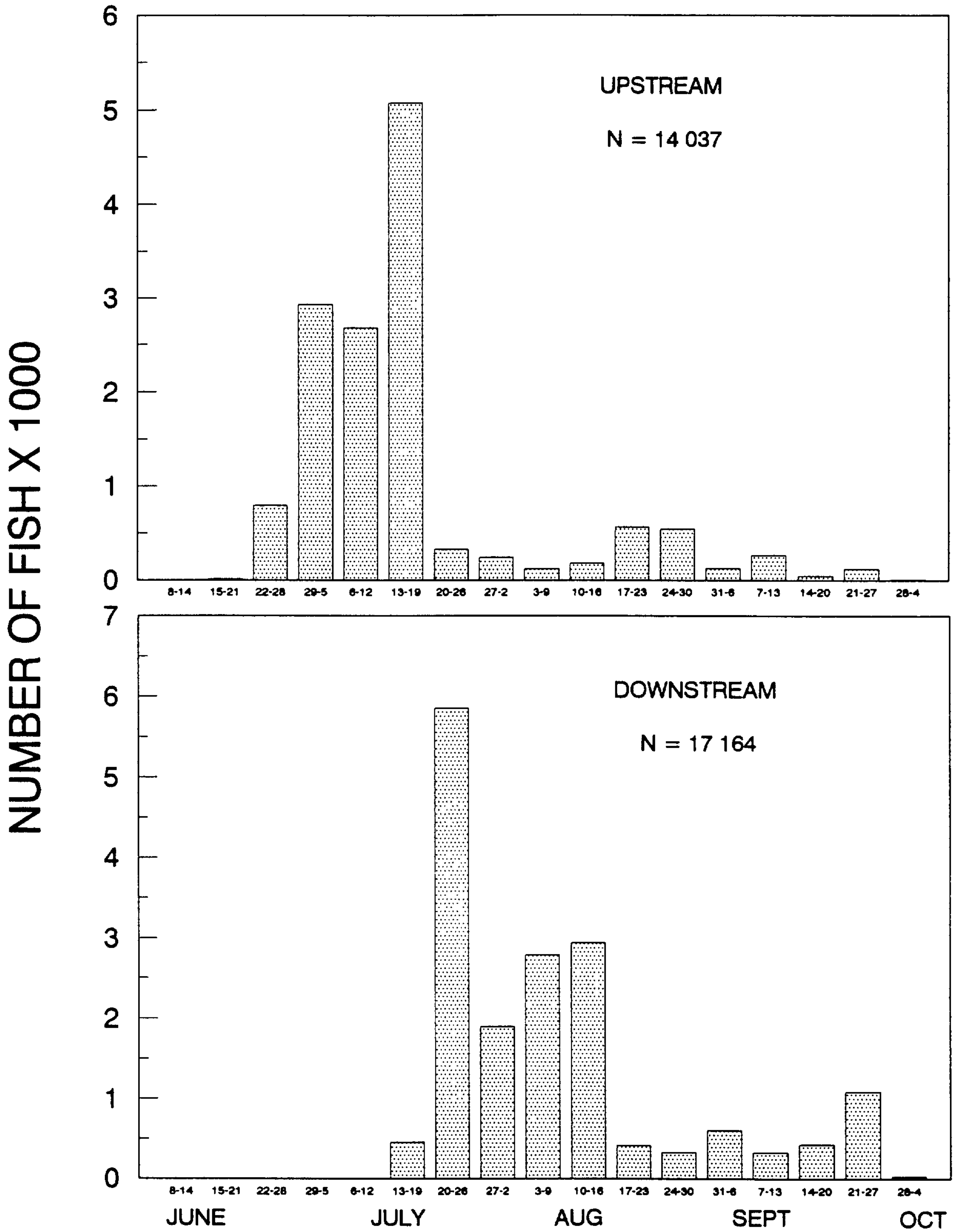


Fig. 22. Total number of least cisco per week moving through the upstream and downstream trap at Kukjuktuk Creek, 1979.

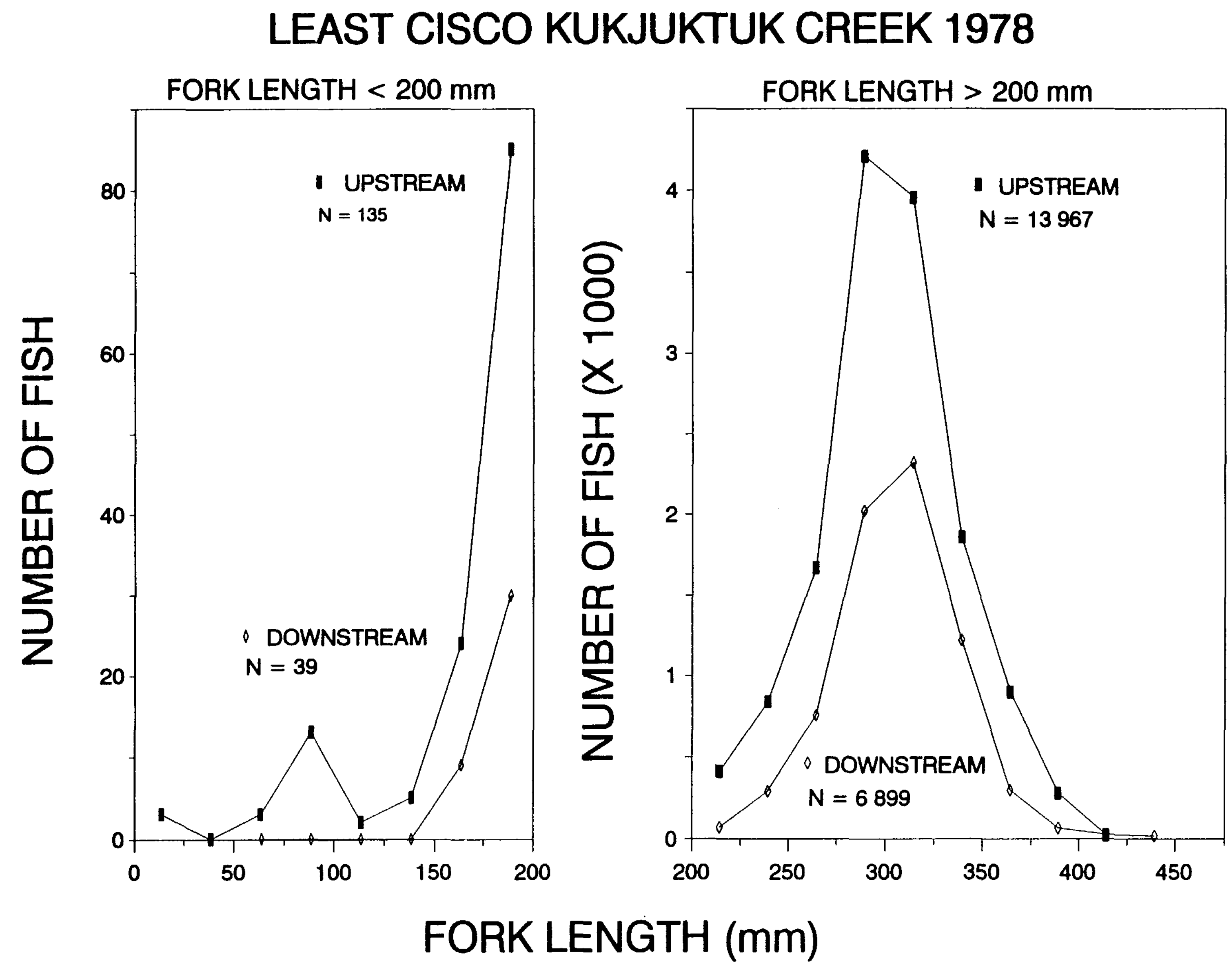


Fig. 23. The estimated overall length-frequency distribution for least cisco in the upstream and downstream migrations in Kukjuktuk Creek in 1978.

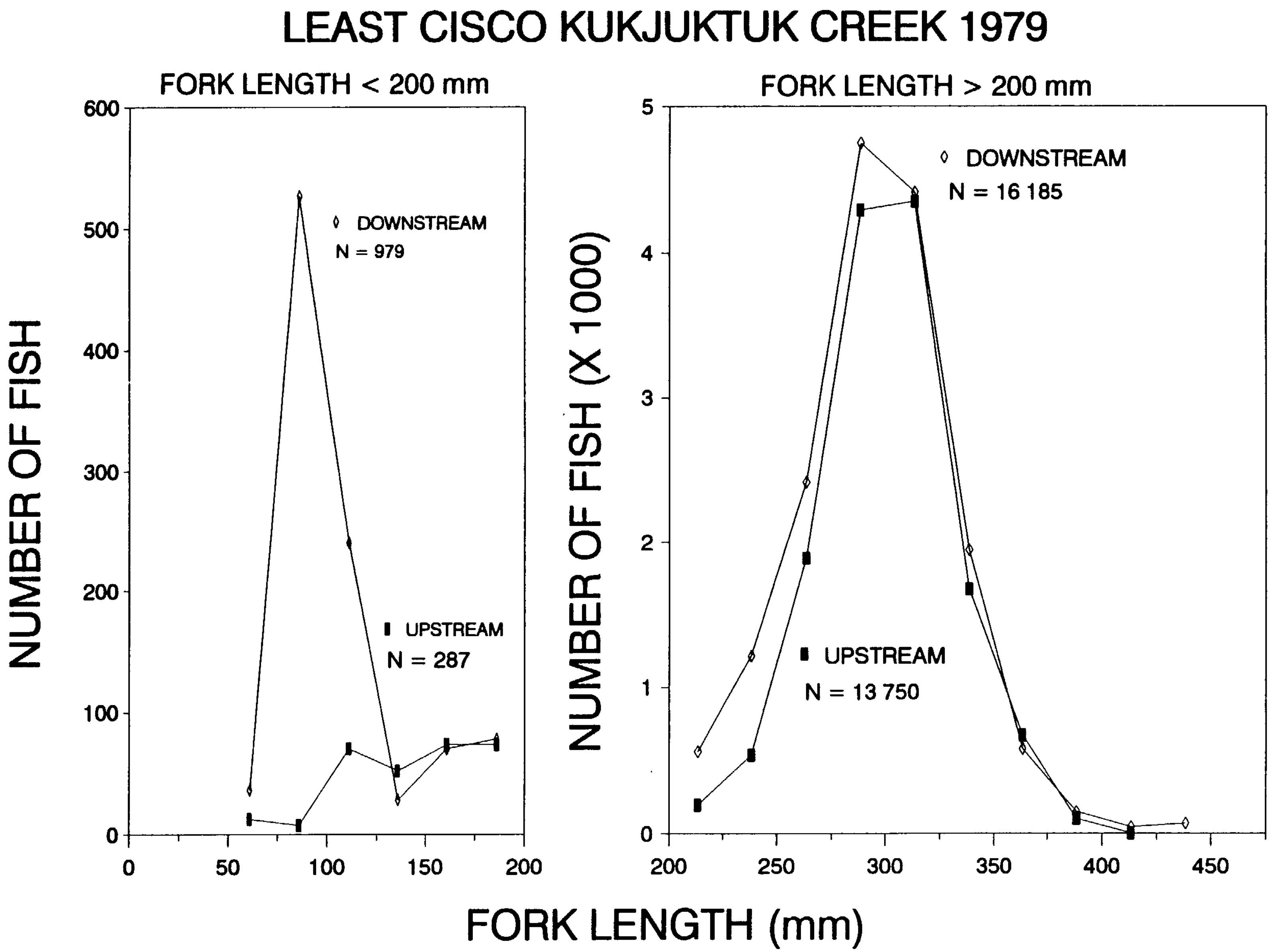


Fig. 24. The estimated overall length-frequency distribution for least cisco in the upstream and downstream migrations in Kukjuktuk Creek in 1979.

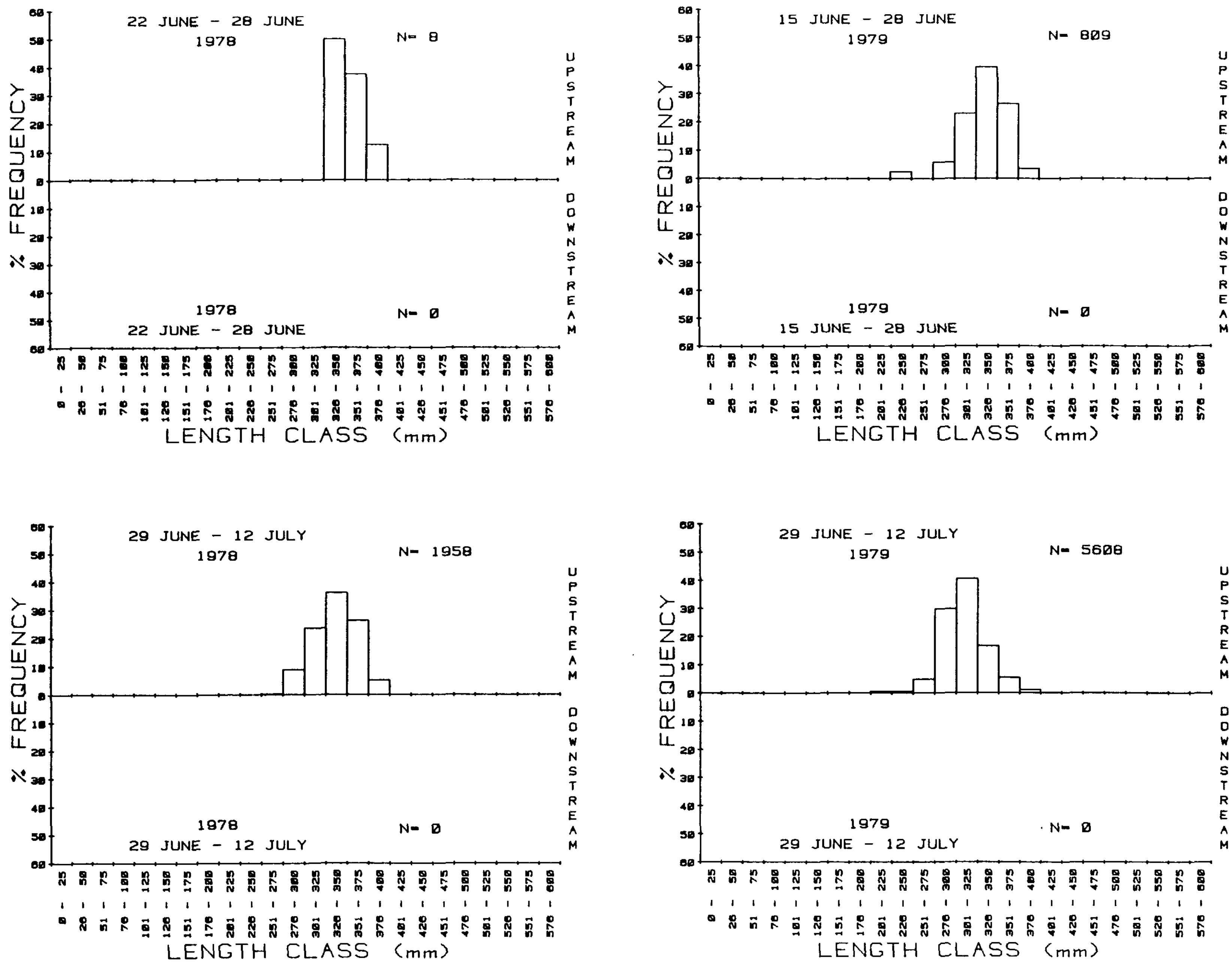


Fig. 25. Length frequency distribution per biweekly period for least cisco migrations in Kukjuktuk Creek in 1978 and 1979.

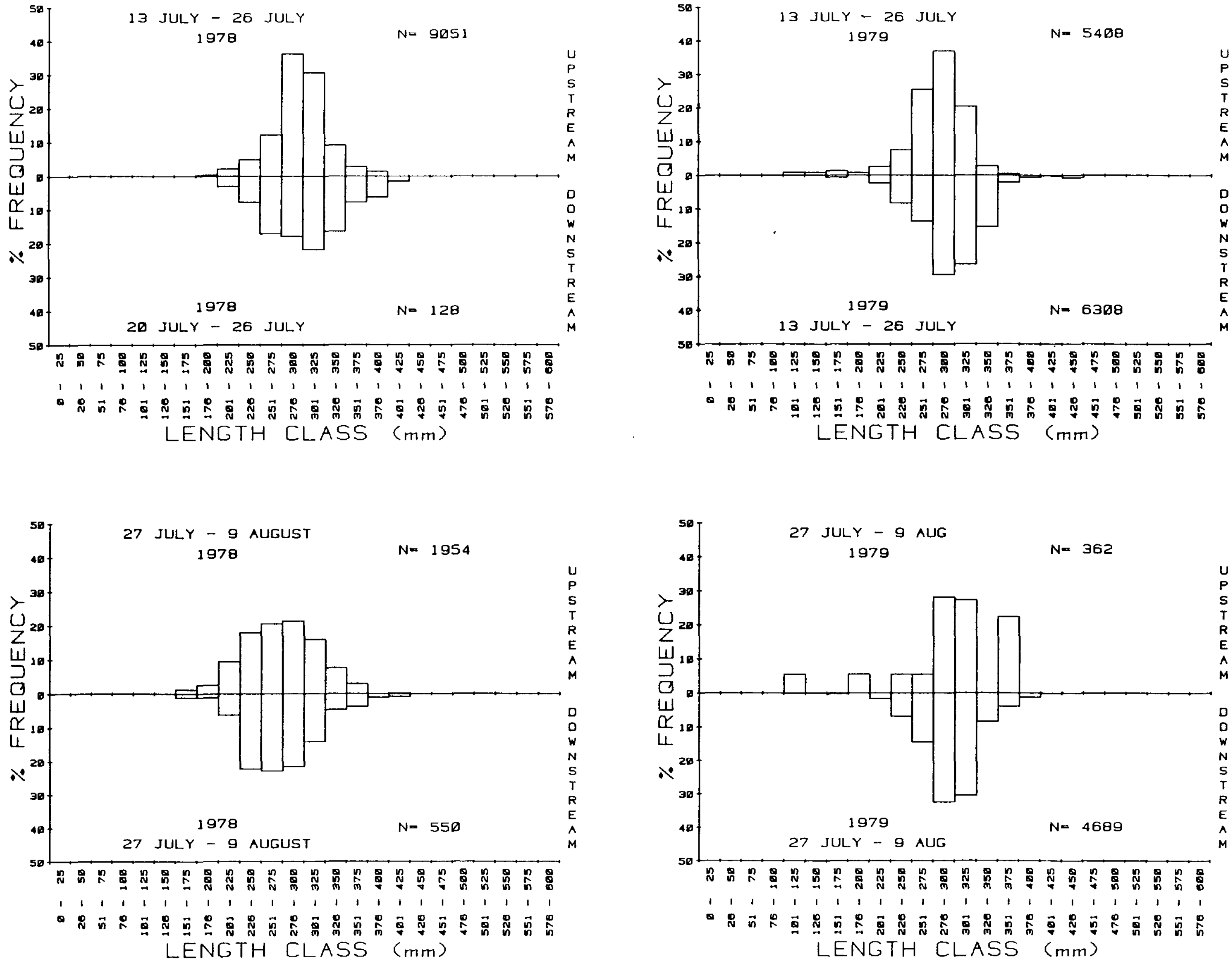

13 JULY - 26 JULY
1978
N= 9051
1978
N= 128
20 JULY - 26 JULY
13 JULY - 26 JULY
1979
N= 5408
1979
N= 6308
13 JULY - 26 JULY
27 JULY - 9 AUGUST
1978
N= 1954
1978
N= 550
27 JULY - 9 AUGUST
27 JULY - 9 AUG
1979
N= 362
1979
N= 4689
27 JULY - 9 AUG
% FREQUENCY
LENGTH CLASS (mm)
UPSTREAM
DOWNSTREAM

Fig. 25. Cont.

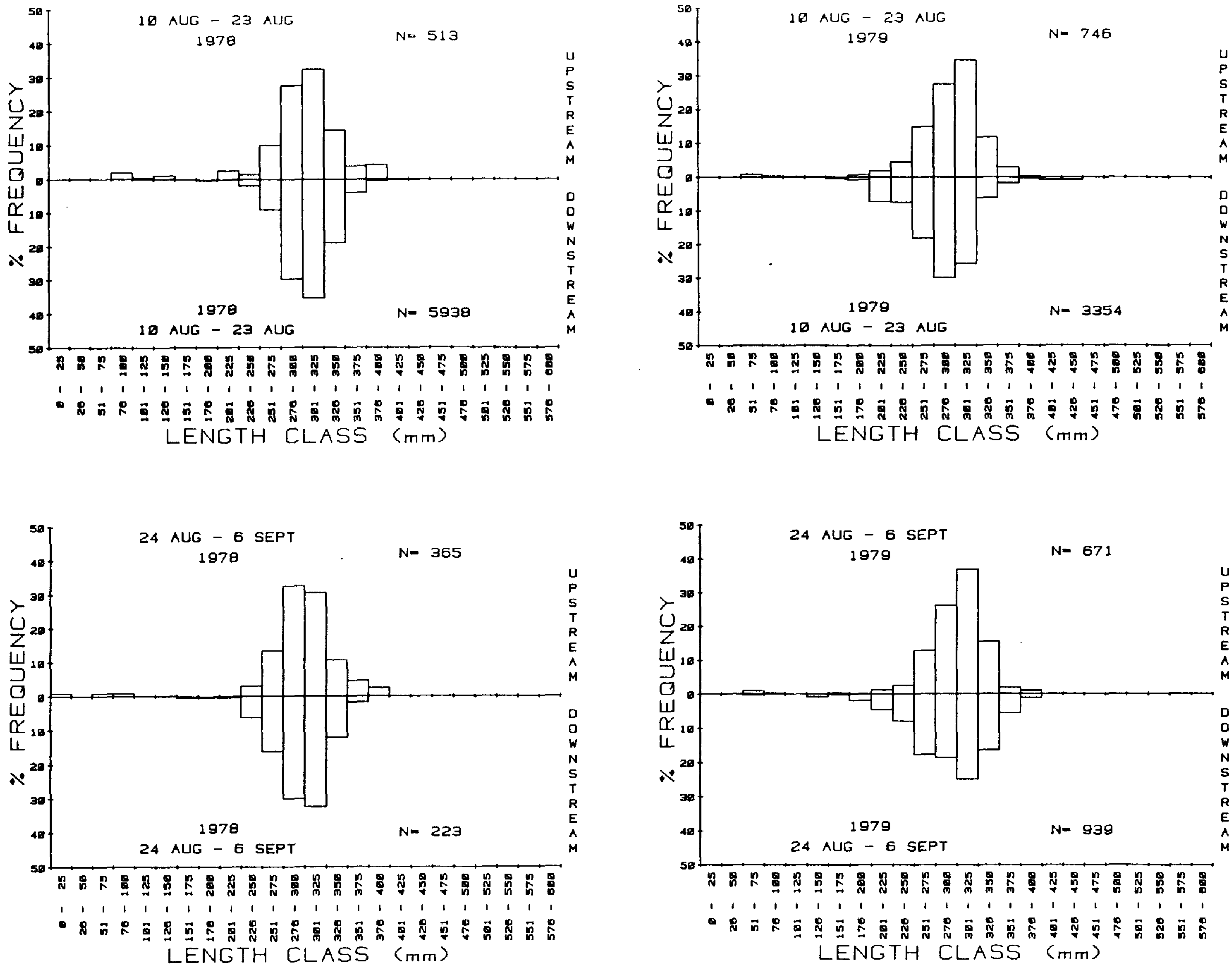

10 AUG - 23 AUG
1978
N= 513
1978
10 AUG - 23 AUG
N= 5938
10 AUG - 23 AUG
1979
N= 746
1979
10 AUG - 23 AUG
N= 3354
24 AUG - 6 SEPT
1978
N= 365
1978
24 AUG - 6 SEPT
N= 223
24 AUG - 6 SEPT
1979
N= 671
1979
24 AUG - 6 SEPT
N= 939
% FREQUENCY
UPSTREAM
DOWNSTREAM
LENGTH CLASS (mm)

Fig. 25. Cont.

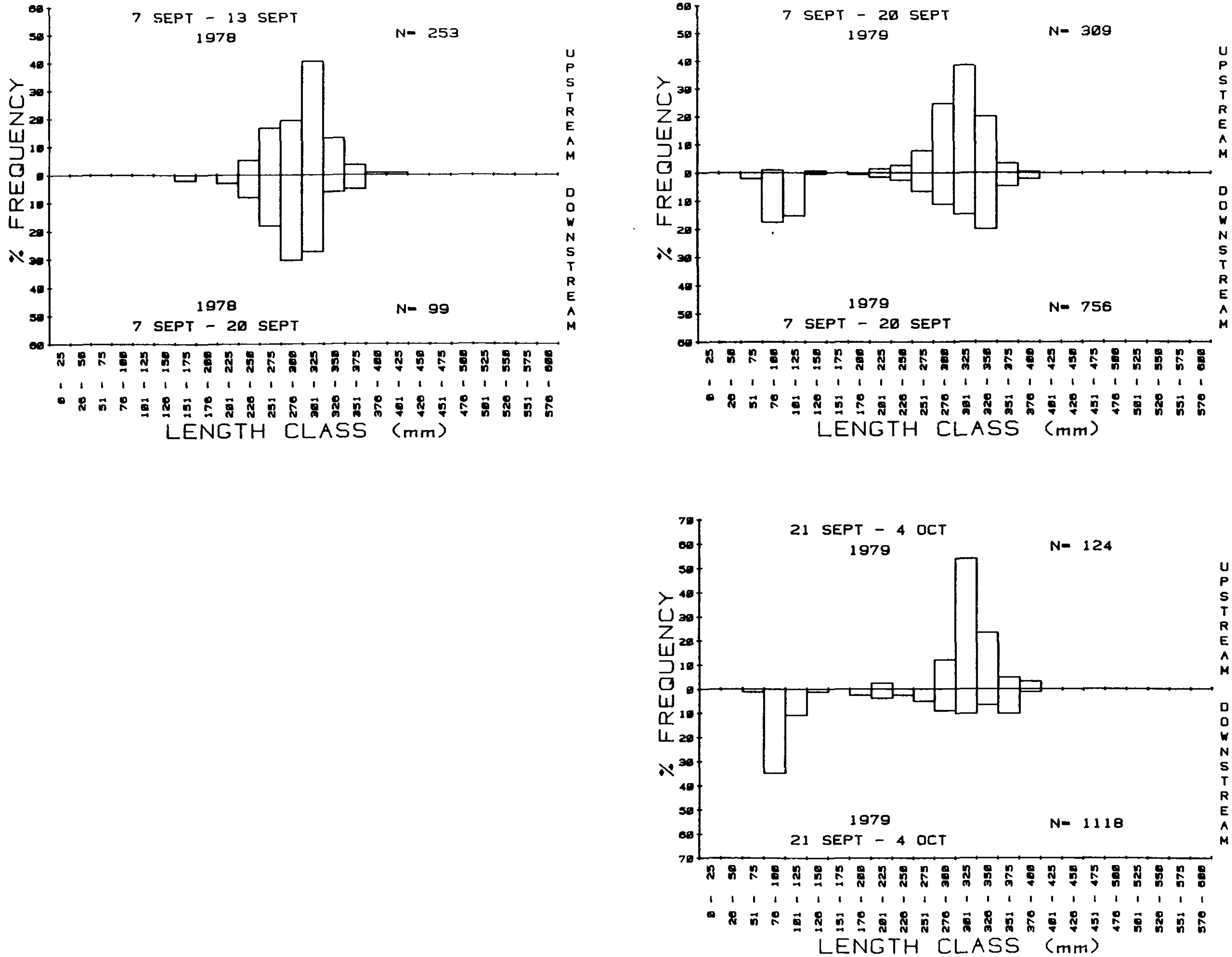

7 SEPT - 13 SEPT
1978
N= 253
% FREQUENCY
UPSTREAM
DOWNSTREAM
1978
N= 99
7 SEPT - 20 SEPT
LENGTH CLASS (mm)
7 SEPT - 20 SEPT
1979
N= 309
% FREQUENCY
UPSTREAM
DOWNSTREAM
1979
N= 756
7 SEPT - 20 SEPT
LENGTH CLASS (mm)
21 SEPT - 4 OCT
1979
N= 124
% FREQUENCY
UPSTREAM
DOWNSTREAM
1979
N= 1118
21 SEPT - 4 OCT
LENGTH CLASS (mm)

Fig. 25. Cont.

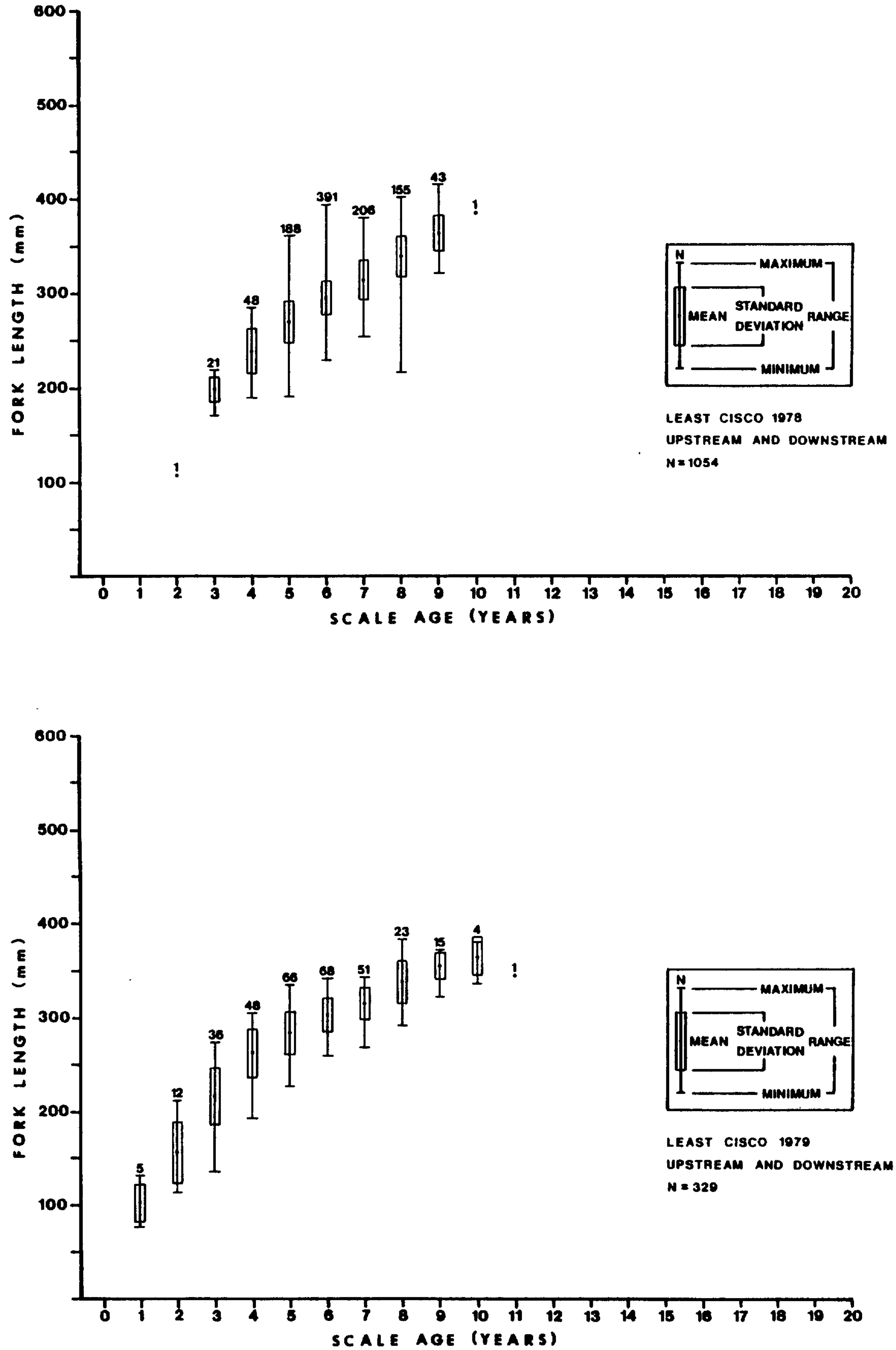


Fig. 26. Growth in fork length for least cisco from Kukjuktuk Creek in 1978 and 1979.

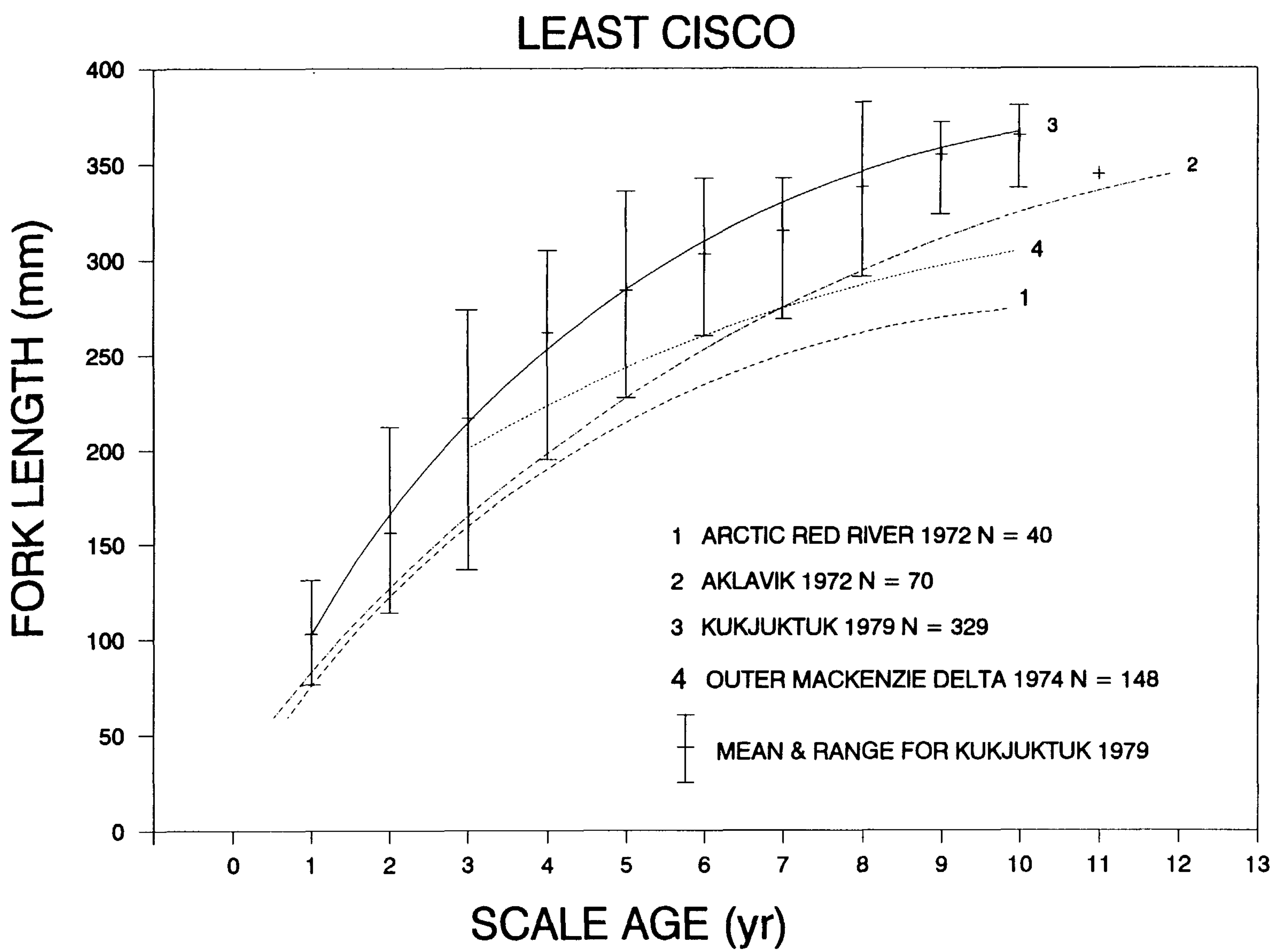


Fig. 27. Comparison of the growth rate for Kukjuktuk Creek least cisco with those from three other areas in the Mackenzie Delta: 1. Arctic Red River/upper Delta (Stein et al. 1973c); 2. Aklavik/middle Delta (Stein et al. 1973c); 4. Outer Delta (Percy, 1975).

Table A1.1. Water chemistry data for Kukjuktuk Creek, 1978.

Date	Water Temp (C°)	Conductivity ($\mu S \cdot cm^{-1}$)	pH	Total Hardness ($mg \cdot L^{-1}$)	Methyl Alkalinity ($mg \cdot L^{-1}$)	Total Discharge ($m^3 \cdot sec^{-1}$)	Suspended Carbon ($\mu g \cdot L^{-1}$)	Suspended Nitrogen ($\mu g \cdot L^{-1}$)	Total Suspended Solids ($mg \cdot L^{-1}$)
13/6/78	1.0		6.8	34	21				
14/6/78	0.9		7.0	34	21				
15/6/78	1.5		7.0	51	27				
16/6/78	1.0		7.0	34	21				
17/6/78	3.1		7.0	34	21				
18/6/78	2.9		7.5	51	34				
19/6/78	3.6		7.5	51	48				
20/6/78	1.0		7.5	51	41				
21/6/78	2.2		7.5	51	41		375	52	5
22/6/78	2.7		7.5	69	41		1080	182	23
23/6/78	3.8	66	7.5	69	41		925	110	16
24/6/78	4.0	73	7.5	69	41		715	112	13
25/6/78*							1145	167	24
							780	137	24
							1100	155	25
	5.3	80	7.5	69	35		915	118	23
							1580	195	30
							1220	159	27
01/7/78	12.7	130	7.5	69	69		885	128	17
02/7/78	10.0	139	7.5	86	73		930	146	15
03/7/78	10.2	130	7.5	86	69		870	111	18
04/7/78	10.8	133	7.5	86	75		1095	130	19
05/7/78	11.6	111	8.5	69	75		1500	181	25
06/7/78	13.7	126	8.5	69	-		1035	136	15
07/7/78	16.8	126	7.5	69	-		1280	160	20
08/7/78	17.3	132	7.5	69	-		1235	135	18
09/7/78*							705	77	13
							965	98	14
	14.6	123	8.5	69			1000	105	14
							1075	122	14
							825	97	13
10/7/78		142	7.0	80	40		995	95	15
11/7/78	12.7	126	7.7	80	40		625	87	11
12/7/78	14.3	123	7.6	80	40		800	94	11
13/7/78	11.1	115	7.8	80	40		775	100	15
14/7/78	10.8	120	7.7	60	40		590	89	12
15/7/78	10.3	118	7.7	60	40		660	87	12
16/7/78	10.9	116	7.3	60	40		455	57	8
17/7/78	13.2	127	-	60	60		405	50	7
18/7/78	12.8	128	7.15	60	40		420	49	7
19/7/78	12.2	122	7.65	60	40		325	45	5
20/7/78	15.3	135	7.75	60	40		280	38	5
21/7/78	13.4	132	7.80	60	60		540	70	9
22/7/78	15.1	135	7.40	80	60		450	54	7
23/7/78*							305	55	4
							315	38	5
							335	50	6
	11.7	121	7.50	80	40		875	75	7
							1640	88	7
							675	59	5
24/7/78	10.6	121	7.50	60	60		1810	114	12
25/7/78	13.2	123	7.64	60	60		1065	72	9
26/7/78	12.9	133	7.50	60	60		980	74	6
27/7/78	14.0	136	7.60	80	60		2045	121	19
28/7/78	13.5	134	7.60	80	60		1810	214	17
29/7/78	13.9	133	7.60	80	60		1180	74	9
30/7/78	-	155	7.40	80	60		460	68	7
31/7/78	11.1	129	7.60	80	60		495	72	7

Table A1.1. Continued.

Date	Water Temp (C°)	Conductivity ($\mu S \cdot cm^{-1}$)	pH	Total Hardness ($mg \cdot L^{-1}$)	Methyl Alkalinity ($mg \cdot L^{-1}$)	Total Discharge ($m^3 \cdot sec^{-1}$)	Suspended Carbon ($\mu g \cdot L^{-1}$)	Suspended Nitrogen ($\mu g \cdot L^{-1}$)	Total Suspended Solids ($mg \cdot L^{-1}$)
01/8/78							ND	ND	ND
02/8/78	16.1	150	7.90	90	40		355	45	2
03/8/78	12.2	134	8.10	90	40		1790	224	28
04/8/78	15.0	145	8.50	100	75		355	35	3
05/8/78	-	134	7.50	170	70		615	76	6
06/8/78*							1845	213	11
							2245	348	25
		130	7.50	70	85		ND	ND	14
							670	68	6
							1155	164	12
							5875	740	82
07/8/78	-	125	8.00	70	85				9
08/8/78	9.1	125	7.70	70	62		745	82	7
09/8/78	8.0	122	7.60	70	62		2275	231	30
10/8/78	8.3	122	7.70	70	62		620	65	2
11/8/78	10.2	127	7.70	70	55		540	72	5
12/8/78	9.5	123	7.70	70	55		520	65	5
13/8/78	10.0	128	7.50	70	75		690	81	6
14/8/78	6.8	115	8.50	100	75		1370	61	7
15/8/78	4.7	115	8.03	-	-		350	43	5
16/8/78	4.5	112	7.50	100	62		500	60	3
17/8/78	4.2	108	7.80	100	75		470	61	3
18/8/78	6.0	120	8.00	70	75		425	57	3
19/8/78	-	131	7.70	70	75		405	54	2
20/8/78*							955	77	7
							825	73	5
	8.8	123	8.00	85	90		750	58	4
							700	73	4
21/8/78	11.0	137	7.90	85	70		584	64	3
22/8/78	8.2	126	7.60	85	75		420	54	2
23/8/78	8.4	132	7.70	100	75		2010	190	23
24/8/78	5.9	120	7.73	100	80		460	62	3
25/8/78	5.2	118	7.72	85	75		560	70	6
26/8/78	4.9	115	7.50	70	55		2250	216	25
27/8/78	2.9	106	7.75	85	70		1925	167	18
28/8/78	3.3	112	7.75	85	70		480	56	4
29/8/78	-	-	-	-	-		ND	ND	6
30/8/78	8.8	115	7.83	85	75		510	60	6
31/8/78	8.7	125	7.85	120	70		620	69	8
01/9/78	8.2	120	7.85	100	75		410	48	3
02/9/78	7.4	128	7.90	85	70		435	49	5
03/9/78	5.6	120	7.80	85	75		903	93	14
04/9/78*							500	63	7
							480	51	6
	6.9	121	7.80	85	70		335	51	6
							ND	ND	6
05/9/78	5.9	121	7.80	80	75		425	48	6
06/9/78	6.8	130	7.70	60	60		845	95	14
07/9/78	-		7.70	-	-		610	74	9
08/9/78	6.5	115	7.49	100	60		330	43	5
09/9/78	6.0	110	7.59	85	80		625	69	10
10/9/78*							370	45	7
							445	58	6
	7.7	134	7.70	100	90		335	44	5
							560	72	7

* Samples taken along transect

Table A1.2. Water chemistry and discharge data for Kukjuktuk Creek, 1979.

Date	Water Temp (C^0) Min.	Water Temp (C^0) Max	Conductivity ($\mu S \cdot cm^{-1}$)	pH	Total Hardness ($mg \cdot L^{-1}$)	Methyl Alkalinity ($mg \cdot L^{-1}$)	Total Discharge ($m^3 \cdot sec^{-1}$)	Suspended Carbon ($\mu g \cdot L^{-1}$)	Suspended Nitrogen ($\mu g \cdot L^{-1}$)	Total Suspended Solids ($mg.L^{-1}$)
07/6/79							.15			
08/6/79							.15			
09/6/79										
10/6/79							.15			
11/6/79							.15			
16/6/79	1.5	4.5	75	7.4	34	68.0		800	127	11
								308	59	3
								276	45	2
								380	73	3
								292	78	3
17/6/79*	1.2	6.2	128	7.4	51	61.2	.38	886	161	20
								676	114	16
								718	139	12
								912	140	15
								822	169	12
18/6/79	2.4	7.5	174	7.2	68	68.0		742	111	11
19/6/79	2.8	8.8	158		68	61.2		590	116	7
20/6/79	3.8	9.0	151	7.7	68	61.2		552	88	9
21/6/79	4.0	11.0	154	7.4	68	68.0		540	131	6
22/6/79	6.2	7.3	147	7.2	68	54.4		556	79	6
23/6/79*	4.5	8.0	146	7.4	68	54.4	.37	526	109	8
								618	228	9
								870	155	11
								696	163	10
								700	136	11
24/6/79*	5.6	12.1	145	7.4	68	68.0		886	143	15
								2614	331	43
								1394	223	17
								1366	192	18
								1076	183	19
25/6/79	4.8	7.5	141		68	61.2		682	135	11
26/6/79*	3.8	8.0		7.3	68	61.2		820	158	14
								1222	170	21
								1464	210	26
								1786	208	29
								1598	228	30
27/6/79	3.8	8.0	198	7.1	51	61.2		714	105	7
28/6/79	5.2	10.0	167	7.2	68	68.0	.38	584	134	9
29/6/79	7.2	13.8		7.3	68	54.4	.33	548	104	12
30/6/79	8.2	15.0	136	7.1	68	68.0	.37	396	77	6
01/7/79	11.0	17.0		7.2	51	47.6	.38	398	76	5
02/7/79*	12.5	18.2	122	7.2	51	47.6	.41	330	59	3
								228	49	3
								232	41	3
								190	33	2
								398	83	6
03/7/79	13.5	19.0	124	7.4	68	47.6	.40	284	59	4
04/7/79	14.5	20.0	225	7.3	68	47.6	.38	240	62	3
05/7/79	12.0	19.0	117	7.3	51	40.8	.38	826	124	13
06/7/79	10.0	11.0	119	7.3	51	40.8	.37	618	93	9
07/7/79	9.5	12.0	120	7.3	51	47.6	.38	840	145	13
08/7/79*	10.0	14.8		7.2	51	47.6		448	65	6
								304	68	5
								266	60	5
								314	51	5
								352	71	6
09/7/79	11.0	13.0	130	7.3	51	47.6		318	56	5
10/7/79	10.5	21.0	128		51	47.6		388	64	4
11/7/79	13.0	19.8			51	47.6		522	84	6
12/7/79	10.0	15.0	125	7.3	51	47.6	.34	440	60	4
13/7/79	11.2	18.0	127	7.2	68	47.6	.33	368	59	4
14/7/79	13.5	21.0	130	7.4	68	47.6	.32	418	60	5
15/7/79*	15.5	21.2	132	7.3	68	54.4	.35	410	80	5

Table A1.2. Continued.

Date	Water Temp (C^0) Min.	Max	Conductivity ($\mu S \cdot cm^{-1}$)	pH	Total Hardness ($mg \cdot L^{-1}$)	Methyl Alkalinity ($mg \cdot L^{-1}$)	Total Discharge ($m^3 \cdot sec^{-1}$)	Suspended Carbon ($\mu g \cdot L^{-1}$)	Suspended Nitrogen ($\mu g \cdot L^{-1}$)	Total Suspended Solids ($mg.L^{-1}$)
								320	50	4
								242	43	3
					68	54.4		258	41	3
					68			244	45	3
16/7/79	17.0	20.5			68	54.4	.33	476	89	7
17/7/79	15.0	21.0	137	7.1	68	54.4	.32	250	50	3
18/7/79	11.5	21.0	139		68	54.4	.29	402	54	6
19/7/79	11.0	21.0	140	7.3	68	54.4	.32	310	39	3
20/7/79	11.0	21.0	142		68	54.4	.32	308	42	3
21/7/79	11.5	22.2	144		68	54.4	.24	252	57	2
22/7/79	13.0	23.0	146		68	54.4	.27	326	88	3
23/7/79*	18.5	21.5	146		68	54.4	.28	406	66	2
								256	68	2
								206	47	1
								322	59	3
								250	62	2
24/7/79	19.5	23.0	148		68	54.4	.25	414	77	4
25/7/79	17.4	22.2	149	7.1	68	54.4	.28	458	48	4
26/7/79	18.0	20.0	150		68	61.2	.23	300	36	2
27/7/79	14.0	19.0	151		68	54.4	.21	398	46	3
28/7/79	13.0	19.0	154		68	61.2	.15	322	58	2
29/7/79*	15.0	19.0	153		68	61.2	.20	298	53	2
								250	56	1
								286	45	2
								276	53	2
								516	77	1
30/7/79	14.0	17.0	152		68	54.4	.19	392	46	3
31/7/79	12.0	18.5	150		68	54.4	.20	442	46	2
01/8/79	12.4	20.5	154		68	68.0	.16	356	36	3
02/8/79	15.5	19.0	155	7.1	68	68.0	.19	448	74	2
03/8/79	14.5	16.5	155	7.1	68	68.0	.18	412	60	3
04/8/79	14.0	17.0	155	7.4	68	68.0	.19	422	58	2
05/8/79*	11.0	18.0	153	7.1	68	68.0	.23	426	55	2
								408	51	3
								368	60	2
								426	49	3
								362	51	3
07/8/79	10.5	15.5	160	6.9	68	68.0		420	61	2
08/8/79	10.5	18.0	158		68			2220	301	3
10/8/79	11.8	19.0	161		68			1910	218	2
11/8/79	15.0	21.0	160	7.6	68	68.0		1900	337	3
12/8/79*	16.2	21.5	160		68		.15	2240	243	2
								2940	420	2
								2590	508	2
								2310	417	3
								732		7
13/8/79	14.0	21.0	159		68	68.0	.23	272		3
14/8/79	14.0	21.0	164		68	68.0	.14	328		2
15/8/79	14.0	22.0	171		68	68.0	.12	752		3
16/8/79	16.0	21.0	168		68	85.0	.13	634		3
17/8/79	15.2	19.5	169		68	85.0	.14	786		5
18/8/79	11.0	15.0	155		68	68.0	.09	616		5
19/8/79*	12.5	14.5	177		68	68.0	.12	708		5
								636	95	3
								688	92	3
								604	111	4
								5492	665	85
20/8/79	10.5	18.0	171		68	61.2	.12	730	90	5
21/8/79	13.2	18.0	171		68	61.2	.12	696	89	4
22/8/79	11.0	17.5	165		68	61.2	.14	1536	179	10
23/8/79	8.2	10.2	149		85	54.4	.20	878	86	5
24/8/79	7.0	11.5	166	7.5	85	68.0	.15	705	104	4
25/8/79	7.5	12.0	163	7.5	68	61.2	.15	688	93	3
26/8/79*	10.0	12.5	167	7.5	68	61.2	.15	710	89	4
								858	121	5

Table A1.2. Continued.

Date	Water Temp (C^{o})		Conductivity ($\mu S \cdot cm^{-1}$)	pH	Total Hardness ($mg \cdot L^{-1}$)	Methyl Alkalinity ($mg \cdot L^{-1}$)	Total Discharge ($m^3 \cdot sec^{-1}$)	Suspended Carbon ($\mu g \cdot L^{-1}$)	Suspended Nitrogen ($\mu g \cdot L^{-1}$)	Total Suspended Solids ($mg.L^{-1}$)
	Min.	Max								
								708	88	4
								716	82	4
								1176	148	11
27/8/79	9.5	12.0	167	7.5	68	61.2	.13	874	103	5
28/8/79	8.5	11.0	140	7.5	68	68.0	.16	804	87	4
29/8/79	9.0	11.0	168	7.5	68	61.2	.17	818	106	9
30/8/79	8.8	10.5	167	7.5	68	61.2	.17	968	114	5
31/8/79	7.5	11.5	165	7.5	68	54.4	.15	752	88	4
01/9/79	8.5	10.5	169	7.5	68	61.2	.14	712	95	3
02/9/79*	8.0	10.0	170	7.5	68	61.2	.16	720	76	3
								630	76	3
								785	100	3
								673	83	4
								765	79	4
03/9/79	8.0	12.0	169	7.5	68	54.4	.17	795	99	4
04/9/79	8.5	10.5	171	7.5	68	61.2	.19	870	80	5
05/9/79	7.8	8.5	105	7.7	68	54.4	.18	934	112	5
06/9/79	7.0	9.0	162	7.7	68	61.2	.16	724	95	4
07/9/79	7.0	10.5	145	7.7	68	61.2	.16	800	94	4
08/9/79	8.2	9.5	172	7.7	68	61.2	.19	762	75	4
09/9/79	7.8	9.1	166	7.7	68	54.4	.19	640	94	3
10/9/79	7.8	9.0	172	7.7	68	61.2	.20	756	101	4
11/9/79	6.0	8.2	167	7.7	68	61.2	.19	824	85	4
12/9/79	4.8	7.0	171	7.7	68	61.2	.20	556	92	4
13/9/79	2.2	4.6	175	7.5	68	61.2		831	98	5
14/9/79	0.5	1.5	230	7.8	68	61.2	.07	760	95	5
15/9/79	0.2	1.0	181	7.8	68	61.2	.03	752	88	4
16/9/79*	0.2	2.8		7.5	68	61.2	.14	1520	209	10
								776	90	6
								810	83	5
								956	112	7
								918	80	7
17/9/79	1.0	2.2		7.5	68	61.2	.18	887	142	5
18/9/79	0.2	1.0		7.5	68	54.4	.17	1008	95	5
19/9/79	0.0	2.6		7.5	68	61.2	.15	980	110	5
20/9/79	0.0	5.0		7.5	68	61.2	.18	773	71	5
21/9/79	1.0	2.8		7.5	68	54.4	.18			
22/9/79	1.0	4.0		7.5	68	61.2	.16			
23/9/79	2.9	5.2		7.5	68	54.4	.14			
24/9/79	2.8	5.0		7.4	68	61.2	.16	737	68	2
25/9/79	1.6	4.0		7.6	68	61.2	.23			
26/9/79	2.7	4.8		7.5	68	61.2	.18	647	55	2
27/9/79	2.0	3.2		7.5	68	54.4	.15			
28/9/79	1.5	3.0		7.5	68	61.2	.15	33	73	2
29/9/79	0.0	0.2		7.5	68	61.2	.12	800	83	3
30/9/79	-	-		7.3	85	61.2		616	83	2

* Samples taken along transect

Table A2.1. Daily totals of broad whitefish, lake whitefish and least cisco at the Kukjuktuk Creek counting fence in 1978.

Date	Broad Whitefish		Lake Whitefish		Least Cisco	
	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream
19 June	4	0	2	0	0	0
20	22	0	23	0	0	0
21	4	0	14	0	0	0
22	1	1	1	1	0	0
23	0	0	2	0	0	0
24	0	0	0	0	0	0
25	2	8	5	3	0	0
26	3	0	8	0	0	0
27	9	0	12	0	0	0
28	10	1	21	0	8	0
29	382	0	154	0	38	0
30	5 669	0	630	0	180	0
1 July	8 427	0[a]	1 151	0[a]	186	0[a]
2	6 734		1 225		200	
3	9 297		1 449		433	
4	4 119		353		242	
5	1 327		115		90	
6	3 750		295		191	
7	3 766		464		126	
8	589		116		89	
9	59		12		10	
10	140		34		68	
11	71		15		26	
12	372		14		79	
13	421		20		88	
14	470		43		892	
15	531		81		1 408	
16	956		143		1 704	
17	3 094		253		2 011	
18	787		42		563	
19	775	32	89	2	425	13
20	690	36	12	0	546	10
21	579	70	22	2	205	26
22	621	108	58	0	173	47
23	78	0	8	0	45	0
24	584	61	31	2	296	27
25	842	60	15	1	329	18
26	989	No Count	18	No Count	366	No Count
27	720		13		403	
28	951	142	15	1	297	24
29	805	160	15	4	196	61
30	504	233	14	2	207	17
31	398	544	8	47	50	95
1 August	376	209	8	26	151	128
2	141	26	5	1	77	7
3	203	230	10	1	118	153
4	658	42	7	2	244	6
5	214	35	2	3	42	7
6	477	93	3	6	54	18
7	380	119	2	19	50	13
8	301	133	1	28	48	7
9	325	125	1	37	17	14
10	265	58	0	24	40	6
11	403	207	2	29	36	17
12	183	207	0	45	5	35
13	142	1 593	0	200	29	502
14	99	3	0	0	2	1
15	103	976	0	151	1	150
16	61	1 216	2	241	0	287
17	157	359	0	58	12	60
18	195	2 144	1	482	3	720
19	170	5 901	0	1 002	5	1 170
20	123	3 757	8	761	70	2 002
21	24	2 966	0	148	51	925

Table A2.1 Continued

Date		Broad Whitefish		Lake Whitefish		Least Cisco	
		Upstream	Downstream	Upstream	Downstream	Upstream	Downstream
22	August	274	264	2	67	259	63
23[b]		0		Fence Flooded			
24		0		Fence Flooded			
25		33	55	1	48	165	20
26		21		Fence Flooded		1	0
27		8	15	0	4	2	9
28		39	404	0	22	0	112
29		0	0	0	0	0	0
30		54	0	0	0	72	0
31		0	0	0	0	0	0
1	September	12	48	0	2	86	26
2		8	86	0	0	17	49
3		1	1	0	0	0	0
4		1	0	0	0	0	0
5		14	38	0	0	22	7
6		0	1	0	0	0	0
7		0	0	0	0	0	0
8		13	309	0	2	41	51
9		36	59	0	2	75	9
10		79	62	0	0	58	14
11		64	94	0	0	79	12
12		0	0	0	0	0	0
13		0	0	0	0	0	0
14		0	0	0	0	0	0
15		0	0	0	0	0	0
16		0	0	0	0	0	0
17		0	0	0	0	0	0
18		0	0	0	0	0	0
19		0	0	0	0	0	13
Total		65 209	23 291	7 070	3 476	14 102	6 951

[a]Downstream trap closed July 1 to July 14 due to large upstream migration.

[b]Fence inundated from August 23 to September 7; partial counts obtained.

Table A2.2 Daily totals of broad whitefish, lake whitefish and least cisco at the Kukjuktuk Creek counting fence in 1979.

	Broad Whitefish				Lake Whitefish		Least Cisco	
	Upstream (US)		Downstream (DS)		US	DS	US	DS
Date	>200 mm	<200 mm	>200 mm	<200 mm				
14 June	0	0	1	0	1	12		0
15	3	0	8	0	11	10		0
16	0	0[a]	2[a]	0[a]	0	2[a]		0[a]
17	19				16		1	
18	170				134		1	
19	278				139		3	
20	374				141		7	
21	1 633				132		0	
22	3 497				497		29	
23	124				48		0	
24	1 490				141		112	
25	3 609				621		383	
26	133				37		12	
27	975				206		64	
28	2 150				422		197	
29	3 608				350		252	
30	7 389				900		510	
1 July	5 876				639		381	
2	5 603				721		586	
3	1 564				184		286	
4	2 139	12			185		549	
5	1 249	14			110		366	
6	680	34			83		178	
7	478	27			51		154	
8	671	230			97		607	
9	748	212			117		397	
10	830	285			28		278	
11	2 940	602			139		534	
12	727	558			68		530	
13	1 743	1 169			92		816	
14	3 308	2 631			37		1 050	
15	2 861	3 497	70	0	41	0	1 305	2
16	1 531	5 164	86	0	37	0	983	0
17	944	3 519	1 054	0	11	48	447	115
18	562	6 465	872	0	6	23	236	97
19	425	9 419	1 669	0	4	78	240	239
20	508	12 459	2 321	0	3	71	154	382
21	132	10 709	3 482	0	1	325	65	618
22	22	7 604	3 158	0	0	302	44	846
23	283	8 350	5 453	0	1	579	42	965
24	0[b]	23 000*	7 393	0	0	827	4	1 090
25	1 328	13 369	4 275	0	0	647	17	1 120
26	357	11 505	2 405	21	1	428	5	834
27	164	7 747	810	0	26	191	62	262

Table A2.2 Cont'd

Date		Broad Whitefish				Lake Whitefish		Least Cisco	
		Upstream (US)		Downstream (DS)		US	DS	US	DS
		>200 mm	<200 mm	>200 mm	<200 mm				
28	July	185	14 372	945	14	11	251	70	384
29		128	2 770	790	39	0	271	7	317
30		283	9 640	954	103	0	163	79	88
31		243	46 416*	956	0	0	192	3	242
1	Aug.	41	48 433*	894	0	4	278	16	221
2		73	41 050*	2 419	83	2	520	8	448
3		18	12 545*	2 594	0	0	222	9	459
4		31	4 050	1 411	0	0	164	9	217
5		263	1 347	667	0	0	226	13	107
6		139	4 269	361	24	2	63	39	109
7		147	5 060	494	0	0	172	0	118
8		174	27 046*	497	0	2	112	24	207
9		12	35 910*	4 635	0	0	538	23	1 510
10		128	343 260*	3 814	0	1	414	0	896
11		4	64 210*	3 341	0	0	295	2	834
12		176	38 360*	1 057	0	0	229	13	600
13		195	36 249*	1 366	0	0	132	35	231
14		13	45 820*	753	0	8	41	12	97
15		21	36 773*	565	51	0	52	67	107
16		11	22 185*	1 244	414	0	85	47	174
17		41	6 330*	495	469	1	11	36	56
18		140	8 233*	22	133	5	2	279	5
19		17	3 935*	662	93	0	15	27	37
20		4	6 936*	284	58	0	147	12	199
21		123	6 695*	348	13	1	42	18	69
22		250	1 600	18	60	4	12	44	13
23		346	1 563	54	64	1	8	154	36
24		384	4 411	109	125	3	0	93	3
25		301	3 339	35	171	16	16	139	33
26		100	1 681	380	82	3	77	104	154
27		96	1 517	19	12	5	3	85	14
28		201	20	56	846	0	8	37	42
29		47	1 378	181	27	4	44	64	46
30		28	1 228	70	26	0	5	23	39
31		12	1 531	162	49	0	25	9	112
1	Sept.	16	1 075	177	26	0	55	27	100
2		38	700	68	35	1	7	22	13
3		22	1 932	149	45	1	50	19	109
4		6	1 140	649	28	1	93	10	192
5		10	939	32	19	3	5	23	55
6		5	339	48	85	0	6	16	27
7		21	625	129	0	0	47	33	88
8		23	1 076	178	1	4	54	52	67
9		12	385	193	3	4	27	14	43

Table A2.2 Cont'd

Date	Broad Whitefish Upstream (US) >200 mm	Broad Whitefish Upstream (US) <200 mm	Broad Whitefish Downstream (DS) >200 mm	Broad Whitefish Downstream (DS) <200 mm	Lake Whitefish US	Lake Whitefish DS	Least Cisco US	Least Cisco DS
10 Sept.	7	299	6	9	2	1	33	12
11	13	698	2	15	1	2	104	11
12	7	193	12	19	6	26	26	79
13	3	44	44	10	0	27	3	28
14	0	26	98	10	0	69	0	35
15	0	82	20	3	0	27	1	18
16	7	362	134	15	0	51	11	56
17	6	208	86	15	0	68	14	87
18	1	61	71	2	0	14	2	34
19	4	61	146	9	0	77	8	82
20	0	59	453	117	0	82	8	116
21	4	12	240	240	0	48	8	224
22	12	54	175	487	0	38	48	158
23	14	43	314	1 149	0	48	0	253
24	0	22	792	2 862	0	30	8	121
25	3	48	451	1 385	0	19	16	42
26	24	156	429	1 051	0	17	29	219
27	43	176	840	859	0	14	10	74
28	10	81	134	121	0	8	5	8
29	8	23	32	93	1	5	0	19
TOTAL	67 819	1 029 662	73 813	11 690	6 575	9 393	14 037	17 164

[a]Downstream trap closed due to large upstream migration.

[b]Upstream trap closed to adult fish for the day.

*Estimated count

Table A3.1. Weekly summary of broad whitefish examined and counted at Kukjuktuk Creek in 1978.

	Number of fish at upstream trap						Number of fish at downstream trap					
					Total						Total	
Weekly Period	D	L	T	R	Analysed (D+L+T+R)	Analysed & counted	D	L	T	R	Analysed (D+L+T+R)	Analysed & counted
15 June - 21 June	3	0	2	0	5	30	0	0	0	0	0	0
22 June - 28 June	1	0	3	0	4	25	0	0	1	0	1	10
29 June - 5 July	77	2	527	1	607	35 955	0	0	0	0	0	0
6 July - 12 July	63	20	538	1	622	8 747	0	0	0	0	0	0
13 July - 19 July	27	6	242	0	275	7 034	3	0	27	0	30	32
20 July - 26 July	59	42	304	0	405	4 383	11	30	188	0	229	335
27 July - 2 Aug.	11	267	105	0	383	3 895	10	140	120	1	271	1 314
3 Aug. - 9 Aug.	20	309	67	0	396	2 558	16	89	150	2	257	777
10 Aug. - 16 Aug.	25	337	38	0	400	1 256	19	118	119	55	311	4 260
17 Aug. - 23 Aug.	15	242	4	4	265	943	37	44	0	227	308	15 391
24 Aug. - 30 Aug.	0	79	2	2	83	155	17	65	56	7	145	474
31 Aug. - 6 Sept.	1	28	0	0	29	36	15	96	17	3	131	174
7 Sept. - 13 Sept.	0	20	9	2	31	192	15	80	203	11	309	524
Total	302	1 352	1 841	10	3 505	65 209	143	662	881	306	1 992	23 291

Downstream trap closed July 1 to July 14 due to large upstream migration. Fence inundated from Aug. 23 to Sept. 7; partial counts obtained.

D = dead sample; L = live sample; T = tagged and released; R = recapture of tagged fish.

Table A3.2. Weekly summary of broad whitefish examined and counted at Kukjuktuk Creek in 1979.

	Number of fish at upstream trap							Number of fish at downstream trap						
					Total							Total		
					Analysed	Analysed & counted						Analysed	Analysed & counted	
Weekly Period	D	L	T	R	(D+L+T+R)	>200 mm	<200 mm	D	L	T	R	(D+L+T+R)	>200 mm	<200 mm
15 June - 21 June	3	0	1 122	33	1 158	2 477	0	0	0	0	0	0	0	0
22 June - 28 June	9	31	746	190	976	11 978	0	0	0	8	0	8	11	0
29 June - 5 July	78	638	307	398	1 421	27 428	26	0	0	0	0	0	0	0
6 July - 12 July	214	567	154	141	1 076	7 074	1 948	0	0	0	0	0	0	0
13 July - 19 July	239	209	87	98	633	11 374	31 864	12	308	156	94	570	3 751	0
20 July - 26 July	87	321	0	3	411	2 630	86 996	42	410	0	557	1 009	28 487	21
27 July - 2 Aug.	75	719	0	1	795	1 117	170 428	8	421	0	361	790	7 768	239
3 Aug. - 9 Aug.	0	369	0	6	375	784	90 227	27	306	0	316	649	10 659	24
10 Aug. - 16 Aug.	11	434	0	0	445	548	586 857	66	520	0	315	901	14 140	465
17 Aug. - 23 Aug.	88	529	3	1	621	921	35 292	37	469	0	37	543	1 883	890
24 Aug. - 30 Aug.	2	1 066	0	0	1 068	1 157	13 574	18	388	0	13	419	850	1 289
31 Aug. - 6 Sept.	4	101	0	1	106	109	7 656	17	212	0	33	262	1 285	287
7 Sept. - 13 Sept.	18	68	0	0	86	86	3 320	9	168	0	16	193	564	57
14 Sept. - 20 Sept.	0	5	0	0	5	18	859	3	23	0	7	33	1 008	171
21 Sept. - 27 Sept.	0	36	0	0	36	100	511	58	308	0	1	367	3 241	8 033
28 Sept. - 4 Oct.	0	0	0	0	0	18	104	0	0	0	0	0	166	214
Total	828	5 093	2 419	872	9 212	67 819	1 029 662	297	3 533	164	750	5 744	73 813	11 690

Downstream trap closed 17 June to 14 July due to large upstream migration.

D = dead sample; T = tagged and released; R = recapture of tagged fish.

Table A3.3. Weekly summary of lake whitefish examined and counted at Kukjuktuk Creek in 1978.

	Number of fish at upstream trap						Number of fish at downstream trap					
					Total						Total	
Weekly Period	D	L	T	R	Analysed (D+L+T+R)	Analysed & counted	D	L	T	R	Analysed (D+L+T+R)	Analysed & counted
15 June - 21 June	1	0	37	0	38	39	0	0	0	0	0	0
22 June - 28 June	12	3	33	0	48	49	0	0	1	1	2	4
29 June - 5 July	83	0	135	0	218	5 077	0	0	0	0	0	0
6 July - 12 July	25	3	94	1	123	950	0	0	0	0	0	0
13 July - 19 July	3	1	34	0	38	671	0	0	2	0	2	2
20 July - 26 July	12	1	19	0	32	164	0	0	4	1	5	5
27 July - 2 Aug.	7	7	10	0	24	78	1	0	1	0	2	81
3 Aug. - 9 Aug.	1	0	4	0	5	26	5	2	6	0	13	96
10 Aug. - 16 Aug.	0	0	1	0	1	4	9	9	8	23	49	690
17 Aug. - 23 Aug.	0	0	0	0	0	11	20	0	0	76	96	2 518
24 Aug. - 30 Aug.	0	0	0	0	0	1	10	7	22	3	42	74
31 Aug. - 6 Sept.	0	0	0	0	0	0	0	2	0	0	2	2
7 Sept. - 13 Sept.	0	0	0	0	0	0	0	0	1	0	1	4
Total	144	15	367	1	527	7 070	45	20	45	104	214	3 476

Downstream trap closed July 1 to July 14 due to large upstream migration. Fence inundated from Aug. 23 to Sept. 7; partial counts obtained.

D = dead sample; L = live sample; T = tagged and released; R = recapture of tagged fish.

Table A3.4. Weekly summary of lake whitefish examined and counted at Kukjuktuk Creek in 1979.

	Number of fish at upstream trap						Number of fish at downstream trap					
					Total						Total	
Weekly Period	D	L	T	R	Analysed (D+L+T+R)	Analysed & counted	D	L	T	R	Analysed (D+L+T+R)	Analysed & counted
8 June - 14 June	0	0	0	0	0	1	0	0	12	1	13	13
15 June - 21 June	10	0	444	28	482	573	2	0	10	0	12	12
22 June - 28 June	15	1	198	61	275	1 972	0	0	0	0	0	0
29 June - 5 July	32	84	76	62	254	3 087	0	0	0	0	0	0
6 July - 12 July	7	57	82	6	152	583	0	0	0	0	0	0
13 July - 19 July	18	1	26	3	48	228	0	12	2	5	19	149
20 July - 26 July	1	0	0	0	1	6	11	51	0	141	203	3 178
27 July - 2 Aug.	0	0	0	0	0	43	1	74	0	158	233	1 866
3 Aug. - 9 Aug.	2	2	0	0	4	4	2	45	0	109	156	1 497
10 Aug. - 16 Aug.	1	0	0	0	1	9	42	29	0	62	133	1 248
17 Aug. - 23 Aug.	11	0	0	0	11	12	70	22	0	8	100	237
24 Aug. - 30 Aug.	21	11	0	0	32	32	22	40	0	6	68	153
31 Aug. - 6 Sept.	0	2	0	0	2	6	12	55	0	17	84	241
7 Sept. - 13 Sept.	0	17	0	0	17	17	6	46	0	18	70	184
14 Sept. - 20 Sept.	1	0	0	0	1	1	8	19	0	16	43	388
21 Sept. - 27 Sept.	0	0	0	0	0	0	8	19	0	1	28	214
28 Sept. - 4 Oct.	0	0	0	0	0	1	0	5	0	0	5	13
Total	119	175	826	160	1 280	6 575	184	417	24	542	1 167	9 393

Downstream trap closed 17 June to 14 July due to large upstream migration.

D = dead sample; L = live sample; T = tagged and released; R = recapture of tagged fish.

Table A3.5. Weekly summary of least cisco examined and counted at Kukjuktuk Creek in 1978.

Weekly Period	Number of fish at upstream trap						Number of fish at downstream trap					
					Total						Total	
	D	L	T	R	Analysed (D+L+T+R)	Analysed & counted	D	L	T	R	Analysed (D+L+T+R)	Analysed & counted
15 June - 21 June	0	0	0	0	0	0	0	0	0	0	0	0
22 June - 28 June	0	0	6	0	6	8	0	0	0	0	0	0
29 June - 5 July	34	0	36	0	70	1 369	0	0	0	0	0	0
6 July - 12 July	21	19	137	0	177	589	0	0	0	0	0	0
13 July - 19 July	35	14	346	0	395	7 091	0	0	0	0	0	13
20 July - 26 July	46	36	198	2	282	1 960	20	2	42	3	67	128
27 July - 2 Aug.	14	100	55	1	170	1 381	11	22	19	0	52	332
3 Aug. - 9 Aug.	15	21	97	1	134	573	12	17	13	1	43	218
10 Aug. - 16 Aug.	0	11	54	1	66	113	22	14	13	37	86	998
17 Aug. - 23 Aug.	15	10	52	5	82	400	19	0	0	127	146	4 940
24 Aug. - 30 Aug.	17	36	31	7	91	240	11	12	19	13	55	141
31 Aug. - 6 Sept.	15	65	16	10	106	125	10	34	8	4	56	82
7 Sept. - 13 Sept.	15	43	38	18	114	253	2	18	24	9	53	86
14 Sept. - 20 Sept.	0	0	0	0	0	0	8	0	5	0	13	13
Total	227	355	1 066	45	1 693	14 102	115	119	143	194	571	6 951

Downstream trap closed July 1 to July 14 due to large upstream migration. Fence inundated from Aug. 23 to Sept. 7; partial counts obtained.

D = dead sample; L = live sample; T = tagged and released; R = recapture of tagged fish.

Table A3.6. Weekly summary of least cisco examined and counted at Kukjuktuk Creek in 1979.

Weekly Period	Number of fish at upstream trap						Number of fish at downstream trap					
					Total						Total	
	D	L	T	R	Analysed (D+L+T+R)	Analysed & counted	D	L	T	R	Analysed (D+L+T+R)	Analysed & counted
15 June - 21 June	0	0	3	0	3	12	0	0	0	0	0	0
22 June - 28 June	4	3	53	26	86	797	0	0	0	0	0	0
29 June - 5 July	48	229	115	79	471	2 930	0	0	0	0	0	0
6 July - 12 July	30	246	147	76	499	2 678	0	0	0	0	0	0
13 July - 19 July	60	96	91	95	342	5 077	0	47	10	7	64	453
20 July - 26 July	27	0	0	0	27	331	13	89	0	36	138	5 855
27 July - 2 Aug.	0	2	0	1	3	245	2	164	0	31	197	1 899
3 Aug. - 9 Aug.	0	5	0	1	6	117	2	155	0	54	211	2 790
10 Aug. - 16 Aug.	9	2	51	2	64	176	36	107	0	97	240	2 939
17 Aug. - 23 Aug.	51	119	327	6	503	570	39	138	0	41	218	415
24 Aug. - 30 Aug.	13	321	163	0	497	545	15	129	0	18	162	331
31 Aug. - 6 Sept.	0	124	0	1	125	126	3	256	0	37	296	608
7 Sept. - 13 Sept.	4	237	0	6	247	265	1	238	0	25	264	328
14 Sept. - 20 Sept.	0	16	0	0	16	44	9	16	0	1	26	428
21 Sept. - 27 Sept.	2	90	0	2	94	119	15	58	0	3	76	1 091
28 Sept. - 4 Oct.	0	5	0	0	5	5	0	11	0	0	11	27
Total	248	1 495	950	295	2 988	14 037	135	1 408	10	350	1 903	17 164

Downstream trap closed 17 June to 14 July due to large upstream migration.

D = dead sample; L = live sample; T = tagged and released; R = recapture of tagged fish.

Table A4.1. Mean fork length and mean condition factor (K) by sex for each age group of broad whitefish sampled from the upstream run at Kukjuktuk Creek in 1978.

Scale Age (yr)	Males					Females					Sex Unknown				Combined				
	N	Mean[a]	S.D.	Range	K	N	Mean	S.D.	Range	K	N	Mean	S.D.	Range	N	Mean	S.D.	Range	t-test
0+											22	77	10.8	61- 92	22	77	10.8	61- 92	
1	3	131	33.2	93-152	0.82	6	188	21.7	161-217	1.10	53	127	30.7	81-223	62	133	34.8	81-223	3.159[b]
2	6	222	35.0	173-276	1.18	11	206	35.1	161-283	1.10	35	243	32.7	151-286	52	233	36.1	151-286	0.899
3	7	263	65.4	162-328	1.16	10	246	20.2	215-273	1.08	118	284	27.4	213-378	135	280	31.4	162-378	0.780
4	9	301	22.7	245-319	1.09	9	276	31.9	232-327	1.08	105	309	26.6	246-376	123	306	27.9	232-376	1.916
5	12	340	21.4	300-380	1.21	17	333	20.0	282-372	1.15	154	337	25.1	268-395	183	337	24.3	268-395	0.902
6	30	352	18.1	302-382	1.18	21	354	22.1	307-398	1.25	277	360	24.3	247-435	328	359	23.7	247-435	0.354
7	16	363	22.3	332-415	1.21	22	371	23.6	340-443	1.26	397	373	20.6	309-506	435	372	20.9	309-506	1.056
8	14	392	30.4	316-442	1.26	10	380	17.1	357-420	1.22	170	386	24.9	283-453	194	386	25.0	283-453	1.123
9	2	399	1.4	398-400	1.32	1	427		427	1.36	43	410	30.9	337-490	46	410	30.1	337-490	
10	1	395		395	1.20						11	402	28.6	359-462	12	401	27.4	359-462	
11						1	445		445	1.19	2	464	63.6	419-509	3	458	46.3	419-509	
12											4	375	20.3	351-393	4	375	20.3	351-393	
13											3	390	12.2	376-398	3	390	12.2	376-398	
Total	100	334	63.4	93-442		108	317	69.8	161-445		1394	340	69.8	61-509	1602	338	69.6	61-509	

[a]Fork length (mm).

[b]Significant difference between means for males and females.

Table A4.2. Mean fork length and mean condition factor (K) by sex for each age group of broad whitefish sampled from the downstream run at Kukjuktuk Creek in 1978.

Scale Age (yr)	Males					Females					Sex Unknown				Combined				
	N	Mean[a]	S.D.	Range	K	N	Mean	S.D.	Range	K	N	Mean	S.D.	Range	N	Mean	S.D.	Range	t-test
0+																			
1	2	163	13.4	153-172	1.04	4	151	12.8	133-163	1.04	33	134	26.8	87-243	39	137	26.2	87-243	1.070
2	2	202	25.5	184-220	1.17	3	217	37.3	191-260	0.96	5	251	33.1	200-280	10	231	36.5	184-280	0.486
3	5	256	21.8	223-282	1.36	4	268	15.7	252-287	1.22	41	285	20.8	227-318	50	281	22.3	223-318	0.921
4	7	308	33.1	257-344	1.29	3	297	12.7	290-312	1.31	29	311	35.6	194-372	39	309	33.6	194-372	0.543
5	1	335		335	1.28	2	341	12.1	332-349	1.35	49	350	22.7	301-418	52	350	22.3	301-418	
6	6	363	23.2	343-402	1.34	7	364	28.6	322-409	1.32	118	371	32.6	260-445	131	370	31.9	260-445	0.068
7	6	402	43.4	352-474	1.43	10	388	14.6	361-404	1.32	188	390	26.7	271-498	204	390	26.8	271-498	0.953
8	11	401	15.7	384-427	1.42	7	409	15.5	394-440	1.40	102	402	25.6	347-475	120	403	24.3	347-475	1.059
9	6	427	20.4	407-461	1.38	6	411	30.5	371-445	1.38	20	414	32.2	354-486	32	416	29.8	354-486	1.068
10	4	458	23.8	428-484	1.54	1	417		417	1.48	13	412	40.8	346-473	18	423	40.6	346-484	
11	2	422	55.9	382-461	1.36	1	393		393	1.22	6	465	31.1	412-509	9	448	42.1	382-509	
12						1	474		474	1.34					1	474		474	
13											1	468		468	1	468		468	
14											2	513	55.9	473-552	2	513	55.9	473-552	
Total	52	361	81.0	153-484		49	346	85.1	133-474		607	362	71.7	87-552	708	361	73.4	87-552	

[a]Fork length (mm).

Table A4.3. Mean fork length and mean condition factor (K) by sex for each age group of broad whitefish sampled from the upstream run at Kukjuktuk Creek in 1979.

Scale Age (yr)	Males					Females					Sex Unknown				Combined					t-test
	N	Mean[a]	S.D.	Range	K	N	Mean	S.D.	Range	K	N	Mean	S.D.	Range	N	Mean	S.D.	Range	K	
0+											15	68	10.3	50-84	15	68	10.3	50-84		
1	2	149	38.2	122-176	1.00						235	108	17.8	78-183	237	108	18.3	78-183	1.16	
2	7	242	18.4	204-259	1.28	1	274		274	1.17					8	246	20.3	204-274	1.27	
3	12	278	13.3	256-297	1.26	5	277	26.2	241-300	1.21					17	278	17.1	241-300	1.23	0.106
4	19	296	23.9	262-334	1.22	7	293	18.2	275-320	1.24					26	295	22.2	262-334	1.23	0.280
5	24	327	24.7	281-365	1.21	4	323	15.5	300-335	1.18					28	326	23.5	281-365	1.21	0.358
6	25	352	26.8	283-393	1.25	6	362	23.1	330-387	1.33					31	354	26.0	283-393	1.27	0.787
7	16	380	15.9	347-403	1.27	14	373	27.6	312-401	1.34					30	377	22.1	312-403	1.30	0.939
8	11	391	21.2	355-429	1.30	1	376		376	1.28	1	420		420	13	392	21.5	355-429	1.30	
9	0					0									0					
10	1	423		423	1.36	1	376		376	1.22					2	400	33.2	376-423	1.29	
11						0									0					
12						1	411		411	1.15					1	411		411	1.15	
Total	117	328	53.4	122-429		40	339	46.5	241-411		251	109	27.0	78-420	408	198	115.8	78-429		

[a]Fork length (mm).

Table A4.4. Mean fork length and mean condition factor (K) by sex for each age group of broad whitefish sampled from the downstream run at Kukjuktuk Creek in 1979.

Scale Age (yr)	Males					Females					Sex Unknown				Combined					t-test
	N	Mean[a]	S.D.	Range	K	N	Mean	S.D.	Range	K	N	Mean	S.D.	Range	N	Mean	S.D.	Range	K	
0+																				
1																				
2	4	164	12.1	154-181	0.94	3	147	15.0	130-157	0.65					7	157	15.2	130-181	0.82	1.669
3	1	246		246	1.41	1	288		288	1.26					2	267	29.7	246-288	1.33	
4	5	305	16.3	278-317	1.33	0									5	305	16.3	278-317	1.33	
5	4	317	18.0	296-339	1.34	2	313	3.5	310-315	1.43					6	315	14.2	296-339	1.37	0.317
6	6	374	30.9	335-430	1.39	4	373	21.3	352-393	1.36					10	374	26.1	335-430	1.38	0.056
7	11	380	25.1	351-435	1.39	4	377	20.0	355-403	1.43					15	379	23.2	351-435	1.40	0.199
8	19	402	29.5	363-472	1.39	13	415	32.8	369-468	1.42	1	409		409	33	407	30.5	363-472	1.40	1.134
9	17	423	29.5	366-460	1.41	18	434	21.0	401-463	1.44					35	429	25.7	366-463	1.43	1.230
10	2	442	2.1	440-443	1.35	11	453	26.9	427-504	1.47					13	451	24.9	427-504	1.45	0.588
11	2	471	29.7	450-492	1.51	2	512	4.9	508-515	1.36					4	491	29.1	450-515	1.43	1.902
12	1	535		535	1.42	1	500		500	1.62					2	518	24.7	500-535	1.52	
Total	72	379	73.3	154-535		59	403	76.6	130-515		1	409		409	132	392	75.6	130-535		

[a]Fork length (mm).

Table A4.5. Mean fork length and mean condition factor (K) by sex for each age group of lake whitefish sampled from the upstream run at Kukjuktuk Creek in 1978.

Scale Age (yr)	Males					Females					Sex Unknown				Combined				
	N	Mean[a]	S.D.	Range	K	N	Mean	S.D.	Range	K	N	Mean	S.D.	Range	N	Mean	S.D.	Range	t-test
0+																			
1																			
2											1	153		153	1	153		153	
3						1	187		187	1.04					1	187		187	
4											1	165		165	1	165		165	
5	1	200		200	0.96	1	207		207	1.16	3	283	58.0	248-350	5	251	59.9	200-350	
6	2	257	17.0	245-269	1.07						3	222	17.9	212-243	5	236	24.4	212-269	
7	3	278	47.6	237-330	1.14	1	231		231	1.05	2	348	70.7	298-398	6	293	63.5	231-398	
8	3	319	5.0	314-324	1.15	1	321		321	1.15	4	303	35.4	251-327	8	311	25.0	251-327	
9	12	328	26.0	292-365	1.14	8	333	33.3	257-377	1.19	17	343	37.5	252-391	37	336	33.0	252-391	0.377
10	12	345	26.6	309-392	1.18	19	339	27.9	292-395	1.20	63	364	25.4	303-426	94	357	28.1	292-426	0.594
11	10	350	29.9	310-398	1.26	19	365	26.5	310-418	1.28	75	376	27.0	316-432	104	371	28.1	310-432	1.387
12	11	385	24.9	341-425	1.22	14	380	26.0	330-418	1.24	72	388	18.0	341-418	97	386	20.0	330-425	0.486
13	3	375	13.6	362-389	1.16	4	387	13.7	372-405	1.24	34	390	20.5	341-425	41	389	19.7	341-425	1.150
14	5	401	26.3	375-438	1.31	5	388	32.9	344-421	1.26	21	400	26.7	329-450	31	398	27.1	329-450	0.690
15											6	397	19.2	374-428	6	397	19.2	374-428	
Total	62	346	46.1	200-438		73	353	44.6	187-421		302	373	38.9	153-450	437	366	42.3	153-450	

[a]Fork length (mm).

Table A4.6. Mean fork length and mean condition factor (K) by sex for each age group of lake whitefish sampled from the downstream run at Kukjuktuk Creek in 1978.

Scale Age (yr)	Males					Females					Sex Unknown				Combined				
	N	Mean[a]	S.D.	Range	K	N	Mean	S.D.	Range	K	N	Mean	S.D.	Range	N	Mean	S.D.	Range	t-test
0+																			
1																			
2																			
3																			
4																			
5																			
6																			
7	1	228		228	1.48						2	348	36.1	322-373	3	308	73.6	228-373	
8	2	407	11.3	399-415	1.28						1	367		367	3	394	24.4	367-415	
9	1	317		317	1.24	1	385		385	1.31	3	333	5.1	329-339	5	340	26.2	317-385	
10	4	365	24.8	355-386	1.32	3	387	2.3	384-388	1.34	9	377	32.8	335-432	16	376	27.4	335-432	1.495
11	5	384	26.8	348-422	1.35	4	392	26.8	362-427	1.46	5	397	15.7	376-418	14	391	22.3	348-427	0.445
12	6	402	27.2	352-429	1.37	6	409	18.4	390-431	1.43	8	406	21.2	367-441	20	406	21.4	352-441	0.522
13	3	411	9.6	401-420	1.40	6	410	22.4	378-447	1.27	10	399	21.7	375-435	19	404	20.5	375-447	0.072
14	1	405		405	1.53	1	430		430	1.19	2	394	15.6	383-405	4	406	19.2	383-430	
Total	23	382	45.0	228-429		21	403	21.5	362-447		40	387	30.6	322-441	84	389	33.9	228-447	

[a]Fork length (mm).

Table A4.7. Mean fork length and mean condition factor (K) by sex for each age group of lake whitefish sampled from the upstream run at Kukjuktuk Creek in 1979.

Scale Age (yr)	Males					Females					Sex Unknown				Combined					t-test
	N	Mean[a]	S.D.	Range	K	N	Mean	S.D.	Range	K	N	Mean	S.D.	Range	N	Mean	S.D.	Range	K	
0+																				
1	1	116		116	0.77	1	116		116	0.77	12	116	9.6	105-136	14	116	8.9	105-136	0.86	
2	6	155	9.5	138-167	0.91	1	167		167	0.97	2	164	14.1	154-174	9	158	10.3	138-174	0.98	
3	1	187		187	1.02	1	213		213	0.93					2	200	18.4	187-213	0.98	
4	3	213	11.4	205-226	1.15	3	237	2.7	235-240	1.22					6	228	12.8	205-240	1.19	2.821[b]
5	6	264	14.7	249-288	1.22	2	246	8.5	240-252	1.07					8	260	15.3	240-288	1.18	1.591
6	1	324		324	1.32	5	290	21.0	269-316	1.24					6	296	23.1	269-324	1.25	
7	10	310	18.9	275-338	1.26	5	310	30.3	236-346	1.26	1	311		311	16	310	21.4	263-346	1.25	0.032
8	7	346	24.2	315-380	1.28	2	356	0.7	355-356	1.30					9	348	21.3	315-380	1.29	0.557
9	8	334	27.7	299-381	1.23	6	364	30.2	324-395	1.22					14	347	31.7	299-395	1.22	1.931
10	2	377	5.0	373-380	1.39	4	372	40.1	315-400	1.32	2	312		312	8	358	38.8	312-400	1.34	0.166
11	2	389	2.1	387-390	1.34										2	389	2.1	387-390	1.34	
12	3	421	20.2	408-444	1.36	2	383	42.4	353-413	1.18					5	406	32.9	353-444	1.29	1.399
13	1	410		410	1.31										1	410		410	1.31	
14	1	422		422	1.34										1	422		422	1.34	
Total	52	300	81.5	116-444		32	308	71.4	116-413		17	156	76.2	105-312	101	279	94.7	105-444		

[a] Fork length (mm).

[b] Significant difference between means for males and females ($P < 0.05$).

Table A4.8. Mean fork length and mean condition factor (K) by sex for each age group of lake whitefish sampled from the downstream run at Kukjuktuk Creek in 1979.

Scale Age (yr)	Males					Females					Sex Unknown				Combined					t-test
	N	Mean[a]	S.D.	Range	K	N	Mean	S.D.	Range	K	N	Mean	S.D.	Range	N	Mean	S.D.	Range	K	
0+																				
1	1	121		121	0.79						19	112	12.2	92-144	20	113	12.0	92-144	0.80	
2	3	164	25.2	118-195	1.03	5	152	21.4	129-133	0.98	1	132		132	14	157	23.8	118-195	1.02	0.881
3	3	182	5.9	175-186	1.03	2	150	3.5	147-152	0.68	1	180		180	6	171	16.9	147-186	0.95	6.710[b]
4	1	257		257	1.12	2	246	36.8	220-272	1.15	1	233		233	4	246	23.4	220-272	1.17	
5																				
6	2	257	22.6	241-273	1.16										2	257	22.6	241-273	1.16	
7	7	318	27.5	286-352	1.26	3	302	30.4	282-337	1.16					10	313	27.7	282-352	1.23	0.821
8	5	370	53.7	298-441	1.21	4	356	26.0	320-375	1.29					9	363	41.8	298-441	1.24	0.474
9	12	347	39.5	263-416	1.35	7	368	20.7	336-395	1.37					19	355	34.7	268-416	1.36	1.296
10	12	377	17.7	353-405	1.34	14	388	16.0	345-408	1.38					26	383	17.4	345-408	1.36	1.664
11	8	395	17.7	371-428	1.37	11	401	23.4	350-433	1.43	1	450		450	20	401	23.4	350-450	1.41	0.603
12	9	425	18.3	393-440	1.32	9	433	14.3	407-451	1.41	1	440		440	19	429	16.2	393-451	1.37	1.033
13	8	421	28.0	376-461	1.37	10	423	14.7	395-444	1.36	1	458		458	19	424	22.0	376-461	1.37	0.196
14						1	432		432	1.29					1	432		432	1.29	
Total	76	340	90.1	118-461		68	366	84.9	129-451		25	161	112.5	92-458	169	324	114.4	92-461		

[a] Fork length (mm)

[b] Significant difference between means for males and females ($P < 0.05$).

Table A4.9. Mean fork length and mean condition factor (K) by sex for each age group of least cisco sampled from the upstream run at Kukjuktuk Creek in 1978.

Scale Age (yr)	Males					Females					Sex Unknown				Combined				
	N	Mean[a]	S.D.	Range	K	N	Mean	S.D.	Range	K	N	Mean	S.D.	Range	N	Mean	S.D.	Range	t-test
0+																			
1																			
2											1	108		108	1	108		108	
3	10	200	10.7	183-219	0.93	6	200	9.6	184-208	0.87	1	172		172	17	198	11.8	172-219	0
4	17	227	13.5	202-259	0.86	3	215	17.7	196-231	0.82	12	267	13.4	241-285	32	241	24.7	196-285	1.366
5	24	264	12.8	235-347	0.97	9	264	23.4	240-316	0.99	109	273	19.2	218-362	142	271	20.3	218-362	0
6	23	296	12.8	277-325	1.04	33	300	16.1	263-331	1.02	259	296	18.1	230-393	315	296	17.5	230-393	0.992
7	15	299	25.5	257-351	1.10	36	320	13.1	296-351	0.98	118	316	21.2	254-380	169	316	20.8	254-380	3.891[b]
8	5	335	18.5	316-361	1.07	26	351	18.5	319-387	0.96	93	339	21.2	217-388	124	341	21.1	217-388	1.771[b]
9						14	365	16.1	343-389	1.02	24	365	18.9	321-415	38	365	17.7	321-415	
10											1	385		385	1	385		385	
Total	94	268	41.5	183-361		127	314	43.9	184-339		618	304	32.5	108-415	839	302	37.6	108-415	

[a]Fork length (mm).

[b]Significant difference between means for males and females ($P < 0.05$).

Table A4.10. Mean fork length and mean condition factor (K) by sex for each age group of least cisco sampled from the downstream run at Kukjuktuk Creek in 1978.

Scale Age (yr)	Males					Females					Sex Unknown				Combined				
	N	Mean[a]	S.D.	Range	K	N	Mean	S.D.	Range	K	N	Mean	S.D.	Range	N	Mean	S.D.	Range	t-test
0+																			
1																			
2																			
3	2	207	17.0	195-219	0.78	2	191	22.6	175-207	0.75					4	199	18.8	175-219	0.800
4	7	228	19.4	190-252	1.02	5	237	20.5	220-272	1.08	4	250	13.1	236-267	16	236	19.5	190-272	0.774
5	11	251	19.5	210-281	1.05	15	261	23.5	192-291	0.99	20	274	14.6	245-300	46	264	20.9	192-300	1.149
6	15	287	18.4	262-325	1.07	20	294	20.4	253-333	1.08	41	291	15.5	259-330	76	291	17.4	253-333	1.047
7	7	301	23.8	270-342	1.09	14	316	15.5	293-346	1.12	16	319	12.7	293-343	37	314	17.0	270-346	1.749
8	1	338		338	1.06	11	333	22.1	312-385	1.13	19	338	24.8	303-402	31	338	23.0	303-402	
9						2	388	9.2	381-394	1.17	3	356	26.3	326-376	5	368	25.9	326-394	
Total	43	268	36.1	190-342		69	294	42.8	175-394		103	301	31.0	236-402	215	292	38.1	175-402	

[a]Fork length (mm).

Table A4.11. Mean fork length and mean condition factor (K) by sex for each age group of least cisco sampled from the upstream run at Kukjuktuk Creek in 1979.

Scale Age (yr)	Males					Females					Sex Unknown				Combined					t-test
	N	Mean[a]	S.D.	Range	K	N	Mean	S.D.	Range	K	N	Mean	S.D.	Range	N	Mean	S.D.	Range	K	
0+																				
1																				
2	1	178		178	0.80	3	158	47.7	121-212	0.97	4	143	35.0	114-189	8	153	36.4	114-212	0.90	
3	8	246	17.1	228-274	0.90	8	226	18.5	207-264	1.04	3	147	12.2	136-160	19	222	38.3	136-274	0.95	2.245[b]
4	7	251	27.7	214-295	1.09	16	255	27.4	193-296	0.99					23	254	27.0	193-296	1.02	0.321
5	28	281	23.8	227-330	1.02	25	287	20.5	246-335	1.10	1	286		286	54	284	22.1	227-335	1.06	0.977
6	19	298	17.0	270-330	1.09	27	303	17.8	272-342	1.06	1	340		340	47	302	18.1	270-342	1.07	0.955
7	11	308	26.4	269-341	1.10	21	314	12.6	285-332	1.01					32	312	18.2	269-341	1.04	0.877
8						14	339	19.8	311-383	1.00					14	339	19.8	311-383	1.00	
9	1	372		372	1.26	7	350	15.3	323-366	0.94					8	353	16.2	323-372	0.98	
10						1	337		337	0.78					1	337		337	0.78	
Total	75	283	33.6	178-372		122	294	43.3	121-383		9	182	78.7	114-340	206	285	47.6	114-383		

[a] Fork length (mm).

[b] Significant difference between means for males and females ($P < 0.05$)

Table A4.12. Mean fork length and mean condition factor (K) by sex for each age group of least cisco sampled from the downstream run at Kukjuktuk Creek in 1979.

Scale Age (yr)	Males					Females					Sex Unknown				Combined					t-test
	N	Mean[a]	S.D.	Range	K	N	Mean	S.D.	Range	K	N	Mean	S.D.	Range	N	Mean	S.D.	Range	K	
0+																				
1	1	132		132	0.74						4	95	12.2	77-103	5	103	19.6	77-132	0.76	
2	2	179	12.0	170-187	0.84	2	146	26.9	127-165	1.01					4	162	25.3	127-187	0.92	1.584
3	10	208	18.2	163-223	0.99	7	215	11.2	197-228	1.03					17	211	15.7	163-228	1.01	0.900
4	11	259	20.1	216-285	1.14	14	279	19.7	225-305	1.08					25	270	21.9	216-305	1.11	2.498[b]
5	7	283	18.4	252-302	1.07	5	289	32.8	243-334	1.05					12	285	24.3	243-334	1.06	0.407
6	5	310	15.1	289-329	1.10	16	304	17.8	260-338	1.02					21	305	17.0	260-338	1.04	0.678
7	4	315	2.6	311-317	1.07	15	322	13.1	300-343	1.06					19	320	12.0	300-343	1.06	1.042
8	1	332		332	0.82	8	336	27.8	292-375	1.03					9	335	26.0	292-375	1.01	
9						7	358	8.8	340-366	1.10					7	358	8.8	340-366	1.10	
10						3	375	6.1	368-380	1.11					3	375	6.1	368-380	1.11	
11	1	345		345	1.24										1	345		345	1.24	
Total	42	259	51.1	132-345		77	301	49.6	127-380		4	95	12.2	77-103	123	280	62.9	77-380		

[a] Fork length (mm).

[b] Significant difference between means for males and females ($P < 0.05$).

Table A5.1. Length-frequency distribution by age group for broad whitefish sampled from the upstream run at Kukjuktuk Creek in 1978.

Fork Length (mm)	Scale Age (yr)														Total
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
51-75	11														11
76-100	11	13													24
101-125	1	29													30
126-150		35													35
151-175		27	8	1											36
176-200		4	7	1											12
201-225		6	26	7											39
226-250		2	12	14	5		1								34
251-275			15	37	15	1									68
276-300			6	45	28	8	4		1						92
301-325				31	53	53	18	9	1						165
326-350				3	18	69	89	37	11	1					228
351-375				1	4	39	142	221	54	3	2		2		468
376-400				1	2	14	69	139	77	16	3		2	3	326
401-425							2	32	47	15	6	1			103
426-450								1	5	8		1			15
451-475									2	1	1				4
476-500										3					3
501-525								1				1			2
Total	23	116	74	141	125	184	325	440	198	47	12	3	4	3	1695

Note: Some additional ages from live sample or tagged fish data are included.

Table A5.2. Length-frequency distribution by age group for broad whitefish sampled from the downstream run at Kukjuktuk Creek in 1978.

Fork Length (mm)	Scale Age (yr)														Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
76-100	1														1
101-125	11														11
126-150	18														18
151-175	8	1													9
176-200	2	3													5
201-225	2	6	1												9
226-250	2	3	4	2											11
251-275		3	17	4		3	1								28
276-300		1	24	9		4									38
301-325			9	12	6	2									29
326-350				12	22	17	9	1		1					62
351-375				2	20	43	49	16	3	2					135
376-400					4	50	93	41	8	3	2				201
401-425					1	10	44	43	9	3	1				111
426-450						4	9	14	8	3					38
451-475							4	5	4	5	5	1	1	1	26
476-500							2		1	1					4
501-525											1				1
526-550															0
551-575														1	1
Total	44	17	55	41	53	133	211	120	33	18	9	1	1	2	738

Note: Some additional ages from live sample or tagged fish data are included.

Table A5.3. Length-frequency distribution by age group for broad whitefish sampled from the upstream run at Kukjuktuk Creek in 1979.

Fork Length (mm)	Scale Age (yr) 0	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
26-50	8														8
51-75	7														7
76-100		102													102
101-125		102													102
126-150		28													28
151-175		3													3
176-200		2	1												3
201-225			4	1	2										7
226-250			3	7	13	13	1								37
251-275				10	21	24	1	1							57
276-300					15	33	26								74
301-325					3	21	31	2						1	58
326-350						5	9	14							28
351-375					1		10	33	6						50
376-400							2	31	40	10	2				85
401-425								3	16	6	11		1		37
426-450									1	1	1	1			4
451-475											1				1
Total	15	237	8	18	55	96	80	84	63	17	15	1	1	1	691

Note: Some additional ages from live sample or tagged fish data are included.

Table A5.4. Length-frequency distribution by age group for broad whitefish sampled from the downstream run at Kukjuktuk Creek in 1979.

Fork Length (mm)	Scale Age (yr) 0	1	2	3	4	5	6	7	8	9	10	11	12	Total
76-100														
101-125														
126-150			1											1
151-175			5											5
176-200			1											1
201-225			1											1
226-250				1										1
251-275					1									1
276-300				1	1	1								3
301-325					4	4								8
326-350						1	1							2
351-375							6	8	4	2				20
376-400							2	5	13	2				22
401-425								2	6	12				20
426-450							1	1	6	11	8	1		28
451-475									4	9	3			16
476-500											1	1	1	3
501-525											1	2		3
526-550													1	1
Total	0	0	8	2	6	6	10	16	33	36	13	4	2	136

Note: Some additional ages from live sample or tagged fish data are included.

Table A5.5. Length-frequency distribution by age group for lake whitefish sampled from the upstream run at Kukjuktuk Creek in 1978.

Fork Length (mm)	Scale Age (yr)																Total
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
151-175			1		1												2
176-200				1		1											2
201-225						1	2										3
226-250						1	2	2		1							6
251-275						1	1	1	1	2							6
276-300								1	0	3	2						6
301-325									6	11	13	6					36
326-350						1		1	1	6	23	23	4	1	2		62
351-375								1		12	30	30	24	12	3	1	113
376-400										3	23	32	45	16	13	3	135
401-425											2	14	25	12	9	1	63
426-450											1	1			4	1	7
Total	0	0	1	1	1	5	5	6	8	38	94	106	98	41	31	6	441

Note: Some additional ages from live sample or tagged fish data are included.

Table A5.6. Length-frequency distribution by age group for lake whitefish sampled from the downstream run at Kukjuktuk Creek in 1978.

Fork Length (mm)	Scale Age (yr)								Total
	7	8	9	10	11	12	13	14	
226-250	1								1
251-275									0
276-300									0
301-325	1		1						2
326-350			3	4	1				8
351-375	1	1		2	2	2	2		10
376-400		1	1	8	7	6	5	1	29
401-425		1		1	3	8	9	2	24
426-450				1	1	4	3	1	10
Total	3	3	5	16	14	20	19	4	84

Table A5.7. Length-frequency distribution by age group for lake whitefish sampled from the upstream run at Kukjuktuk Creek in 1979.

Fork Length (mm)	Scale Age (yr)															Total
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
101-125		12														12
126-150		2	1													3
151-175			8													8
176-200				1												1
201-225				1	2											3
226-250					4	2										6
251-275					1	6	4	2								13
276-300					1	1	10	10	2	1						25
301-325						1	9	17	13	8	7					55
326-350								7	14	15	5	1				42
351-375									3	8	11	4	3	1		30
376-400								2	2	9	15	10	5	2	1	46
401-425										1	1	4	9	3	1	19
426-450												2	2	1		5
451-475														1		1
Total	0	14	9	2	8	10	23	38	34	42	39	21	19	8	2	269

Note: Some additional ages from live sample or tagged fish data are included.

Table A5.8. Length-frequency distribution by age group for lake whitefish sampled from the downstream run at Kukjuktuk Creek in 1979.

Fork Length (mm)	Scale Age (yr)														Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
76-100	1														1
101-125	17	1													18
126-150	2	6	1												9
151-175		3	2												5
176-200		4	3												7
201-225				1											1
226-250				1		1									2
251-275				2		1			1						4
276-300							5	1							6
301-325								1	1						2
326-350							5		6	1	1				13
351-375							1	5	7	7	1				21
376-400								1	4	14	8	2	3		32
401-425									1	4	6	3	8		22
426-450								1			4	13	6	1	25
451-475												1	2		3
Total	20	14	6	4	0	2	11	9	20	26	20	19	19	1	171

Note: Some additional ages from live sample or tagged fish data are included.

Table A5.9. Length-frequency distribution by age group for least cisco sampled from the upstream run at Kukjuktuk Creek in 1978.

Fork Length (mm)	Scale Age (yr) 2	3	4	5	6	7	8	9	10	Total
101-125	1									1
126-150										0
151-175	1	1								2
176-200		7	1							8
201-225		10	13	3			1			27
226-250			19	22	3	1				45
251-275			8	81	32	6				127
276-300			3	46	183	29	1			262
301-325				4	104	94	26	2		230
326-350				2	8	40	66	6		122
351-375				1	1	7	34	20		63
376-400					2	1	5	11	1	20
401-425								1		1
Total	2	18	44	159	333	178	133	40	1	908

Note: Some additional ages from live sample or tagged fish data are included.

Table A5.10. Length-frequency distribution by age group for least cisco sampled from the downstream run at Kukjuktuk Creek in 1978.

Fork Length (mm)	Scale Age (yr) 3	4	5	6	7	8	9	Total
151-175	1							1
176-200	1	1	1					3
201-225	2	3	1					6
226-250		10	7					17
251-275		4	24	17	1			46
276-300			13	38	6			57
301-325				20	22	11		53
326-350				2	8	13	1	24
351-375						4	1	5
376-400						2	3	5
401-425						1		1
Total	4	18	46	77	37	31	5	218

Note: Some additional ages from live sample or tagged fish data are included.

Table A5.11. Length-frequency distribution by age group for least cisco sampled from the upstream run at Kukjuktuk Creek in 1979.

Fork Length (mm)	Scale Age (yr) 1	2	3	4	5	6	7	8	9	10	Total
126-150		3									3
151-175		1	2								3
176-200		1	1								2
201-225		2		1							3
226-250		1	5	2							8
251-275			7	6	5						18
276-300		1	9	18	15	4	2				49
301-325			1	16	64	22	6				109
326-350				3	44	41	21	6	1		116
351-375					6	15	22	14	2	1	60
376-400						1	4	4	6		15
401-425								1	1		2
Total	0	9	25	46	134	83	55	25	10	1	388

Note: Some additional ages from live sample or tagged fish data are included.

Table A5.12. Length-frequency distribution by age group for least cisco sampled from the downstream run at Kukjuktuk Creek in 1979.

Fork Length (mm)	Scale Age (yr) 1	2	3	4	5	6	7	8	9	10	11	Total
76-100	2											2
101-125	2											2
126-150	1	1										2
151-175		2	1									3
176-200		1	2									3
201-225			13	2								15
226-250			1	3	1							5
251-275				8	2	1						11
276-300				11	7	6	1	1				26
301-325				1	1	11	13	3				29
326-350					1	3	5	3	1		1	14
351-375								2	6	1		9
376-400										2		2
Total	5	4	17	25	12	21	19	9	7	3	1	123