An Assessment of the Exploratory Fishery and Investigation of the Population Structure of Broad Whitefish *(Coregonus nasus)* from the Mackenzie River Delta, 1989 - 1993

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Biological data from broad whitefish (fork length, age, gonadosomatic index and instantaneous mortality) were analysed to assess the impact of an exploratory fishery carried out in the Mackenzie River Delta between 1989 and 1993 The data were collected using variable mesh experimental gill nets and commercial harvesters' 139 mm mesh gill nets

The data suggest that the broad whitefish population might be separated, with larger mature spawners gathering in the main channels prior to spawning and smaller, immature or resting fish staying in side channels away from strong currents

From this analysis we conclude that the size and structure of the broad whitefish population(s) found in this area are stable at the current level of total harvest (commercial and subsistence combined) There may be room for increased harvests but to what level is uncertain

Key words broad whitefish, Coregonus nasus, anadromous, catch statistics, catch curve, experimental gill netting, Mackenzie River

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Des données biologiques (longueur à la fourche, âge, indice gonadosomatique et taux de mortalité instantanée) ayant trait au corégone tschir ont été évaluées afin de déterminer l'incidence d'une pêche exploratoire effectuée de 1989 à 1993 dans le delta du fleuve Mackenzie Les données ont été obtenues de poissons capturés à l'aide de filets maillants expérimentaux à maillage variable ou dans les filets maillants à mailles de 139 mm des pêcheurs commerciaux

Les données indiquent que la population de corégone tschir pourrait être divisée en une composante formée de géniteurs matures de plus grande taille se rassemblant dans les principaux chenaux avant le frai et en une composante de poissons immatures plus petits demeurant dans les chenaux latéraux à l'abri des courants forts

Cette analyse nous a permis de conclure que l'effectif et la structure de la population (ou des populations) se trouvant dans cette zone demeuraient stables au niveau actuel de récolte totale (pêches commerciale et de subsistance) Il pourrait être possible d'accroître la récolte, mais nous ne savons pas dans quelle mesure

Mots clés corégone tschir, Coregonus nasus, anadrome, statistiques des captures, courbe des captures, pêche au filet maillant expérimental, fleuve Mackenzie

INTRODUCTION

In Canada, broad whitefish (Coregonus nasus) occupy fresh and brackish waters of the Yukon Territory and the north-western Northwest Territories (including the Coppermine River)(Scott and Crossman 1973) They are abundant in the Mackenzie River Delta, lower Mackenzie River (downstream of Ft Good Hope), and it's tributaries, and have been a staple food item for the Inuvialuit, Gwich'in and Sahtu Dene, and Metis people living in this region While there has been a decrease over the last 15 to 20 years in the number of families involved in traditional harvesting activities, there is still a strong social and cultural importance tied to the whitefish fishery A core group of harvesters in each community still rely on fisheries and other wildlife resources for subsistence purposes and in some cases for their livelihood

There are two and possibly three life history types of broad whitefish in the lower Mackenzie River drainage area (Reist 1987) Anadromous and lacustrine types have been identified and it is possible that riverine types may also be present The anadromous type is probably the most abundant and likely the main type harvested in the seasonal fisheries of the Inuvialuit Settlement Region Several separate populations within this life history type may exist, given that several spawning areas have been located along the Mackenzie River and it's two major tributaries, the Peel and Arctic Red Rivers (Chang-Kue and Jessop 1983 Chang-Kue and Jessop, 1997)

The majority of anadromous broad whitefish from the Mackenzie River reach sexual maturity at age seven to nine years (Bond 1982, Chang-Kue and Jessop 1992), although younger ages (three to four years) have been reported (Percy 1975) Mature broad whitefish migrate from feeding areas along the Tuktoyaktuk Peninsula coast and the outer delta to spawning areas as far as Ramparts Rapids near Ft Good Hope (Chang-Kue and Jessop 1983) Low water levels in the fall cause a narrow chute and a one to two meter waterfall to develop at Ramparts Rapids, thus creating a velocity barrier to migration upstream (broad whitefish may be able to move past the ramparts in spring and summer when flows are higher) (K Chang-Kue, DFO-Winnipeg, personal communication) Spawning occurs under the ice during late October and early November when the water temperature is approximately 0°C Once spawning is completed the broad whitefish move downstream to overwinter in the outer delta (Chang-Kue and Jessop 1983) Eggs hatch in the spring and larvae are carried downstream with the flood waters (Chang-Kue and Jessop 1992, Bond and Erickson 1985) Some young-of-the-year broad whitefish move into Delta lakes (Taylor et al 1982) but the majority move with the current and eventually make their way to lakes and streams on Richards Island and the Tuktoyaktuk Peninsula Young fish (0+ to four years) may remain in these coastal drainages for several years while larger, older fish (five to 12 years) may use them for feeding but move to deeper nearshore or Delta areas for overwintering (Chang-Kue and Jessop 1992, Bond and Erickson 1985, Lawrence et al 1984) When these fish reach maturity they become spawners and the cycle is repeated Mature broad whitefish may spawn several times during their lives However, it is likely that individuals do not spawn every year and instead rest for one or more years while they build up the energy required to spawn (Craig 1989)

Precise understanding of several aspects of the biology of broad whitefish are important to the management of a commercial fishery in the Mackenzie River delta First, the migratory nature of the populations and thus the location and timing of the fishery make this an "interception fishery" This type of fishery can be more difficult to manage than a "terminal fishery" - that is a fishery which takes place at or near the spawning grounds (Larkin 1978) In an interception fishery population abundance indicators, such as catch per unit effort (CPUE), are more heavily influenced by factors other than changes in population abundance For example, migratory routes and timing could change from year to year giving the impression that population abundance is fluctuating when it is not Also, if there are several types and genetically or demographically distinct populations within these types, the fishery may be impacting an unknown and possibly changeable mixture of populations Management of harvest from stock mixtures is complicated by the risk of extinction of some stocks due to over-exploitation and the possibility of changes in apparent population abundance due to changes in contributions of various stocks from year to year Third, the age of recruitment is relatively late compared to many species, consequently there is a longer period of juvenile mortality and thus greater potential for a lack of a stock-recruitment relationship The above factors have influenced our approach to analysis The possibility of bias in CPUE analysis and the likelihood of multiple stocks in the harvested population has led us to also analyse the demographic characteristics (age structure, age at maturity, size at age, and mortality) of the population as indicators of fishery impacts

Interest in developing economic opportunities prompted the Inuvik Hunters and Trappers Committee (HTC) to request a exploratory fishery license for the Middle Channel area of the Mackenzie Delta in 1989 The request was granted and a five year exploratory fishery program was begun The HTC subsequently transferred the co-ordination and management of this fishery to the Uummarmiut Development Corporation (UDC) The Department of Fisheries and Oceans Western Arctic Area Office, based in Inuvik, was responsible for collecting biological information throughout the five year fishery This report examines broad whitefish data collected during this exploratory fishery, 1989 to 1993 Data from a sub-sample of the fish harvesters catch were analysed (exploratory fishery assessment) as well as data from variable mesh experimental gill nets (population assessment) Experimental gill nets sample a wider size and age range of fish than the fishery nets and are therefore better able to reflect the populations' characteristics An economic analysis of the commercial viability and potential of this fishery is reported in Anderson (1995) Biological data for species other than broad whitefish were analysed and a report is in progress

STUDY AREA

The Mackenzie River, situated in the western Canadian Arctic, drains an area of 1 75 million km^2, discharges 333 km^3 of water per year and carries 118 million tonnes of suspended sediment which is deposited over the largest delta in Canada (12,170 km^2) (Fig 1) Two-thirds of the rivers flow follows the Middle Channel through the delta (Brunskill 1986) The Mackenzie River Valley has moderated the sub-arctic and tundra climate that surrounds it to such an extent that the southern boreal forest has extended northward through these zones into the Delta (Rosenberg and Barton 1986)

The ice-free season for the lower Mackenzie River is late June to early October Subsistence fishing for broad whitefish begins in early July and continues through to freeze-up Some harvesters resume fishing under the ice, shortly after freeze-up, and continue for one to two months until catch-per-unit effort drops and the ice becomes too thick to set or pull nets

HISTORIC FISHERIES

Commercial development of broad whitefish from the Mackenzie River has been attempted in the past The Department of Northern Affairs and National Resources established several small fisheries at Aklavik, Kittigazuit and the mouth of the Peel River in 1960 and 1961 (Davies et al 1987, Barlishen and Webber 1973) These were followed by a fishery at Holmes Creek in 1963 and 1964 which was sponsored by the Department of Indian Affairs and Northern Development (Davies et al 1987, Bissett 1967) In 1965 and 1966 Menzies Fish Co , based out of Great Slave Lake, tried to develop a fishery based out of Inuvik (Davies et al 1987, Bissett 1967) Six years later the Northwest Territorial Government made another attempt to establish a export commercial fishery based at the mouth of Holmes Creek on the East Channel of the Mackenzie River Delta This fishery operated for two years, 1972 and 1973 In 1974 it was moved to Inuvik and subsequently closed (Davies et al 1987) The primary factors for the failure of these fisheries were technical difficulties (equipment failures and inadequate handling facilities) and a market that could not provide sufficient returns (Davies et al 1987) Commercial sales of broad whitefish and other species continued but on a much smaller, local level Harvesters who fish primarily for subsistence purposes will purchase a commercial license which allows them to sell a portion of their catch to local businesses, other community members and tourists

Data available on the broad whitefish fishery harvests has varied with time and data collection efforts The estimated weight of broad whitefish sold during export commercial fisheries from 1960-1974 (Table 1) shows sales ranged from a high of 37,399 (1966) to a low of 1,507 (1972) Annual estimates of local commercial sales from all communities along the lower Mackenzie River from 1975-1988 ranged from

460 kg to 23,374 kg (Treble 1996) Estimates of subsistence harvest and domestic (licensed) catches ranged from 25,436 kg to 299,378 for 1975-1993 (Treble 1996) For 1988, the subsistence harvest was estimated to be 295,693 kg, this included the majority of harvesters in the Inuvialuit Settlement Area (Fabijan 1991a, 1991b, 1991c) and in the communities of Ft Good Hope, Ft McPherson and Tsiigehtchic (Lutra Assoc 1989) Treble (1996) suggests that the total broad whitefish harvest falls within a range of approximately 100,000 kg to 300,000 kg A more precise estimate may be possible once all harvest monitoring programs are in place

EXPLORATORY FISHERY, 1989-1993

The 1989-1993 exploratory fishery began each year in early September and lasted for approximately one month with the start and end dates varying only slightly from year to year At this time of year broad whitefish are plentiful and in peak condition Also, water and air temperatures are beginning to decrease making it easier to keep the fish fresh and of good quality

The fishery was conducted within a 30 km section of the Middle Channel (Figs 2 to 6) Fishing was carried out primarily in the Middle Channel within the vicinity of fish camps However, other locations included Jackfish Lakes area (near Location 2 in 1990 and possibly other years), Crooked Channel (near Location 8 in 1990), Thrasher Channel (near Location 6 in 1992 and 1993), and near the junction of Oniak Channel and East Channel (near Location 7 in 1993) Table 2 contains data on the assigned quota and on the amount of fish harvested from all locations combined for each year of the exploratory fishery, 1989-1993

MATERIALS AND METHODS

Over the five years of the exploratory fishery, the biological monitoring program was co-ordinated (in different years) by three DFO biologists resulting in some differences in the specifics of program design among years (e g more or fewer sampling locations, changes in the ageing structure sampled) (see Appendix 3)

The original Lotus data files were verified and their formats standardised prior to the creation of a database on a Micro Vax computer The database was checked for outliers or erroneous data points using plots of fork length against age, round weight against age, and round weight against fork length Extreme outliers and data points that were determined to be in error were removed prior to analysis All statistical analyses described below were performed by The Statistical Analysis System (SAS release 6 08) on a Micro Vax computer and were considered significant at the 95% level The personal computer software packages, CorelDraw (4 0), SigmaPlot (4 0) and Freelance (4 0) were used to create figures and tables

The following is a summary of the methods used for the two components of the biological monitoring program, the exploratory fishery assessment and the population assessment Also, Orman (1992) provides full details concerning the sampling protocols for 1991

EXPLORATORY FISHERY ASSESSMENT

Production

Each harvesters' catch as well as the total production from the fishery were recorded by the manager at the Inuvik fish plant In 1989-1992 fish were exported from the NT through the Freshwater Fish Marketing Corporation, with a small amount of frozen, whole or filleted fish available for sale locally In 1993, the entire catch was marketed locally by the UDC

Catch per unit effort

Log books were used in 1990 and subsequent years so that individual harvesters could record catch information each time they checked a net Time of net check, time of the last check, net length and the number of species caught were to be recorded The use of log books continued in each subsequent year

Catch per unit effort (CPUE) was calculated using the following formula CPUE = [No of fish caught x (45 9 m/net length)] x (24 hours/hours set) The standard net length was set at 45 9 m (50 yd) to correspond with the length of the experimental and control gill nets Most harvesters used 50 yd or 100 yd gill nets When the same number of nets were fished consistently throughout the day, a total CPUE for the day could be calculated However, in the cases where changes in nets were made, or the length of set was not uniform over all nets, an average CPUE for the nets fished that day was calculated Some harvesters referred to their nets by number with no corresponding length In these cases a CPUE per "net" was calculated using the following formulae CPUE = [No of fish caught x (1 net/nets fished)] x (24 hours/hours set) A mean CPUE for each location, and an overall mean CPUE for all locations combined (using data from nets of known length only), was calculated for each year

Biological evaluation

Sampling sites and methods In 1989, broad whitefish and northern pike were sampled during six day trips to six of the harvesters' camps (Fig 2) (Polakoff 1989) Fork lengths (mm) and round or dressed weight (g) were recorded, and the dorsal fin removed for age determination (See Appendix 3) Sex information was collected from two locations

In 1990, two harvesters (Locations 2 and 4) were chosen and agreed to have their catch sampled (Fig 3) Fork lengths were collected from as many fish as possible and a random subsample of the catch was sampled for fork length, round weight, dressed weight, sex, maturity, and gonad weight The removal of otoliths would damage fish that were to be marketed, so the right pelvic fin and scales were removed for age determination Species other than broad whitefish, (e g lake whitefish, inconnu and northern pike) were sampled for fork length and round weight only

The sampling procedures used in 1991 were similar to those used in 1990 except that 1) the left pectoral fin was removed for age determination, and 2) gonad weight was collected for only a small number of samples from Location 4 and the experimental gillnetting site (Orman 1992) (Fig 4)

A third monitoring station (Location 6) was added in 1992 (Fig 5) and the collection of gonad weight from fully sampled fish was re-instated at all locations

In 1993 some sampling was carried out at the fish plant in Inuvik in addition to the fish camp locations Inconnu from all the harvesters' camps and broad whitefish from two Locations 5 and 7 (Fig 6) were sampled at the fish plant for fork length, dressed weight and ageing structure (the left pelvic fin was collected from all locations in 1993)

Ageing methods: The first three fin rays were removed as close to the body as possible, dried, trimmed, cleaned, dipped in epoxy resin and placed on a non-stick surface to cure (Chilton and Beamish 1982) A low speed saw with a diamond edged blade was used to cut three thin cross-sections which were mounted on glass microscope slides The cross-sections were viewed under a compound microscope using transmitted light Clear rings or translucent zones around the centre of each individual ray are considered annuli and one annulus is believed to correspond to one year of growth

A method similar to that described in Barber and McFarlane (1987) was used to age the otoliths A scalpel was used to score and break the otolith through its nucleus One of the halves was then burned in an alcohol flame, taking care not to scorch it to the point where it becomes brittle The otolith was then placed burnt side up in a piece of modelling clay and cooking oil was applied to the burnt surface to improve contrast between zones The otolith was then viewed using a dissecting microscope and reflected light The dark bands that surround the central nucleus were counted as annuli

Data analysis.

LENGTH, AGE, AND MATURITY Frequency distributions for broad whitefish length and age were produced by sex, location, and year Comparisons between sexes were made using the Kolmogorov-Smirnov two-sample test for equality of distributions (Sokal and Rohlf 1981) Analysis of co-variance (Sokal and Rohlf 1981) was used to compare sexes for length adjusted by age The model was as follows $Yij = \mu + \alpha i + \beta j(Xij - \chi) + \varepsilon ij$, where $Yij =$ jth fork length in the ith group, $\mu =$ grand mean, $\alpha i =$ fixed effects for group i, $\beta j(Xij - \chi i)$ =effect explained by the difference of the variate age (X_{ij}) from the mean of the ith group (x_i), $\varepsilon ij =$ random deviation Mean length and age were also calculated for each sex by location and year and comparisons made between sexes using Students' T-test (Sokal and Rohlf 1981)

Within and between year comparisons of mean length and age for both sexes combined were made using an analysis of variance test (ANOVA) (Sokal and Rohlf 1981)

Gonad weight was collected to quantify gonad development using the Gonadosomatic Index (GSI) This index was calculated using the following formula GSI=(gonad wt (g)*100)/round weight (g) GSI values were plotted against fork length and Julian day for each sex by location and year Mean GSI was calculated for the entire sample as well as for immature/resting, and mature females (GSI £ 5 0 and > 5 0, respectively) and immature/resting, and mature males (GSI £ 0 3 and > 0 3, respectively) The GSI values that we used to classify broad whitefish as mature and immature/resting were selected based on the distribution of data points in the plots described above Although the maturity of sampled broad whitefish was assessed by the field technicians in most years, inconsistencies in the codes used and the definition of the codes rendered these data suspect and they have not been considered further in this report (see Appendix 3) GSI values were used to calculate percent mature and age at maturity values for that portion of the population vulnerable to the fishery

GROWTH Weight-length relationships were calculated using least squares regression analysis on log transformed data for length and weight The model was as follows Log_{10} W=a(log_{10} L)+b, where W=round weight (g), L=fork length (mm), a=slope of the regression line and b=y-axis intercept (Sokal and Rohlf 1981) Using ANCOVA we compared weight differences among sexes For each combination of year and location we performed an ANCOVA on Log_{10} transformed data to determine if sexes differed in weight using length as the covariate The model was the same as that given above with $Yij = j^{th}$ log_{10} weight in the i^{th} group and $X_{ij}=j^{th}$ log_{10} length in the i^{th} group

The above ANCOVA model was also used to compare weight adjusted for length between locations within year, for male and female broad whitefish

A weighted mean length at age was calculated for Locations 2 and 4 which were sampled consistently throughout the fishery They were located on the Middle Channel, one near each end of the section of the delta in which the fishery occurred, approximately 30 km apart (Fig 2)

Fulton's condition factor (K) was calculated using the following formula K=Round Wt (g)*10^5/$length^3$ (mm) (Anderson and Gutreuter 1983)

For both sexes combined the mean fork length at age was plotted for each year Regression analysis on log_{10} transformed data was used to determine whether or not the slope of the regression line was equal to zero

MORTALITY Catch curves (natural log of age class frequency against age) were plotted for each location and year These curves provide a visual representation of the age structure of the catch but they can also provide additional information The instantaneous mortality rate (Z) is the positive slope of the least squares regression fitted to the descending limb of the catch curve (Ricker 1975) This regression includes the catches from the age class with the greatest abundance plus one year, to the oldest age class The annual survival rate (S) is calculated as follows e^{-z} and the annual mortality rate (A) is equal to 1-S (Ricker 1975)

SEX RATIO It is assumed that sub-sampling of the harvesters' catch was done in a random manner and that the sex ratio was an accurate representation of the fishery population at that time and location The ratio of female to male broad whitefish was calculated by year and location with a total (all locations combined) catch ratio calculated for each year In order to examine short term temporal trends, the sex ratio was also calculated for each day of the fishery

POPULATION ASSESSMENT

Trap netting

In 1990 and 1991 the feasibility of using trap nets in the Mackenzie Delta channels was tested In 1990, Horseshoe Bend (Fig 3) was fished with a bottom set trap net from 20-23 and 25-27 September (Fricke 1991) Few broad whitefish were captured (approximately 78 kg of whitefish species (Fricke 1991)) and the biological data have not been located In 1991 a floating trap net was added One was fished at two locations on the Middle Channel (Fig 4) with only 45 broad whitefish caught over 15 days of fishing (7-25 September) (Orman 1992) The second trap net was fished further downstream in the East Channel at Lucas Point (Fig 1), but only two broad whitefish were caught in over 21 days (29 August to 18 September) (Orman

1992) With respect to the Lucas Point location, it has been suggested that fishing is best in the East Channel during June, July and early August so the timing of the trap netting at Lucas Point may have been a factor in the poor catch (Earl Jessop, DFO-Winnipeg, personal communication) However, it is difficult to find the special conditions and near perfect locations required for effective operation of trap nets in rivers (Earl Jessop, DFO-Winnipeg, personal communication) It was concluded that trap nets were not well suited for the large, deep channels of the Mackenzie River Delta, and none of the data from these efforts have been analysed further

Experimental gill netting

An experimental gill netting program was initiated in 1990 Samples were collected using a 45 9 m (50 yd) net, 1 83 m (6 ft) deep, divided into 9 1 m (30 ft) panels of 38 mm (1 5"), 64 mm (2 5"), 89 mm (3 5"), 114 mm (4 5") and 139 mm (5 5") green monofilament mesh attached together to form a continuous mesh gang Nets were set at or near the surface (as per local custom when fishing in the river channels) and in locations adjacent to those used by commercial harvesters from Locations 2 and 4 (Fig 3)

In 1991 the experimental gill netting site was moved to a location separate from the exploratory fishery locations (Fig 4) and a 45 9 m (50 yd), 139 mm mesh monofilament gill net was fished near the experimental gill net to provide "commercial net" data to compare with the experimental net data from this site

Biological evaluation

Sampling sites and methods In 1990 two locations were chosen to test for spatial differences, Location 2 at the north end and Location 4 at the south end of the exploratory fishery area (Fig 3) Location, duration and catch per mesh were recorded for all species caught Biological data consisted of, fork length (mm), round weight (g), dressed weight (g) (for a subset of samples only), sex, maturity, and gonad weight (g) Some fish were sampled for length and weight data only, due to sampling time restrictions

Scales and a right pelvic fin were chosen for age determination in order to be consistent with samples collected during the monitoring of the fishery and with samples previously collected from this region (leaving the left side intact on fish that were to be analysed for meristic and morphometric information)

The Pete's Creek and Holmes Creek areas, located downstream of the exploratory fishery, were identified by resource users as having the potential to produce large, good quality broad whitefish (Fig 1) Commercial fisheries had been previously conducted at Holmes Creek in 1963 and 1964, and again in 1972 to 1974 In 1990 an effort was made to collect data and assess fishery potential in these areas Experimental gill nets were fished at each site on two separate occasions (Sept 13 to 15 and 23 to 26) A total of 83 broad whitefish were caught (with an additional 5 broad whitefish from a 139 mm mesh gill net fished at Homes Creek, Sept 24 to 25) As these locations were not fished in subsequent years the data have not been included here

Experimental gill netting continued in 1991 with slight modifications to the 1990 procedures A single Experimental Gill Netting Site was located on the east bank of the Middle Channel (Fig 4) An experimental gill net and a "control" net (described above) were fished during alternate days (i e experimental net on Day 1 followed by the 139 mm control net on Day 2) On every other set involving the experimental gill net the nets were reversed end for end to vary the location of the large and small meshes Net panels were numbered in relation to their position relative to the river bank With panel one next to the bank and panel five away from the bank, nearest the net marker buoy The control net was also divided into 9 1 m (10 yd) panels, to match the experimental net (Orman 1992) Biological data were collected as in 1990 with the exception of the ageing structures In addition to scales, the left pectoral fin and otoliths were collected

The experimental site chosen in 1991 was also used in 1992 and 1993 (Fig 5 and 6) Data collected were similar in both years except that 1) the recording of catch by net panel was discontinued following 1991, and 2) the pelvic fin was collected for age determination in 1993

Ageing methods Ages were determined as described above for the Exploratory Fishery Assessment

Data analysis Data from the 139 mm mesh "control" nets from the Population Assessment Program were included in the comparative analyses for the Exploratory Fishery Assessment Any comparative analyses described below used data from the variable mesh experimental gill nets only

LENGTH, AGE AND MATURITY Length and age frequency histograms were prepared to display catch composition by sex and year with location added for the 1990 data These distributions and mean length and age values were compared as above for the exploratory fishery assessment For both sexes combined, mean age and length from the two 1990 locations were compared using Students' T-test Mean age and length for both sexes combined were also compared among years The Gonadosomatic Indices were analysed as in the exploratory fishery assessment methods

GROWTH Weight-length regression analyses were performed on the data as described above for the exploratory fishery assessment samples Comparisons were made between sexes, between locations (for 1990), and between years, using ANCOVA

Mean length at age and Fulton's condition factor were also calculated and analyses conducted as above

MORTALITY Instantaneous mortality (Z), annual survival rate (S), and annual mortality rate (A) were calculated for 1990, 1992 and 1993 as described above for the exploratory fishery assessment data

SEX RATIO All the fish caught at the Experimental Site were sampled Analyses were conducted as described above for the exploratory fishery assessment data

RESULTS AND DISCUSSION

EXPLORATORY FISHERY ASSESSMENT

Of the catch reported previously, 102, 376, 854, 1,178, and 1,218, broad whitefish were fully or partially sampled for biological information in 1989, 1990, 1991, 1992, and 1993, respectively

Production

The UDC Exploratory Fishery quotas and production levels for all species are provided in Table 2 The quota for broad whitefish was initially set at 16,000 kg and then increased to 20,450 kg in 1991 Broad whitefish harvest ranged from 5,781 kg in 1989 to 19,234 kg in 1991

Catch per unit of effort (CPUE)

Table 3 contains annual mean CPUE data for each location The mean CPUE for nets of known length ranged from 5 4 to 17 5 fish/45 9 m net/24 hours There were no observable trends to this data either between locations within year or within location between years, nor were there any trends in the daily CPUE data from which these means were derived (Treble et al , unpubl data report) These results should be interpreted with caution, as in this case, CPUE may not be a reliable measure of relative abundance The fishery occurred at a time when several broad whitefish stocks may have been moving through the area as part of their spawning migration

Biological evaluation

Data analysis

LENGTH, AGE, AND MATURITY To examine the hypothesis that there was no difference among sexes, data (length and age distribution, length adjusted for age, and mean length and age) from 16 different combinations of location and year were compared Only one (Location 6, 1992) of 16 comparisons was significant for age frequency distribution (P=0 0028) and only two were significant for length frequency distribution Location 2, 1990 (P=0 0085) and Location 6, 1992 (P=0 0132) at p<0 05 Location 2, 1990 was the only sample that showed a significant difference in length adjusted for age (P=0 0093) The t-test's of mean age and length proved to be invalid as a majority of the 16 samples were not normally distributed A Log_{10} transformation was not able to correct this

The differences between the sexes described above were determined to be within the range of expected variability (one comparison in 20) and therefore in all cases they were combined for further analyses

Table 4 contains a statistical summary of the age, fork length and GSI for all broad whitefish sampled (sexes combined) Fork lengths ranged from 253-685 mm with the majority within 450-600 mm For the 1990 Jackfish Lakes sample, 18 0% were <465 mm, compared to 2 7% and 5 4% for Locations 2 and 4, respectively (Treble et al , unpubl data report) However, the mean and modal lengths did not reflect this difference between locations The samples from Location 6 were also comprised of a larger proportion fish <465 mm (29 9% in 1992 and 49 5% in 1993) as compared to Location 2 (16 8% in 1992 and 16 7% in 1993) and Location 4 (18 8% in 1992 and 14 2% in 1993) (Treble et al , unpubl data report)

There were no significant differences between locations for mean lengths in 1990 and 1991 but there was for both 1992 (P=0 0014) and 1993 (P=0 0001) The GT2 and Tukey-Kramer multiple comparison procedures (MCP's) showed that Location 6 was different from the other locations in 1992 and 1993 There was no significant difference between locations for either 1992 or 1993 when Location 6 was removed from the analysis

Data for Location 6 was removed and the data from the other locations combined for comparison between years The ANOVA of mean length between years proved to be significant (P=0 0001) The MCP's showed 1991 to be significantly different from 1992 and 1993, although no trend was evident, as 1990 data were not significantly different from these later years

Ages were relatively constant through all years of the fishery and ranged from three to 23 years with the majority falling between nine and 14 years One fish aged 30 years was caught in 1991 The modal age varied between nine and 14 years for the majority of locations (Table 4) Jackfish Lakes and Location 6 were similar and appeared to differ from the other locations with modal ages of seven and six years, respectively (Table 4)

Mean age varied between 10 8 and 12 9 for locations other than Jackfish Lakes (9 6 years) and Location 6 (8 6 to 9 1 years) (Table 4) and an ANOVA showed significant differences between locations for all years The GT2 and Tukey-Kramer MCP's suggeste that the Jackfish Lakes sample was different from the other locations in 1990, all three locations differed from each other in 1991, and Location 6 was different from the other locations in 1992 and 1993 Unlike in the mean length analysis above, when the side channel locations were removed, only the 1990 locations become non-significant at P<0 05 Therefore due to differences between locations the samples were not combined for comparison between years Location's 2 and 4 were examined for between year differences (they were two locations which were sampled continuously over the length of the fishery) There were no significant differences between years for Location 4 (P=0 0667) but there were for Location 2 (P=0 0003) However, the MCP's showed no trend in the results for Location 2 with 1990 and 1993 similar to each other but different from 1991 and 1992, which were also similar to each other

Location 6 differs from the others and this data may represent a "west side" population of broad whitefish that were making their way into the Upper Delta to spawn Alternately, Location 6 and Jackfish Lakes may represent "static habitat sites" where more life history stages may be found, as opposed to "transitory habitat sites/migration routes" where there is an influx of adult migrants that are passing through or holding at the sampling times (Ken Chang-Kue, DFO-Winnipeg, personnel communication) Also, it may be that catch efficiency was better in the lakes and smaller side channels because net placement was not as restricted and currents were not as strong as in the large main channel (i e the nets may sample a better cross-section of the population present at that point and time)

Age frequencies can give an indication of what is happening to a stock If there is a steady decline in the number of age groups and the number of older age fish in the fishery this is an indication of over-harvest Fisheries that take from a few age classes have much less stability than those that maintain a large number of age groups in the stock This is because the former situation relies on consistently good recruitment (both at the level of reproduction and survivorship to the age of recruitment to the fishery) In the case of the fishery analysed here, the wide range and high number of year classes combined with a steady age structure across the years examined indicates that the population(s) are stable and the fishery is having little effect

Mean gonadosomatic index (GSI) ranged from 0 42 to 1 23 for male broad whitefish and from 3 29 to 18 77 for females (Table 4) Many points for the 1991 male GSI's from Location 4 were out of the expected range (>3 2) suggesting that there may have been a malfunction in the scale used to weigh the gonads or the weights were misinterpreted Therefore, this location has been omitted from any further analysis Scatter plots of GSI against fork length and Julian day showed a greater portion of the catch from Location 6 was immature or resting as compared to the other locations for both females in 1992 and 1993 (Fig 7 and 8) and males in 1993 (Fig 9) (Treble et al , unpubl data report) A comparison of the means and modes for this location support this observation (Table 4) For example, the GSI mean and mode for females from Location 6 was 3 29 and 1 0, respectively, as compared to approximately 16 5 and 17 0, respectively for the other locations in 1993 The difference for the male GSI is not as marked as that for the female but is still evident with a mean of 0 42 and a mode of 0 10 for Location 6 and a mean and mode of approximately 1 10 for the other locations in 1993 These data were not examined for statistical differences

The mean GSI for mature females (GSI>5) varied from 15 7 to 20 4 and for immature females (GSI≤5) from 0 44 to 1 51 (Treble et al , unpubl data report) Male broad whitefish had mature (GSI>0 3) and immature (GSI≤0 3) values for mean GSI that ranged from 0 86 to 1 44 and 0 07 to 0 29, respectively (Treble et al , unpubl data report) The youngest mature females and males were aged five and four, respectively Age of maturity based on data from all locations combined was eight years for females and five to six years for males (Fig 10 and 11) These were the age groups in which at least 50% of the fish were current year spawners (Morin et al 1982) However, the data are from a single mesh size (139 mm) and therefore these ages of maturity may not correspond to the population as a whole

GROWTH Ten of the sixteen samples showed a significant difference between male and female broad whitefish for weight adjusted for length Females were on average heavier at a given length than the males This may be expected because samples were collected almost exclusively from mature individuals prior to spawning, when females are gravid and maturity varies

Tables 6 and 8 contain the parameters of the length-weight relationship for male and female broad whitefish, respectively (Location 6 is included in this data for 1992 and 1993) Mean length at age eight years ranged from 476 mm to 519 mm and at age 12 from 500 mm to 651 mm, across all years for the pooled samples (Appendix 2) The ANCOVA showed that for both males and females there was a significant difference in weight adjusted for length between locations for 1991, 1992 and 1993 A multiple comparison procedure using the least squares means suggested that the Experimental Site contributed to the significant result in 1991 (male p=0 0491 and female p=0 020,) and that Location 6 contributed to the significant result for 1992 (male p=0 0001 and female p=0 0001) and 1993 (male p=0 0007 and female p=0 0010) With Location 6 removed the comparisons for 1992 continued to be significant for both males and females (at least one location was different from the others) but 1993 locations were no longer significantly different

Length-weight relationships, as discussed above, are too strongly affected by seasonal patterns for one to say anything about inter-annual variation, particularly since there is no accepted response of length-weight relationships to changes in stock size Also, length-weight regressions do not explain much about what is going on in a fishery because they are highly variable within year Fish can change their weight up or down rapidly especially near to spawning For example if fish stop feeding as they migrate their condition will decrease as they approach spawning and probably only recover after the post spawning migration The length-weight relationship is useful as a condition index (Cone 1989) and in calculating catch at age (the percentage of length category j that is comprised of age i) if you also have catch weight with accompanying length frequency samples and an age-length key Even if the fishery is at the same time each year, changes in length-weight most likely reflect changes in the state of readiness for spawning than anything else

In contrast, length or size at age summarises all of the growth throughout the year and can only go in one direction with age It is generally thought to be a good indicator of growth conditions and population size, particularly for closed populations (Healey 1975) As a result, size at age is an indicator of population changes brought on by fishing The fishery removes fish of particular size classes At the age of first recruitment the fastest growing segment is selectively removed If the fishery is taking only a small portion of the stock then size at age should remain more or less constant The stock size is remaining stable and so intra-specific competition for resources for growth remain constant If the fishery is taking moderate levels and the stock is still stable then there may be an increase in growth rate and size at age as a result of the increase in available resources per individual fish However, if the fishery is taking a large portion of the stock then there will be a drastic increase in size at age ultimately followed by a decrease in size at age as only one or two age classes come to dominate the fishery These indicators are independent of the mesh size that is used in the fishery In very intense fisheries this can lead to a decline in size at age This model is commonly referred to as the density dependent theory of population regulation

In this fishery growth curves of mean length plotted against age showed no trends or observable differences between sexes Also, for the sexes combined, there were no noticeable differences between locations for any of the four years 1990 to 1993 (Treble et al , unpubl data report) Figure 12 shows mean length at age for each year, all locations combined while figure 14 shows scatter plots and regression lines for $\log_{10}$ transformed length and age data The regression lines for 1990 to 1993 (all locations combined and the middle channel locations) are plotted again in Figure 16 for easier comparison We concluded that there were no differences in mean length at age among years as the data are nearly superimposed on one another from one year to the next (Neter et al 1983) This suggests that, based on the above theory, the fishery is having minimal effects on length composition or stock size However, this theory may not be directly applicable due to the type of fishery (interception) and the migratory nature of the broad whitefish

AGE AND SIZE AT FULL RECRUITMENT Age at full recruitment is considered to be the modal age plus one year as determined by the natural log frequency of each age in the catch (Ricker 1975) Age at full recruitment varied between 10 to 12 years for all locations combined (Fig 17) However, the catch curves for 1992 and 1993 are affected somewhat by Location 6 where the age at full recruitment was seven years (Figs 18 and 19) Among years, the mean length at age 11 and 12 years fluctuated between 500 and 508 mm and at age seven between 472 to 493 mm (Appendix 2)

The weighted mean length for locations 2 and 4 are given in Table 10 and are 499 mm to 509 mm for ages 11 and 12 and 479 mm to 495 mm for age 7 Size at age does not vary a great deal across years, particularly for ages 10 and older Neither does size increase from age class to age class as you follow a cohort from one year to the next

MORTALITY As with CPUE, inter-annual comparisons of mortalities assumes that you have a closed population If there is movement in and out of the population the reliability of mortality estimates may be questionable However, mortalities are calculated from less aggregated data than CPUE since they are based on several age classes Therefore, they should be more reliable as biological indicators than CPUE

The instantaneous total mortality rate (Z) is calculated on those ages that are fully recruited to the fishery Post-recruitment mortality can give an indication of the effects of the fishery when age and size at first recruitment are more or less constant, as was the case in this fishery Instantaneous mortality (Z) ranged from 0 24 to 0 44 over all but one location for 1990 to 1993 (Table 11) and (Figs 16 to 18) A lower value (0 19) occurred at the Experimental Site in 1991 but was likely influenced by one outlying sample aged 30 years For comparison, a natural mortality rate of 0 2 is often used for fish with life spans similar to broad whitefish

Mortality estimates fluctuated but did not increase across the years for Location 2, and remained stable for Location 4 (Table 11) suggesting that the fishery is only taking a small fraction of the available stock and natural mortality factors are dwarfing the effects of the fishery If the fishery was having a serious depleting effect on the stock then mortality would increase from year to year because the fishery would be harvesting a greater and greater percentage of the stock and the probability of dying per individual fish would be going up each year

SEX RATIO Sometimes because of size, growth rate differences, or age at maturity differences between the sexes the fishery may reduce the number of females more rapidly than males (females often have to attain a larger size to have reproductive success, egg production goes up as a cube function of their length) If the percentage of females is declining in the fishery this may be a cause for concern because the reproductive potential of the stock is dependent upon the number of females It should be pointed out also that the overall percentage of females can remain constant but if they are mainly smaller, younger aged fish compared to previously then they will have a much reduced potential contribution to the population reproductive output

There were no obvious trends in the sex ratio for this fishery The overall value for combined locations ranged from 0 86 to 0 97 for 1990 to 1993 (Table 12) Male broad whitefish are known to begin their spawning migration prior to females However, there was no evidence to suggest that this temporal segregation was occurring at this point and time (Table 13) This result is not unexpected given that broad whitefish migrations are known to peak in late October at upstream locations and the fishery was conducted in September in a section of the river that is believed to be a staging area for both sexes, prior to the commencement of their spawning migration

POPULATION ASSESSMENT

Experimental gill netting

A total of 122 (from 46 gill net sets), 40 (27 sets), 39 (19 sets) and 66 (17 sets), broad whitefish were caught and sampled using experimental gill nets in 1990, 1991, 1992, and 1993, respectively Tables 14 to 17 show the catch per mesh size for each year Catch per unit effort varied from 2 4 to 5 2 fish per 45 9 m net/24 hours (Table 3) The low CPUE could be attributed to the fact that the majority of fish available at this location and time are mature adults that were susceptible to capture in the larger mesh sizes which comprised only a small portion of the net Also, the size of the eddies restrict the length of net that can be fished and the size of mesh placed near shore is another factor (Earl Jessop, DFO-Winnipeg, personal communication) The results presented below should be used cautiously given the low sample sizes

Biological evaluation

Data analysis

LENGTH, AGE AND MATURITY Since this fishery uses only one mesh size it is difficult to conclude anything from length distributions of the catch alone Normally you would refer to the experimental net sampling to give you a less biased estimate of length frequency changes Unfortunately, the sample sizes from the experimental nets are too small to draw definitive conclusions

There were no significant differences in length or age frequency distributions, length adjusted for age, or in mean age between males and females The Experimental Site 1993 was only one of five samples that showed a significant difference (p=0 0305) in mean length between male and female broad whitefish, therefore the sexes were combined for further analysis

There were no differences between Location 2 and 4 for the 1990 samples for mean length and age so these were combined for further analysis There were no significant differences between years for mean length or age Ages ranged from 2 to 25 years The modal ages for 1990 to 1993 ranged from 9 to 13 years and the means were 12 3 to 13 2 years (Table 5) Lengths ranged from 142 mm to 617 mm Mean length varied from 494 7 mm to 499 5 mm while the mode ranged from 495 mm to 525 mm (Table 5)

The GSI for males varied from 0 13 to 2 22 with a mean of approximately 1 2 (Table 5) Female GSI ranged from 0 21 to 23 36 with a mean of approximately 15 00 (Table 5) Further GSI analysis including age of maturity data is not presented here due small sample sizes

GROWTH A comparison of weight adjusted for length between male and female broad whitefish resulted in a positive significant difference for two of the five groups of samples (p=0 0207 and p=0 0001) A majority of the fishery samples presented previously were significantly different Therefore, it is concluded that there is a difference in weight between male and female broad whitefish at this location and time Estimates for mean weight (males) minus mean weight (females) showed that females are heavier than males for these samples

There were no significant difference between the two 1990 Locations (2 and 4) or between years for males or females Regression parameters for the relationship are given for each year in Tables 7 and 9 The common slopes were 3 19 for males and 3 20 for females

Mean length at age growth curves for the experimental gill net samples are more variable than those from the fishery samples due primarily to smaller sample sizes (Fig 12 and 13) Also, there were one or two smaller fish caught in the 1990 and 1992 experimental nets that resulted in a steep ascending growth pattern from age 2 to 6, which is absent from the other growth curves The latter curves illustrate how the 139 mm mesh gill nets were selecting fish from the upper portion of the growth curve Regression analysis on $\log_{10}$ transformed age and length data were not conducted due to small sample sizes

MORTALITY Catch curve parameters for the 1990 population assessment data are instantaneous mortality (Z), 0 32, survival (S), 0 73, and annual mortality (A), 0 27 Results for 1991 to 1993 are questionable due to small sample sizes

SEX RATIO Small sample sizes make the interpretation of the sex ratio data (F/M) presented in Tables 12 and 13 difficult The F/M ratio varied from 0 47 to 1 02 across the years Daily sex ratios were calculated for 1990 only (Table 13) No trends were observed in any of these data

SUMMARY AND CONCLUSIONS

We suggest that the fishery has had little impact on the overall population(s) abundance or the population size of any age group The evidence for this hypothesis are 1) the weighted mean fork lengths for two middle channel locations, (Locations 2 and 4) consistently sampled across four years showed no noticeable trend within age groups across the years sampled, 2) mean age was stable (excluding side channel locations), 3) age range was broad with many ages represented in the catch, 4-21 in 1990, 3-22 in 1991, 4-22 in 1992 and 5-22 in 1993, 4) the older ages remained a significant portion of the catch throughout 1990 to 1993 The large number of ages and lack of any change in age structure indicates that this fishery is at a stable equilibrium with little negative impact on the population In addition, data from Percy (1975) and Treble (1996) suggest that little change in age and length parameters has occurred since the 1973 Holmes Creek Fishery

Previously reported ages at maturity were approximately 7 to 8 years (Chang-Kue and Jessop 1992, Bond and Erickson 1982 and de Graaf and Machniak 1977) For data from this fishery, ages of maturity for females and males was found to be eight and five to six, respectively, based on the 50% mature criteria for northern fish populations suggested by Morin et al (1982)

Assuming that instantaneous natural mortality after the age of full recruitment averages 0 2, the fishing mortality at Locations 2 and 4 would be between 0 09 and 0 24 with no apparent trend from 1990 to 1993 at either location These mortality levels indicate low levels of exploitation in the fishery with relative stability in the population(s) The age at full recruitment was high, 11-12 years and suggests that many age groups contribute to recruitment Thus fluctuations due to inter-annual difference in growth and natural mortality will be dampened, and recruitment should show greater stability in this population(s) As well, the high age at recruitment is typical of populations that are not heavily exploited

There were no significant trends in sex ratio data, which was steady at approximately 1 0

Broad whitefish from Location 6 were on average smaller and younger, and a greater proportion were immature, compared to broad whitefish from the other locations The data suggest that more life history stages (from small immature fish to adults) were present in this side channel location, in contrast to main channel locations where adult, spawning migrants were more prevalent

Broad whitefish harvested during the 1989 to 1993 exploratory fishery fell within the range of estimated harvests for previous export fisheries Estimates of local commercial broad whitefish sales for 1975 to 1988 for the entire Lower Mackenzie River varied between 460 and 23,374 kg However, estimates of the subsistence and domestic license harvests of broad whitefish varied from 25,436 kg to 299,378 kg The commercial fishery continues to be a small fraction of the total broad whitefish harvest

The broad whitefish population(s) sampled along the Middle Channel west of Inuvik appears healthy and stable at the current level of total harvest (commercial and subsistence fisheries) There may be room for increased harvests but to what level is uncertain given that we do not have an accurate account of the current subsistence levels, only a range within which the harvest may fluctuate, nor do we have complete knowledge of broad whitefish biology with regards to 1) whether traditional density dependent theories on population regulation can be applied, 2) the relationship between the population(s) and recruitment to the fishery (juvenile survivorship), and 3) the composition of the catch over the duration of the fishery (Does it change? Is it comprised of a single population or a mixture of populations?) Another factor is that we do not know the level of risk associated with an increase in quota because we do not know whether we are near an optimum harvest level (the traditional method used to determine appropriate harvest levels) We do not know how the population(s) would respond to a two, four or ten fold increase in quota Finally, when making decisions, mangers must appreciate that the carrying capacity may vary with time and therefore what is today's optimum sustainable level of harvest may not be sustainable indefinitely

RECOMMENDATIONS

1) Monitoring and collection of biological data should be undertaken for fisheries that operate in the Delta Ideally both commercial and subsistence fisheries should be monitored because the power of data sets increases as more data is added over time Basic length and weight data, and ageing structures could be collected at the fish plant with a small field component to supplement that data, thereby reducing some of the sampling costs Sampling procedures and methods should be developed and implemented on a consistent basis for easy comparison between locations and years Data should be analysed using age structured models if possible Ultimately, sophisticated analyses such as cohort analysis (Pope 1972) could be performed to assist in the management of the fishery

2) The differences between the main and side-channel locations observed here are interesting Export commercial fisheries have targeted the large adult spawners that move through the Middle Channel However, this may not always be the case Research to further test differences observed between these areas would provide information useful to understanding more completely broad whitefish behaviour and life history, and ultimately lead to better management

3) Other research areas/projects might include the stock/recruitment relationship and juvenile survivorship, an examination of the catch composition over time, and the extrapolation of the data from the sampled fish to the entire catch to determine an overall age frequency and biomass at age for the fishery

4) The subsistence harvest monitoring programs developed by the Inuvialuit, Gwich'in and Sahtu should continue to collect broad whitefish harvest and fishing location information It should be noted that data that is summarised by fishing location is more valuable to fisheries managers than data that are summarised by the harvesters' community For example, data presented here suggests that fish occupying the smaller side-channels and lakes may differ in size, age and maturity from those occupying the Middle Channel How the fishing is distributed across the delta and along the Lower Mackenzie River could be important in light of this information It would not be feasible to summarise harvests from each individual location However, it is important that this information is collected and available to managers If the primary reporting document has data summarised by community, then a separate document of limited circulation could be produced for fisheries managers that summarises fish harvests by fisheries management area

5) Any increase in quota will be accompanied by some level of risk of loss of future production All communities and land claim groups who harvest broad whitefish (and any other species caught as by-catch in a commercial fishery) should be included in the decision making process surrounding commercial fishery quotas

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Table 1. Estimates of broad whitefish harvests for the years in which export commercial fisheries operated in the Mackenzie River Delta.
Source: Treble (1996).

Year	1960	1961	1963	1964	1965	1966	1972	1973	1974
Harvest (Rd Kg)	8,798	19,590	5,730	27,584	7,955	37,399	1,507	20,417	13,971

Table 2. Uummarmiut Development Corporation Exploratory Fishery harvest data (rd kgs) and quota, in brackets. Source: Department of Fisheries and Oceans (1992a, 1992b, 1993, 1994, and 1995).

	Year				
	1989	1990	1991	1992	1993
Broad Whitefish	5,781 (16,000)	13,101 (16,000)	19,234 (20,450)	17,797 (20,450)	11,821 (20,450)
Lake Whitefish	6,451 (6,000)				
Inconnu	474 (6,000)	1,042 (5,000)	2,187 (3,400)	9,086 (3,400)	1,124 (3,400)
Northern Pike	1,661 (6,000)	7,184 (5,000)	8,757 (10,200)	2,160 (10,200)	0 (10,200)
Total	14,367 (34,000)	21,327 (26,000)	30,178 (34,050)	30,863 (34,050)	12,945 (34,050)

Table 3. Mean catch per unit of effort (CPUE), by location and net type, for broad whitefish, 1990 to 1993. An overall mean CPUE has been calculated for the 139 mm mesh gill nets of known length.

Location	1990	1991	1992	1993
Location 2-Exp. Net	2.6			
Location 4-Exp. Net	4.1			
Exp. Site-Exp. Net		2.4	5.2	4.2
-139mm Mesh Net		15.8	10.7	9.6
Location 1-139mm Mesh	16.5			
Location 2-139mm Mesh	10.4	5.4	14.7 *	10.3 *
Location 3-139mm Mesh	17.5	20.7	12.3	
Location 4-139mm Mesh	7.9	16.2 *	25.0 *	
Location 5-139mm Mesh			18.6 *	17.3 *
Location 6-139mm Mesh			9.8	7.2 *
Location 7-139mm Mesh				6.7 *
MEAN CPUE	13.1	14.0	10.9	9.6

* This value was not used in calculating the mean because net size was unknown.

Table 4. Summary statistics for broad whitefish from 139 mm mesh gill nets, 1989 to 1993. Source: Treble, et al. unpubl. data report.

Year	Location No.	Age (yrs) n	Mean	Mode	Range	Fork Length (mm) n	Mean	Mode	Range
1989*	1	17	9 8	9, 10	7-14	20	504	475	460-651
	2	20	8 8	7, 9	6-13	20	489	495	440-540
	3	18	9 1	9	7-11	22	500	495, 515	460-595
	4	20	8 9	8	7-14	20	494	505	465-544
	5	19	9 3	10	6-13	20	514	515	483-584
1990	2	130	11 8	12	5-20	189	500	495	440-603
	4	146	11 4	11	4-21	147	504	495	442-588
	J Lakes	27	9 6	7	3-17	39	498	505	420-590
1991	2	199	10 8	10	3-19	200	504	505	389-603
	4	271	12 1	10	3-22	654	509	495	354-614
	Exp Site	202	12 9	10, 11	5-30	250	507	495	305-622
1992	2	348	10 9	11	4-22	405	499	495	415-613
	4	407	11 5	11	4-22	415	499	505	379-620
	6	352	9 1	6	4-19	351	491	465	253-610
	Exp Site	79	11 7	11	5-19	78	500	495	450-647
1993	2	311	11 7	9	5-21	312	498	495	417-630
	4	297	11 5	9	5-22	332	498	475	377-645
	5	117	12 1	14	6-22	117	492	475	430-586
	6	301	8 6	6	4-20	317	475	465	337-655
	7	136	11 4	**	6-18	140	496	475	421-564
	Exp Site	157	12 7	14	6-22	158	502	475, 485	442-574

* Age data for 1989 is suspect and has not been used (Appendix 3).
** Ages 10, 11, 12, and 13 had equal frequencies.

Table 4. Con't.

Year	Location No.	GSI-Male n	Mean	Mode	Range	GSI-Female n	Mean	Mode	Range
1990	2	66	0.99	0.9	0.12-1.75	64	17.79	17, 21	0.19-25.85
	4	77	1.11	0.9	0.68-2.27	70	18.77	21	0.95-26.90
	J. Lakes	15	1.08	0.9	0 08-1.66	12	10.26	1 0	0.09-21 33
1991	4*	33	1.98	0.5	0.07-5.0	38	14.52	19, 21	0.45-23.03
	Exp. Site	109	1.23	1.3	0.29-2.14	102	19.26	19	0.23-28.98
1992	2	7	0.50	0.1	0.04-1.78	49	14.34	1.0	0.64-31.67
	4	186	1.15	1.1	0.08-3.08	174	16.02	15, 19	0.53-27.45
	6	22	0.81	0.4	0.10-1.46	109	4.46	1 0	0.25-24
	Exp. Site	9	1.20	1.1, 1.5	0 72-1.5	14	16.85	**	1.35-22.91
1993	2	174	1.00	1.1	0.05-2.06	138	16 35	17	0.17-24 32
	4	135	1.16	0.9	0.10-2.35	131	17.56	17	0.51-25.52
	6	103	0.42	0.1	0.06-1.49	125	3.29	1.0	0.07-24.0
	Exp. Site	100	1.18	1.1	0.47-2.26	50	16.07	17	10.9-24.58

* Several male broad whitefish samples had unusually high GSI values (>3.2) which suggests that the scale may have been malfunctioning or the weight mis-interpreted.

** The gonadosomatic indices of 15, 17, and 21 had equal frequencies.

Table 5. Summary statistics for broad whitefish from 38 mm to 139 mm multi-mesh experimental gill nets. Source: Treble, et al. unpubl. data report.

Year	Age (yrs)				Fork Length (mm)				GSI - Male				GSI - Female			
	n	Mean	Mode	Range	n	Mean	Mode	Range	n	Mean	Mode	Range	n	Mean	Mode	Range
1990	120	12 3	11, 12	2-21	122	497	525	142-576	60	1 11	1 1	0 75-2 22	61	16 52	17	0 29-22 79
1991	34	13 2	9, 10	4-25	40	500	505, 525	360-570	15	1 14	1 3	0.13-1 82	17	14 57	13, 17	0 21-21 43
1992	37	12 3	11	3-20	39	495	505	175-617	4	1 18	1 1	0 62-1 88	3	15 08	15	14 76-15.59
1993	66	12 4	13	6-19	66	495	495	440-577	38	1 15	0 9, 1 1	0 55-2 02	18	17 34	15	13 29-23 36

Table 6. Weight-length regression parameters for male broad whitefish from 139 mm mesh gill nets, 1989 to 1993.

Year	Slope	Intercept	R-square	Total DF	F-value	p-value
1989	2.648	-3.845	0.759	15	44.122	0.0001
1990	3.070	-5.013	0.763	172	549.029	0.0001
1991	2.759	-4.167	0.725	340	892.091	0.0001
1992	2.451	-3.352	0.578	485	664.014	0.0001
1993	2.488	-3.451	0.737	571	1594.654	0.0001

Table 7. Weight-length regression parameters for male broad whitefish from 38 mm to 139 mm multi-mesh experimental gill nets, 1990 to 1993.

Year	Slope	Intercept	R-square	Total DF	F-value	p-value
1990	3.229	-5.450	0.774	59	198.415	0.0001
1991	2.978	-4.771	0.868	14	85.212	0.0001
1992	2.148	-2.502	0.490	17	15.339	0.0012
1993	3.098	-5.101	0.819	40	176.459	0.0001

Table 8. Weight-length regression parameters for female broad whitefish from 139 mm mesh gill nets, 1989 to 1993.

Year	Slope	Intercept	R-square	Total DF	F-value	p-value
1989	1.834	-1.643	0.366	23	12.714	0.0017
1990	2.879	-4.474	0.668	157	314.222	0.0001
1991	2.819	-4.298	0.721	330	849.827	0.0001
1992	2.517	-3.517	0.549	487	590.704	0.0001
1993	2.542	-3.575	0.709	495	1203.576	0.0001

Table 9. Weight-length regression parameters for female broad whitefish from 38 mm to 139 mm multi-mesh experimental gill nets, 1990 to 1993.

Year	Slope	Intercept	R-square	Total DF	F-value	p-value
1990	3.197	-5.341	0.798	60	233.501	0.0001
1991	3.167	-5.246	0.701	16	35.150	0.0001
1992	2.829	-4.344	0.786	18	62.490	0.0012
1993	3.119	-5.117	0.929	18	223.876	0.0001

Table 10. Weighted mean fork lengths (mm) at age with the corresponding sample size in brackets for broad whitefish from Locations 2 and 4 combined. Source: Treble et al., unpubl. data report.

Age	1990	1991	1992	1993
3		427 (2)		
4	517 (1)		429 (3)	
5	524 (2)	493 (5)	454 (14)	468 (5)
6	516 (3)	478 (16)	468 (34)	470 (26)
7	479 (3)	495 (25)	479 (28)	479 (38)
8	491 (19)	487 (29)	490 (78)	479 (32)
9	498 (26)	501 (40)	493 (62)	485 (91)
10	496 (41)	507 (71)	500 (72)	494 (59)
11	504 (49)	508 (66)	500 (127)	503 (48)
12	501 (47)	509 (65)	503 (105)	499 (71)
13	502 (31)	517 (43)	506 (80)	506 (62)
14	509 (19)	511 (24)	506 (57)	505 (69)
15	513 (9)	519 (24)	515 (31)	514 (44)
16	503 (7)	517 (13)	522 (24)	518 (21)
17	498 (7)	532 (19)	509 (8)	508 (11)
18	500 (4)	548 (9)	507 (13)	521 (13)
19	505 (2)	531 (11)	526 (10)	535 (8)
20	529 (4)	564 (5)	534 (6)	526 (6)
21	488 (1)	612 (2)	572 (1)	553 (5)
22		563 (1)	488 (2)	590 (1)

Table 11. Instantaneous mortality (Z) for broad whitefish from 139 mm mesh gill nets, 1990 to 1993.

Location No.	1990	1991	1992	1993
2	0.41	0.34	0.44	0.24
4	0.30	0.29	0.34	0.33
5				0.30
6			0.27	0.25
7				0.27
Exp. Site		0.19	0.29	0.34

Table 12. Sex ratio for female to male broad whitefish (F/M) from 139 mm mesh and 38 mm to 139 mm multi-mesh experimental gill nets, 1990 to 1993.

Year	Location	Net Type	Females	Males	Sex Ratio (F/M)
1990	4	139 mm	70	77	0.91
		Experimental	30	33	0.91
	2	139 mm	75	81	0.93
		Experimental	31	27	1.15
	Jackfish Lakes	139 mm	13	15	0.87
	Overall	139 mm	158	173	0.91
	Overall	Experimental	61	60	1.02
1991	4	139 mm	133	140	0.95
	2	139 mm	102	98	1.04
	Exp. Site	139 mm	102	109	0.94
	Overall	139 mm	337	347	0.97
		Experimental	19	16	1.19
1992	4	139 mm	200	212	0.94
	2	139 mm	167	182	0.92
	6	139 mm	180	177	1.03
	Exp. Site	139 mm	38	40	0.95
	Overall	139 mm	585	611	0.96
		Experimental	20	18	1.11
1993	4	139 mm	154	173	0.89
	2	139 mm	138	174	0.79
	6	139 mm	164	138	1.19
	Exp. Site	139 mm	51	107	0.48
	Overall	139 mm	507	592	0.86
		Experimental	21	45	0.47

Table 13. The female to male sex ratio (F/M) and sample size (N) for broad whitefish from 139 mm mesh gill nets for 1990 to 1993, and from 38 mm to 139 mm multi-mesh experimental gill nets for 1990 only (1990-Exp).

Date	1990 - Exp		1990		1991		1992		1993	
	N	F/M	N	F/M	N	F/M	N	F/M	N	F/M
Aug. 26									6	5.00
" 27									5	0.67
" 28							55	1.39	5	0.25
" 29									7	0.40
" 30							5	0.67		
" 31							7	2.50		
Sept. 1										
" 2							4	1.00	3	0.50
" 3							8	1.67	6	0.50
" 4							5	1.50		
" 5							96	0.88	18	0.29
" 6					18	1.00	88	1.05	17	0.42
" 7					7	0.75	56	1.07	7	0.17
" 8					3	2.00	96	1.00		
" 9					10	1.00	45	0.73	12	0.33
" 10					15	1.50	51	1.04	34	0.79
" 11					7	0.75	34	1.00	95	1.07
" 12					14	1.00	23	1.56	92	1.09
" 13					23	0.64	13	1.60	74	0.76
" 14	11	0.57	16	0.33	29	0.81	52	1.36	89	1.07
" 15	6	1.00	23	0.64	23	2 30	7	0 75	69	1.09
" 16	6	0.20	10	0.25	55	0.90	87	0.53	64	1.06
" 17	10	0.43	71	0.87	30	0.76	59	0.97		
" 18	14	1.33	19	0.90	18	1.25	41	1.41	89	0.78
" 19	11	1.75	38	0.65	56	0.75	57	0.97	65	0.86
" 20					71	0.87	67	1.09	54	0.80
" 21	3	2.00			39	0.86	89	0.75		
" 22	11	0.83			45	1.50	68	0.89	18	1.25
" 23	17	1.83	17	1.43	27	1.25	75	0.92	45	0.67
" 24	13	1.17	50	1.27	73	0.92			62	1.07
" 25	15	1.50	77	1.20	14	1.00			66	0.83
" 26	2	1.00	7	0 75	54	1.16			79	0 72
" 27									17	0.55
" 28					9	2.00				
" 29					8	0.33				
" 30					10	0.67				
Oct. 1										
" 2					9	2.00				
" 3					11	0.83				
" 4					4	0.33				
TOTAL	121	1.02	331	0.91	684	0.97	1196	0.96	1099	0.86

Table 14. Male and female broad whitefish numbers caught in each mesh size from 38 mm to 139 mm multi-mesh gill nets, 1990.

	Mesh Size (mm)				
	38	64	89	114	139
Male	0	0	13	22	25
Female	0	2	16	19	24
Total*	1	2	29	41	49

* Fish of unknown sex are included in the total

Table 15. Male and female broad whitefish numbers caught in each mesh size from 38 mm to 139 mm multi-mesh gill nets, 1991.

	Mesh Size (mm)				
	38	64	89	114	139
Male	0	1	2	10	3
Female	0	1	7	7	4
Total*	0	2	11	18	9

* Fish of unknown sex are included in the total

Table 16. Male and female broad whitefish numbers caught in each mesh size from 38 mm to 139 mm multi-mesh gill nets, 1992.

	Mesh Size (mm)				
	38	64	89	114	139
Male	0	3	4	4	7
Female	0	0	10	2	8
Total*	1	3	14	6	15

* Fish of unknown sex are included in the total

Table 17. Male and female broad whitefish numbers caught in each mesh size from 38 mm to 139 mm multi-mesh gill nets, 1993.

	Mesh Size (mm)				
	38	64	89	114	139
Male	0	0	2	17	26
Female	0	0	0	10	11
Total	0	0	2	27	37

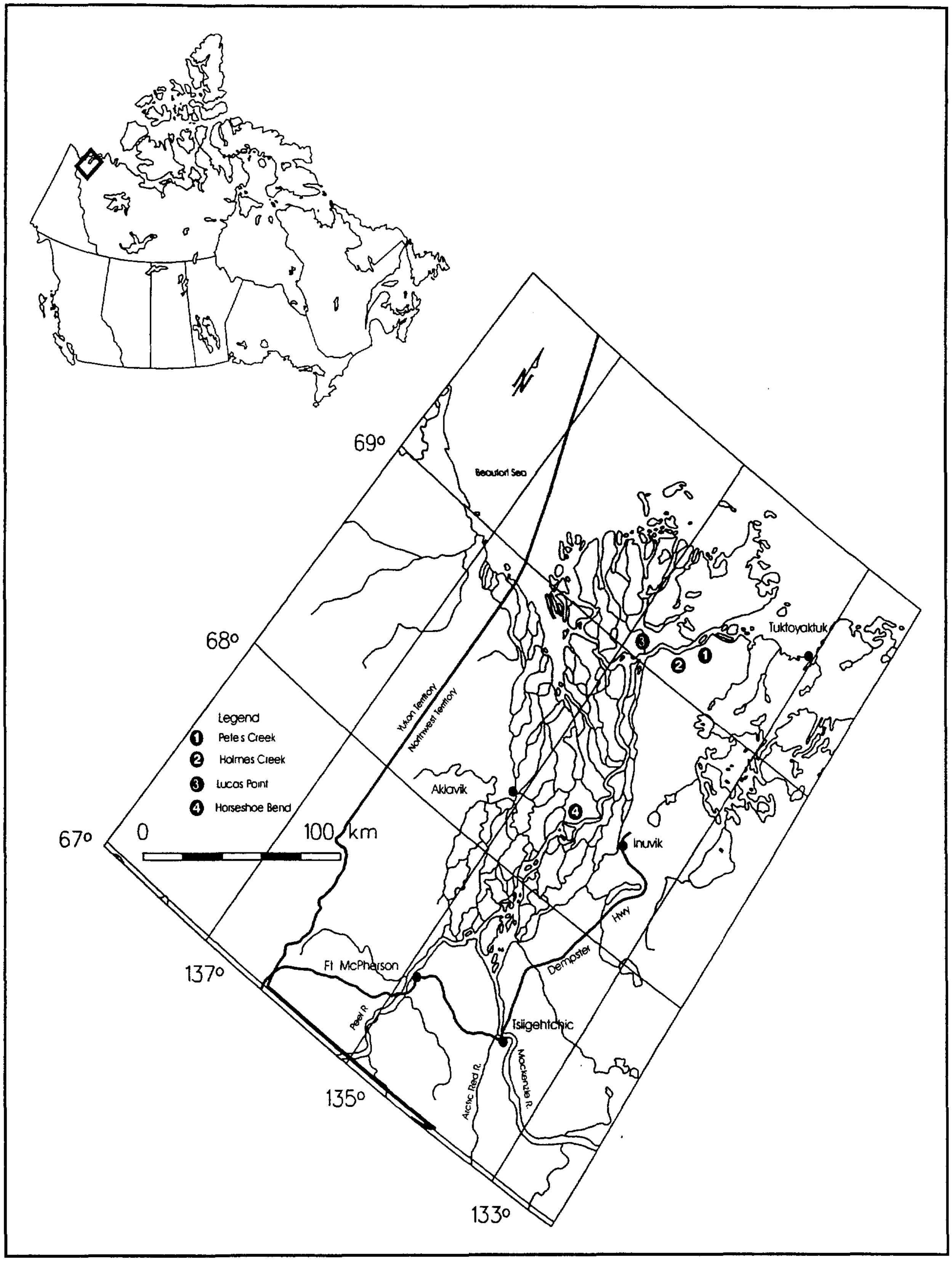

Figure 1 The Mackenzie River delta showing communities and sample collection sites for the Uummarmiut Development Corporation Exploratory Fishery, 1989-1993

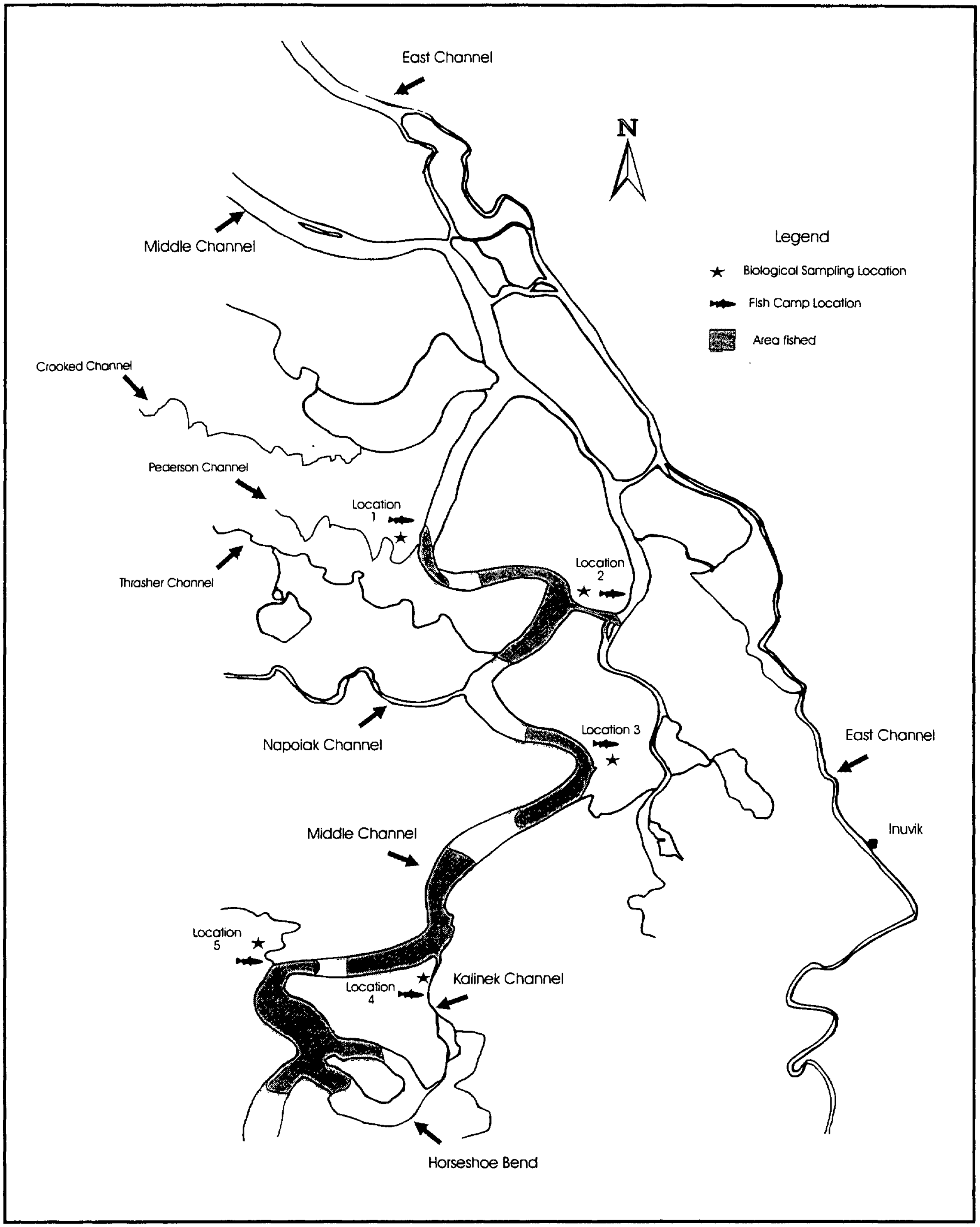

Figure 2 Biological sampling and fish camp locations in the Horseshoe Bend area, 1989

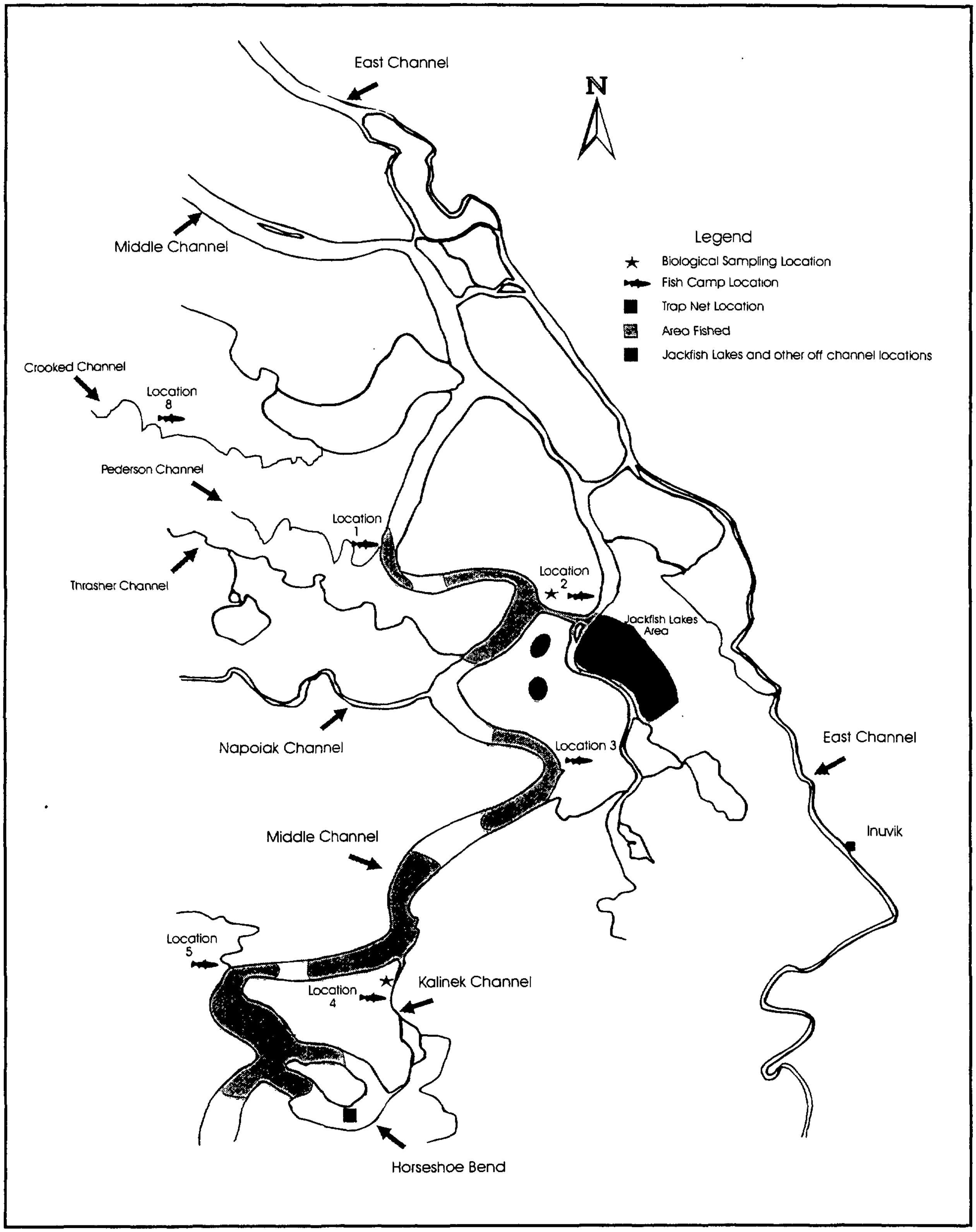

Figure 3 Biological sampling and fish camp locations in the Horseshoe Bend area, 1990

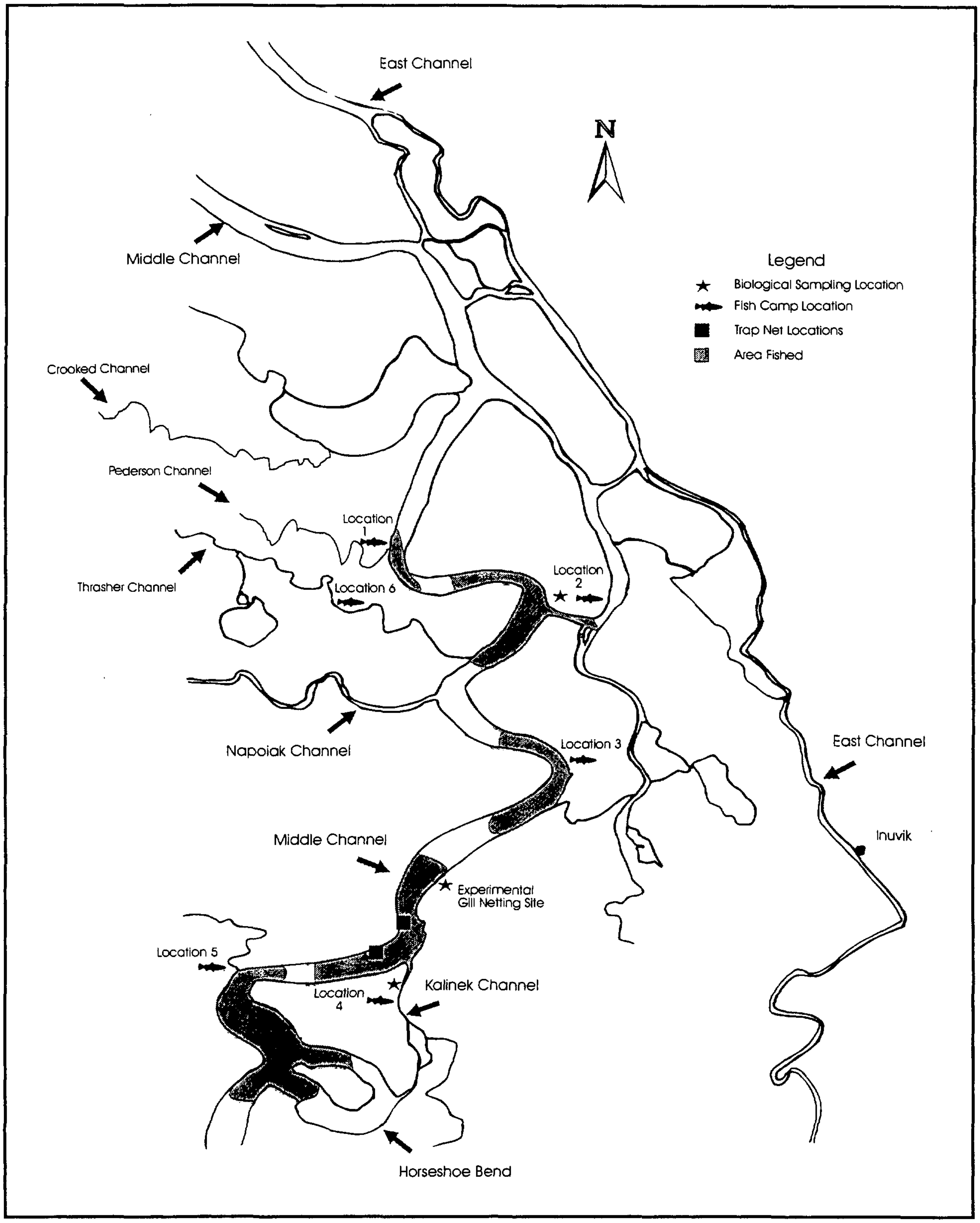

Figure 4 Biological sampling and fish camp locations in the Horseshoe Bend area, 1991

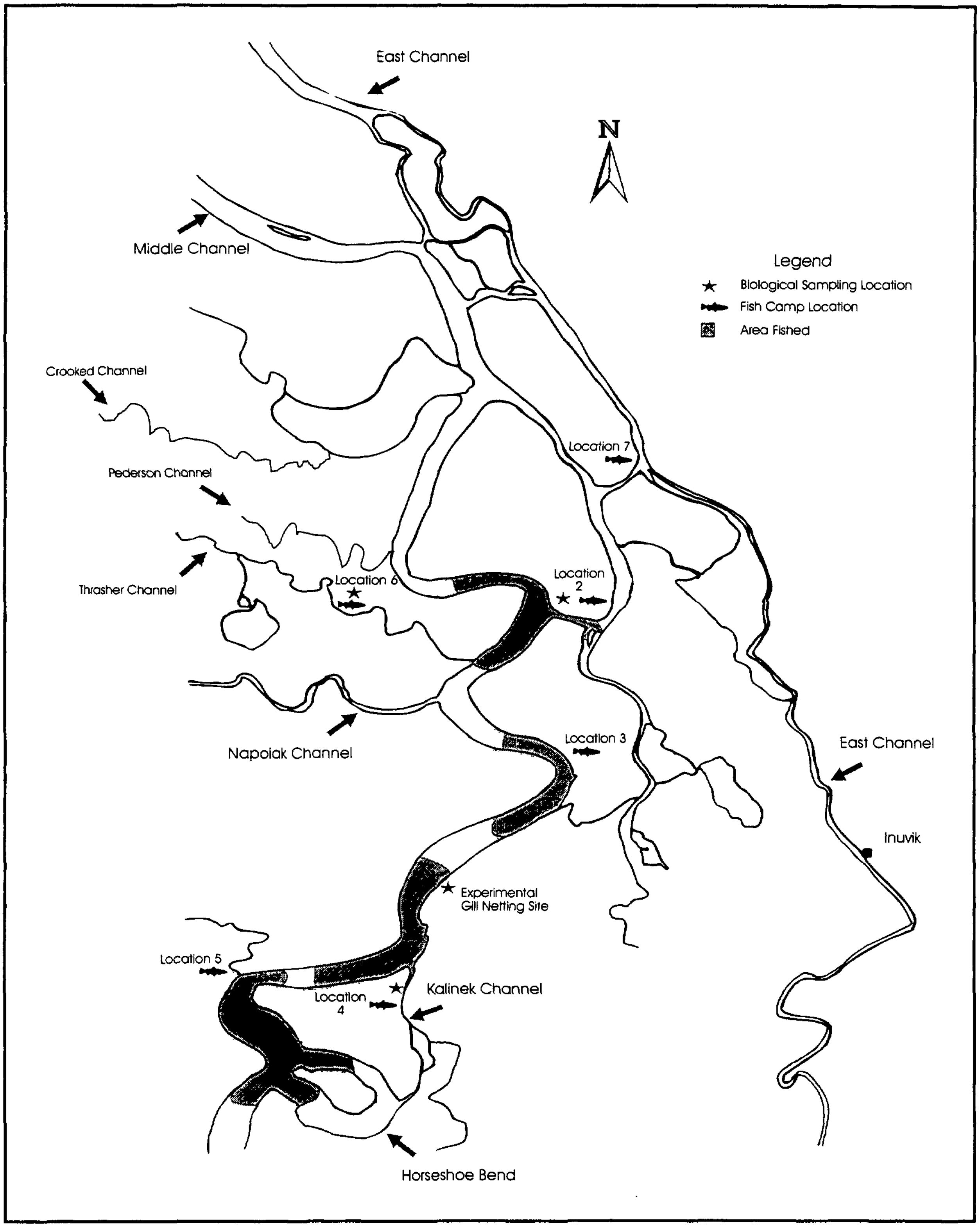

Figure 5 Biological sampling and fish camp locations in the Horseshoe Bend area, 1992

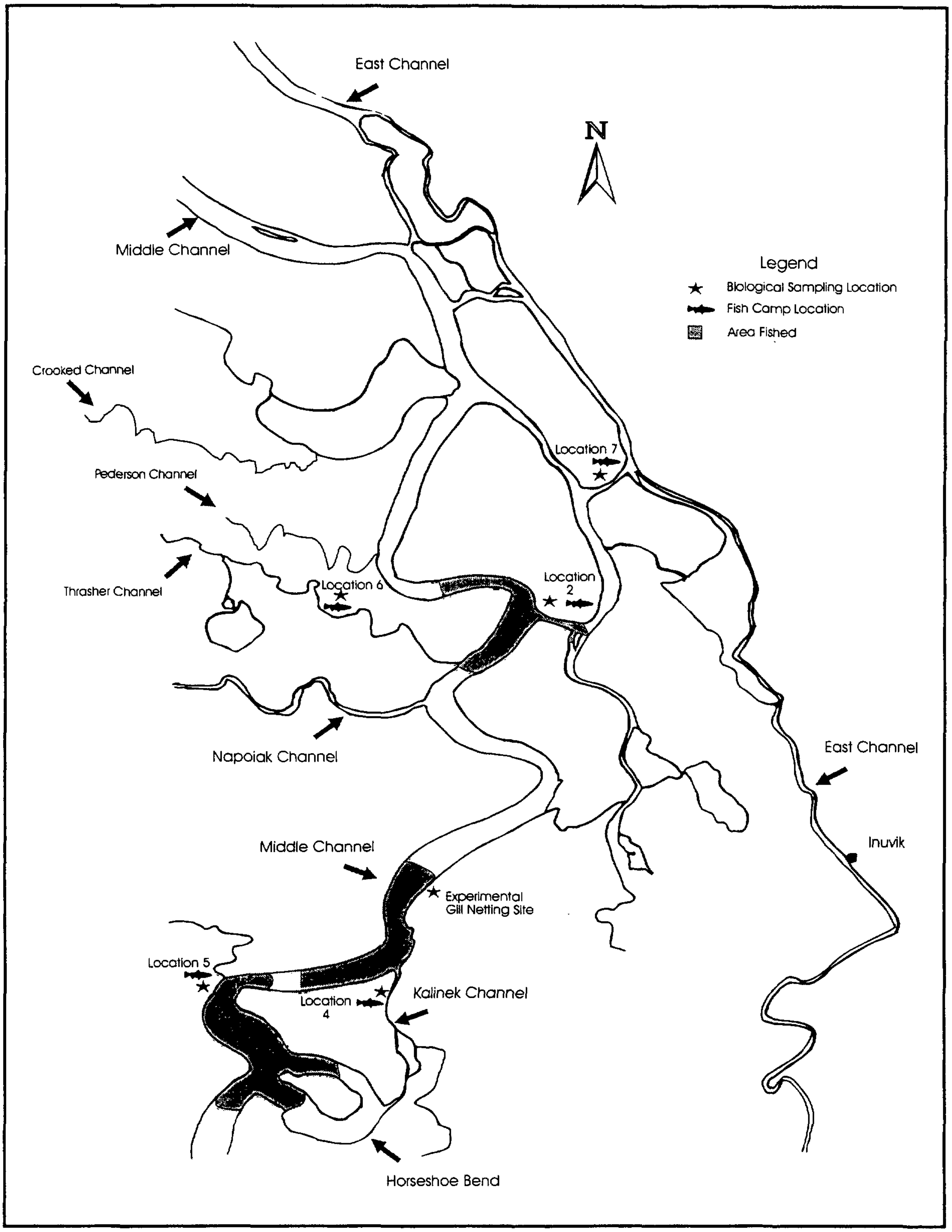

Figure 6 Biological sampling and fish camp locations in the Horseshoe Bend area, 1993

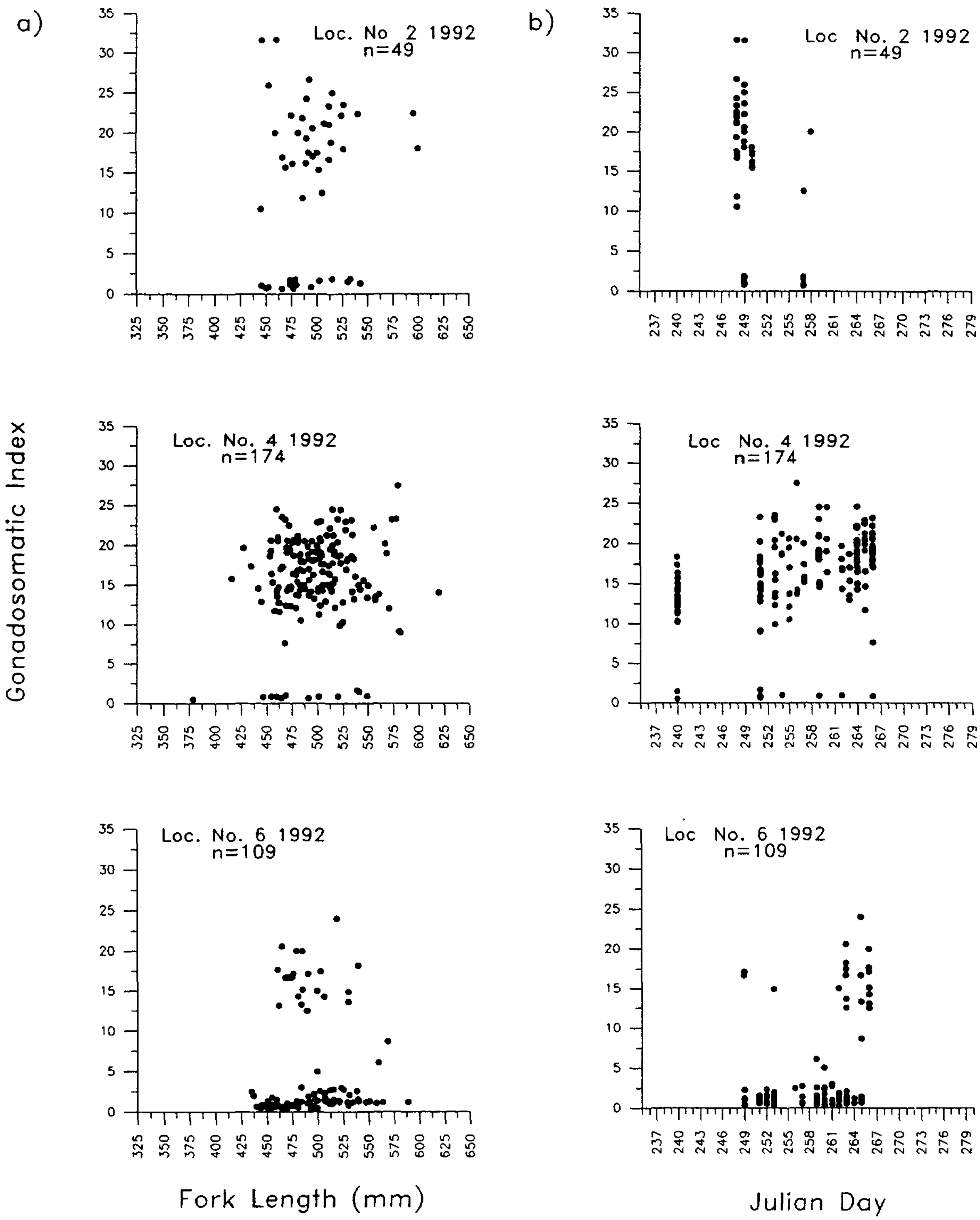

Figure 7. Gonadosomatic index plotted against fork length in a), and julian day in b), for female broad whitefish from 139 mm gill nets, 1992.

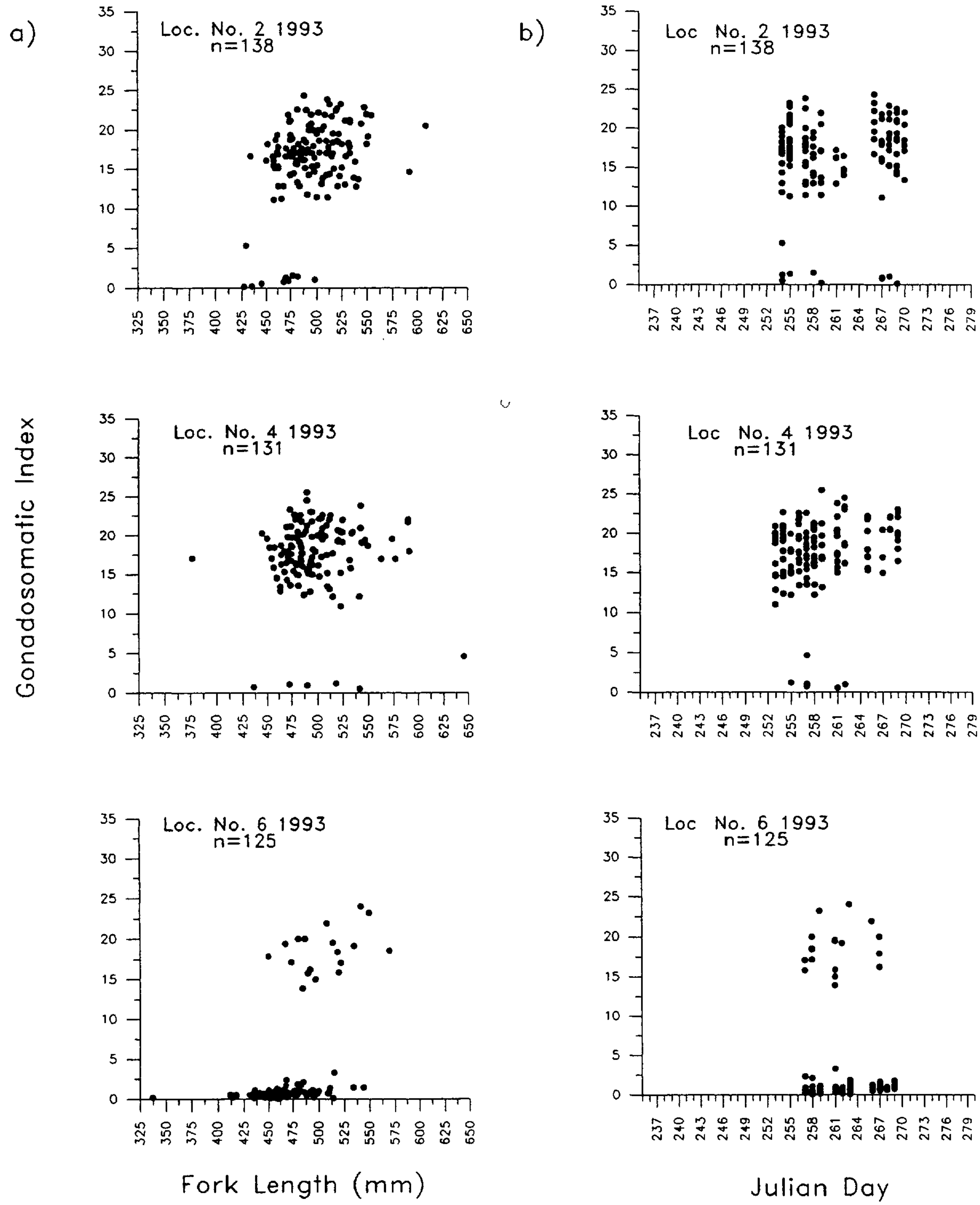

Figure 8. Gonadosomatic index plotted against fork length in a), and julian day in b), for female broad whitefish from 139 mm gill nets, 1993.

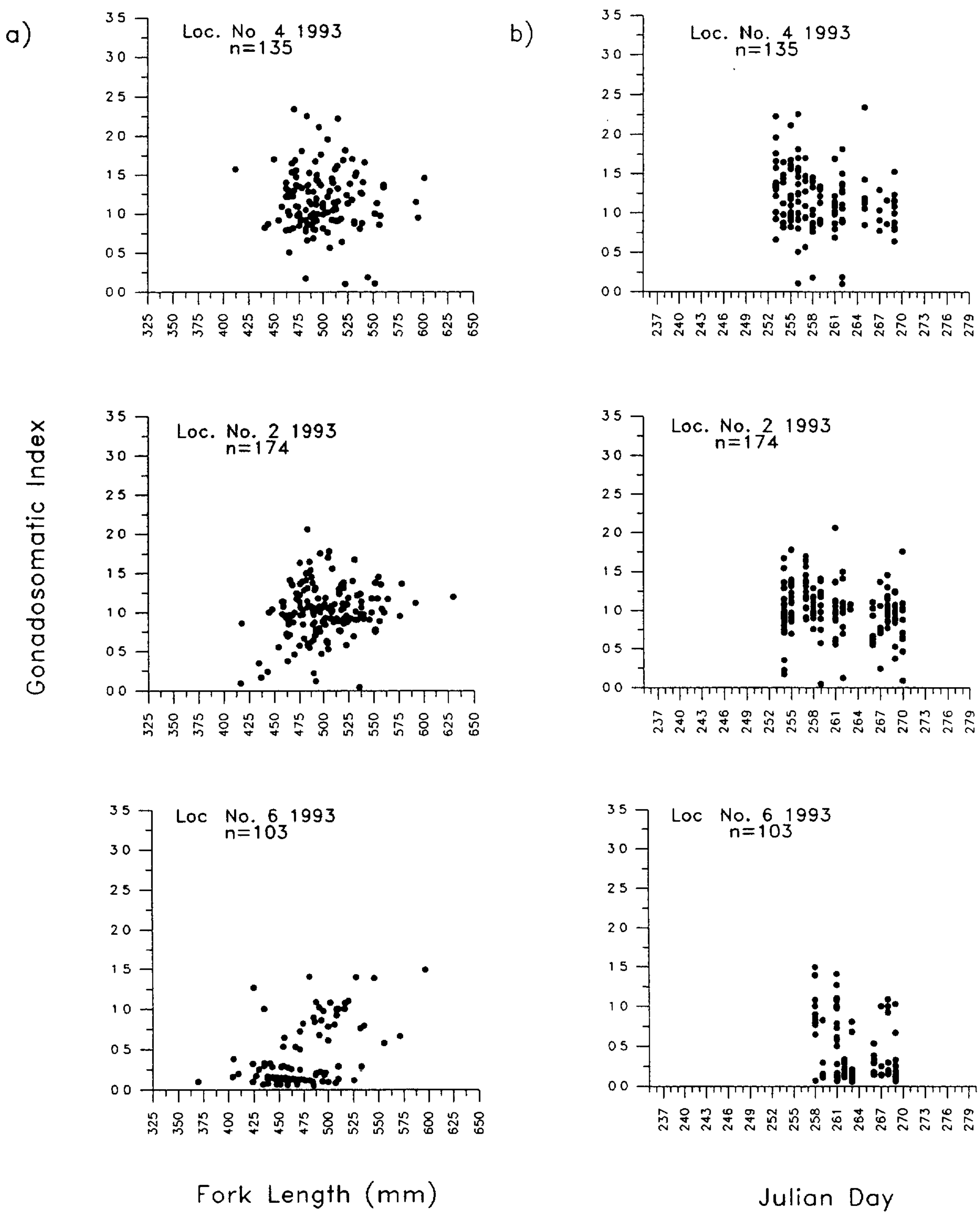

Figure 9. Gonadosomatic index plotted against fork length in a), and julian day in b), for male broad whitefish from 139 mm gill nets, 1993.

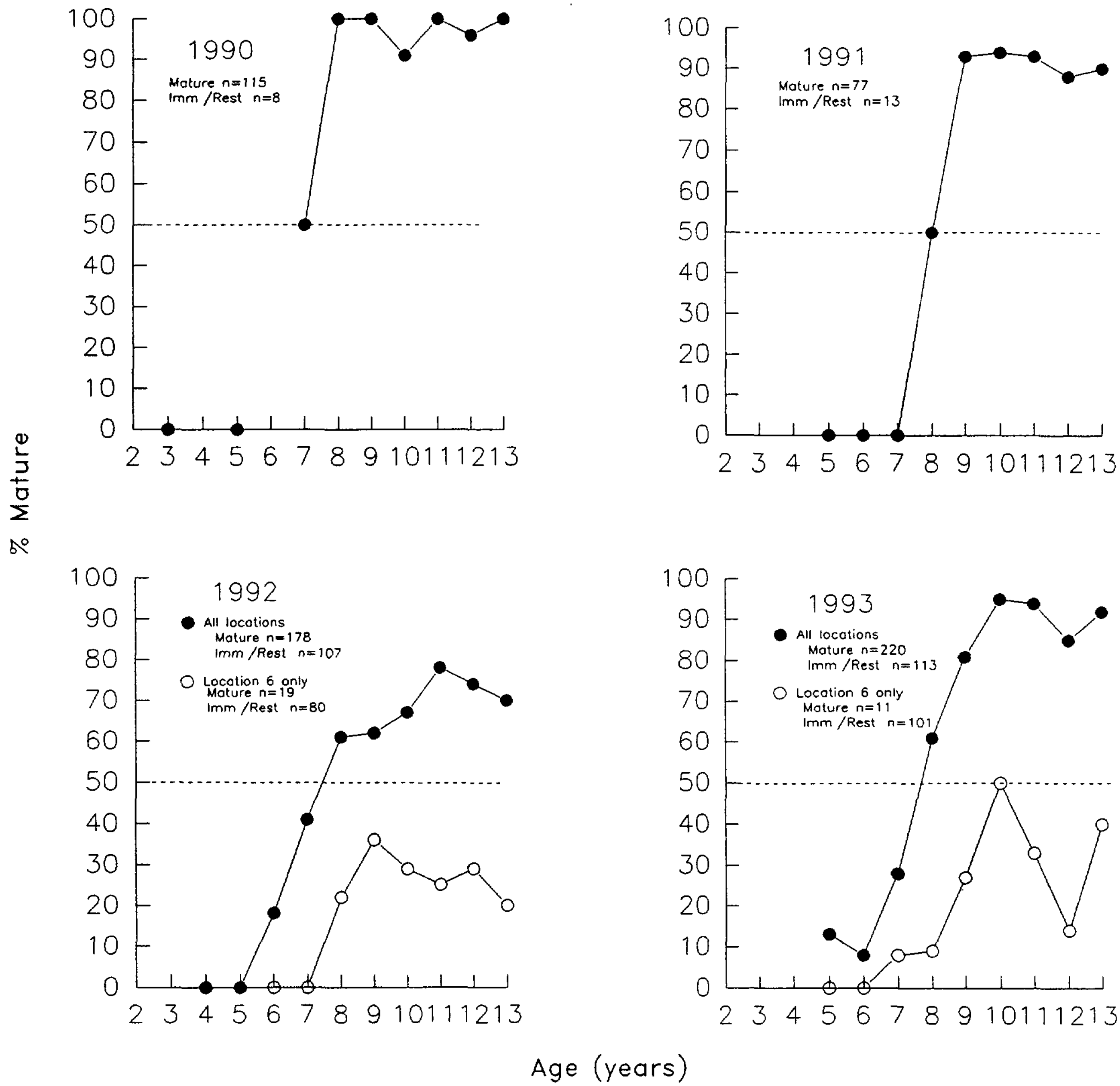

Figure 10. Percent mature females in each age class for broad whitefish from 139 mm gill nets, 1990 to 1993. Broken lines indicate the 50% mature level.

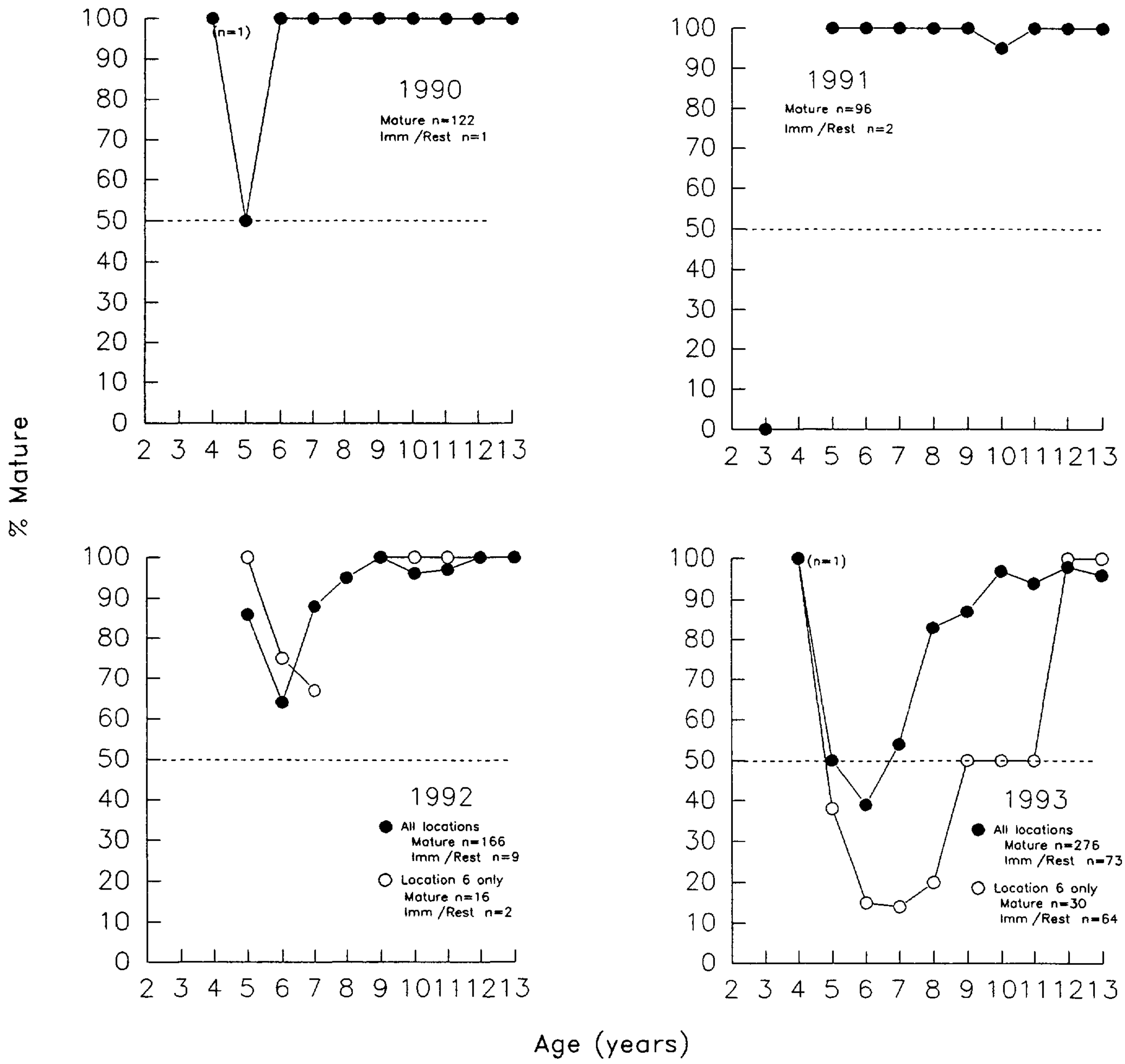

Figure 11. Percent mature males in each age class for broad whitefish from 139 mm gill nets, 1990 to 1993. Broken lines indicate the 50% mature level.

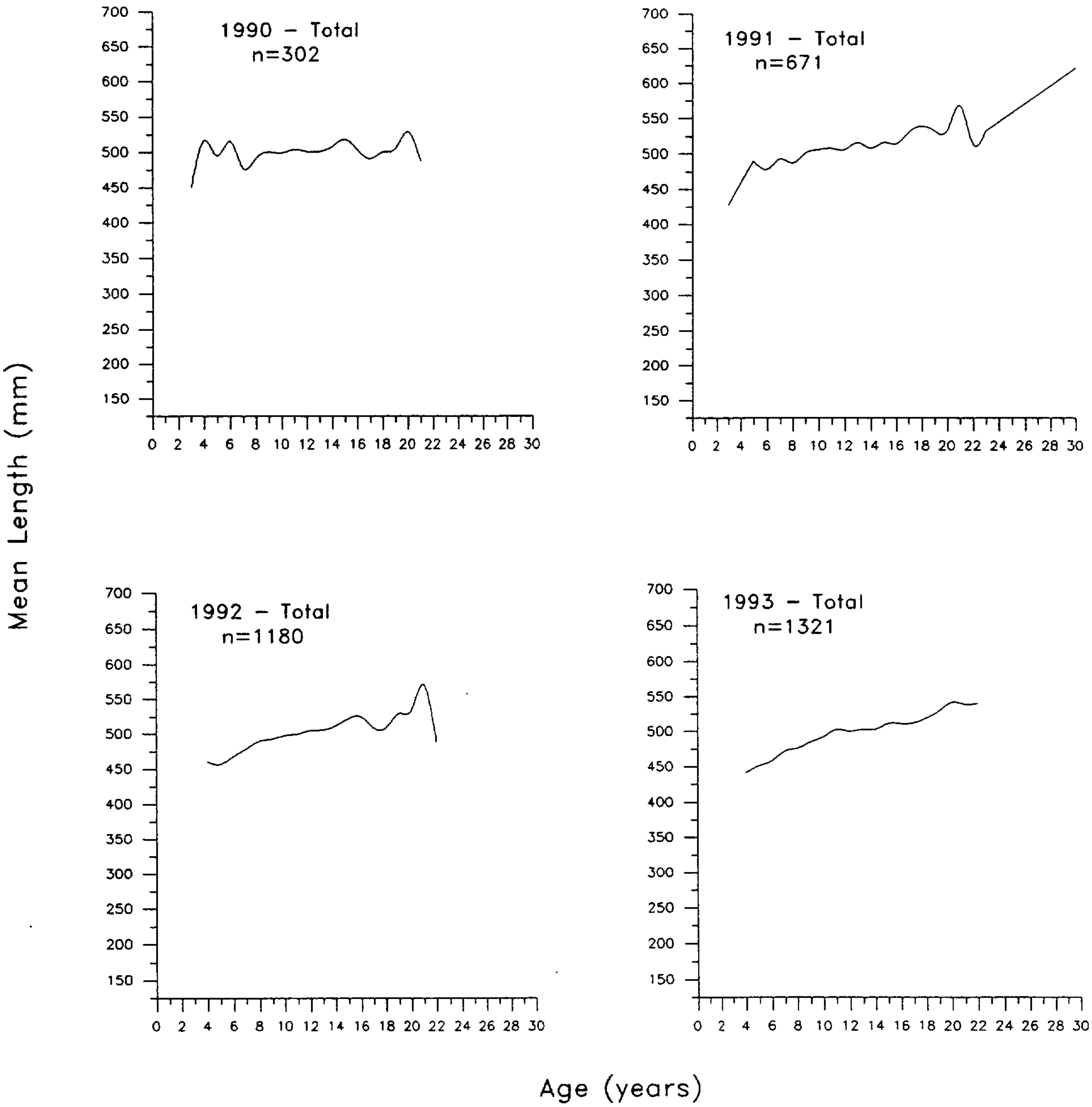

Figure 12. Growth curves (length at age) for broad whitefish from 139 mm gill nets, 1990 to 1993.

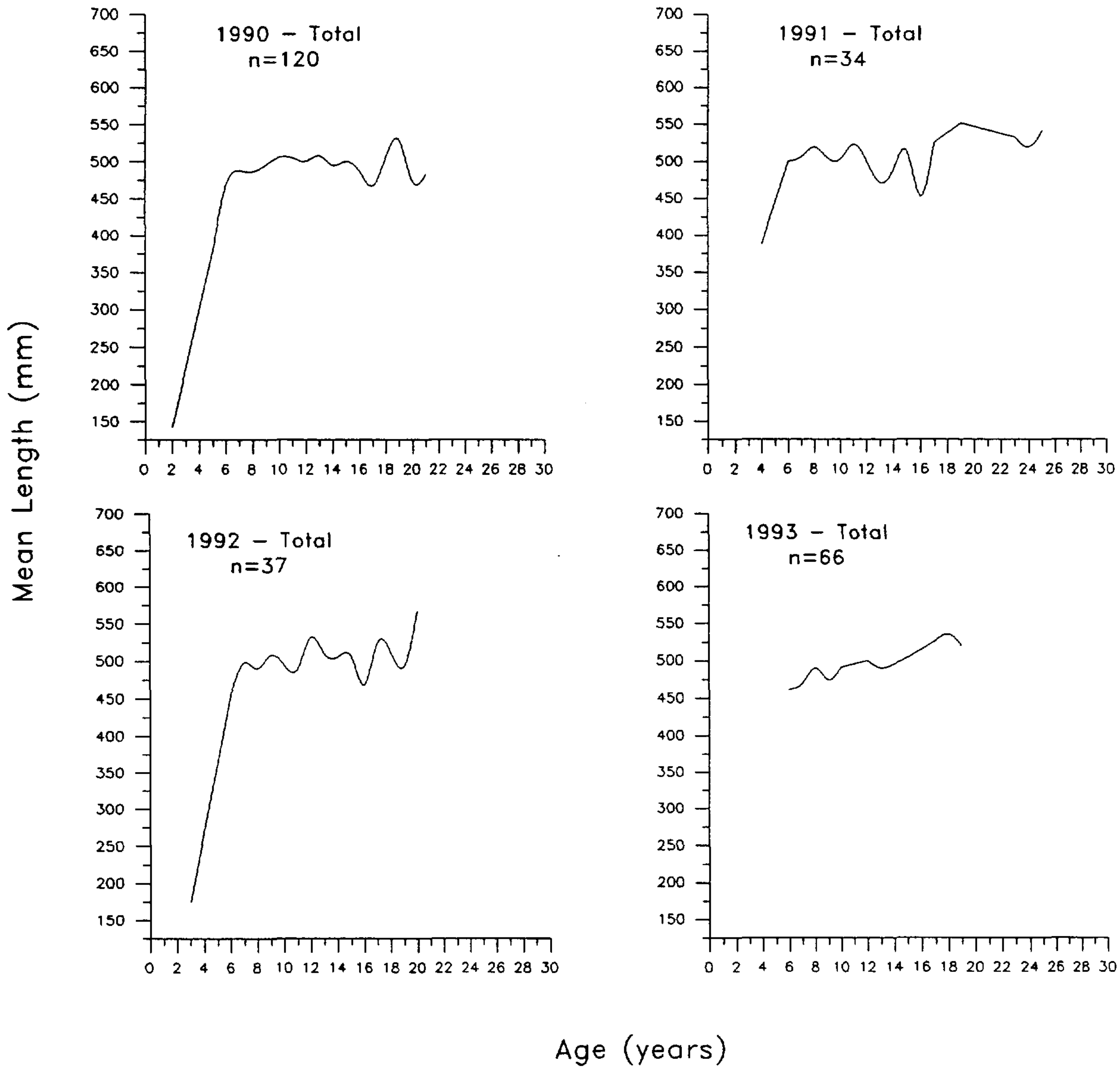

Figure 13. Growth curves (length at age) for all broad whitefish from 38 mm to 139 mm multi-mesh experimental gill nets, 1990 to 1993.

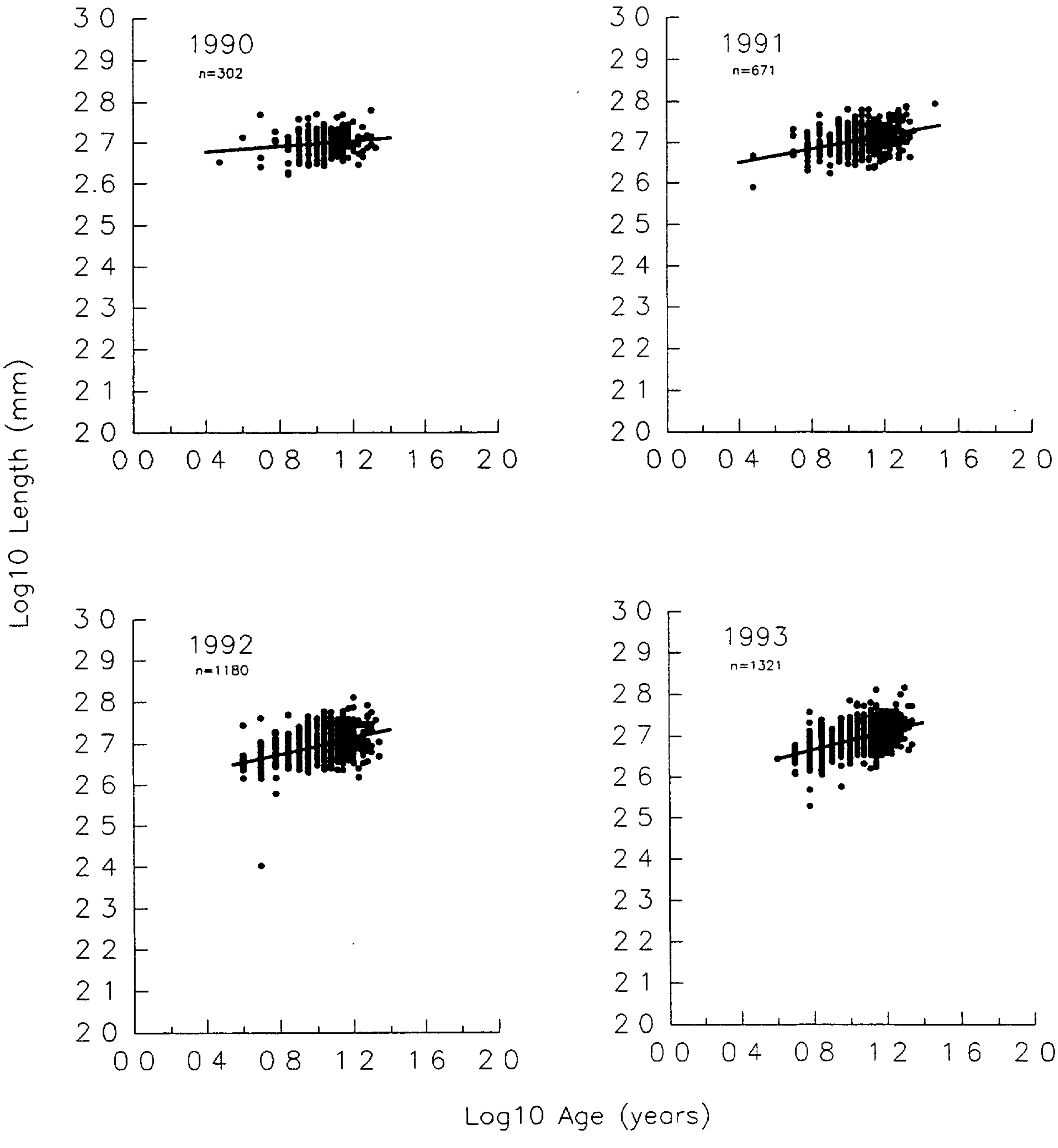

Figure 14 Log10 length vs log10 age data and regression plots for broad whitefish from 139 mm mesh gill nets, 1990 to 1993

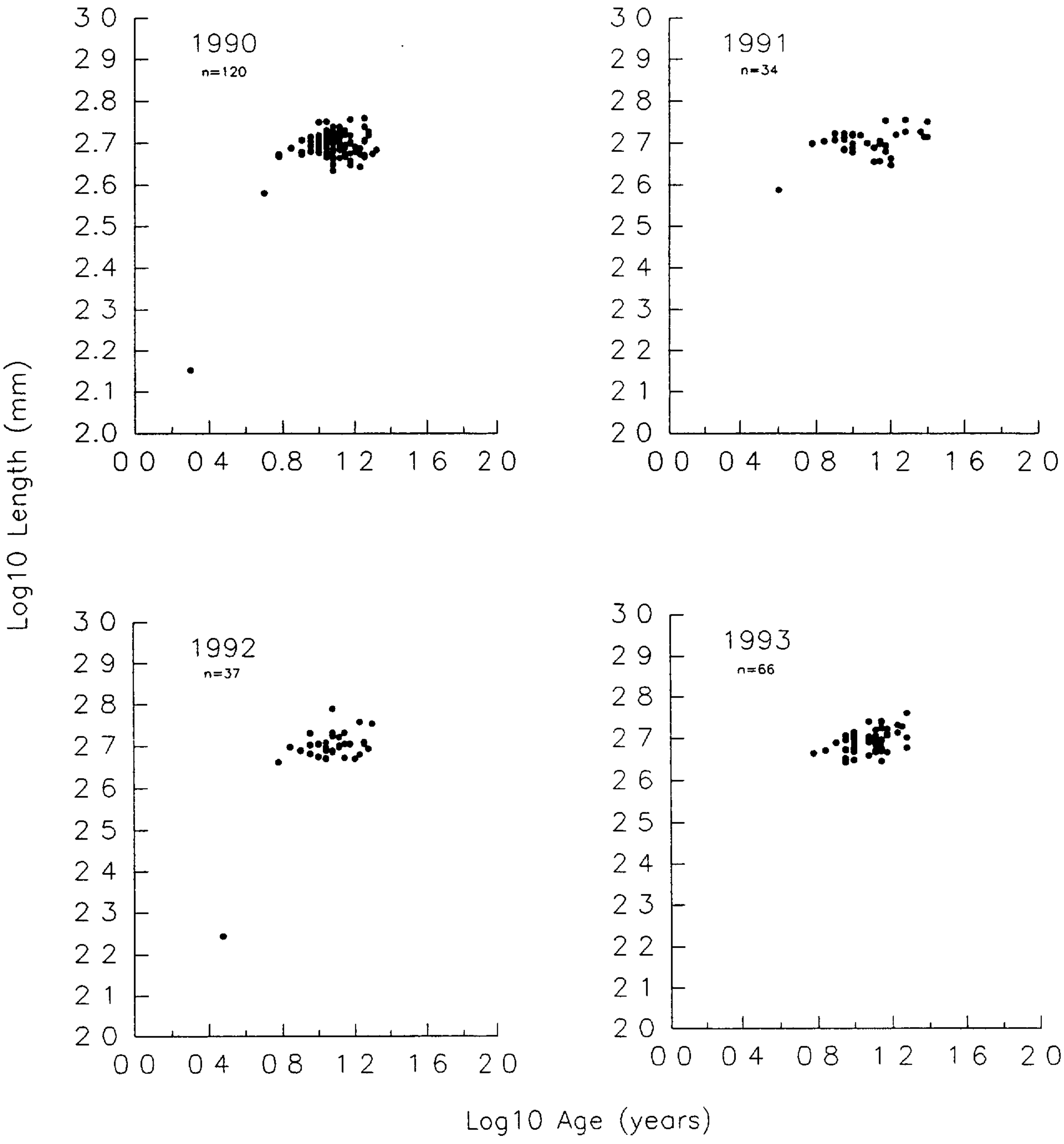

Figure 15 Log10 length vs log10 age plots for broad whitefish from 38 mm to 139 mm multi-mesh experimental gill nets, 1990 to 1993

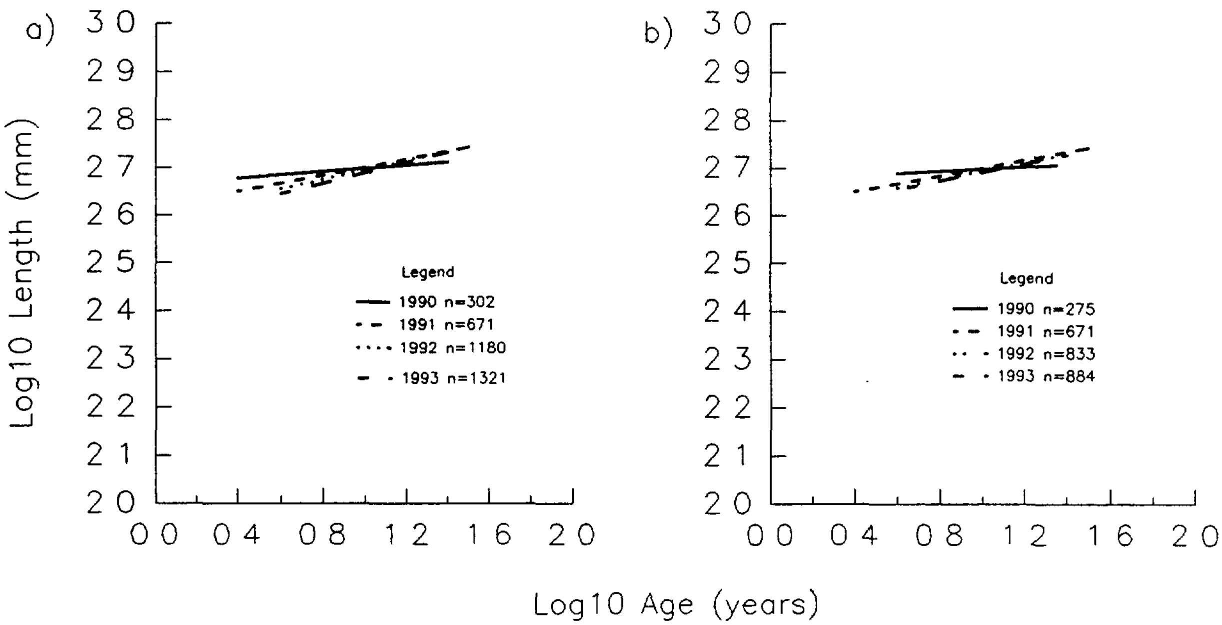

Figure 16 Log10 length vs log10 age regression plots for broad whitefish from 139 mm mesh gill nets, 1990 to 1993 a) all locations, b) middle channel locations only

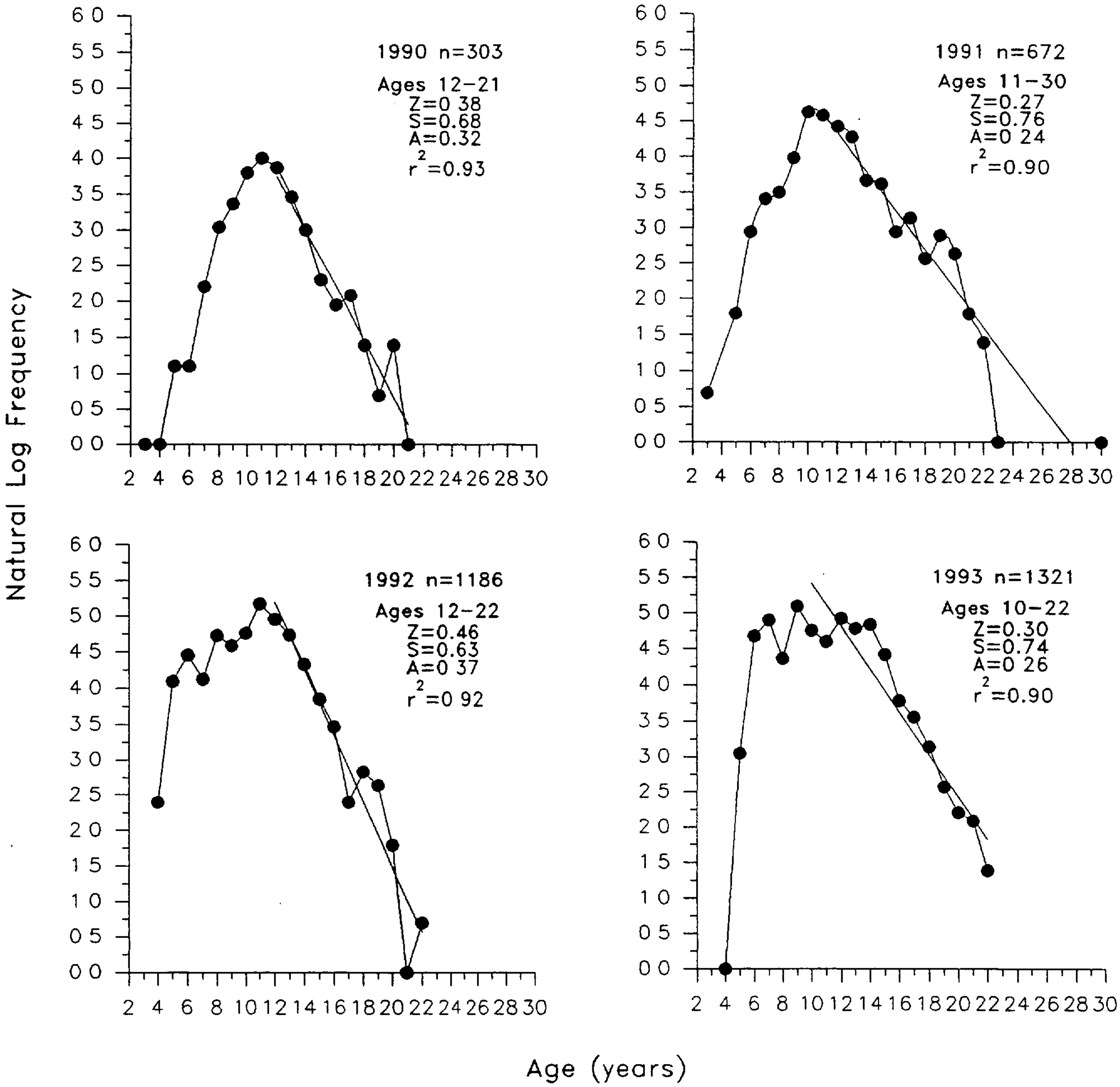

Figure 17. Age frequency catch curves for broad whitefish from 139 mm mesh gillnets, 1990 to 1993. Instantaneous mortality (Z), survival (S), and annual mortality (A), have been calculated from the regression line for the descending limb of each curve.

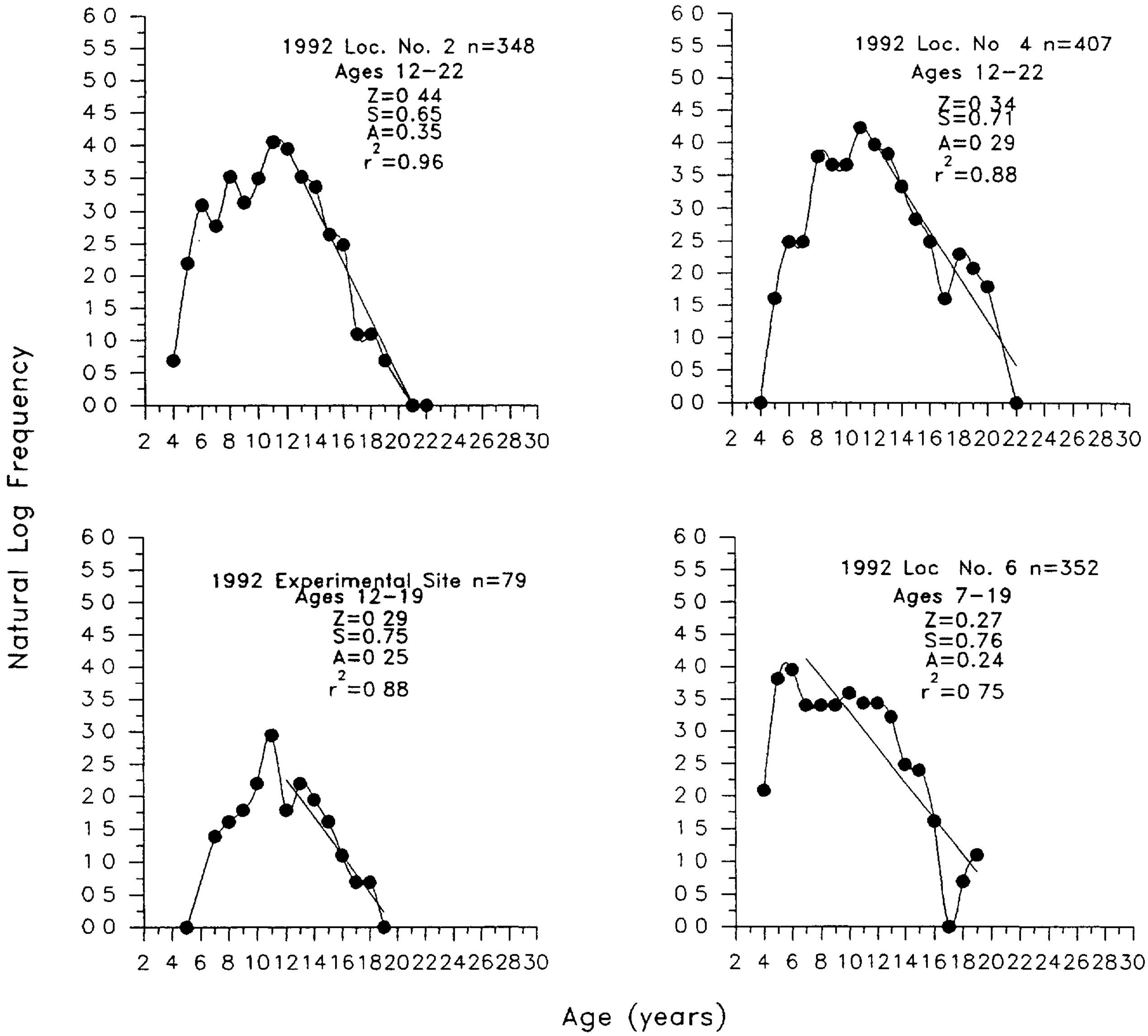

Figure 18. Age frequency catch curves for broad whitefish from 139 mm gill nets, 1992.

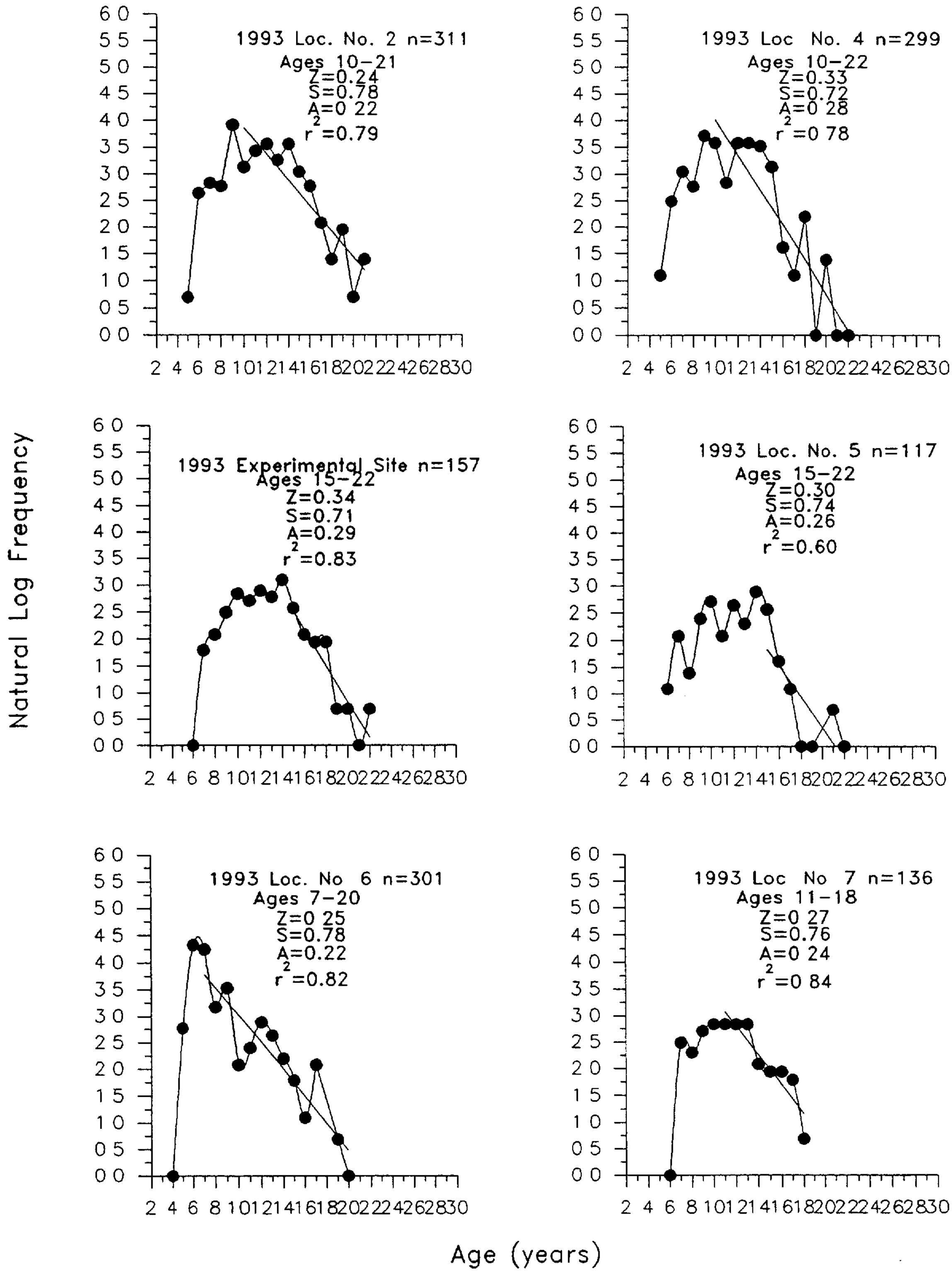

Figure 19. Age frequency catch curves for broad whitefish from 139 mm gill nets, 1993.

Appendix 1. Biological data by length class for broad whitefish from the UDC Exploratory Fishery, 139 mm mesh gill nets (Net=C) and 38 mm to 139 mm multi-mesh experimental gill nets (Net=T), all locations combined, 1989 to 1993.

YEAR=89 NET=C

LENGTH INTERVAL (MM)	MALES N	MALES LENGTH(MM) MEAN	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K
440	.	.	.	.	.	.	.	.	.	.	3	443	.	.	.
460	2	465	1650	354	1.64	1	465	1700	.	1.69	9	464	1667	252	1.66
470	1	477	1610	.	1.48	3	477	1800	173	1.66	11	475	1753	170	1.62
480	1	487	2000	.	1.73	4	485	1925	126	1.69	16	484	1940	114	1.70
490	1	493	2000	.	1.67	2	492	1950	354	1.64	14	493	1967	252	1.65
500	4	505	2025	171	1.58	4	502	2250	265	1.78	12	503	2138	239	1.68
510	4	513	2275	150	1.68	4	515	2025	222	1.48	15	512	2150	220	1.58
520	1	525	2300	.	1.59	4	524	2300	82	1.60	12	524	2300	71	1.60
530	1	539	2300	.	1.47	1	530	2300	.	1.54	3	535	2300	0	1.51
540	.	.	.	.	.	1	544	2100	.	1.30	3	541	2100	.	1.30
570	.	.	.	.	.	.	.	.	.	.	1	570	.	.	.
580	1	584	2900	.	1.46	.	.	.	.	.	1	584	2900	.	1.46
590	.	.	.	.	.	.	.	.	.	.	1	595	.	.	.
650	.	.	.	.	.	.	.	.	.	.	1	651	.	.	.
TOTAL	16					24					102				
MEAN		507	2101	347	1.61		502	2058	254	1.63		500	2075	291	1.62

Appendix 1. (continued).

YEAR=90 NET=C

LENGTH INTERVAL (MM)	MALES N	MALES LENGTH(MM) MEAN	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K
420	.	.	.	.	.	2	422	1065	7	1.42	2	422	1065	7	1.42
430	1	438	1300	.	1.55	.	.	.	.	.	1	438	1300	.	1.55
440	4	445	1361	173	1.54	4	444	1333	71	1.52	8	445	1347	123	1.53
450	3	456	1466	57	1.55	5	453	1534	57	1.65	9	454	1498	68	1.60
460	8	464	1486	139	1.49	9	465	1634	124	1.62	18	465	1569	145	1.56
470	14	474	1549	137	1.45	15	475	1694	138	1.58	35	475	1639	151	1.53
480	24	484	1690	154	1.49	25	485	1781	164	1.56	57	485	1746	164	1.53
490	25	495	1802	176	1.48	30	493	1952	228	1.63	59	494	1888	212	1.57
500	25	505	2014	185	1.57	22	504	2098	236	1.63	53	504	2051	209	1.60
510	25	514	2104	220	1.55	15	514	2205	216	1.62	46	514	2154	235	1.58
520	14	524	2180	238	1.51	10	524	2313	372	1.61	31	524	2239	280	1.55
530	14	534	2261	262	1.48	7	535	2520	196	1.65	24	534	2395	285	1.57
540	7	545	2432	109	1.51	8	544	2587	434	1.61	16	544	2525	317	1.57
550	3	553	2421	395	1.43	2	557	2785	155	1.62	5	555	2566	351	1.50
560	3	562	2813	188	1.58	.	.	.	.	.	4	562	2880	203	1.62
570	1	573	2891	.	1.54	1	577	2850	.	1.48	2	575	2871	29	1.51
580	1	588	3097	.	1.52	2	584	2684	876	1.36	3	585	2821	664	1.41
590	.	.	.	.	.	1	590	2180	.	1.06	1	590	2180	.	1.06
600	1	603	3210	.	1.46	.	.	.	.	.	1	603	3210	.	1.46
TOTAL	173					158					375				
MEAN		504	1950	386	1.51		498	1994	406	1.60		501	1982	395	1.56

Appendix 1. (continued).

YEAR=90 NET=T

LENGTH INTERVAL (MM)	MALES					FEMALES					COMBINED				
		LENGTH(MM)	WEIGHT(G)				LENGTH(MM)	WEIGHT(G)				LENGTH(MM)	WEIGHT(G)		
	N	MEAN	MEAN	SD	K	N	MEAN	MEAN	SD	K	N	MEAN	MEAN	SD	K
140	.	.	.	.	.	.	.	.	.	.	1	142	35	.	1.22
380	.	.	.	.	.	1	381	720	.	1.30	1	381	720	.	1.30
430	.	.	.	.	.	1	432	1261	.	1.56	1	432	1261	.	1.56
440	2	447	1318	84	1.48	1	441	1165	.	1.36	3	445	1267	106	1.44
450	1	456	1296	.	1.37	.	.	.	.	.	1	456	1296	.	1.37
460	5	466	1503	151	1.48	5	465	1494	270	1.49	10	465	1498	206	1.48
470	6	473	1531	182	1.44	10	476	1729	258	1.61	16	475	1655	246	1.55
480	8	484	1634	149	1.44	6	487	1809	115	1.57	14	485	1709	159	1.50
490	7	495	1747	159	1.44	8	494	1910	133	1.58	15	495	1834	164	1.52
500	7	505	1959	156	1.52	8	503	1936	208	1.52	15	504	1947	180	1.52
510	6	514	2087	97	1.54	5	515	2200	177	1.61	11	514	2138	144	1.57
520	10	525	2142	182	1.48	7	523	2255	210	1.58	17	524	2189	196	1.52
530	5	534	2413	378	1.59	4	533	2390	214	1.58	9	533	2403	298	1.59
540	.	.	.	.	.	2	544	2423	24	1.51	2	544	2423	24	1.51
550	2	550	2261	296	1.36	.	.	.	.	.	2	550	2261	296	1.36
560	1	562	2675	.	1.51	1	565	2684	.	1.49	2	564	2680	6	1.50
570	.	.	.	.	.	2	574	2814	149	1.49	2	574	2814	149	1.49
TOTAL	60					61					122				
MEAN		501	1881	370	1.48		498	1951	417	1.56		497	1901	428	1.52

Appendix 1. (continued).

YEAR=91 NET=C

LENGTH	MALES					FEMALES					COMBINED				
INTERVAL		LENGTH(MM)	WEIGHT(G)				LENGTH(MM)	WEIGHT(G)				LENGTH(MM)	WEIGHT(G)		
(MM)	N	MEAN	MEAN	SD	K	N	MEAN	MEAN	SD	K	N	MEAN	MEAN	SD	K
300	.	.	.	.	.	.	.	.	.	.	1	305	.	.	.
350	.	.	.	.	.	.	.	.	.	.	1	354	.	.	.
360	.	.	.	.	.	.	.	.	.	.	1	364	.	.	.
380	1	389	700	.	1.19	.	.	.	.	.	1	389	700	.	1.19
420	1	421	1000	.	1.34	1	427	1140	.	1.46	2	424	1070	99	1.40
430	5	436	1280	92	1.55	.	.	.	.	.	5	436	1280	92	1.55
440	.	.	.	.	.	4	445	1384	168	1.57	6	445	1384	168	1.57
450	9	453	1348	139	1.45	8	456	1590	90	1.68	23	455	1462	170	1.56
460	22	465	1609	218	1.60	20	465	1621	187	1.62	56	465	1614	202	1.61
470	26	474	1685	276	1.58	31	474	1758	198	1.64	81	475	1725	236	1.62
480	35	484	1776	200	1.56	43	484	1884	226	1.67	126	484	1836	220	1.62
490	44	493	1865	185	1.55	39	493	1967	222	1.64	161	493	1915	208	1.60
500	39	503	1937	211	1.52	38	504	2120	158	1.66	144	504	2031	208	1.59
510	31	513	2079	139	1.54	35	514	2245	206	1.66	122	514	2161	196	1.60
520	35	525	2201	204	1.52	29	523	2397	260	1.67	109	524	2290	249	1.59
530	32	533	2228	284	1.47	26	533	2517	295	1.66	96	534	2364	318	1.56
540	27	543	2433	243	1.52	18	545	2661	326	1.64	73	544	2524	297	1.57
550	18	553	2297	285	1.36	20	554	2521	410	1.48	46	554	2418	371	1.42
560	5	563	2530	237	1.42	7	562	2720	424	1.53	14	562	2641	358	1.49
570	5	573	3064	447	1.63	6	572	2986	349	1.59	12	573	3025	380	1.61
580	6	581	2810	142	1.43	7	583	3120	473	1.58	13	582	2965	370	1.50
590	.	.	.	.	.	1	590	3250	.	1.58	2	593	3250	.	1.58
600	4	602	3385	308	1.55	1	603	3400	.	1.55	5	602	3388	266	1.55
610	2	616	3233	187	1.39	1	610	4150	.	1.83	3	614	3538	546	1.53
620	.	.	.	.	.	1	622	3570	.	1.48	1	622	3570	.	1.48
TOTAL	347					336					1104				
MEAN		509	2032	435	1.52		508	2168	471	1.64		507	2100	456	1.58

Appendix 1. (continued).

YEAR=91 NET=T

LENGTH INTERVAL (MM)	MALES N	MALES LENGTH(MM) MEAN	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K
360	1	360	650	.	1.39	.	.	.	.	.	1	360	650	.	1.39
380	1	387	800	.	1.38	.	.	.	.	.	1	387	800	.	1.38
440	1	445	1230	.	1.40	.	.	.	.	.	1	445	1230	.	1.40
450	1	454	2050	.	2.19	1	455	1280	.	1.36	2	455	1665	544	1.77
460	.	.	.	.	.	1	461	.	.	.	1	461	.	.	.
470	.	.	.	.	.	1	477	1800	.	1.66	2	478	1800	.	1.66
480	2	482	1655	7	1.48	2	487	1825	318	1.59	6	484	1740	208	1.53
490	1	495	1620	.	1.34	1	490	2020	.	1.72	2	493	1820	283	1.53
500	3	503	1863	335	1.46	4	504	2200	141	1.72	7	503	2056	282	1.61
510	.	.	.	.	.	3	516	2163	124	1.59	4	517	2163	124	1.59
520	5	525	2225	225	1.54	2	526	2500	566	1.72	7	525	2317	339	1.60
530	.	.	.	.	.	2	533	2185	304	1.44	3	535	2185	304	1.44
560	1	567	2250	.	1.23	1	565	2730	.	1.51	2	566	2490	339	1.37
570	.	.	.	.	.	1	570	3300	.	1.78	1	570	3300	.	1.78
TOTAL	16					19					40				
MEAN		488	1760	539	1.50		509	2193	473	1.62		500	1990	543	1.56

Appendix 1. (continued).

YEAR=92 NET=C

LENGTH INTERVAL (MM)	MALES N	MALES LENGTH(MM) MEAN	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K
250	1	253	.	.	.	.	.	.	.	.	1	253	.	.	.
370	.	.	.	.	.	1	379	678	.	1.25	1	379	678	.	1.25
410	2	415	1175	247	1.65	4	415	1263	541	1.76	6	415	1233	436	1.73
420	.	.	.	.	.	2	426	2025	1096	2.61	2	426	2025	1096	2.61
430	12	435	1375	134	1.67	5	437	1225	287	1.47	17	436	1325	198	1.60
440	18	445	1540	414	1.74	20	445	1486	391	1.69	39	445	1500	393	1.70
450	38	455	1435	167	1.52	34	455	1436	175	1.53	75	455	1433	169	1.52
460	60	464	1578	208	1.58	56	464	1593	243	1.60	119	464	1585	224	1.59
470	70	475	1598	189	1.50	56	475	1673	175	1.57	131	475	1634	185	1.53
480	55	485	1640	202	1.44	67	484	1791	232	1.58	125	484	1727	230	1.52
490	91	494	1791	196	1.49	69	494	1850	201	1.53	173	494	1816	200	1.51
500	81	504	1851	239	1.44	67	504	1938	221	1.52	157	504	1891	234	1.48
510	48	514	1930	217	1.42	60	514	2010	359	1.48	114	514	1975	306	1.46
520	41	524	2049	296	1.43	49	524	2126	308	1.48	100	524	2084	302	1.45
530	30	534	2315	186	1.53	32	534	2355	252	1.55	63	534	2335	219	1.54
540	16	544	2350	240	1.47	19	544	2265	326	1.41	37	544	2299	292	1.44
550	16	555	2374	372	1.40	13	554	2439	431	1.43	29	554	2406	394	1.41
560	11	563	2509	155	1.41	12	565	2219	562	1.24	24	564	2364	427	1.32
570	9	573	2621	533	1.39	5	573	3220	461	1.71	15	573	2839	570	1.50
580	2	582	2494	80	1.27	6	583	2729	314	1.37	8	583	2662	283	1.34
590	4	594	2982	665	1.41	1	595	4000	.	1.90	6	594	3237	744	1.54
600	.	.	.	.	.	2	604	3325	318	1.51	2	604	3325	318	1.51
610	1	613	.	.	.	1	610	.	.	.	2	612	.	.	.
620	.	.	.	.	.	1	620	3365	.	1.41	1	620	3365	.	1.41
630	1	633	2500	.	0.99	.	.	.	.	.	1	633	2500	.	0.99
640	.	.	.	.	.	1	647	4050	.	1.50	1	647	4050	.	1.50
680	1	685	3000	.	0.93	.	.	.	.	.	1	685	3000	.	0.93
TOTAL	606					584					1249				
MEAN		496	1820	379	1.49		498	1896	451	1.54		497	1857	418	1.51

Appendix 1. (continued).

YEAR=92 NET=T

LENGTH INTERVAL (MM)	MALES N	MALES LENGTH(MM) MEAN	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K
170	.	.	.	.	.	.	.	.	.	.	1	175	50	.	0.93
440	.	.	.	.	.	1	445	1500	.	1.70	1	445	1500	.	1.70
450	1	458	1500	.	1.56	.	.	.	.	.	1	458	1500	.	1.56
460	2	469	2225	955	2.17	1	468	1700	.	1.66	3	468	2050	740	2.00
470	1	479	1400	.	1.27	2	472	1650	0	1.57	3	474	1567	144	1.47
480	.	.	.	.	.	5	486	1713	118	1.50	5	486	1713	118	1.50
490	3	497	1933	144	1.58	4	494	1938	125	1.61	7	495	1936	121	1.60
500	3	506	1900	180	1.47	5	507	1990	143	1.53	8	506	1956	152	1.51
510	2	512	2025	106	1.51	.	.	.	.	.	2	512	2025	106	1.51
520	1	527	2150	.	1.47	.	.	.	.	.	1	527	2150	.	1.47
530	2	535	2375	106	1.56	2	539	2550	141	1.63	4	537	2463	144	1.60
560	1	568	2850	.	1.56	.	.	.	.	.	1	568	2850	.	1.56
570	1	571	3150	.	1.69	.	.	.	.	.	1	571	3150	.	1.69
610	1	617	2750	.	1.17	.	.	.	.	.	1	617	2750	.	1.17
TOTAL	18					20					39				
MEAN		514	2142	506	1.57		494	1903	293	1.57		495	1967	525	1.56

Appendix 1. (continued).

YEAR=93 NET=C

LENGTH INTERVAL (MM)	MALES N	MALES LENGTH(MM) MEAN	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K
330	.	.	.	.	.	1	337	1350	.	3.53	1	337	1350	.	3.53
370	1	370	1000	.	1.97	1	377	1695	.	3.16	2	374	1348	491	2.57
400	2	405	1150	141	1.74	.	.	.	.	.	3	404	1067	176	1.62
410	5	414	1369	413	1.93	4	415	1188	63	1.66	9	414	1288	310	1.81
420	4	425	1513	665	1.97	2	428	1550	495	1.97	7	425	1525	561	1.97
430	11	435	1282	108	1.56	14	436	1343	323	1.62	28	435	1316	250	1.59
440	19	445	1343	97	1.53	20	446	1424	239	1.61	46	445	1380	180	1.56
450	31	455	1481	227	1.57	38	455	1500	151	1.59	85	455	1485	186	1.58
460	54	465	1521	186	1.51	56	465	1567	126	1.56	143	465	1544	158	1.54
470	77	474	1600	110	1.50	66	475	1677	138	1.57	189	475	1631	132	1.53
480	72	485	1681	138	1.47	70	484	1767	140	1.56	174	484	1725	145	1.52
490	74	493	1779	142	1.48	67	494	1875	178	1.56	171	494	1826	167	1.52
500	61	504	1876	140	1.46	39	504	1978	168	1.54	130	504	1916	158	1.50
510	50	514	1944	195	1.43	39	513	2077	207	1.54	113	514	2002	210	1.48
520	39	524	2023	161	1.41	31	523	2199	200	1.54	89	523	2102	198	1.46
530	34	534	2235	216	1.47	21	534	2346	245	1.54	73	534	2277	230	1.49
540	24	544	2299	285	1.43	15	543	2533	270	1.58	47	544	2393	295	1.49
550	18	554	2404	290	1.41	7	553	2569	271	1.52	29	554	2454	289	1.45
560	5	562	2677	155	1.51	3	564	2485	211	1.39	12	563	2605	191	1.46
570	4	575	2691	246	1.42	7	573	2712	408	1.45	11	573	2704	336	1.44
580	.	.	.	.	.	.	.	.	.	.	1	586	.	.	.
590	4	594	2829	906	1.35	4	591	3085	1131	1.50	8	593	2957	958	1.42
600	1	601	3565	.	1.64	1	608	4150	.	1.85	2	605	3858	414	1.74
630	1	630	3000	.	1.20	.	.	.	.	.	1	630	3000	.	1.20
640	.	.	.	.	.	1	645	3825	.	1.43	1	645	3825	.	1.43
650	1	655	4600	.	1.64	.	.	.	.	.	1	655	4600	.	1.64
TOTAL	592					507					1376				
MEAN		495	1809	387	1.49		490	1855	411	1.57		492	1826	399	1.52

Appendix 1. (continued).

YEAR=93 NET=T

LENGTH INTERVAL (MM)	MALES N	MALES LENGTH(MM) MEAN	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K
440	1	442	1150	.	1.33	3	443	1388	82	1.59	4	443	1329	137	1.53
450	.	.	.	.	.	2	453	1625	.	1.71	2	453	1625	.	1.71
460	6	465	1519	124	1.50	1	465	1635	.	1.63	7	465	1538	121	1.52
470	6	475	1573	68	1.47	3	471	1600	134	1.53	9	474	1579	78	1.48
480	2	489	1655	64	1.42	2	486	1765	78	1.54	4	487	1710	86	1.48
490	8	492	1753	140	1.47	5	496	1957	125	1.60	13	494	1832	165	1.52
500	8	507	1906	92	1.46	3	503	2057	171	1.62	11	506	1952	132	1.51
510	6	515	1924	141	1.41	.	.	.	.	.	6	515	1924	141	1.41
520	1	526	2135	.	1.47	1	529	2395	.	1.62	2	528	2265	184	1.54
530	3	533	2233	459	1.47	.	.	.	.	.	3	533	2233	459	1.47
540	2	544	2388	103	1.49	.	.	.	.	.	2	544	2388	103	1.49
550	1	552	.	.	.	1	550	2760	.	1.66	2	551	2760	.	1.66
570	1	577	3055	.	1.59	.	.	.	.	.	1	577	3055	.	1.59
TOTAL	45					21					66				
MEAN		500	1833	355	1.46		484	1856	361	1.60		495	1840	354	1.51

Appendix 2. Biological data by age class for broad whitefish from the UDC Exploratory Fishery, 139 mm mesh gill nets (Net=C) and 38 mm to 139 mm multi-mesh experimental gill nets (Net=T), all locations combined, 1989 to 1993.

YEAR=89 NET=C

AGE	MALES						FEMALES						COMBINED					
		LENGTH(MM)		WEIGHT(G)				LENGTH(MM)		WEIGHT(G)				LENGTH(MM)		WEIGHT(G)		
(YR)	N	MEAN	SD	MEAN	SD	K	N	MEAN	SD	MEAN	SD	K	N	MEAN	SD	MEAN	SD	K
6	.	.	.	.	.	.	1	501	.	2500	.	1.99	2	472	42	2500	.	1.99
7	2	471	8	1505	148	1.44	3	507	25	2100	436	1.59	12	482	23	1862	455	1.53
8	5	505	11	2140	89	1.66	4	490	36	1900	163	1.63	19	495	26	2033	173	1.65
9	5	500	27	2000	187	1.60	6	498	13	2100	190	1.71	28	498	21	2055	186	1.66
10	2	518	11	2250	71	1.62	5	503	18	2000	245	1.57	18	501	21	2071	236	1.59
11	.	.	.	.	.	.	4	514	17	2150	238	1.58	9	518	32	2150	238	1.58
12	.	.	.	.	.	.	.	.	.	.	.	.	1	651	.	.	.	.
13	1	584	.	2900	.	1.46	.	.	.	.	.	.	3	534	45	2900	.	1.46
14	.	.	.	.	.	.	1	515	.	1800	.	1.32	2	543	39	1800	.	1.32
TOTAL	15						24						94					
MEAN		506	30	2074	342	1.59		502	21	2058	254	1.63		501	31	2064	287	1.61
MEAN AGE		8.8						9.2						9.1				

Appendix 2. (continued).

YEAR=90 NET=C

AGE	MALES						FEMALES						COMBINED					
		LENGTH(MM)		WEIGHT(G)				LENGTH(MM)		WEIGHT(G)				LENGTH(MM)		WEIGHT(G)		
(YR)	N	MEAN	SD	MEAN	SD	K	N	MEAN	SD	MEAN	SD	K	N	MEAN	SD	MEAN	SD	K
3	.	.	.	.	.	.	1	450	.	1460	.	1.60	1	450	.	1460	.	1.60
4	1	517	.	2750	.	1.99	.	.	.	.	.	.	1	517	.	2750	.	1.99
5	2	449	16	1400	141	1.54	1	587	.	2064	.	1.02	3	495	80	1621	396	1.37
6	3	516	16	2328	476	1.68	.	.	.	.	.	.	3	516	16	2328	476	1.68
7	3	506	1	2077	386	1.60	6	463	39	1618	572	1.57	9	477	38	1771	542	1.58
8	15	492	35	1897	446	1.57	6	490	31	2031	505	1.70	21	492	33	1935	455	1.61
9	11	505	33	1973	491	1.51	18	498	28	2051	384	1.65	29	500	29	2021	421	1.60
10	23	500	19	1886	251	1.50	22	497	32	1978	420	1.60	45	499	26	1931	343	1.55
11	29	506	28	1957	378	1.49	25	501	24	2088	447	1.64	54	504	26	2018	412	1.56
12	21	508	24	2016	331	1.53	27	496	20	1953	312	1.59	48	501	22	1981	318	1.57
13	15	496	15	1815	198	1.49	17	506	30	2089	421	1.60	32	501	25	1961	358	1.55
14	9	506	39	1886	483	1.44	11	510	31	2075	421	1.55	20	508	34	1990	448	1.50
15	7	517	35	2039	492	1.45	3	520	26	2173	337	1.53	10	518	31	2080	437	1.48
16	3	514	46	2183	756	1.57	4	495	4	1691	204	1.39	7	503	28	1902	530	1.47
17	6	503	18	1896	196	1.49	2	457	19	1527	151	1.60	8	491	27	1803	245	1.52
18	4	500	38	1902	467	1.50	.	.	.	.	.	.	4	500	38	1902	467	1.50
19	2	505	24	1725	389	1.33	.	.	.	.	.	.	2	505	24	1725	389	1.33
20	3	539	57	2346	753	1.46	1	496	.	2100	.	1.72	4	529	51	2285	627	1.53
21	.	.	.	.	.	.	1	488	.	1620	.	1.39	1	488	.	1620	.	1.39
TOTAL	157						145						302					
MEAN		504	28	1948	390	1.51		498	29	1994	410	1.60		501	29	1970	400	1.55
MEAN AGE	11.6						11.3						11.4					

Appendix 2. (continued).

YEAR=90 NET=T

AGE	MALES						FEMALES						COMBINED					
	LENGTH(MM)			WEIGHT(G)			LENGTH(MM)			WEIGHT(G)			LENGTH(MM)			WEIGHT(G)		
(YR)	N	MEAN	SD	MEAN	SD	K	N	MEAN	SD	MEAN	SD	K	N	MEAN	SD	MEAN	SD	K
2	.	.	.	.	.	.	.	.	.	.	.	.	1	142	.	35	.	1.22
5	.	.	.	.	.	.	1	381	.	720	.	1.30	1	381	.	720	.	1.30
6	1	467	.	1726	.	1.69	1	472	.	2064	.	1.96	2	470	4	1895	239	1.83
7	1	488	.	1700	.	1.46	1	488	.	1897	.	1.63	2	488	0	1799	139	1.55
8	1	511	.	2149	.	1.61	2	475	4	1904	295	1.78	3	487	21	1985	252	1.72
9	4	494	10	1837	242	1.52	3	499	21	2224	328	1.78	7	496	14	2002	328	1.63
10	10	511	22	1991	298	1.48	5	496	15	1924	193	1.58	15	506	21	1968	262	1.51
11	9	503	29	2014	424	1.57	12	508	30	2043	396	1.55	21	505	29	2031	398	1.56
12	10	498	28	1896	457	1.51	11	503	36	2058	500	1.59	21	500	32	1981	475	1.55
13	10	515	21	2055	295	1.50	5	495	21	1888	272	1.55	15	508	22	1999	289	1.52
14	4	494	33	1524	223	1.26	3	497	26	1867	261	1.52	7	495	28	1671	285	1.37
15	3	476	43	1548	470	1.41	5	515	36	1994	555	1.44	8	500	41	1827	541	1.43
16	1	480	.	1447	.	1.31	2	491	1	1782	79	1.51	3	487	6	1670	201	1.44
17	1	472	.	1677	.	1.59	2	465	34	1398	329	1.38	3	467	24	1491	283	1.45
18	3	497	46	1670	335	1.36	4	514	46	2060	579	1.48	7	507	43	1893	498	1.43
19	1	524	.	2100	.	1.46	1	534	.	2120	.	1.39	2	529	7	2110	14	1.43
20	.	.	.	.	.	.	1	473	.	1540	.	1.46	1	473	.	1540	.	1.46
21	1	483	.	1420	.	1.26	.	.	.	.	.	.	1	483	.	1420	.	1.26
TOTAL	60						59						120					
MEAN		501	27	1881	370	1.48		498	33	1952	424	1.56		497	44	1901	431	1.52
MEAN AGE	12.2						12.4						12.3					

Appendix 2. (continued).

YEAR=91 NET=C

AGE (YR)	MALES N	MALES LENGTH(MM) MEAN	MALES LENGTH(MM) SD	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES LENGTH(MM) SD	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED LENGTH(MM) SD	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K
3	2	427	54	1120	594	1.36	.	.	.	.	.	.	2	427	54	1120	594	1.36
5	5	494	34	2022	278	1.68	1	470	.	1500	.	1.44	6	490	32	1935	328	1.64
6	12	479	26	1664	323	1.50	7	475	29	1654	415	1.51	19	478	27	1660	350	1.50
7	17	487	23	1775	338	1.53	13	502	34	2125	499	1.67	30	493	29	1932	447	1.59
8	20	488	25	1826	359	1.55	13	486	10	1888	219	1.64	33	487	20	1850	309	1.59
9	25	508	26	1992	252	1.53	28	495	30	2050	401	1.68	53	501	29	2024	339	1.61
10	48	509	32	2126	489	1.58	54	504	27	2161	407	1.68	102	506	30	2145	445	1.63
11	53	509	28	2121	400	1.60	44	507	28	2187	379	1.66	97	508	28	2150	390	1.63
12	41	505	36	1948	452	1.50	42	506	28	2161	428	1.65	83	506	32	2055	450	1.57
13	36	516	28	2061	355	1.49	36	516	34	2235	458	1.62	72	516	31	2148	417	1.56
14	22	512	39	2035	508	1.49	17	503	28	2081	393	1.62	39	508	34	2056	453	1.55
15	16	522	19	2130	240	1.49	21	512	38	2178	519	1.60	37	516	31	2157	418	1.55
16	12	518	25	1965	316	1.40	7	506	33	2051	489	1.56	19	514	28	1997	378	1.46
17	10	547	32	2375	473	1.44	13	516	39	2139	547	1.58	23	530	39	2246	517	1.51
18	1	510	.	2000	.	1.51	12	542	32	2442	445	1.53	13	539	32	2408	443	1.53
19	8	532	45	2226	638	1.44	10	534	39	2351	728	1.53	18	533	41	2292	669	1.49
20	7	536	28	2099	310	1.36	7	530	34	2477	547	1.72	14	533	30	2273	460	1.53
21	1	614	.	3365	.	1.45	4	556	51	3025	961	1.71	5	568	51	3093	846	1.66
22	4	514	42	1975	470	1.43	.	.	.	.	.	.	4	514	42	1975	470	1.43
23	.	.	.	.	.	.	1	533	.	2380	.	1.57	1	533	.	2380	.	1.57
30	.	.	.	.	.	.	1	622	.	3570	.	1.48	1	622	.	3570	.	1.48
TOTAL	340						331						671					
MEAN		509	34	2029	431	1.52		508	33	2169	473	1.64		509	33	2098	457	1.58
MEAN AGE	11.6						12.3						11.9					

Appendix 2. (continued).

YEAR=91 NET=T

AGE	MALES						FEMALES						COMBINED					
		LENGTH(MM)		WEIGHT(G)				LENGTH(MM)		WEIGHT(G)				LENGTH(MM)		WEIGHT(G)		
(YR)	N	MEAN	SD	MEAN	SD	K	N	MEAN	SD	MEAN	SD	K	N	MEAN	SD	MEAN	SD	K
4	1	387	.	800	.	1.38	.	.	.	.	.	.	1	387	.	800	.	1.38
6	1	500	.	1750	.	1.40	.	.	.	.	.	.	1	500	.	1750	.	1.40
7	.	.	.	.	.	.	1	506	.	2200	.	1.70	1	506	.	2200	.	1.70
8	2	519	13	2395	219	1.72	.	.	.	.	.	.	2	519	13	2395	219	1.72
9	2	506	32	1930	382	1.48	3	505	18	2150	141	1.75	5	505	20	2040	267	1.62
10	1	527	.	.	.	.	4	498	21	1900	245	1.54	5	503	22	1900	245	1.54
11	1	523	.	2100	.	1.47	.	.	.	.	.	.	1	523	.	2100	.	1.47
12	.	.	.	.	.	.	1	501	.	2400	.	1.91	1	501	.	2400	.	1.91
13	1	454	.	2050	.	2.19	1	490	.	2020	.	1.72	2	472	25	2035	21	1.95
14	1	500	.	1600	.	1.28	2	482	37	1690	580	1.48	3	488	29	1660	413	1.41
15	3	514	47	1840	355	1.35	.	.	.	.	.	.	3	514	47	1840	355	1.35
16	1	445	.	1230	.	1.40	1	461	.	.	.	.	2	453	11	1230	.	1.40
17	.	.	.	.	.	.	1	526	.	2900	.	1.99	1	526	.	2900	.	1.99
19	.	.	.	.	.	.	2	552	26	2850	636	1.68	2	552	26	2850	636	1.68
23	.	.	.	.	.	.	1	533	.	1970	.	1.30	1	533	.	1970	.	1.30
24	1	520	.	2050	.	1.46	.	.	.	.	.	.	1	520	.	2050	.	1.46
25	.	.	.	.	.	.	2	542	33	2403	463	1.50	2	542	33	2403	463	1.50
TOTAL	15						19						34					
MEAN		496	43	1839	460	1.50		509	30	2193	473	1.62		503	37	2033	493	1.57
MEAN AGE	11.8						14.3						13.2					

Appendix 2. (continued).

YEAR=92 NET=C

AGE (YR)	MALES N	MALES LENGTH(MM) MEAN	MALES LENGTH(MM) SD	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES LENGTH(MM) SD	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED LENGTH(MM) SD	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K
4	6	445	20	1275	352	1.49	4	484	49	1483	76	1.34	10	460	38	1364	276	1.43
5	41	458	41	1474	237	1.50	17	453	26	1496	407	1.60	59	457	37	1476	288	1.52
6	43	471	24	1647	356	1.55	42	465	23	1573	324	1.57	86	468	23	1610	337	1.56
7	30	475	22	1680	232	1.60	32	484	33	1724	420	1.52	62	479	29	1704	344	1.55
8	65	490	24	1835	304	1.55	47	489	24	1840	400	1.55	113	490	24	1836	348	1.55
9	52	492	29	1852	348	1.55	45	496	31	1938	387	1.65	98	493	30	1884	373	1.59
10	60	499	19	1853	263	1.49	57	497	29	1882	495	1.52	117	498	25	1868	393	1.51
11	72	502	31	1859	393	1.45	101	499	25	1940	340	1.56	175	500	28	1908	363	1.51
12	62	505	26	1869	334	1.46	79	504	32	1931	440	1.52	141	505	29	1904	397	1.49
13	46	502	28	1891	344	1.50	67	508	29	1932	382	1.49	114	506	29	1914	364	1.49
14	46	515	35	1844	376	1.37	30	508	33	2041	485	1.57	76	512	34	1931	436	1.46
15	30	517	33	1970	506	1.43	17	533	38	2185	480	1.44	47	522	35	2038	503	1.43
16	18	525	41	2090	513	1.46	14	525	51	2164	849	1.44	32	525	45	2118	642	1.46
17	4	494	38	1600	200	1.35	7	517	53	2262	565	1.66	11	509	48	2021	562	1.55
18	14	511	33	1934	395	1.44	3	501	5	1881	105	1.50	17	509	30	1924	353	1.45
19	4	515	31	2027	291	1.43	9	537	58	2164	788	1.40	13	530	51	2126	675	1.41
20	2	537	82	2633	1297	1.62	4	532	26	2212	478	1.45	6	534	42	2352	722	1.51
21	1	572	.	2200	.	1.18	.	.	.	.	.	.	1	572	.	2200	.	1.18
22	2	488	28	1747	207	1.51	.	.	.	.	.	.	2	488	28	1747	207	1.51
TOTAL	598						575						1180					
MEAN		496	34	1821	378	1.49		498	34	1897	450	1.54		497	34	1857	417	1.51
MEAN AGE		10.5						10.7						10.6				

Appendix 2. (continued).

YEAR=92 NET=T

AGE (YR)	MALES N	MALES LENGTH(MM) MEAN	MALES LENGTH(MM) SD	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES LENGTH(MM) SD	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED LENGTH(MM) SD	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K
3	.	.	.	.	.	.	.	.	.	.	.	.	1	175	.	50	.	0.93
6	1	458	.	1500	.	1.56	.	.	.	.	.	.	1	458	.	1500	.	1.56
7	1	498	.	2100	.	1.70	.	.	.	.	.	.	1	498	.	2100	.	1.70
8	.	.	.	.	.	.	1	490	.	2100	.	1.78	1	490	.	2100	.	1.78
9	.	.	.	.	.	.	3	508	29	2050	522	1.55	3	508	29	2050	522	1.55
10	.	.	.	.	.	.	3	495	19	1933	275	1.58	3	495	19	1933	275	1.58
11	4	487	22	2100	579	1.85	3	492	3	1833	58	1.54	7	489	16	1986	435	1.72
12	3	562	48	2500	229	1.43	2	487	3	1800	.	1.58	5	532	53	2325	397	1.47
13	2	516	16	2050	141	1.50	1	498	.	1950	.	1.58	3	510	15	2017	115	1.52
14	1	507	.	1700	.	1.30	2	505	49	2050	566	1.58	3	505	35	1933	448	1.49
15	1	506	.	2050	.	1.58	1	507	.	2000	.	1.53	2	507	1	2025	35	1.56
16	.	.	.	.	.	.	1	468	.	1700	.	1.66	1	468	.	1700	.	1.66
17	2	525	65	2275	1237	1.48	.	.	.	.	.	.	2	525	65	2275	1237	1.48
18	1	513	.	1950	.	1.44	1	508	.	2000	.	1.53	2	511	4	1975	35	1.48
19	1	493	.	1850	.	1.54	.	.	.	.	.	.	1	493	.	1850	.	1.54
20	1	568	.	2850	.	1.56	.	.	.	.	.	.	1	568	.	2850	.	1.56
TOTAL	18						18						37					
MEAN		514	40	2142	506	1.57		497	20	1947	277	1.58		497	63	1992	529	1.56
MEAN AGE	13.3						11.8						12.3					

Appendix 2. (continued).

YEAR=93 NET=C

AGE (YR)	MALES N	MALES LENGTH(MM) MEAN	MALES LENGTH(MM) SD	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES LENGTH(MM) SD	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED LENGTH(MM) SD	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K
4	1	441	.	1200	.	1.40	.	.	.	.	.	.	1	441	.	1200	.	1.40
5	13	448	23	1401	226	1.56	8	456	12	1460	112	1.54	21	451	19	1425	187	1.55
6	48	458	24	1488	230	1.55	55	458	30	1525	293	1.60	107	458	28	1508	265	1.58
7	64	471	25	1620	283	1.56	50	470	24	1650	344	1.57	134	472	25	1634	310	1.56
8	30	482	22	1685	229	1.50	34	475	18	1665	253	1.55	78	476	20	1674	240	1.52
9	74	486	21	1697	219	1.49	63	485	26	1811	275	1.60	163	485	24	1749	252	1.54
10	38	495	29	1812	312	1.47	46	490	32	1888	482	1.56	116	492	29	1853	413	1.52
11	37	503	29	1921	390	1.49	37	505	31	2078	459	1.60	99	503	28	2001	431	1.55
12	55	503	25	1824	285	1.44	52	494	28	1847	304	1.54	138	500	27	1835	293	1.49
13	52	506	31	1955	396	1.50	40	504	27	1957	324	1.52	119	503	28	1956	364	1.51
14	58	506	28	1897	352	1.46	42	499	35	1978	424	1.59	126	503	32	1932	384	1.51
15	38	512	30	1943	368	1.42	25	510	32	2083	485	1.57	83	511	30	2001	422	1.48
16	22	521	30	2063	459	1.44	10	506	28	2033	242	1.57	44	511	30	2053	400	1.48
17	13	514	26	2045	386	1.50	13	513	30	2038	282	1.51	35	512	30	2042	331	1.50
18	9	520	39	1881	476	1.32	11	527	32	2273	385	1.55	23	519	35	2108	458	1.45
19	9	536	45	2166	508	1.39	3	521	22	2083	401	1.46	13	529	40	2145	467	1.41
20	9	542	46	2349	896	1.43	.	.	.	.	.	.	9	542	46	2349	896	1.43
21	4	546	32	2338	465	1.42	2	562	41	2570	99	1.46	8	539	41	2415	382	1.44
22	2	545	0	2373	541	1.47	1	590	.	3850	.	1.87	4	540	46	2865	935	1.60
TOTAL	576						492						1321					
MEAN		494	34	1806	387	1.48		489	34	1848	411	1.57		492	33	1825	399	1.52
MEAN AGE	11.2						10.6						11.1					

Appendix 2. (continued).

YEAR=93 NET=T

AGE (YR)	MALES N	MALES LENGTH(MM) MEAN	MALES LENGTH(MM) SD	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES LENGTH(MM) SD	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED LENGTH(MM) SD	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K
6	1	461	.	.	.	.	.	.	.	.	.	.	1	461	.	.	.	.
7	1	469	.	1685	.	1.63	.	.	.	.	.	.	1	469	.	1685	.	1.63
8	2	490	1	1750	71	1.49	.	.	.	.	.	.	2	490	1	1750	71	1.49
9	4	497	17	1778	203	1.48	4	452	14	1358	88	1.57	8	474	28	1610	275	1.52
10	8	495	21	1735	197	1.46	3	482	32	1847	383	1.63	11	491	23	1769	248	1.51
12	3	497	7	1743	153	1.42	5	501	33	2088	418	1.64	8	500	26	1959	372	1.56
13	7	497	19	1736	241	1.41	5	480	11	1688	123	1.53	12	490	18	1716	194	1.46
14	8	498	40	1846	514	1.53	3	489	15	1912	196	1.63	11	495	35	1866	431	1.56
15	3	496	27	1845	400	1.49	1	529	.	2395	.	1.62	4	504	28	1983	427	1.52
17	3	526	13	1998	276	1.37	.	.	.	.	.	.	3	526	13	1998	276	1.37
18	2	535	0	2065	502	1.35	.	.	.	.	.	.	2	535	0	2065	502	1.35
19	3	519	53	2173	795	1.51	.	.	.	.	.	.	3	519	53	2173	795	1.51
TOTAL	45						21						66					
MEAN		500	28	1833	355	1.46		484	28	1856	361	1.60		495	29	1840	354	1.51
MEAN AGE	12.7						11.8						12.4					

APPENDIX 3

DATA DEFICIENCIES

A qualitative evaluation of maturity was performed on each species for the years 1990 to 1993 However, the code used varied between years and field personnel not familiar with a particular code may have misinterpreted the different maturity stages Due to the inconsistencies and possibility of error, these data were not analysed In order to provide some information on maturity or gonad development, the gonadosomatic index (GSI) was used

Where results from samples collected in 1989 are presented it was for information purposes only There are two significant problems with this data which make comparison with other years and locations difficult The first involves the structure chosen for age determination The dorsal fin was collected for age determination in 1989 This fin is not traditionally used to age coregonids and it was extremely difficult and often impossible to read (Carol Read, DFO-Winnipeg, personal communication) The second problem was that sample size was inadequate for the type of analyses required to assess the exploratory fishery for the purposes of management

Several different people were involved in the determination of ages over the five years of this exploratory fishery, which coupled with the inconsistency in the choice of ageing structure (pelvic fin for 1990 and 1993, pectoral fin for 1991 and 1992, and otolith for 70 samples in 1991), could be cause for concern However, for the most part everyone was experienced at ageing or had assistance from experienced individuals The readability of the broad whitefish pectoral and pelvic fin rays is similar (Rick Wastle, Ageing Consultant-Winnipeg, personal communication) and ages from these two structures for lake whitefish from southern Canada have been comparable (Dr Ken Mills, DFO-Winnipeg, personal communication) A comparison between broad whitefish aged 1 to 18 years showed no significant difference between otolith age and pelvic fin age (Treble, 1992) Standard age structure preparation techniques were used and in 1993 discussions were held and a comparison made between readers from the Inuvik Ageing Lab and Rick Wastle For a sub-section of the 1993 samples, the Inuvik lab was accurate to within one year for 85% of the samples (Donna Rystephanuk, Ageing Consultant-Rocky Mountain House, personal communication) Therefore, concerns surrounding the age data are minimal, except as discussed for the 1989 samples

The experimental gill nets were not very efficient at catching the larger mature broad whitefish that are found in the Middle Channel A much more intensive and extensive experimental gill netting program would have been necessary to provide sufficient data for most of the standard fishery analysis techniques Therefore, any results and/or comparisons between these data and others should be made with this limitation in mind