Monitoring Spawning Populations of Migratory Coregonids in the Peel River, NT: The Peel River Fish Study 1998-2002

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MONITORING SPAWNING POPULATIONS OF MIGRATORY COREGONIDS IN THE PEEL RIVER, NT: THE PEEL RIVER FISH STUDY 1998-2002

by

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ABSTRACT

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The Peel River provides spawning habitat for migratory Inconnu, Arctic Cisco, Broad Whitefish, Lake Whitefish, and Least Cisco. From 1998 to 2002, the Peel River Fish Study collected information on species migration timing, spawning timing, fecundity, sex ratio, fork length, and age. In general, pre-spawning fish were caught migrating up the Peel River from mid-July until river freeze-up; after which spent fish were caught migrating downstream. Species fecundity was highly variable, but all were positively correlated to fork length. In all species, male fish were caught more frequently than female fish. Length-frequency distributions were similar to those reported by previous literature for all species, except Broad Whitefish; which had a greater proportion of larger fish. Age-frequency distributions of all species had a greater range with a higher proportion of older fish than those reported by previous studies.

Key Words: Peel River, Broad Whitefish, Lake Whitefish, Arctic Cisco, Least Cisco, Inconnu, life history, Coregonid, Coregonus, Stenodus, Mackenzie, anadromous

RÉSUMÉ

VanGerwen-Toyne, M., J. Walker-Larsen, et R.F. Tallman. 2008. Surveillance des populations reproductrices corégonidés migrateurs de la rivière Peel (T.N.-O.) : étude sur les poissons dans la rivière Peel 1998-2002. Can. Manuscr. Rep. Fish. Aquat. Sci. 2851: vi + 56 p.

La rivière Peel offre une frayère aux poissons migrateurs suivants : inconnu; cisco arctique; corégone tschir; grand corégone; cisco sardinelle. De 1998 à 2002, dans le cadre de l’étude sur les poissons de la rivière Peel, on a recueilli de l’information sur la période de migration et de frai, la fécondité, la sex-ratio, la longueur à la fourche et l’âge des espèces. En général, les poissons en période de pré-frai ont été attrapés en migration en amont de la rivière Peel, entre la mi-juillet et la prise de la glace de la rivière; ensuite, les poissons ayant frayé ont été attrapés en migration en aval. Les taux de fécondité des espèces étaient hautement variables, mais tous étaient en corrélation positive avec la longueur à la fourche. Des poissons mâles de toutes les espèces ont été attrapés plus fréquemment que des poissons femelles. Pour l’ensemble des espèces, les distributions des fréquences de longueur étaient semblables à celles consignées dans la documentation antérieure, à l’exception du corégone tschir dont la proportion de grands poissons était plus importante. Pour l’ensemble des espèces, les distributions des fréquences d’âge étaient plus variables : il y avait une plus grande proportion de poissons plus âgés par rapport aux études antérieures.

Mots Clés : rivière Peel, corégone tschir, grand corégone, cisco arctique, cisco sardinelle, inconnu, cycle biologique, corégonidés, coregonus, stenodus, Mackenzie, anadrome

INTRODUCTION

The Peel River is an important spawning area for many migratory fish species including Inconnu (*Stenodus leucichthyes*), Arctic Cisco (*Coregonus autumnalis*), Broad Whitefish (*Coregonus nasus*), Lake Whitefish (*Coregonus clupeaformis*), and Least Cisco (*Coregonus sardinella*). The Peel River is unique to other Mackenzie River tributaries in that it was the only extensive unglaciated part of the present Mackenzie drainage during the Pleistocene and was connected to the Yukon River system during part of this time (Bodaly and Lindsey 1977). As a result, the Peel River likely supports relict fish populations and populations with ancestors from the Yukon River system. There is morphological and biochemical evidence suggesting that several Peel River fish populations contain racial types that are distinct from other Mackenzie River populations (Bodaly and Lindsey 1977).

Migratory coregonid fish species are the basis for subsistence fisheries throughout the Mackenzie River system and Peel River fish are harvested along their spawning route each year in the Inuvialuit, Gwich'in, and Sahtu Settlement areas (Corkum and McCart 1981; Gwich'in Renewable Resource Board 1997; Gwich'in Renewable Resource Board 2001; McCart 1986; Sparling and Sparling 1988; Stewart 1996). Migratory fish populations are difficult to manage and tend to be vulnerable to over-fishing. Large groups of fish travel through restricted areas at predictable times of year, making them relatively easy to capture (Reist and Bond 1988; Reist and Treble 1998). The fish also travel long distances, so the same group is targeted many times during both their upstream and downstream migration (Reist 1997). Further, suitable spawning and over-wintering habitats are often localized and/or rare. Therefore, relatively small disturbances that degrade such critical habitat may have large impacts on the fish population. Travelling through many different areas over long distances can also expose fish to multiple stresses.

The Peel River Fish Study was designed by the Gwich'in Renewable Resource Board (GRRB) in partnership with Fisheries & Oceans Canada and the Fort McPherson (Tetlit) Renewable Resource Council in 1998. The study was designed to address community concerns that future developments in the Peel River watershed, such as mining and oil and gas development, may impact the migratory fish populations and the subsistence harvest. The objective of the study was to collect migration timing and biological information about the spawning populations of Peel River coregonids. The information collected can serve as a baseline for future monitoring of these fish stocks.

STUDY AREA

The Peel River is a large tributary of the Mackenzie River that originates in the Olgilvie Mountains of the Yukon Territory. The river first flows east across the Porcupine Plateau and then flows generally north across the Peel Plateau and onto the Peel Plain in the District of Mackenzie. It empties into the Mackenzie River Delta just downstream from Fort McPherson (Figure 1). The Peel River has a total length of 585 km and drains an area of approximately 70,600 km^2 (Water Survey of Canada 2004). The majority of river flow (90% of annual runoff) occurs in the summer from May to September with peak flows accounting for 50% of annual runoff during the snow melt period from mid-May to mid-June (Canada Department of Northern Affairs and Natural Resources 1965). A large fluctuation in water flow throughout the year has been recorded by a Water Survey of Canada hydrometric station on the Peel River upstream of Fort McPherson. Daily discharges of the Peel River from 1993-1999 ranged from a low of 500 m^3/s during the winter to 7000 m^3/s at river break-up (Water Survey of Canada 2004). The downstream portion of the river bottom is mostly bedrock but upstream areas contain extensive gravel beds that provide ideal spawning habitat for migratory coregonids (Dryden et al. 1973; Hatfield et al. 1972).

METHODS & MATERIALS

Fish Capture

A total of five community monitors from Fort McPherson were hired to catch and process fish at their camps along the Peel River including Basook Creek, Cutoff, Koe Camp, Scrapper Hill, Road River, and Trail River (Figure 2). In all cases gill nets were set perpendicular to shore in eddies for 12 to 24- hour periods, three days a week. Nets were removed during river freeze-up and re-set under the ice when safety permitted.

In 1998 and 1999 the study was designed to target Broad Whitefish. One monitor worked at each of Basook Creek, Scrapper Hill, and Trail River for six weeks starting in late September or early October (Table 1). All monitors fished using one 12.7 cm (five-inch) stretched-mesh gill net with a length of 22.9 m (75 ft). A single experimental net with panels of stretched-mesh ranging in size from 3.8 cm (1.5 inch) to 12.7 cm (five-inch) and a total length of 22.9 m (75 feet) was used occasionally at each camp (Table 1).

In subsequent years the study design was altered to capture all migratory coregonids using the Peel River. The sampling period was extended to 17 weeks beginning in mid-July to capture the earlier migrating species. Experimental gill nets were also used regularly to capture a greater range of fish sizes (Table 1).

In 2000, one monitor at Koe Camp worked for 17 weeks from mid-July to mid-November using the experimental gill net. A second monitor at Road River worked for six weeks from late September to mid-October using the 12.7 cm (five-inch) gill net. In 2001, one monitor at Koe Camp worked for 17 weeks from mid-July to mid-November using both the experimental gill net and the 12.7 cm (five-inch) gill net. A second monitor at Road River worked for two weeks from mid- to late October using only the 12.7 cm (five-inch) gill net. In 2002, a single monitor at Koe Camp worked for 17 weeks from mid-July to mid-November using both the experimental and 12.7 cm (five-inch) gill nets throughout.

Fish Sampling
Monitors checked the nets and processed fish once or twice a day. For each fish caught, monitors recorded species, fork length (mm), round weight (g), sex, maturity stage, and gonad weight (g). The presence or absence of eggs and gonadal development was used to determine sex and maturity (modified from Bond & Erickson 1985). Sagittal otoliths were collected to determine the age of each fish. Gonads of ripe females were removed and preserved in 10% buffered formalin solution to determine fecundity.

Laboratory Methods
Otolith age of all fish was estimated using the “break and burn” procedure of Chilton and Beamish (1982). To estimate fecundity, gonads were rinsed, dried, and weighed. Three sub-samples of 200 eggs were counted and weighed to the nearest 0.001 g. Fecundity was calculated as the average weight of sub-sample / weight of all eggs * size of sub-sample.

Data Analysis
Migration timing was determined using data from Koe Camp. Catch per unit effort (CPUE) was calculated for every week of the sampling period as the number of fish captured per week / number of hours fished * 24 hours of net soak time. Data from the first two years of the study (1998 and 1999) were not included in the analysis because of the short sampling period (six weeks).

Data from female fish caught during the study from 1998 to 2001 were used to calculate gonadosomatic index (GSI). GSI was calculated as [gonad weight / (round weight – gonad weight) * 100]. GSI was not calculated for data from 2002 due to equipment malfunction causing incorrect measurements of gonad weight.
A female fish was classified as pre-spawning if it had a relatively high GSI and developing eggs within the gonad. A female fish with a reduced relative GSI, broken-down gonadal tissue, and a few eggs remaining loose in the body cavity was classified as post-spawning (or spent).

Fecundity-length relationships for each species were calculated using least squares regression analysis and described by the equation:

$$F = a + b(L)$$

Where F = fecundity (number eggs)
L = fork length (mm)
a = y-intercept
b = slope of the regression

To determine if the type of net used, five-inch or experimental, influenced the length of Broad Whitefish, Inconnu, and Lake Whitefish captured, the median fork lengths of fish caught in each net type were compared using the Wilcoxon two-sample test (Sokal and Rohlf 1995). For this analysis, data from 2001 and 2002 were used because this was the only time both nets were fished simultaneously. If a significant difference in median fork length between nets was found, the length-frequency distribution was compiled separately for each net type. If a significant difference was not found the length data for both net types were pooled within species. In either case, the length-frequency distributions were composed of all available data from 1998 through 2002. The same sequence of analysis was also performed on age data for Inconnu, Broad Whitefish, and Lake Whitefish. Tests comparing median fish length or age between net types were not performed on Arctic Cisco or Least Cisco because no fish were caught in the five-inch mesh net for either species.

For all species, median male and female fork length-at-age was compared using the Wilcoxon two-sample test.

Weight-length relationships for each species (males, females, and combined sex) were calculated using least squares regression analysis on log transformed data for length and weight. Relationships were described by the equation:

$$\mathrm{Log}_{10}W = a + b(\mathrm{Log}_{10} L)$$

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

RESULTS & DISCUSSION

A total of 12 species of fish were caught during the five-year study (Table 2). The total catch of 3,144 fish consisted of 88.6% target species and 11.4% bi-catch species (Table 3). Of the target species, Broad Whitefish were captured most frequently (48.1%), followed by Lake Whitefish (15.4%), Arctic Cisco (11.4%), Inconnu (9.4%), and Least Cisco (4.4%). Northern Pike was by far the most abundant bi-catch species caught representing 9.9% of the total fish relative abundance. Chum Salmon was the second most abundant bi-catch species with 30 fish (1.0%) captured, all in 1998. All other bi-catch species consisted of less than 1% of the total catch. This report summarizes data from the target species.

Inconnu

Relative Abundance

A total of 296 Inconnu were caught during the five-year study (Table 3). Yearly catches varied from 18 fish in 1999 to 126 fish in 2001 (Table 4).

Migration Timing

Within each year, the timing of migration between male and female Inconnu was similar (Figure 3).

The overall Inconnu migration run was similar in all years but only in 2001 were the catch frequencies large enough to clearly observe the trends (Figure 3). Peak catches of Inconnu occurred from the beginning of the sampling period in mid-July through late August. Few fish were caught in September, but in early October catches increased slightly. No Inconnu were caught in late October or November in any year. Therefore it appears that mid-July (or earlier) through August and then again in early October are important times for the spawning migration of Inconnu. Similar timing of peak Inconnu runs was reported in the Arctic Red River and Aklavik (Howland et al. 2000; Stein et al. 1973). Howland et al. (2001) also reported low numbers of Inconnu caught in September in the Mackenzie River. Gwich'in traditional knowledge also reports that Inconnu migrate upstream in June and July, and return downstream in October (Gwich'in Renewable Resource Board 1997).

Spawning Timing

Gonadosomatic index (GSI) of female Inconnu rose steadily from < 1.0 g in mid-July to 15.77 g in late August indicating, along with visual inspection of gonads, that the fish were preparing to spawn (Figure 4). All female Inconnu captured after October 1st (n = 29) were in post-spawning condition. This suggests that Inconnu in the Peel River spawn in late September prior to river freeze-up. This agrees with previous literature for Inconnu in the Peel River (Percy 1975) as well as in the mainstem Mackenzie River (Jessop and Lilley 1975) and the Arctic Red River (Howland et al. 2000). Gwich'in traditional knowledge reports that Inconnu spawn in eddies during the downstream migration in early October (Gwich'in Renewable Resource Board 1997).

Fecundity

Fecundity of Inconnu ranged between 42,461 and 152,521 eggs per individual (Figure 5). Mean fecundity ± 1 standard deviation was 80,556 ± 25,938 eggs (n = 26). A strong positive relationship between fecundity and fork length was found and described by the equation:

$F = 0.32 (L) – 181.46 (R^2 = 0.81)$.

Sex Ratio

In all years of the study male Inconnu were caught more frequently than female (Table 5). The male percentage of the catch ranged from 54% in 2002 to 71% in 1999. The overall mean frequency of all male fish caught during the five-year study was 62.8%. Conversely, Howland et al. (2001) found a greater proportion of females in the Mackenzie River.

Fork Length

Median fork length of Inconnu caught in the five-inch and experimental mesh gill nets were not significantly different (Table 6), therefore all data were pooled.
Yearly length-frequency distributions appeared highly variable between years (Figure 6). The length-frequency distribution for all Inconnu caught during the five-year study was somewhat bell-shaped and lengths ranged from 403 mm to 1030 mm. Howland et al. (2001) also reported variability in yearly length-frequency distributions for Inconnu caught in the Mackenzie River. Howland et al. (2001) and Stein et al. (1973) both reported minimum and maximum fish sizes slightly smaller than that reported here.

Mean fish length varied between years for this study, ranging from 715 mm in 1999 to 752 in 2002 (Figure 6). Howland et al. (2001) reported a minimum mean fish length slightly smaller than this, but similar maximum mean length. Babaluk et al. (2001) reported an equivalent mean length. Yearly, median length in this study was more consistent being 730 mm from 1998 through 2001, but increased to 760 mm in 2002. These are within the modal lengths reported by both Stein et al. (1973) and Howland et al. (2001). The median and mean fish length for all fish caught during the five-year study was 735 and 746 mm, respectively.

Median fork length of female Inconnu were significantly different than those of male fish for seven out of 15 age classes tested (Table 7). Females were larger from ages 14 through 21 years, with the exception of age 18 years in which no significant difference was found. Other studies have also found that female Inconnu are larger than males (Hatfield et al. 1972; Stein et al. 1973).

The relationship between fork length and round weight for Inconnu females, males, and combined sexes were described by the equations:

$Log_{10} W = 2.95 (Log_{10} L) – 4.85 (R^2 = 0.81)$,

$Log_{10} W = 2.85 (Log_{10} L) – 4.57 (R^2 = 0.84)$,

and

$Log_{10} W = 2.94 (Log_{10} L) – 4.85 (R^2 = 0.87)$,

respectively.

Age

Inconnu caught in the five-inch and experimental mesh gill nets did not differ significantly in median age (Table 8), therefore all data was pooled.

Yearly age-frequency distributions were variable and differed in the range of ages found (Figure 7). The age-frequency distribution for all Inconnu caught during the five-year study appeared uni-modal and ranged from seven to 37 years. The age distribution found in this study has a greater proportion of older fish than age distributions for Inconnu documented in other studies (Stein et al. 1973; Howland et al. 2001).

Median age of Inconnu caught during this study ranged from 13 years in 2000 to 17 years in 1998 and 2001. Mean age ranged from 13 years in 2000 to 17.5 years in 1998. The compiled five-year median and mean ages were 17 and 16.2 years, respectively with dominant age classes between 14 and 17 years comprising 46.9% of the total Inconnu catch. The mean age found here is older than that reported by Babaluk et al. (2001) and Howland et al. (2001).

Previous literature document a minimum age-at-maturity of six years for Inconnu in the Mackenzie River system (Stein et al. 1973). All Inconnu captured during this study were seven years or older. However, differences in age-at-maturity may be due to differences in age determination techniques. This study used otoliths to determine fish age while Stein et al. (1973) used scales, which have been noted to underestimate age in older fish (Howland et al. 2004).

Arctic Cisco

Relative Abundance

A total of 358 Arctic Cisco were caught during the five-year study (Table 3). In all years, Arctic Cisco was caught exclusively by the experimental mesh gill net, even though the five-inch gill net was also used. However, yearly catches in the experimental net varied substantially (Table 4). In 1998 and 1999 few fish were caught (n = 1 and 11, respectively). This is likely due to the fact that the study design targeted larger fish in those years and thus used a larger mesh net primarily; the experimental net was used only occasionally in 1998 and 1999. Also, the study began later in the season and likely missed the majority of the Arctic Cisco migration. However, catches also varied even when the study design was adapted to target Arctic Cisco. In 2000, 257 fish were caught; over five times as many fish as that in 2001 and 2002 (n = 42 and 47, respectively).

Migration Timing

Within each year, the timing of migration between male and female Arctic Cisco were similar to one another (Figure 8).

The yearly timing of migration for both sexes combined varied slightly, but in general, Arctic Cisco were caught most frequently in August and catch numbers decreased after that until few to no fish were caught by late September (Figure 8). The trend was most apparent in 2000 when catches peaked in early August and decreased thereafter. Stein et al. (1973) also reported peak runs of fish in August at the mouth of the Peel River. Dillinger et al. (1992) noted that catches varied by year but they found that catches peaked slightly earlier, in late July.

Spawning Timing

A specific spawning time for Arctic Cisco could not be identified from study results although data suggests that spawning does not occur before river freeze-up. All females caught prior to mid-October each year from Koe Camp were in pre-spawning condition (Figure 9). Female gonadosomatic index (GSI) rose steadily from 4.69 g in mid-July to 30.9 g in late September indicating, along with visual inspection, that eggs were maturing and the fish were preparing to spawn. Few female fish were captured after the end of September, but in 1999 one ripe female with a GSI of 41.9 g was caught on October 21st. It is unclear whether this fish was arriving late to the spawning area or alternatively, if earlier-arriving pre-spawning fish were still congregating at the spawning area during this time. This is because a downstream run of spent female Arctic Cisco was not detected by this study. In fact, only one spent female was captured during the entire five-year study; in early November of 2000 at Road River. Stein et al. (1973) reported marked downstream runs of spent fish in the Peel River and Peel Channel from October 6th through 26th. Jessop and Lilly (1975) also reported a downstream migration in October. These dates coincide with river freeze-up during this study (Table 1), therefore, it is possible that each year post-spawning fish moved quickly downstream from spawning areas during river freeze-up when fishing had temporarily ceased.

Fecundity

Fecundity of Arctic Cisco ranged from 11,316 to 30,267 eggs per individual (Figure 10). Mean fecundity ± 1 standard deviation was 17,714 ± 4,219 eggs (n = 27). There was a slight positive relationship between fecundity and fork length and it was described by the equation:

$F = 0.17 (L) – 42.07 (R^2 = 0.33)$.

Sex Ratio

In all years of the study, more male Arctic Ciscoes were caught than females (Table 9). The male proportion of the catch in 1998 and 1999 were 100% and 82%, however few fish were caught during these years (n = 1 and 11, respectively). From 2000 through 2002 when more fish were caught, the percentage of males was consistently around 60%. The overall mean frequency of male fish was also 60%.

Fork Length

Arctic Ciscoes were caught exclusively in the experimental mesh gill nets; therefore, a comparison between nets is not applicable.

The yearly fork length-frequency distribution for Arctic Cisco varied in appearance during the five-year study (Figure 11). The fork length-frequency distribution of all Arctic Cisco caught during the five-year study was uni-modal and slightly skewed to the smaller sizes (Figure 11). Fork lengths ranged from 220 mm to 490 mm.

Yearly median fork lengths of Arctic Cisco ranged from 350 mm to 360 mm and mean fish lengths ranged from 354 mm to 363 mm (Figure 11). The median and mean fish lengths for all Arctic Cisco caught during the five-year study were 350 mm and 356 mm, respectively. This size is comparable to values reported by Jessop and Chang-Kue (1993) and Stein et al. (1973).

Male and female Arctic Ciscoes were significantly different in median fork length at four out of nine age classes tested (Table 10). Females were larger from ages nine through 12 years.

The relationship between fork length and round weight for Arctic Cisco females, males, and combined sexes were described by the equations:

$Log_{10} W = 3.46(Log_{10} L) - 6.13 (R^2 = 0.81)$

$Log_{10} W = 2.96 (Log_{10} L) – 4.9 (R^2 = 0.69)$,

and

$Log_{10} W = 3.41 (Log_{10} L) – 6.02 (R^2 = 0.78)$,

respectively.

Age

Yearly age-frequency distributions of Arctic Cisco all appeared uni-modal with similar length ranges, although few fish were caught in 1998 and 1999 (n = 1 and 11, respectively) (Figure 12). The age-frequency distribution of all Arctic Cisco caught during the five-year study appeared to be uni-modal but slightly skewed to older ages (Figure 12). Age ranged from five to 19 years with age classes eight through 13 years comprising 89.6% of the catch. Stein et al. (1973) reported the same minimum age but a lower maximum age for Arctic Cisco caught in the Arctic Red River (five to 10 years). However, Stein et al. (1973) used scales to determine fish age while this study used otoliths and scales have been shown to underestimate the age of older fish (Howland et al. 2004).

Yearly median age of Arctic Cisco ranged from 10 years in 1999 and 2002 to 12 years in 2000. Mean fish age ranged from 9.8 years in 1999 to 11.4 years in 2001 and 2002. Median and mean ages for the five-year study were 10 and 10.7 years, respectively.

Previous studies suggest that Arctic Cisco do not mature sexually until at least six years of age (Lawrence et al. 1984; Stein et al. 1973). All but one Arctic Cisco captured during this study were mature and at least seven years of age. One five-year old immature female caught in late July.

Broad Whitefish

Relative Abundance

A total of 1513 Broad Whitefish were caught during the five-year study (Table 3). The highest catch of 422 fish was recorded in 1998 (Table 4), however this year one monitoring location (Basook) was located close to the Mackenzie River and catches at this camp may have included fish roaming into the Peel from the Mackenzie River. For that reason, Basook was not used as a sampling camp in further years. Catches recorded in subsequent years were more similar to one another and ranged from 242 fish caught in 2000 to 288 fish caught in 2001 (Table 4).

Migration Timing
Within each year, the timing of migration between male and female Broad Whitefish appeared similar (Figure 13). The only deviation from this was in early October of 2001 when a large peak of male Broad Whitefish was caught.

The combined-sex catch of Broad Whitefish was also relatively consistent within each year except for the peak catch of fish in 2001 (Figure 13). This was unexpected given previous literature. Radio-tagging studies by Chang-Kue and Jessop (1983, 1991, 1997) suggested that Broad Whitefish make a concerted run to spawning areas, including the Peel River, in early October. It is possible that peak movements of pre-spawning Broad Whitefish targeted in the Peel River Fish Study occurred during periods of river freeze-up when fishing had temporarily ceased and thus were not detected by the study. However, Gwich'in traditional knowledge reports that the Broad Whitefish upstream migration begins in mid-June and return downstream migrations begin in October with many fish also caught in early November (Gwich'in Renewable Resource Board 1997).

Spawning Timing
The results of this study indicate that Broad Whitefish in the Peel River spawn in late October, just after river freeze-up. Gonadosomatic index (GSI) rose steadily from 3.28 g in late July to 44.42 g in late October indicating, along with visual inspection of gonads, that the fish were preparing to spawn (Figure 14). After October 25th, 88% of female fish captured (n = 203) were in post-spawning condition. Female fish with low GSI (< 4.0 g) were captured in low numbers throughout the study but they were not identified as spent by community monitors. These are likely resting fish that moved into the Peel River from over-wintering or feeding areas in surrounding lakes, rivers, or the delta. In all years the first post-spawning female was captured between October 25th and October 30th. Previous studies report a slightly later spawning time of early November in the Mackenzie River (Chang-Kue and Jessop 1983; Stein et al. 1973). Although the actual dates identified as spawning times varied slightly between this study and previous reports, all above mentioned studies note that spawning occurs around the time of river freeze-up. Thus this is likely an important factor in Broad Whitefish spawning and the cause of difference in spawning time recorded, since the timing of river-freeze-up varies with environmental conditions. Gwich'in traditional knowledge also reports that Broad Whitefish spawn in the fall, but that spawning occurs in eddies during the downstream migration (Gwich'in Renewable Resource Board 1997).

Fecundity
Fecundity of Broad Whitefish ranged between 10,070 and 117,687 eggs per individual (Figure 15) with a mean fecundity ± one standard deviation of 58,617 eggs ± 19,731 (n = 205). There was a positive relationship between fecundity and fork length and it was described by the equation:

$F = 0.35(L) – 122.11$ ($R^2 = 0.33$).

Sex Ratio
In all years of the study, male Broad Whitefish were captured more frequently than females. The percentage of male fish ranged from 51% in 2000 to 70% in 1998 (Table 11). The overall mean frequency of male fish was 60%.

Fork Length
Median fork length of Broad Whitefish varied significantly between catches of the five-inch and experimental mesh gill nets (Table 6).

The yearly length-frequency distributions of fish caught in the five-inch mesh nets varied in overall shape, some appearing uni-modal and others appearing bi-modal and each had differing ranges of length (Figure 16). The length-frequency distribution of all Broad Whitefish caught during the five-year study in five-inch mesh nets was uni-modal, with lengths ranging from 390 mm to 740 mm. Length classes between 480 mm to 540 mm represented 68.5% of the catch.

The yearly median lengths of Broad Whitefish caught in the five-inch mesh nets varied from 500 mm in 1999 and 2000 to a high of 525 mm in 2002 (Figure 16). The yearly mean lengths ranged from 501 mm in 1999 to 524 mm in 2002. The five-year median and mean lengths were 510 mm and 512 mm, respectively.

Broad Whitefish caught in the experimental mesh gill nets from 2000 to 2002 were, on average, smaller than those caught in the five-inch mesh nets. The yearly length-frequency distributions of fish caught in the experimental mesh nets appeared bi-modal but each had differing ranges of length (Figure 17). The length-frequency distribution of all Broad Whitefish caught during the five-year study in experimental mesh nets was generally bell-shaped, with lengths ranging from 370 mm to 700 mm.

The yearly median and mean fork length of Broad Whitefish caught in the experimental mesh nets were higher in 2000 and 2001 compared to 2002 and fluctuated between 505 mm and 520 mm (Figure 17). The five-year median and mean lengths were 510 mm and 511 mm, respectively.

When all data of Broad Whitefish caught from both net types were combined, the length-frequency distribution ranged from 370 to 740 mm. The overall population median and mean lengths were 510 mm and 512 mm, respectively. This size is larger than that reported in previous literature for Broad Whitefish in the Peel River (Treble and Read 1994) as well as the Mackenzie River and delta channels (Babaluk et al. 2001; Jessop and Chang-Kue 1993; Treble and Tallman 1997).

The median fork lengths of male and female Broad Whitefish caught in both net types combined were not significantly different in 16 out of 17 age classes tested (Table 12). Male fish were found to be significantly larger only at 12 years of age.

The relationship between fork length and round weight for Broad Whitefish females, males, and combined sexes were described by the equations:

$Log_{10} W = 2.95 (Log_{10} L) – 4.68 (R^2 = 0.57)$,

$Log_{10} W = 2.82 (Log_{10} L) – 4.33 (R^2 = 0.66)$,

and

$Log_{10} W = 2.87 (Log_{10} L) – 4.46 (R^2 = 0.62)$,

respectively.

Age

Broad Whitefish caught in the five-inch and experimental mesh gill nets did not differ significantly in median age (Table 8), therefore data was pooled.

Yearly age-frequency distributions varied in appearance with 1998 through 2000 appearing uni-modal and 2001 to 2002 appearing bi-modal (Figure 18). However, all were skewed to older ages as would be expected in a spawning population. The age-frequency distribution of all Broad Whitefish caught during the five-year study appeared slightly bi-modal and skewed to older ages (Figure 18). The age of fish caught ranged from five to 24 years. Age classes between nine and 12 years accounted for 51.6% of the total catch.

Yearly median age of Broad Whitefish ranged from nine years in 2000 to 13 years in 2001 (Figure 18). The yearly mean age ranged from 10.2 years in 2000 to 13 years in 2001. The median age of all Broad Whitefish caught during the five-year study was 11 years. The mean age was 11.4 years, and modal ages were at nine and 12 years.

The results of this study agree with that of Babaluk et al. (2001), Treble and Read (1994), and Treble and Tallman (1997).

A small number of sexually mature six year old females and five year old males were captured during this study, however the majority of spawning Broad Whitefish captured were seven years or older. This result is similar to results from previous studies in the Mackenzie River system (Bond and Erickson 1985; Chang-Kue and Jessop 1992; Treble and Tallman 1997).

Lake Whitefish

Relative Abundance

A total of 483 Lake Whitefish were caught during the five-year study (Table 3). Yearly catches ranged from 59 fish in 1998 to 153 fish in 2000 (Table 4).

Migration Timing
Within each year, there did not appear to be a difference in migration timing between male and female Lake Whitefish (Figure 19).

Overall catches of combined-sexes varied from year to year but in general, peak catches occurred in late July and early August (Figure 19). The number of fish caught decreased through September and early October, but then increased after river freeze-up in mid-October. Similarly, Gwich'in traditional knowledge reports that Lake Whitefish migrate upstream in August and September and return downstream in late October or early November (Gwich'in Renewable Resource Board 2001). Conversely, Stein et al. (1973) and Jessop and Lilly (1975) recorded spawning runs of Lake Whitefish in mid- to late September in the mainstem Mackenzie River.

Spawning Timing
Results from this study suggest that Lake Whitefish in the Peel River spawn in late September or early October, around the time of river freeze-up. Gonadosomatic index (GSI) rose steadily from < 1.0 g in mid-July to 23.89 g by late September indicating, along with visual inspection of gonads, that the fish were preparing to spawn (Figure 20). Female fish with low GSI (< 4.0 g) were captured in low numbers throughout the study but they were not identified as spent by community monitors. These fish are likely non-spawners that moved into the Peel River from over-wintering or feeding areas in surrounding lakes, rivers, or the delta. Of the female fish caught after October 1st, 84% (n = 83) were in post-spawning condition. Previous research supports our conclusions on Lake Whitefish spawning times (Howland et al. 2001; Stein et al. 1973).

Fecundity
Fecundity of Lake Whitefish ranged between 11,787 and 73,683 eggs per individual (Figure 21) with a mean fecundity of 32,937 eggs and one standard deviation of 10,472 eggs (n = 55). There was a positive relationship found between fecundity and fork length and it was described by the equation:

$$F = 0.18 (L) – 46.97 (R^2 = 0.37).$$

Sex Ratio
In all years of the study, except 2001, the percent of male Lake Whitefish caught ranged from 50% to 59% (Table 13). In 2001, male fish represented 45% of the yearly catch. The overall mean frequency of male fish was 53%. Howland et al. (2001) also note relatively equal numbers of male and female fish, however with female fish being slightly more abundant than male.

Fork Length
Median fork length of Lake Whitefish was significantly different between catches of the five-inch and experimental mesh gill nets (Table 6).

The yearly length-frequency distributions of fish caught in the five-inch mesh gill nets varied in overall shape, some appearing uni-modal and others appearing bi-modal and each had differing ranges of length (Figure 22). The length-frequency distribution of all Lake Whitefish caught during the five-year study in five-inch mesh gill nets was uni-modal, with lengths ranging from 240 mm to 580 mm.

The yearly median fork length of Lake Whitefish caught in the five-inch mesh gill nets ranged between 430 mm and 450 mm, while mean lengths ranged between 420 mm and 448 mm (Figure 22). The five-year median and mean lengths were both 430 mm.

Lake Whitefish caught in the experimental mesh nets were, on average, smaller than those caught in the five-inch mesh nets. The yearly length-frequency distributions of fish caught in the experimental mesh nets all appeared bi-modal, but each had differing ranges of length (Figure 23). The length-frequency distribution of all Lake Whitefish caught during the five-year study in experimental mesh nets was also bi-modal, with lengths ranging from 239 mm to 595 mm.

The yearly median lengths of Lake Whitefish caught in experimental nets were 410 mm in 2000 and 2001 but increased to 420 mm in 2002. The mean lengths fluctuated yearly.

The five-year median and mean lengths were 420 mm and 411 mm, respectively.

When all data of Lake Whitefish caught from both net types in all years were combined, the length frequency distribution ranged from 239 mm to 595 mm. The overall population median and mean lengths were 423 mm and 418 mm, respectively. While the range in fish size recorded during this study encompass that recorded by Babaluk et al. (2001), Howland et al. (2001), and Jessop and Chang-Kue (1993), the mean and median fish length recorded in this study are smaller than that reported by Stein et al. (1973).

The median fork length of male and female Lake Whitefish were not significantly different in any of the 14 age classes tested (Table 14).

The relationship between fork length and round weight for Lake Whitefish females, males, and combined sexes were described by the equations:

$Log_{10} W = 3.18 (Log_{10} L) – 5.32 (R^2 = 0.69)$,

$Log_{10} W = 3.26 (Log_{10} L) – 5.54 (R^2 = 0.80)$,

and

$Log_{10} W = 3.24 (Log_{10} L) – 5.48 (R^2 = 0.75)$.

respectively.

Age

Median age of Lake Whitefish varied significantly between catches of the five-inch and experimental mesh gill nets (Table 8).

Yearly age-frequency distributions from fish caught in the five-inch mesh net were all variable in overall appearance (Figure 24). The age-frequency distribution for all Lake Whitefish caught during the five-year study in a five-inch mesh net was uni-modal and ranged in age from six to 23 years (Figure 24).

The yearly median age of Lake Whitefish caught in the five-inch mesh nets ranged from 12 years in 1999 to 14 years in 1998 and 2001 (Figure 24). The mean age ranged from 12 years in 1999 to 14.5 years in 1998. The median and mean ages for all Lake Whitefish caught in the five-inch mesh nets for the five-year study were both 13.0 years.

The experimental mesh gill net caught a greater proportion of younger Lake Whitefish compared to the five-inch mesh net. The yearly age-frequency distributions of fish caught in experimental nets were variable in both overall appearance and range (Figure 25). The age-frequency distribution for all Lake Whitefish caught in experimental nets during the five-year study ranged in age from five to 23 years, but ages seven through 13 years dominated with 81.3% of the total catch.

Yearly median age of Lake Whitefish caught in the experimental nets were nine years in 2000, but increased to 11 years in both 2001 and 2002 (Figure 25). Mean age followed a similar trend; in 2000 it was 10 years and then increased to 11.4 and 11.5 years in 2001 and 2002, respectively. Median and mean ages for Lake Whitefish caught in the experimental mesh nets during the five-year study were 10.7 and 10 years respectively.

When all data from Lake Whitefish caught in both net types were combined, the age frequency distribution ranged from five to 23 years with age classes nine to 14 years dominating 63.8% of the catch. The total median and mean ages were 12 and 11.8 years, respectively. These results correspond with those reported by Howland et al. (2001). However, Babaluk et al. (2001) reported both an older maximum age as well as an older mean age (30 and 18.1 years, respectively) for Lake Whitefish caught in the Mackenzie River in 1993.

Previous studies suggest a minimum age-at-maturity of six to seven years for Lake Whitefish (Bond and Erickson 1985; Howland et al. 2001; Stein et al. 1973). This study supports that conclusion; five sexually mature six- year old female Lake Whitefish were captured during this study but the majority of sexually mature fish were seven years or older.

Least Cisco

Relative Abundance

A total of 137 Least Cisco were caught during the five-year study (Table 3). Yearly catches fluctuated with high relative catches found in 1998 (n = 56), 2000 (n = 54), and 2002 (n = 23) and low relative catches in 1999 (n = 0) and 2001 (n = 4) (Table 4). Least Ciscoes were caught exclusively by the experimental net therefore, the two analyses comparing the median fork length and median age of fish caught in the five-inch and experimental mesh nets are not applicable. Further, the numbers of Least Cisco caught in the experimental mesh nets throughout the study were low. This makes interpretation of the results difficult; however, this report does provide interpretation based on the available data.

Migration Timing

Within each year, the timing of migration between male and female Least Cisco appeared to be similar, although male fish were more abundant (Figure 26).

The overall timing of the migration for both sexes combined appeared similar between years (Figure 26). Catch numbers peaked in late September before river freeze-up and to a lesser extent in early November. However, only in 2000 were fish caught in mid-July and early August.

Spawning Timing

A specific spawning time for Least Cisco could not be identified from study results, although data suggests that spawning does not occur until after early October. Gonadosomatic index (GSI) rose through September and peaked in early October (Figure 27). One spent female was captured in early November of 2000, which may indicate that spawning had ended at this time, however, with only one fish this can not be stated with certainty. Occasionally females with low GSI were captured in August and September but these fish were not identified as spent by community monitors (Figure 27).

Fecundity

Fecundity of female Least Cisco ranged between 10,505 and 16,904 eggs per individual (Figure 28). Mean fecundity was 13,318 eggs with one standard deviation of 2,384 eggs (n = 10). This is encompassed within the fecundity range of 7,886 to 19,261 eggs per fish reported for Least Cisco females between 205 mm to 340 mm in length captured at Trout Lake, Yukon Territory (Mann and McCart 1981).

There was a positive relationship found between fecundity and fork length and it was described by the equation:

$$F = 0.18 (L) – 38.30 (R^2 = 0.45).$$

Sex Ratio

In all years of the study where Least Cisco were caught, there was a higher percentage of male fish than female (Table 15). The percent of male fish caught ranged from a low of 62% in 2000 to a high of 78% in 2002. The overall mean frequency of male fish was 71%.

Fork Length

The yearly fork length-frequency distributions for Least Cisco all appeared to be uni-modal but variable in range (Figure 29). The length-frequency distribution of all Least Cisco caught during the five-year study was uni-modal with lengths ranging from 163 mm to 390 mm.

Yearly median fish lengths were 270 mm in 1998, 2001 and 2002, and 280 mm in 2000 (Figure 29). No Least Ciscoes were caught in 1999. Mean fish lengths varied yearly. The median fork length for all Least Cisco caught during the five-year study was 270 mm and mean fork length was 278 mm. The results of this study are consistent with those of Jessop and Chang-Kue (1993) and Stein et al. (1973).

Median fork length of male and female Least Ciscoes were significantly different at two out of seven age classes tested (Table 16). Female fish were significantly lager than males at ages nine and 10 years.

The relationship between fork length and round weight for Least Cisco females, males, and combined sexes were described by the equations:

$$Log_{10} W = 2.82 (Log_{10} L) - 4.60 (R^2 = 0.63),$$

$$Log_{10} W = 2.63 (Log_{10} L) – 4.15 (R^2 = 0.43),$$

and

$Log_{10} W = 2.85 (Log_{10} L) – 4.70 (R^2 = 0.54)$

respectively.

Age

The yearly age-frequency distributions for Least Cisco caught in the experimental mesh gill nets were uni-modal only in 1998 and 2000 (Figure 30). The age-frequency distribution for all Least Cisco caught during the five-year study was uni-modal, ranging in age from three to 16 years. Dominant age classes of eight to 10 years comprised 61% of the population. The age-frequency distribution found by this study has a greater range and a greater proportion of older fish than age distributions reported in the past (Stein et al. 1973). Although, the later were determined using scales, and thus are not as reliable (Howland et al. 2004).

Yearly median age of Least Cisco caught in the experimental mesh nets was nine years in 1998 but increased to 10 years in all subsequent years. Yearly mean age ranged from 9.1 years in 1998 to 10.3 years in 2001. The median and mean ages for all Least Cisco caught during the five-year study were nine and 9.5 years, respectively.

Previous literature suggests a minimum age-at-maturity for Least Cisco to be four years (Bond and Erickson 1985; Stein et al. 1973). All sexually mature Least Cisco captured during this study were six years or older.

CONCLUSIONS

The Peel River Fish Study has provided baseline data of fish migration timing, spawning timing, fecundity, sex composition, fork length, and age for spawning stocks of migratory coregonid fish species, particularly Broad Whitefish. This information will be useful for future monitoring of fish stocks in the Peel River.

Information about migration timing and timing of spawning collected during the study is variable between years and therefore somewhat difficult to interpret. This is most likely a result of environmental conditions that made it difficult to obtain representative samples of the spawning fish populations throughout their migratory period. First, all nets were set in eddies instead of the main river channel, due to strong currents. The composition of fish resting and captured in these eddies may not reflect the composition of the fish stock as a whole. Second, there is no fishing during river freeze-up, which may last up to two weeks, and it appears likely that there are movements of fish during this time. However, general conclusions may be inferred from the results of this study. It appears that mid-July through August are important times for the upstream migration of pre-spawning Inconnu, Arctic Cisco, and Lake Whitefish and that spent Inconnu and Lake Whitefish migrate downstream after river freeze-up. The downstream migration of spent Arctic Cisco, however, was not observed by this study. That migration may have occurred during river freeze-up, when fishing had temporarily ceased, or after the study ended. September appears to be the most important time for the upstream migration of pre-spawning Least Cisco but, as with Arctic Cisco, a downstream run of spent fish was not detected in this study. The migration of pre-spawning Broad Whitefish was different from other species in that it was the longest in duration with mid-July until river freeze-up all appearing to be equally important times. The downstream migration of spent Broad Whitefish was much more concerted, occurring shortly after river freeze-up.

A positive relationship between fecundity and fork length was observed for all species in this study. As might then be expected, the smallest species, Least Cisco, had the lowest average number of eggs and the largest species, Inconnu, had the highest average.

In all species, male fish were caught more frequently than female fish. Male fish comprised approximately 60% of the total (five-year) population for Inconnu, Arctic Cisco, and Broad Whitefish. However, while male Lake Whitefish and Least Cisco were still more abundant than females, the percentages were lower for Lake Whitefish (54%) and higher for Least Cisco (71%).

The lengths of fish found in this study were similar to those previously reported for all species, except Broad Whitefish. The maximum length of Broad Whitefish documented in this study (740 mm) was larger than those reported in the past (600 mm, 656 mm, 617 mm, 643 mm, respectively for Jessop and Chang-Kue (1999), Treble and Read (1994), Treble and Tallman (1997), and Babaluk et al. (2001). The median and mean lengths of Broad Whitefish reported here (510 mm and 512 mm, respectively) were also consistently larger than the previous reports.

The ages of fish found in this study were consistent with previous reports (using equivalent ageing structures) for Inconnu, Broad Whitefish, and Lake Whitefish in all cases except one. Babaluk et al. (2001) reported both an older maximum age as well as an older mean age (30 and 18.1 years, respectively) for Lake Whitefish caught in the Mackenzie River in 1993. Conversely, the mean fish age of both Least Cisco and Arctic Cisco reported in this study were higher than previously reported. However, in both cases comparison was made only to reports in which scales were used, and thus are not as accurate in determining fish age (Howland et al. 2004). Therefore, it can not be stated with confidence that Least Cisco and Arctic Cisco are reaching an older age now compared to the past.

Based on the Peel River Fish Study, the following recommendations can be made for future monitoring of migratory fish stocks in the Peel River:

1) Both five-inch mesh nets and experimental mesh nets should be fished simultaneously to provide good sample sizes. We found that relatively small numbers of Broad Whitefish were captured in the experimental mesh nets and few Arctic or Least Cisco were captured in five-inch mesh nets.
2) Fishing should occur at, or upstream of, Fort McPherson to target the spawning populations. Many more non-spawning fish were caught at Basook Creek and Cut Off than at any other sampling location during this study.
3) The study should extend as long as possible from spring through fall and after river freeze-up to maximize the potential of all species being adequately represented. Species representation was greatly improved in this study once the field season was executed from mid-July through November.
4) Fort McPherson fishermen and the Renewable Resource Council should be involved. This study benefited greatly from the extensive knowledge about the Peel River fish that these individuals shared.

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Table 1: Summary of sampling locations and sampling periods for the Peel River Fish Study.

Year	Location	5" Mesh Net Sampling Period	Experimental Net Sampling Period	Dates of Freeze up (No Sampling)
1998	Basook Creek	Sept 24 - Oct 28	Sept 25, Oct 1	Oct 9 – Oct 14
	Scraper Hill	Sept 22 - Nov 17	Sept 27	Oct 8 – Oct 11
	Trail River	Sept 25 - Oct 19	Oct 1	Oct 8 – Oct 12
1999	Cutoff	Oct 7 - Nov 17	Nov 9 – Nov 12	Oct 1 – Oct 6
	Road River	Oct 19 - Nov 10	-	Oct 1 – Oct 18
	Scraper Hill	Oct 7 - Nov 17	Oct 19 – Oct 20	Oct 1 – Oct 6
2000	Koe Camp	-	Jul 18 - Nov 17	Oct 1 - Oct 11
	Road River	Sept 25 - Nov 8	-	Oct 5 – Oct 17
2001	Koe Camp	Jul 16 - Nov 16	Jul 16 - Nov 16	Oct 15 - Oct 21
	Road River	Oct 10 - Oct 29	-	Oct 22 - Oct 25
2002	Koe Camp	Jul 15 - Nov 15	Jul 15 - Nov 15	Oct 9 - Oct 12

Table 2: Scientific and common names of fishes captured during the Peel River Fish Study.

Scientific Name	Common Name	Code
Family Salmonidae		
Coregonus autumnalis (Pallas)	Arctic Cisco	ARCS
Coregonus sardinella (Valenciennes)	Least Cisco	LSCS
Coregonus clupeaformis (Mitchill)	Lake Whitefish	LKWT
Coregonus nasus (Pallas)	Broad Whitefish	BDWT
Stenodus leucichthyes (Guldenstadt)	Inconnu	INCO
Oncorhynchus keta (Walbaum)	Chum Salmon	CHUM
Family Esocidae		
Esox lucius (Linnaeus)	Northern Pike	NRPK
Family Percidae		
Stizostedion vitreum (Mitchill)	Walleye	WALL
Family Catostomidae		
Catostomus catostomus (Forster)	Longnose Sucker	LNSK

Table 3: Species composition of all fish caught during the Peel River Fish Study.

Species	Number Captured	% of Total Catch
Target Species		
Inconnu	296	9.4
Arctic Cisco	358	11.4
Broad Whitefish	1513	48.1
Least Cisco	137	4.4
Lake Whitefish	483	15.4
Other Species		
Longnose Sucker	8	0.3
Burbot	1	0.0
Chum Salmon	30	1.0
Lake Cisco	2	0.1
Mountain Whitefish	1	0.0
Northern Pike	310	9.9
Walleye	5	0.2
Grand Total	*3144*	

Table 4: Detailed composition of target species caught by year at each monitoring station during the Peel River Fish Study.

Species	**Year**	**Basook Cr.**	**Cutoff**	**Fort McPherson**	**Road R.**	**Scraper Hill**	**Trail R.**	**Total**
ARCS	1998	0	0	0	0	0	1	1
	1999	0	5	0	0	6	0	11
	2000	0	0	238	19	0	0	257
	2001	0	0	42	0	0	0	42
	2002	0	0	47	0	0	0	47
	Total	0	5	327	19	6	1	358
BDWT	1998	215	0	0	0	171	36	422
	1999	0	129	0	55	117	0	301
	2000	0	0	156	86	0	0	242
	2001	0	0	196	92	0	0	288
	2002	0	0	260	0	0	0	260
	Total	215	129	612	233	288	36	1513
INCO	1998	19	0	0	0	17	15	51
	1999	0	11	0	1	6	0	18
	2000	0	0	37	0	0	0	37
	2001	0	0	126	0	0	0	126
	2002	0	0	64	0	0	0	64
	Total	19	11	227	1	23	15	296
LKWT	1998	23	0	0	0	22	14	59
	1999	0	53	0	9	37	0	99
	2000	0	0	110	43	0	0	153
	2001	0	0	74	8	0	0	82
	2002	0	0	90	0	0	0	90
	Total	23	53	274	60	59	14	483
LSCS	1998	40	0	0	0	14	2	56
	2000	0	0	41	13	0	0	54
	2001	0	0	4	0	0	0	4
	2002	0	0	23	0	0	0	23
	Total	40	0	68	13	14	2	137
						Grand Total		*2787*

Table 5: Yearly catch and sex ratio of Inconnu (*Stenodus leucichthyes*) captured during the Peel River Fish Study.

Year	Number of Fish	Number of Females	Number of Males	% Males
1998	51	20	31	61
1999	17	5	12	71
2000	37	14	23	62
2001	125	43	82	66
2002	63	29	34	54
Total	293	111	182	62

Table 6: Comparison of median fish lengths for species captured by each net type (experimental and five-inch mesh) fished simultaneously during the Peel River Fish Study in 2001-2002. Median, range, and sample size (n) are provided along with the Wilcoxon two-sample test statistic and approximate probability.

Species	Experimental Net Fork Lengths (mm)			5-inch Mesh Net Fork Lengths (mm)			Wilcoxon Two-Sample Test		
	n	Median	Range	n	Median	Range	S	P <	
Arctic Cisco	87	455	260 - 438	0	-	-	-	-	
Broad Whitefish	126	507.5	368 - 635	435	520	406-740	29647	0.0003	*
Inconnu	53	740	403 - 873	135	745	543 - 1030	4973	0.9170	
Lake Whitefish	107	415	240 - 488	65	440	350 - 580	7380	0.0001	*
Least Cisco	27	270	210 - 330	0	-	-	-	-	

* indicates species with a significant difference (P < 0.05) between fork lengths of fish captured by each net type.

Table 7: Comparison of median fork length at each age for male and female Inconnu captured during the Peel River Fish Study. Median, range, and sample size (n) are provided along with the Wilcoxon two-sample test statistic and approximate probability.

Otolith Age	Female Fork Length (mm)			Male Fork Length (mm)			Wilcoxon Two-Sample Test		
(year)	n	Median	Range	n	Median	Range	S	P <	
7	0	-	-	1	545	-	-	-	
8	2	579.5	574 - 585	2	607.5	565 - 650	5	0.6985	
9	2	645	625 - 665	6	601.5	575 - 695	12	0.4018	
10	1	585	-	6	646	554 - 688	3	0.8026	
11	2	714	658 - 770	11	627	543 - 690	21.5	0.1665	
12	2	675	665 - 685	9	686	650 - 708	9	0.5557	
13	5	720	640 - 770	11	710	610 - 734	50	0.4271	
14	8	775	740 - 870	19	699	630 - 752	184.5	0.0001	*
15	4	807	714 - 840	19	713	660 - 770	77	0.0206	*
16	11	775	715 - 900	21	727	665 -778	260.5	0.0018	*
17	21	818	545 - 875	16	740	690 - 802	177.5	0.0001	*
18	10	790.5	730 - 925	10	775	660 - 895	90	0.2727	
19	6	815	767 - 860	8	755	691 - 820	63	0.0237	*
20	6	854	750 - 960	5	744	730 - 829	18.5	0.0441	*
21	7	860	835 - 900	9	755	715 - 879	87	0.0042	*
22	3	880	878 - 882	4	800	762 - 826	18	0.0518	
23	5	912	843 - 976	0	-	-	-	-	
24	1	860	-	1	770	-	-	-	
25	0	-	-	0	-	-	-	-	
26	1	990	-	1	760	-	-	-	
27	1	970	-	0	-	-	-	-	
28	1	890	-	1	890	-	-	-	
29	1	863	-	0	-	-	-	-	
30	1	1030	-	0	-	-	-	-	
37	1	1000	-	0	-	-	-	-	

* indicates age classes with a significant difference ($P < 0.05$) between fork lengths of males and females.

Table 8: Comparison of median fish age for species captured by each net type (experimental and five-inch mesh) fished simultaneously during the Peel River Fish Study in 2001-2002. Median, range, and sample size (n) are provided along with the Wilcoxon two-sample test statistic and approximate probability.

Species	Experimental Net Fish Age (years)			Five-inch Mesh Net Fish Age (years)			Wilcoxon Two-Sample Test		
	n	Median	Range	n	Median	Range	S	P <	
Arctic Cisco	83	11	8 - 17	0	-	-	-	-	
Broad Whitefish	124	12	7 - 24	430	12	6 - 24	32498.5	0.2204	
Inconnu	53	16	9 - 29	135	15	9 - 30	4778.5	0.5923	
Lake Whitefish	103	11	6 - 23	64	13.5	8 - 20	6728	0.0001	*
Least Cisco	25	10	6 - 14	0	-	-	-	-	

* indicates species with a significant difference (P < 0.05) between fork lengths of fish captured by each net type.

Table 9: Yearly catch and sex ratio of Arctic Cisco (*Coregonus autumnalis*) captured during the Peel River Fish Study.

Year	Number of Fish	Number of Females	Number of Males	% Males
1998	1	0	1	100
1999	11	2	9	82
2000	257	103	154	60
2001	43	18	25	58
2002	47	19	28	60
Total	358	142	217	60

Table 10: Comparison of median fork length at each age for male and female Arctic Cisco captured during the Peel River Fish Study. Median, range, and sample size (n) are provided along with the Wilcoxon two-sample test statistic and approximate probability.

Otolith Age	Female Fork Length (mm)			Male Fork Length (mm)			Wilcoxon Two-Sample Test		
(year)	n	Median	Range	n	Median	Range	S	P <	
5	1	283	-	0	-	-	-	-	
6	0	-	-	0	-	-	-	-	
7	2	383.5	380 - 387	2	332.5	330 - 335	3	0.2485	
8	8	347.5	280 - 375	23	340	305 - 375	163.5	0.1127	
9	21	360	320 - 385	39	339	260 - 375	935.5	0.0001	*
10	25	370	330 - 400	36	352.5	310 - 383	1039.5	0.0001	*
11	33	360	275 - 400	32	345	330 - 385	717.5	0.0001	*
12	20	370	310 - 400	28	357.5	312 - 393	596	0.0270	*
13	12	367.5	290 - 425	17	360	335 - 380	218.5	0.0914	
14	4	372.5	360 - 390	12	360	345 - 385	46	0.1515	
15	1	390	-	6	364	340 - 385	7	0.2113	
16	0	-	-	0	-	-	-	-	
17	1	438	-	0	-	-	-	-	
18	0	-	-	0	-	-	-	-	
19	0	-	-	1	370	-	-	-	

* indicates age classes with a significant difference (P < 0.05) between fork lengths of males and females.

Table 11: Yearly catch and sex ratio of Broad Whitefish (*Coregonus nasus*) captured during the Peel River Fish Study.

Year	Number of Fish	Number of Females	Number of Males	% Males
1998	417	127	290	70
1999	271	117	154	57
2000	242	118	124	51
2001	286	110	176	62
2002	260	117	143	55
Total	1476	589	887	60

Table 12: Comparison of median fork length at each age for male and female Broad Whitefish captured during the Peel River Fish Study. Median, range, and sample size (n) are provided along with the Wilcoxon two-sample test statistic and approximate probability.

Otolith Age	Female Fork Length (mm)			Male Fork Length (mm)			Wilcoxon Two-Sample Test		
(year)	n	Median	Range	n	Median	Range	S	P <	
5	0	-	-	1	455	-	-	-	
6	6	482.5	460 - 528	4	494.5	482 - 520	26	0.4542	
7	31	495	430 - 540	60	494	405 - 553	1411	0.9033	
8	56	500	430 - 620	89	521	425 - 590	4069	0.9401	
9	76	501.5	394 - 570	117	510	375 - 615	7082	0.4448	
10	75	515	433 - 620	90	508	440 - 600	6507	0.3565	
11	80	517	460 - 573	95	512	406 - 575	7311	0.4175	
12	77	505	445 - 575	131	518	400 - 600	6975	0.0105	*
13	72	516	420 - 700	95	517	400 - 598	5980	0.8260	
14	36	522.5	465 - 620	61	512	460 - 585	1900	0.3130	
15	10	512	455 - 566	26	540	440 - 590	540	0.2424	
16	18	525	416 - 635	20	536	450 - 595	536	0.4043	
17	10	510	438 - 582	19	540	425 - 607	540	0.0892	
18	4	529	465 - 575	16	520	435 - 600	42	0.9623	
19	3	500	450 - 530	10	535	470 - 553	13	0.1709	
20	7	530	440 - 560	7	493	475 - 670	56	0.7015	
21	5	529	585 - 560	6	532.5	442 - 738	29	0.9273	
22	2	497.5	460 - 535	2	512.5	480 - 545	6	0.6985	
23	1	504	-	1	637	-	-	-	
24	1	565	-	0	-	-	-	-	

* indicates age classes with a significant difference (P < 0.05) between fork lengths of males and females.

Table 13: Yearly catch and sex ratio of Lake Whitefish (*Coregonus clupeaformis*) captured during the Peel River Fish Study.

Year	Number of Fish	Number of Females	Number of Males	% Males
1998	58	28	30	52
1999	99	45	54	55
2000	153	63	90	59
2001	82	45	37	45
2002	90	45	45	50
Total	482	226	256	53

Table 14: Comparison of median fork length at each age for male and female Lake Whitefish captured during the Peel River Fish Study. Median, range, and sample size (n) are provided along with the Wilcoxon two-sample test statistic and approximate probability.

Otolith Age	Female Fork Length (mm)			Male Fork Length (mm)			Wilcoxon Two-Sample Test	
(year)	n	Median	Range	n	Median	Range	S	P <
5	2	341.5	338 - 345	1	353	-	-	-
6	2	364	338 - 390	4	343.5	330 - 375	8	0.8170
7	14	387.5	300 - 500	17	382	245 - 453	238	0.5914
8	17	389	336 - 490	18	387.5	330 - 430	326	0.5195
9	18	395	333 - 425	22	390	314 - 445	382.5	0.7233
10	20	418.5	390 - 488	25	408	340 - 451	524	0.1459
11	24	420	393 - 470	26	419	358 - 458	605.5	0.9072
12	19	432	359 - 580	27	427	383 - 457	502	0.2189
13	24	426.5	395 - 465	28	430	395 - 476	613	0.6791
14	30	435.5	239 - 595	20	437.5	378 - 484	476	0.5066
15	9	438	385 - 463	10	455	410 - 480	74.5	0.2197
16	14	461.5	420 - 510	10	437	407 - 500	102	0.1874
17	13	440	415 - 490	4	429	420 - 485	27.5	0.3647
18	2	434	433 - 435	3	465	455 - 470	3	0.1489
19	2	475.5	462 - 488	2	457.5	450 - 465	6	0.6985
20	1	477	-	1	485	-	-	-
21	1	410	-	1	458	-	-	-
22	0	-	-	0	-	-	-	-
23	1	490	-	2	439	390 - 488	-	-

Table 15: Yearly catch and sex ratio of Least Cisco (*Coregonus sardinella*) captured during the Peel River Fish Study.

Year	Number of Fish	Number of Females	Number of Males	% Males
1998	56	15	41	73
1999	0	-	-	-
2000	54	21	33	61
2001	4	1	3	75
2002	23	5	18	78
Total	137	42	95	69

Table 16: Comparison of median fork length at each age for male and female Least Cisco captured during the Peel River Fish Study. Median, range, and sample size (n) are provided along with the Wilcoxon two-sample test statistic and approximate probability.

Otolith Age	Female Fork Length (mm)			Male Fork Length (mm)			Wilcoxon Two-Sample Test		
(year)	n	Median	Range	n	Median	Range	S	P <	
3	0	-	-	1	163	-	-	-	
4	0	-	-	0	-	-	-	-	
5	0	-	-	0	-	-	-	-	
6	0	-	-	1	248	-	-	-	
7	1	270	-	9	260	244 - 304	7	0.7245	
8	5	283	275 - 287	23	268	225 - 330	99.5	0.1113	
9	9	280	257 - 295	17	270	248 - 285	163.5	0.0249	*
10	8	297.5	275 - 390	17	280	245 - 291	155.5	0.0029	*
11	4	287.5	285 - 320	11	277	260 - 290	51.5	0.0129	*
12	3	297	290 - 310	10	282.5	275 - 315	32.5	0.0576	
13	3	285	260 - 291	1	280	-	2	1	
14	1	305	-	0	-	-	-	-	
15	0	-	-	1	285	-	-	-	
16	1	310	-	0	-	-	-	-	

* indicates age classes with a significant difference (P < 0.05) between fork lengths of males and females.

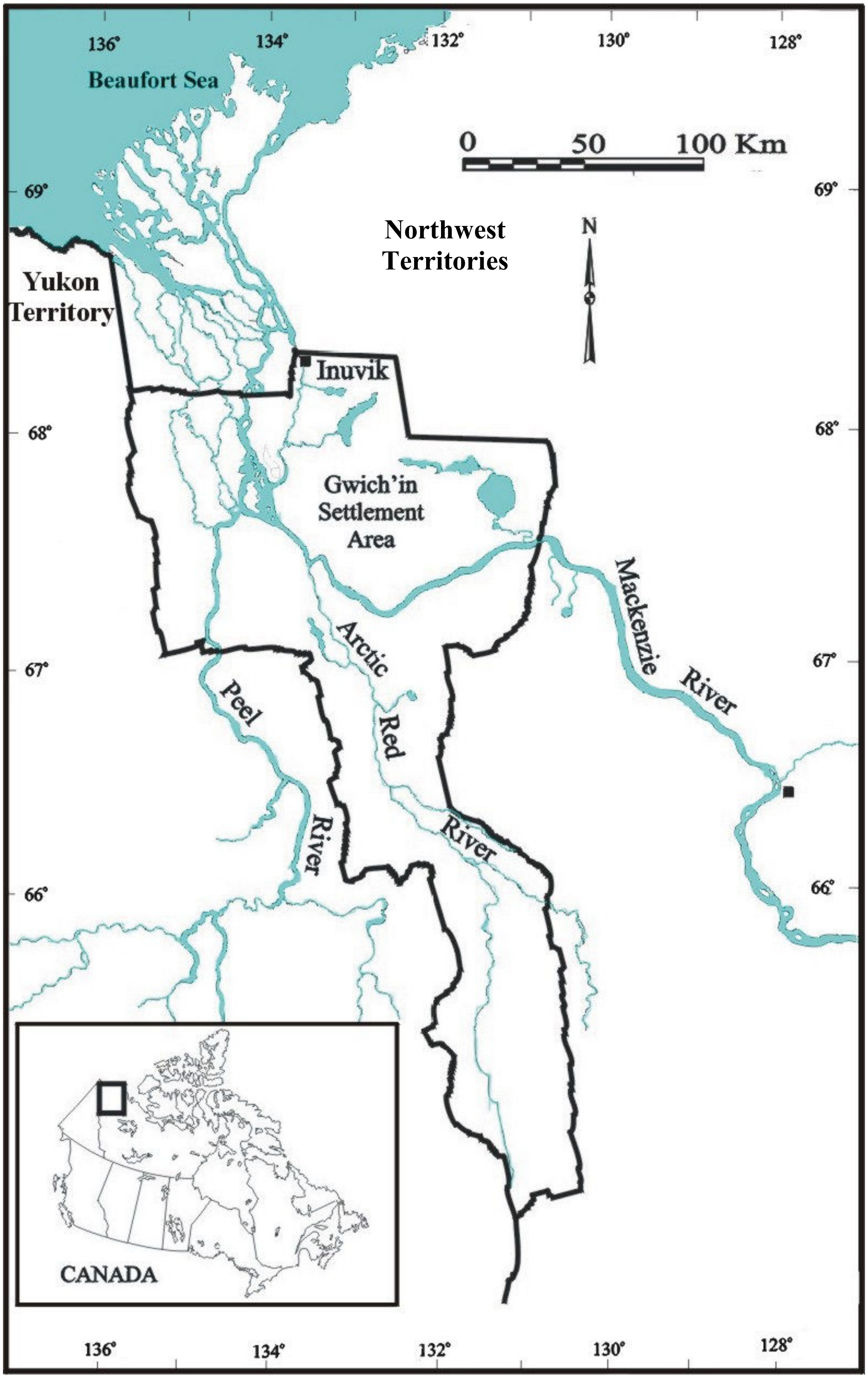

Figure 1. Map of the Mackenzie River delta region showing the location of the lower Peel River.

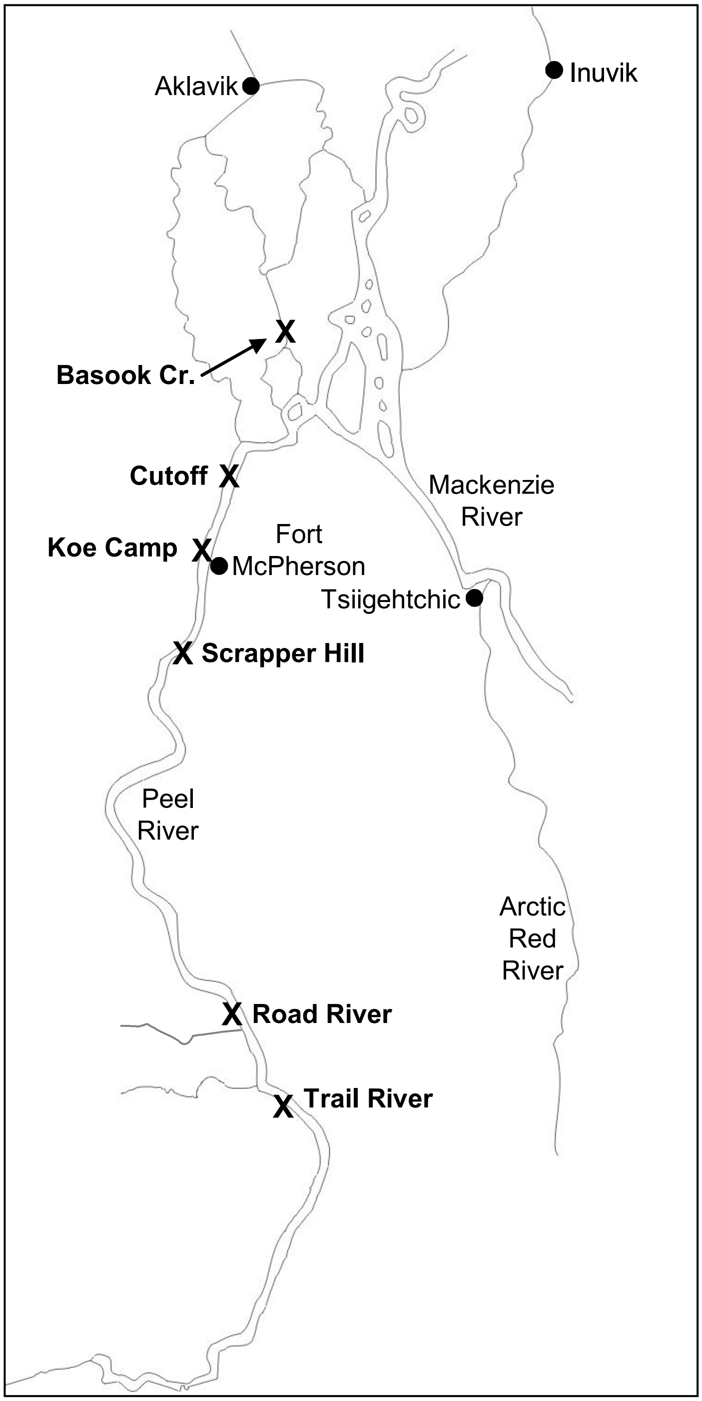

Figure 2. Map showing fish sampling locations for the Peel River Fish Study.

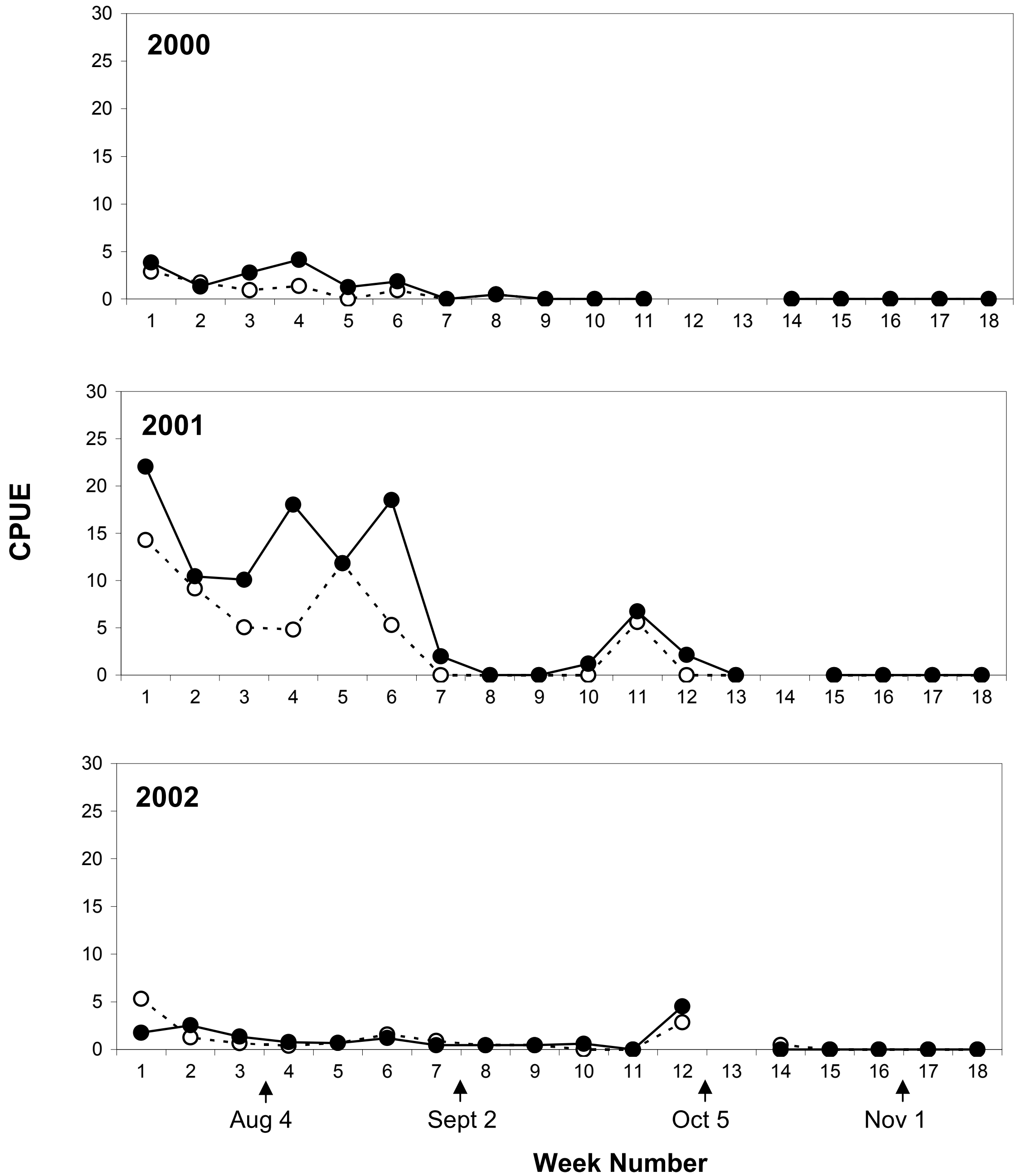

Figure 3. Catch-per-unit-effort (CPUE) for Inconnu (*Stenodus leucichthyes*) captured with the experimental mesh gill net at Koe Camp during the Peel River Fish Study from 2000 to 2002. Week one starts on July 15 each year. Male CPUE is a solid circle and female CPUE is an open circle.

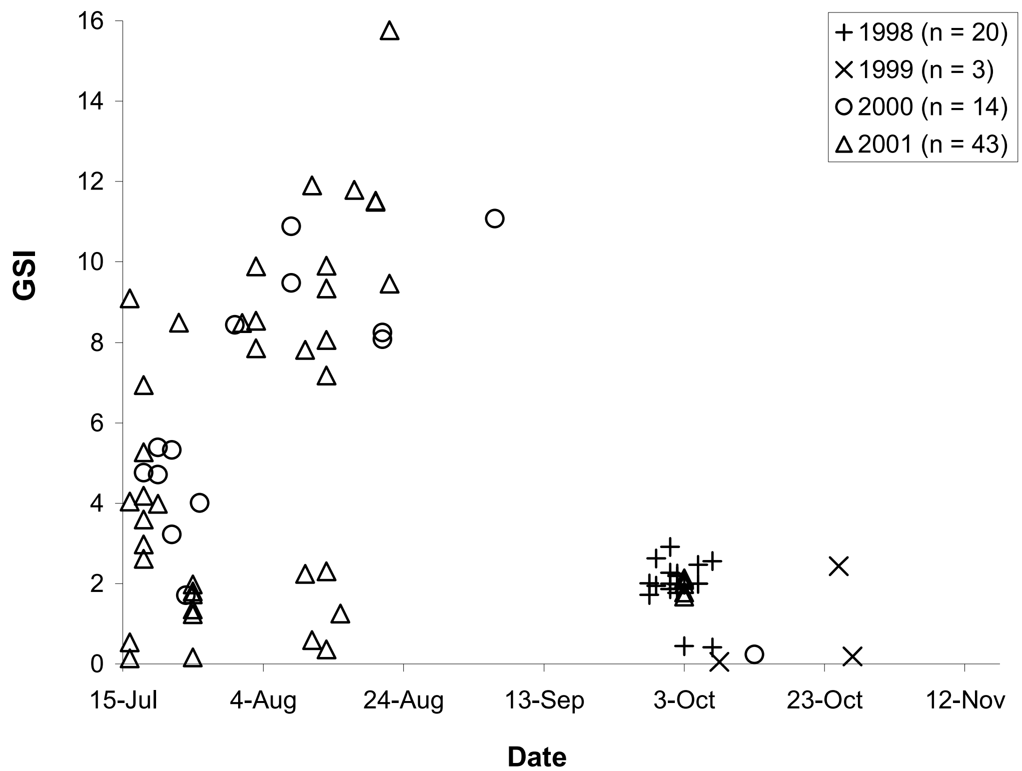

Figure 4. Gonadosomatic index (GSI) of female Inconnu captured with the five-inch and experimental mesh gill nets during the Peel River Fish Study from 1998 to 2001.

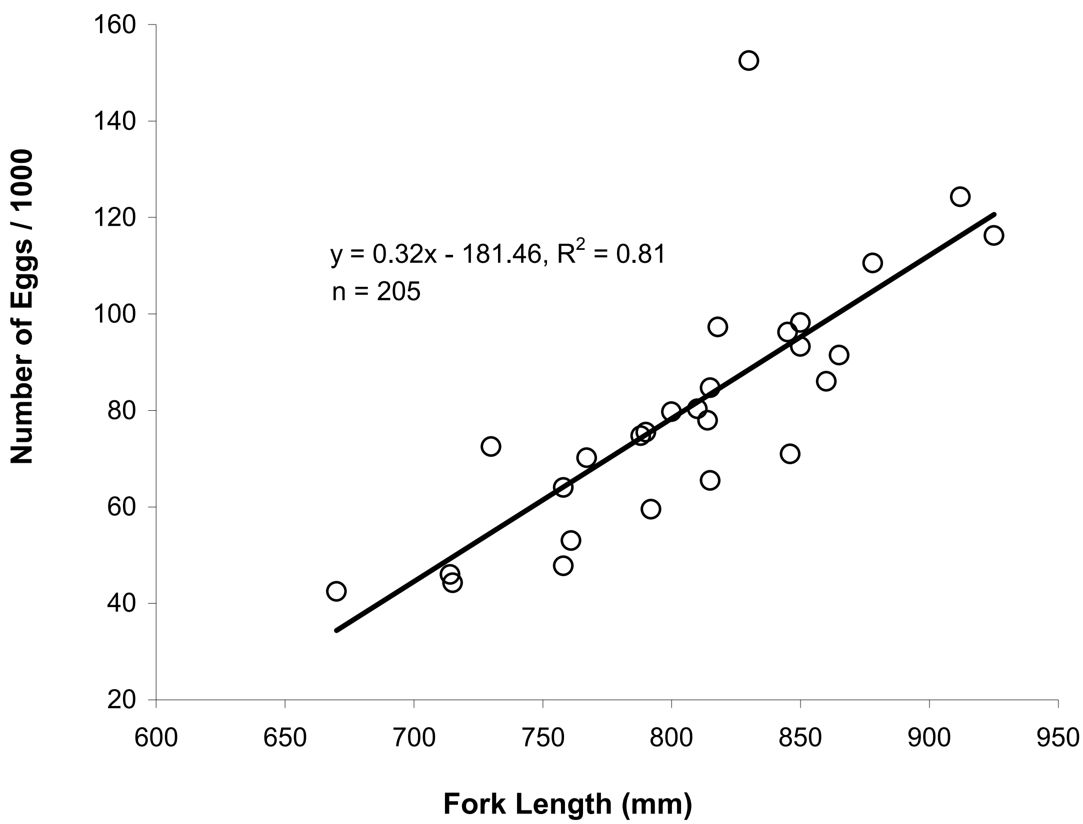

Figure 5. The relationship between fecundity and fork length for female Inconnu captured with the five-inch and experimental mesh gill nets during the Peel River Fish Study from 1998 to 2002.

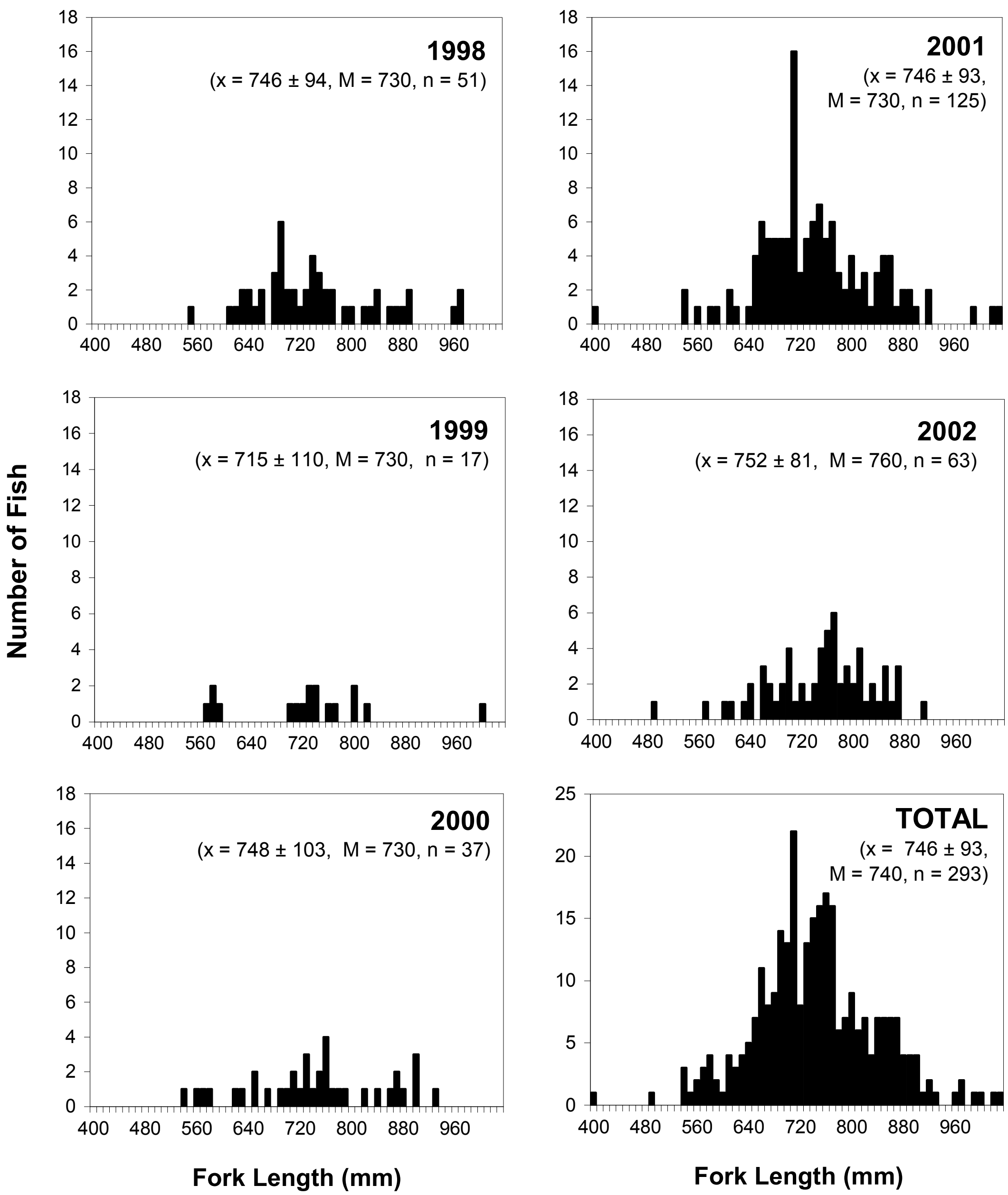

Figure 6. Length-frequency distributions for Inconnu captured with five-inch and experimental mesh gill nets during the Peel River Fish Study from 1998 to 2002. Mean (x) ± 1 SD, median (M), and the sample size (n) are given.

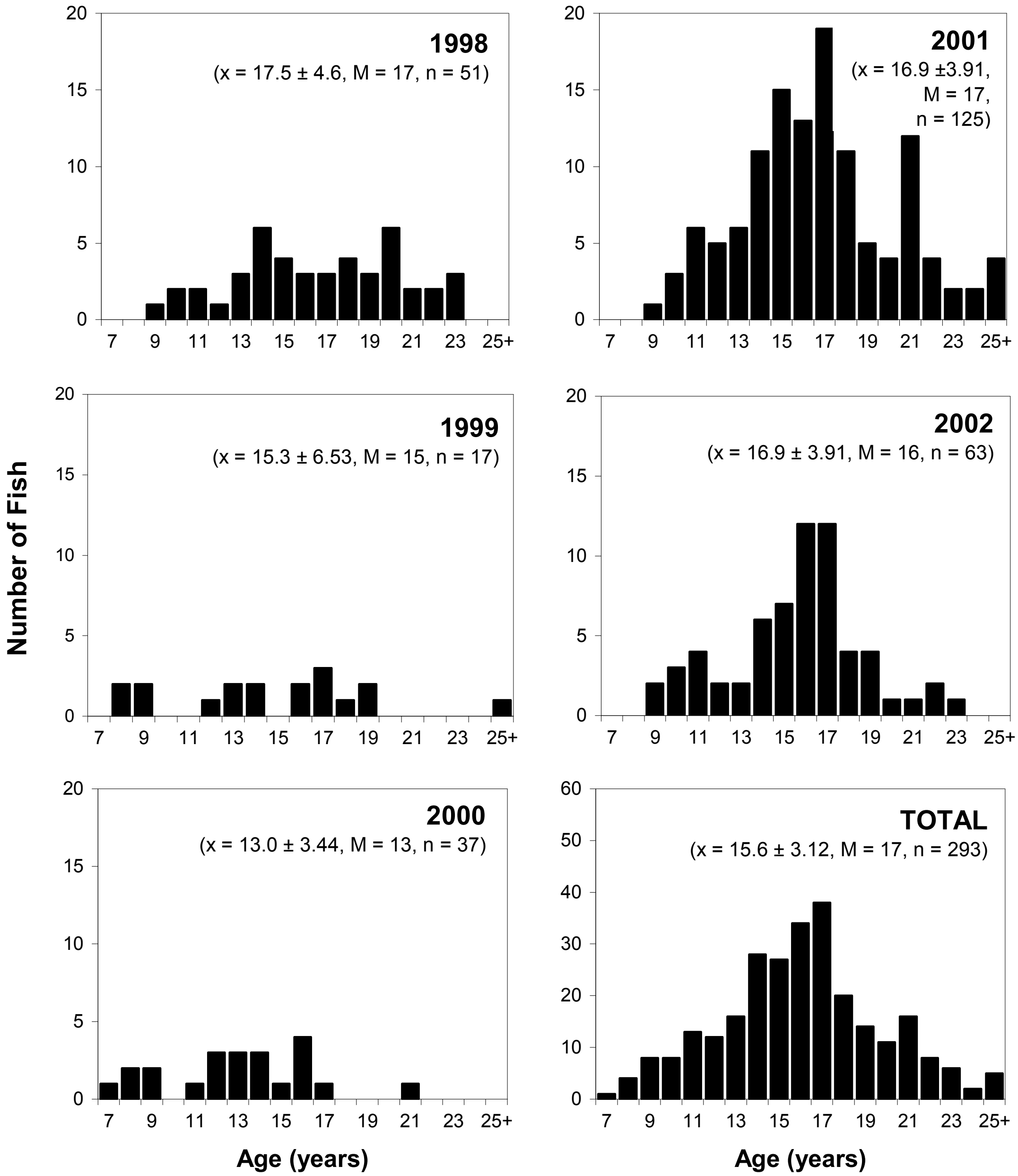

Figure 7. Age-frequency distribution for Inconnu captured with the five-inch and experimental mesh gill nets during the Peel River Fish Study from 1998 to 2002. Mean (x) ± 1 SD, median (M), and the sample size (n) are given.

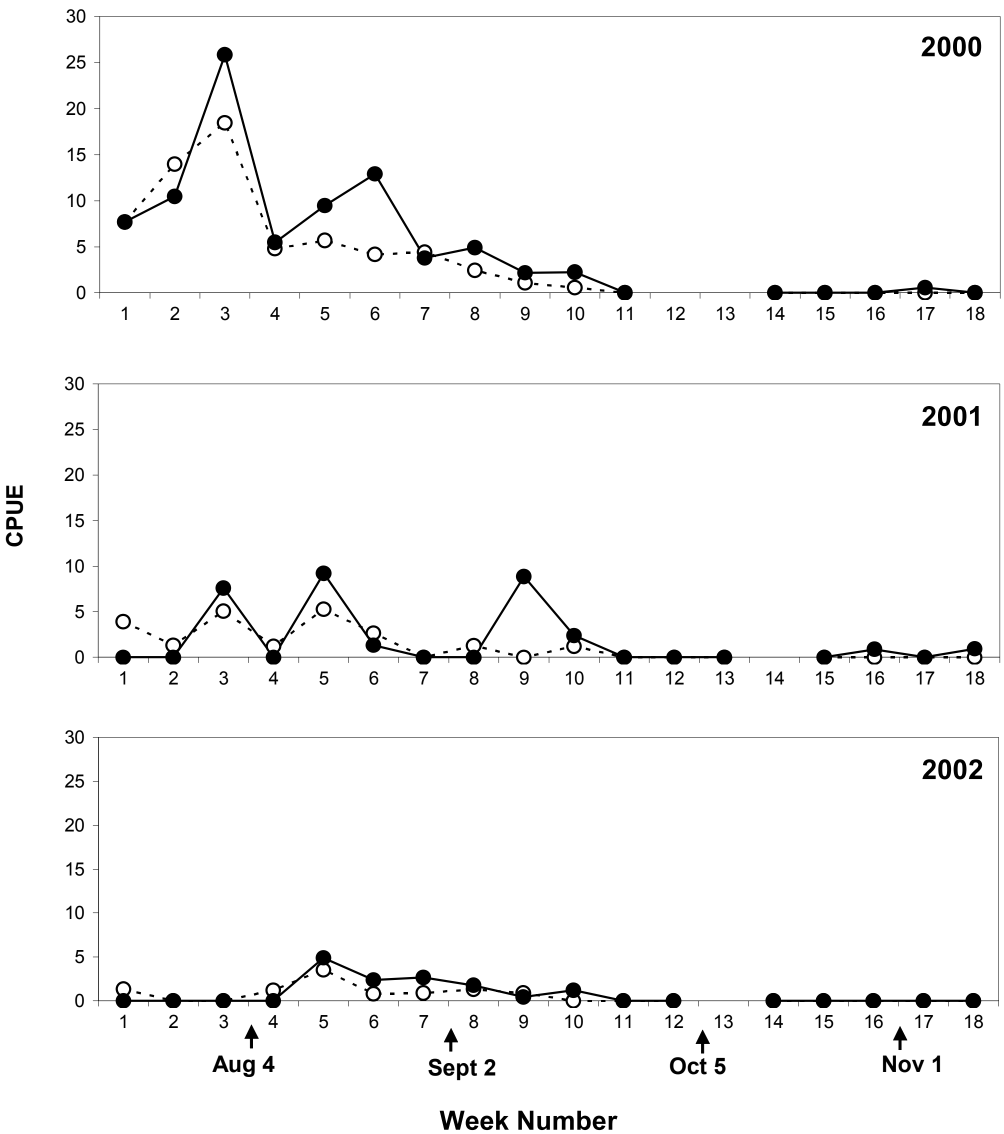

Figure 8. Catch-per-unit-effort (CPUE) for Arctic Cisco (*Coregonus autumnalis*) captured with the experimental mesh gill net at Koe Camp during the Peel River Fish Study from 2000 to 2002. Week one starts on July 15 each year. Male CPUE is a solid circle and female CPUE is an open circle.

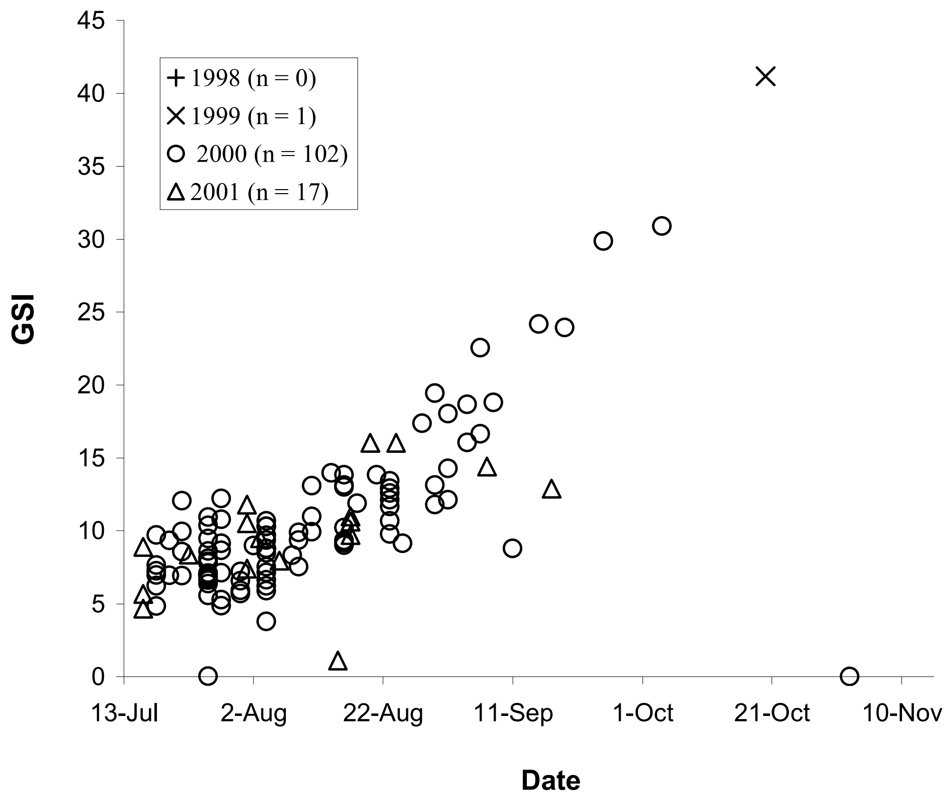

Figure 9. Gonadosomatic index (GSI) of female Arctic Cisco captured in the experimental mesh gill net during the Peel River Fish Study from 1998 to 2001.

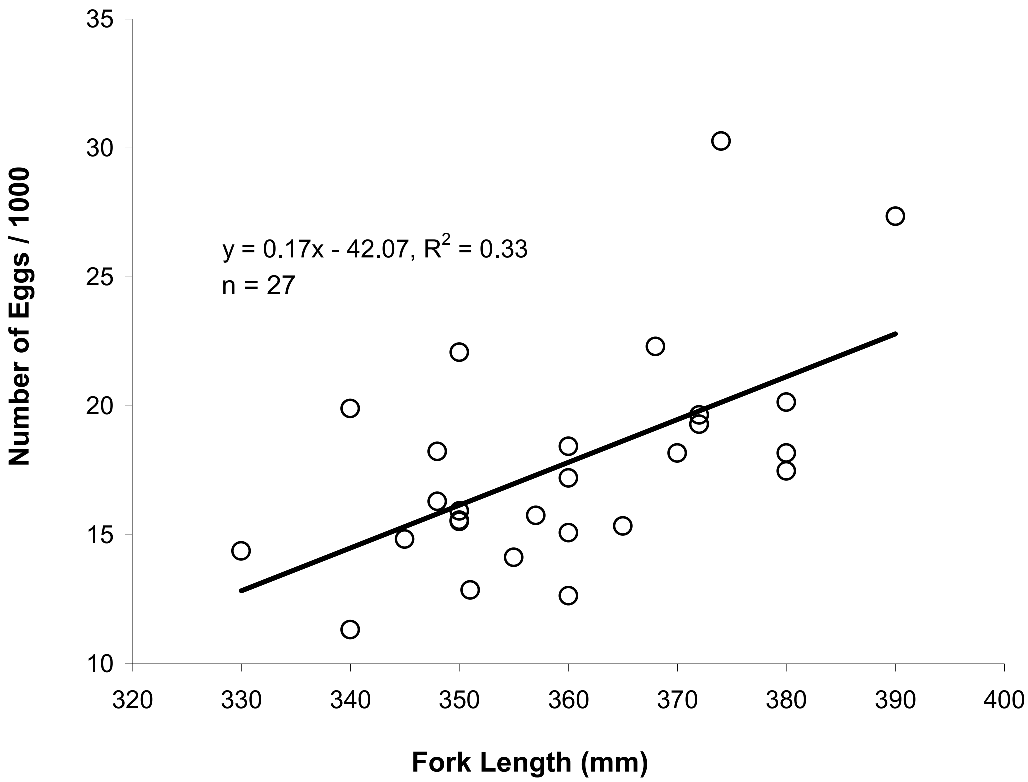

Figure 10. The relationship between fecundity and fork length for female Arctic Cisco captured in the experimental mesh gill net during the Peel River Fish Study from 1998 to 2002.

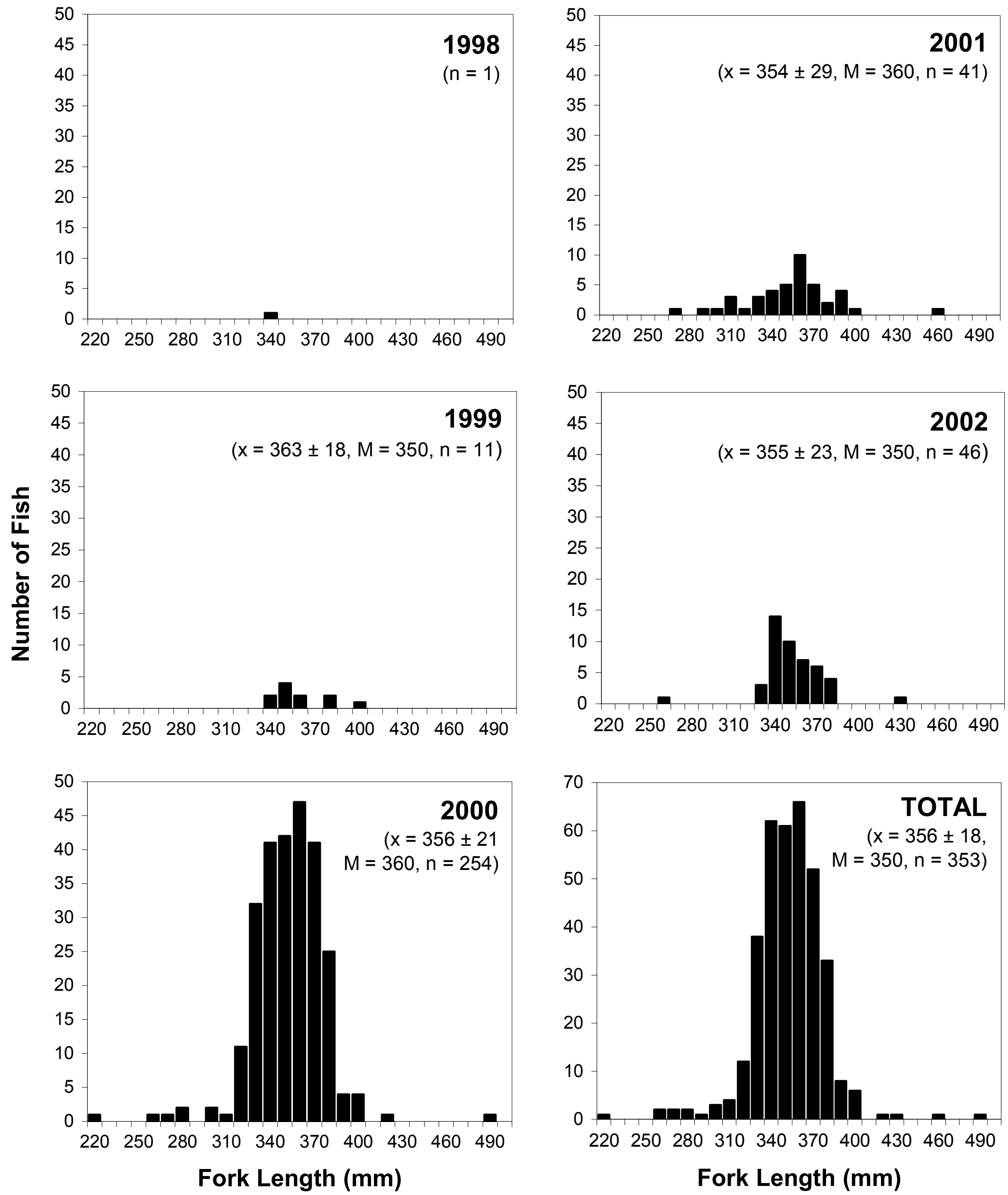

Figure 11. Length-frequency distribution of Arctic Cisco captured in the experimental mesh gill net during the Peel River Fish Study from 1998 to 2002. Mean (x) ± 1 SD, median (M), and the sample size (n) are given.

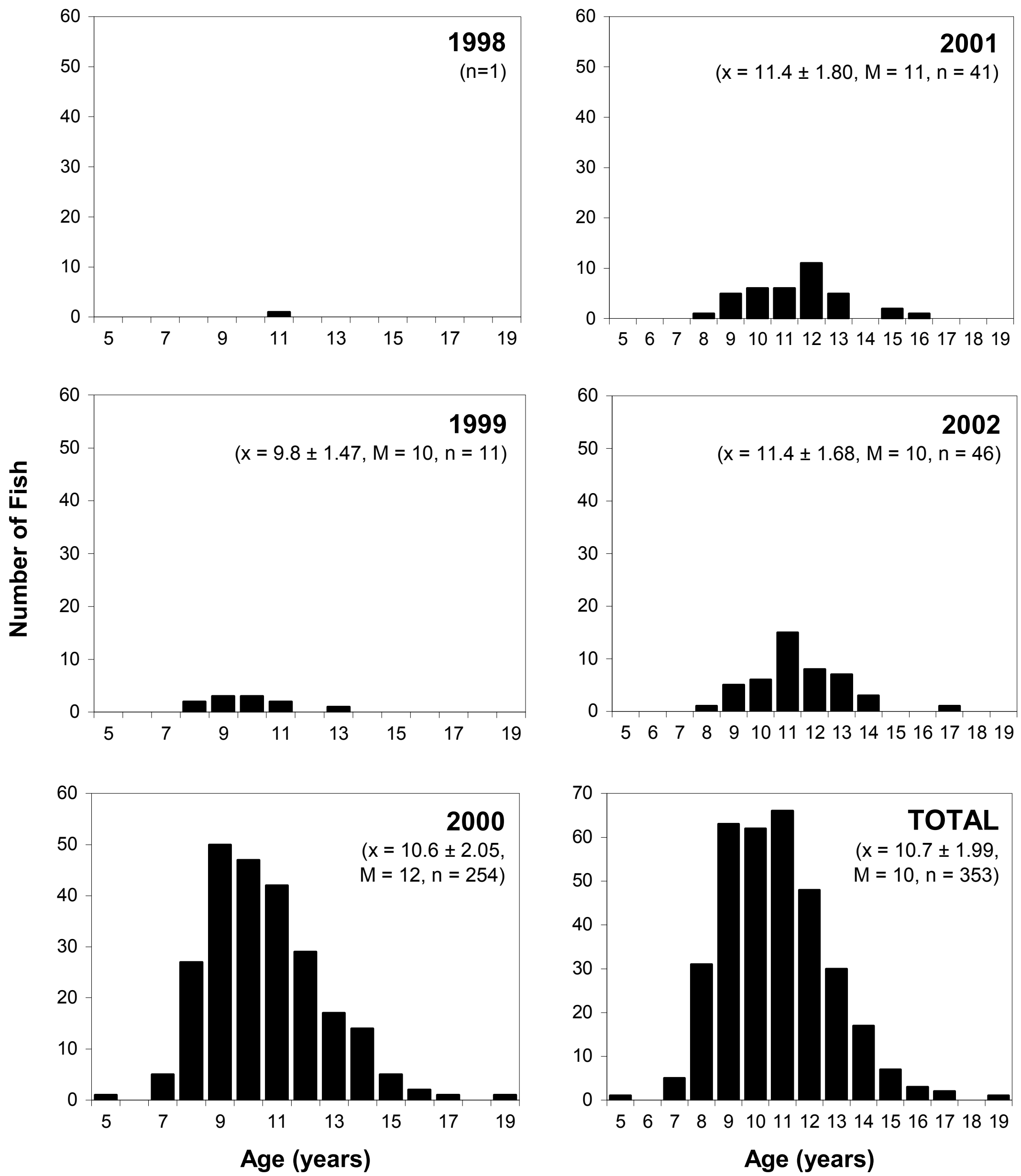

Figure 12. Age-frequency distribution for Arctic Cisco captured in the experimental mesh gill net during the Peel River Fish Study from 1998 to 2002. Mean (x) ± 1 SD, median (M), and the sample size (n) are given.

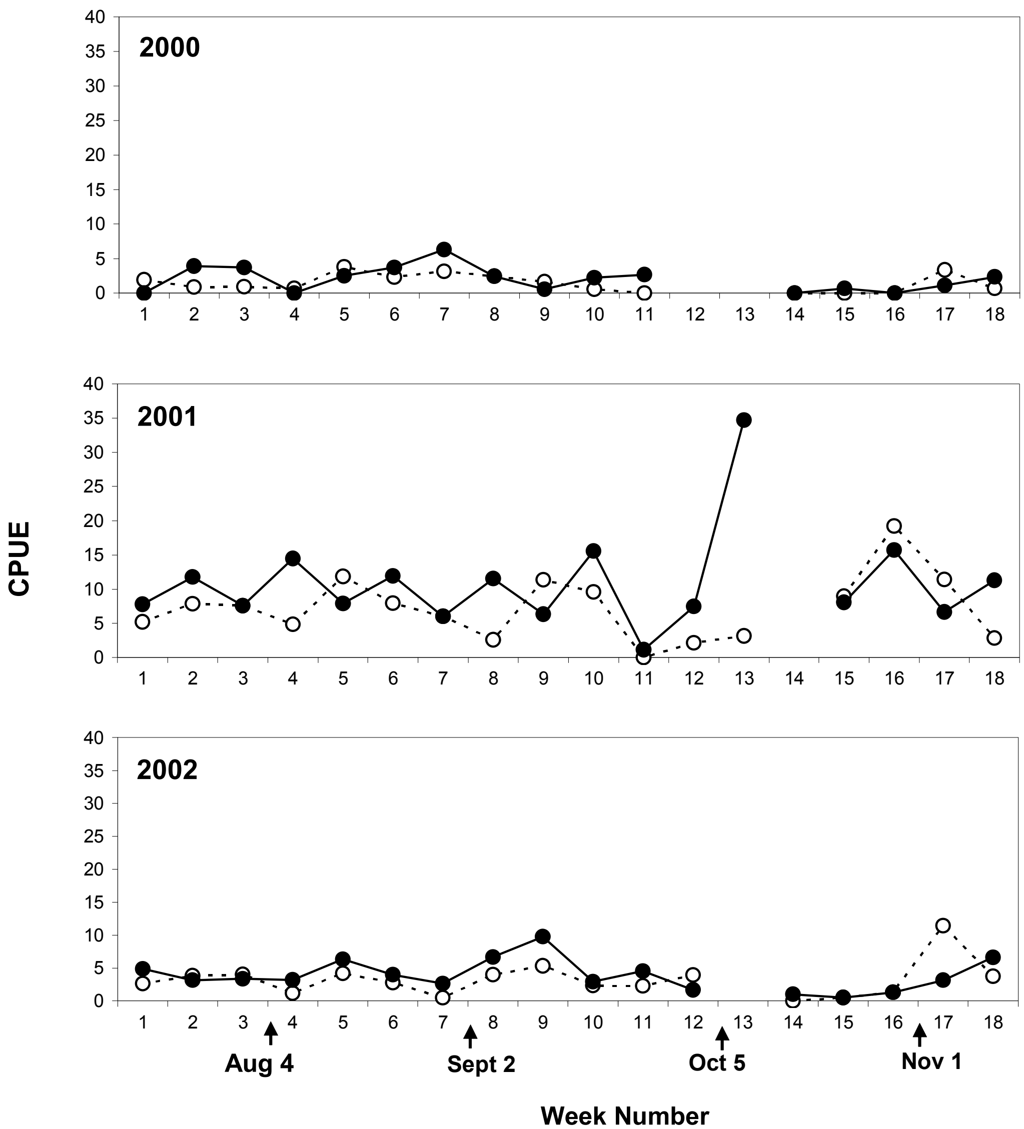

Figure 13. Catch-per-unit-effort (CPUE) for Broad Whitefish (*Coregonus nasus*) captured with the experimental mesh gill net at Koe Camp during the Peel River Fish Study from 2000 to 2002. Week one starts on July 15 each year. Male CPUE is a solid circle and female CPUE is an open circle.

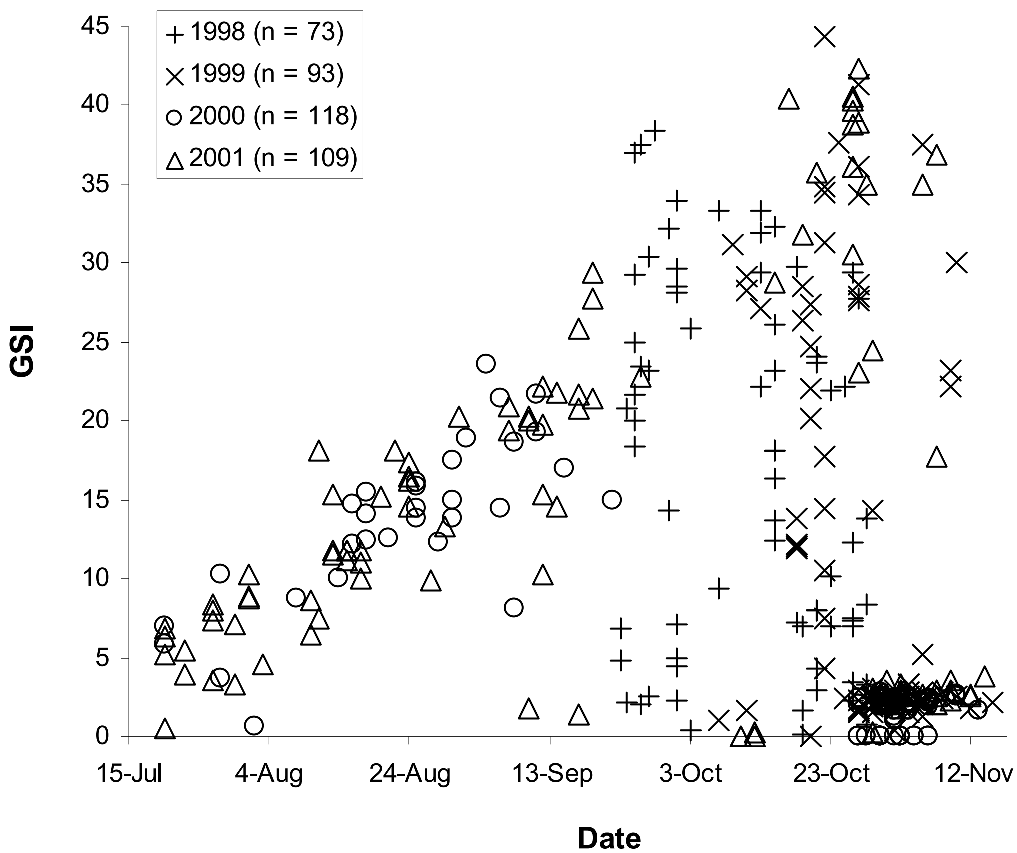

Figure 14. Gonadosomatic index (GSI) of female Broad Whitefish captured with the five-inch and experimental mesh gill nets during the Peel River Fish Study from 1998 to 2001.

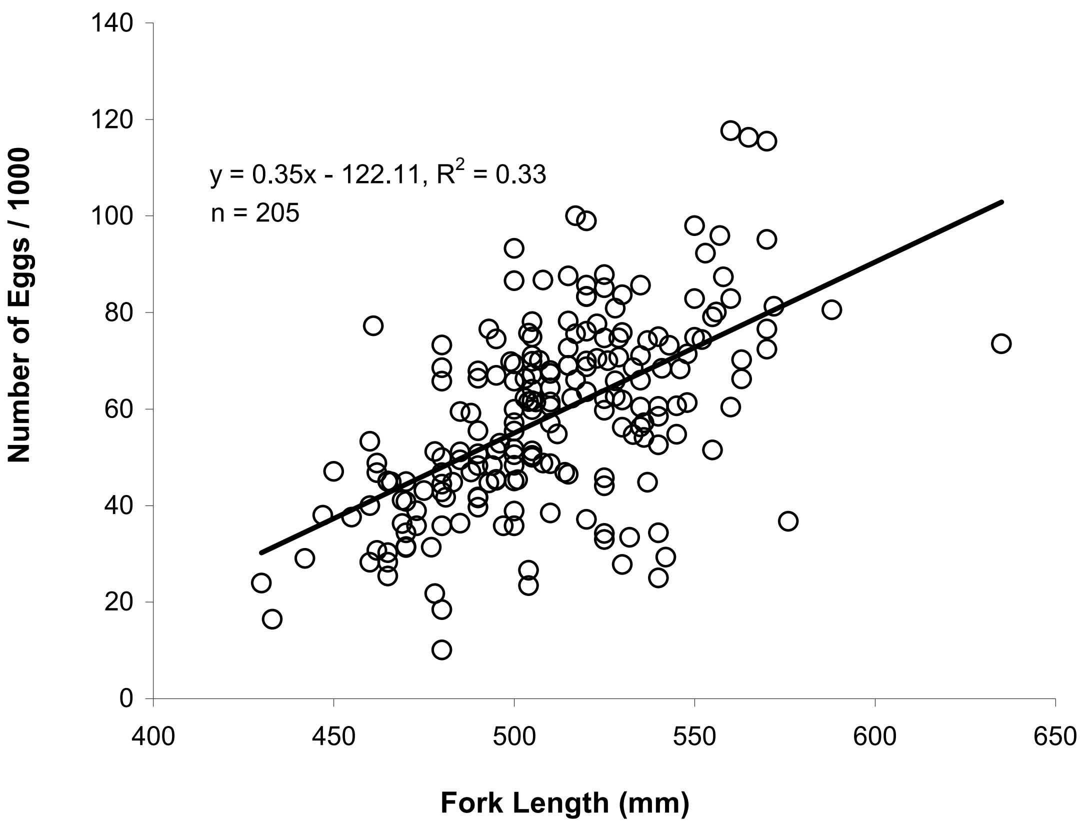

Figure 15. The relationship between fish fecundity and fork length for female Broad Whitefish captured in the five-inch and experimental mesh gill nets during the Peel River Fish Study from 1998 to 2002.

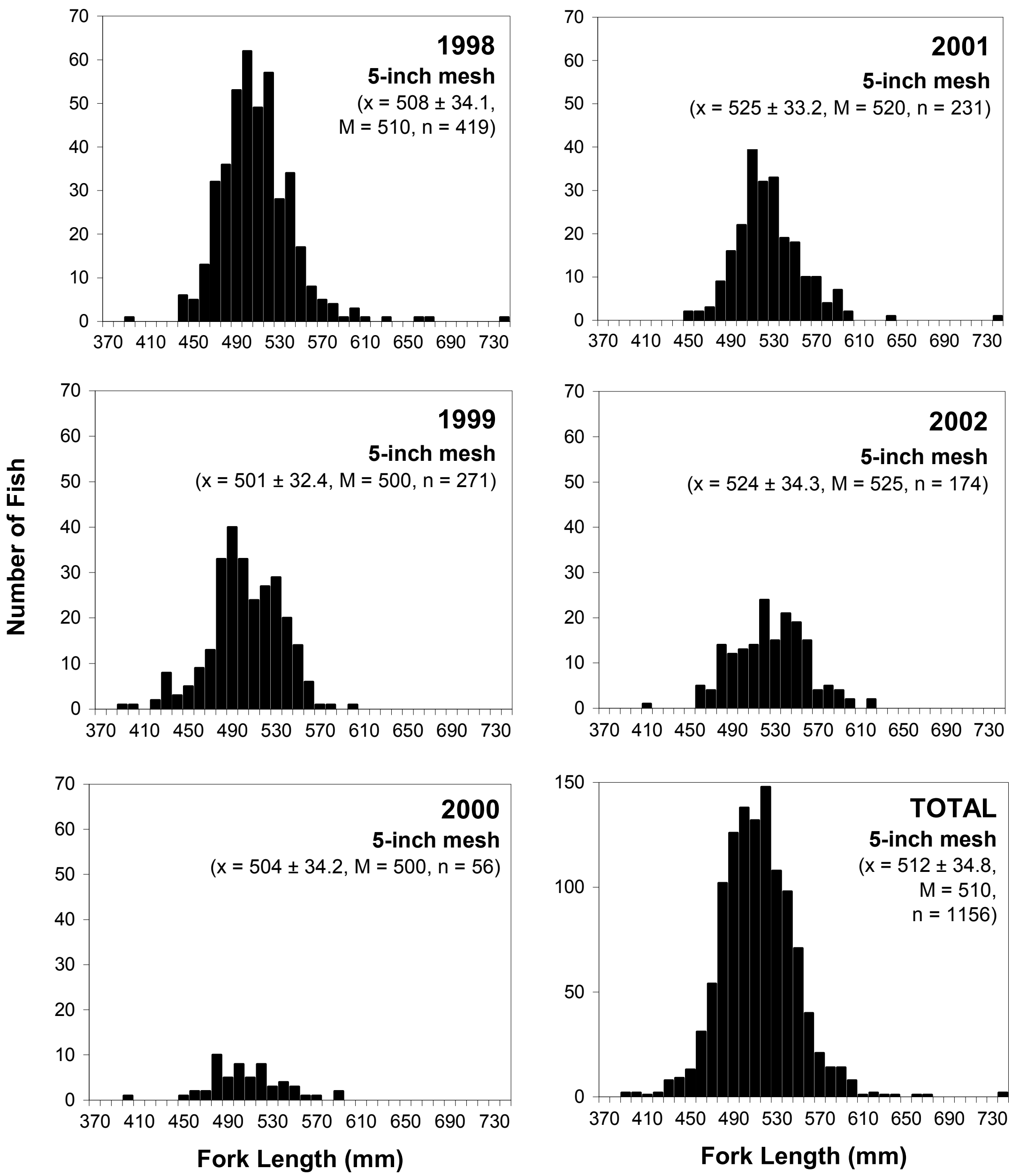

Figure 16. Length-frequency distribution of Broad Whitefish captured with the five-inch mesh gill nets during the Peel River Fish Study from 1998 to 2002. Mean (x) ± 1 SD, median (M), and the sample size (n) are given.

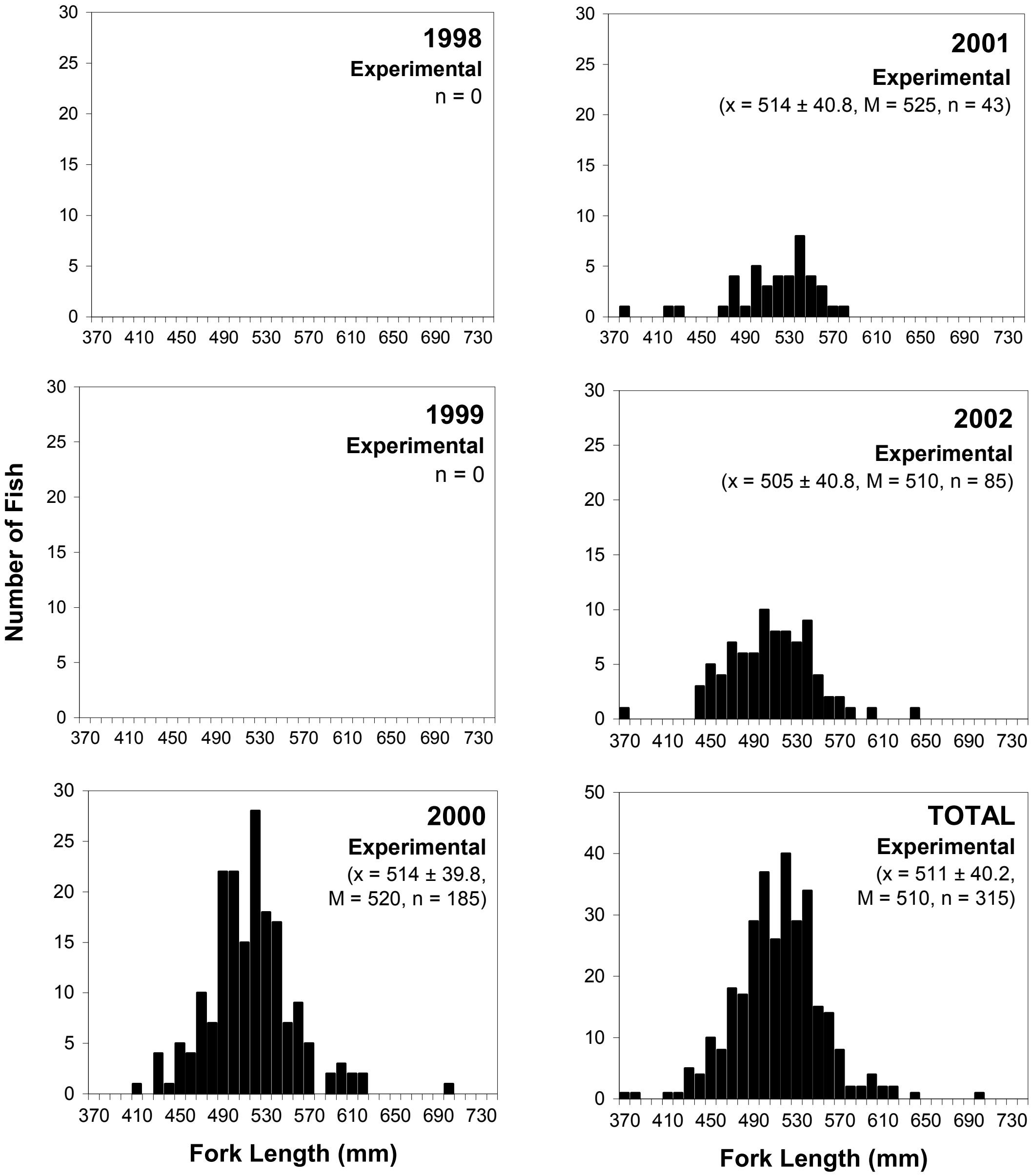

Figure 17. Length-frequency distribution of Broad Whitefish captured with the experimental mesh gill nets during the Peel River Fish Study from 1998 to 2002. Mean (x) ± 1 SD, median (M), and the sample size (n) are given.

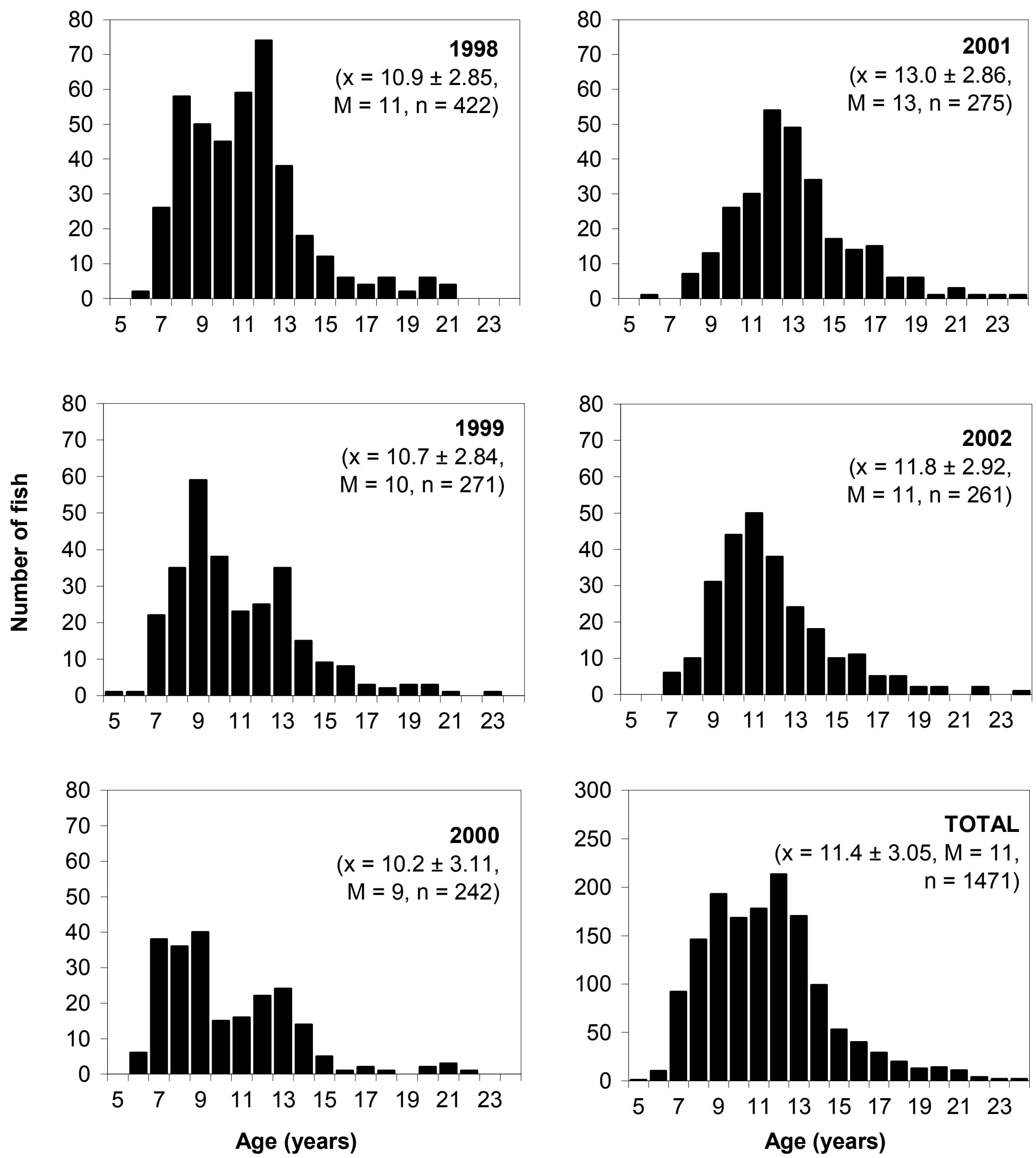

Figure 18. Age-frequency distribution for Broad Whitefish caught in the five-inch and experimental mesh gill nets during the Peel River Fish Study from 1998 to 2002. Mean (x) ± 1 SD, median (M), and the sample size (n) are given.

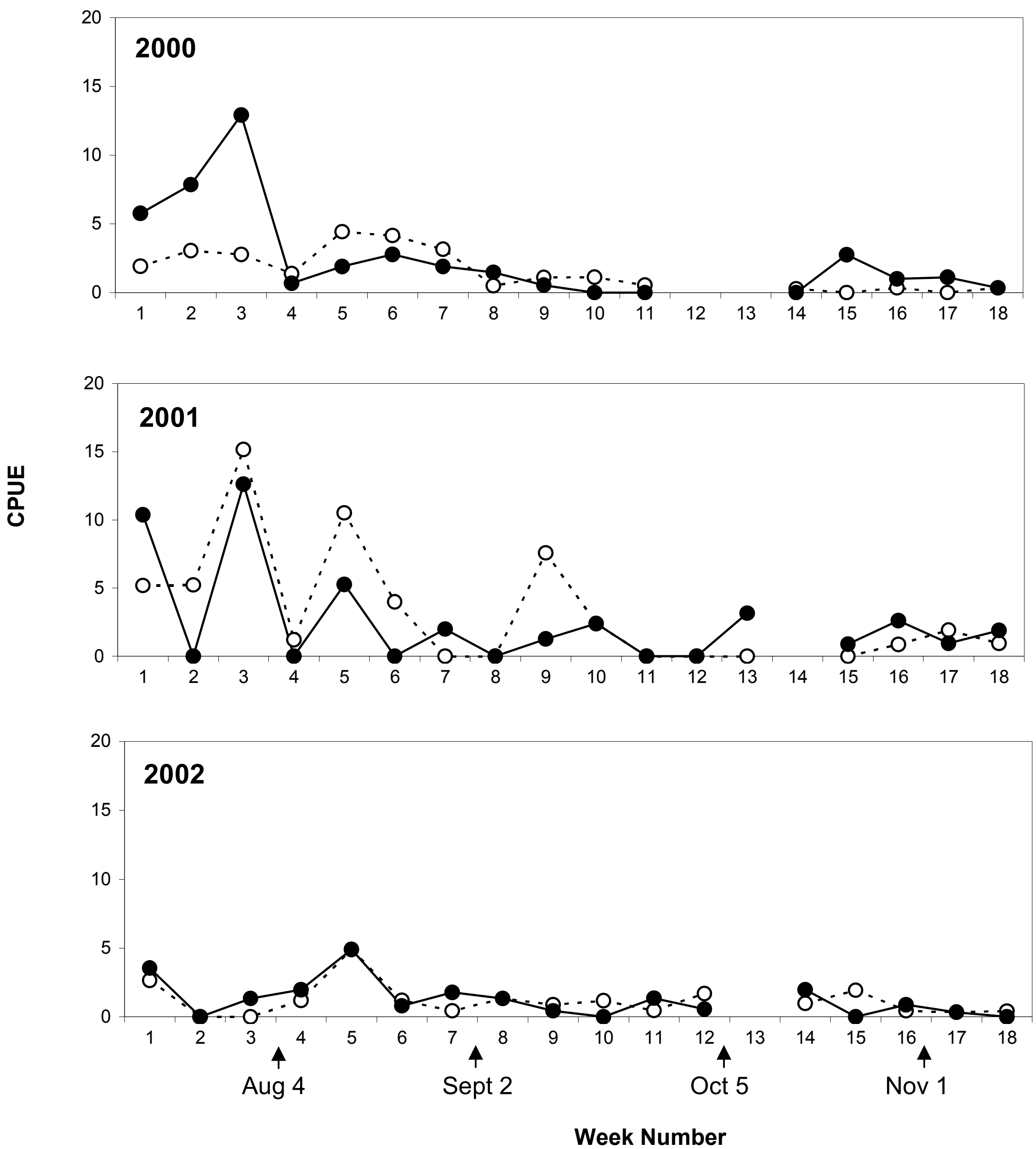

Figure 19. Catch-per-unit-effort (CPUE) for Lake Whitefish (*Coregonus clupeaformis*) captured in the experimental mesh gill net at Koe Camp during the Peel River Fish Study from 2000 to 2002. Week one starts on July 15 each year. Male CPUE is a solid circle and female CPUE is an open circle.

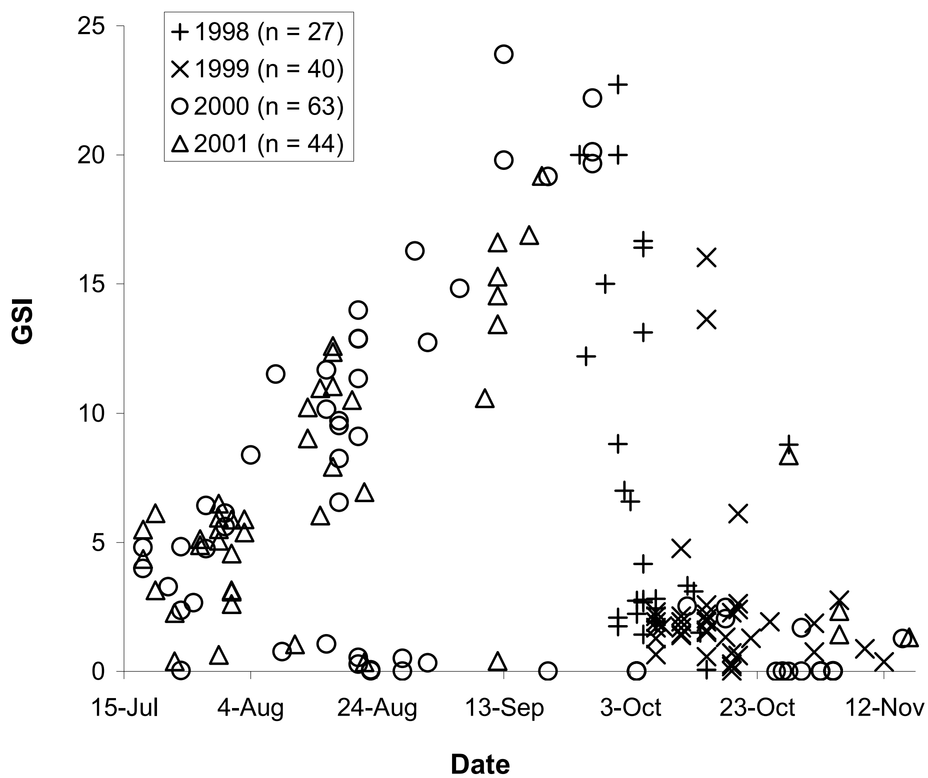

Figure 20. Gonadosomatic index (GSI) of female Lake Whitefish captured in the five-inch and experimental mesh gill nets during the Peel River Fish Study from 1998 to 2001.

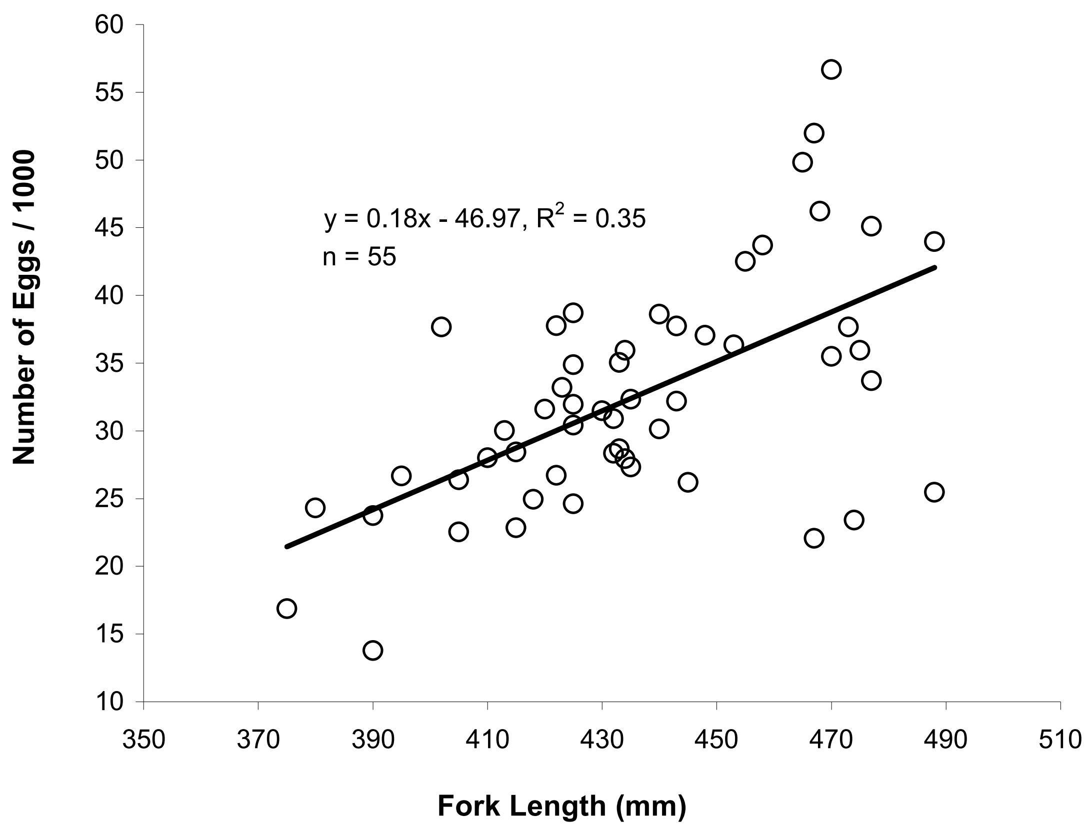

Figure 21. The relationship between fecundity and fork length for female Lake Whitefish captured in the five-inch and experimental mesh gill nets during the Peel River Fish Study from 1998 to 2002.

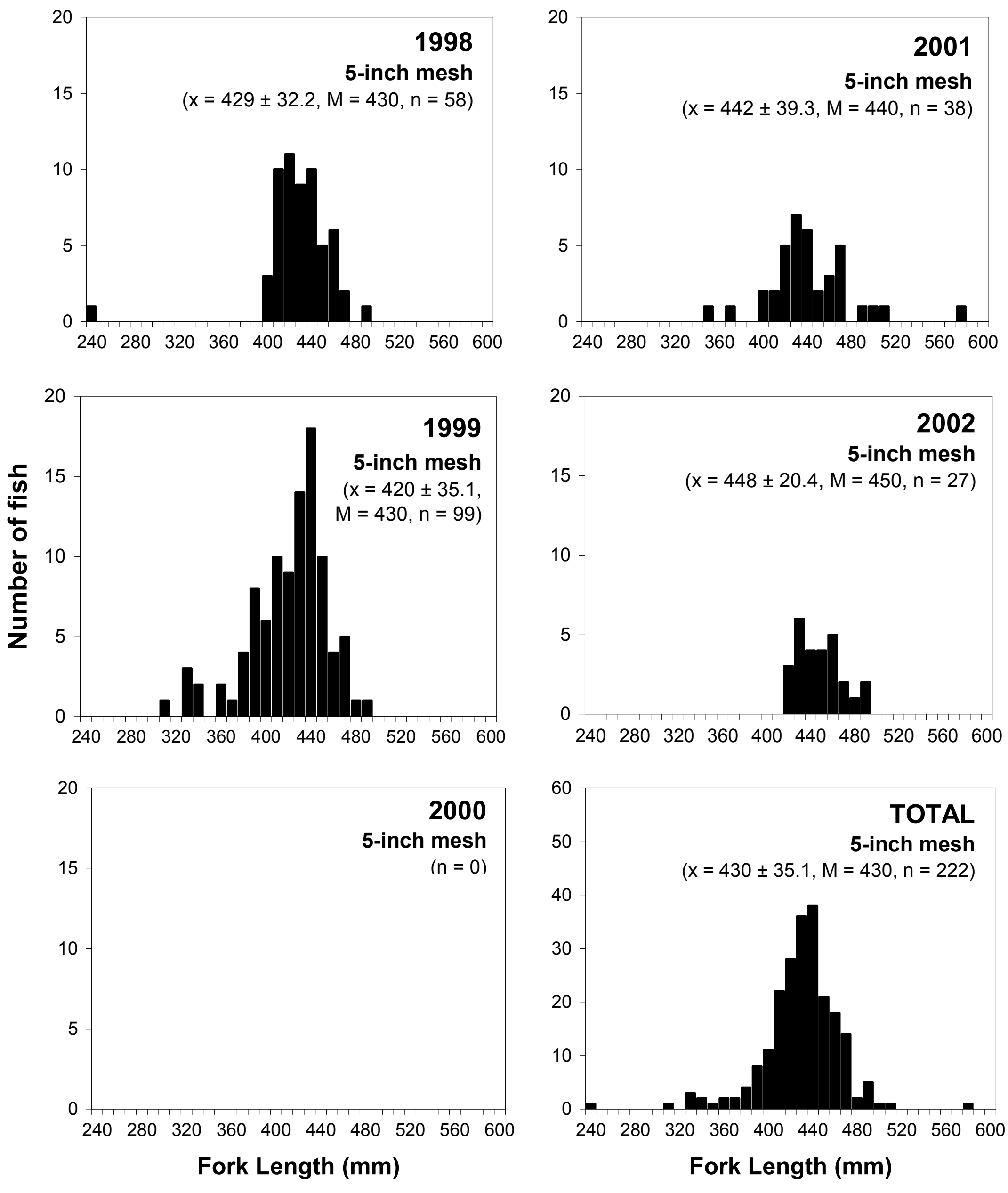

Figure 22. Length-frequency distribution for Lake Whitefish captured with the five-inch mesh gill nets during the Peel River Fish Study from 1998 to 2002. Mean (x) ± 1 SD, median (M), and the sample size (n) are given.

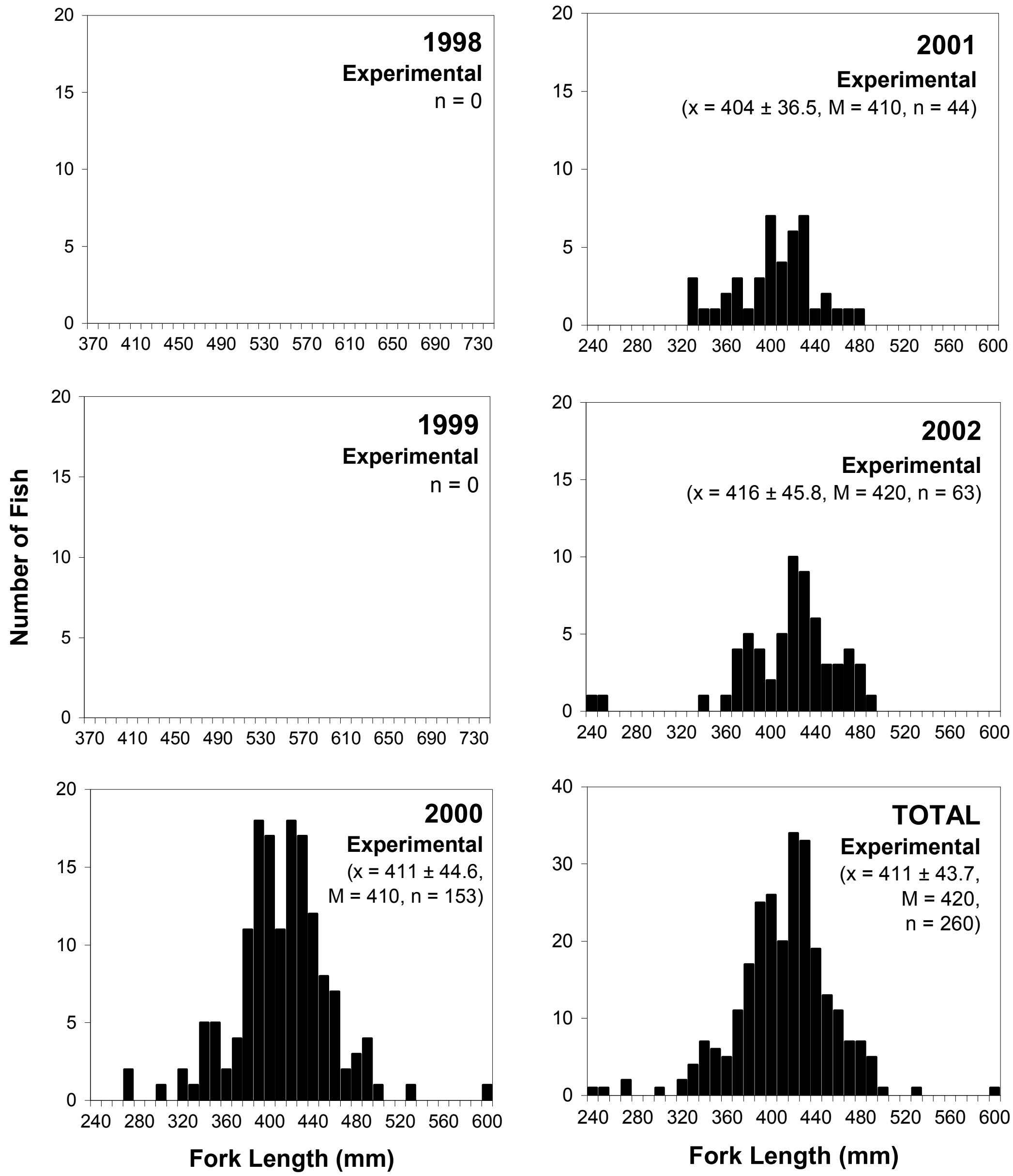

Figure 23. Length-frequency distribution for Lake Whitefish captured with the experimental mesh gill nets during the Peel River Fish Study from 1998 to 2002. Mean (x) ± 1 SD, median (M), and the sample size (n) are given.

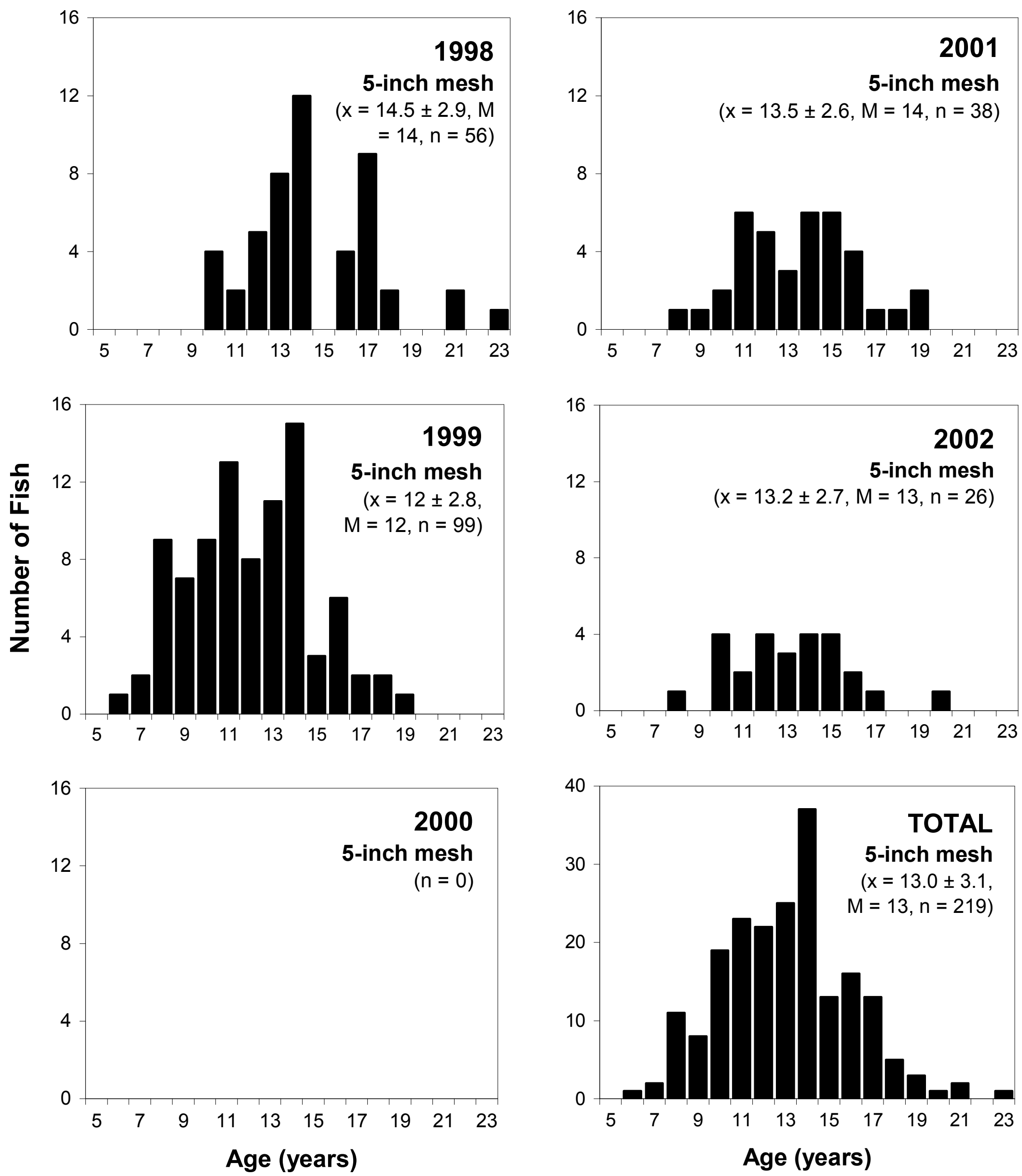

Figure 24. Age-frequency distribution for Lake Whitefish captured with the five-inch mesh gill nets during the Peel River Fish Study from 1998 to 2002. Mean (x) ± 1 SD, median (M), and the sample size (n) are given.

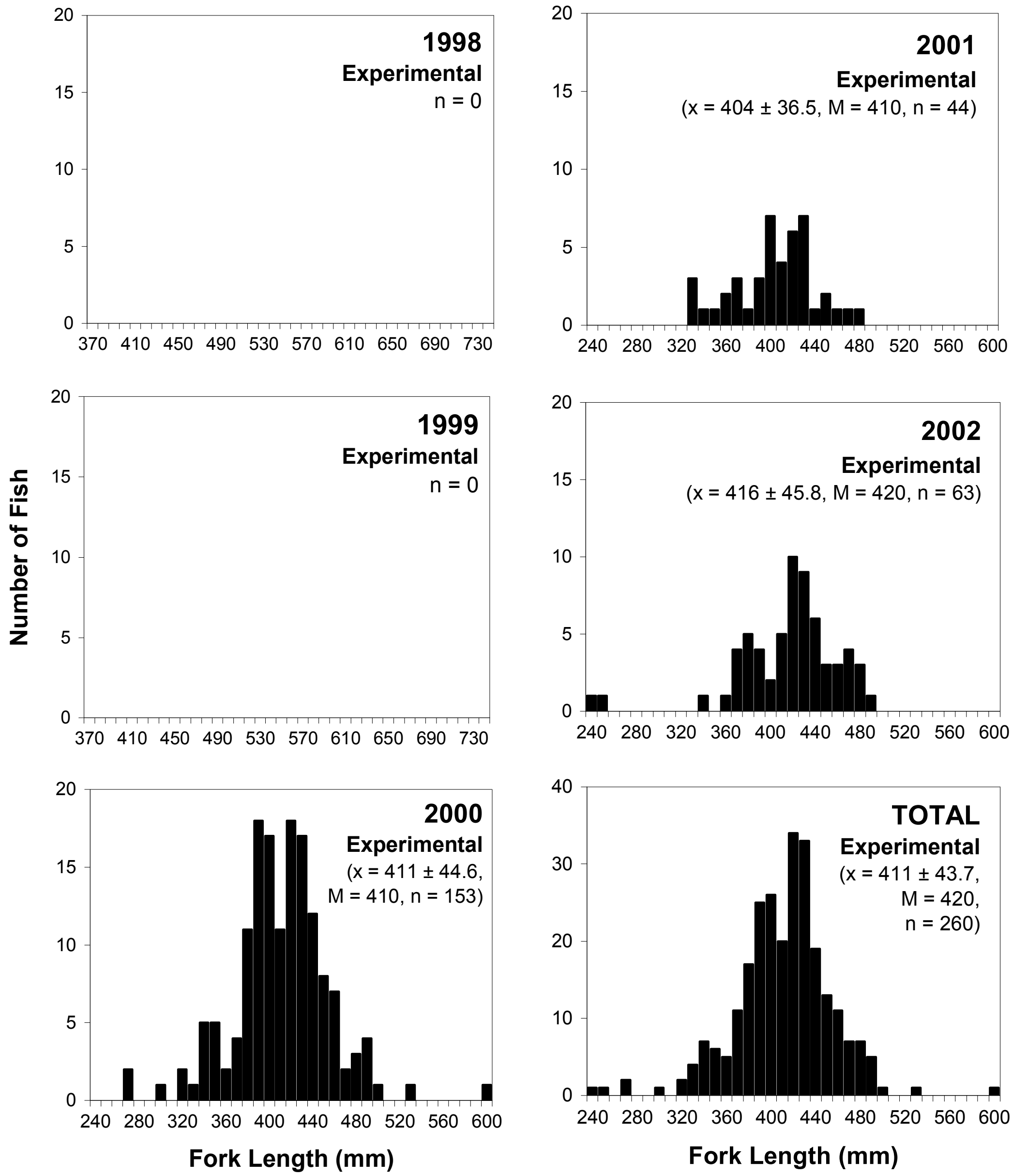

Figure 25. Length-frequency distribution for Lake Whitefish captured with the experimental mesh gill nets during the Peel River Fish Study from 1998 to 2002. Mean (x) ± 1 SD, median (M), and the sample size (n) are given.

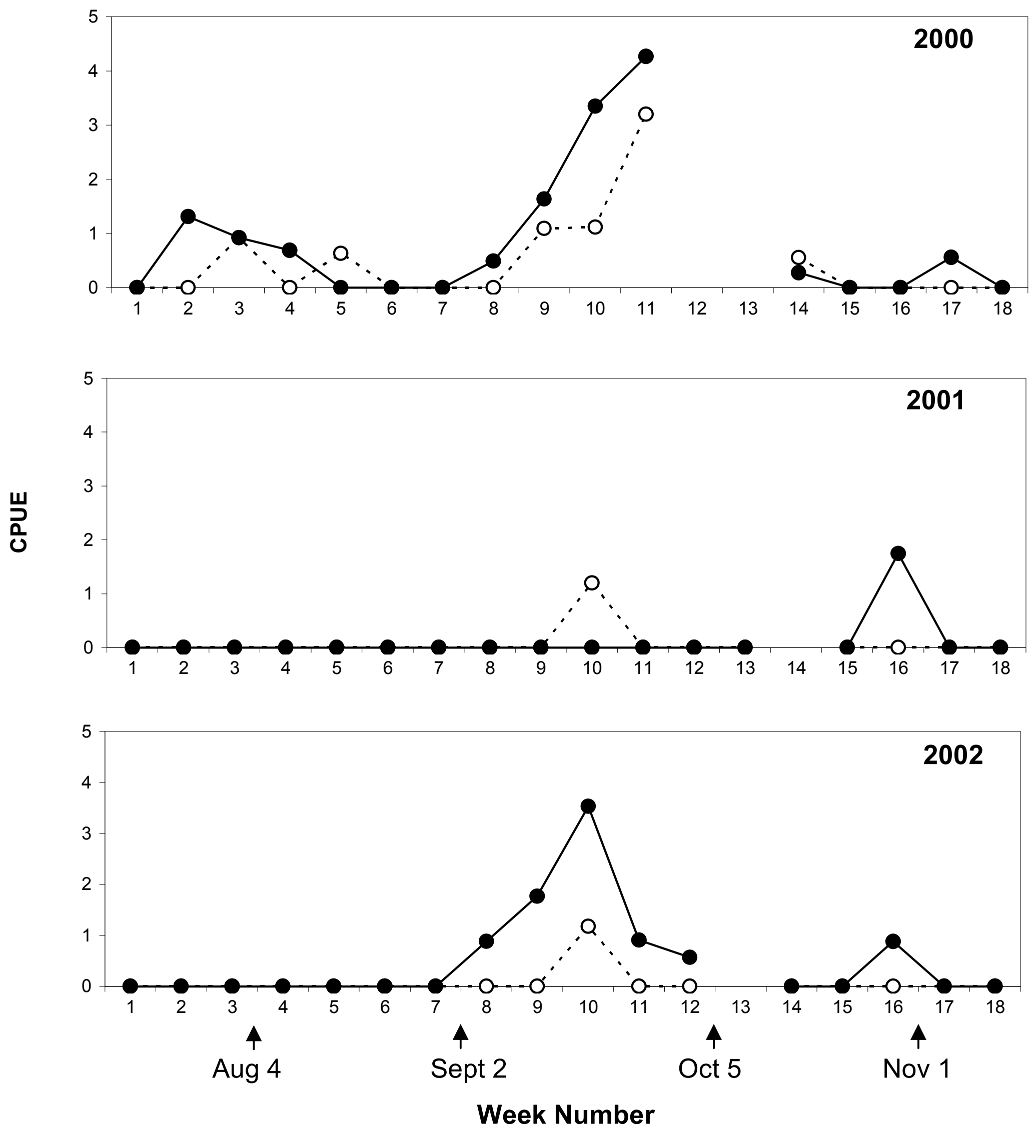

Figure 26. Catch-per-unit-effort (CPUE) of Least Cisco (*Coregonus sardinella*) captured with the experimental mesh gill net at Koe Camp during the Peel River Fish Study from 2000 to 2002. Week one starts on July 15 each year. Male CPUE is a solid circle and female CPUE is an open circle.

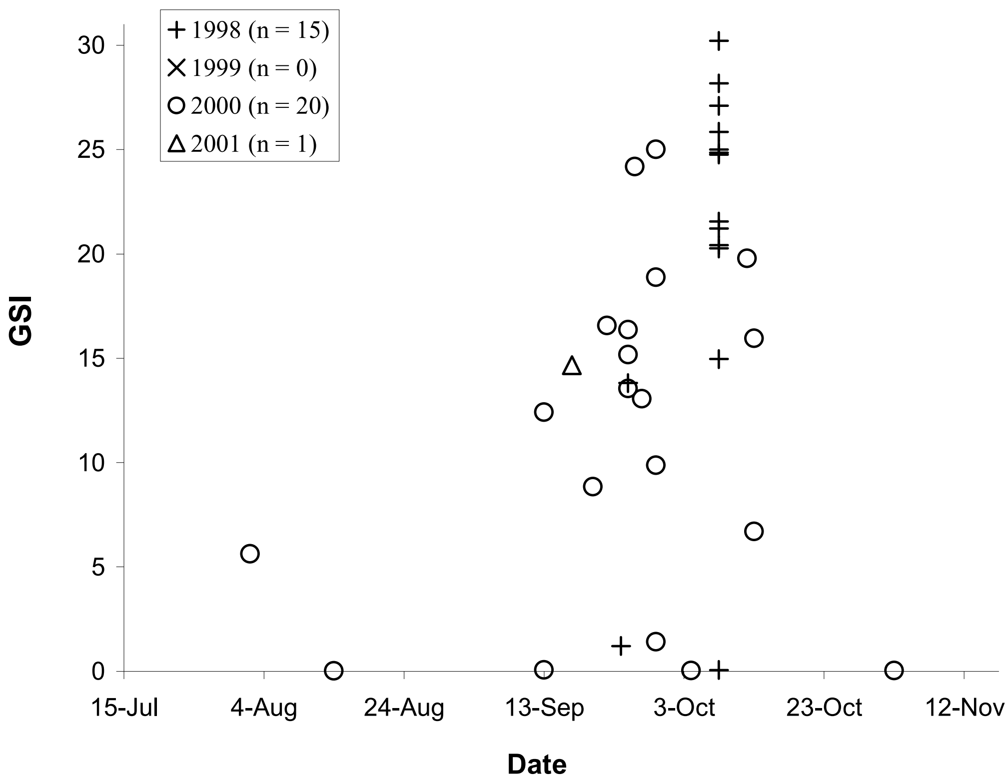

Figure 27. Gonadosomatic index (GSI) of female Least Cisco captured with the experimental mesh gill nets during the Peel River Fish Study from 1998 to 2001.

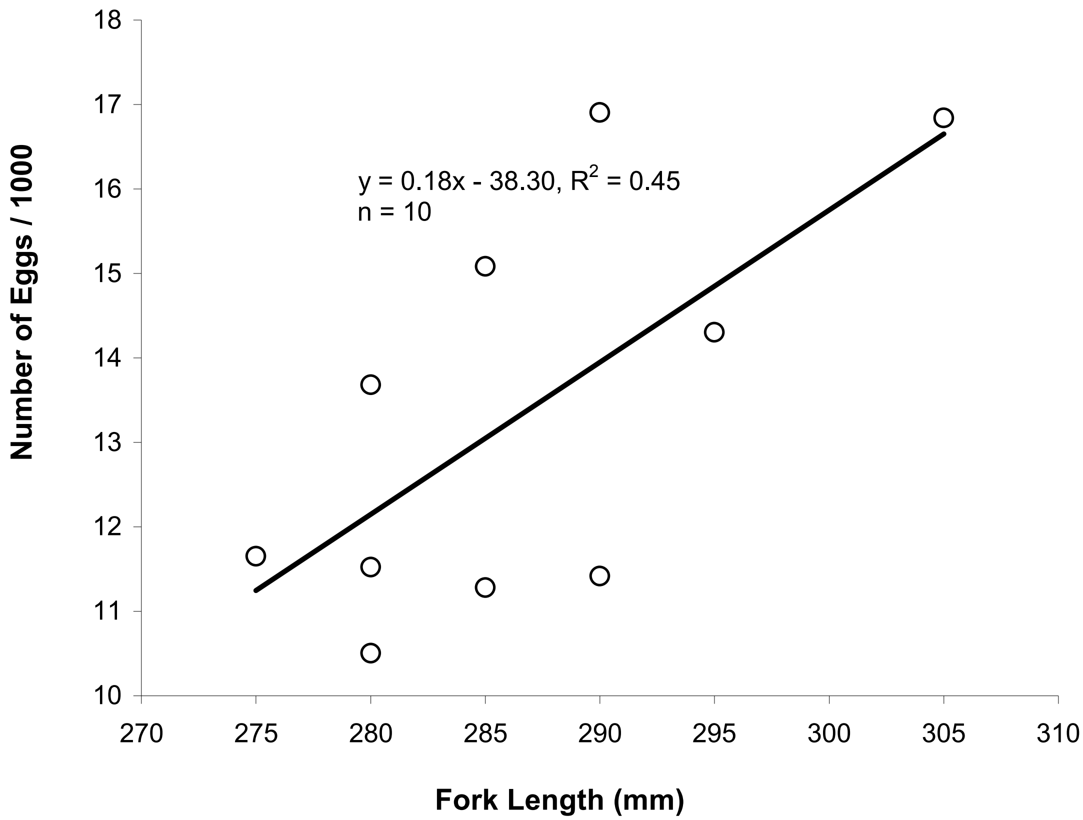

Figure 28. The relationship between fecundity and fork length for female Least Cisco captured with the experimental mesh gill nets during the Peel River Fish Study from 1998 to 2002.

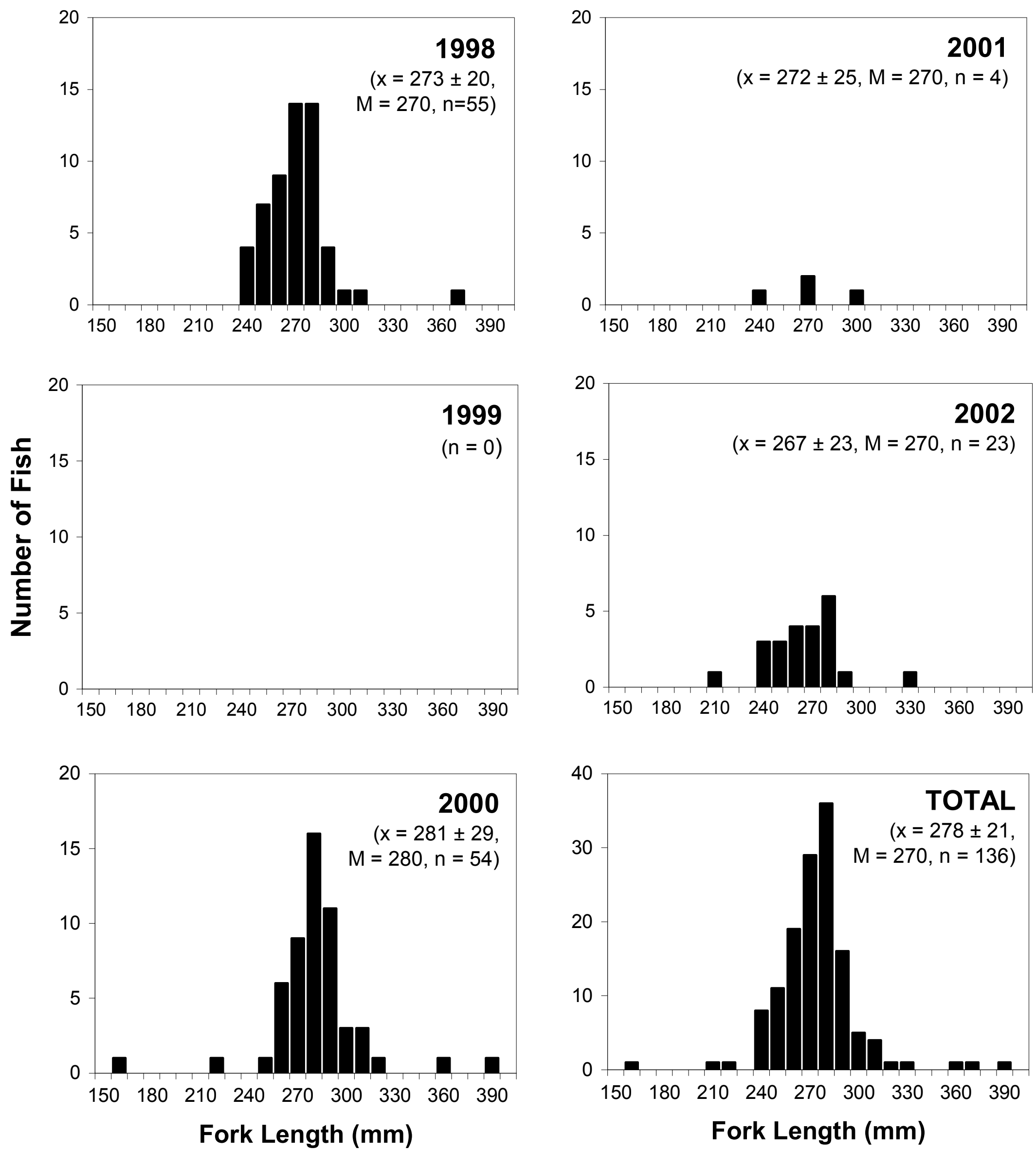

Figure 29. Length-frequency distribution for Least Cisco captured with the experimental mesh gill nets during the Peel River Fish Study from 1998 to 2002. Mean (x) ± 1 SD, median (M), and the sample size (n) are given.

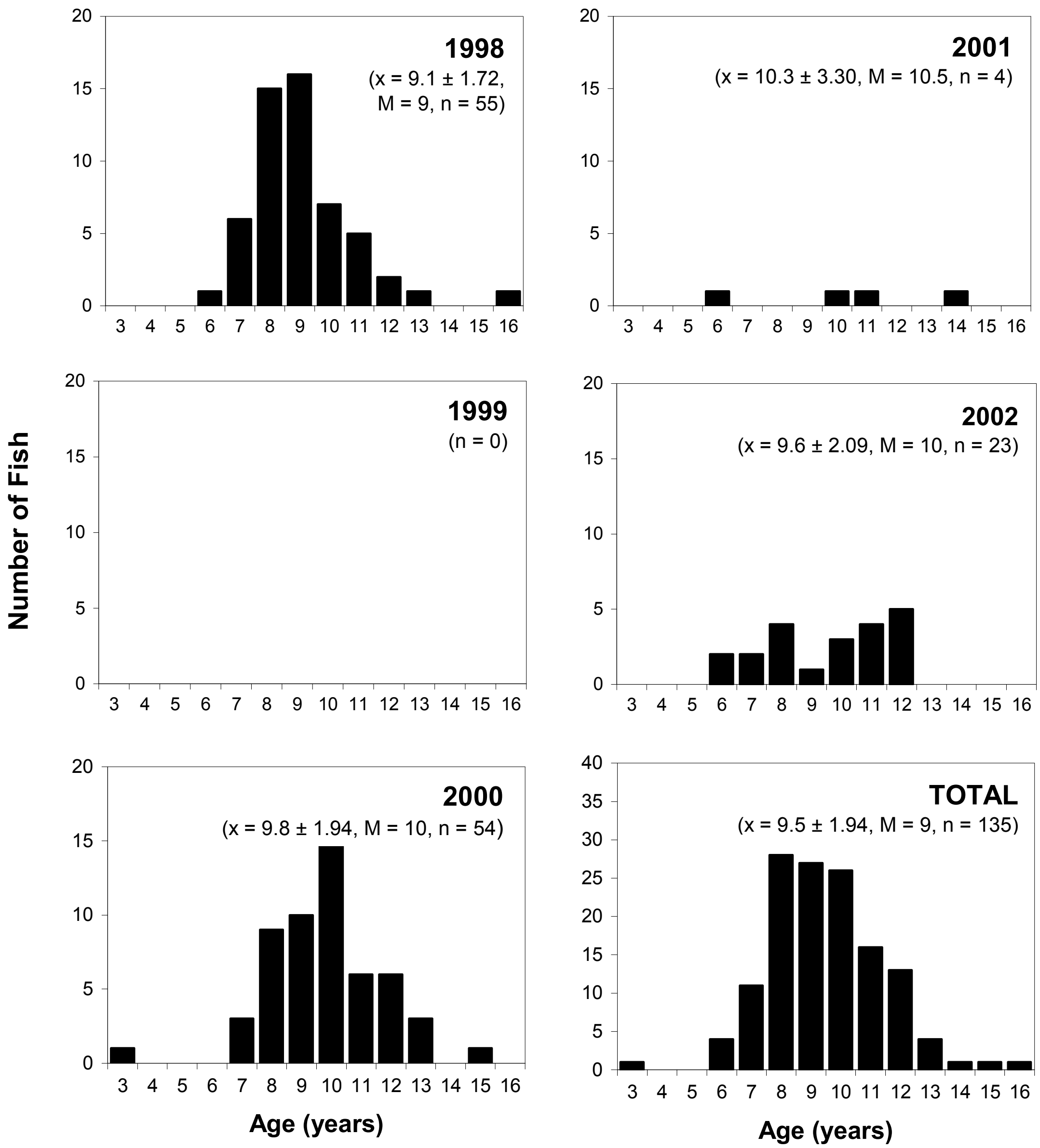

Figure 30. Age-frequency distribution for Least Cisco captured with the experimental mesh gill nets during the Peel River Fish Study from 1998 to 2002. Mean (x) ± 1 SD, median (M), and the sample size (n) are given.