QUIRK CREEK BROOK TROUT SUPPRESSION PROJECT
2004 – 2006

Alberta Sustainable Resource Development
Fish and Wildlife Division
Cochrane, Alberta

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June 2007

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Cover photo: Brook trout

Suggested Citation: Earle, J.E., J.D. Stelfox and B.E. Meagher. 2007. Quirk Creek brook trout suppression project – 2004 to 2006. Unpublished report, Fish and Wildlife Division, Alberta Sustainable Resource Development, Cochrane, Alberta.

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ACKNOWLEDGMENTS

The Quirk Creek Brook Trout Suppression Project is a collaborative effort involving the Fish & Wildlife Division of Alberta Sustainable Resource Development and Trout Unlimited Canada (TUC). Previous TUC staff — Dean Baayens (1998-2001) and Greg Eisler (2002-2003) — spent considerable time administering the fish identification test to volunteer anglers, coordinating and supervising outings, sampling harvested brook trout, and collecting and entering creel data. Ultimately, this project would not have been possible without the participation of many volunteer anglers over the years, and in particular those dedicated anglers who have harvested most of the brook trout in recent years on unsupervised outings. Funds from Anadarko Canada Corporation, the Alberta Conservation Association and the Parks Venture Fund supported this project.

EXECUTIVE SUMMARY

In southern Alberta, non-native brook trout *Salvelinus fontinalis* populations have generally increased while native westslope cutthroat trout *Oncorhynchus clarkii lewisi* and bull trout *Salvelinus confluentus* populations have declined. Since their introduction to the Elbow River watershed in 1940, brook trout colonized the entirety of Quirk Creek by 1995, comprising 92% of the fish population. Angling was used from 1998–2006, as part of a brook trout suppression project. The objective of the study was to determine whether angling could be an effective method for reducing densities of brook trout, to facilitate recovery of the native trout populations. Anglers participating in the project were required to pass a fish identification test and had to harvest all brook trout caught. The stream was divided into an upper and lower reach and anglers recorded all fish caught on supervised and unsupervised outings.

The fish identification key proved to be effective in teaching anglers how to identify fish, as only 15 (0.2%) of the 8886 fish harvested by anglers participating in the project were not brook trout. Fishing effort and brook trout harvest rates peaked in the early years of the project. Effort was generally higher in the more accessible lower reach but declined substantially in both reaches. Higher catch rates of anglers on unsupervised outings resulted in an increase in the relative importance of unsupervised outings for brook trout harvest in both reaches.

Based on their larger size and higher catchability, bull trout and cutthroat trout have the potential to provide a better quality fishery in Quirk Creek. Since initiation of the project, only 5% of the brook trout harvested by anglers have exceeded 250 mm in length, compared to 23% of cutthroat trout and 29% of bull trout.

The estimated percentage of large (>150 mm) brook trout in the population harvested by angling averaged 26% and attained a high of 61% in the upper reach but has declined considerably since 1999. It has been substantially higher in the lower reach, averaging 40%, and has not exhibited the declines observed in the upper reach. Electrofishing results confirmed a decrease in estimated biomass since 1998–2000. In the upper reach, angler harvest declined from 79 to 4% of the estimated biomass from 1999 to 2006. In the lower reach, declines were less dramatic and increased to 87% in 2006.

A comparison of brook trout catch-per-unit-effort (CPUE) indicated that electrofishing resulted in both a higher number and biomass of brook trout caught per hour when compared to angling. Depending on the amount of sample processing, the results suggested that although the number of fish CPUE can be considerably higher during electrofishing, the angling biomass CPUE can be comparable, in particular for unsupervised outings.

In conclusion, angling, particularly unsupervised outings, appears to be sufficient on the lower reach to keep the number of large brook trout at a relatively low level. For the more remote upper reach, however, we have been unsuccessful in getting anglers to exert sufficient pressure and to harvest enough brook trout, to substantially reduce the population and maintain it at low levels. The approach used in the suppression project has the potential to work, provided that the streams selected are readily accessible by anglers and sufficient angling pressure can be exerted over multiple years.

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1.0 INTRODUCTION

1.1 Project Overview

Brook trout *Salvelinus fontinalis*, although not native to Alberta, are present in many montane and foothills waters as a result of extensive stocking. In southern Alberta, brook trout populations have generally increased while native westslope cutthroat trout *Oncorhynchus clarkii lewisi* and bull trout *Salvelinus confluentus* populations have declined. Brook trout life history attributes (early spawning age, reduced longevity and low catchability) have resulted in the replacement of native bull trout and cutthroat trout fisheries with fisheries for smaller, less-catchable, non-native brook trout.

Brook trout colonized Quirk Creek subsequent to their introduction to the Elbow River watershed in 1940. Although native cutthroat trout and bull trout were the only fish captured in Quirk Creek in 1948, brook trout had colonized the lower 3 km of the creek by 1978, where they comprised 35% of the electrofishing catch (Tripp et al. 1979), and spread throughout the entire creek by 1995, comprising 92% of the fish population (Paul and Post 1996). Electrofishing surveys of Quirk Creek continued in 1996 with the addition of two more sampling sites; however, results were similar to 1995 in that brook trout comprised greater than 90% of the total catch (Paul and Post 1997). These changes occurred despite the implementation of reduced bag limits and minimum size limits designed to provide more protection for native trout (Stelfox et al. 2001a). Since 1998, harvest of all fish has been prohibited in Quirk Creek, except by anglers participating in the brook trout suppression project.

Management programs to reduce or eliminate non-native trout populations often involve piscicides and/or electrofishing (Moore et al 1983; Buktenika 1997; Kulp and Moore 2000). However, Larson et al. (1986) suggested that experimental angling programs might offer a cost-effective, alternative method for reducing densities of non-native trout. Although Larson's study only ran nine weeks, it appeared that anglers reduced the non-native trout population by about 10%.

Since piscicides are only suitable in certain situations and there are insufficient resources to attempt removal of non-native trout by electrofishing in all streams where native trout populations appear to be threatened, the option of selectively removing non-native trout by angling provides an appealing alternative. Our objective in this study was to determine whether angling could be an effective method for reducing densities of non-native brook trout in Quirk Creek, to facilitate recovery of the native trout population.

Data on the angling component of the project was previously presented in Stelfox et al. (2001a and 2004); the latter paper summarized information collected up to 2003. The following report summarizes new angling data collected from 2004 to 2006 and compares it to data collected from 1998 to 2003.

1.2 Study Area

Quirk Creek is located 50 km southwest of Calgary in a designated off-highway vehicle (OHV) area. A good dirt road comes within 0.5 km of the creek for most of its length. Anglers participating in this project were allowed direct vehicle access to this road by fording the Elbow River, but only on supervised outings under the direction of the volunteer coordinator. A locked gate prevents anglers on unsupervised outings from crossing the Elbow River by vehicle.

Most of Quirk Creek meanders through a large wet meadow dominated by grasses and low (< 1 m) shrubs. Although cattle and OHVs have degraded streambanks in a few areas, most of the streambanks are undamaged and provide good fish habitat, consisting of deeply undercut banks with overhanging terrestrial vegetation. The lower 2 km of creek flows through a narrow valley before joining the Elbow River at an elevation of 1530 m. There are no permanent barriers on the creek, although beaverdams up to 1.5 m high are scattered along the creek.

A bridge divides Quirk Creek into a 6.48 km upper reach and a 6.18 km lower reach, with the lower reach serving as a control during the first two years of the project (Figure 1). Surface areas of the upper and lower reaches were calculated to be 1.63 and 3.05 ha, respectively, based on mean stream widths of 2.5 and 4.9 m, respectively, which were obtained by measuring stream widths every 20 m in both reaches in 2004.

From 1987 to 1997, the entire length of Quirk Creek was open to angling under the general sportfishing regulations for Alberta's eastern slopes. In 1987, minimum-size limits of 25 cm for cutthroat trout and 40 cm for bull trout were implemented. In 1995, the harvest of bull trout was prohibited. In 1998, Quirk Creek was designated a catch-and-release stream. However, anglers who had passed a fish identification test and were participating in an outing supervised by a volunteer coordinator were permitted to harvest all brook trout they caught in Quirk Creek upstream of the bridge near Mac Creek (Stelfox et al. 2001a). In 2000, the area of brook trout harvest was extended to include all of Quirk Creek, and, beginning in 2001, a select group of anglers were permitted to harvest brook trout on unsupervised outings in either reach. A summary of prior fishing regulations for Quirk Creek can be found in Stelfox et al. (2001a).

2.0 METHODS

2.1 Fish Identification Education

To participate in the project, all anglers had to pass a fish identification test on an annual basis to demonstrate their ability to identify the three fish species found in Quirk Creek. If a person failed the test on their first attempt, they were given a dichotomous key with pictures of the key-identifying features (a list of key-identifying features in 1998) and were permitted to take the test a second time with the key (list) in front of them. In addition, anglers were shown pictures of juvenile fish of all three species, as well as brook trout x bull trout hybrids, and the key-identifying features were discussed. For a more detailed discussion of the fish identification test and results up to 2000, refer to Stelfox et al. (2001b and 2004).

2.2 Angling

Participating anglers were required to harvest all brook trout caught and were initially only allowed to harvest brook trout from the upper reach of Quirk Creek on supervised outings. However, beginning in 2000, anglers also harvested fish from the lower reach to assess brook trout immigration and, starting in 2001, some of the more skilled anglers harvested fish on unsupervised outings. Anglers only fished from June to October, could not use bait and were required to release all bull trout and cutthroat trout after recording the length of each fish in 5-cm size classes.

All harvested brook trout were delivered whole to the volunteer coordinator at the end of each outing for measuring (fork length, nearest 1 mm) and weighing (nearest 1 g) and then returned to the angler. Anglers on unsupervised outings recorded fork lengths (nearest 1 mm) of all brook trout caught and filled in creel cards. Weights for brook trout caught on unsupervised outings were derived using length-class-specific condition factors from fish captured during the supervised outings during that same year. In a few instances, brook trout lengths were not measured for an unsupervised outing, but the number of brook trout harvested in each size category was recorded on the creel card. In these cases, a length was assigned to each fish by using the mid-point of the 5-cm size category on the angler’s creel card (e.g., 17.5 cm for the 15-20 cm size category).

2.3 Electrofishing

As part of the brook trout suppression project and a project looking at bull trout population dynamics throughout Alberta (Paul and Post 1996, 1997), electrofishing surveys in Quirk Creek continued from 1997 to 2006 (Paul et al. 2001; Paul 2003; Paul 2004; Dormer and Paul 2005; Earle et al. 2007). Abundance estimates were determined by removal-depletion methods at an upper and lower site. In addition, because removal of brook trout by angling had not produced the desired reduction in brook trout by 2003 (Paul et al. 2003; Paul 2004), one-pass electrofishing was used in addition to angling to selectively remove brook trout above Mac Creek from 2004 to 2006. For detailed methods and results of the electrofishing component of the study, refer to Earle et al. (2007).

For the calculations of catch-per-unit-effort for electrofishing, person-hours were based on an electrofishing crew of three and the number of volunteers, which varied according to day and year. Travel time was not included in the estimates. In 2006, a group of 15 field ecology students assisted the crew; however, for this day, a volunteer crew size of seven was used in the calculation of total time, since this was considered an ideal crew size and was comparable to the other days' sampling efforts.

The estimated biomass (kg/ha) of brook trout present in the creek was determined in each year from population estimate sites sampled by removal-depletion methods in the upper and lower reach. The angler harvest of brook trout (kg/ha) was then compared to the estimated biomass in each reach.

To estimate the percentage of the large (>150 mm) brook trout population harvested by angling, we extrapolated the number of large (>150 mm) brook trout estimated to be present in each population estimate site to the entire reach and then added this estimate to the number of large (>150 mm) brook trout harvested from that reach prior to the electrofishing date. This roughly estimated the number of large (> 150 mm) brook trout present at the start of each angling season, and was then compared to the number of large (>150 mm) brook trout harvested during the entire angling season in that reach.

2.4 Hybrids

All brook trout x bull trout hybrids angled by the volunteer coordinators and captured during the one-pass electrofishing were harvested. Anglers were instructed to not harvest hybrids, so as to reduce the risk of bull trout being mistakenly harvested as hybrids; however, some hybrids were harvested by the more experienced anglers.

Brook trout x bull trout hybrids were identified in the field based primarily on the presence of pale spots or faint black markings on the dorsal fin and faint worm-like vermiculations on the dorsal surface. Genetic analyses conducted on 61 suspected hybrids collected from Quirk Creek during the 1998–2002 period confirmed that they were all hybrids (Ryan Popowich personal communication). Hybrids were counted as brook trout in the analyses of angling and electrofishing data. For a discussion of hybrid abundance and distribution, refer to Earle et al. (2007).

3.0 RESULTS AND DISCUSSION

3.1 Angling

The fish identification key proved to be effective in teaching anglers how to identify fish, considering that only 15 (0.2%) of the 8886 fish harvested by anglers participating in the project were not brook trout. This clearly indicates that the fish ID testing of all anglers as a condition of participation was very effective in reducing misidentification and accidental harvest of fish.

Average annual catch rate for brook trout in the upper reach remained high (2.2–2.5 fish/h) during the first three years of the study, but declined to 0.5 fish/h by 2006 (Table 1). In contrast, catch rates for brook trout in the lower reach changed relatively little, ranging from 0.9 to 1.8 fish/h. Aggregate catch rates in both reaches were generally about 1.0 fish/h higher than for brook trout alone (Table 1).

While the percentage of brook trout in the angler catch in the upper reach declined from 72% in 1998 to 27% in 2006, it remained virtually unchanged (63–65%) in the lower reach until 2004 when it declined to 30% (Table 1). Since 2004, it has gradually increased to 45%. In the upper reach, the substantial decline in relative abundance of brook trout observed in the angling data was not supported by the electrofishing data. At the upper population estimate site, brook trout decreased in relative abundance from 91 to 58%, from 2002 to 2005; however, with the exception of 2005, brook trout generally accounted for up to or greater than 70% of the catch over the course of the study. Furthermore, the decline observed in 2005 did not continue into 2006, as brook trout increased to 73% of the electrofishing catch (Earle et al. 2007). At the lower population estimate site, the percent composition of brook trout also decreased in 2003/2004, however, since then it increased for the third consecutive year from 43 to 77%. The latter value represents a considerable increase over those observed in the last three years in the angling catch of the lower reach.

The number of hours fished on supervised outings has declined substantially since initiation of unsupervised outings in 2001 (Figure 2). With the exception of 2006, the number of hours fished has been consistently higher on supervised outings. During the 2001 to 2003 period, the decline in hours fished on supervised outings, in conjunction with the higher catch rates of anglers on unsupervised outings (Figure 3), resulted in an increase in the relative importance of unsupervised outings for brook trout harvest in both reaches (Figure 4). By 2006, about 70% of all brook trout harvested in the lower reach were taken by anglers on unsupervised outings. In the upper reach, no brook trout have been harvested by anglers on unsupervised outings since 2003, because no unsupervised outings occurred in the upper reach during this period. This was primarily because greater effort is required to access the upper reach without the vehicle assistance provided during the supervised outings and because another road accessing the upper creek, which was previously vehicle accessible to the public, was reclaimed in late 2001.

Fishing effort peaked at 403 h/ha in the upper reach in 1999 and 324 h/ha in the lower reach in 2000 (Figures 5 and 6). Since then, fishing effort has generally been higher in the lower reach, but has declined substantially in both reaches. Although still low, relative to the first three years of the study, effort in the lower reach in 2006 showed an increase over the previous three years. Brook trout harvest rates (fish/ha) closely mirrored the effort in both reaches (Figures 5 and 6).

Harvest rates peaked at 868 brook trout/ha (83.1 kg/ha) in the upper reach in 1999 and 539 brook trout/ha (55.7 kg/ha) in the lower reach in 2000 (Table 2). In terms of linear stream distance, this equates to a high of 218 brook trout/km (21 kg/km) in the upper reach, and 266 brook trout/km (27 kg/km) in the lower reach (Table 2). Since then, harvest rates have declined substantially in both reaches to a low of 10 brook trout/ha (1.8 kg/ha) in the upper reach in 2006, but, with the exception of 2004 and 2005, have been greater in the lower reach since 2001 (Table 2).

Although a relatively sharp decline occurred in the mean length of brook trout harvested in the lower reach in 2001, the mean length has changed relatively little over the study, ranging from 173 to 208 mm during the 1998–2005 period (Figure 7). The sharp increase in mean length of brook trout harvested in the upper reach in 2006 should be viewed with caution, as it is based on a small sample size of only 17 fish.

Only 4% of the angler-caught brook trout in the upper reach were longer than 250 mm, compared to 32% of the bull trout and 23% of the cutthroat trout (Table 3). The relationship was similar in the lower reach, where only 6% of the angler-caught brook trout were longer than 250 mm, compared to 25% of the bull trout and 24% of the cutthroat trout. Based on their larger size and higher catchability, bull trout and cutthroat trout have the potential to provide a better quality fishery in Quirk Creek. Paul et al. (2003) determined that the catchability of similar-sized bull trout and cutthroat trout was 2.5-fold greater than for brook trout. This higher catchability, however, could prevent a recovery of the native trout population. Using a model developed with data from the Quirk Creek project, Paul et al. (2003), calculated that bull trout and cutthroat trout populations in the upper reach would be extinct within five years at a hooking mortality rate of 10% and an angler effort of 656 angler-hours/year — equivalent to the angler effort in 1999. At hooking mortality rates of 2.5 and 5%, they could still decline.

The minimum size of brook trout vulnerable to angling was generally in the 120 to 130 mm range, although fish as small as 79 mm were caught by angling (Figures 8 and 9). Although angler harvest appeared to have little impact on the size distribution of angled brook trout in the upper reach during the first three years of the study, the shift in size distribution of angled brook trout in the lower reach in 2001 suggests that the initiation of harvest in the lower reach the previous year may have had an effect on the population.

Since bull trout and cutthroat trout were measured in 5-cm size classes, their length frequencies are presented according to these categories. Bull trout size distribution appears to have changed little in the upper reach, with fish in the 20 to 25 cm size range being most frequently caught (Figure 10). The proportion of large bull trout in the catch appears to have increased in the upper reach since 2003 (Figure 11), possibly reflecting poor recruitment since then. Cutthroat trout captured in the upper reach were most frequently in the 20 to 25 cm range (Figure 12). In the lower reach, cutthroat trout in the 20 to 25 cm size range were dominant in the first two years of the study; however, smaller (10-15 cm) fish dominated the catch from 2002 to 2004 (Figure 13). Since then, the proportion of large cutthroat trout has increased in the catch, possibly reflecting the emergence of a strong year class. This was supported by length frequency data from the lower population estimate site which showed a strong young-of-the-year class in 2003 (Earle et al. 2007).

By adding each removal-method estimate to the number of brook trout harvested prior to the electrofishing date, we extrapolated the number of large (> 150 mm) brook trout present at the start of each fishing season. The estimated percentage of large (>150 mm) brook trout in the population harvested by angling indicated that the peak was attained in the early years of the study in the upper reach and has declined in both numbers and biomass through to 2006 (Figures 14 and 15). In the lower reach, the numbers and biomass peaked in 2003 and then declined for the two subsequent years. In 2006, however, it was estimated that 58 and 69% of the number and biomass, respectively of large brook trout were removed from the lower reach by angling. This increase also coincided with an increase in the number of hours fished relative to the three previous years. The data indicated that a greater percentage by both number and biomass were removed from the lower reach compared to the upper reach in each year sampled. In comparison, in the upper reach, the estimated percentage harvested has not exceeded 23% by either number or biomass in the last five years. The difference between lower and upper reaches is partly explained by the greater effort expended in the lower reach.

In comparison, Meyer et al. (2006), estimated average removal efficiency by electrofishing as 89% for age-1 and older brook trout in a small rocky mountain stream. In spite of this high removal efficiency, electrofishing was unsuccessful at removing brook trout and did not increase the number of native salmonids during the project. The authors suggested that brook trout populations in small streams appear to be well adapted for withstanding high rates of mortality, whether from natural causes, angling exploitation, or electrofishing removals.

Biomass estimates for all sizes of brook trout (kg/ha) were determined from electrofishing population estimates in each of the lower and upper reaches. In the upper reach, the highest angler harvest relative to estimated biomass present occurred in the first three years of the study, with a maximum of 79% of estimated biomass removed in 1999 (Figure 16). This rapidly declined in direct combination with the angler effort to a low of only 4% of biomass removed in 2006. This figure also shows a substantial decrease in the estimated biomass in the upper reach in 2002 relative to the 1998 to 2000 period. This was followed by an increase in estimated biomass over 2002 levels from 2003 to 2006, although levels have still remained less than half of what they were at the start of the project. In the lower reach, angling effort was typically higher and this resulted in a greater biomass harvested relative to estimated biomass present (Figure 17). The maximum biomass harvested by angling relative to estimated biomass was 87% (in 2006) and otherwise ranged between 27 and 65%. Similar to the upper reach, the estimated biomass has declined substantially since the 1998–2000 period and has been at lower levels than the upper reach since 2003. In the lower reach, it therefore appears that angling has been, in part, responsible for keeping brook trout biomass at reduced levels.

Overall, high angler harvest from the upper reach from 1998–2000 and starting in 2000 in the lower reach appeared to have an effect in reducing estimated brook trout biomass in subsequent years but was insufficient to collapse the population. Larson et al. (1986) showed that selective angler harvest has the potential to be a cost-effective method for reducing densities of non-native trout in a large mountain stream. However, the authors state that the fishery has little immediate impact on the smallest size classes of fish and suggest this may not provide satisfactory results when drastic reductions in the density of non-natives, including the smaller size classes of fish, are required. In such cases, the authors suggest that electrofishing (or a combination of angling and electrofishing) is probably the most practical method to employ. In the following section, we discuss some of the results of the electrofishing component of the project and, in particular, how they relate to the angling data.

3.2 Electrofishing

With the exception of 2005, bull trout have not exceeded 100 fish/ha in either reach and numbers of bull trout captured have often been too low to obtain valid population estimates (Table 2). In 2005, bull trout population estimates attained 265 fish/ha, however, as discussed in Earle et al. (2007), it appears that this increase was due to misidentification of YOY hybrids as bull trout. Hybrid abundance greatly increased in 2006 when they comprised 12% of the catch at the upper population estimate site. Previous levels at the population estimate sites had generally not exceeded 1% of the electrofishing catch (Earle et al., 2007).

From 1987 to 1995, cutthroat trout declined from 571 to 25 fish/ha in the lower reach (Table 2). In subsequent years, cutthroat trout density exceeded that in 1995 and 1996 to a maximum of 872 fish/ha in 2003, after which time density has declined for the last three years. In the upper reach, density of cutthroat trout increased to a maximum of 935 fish/ha in 2004, followed by a decline in the last two years. Despite the decline in density since 2003 and 2004 in the lower and upper reaches, respectively, biomass of cutthroat trout has increased in the last couple of years (Table 2), reflecting an increase in large cutthroat trout at both sites.

Based on information from the population estimate sites, the brook trout population in the lower reach increased from 247 fish/ha in 1987, to a high of 2804 fish/ha in 2000 (Table 2). The density declined considerably after 2000 and was in fact, lower than the cutthroat trout density in 2003 and 2004. Since then, however, brook trout density has been high relative to the other two species. Brook trout density was higher in the upper reach than in the lower reach over the course of the study and peaked in 2000 at 3473 fish/ha. Brook trout density in the upper reach has remained considerably higher than that of cutthroat trout and bull trout over the 1998–2006 period. Brook trout biomass in the upper reach was highest at the start of the study (117 kg/ha in 2000) and by 2006, had declined to about half the levels in the 1998–2000 period. In the lower reach, brook trout biomass peaked in 1998 (88 kg/ha) and declined to only 13 kg/ha in 2006.

The harvest of 662 and 868 brook trout/ha in the upper reach in 1998 and 1999, respectively, appeared to have very little impact on the density of large (> 150 mm) brook trout in the upper reach relative to the lower reach, which served as a control section until 2000 (Table 2; Figure 18). Subsequent to initiation of brook trout harvest in the lower reach in 2000, the density of large (> 150 mm) brook trout in the lower reach declined by 93% to 50 fish/ha in 2004 — the lowest level recorded since the study was initiated (Table 2; Figure 18). In the last two years, the density in the lower reach has more than doubled relative to 2004 levels in spite of an increase in angler harvest over the same period. The density of large (> 150 mm) brook trout in the upper reach also declined over the 2002–2006 period relative to the early years; however, a decline in fishing effort and angler harvest to a low of 10 fish/ha in 2006, has resulted in little change in the density of large brook trout in the last three years. Similar trends were observed in the biomass of large brook trout (Table 2).

It is possible that the density of large brook trout affects the survival of cutthroat trout. Larson and Moore (1985), in a study of stream populations of brook trout and rainbow trout, found that abundance of age-0 fish of either species was greatly reduced in the presence of 300 or more adults/ha of the other species. A comparable relationship may exist between brook trout and cutthroat trout in Quirk Creek, given that relatively good survival of the 1996 cutthroat trout year-class occurred when there were 219 large (> 150 mm) brook trout/ha, whereas relatively poor survival of the 2000 cutthroat trout year-class occurred when there were more than 600 large brook trout/ha (Table 2).

If density of large brook trout is a major factor in the survival of cutthroat trout fry, then recovery of the cutthroat trout population will be contingent upon preventing the adult brook trout population from increasing to previous high levels. However, this may be difficult to accomplish on the upper reach, where only 2.4% of the extrapolated population of large (> 150 mm) brook trout were harvested in 2006 compared to 58% in the more accessible lower reach, largely due to a reduction in the number of supervised outings.

A comparison of the length-frequency distributions of brook trout caught by angling and electrofishing in 1999 (Figure 19) indicated that vulnerability to angling declined below about 210 mm and that anglers were very ineffective at catching brook trout smaller than 150 mm. Brook trout <150 mm comprised 50–70% of the electrofishing catch, but only 3–11% of the brook trout harvest in the upper reach during the 1998–2000 period. Although electrofishing is less size selective than angling, data on electrofishing efficiency collected in 2006 indicated that larger fish were more effectively caught than smaller fish (Earle et al. 2007). This difference translated into an estimated percentage of brook trout biomass removed by electrofishing of only 50% for fish 71–150 mm compared to 97% of brook trout >150 mm (Earle et al. 2007).

To assess immigration of large (>150 mm) brook trout into the upper reach from the lower reach, the upper 2.5 km of the lower reach was electrofished in May 2000 and June 2001 to capture, mark, and release 750 and 92 large brook trout, respectively (Stelfox et al. 2004). Of the 750 large (> 150 mm) brook trout marked in 2000, anglers subsequently harvested 391 (52%) — 349 (46%) in 2000 and 42 (6%) in 2001. Only eight (2%) of these marked fish were taken from the upper reach — four in 2000 and four in 2001. Of the 92 large brook trout marked in 2001, anglers subsequently harvested 33 (36%) in 2001. None were taken from the upper reach. Gowan and Fausch (1996) found that movement was relatively common, with brook trout usually moving in the upstream direction during and just after runoff, and before spawning. However, in our study, upstream movement did not appear to be sufficient to mask the effects of brook trout harvest in the upper reach, since only 2% of the recaptured brook trout had immigrated into the upper reach.

A comparison of percent composition of the catch illustrated that brook trout accounted for a greater proportion of the electrofishing catch than the angling catch in both the upper and lower reaches (Figures 20 and 21). Angling underrepresented brook trout in the catch relative to the electrofishing results by 12 to 46%. Examining the angling species composition in isolation would suggest that brook trout were less abundant, and hence cutthroat trout and bull trout were more abundant, than was actually the case. Since it has been shown that the catchability of the native species in Quirk Creek was much greater than that for non-natives (Paul et al. 2003), this underscores the importance of understanding differences in species catchability and using multiple sampling methods to obtain population information.

The total biomass of brook trout caught by one-pass electrofishing in comparable sections of the upper reach from 2004 to 2006 was considerably greater than that caught by angling in the upper reach (Table 4). Total electrofishing biomass in the most productive section of the upper reach attained a maximum of 27.5 kg (section 2.6–4.7) compared to a maximum of only 12.3 kg for angling in the entire upper reach (6.5 km). In the lower reach, biomass caught by angling was generally much greater than in the upper reach and ranged between 11.4 and 35.2 kg for the 2004–2006 period. In 2000, one-pass electrofishing over a 2.7 km section of the lower reach resulted in a total brook trout biomass of 79.4 kg. It is therefore evident that the electrofishing conducted as part of this project, removed a much greater biomass of brook trout than angling. However, the biomass numbers do not take into account the effort expended in each activity. Angling requires a minimum of one person, whereas electrofishing is more labour intensive. A discussion of the catch-per-unit effort (CPUE) for both angling and electrofishing is provided below.

A comparison of brook trout CPUE indicated that electrofishing resulted in both a higher number and biomass of brook trout caught per hour when compared to angling (Table 5). The amount of processing associated with the sampling had a substantial effect on the CPUE. For example, the greatest CPUE (34 fish/h or 1.37 kg/h) was achieved during electrofishing in 2003 when brook trout were measured, but not weighed, and released. In 2005 and 2006, the CPUE dropped to 6.6–6.9 fish/h (0.23–0.31 kg/h) when brook trout were killed (both years) and weighed (2006 only). These CPUE values were, however, higher than in 2004 when fish were weighed and killed and more effort was expended to catch young-of-the-year. It was evident that the angling CPUE was higher for unsupervised rather than supervised outings in terms of both number of fish and biomass caught per hour (Table 5). The highest number per hour CPUE for angling occurred for unsupervised outings in the lower reach in 2001 (2.96 fish/h or 0.17 kg/h); the highest biomass CPUE was 0.2 kg/h in 2003. This latter biomass CPUE was similar to those values encountered for electrofishing in 2006 and in the middle section of the creek in 2004. This suggested that although the number of fish caught per hour can be considerably higher during electrofishing, the angling biomass per hour can be comparable, in particular for unsupervised outings. The issue, however, is maintaining a high level of angling effort over successive years. This can be difficult as it depends on weather and stream conditions and maintaining a high degree of interest in the project.

4.0 CONCLUSIONS

Angling, in particular unsupervised outings, appears to be sufficient on the lower reach to keep the number of large brook trout at a relatively low level. Based on the fishing pressure and harvest in 2006, it appears that about 100 angler-h/ha may be sufficient to keep the brook trout population from rebounding to previous high levels, whereas it took about 200 to 300 angler-h/ha at the start of the study to reduce the population, when the number of large (>150 mm) brook trout was about four to six times higher. The data from this project also suggest that it is necessary to harvest at least 50% of the large (>150 mm) brook trout population to have an effect on that population.

For the more remote upper reach, however, we have been unsuccessful in getting anglers (especially on unsupervised outings) to exert sufficient pressure and to harvest enough brook trout, to substantially reduce the population and maintain it at levels comparable to the lower reach. For this reason, brook trout removal using one-pass electrofishing was started in the upper reach in 2004.

The approach used in the suppression project has the potential to work, provided that the streams selected are readily accessible by anglers (relatively close to a road) and sufficient angling pressure can be exerted over multiple years.

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Personal Communication

Ryan Popowich. Fisheries Biologist. Applied Aquatic Research Ltd. Calgary, Alberta.

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6.0 COLLECTION OF FIGURES

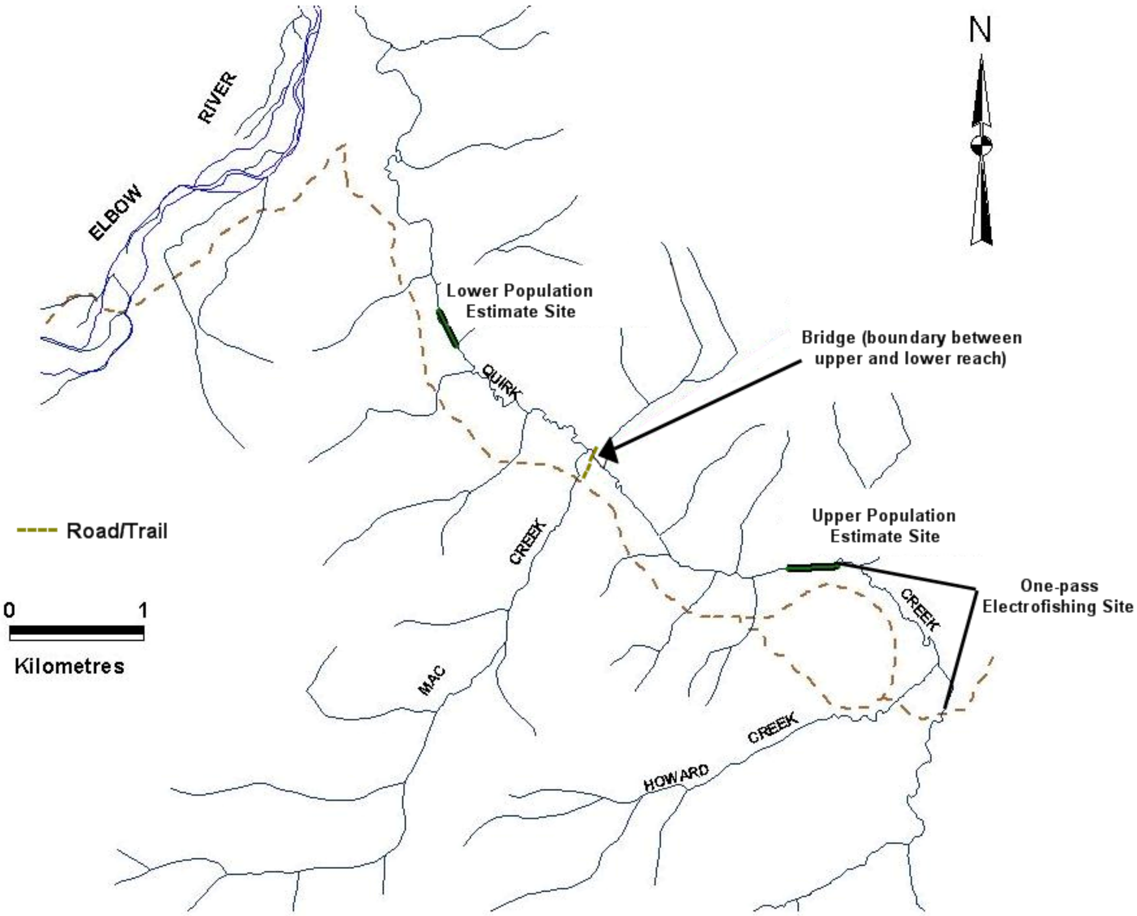

Figure 1 – Quirk Creek study area and location of sampling sites.

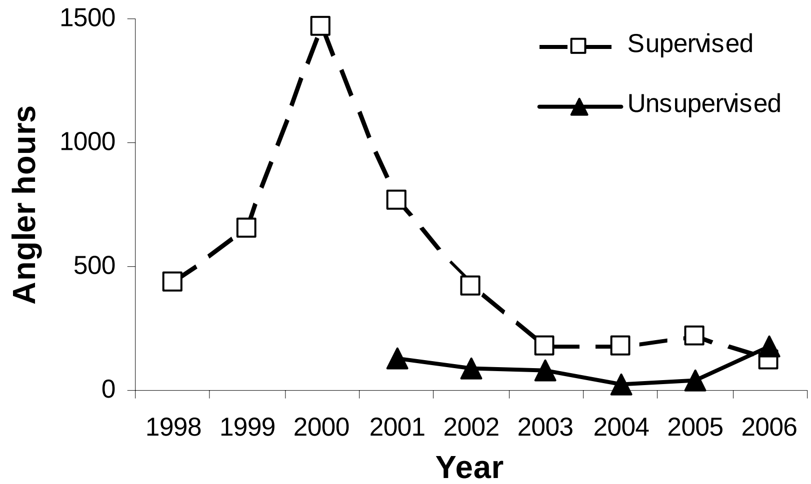

Figure 2 – Number of hours fished by anglers on supervised and unsupervised outings on Quirk Creek.

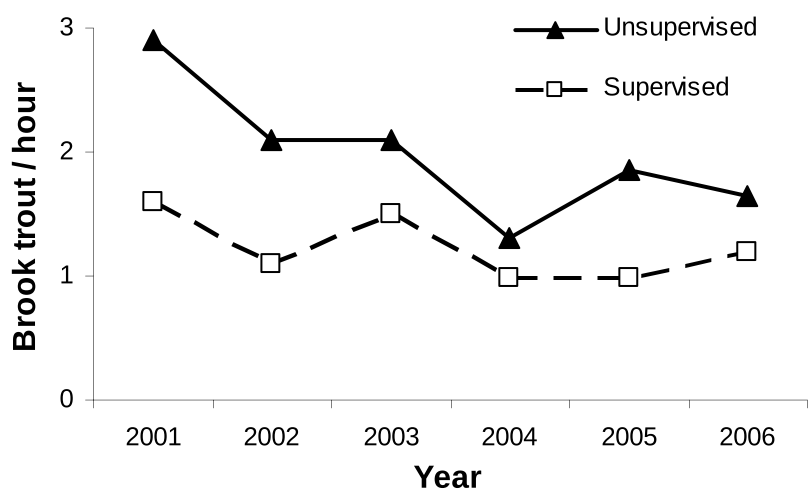

Figure 3 – Brook trout catch rates for anglers on supervised and unsupervised outings on Quirk Creek.

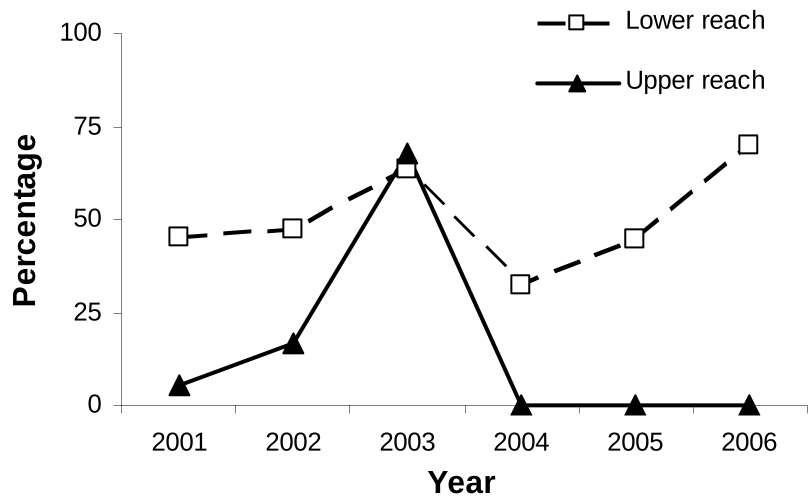

Figure 4 – Percentage of brook trout harvested by anglers on unsupervised outings on Quirk Creek. No outings occurred in 2004–2006 on the upper reach.

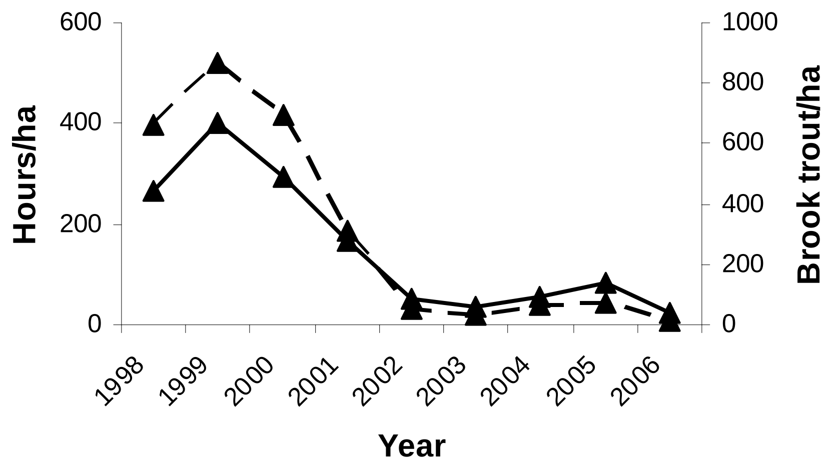

Figure 5 – Fishing effort (solid lines) and brook trout harvest rates (dashed lines) in the upper reach of Quirk Creek.

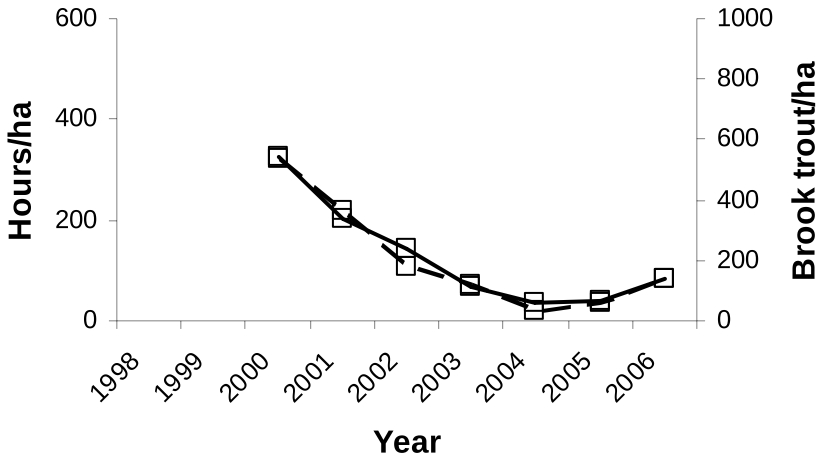

Figure 6 – Fishing effort (solid lines) and brook trout harvest rates (dashed lines) in the lower reach of Quirk Creek.

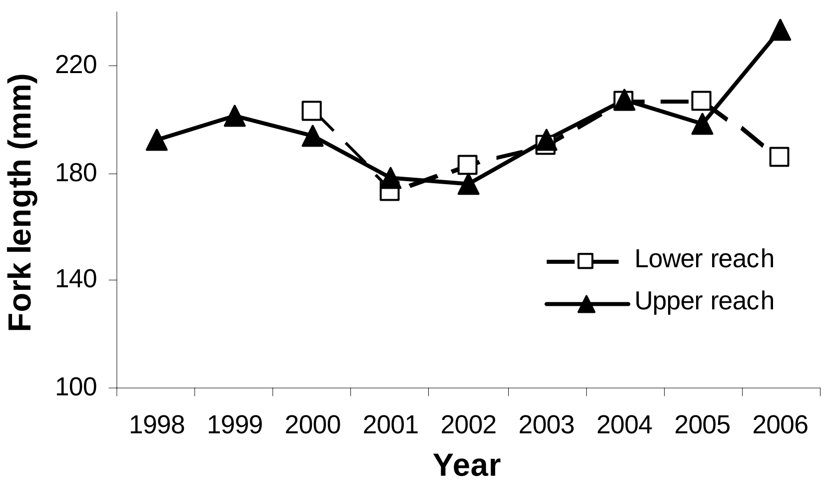

Figure 7 – Mean lengths of brook trout harvested by anglers from the upper and lower reaches of Quirk Creek.

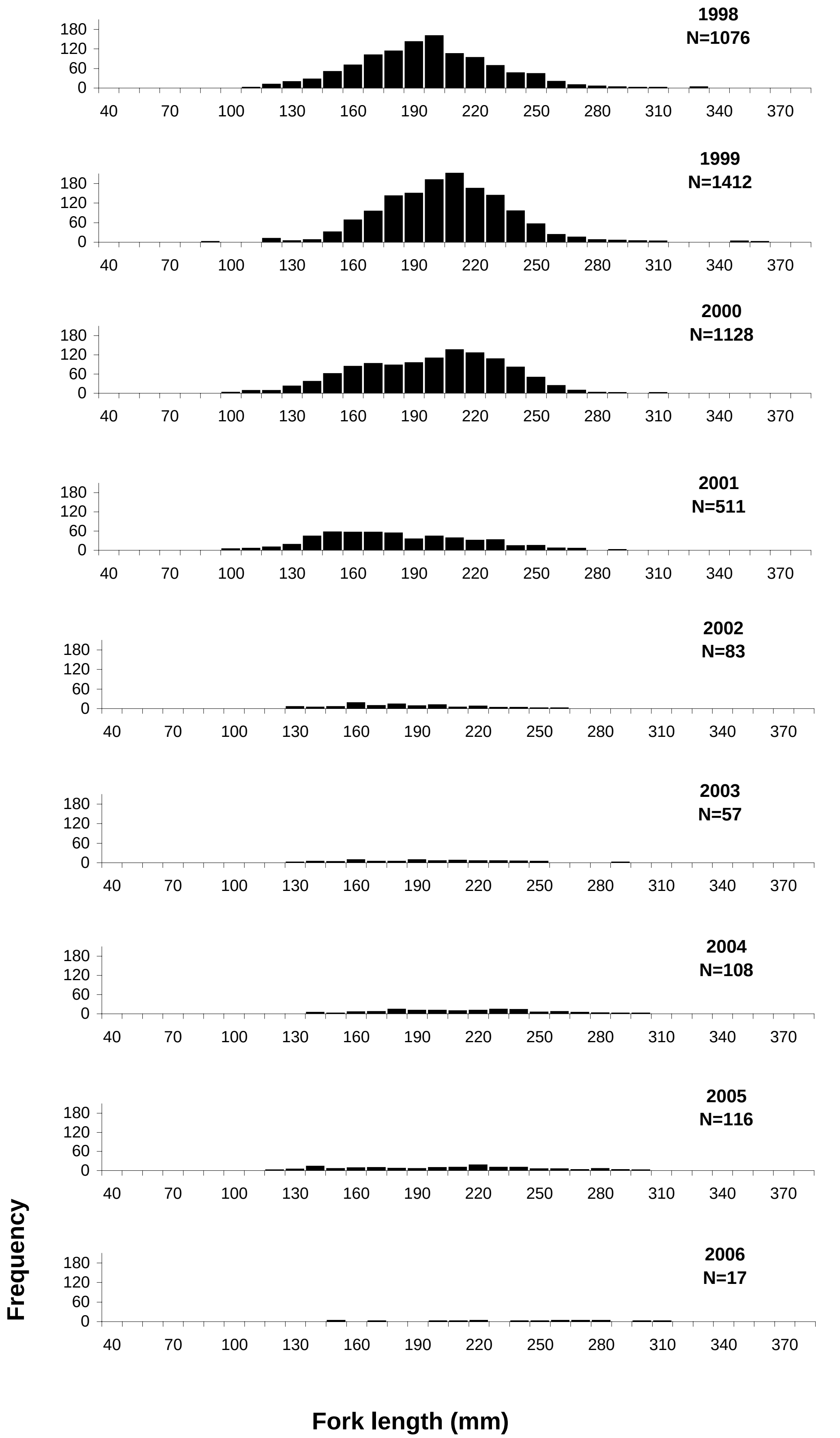

Figure 8 – Length frequencies for brook trout harvested by anglers in the upper reach of Quirk Creek, 1998–2006.

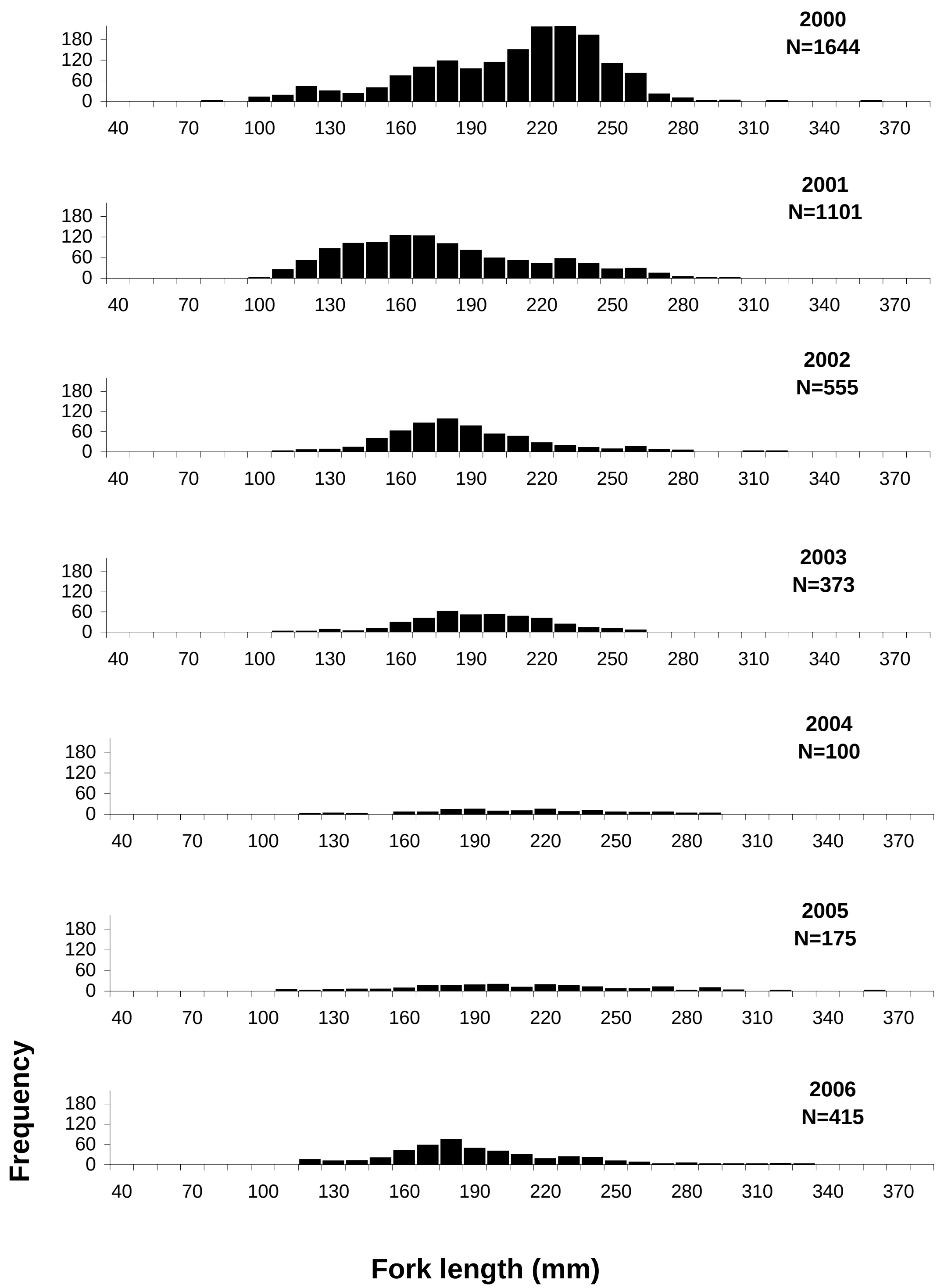

Figure 9 – Length frequencies for brook trout harvested by anglers in the lower reach of Quirk Creek, 2000–2006.

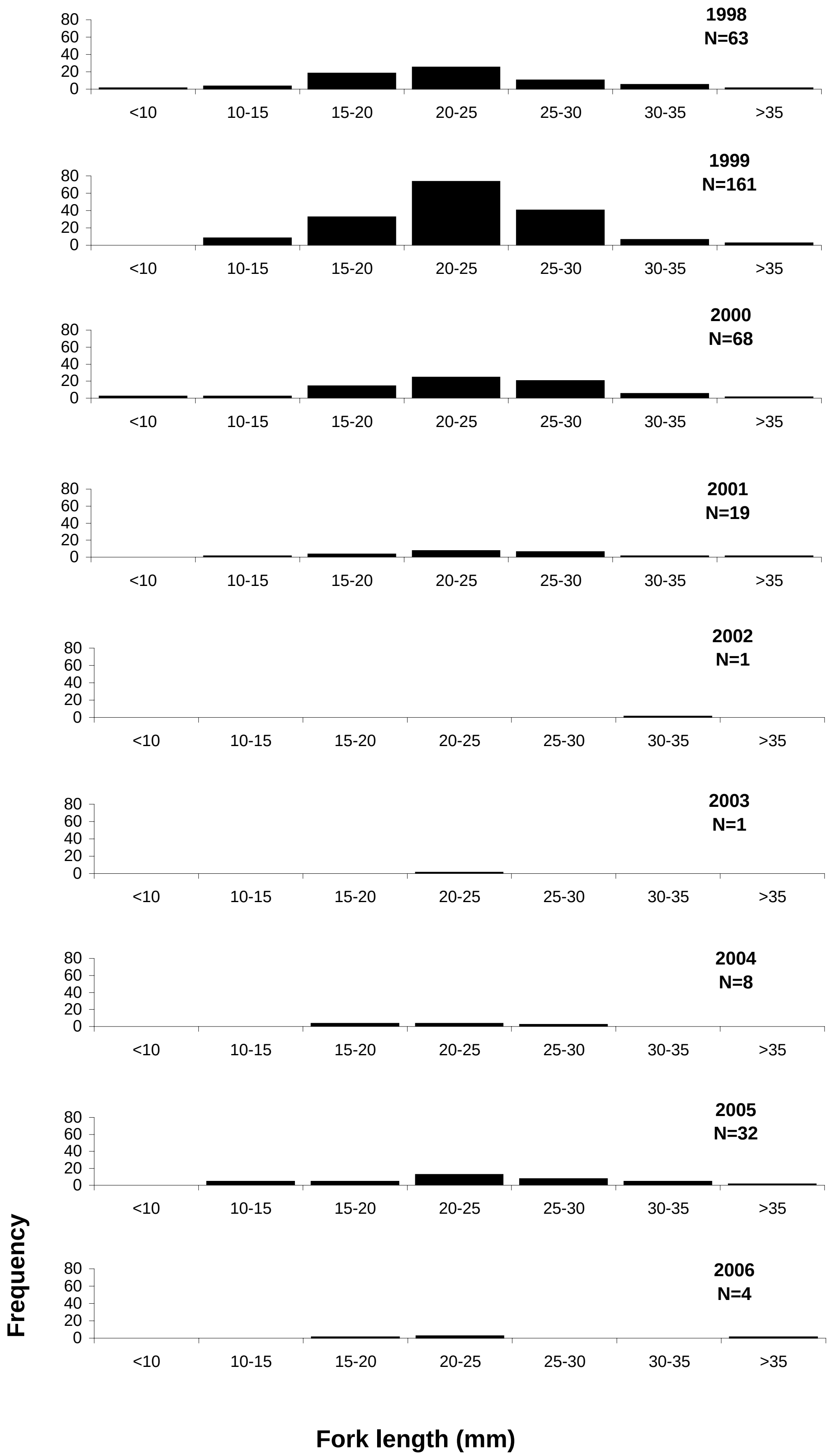

Figure 10 – Length frequencies for bull trout captured by anglers in the upper reach of Quirk Creek, 1998–2006.

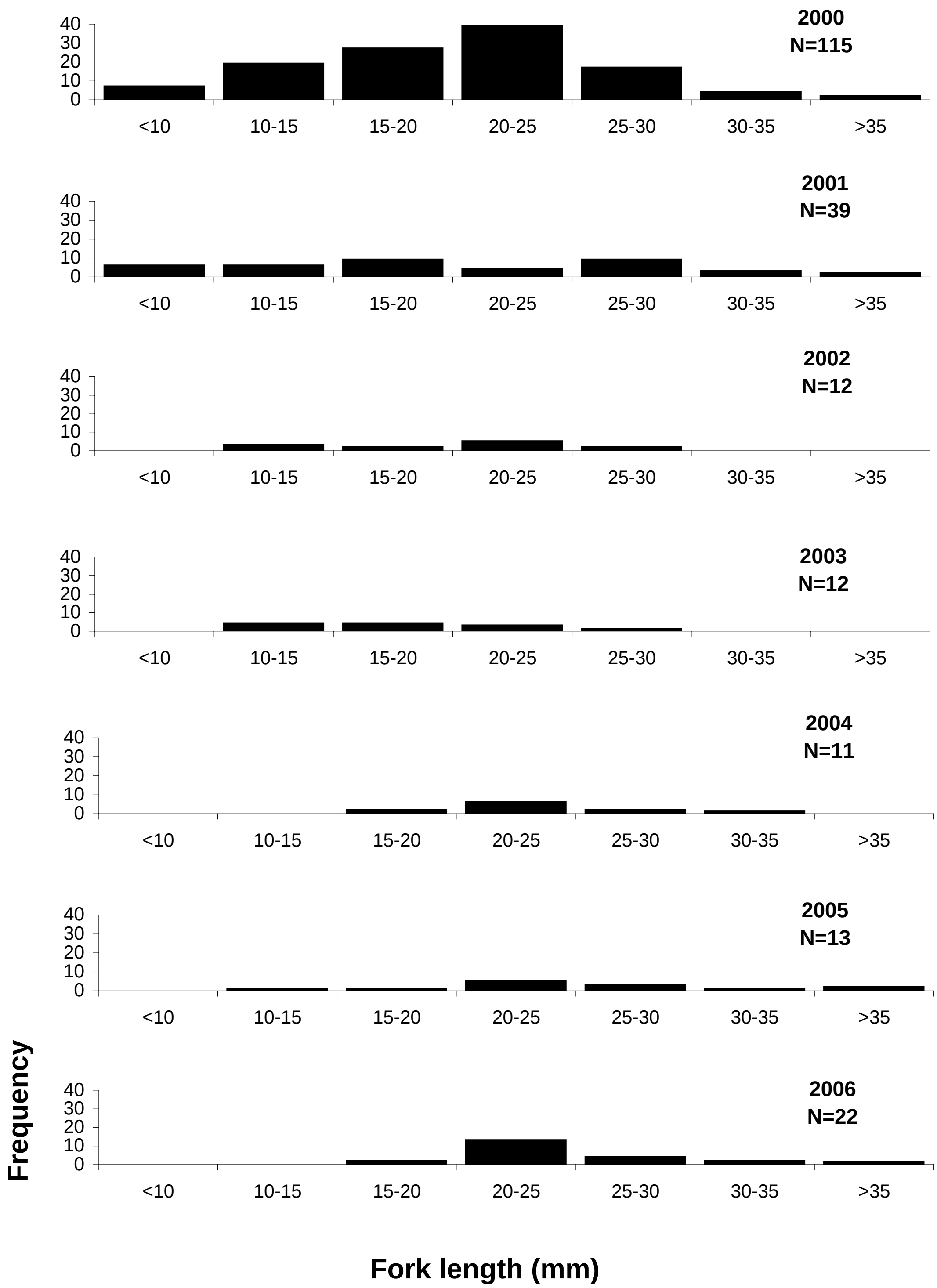

Figure 11 – Length frequencies for bull trout captured by anglers in the lower reach of Quirk Creek, 2000–2006.

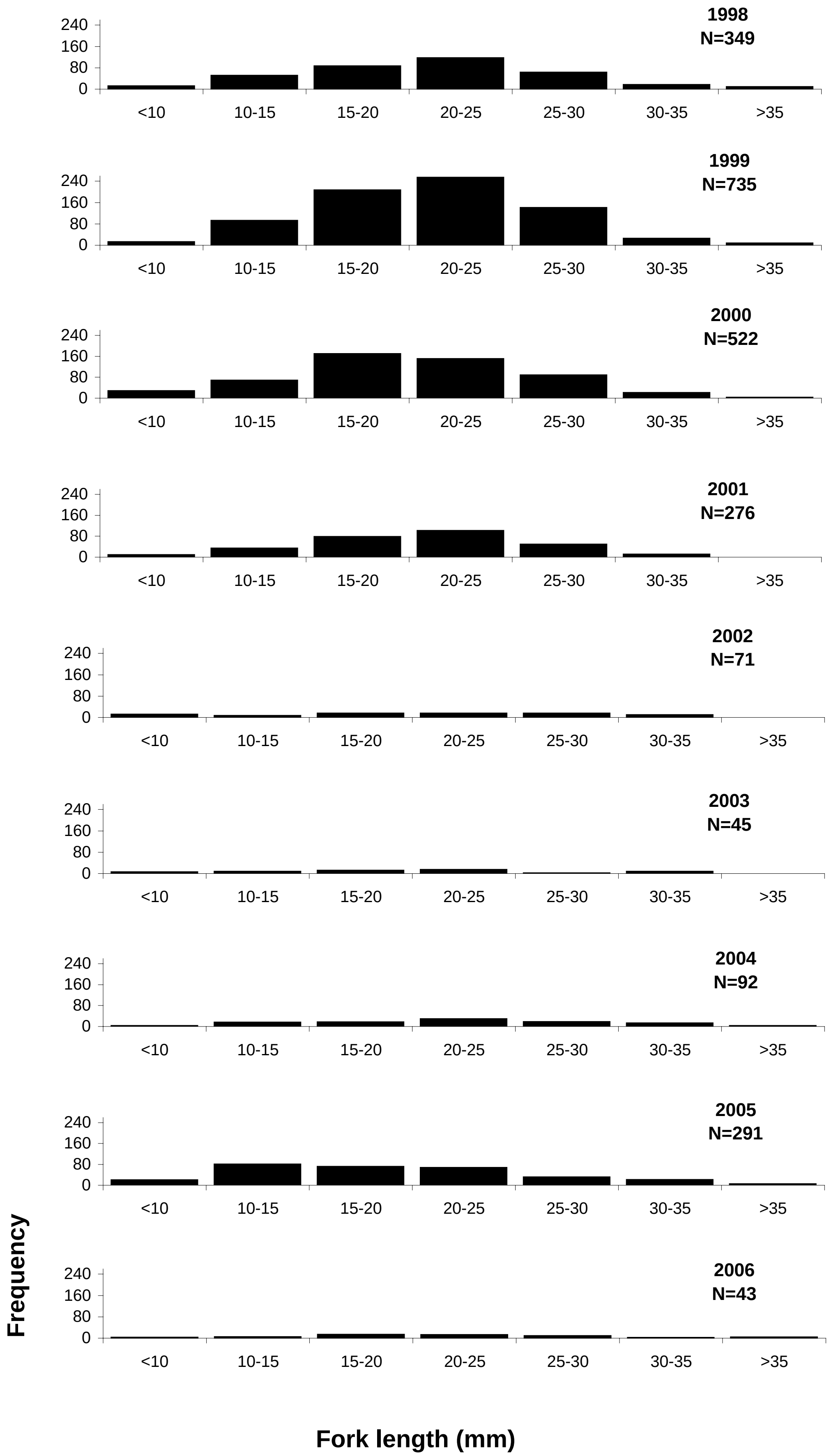

Figure 12 – Length frequencies for cutthroat trout captured by anglers in the upper reach of Quirk Creek, 1998–2006.

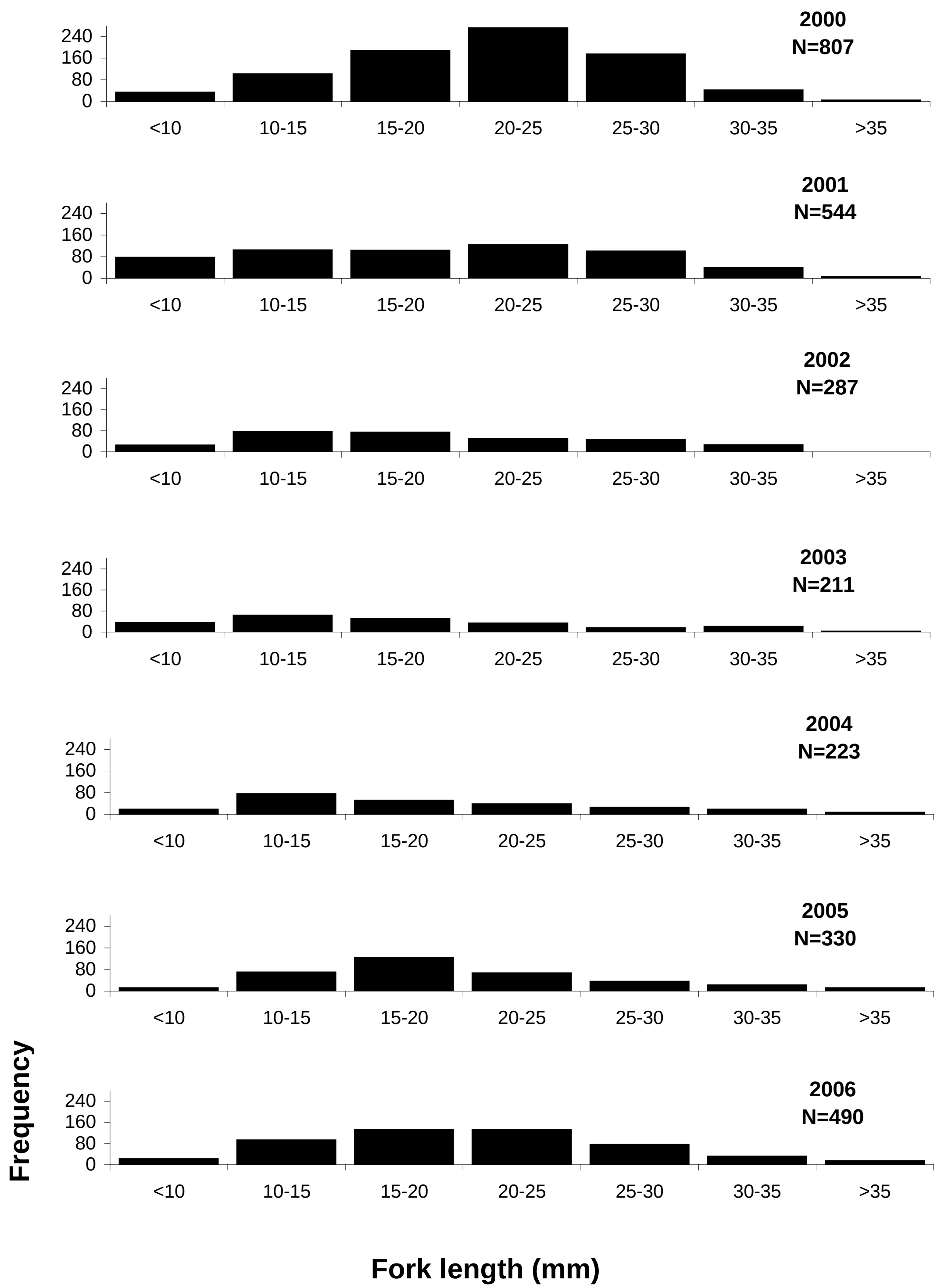

Figure 13 – Length frequencies for cutthroat trout captured by anglers in the lower reach of Quirk Creek, 2000–2006.

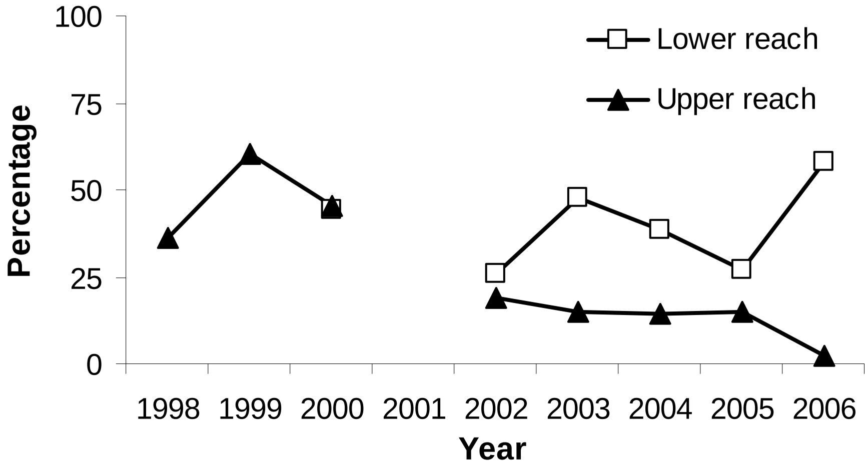

Figure 14 – Estimated percentage by number of the large (>150 mm) brook trout population harvested by angling on the lower and upper reaches of Quirk Creek.

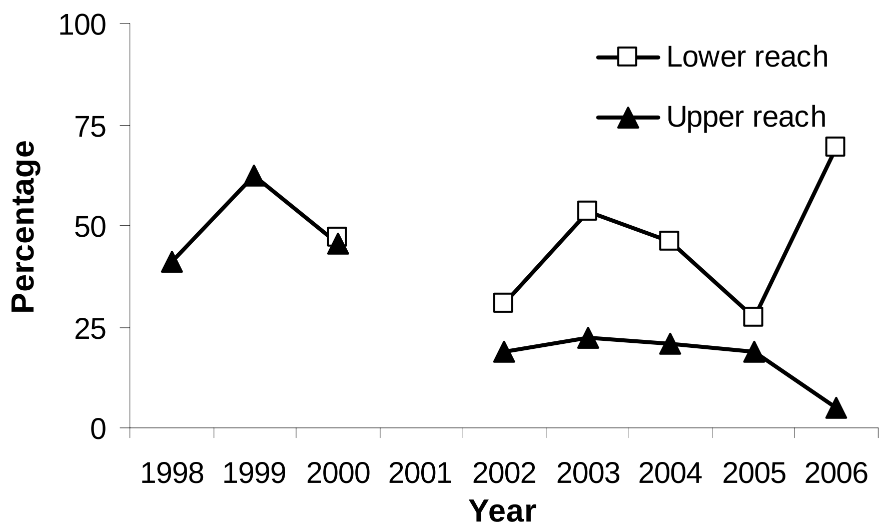

Figure 15 – Estimated percentage by biomass of the large (>150 mm) brook trout population harvested by angling on the lower and upper reaches of Quirk Creek.

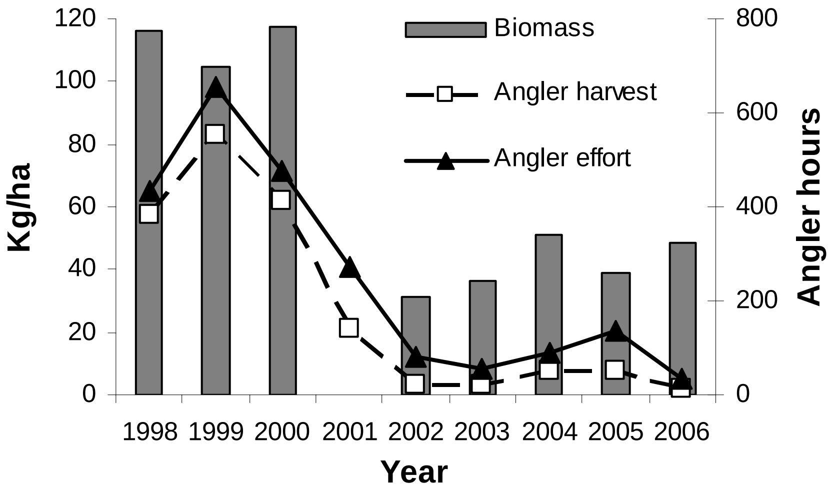

Figure 16 – Estimated biomass and harvest of brook trout in the upper reach of Quirk Creek.

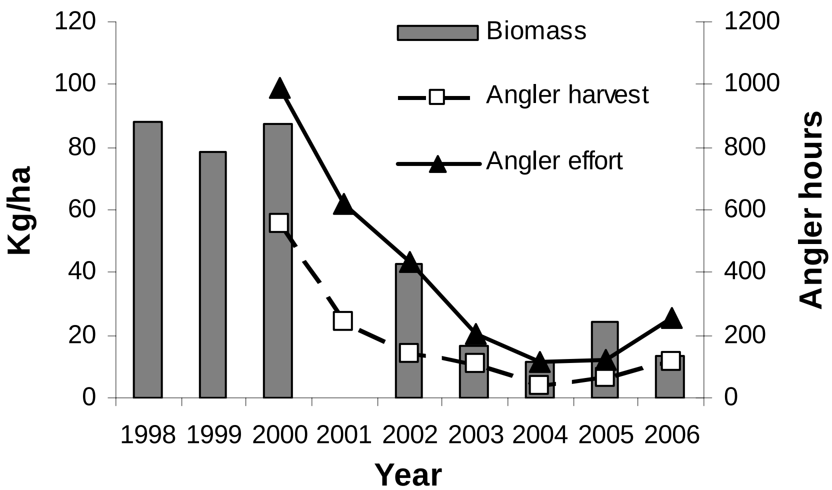

Figure 17 – Estimated biomass and harvest of brook trout in the lower reach of Quirk Creek.

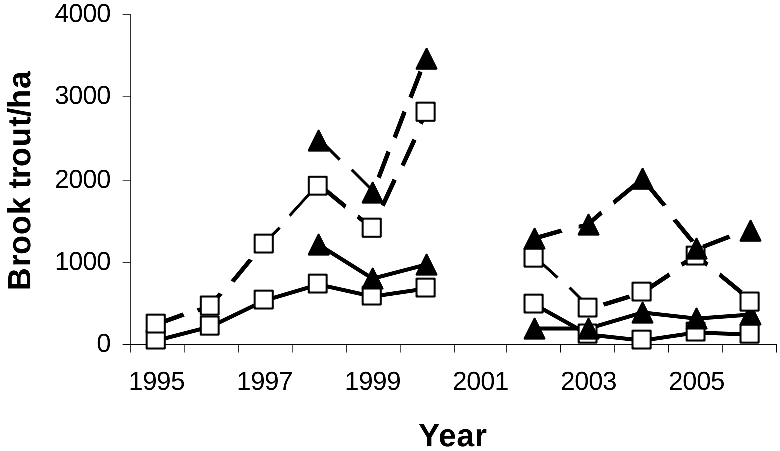

Figure 18 – Densities of large (> 150 mm) brook trout (solid lines) and all brook trout (dashed lines) in the upper (triangles) and lower (squares) reaches of Quirk Creek.

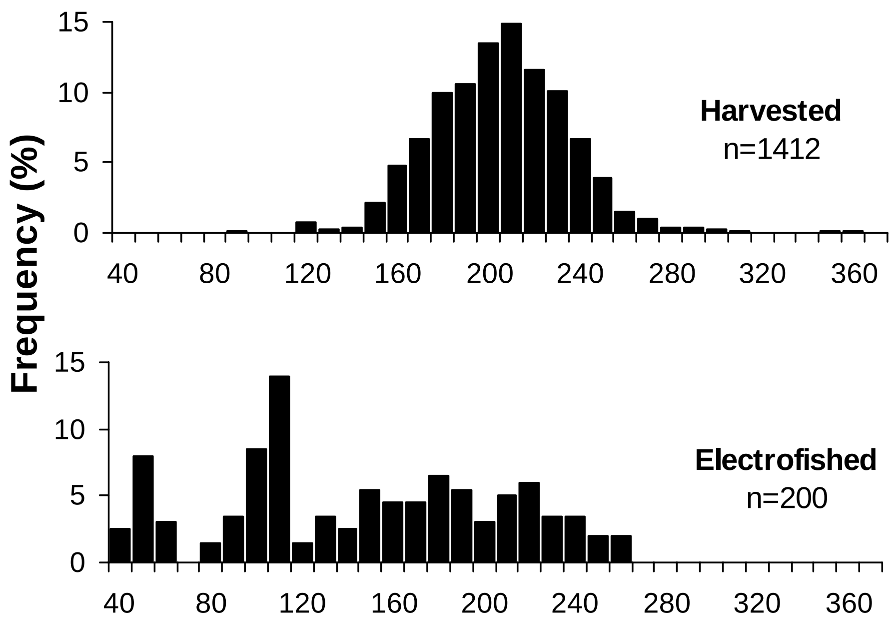

Figure 19 – Size distribution of brook trout harvested in 1999 and electrofished on 16 August 1999 from the upper reach of Quirk Creek.

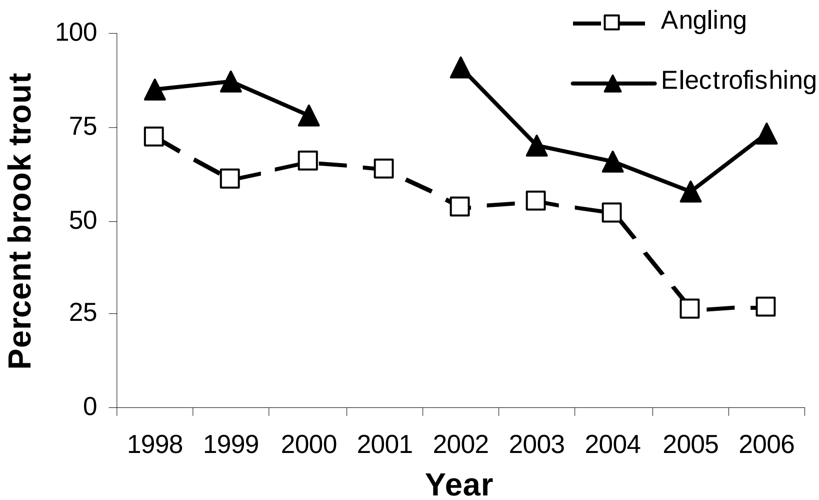

Figure 20 – Percent composition of brook trout in the angling and electrofishing catch in the upper reach of Quirk Creek.

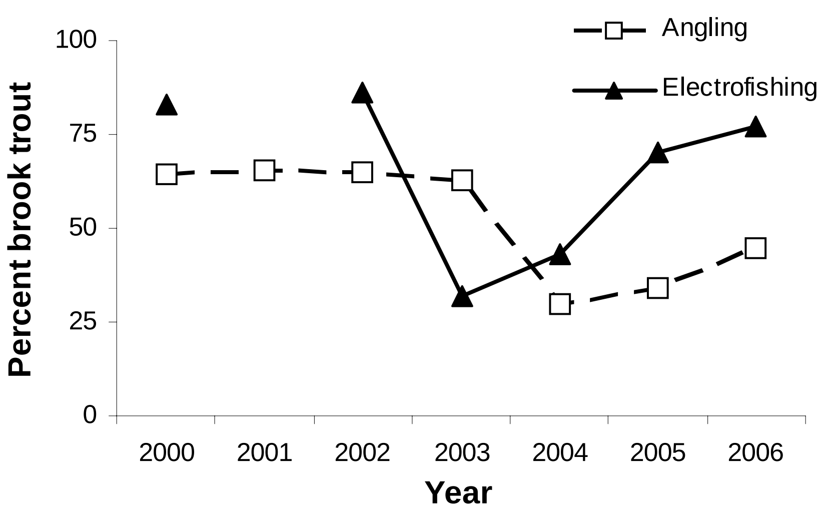

Figure 21 – Percent composition of brook trout in the angling and electrofishing catch in the lower reach of Quirk Creek.

7.0 COLLECTION OF TABLES

Table 1 – Angling data summary for Quirk Creek, 1998-2006. All brook trout were harvested.

Year	Number of anglers	Number of fish caught: Bull trout	Cutthroat trout	Brook trout	Total	Number of hours fished	Catch rate: fish/h	BKTR/h	Percentage of catch: Bull trout	Cutthroat trout	Brook trout
Upper reach											
1998	97	63	349	1076	1488	436.0	3.4	2.5	4.2	23.5	72.3
1999	146	161	735	1412	2308	655.5	3.5	2.2	7.0	31.8	61.2
2000	111	68	522	1128	1718	477.3	3.6	2.4	4.0	30.4	65.7
2001	70	19	276	511	806	271.3	3.0	1.9	2.4	34.2	63.4
2002	26	1	71	83	155	82.5	1.9	1.0	0.6	45.8	53.5
2003	15	1	45	57	103	55.5	1.9	1.0	1.0	43.7	55.3
2004	26	8	92	108	208	88.5	2.4	1.2	3.8	44.2	51.9
2005	34	32	291	116	439	134.5	3.3	0.9	7.3	66.3	26.4
2006	7	4	43	17	64	36.0	1.8	0.5	6.3	67.2	26.6
Upper total	**532**	**357**	**2424**	**4508**	**7289**	**2237.1**	**3.3**	**2.0**	**4.9**	**33.3**	**61.8**
Lower reach											
2000	204	115	807	1644	2566	988.8	2.6	1.7	4.5	31.4	64.1
2001	142	39	544	1101	1684	619.0	2.7	1.8	2.3	32.3	65.4
2002	119	12	287	555	854	432.5	2.0	1.3	1.4	33.6	65.0
2003	56	12	211	373	596	206.0	2.9	1.8	2.0	35.4	62.6
2004	30	11	223	100	334	113.5	2.9	0.9	3.3	66.8	29.9
2005	31	13	330	175	518	123.5	4.2	1.4	2.5	63.7	33.8
2006	38	22	490	415	927	258.3	3.6	1.6	2.4	52.9	44.8
Lower total	**620**	**224**	**2892**	**4363**	**7479**	**2741.6**	**2.7**	**1.6**	**3.0**	**38.7**	**58.3**
Grand total	**1152**	**581**	**5316**	**8871**	**14768**	**4978.7**	**3.0**	**1.8**	**3.9**	**36.0**	**60.1**

Table 2 – Fish population estimates for, and brook trout known to be harvested from, Quirk Creek. With the exception of the mark-recapture estimate in 1987, all population estimates were obtained by the removal method.

		Trout population estimates					Brook trout
					Brook		
Reach	Year	Total	Bull	Cutthroat	All	>150 mm	harvested
		Number per hectare					
Upper	1998	2900	81	335	2485	1204	662
	1999	2096	42	212	1842	808	868
	2000	4431	50	908	3473	981	694
	2001						314
	2002	1373	[b]	92	1281	204	51
	2003	2169	100	604	1465	192	35
	2004	3008	62	935	2012	377	66
	2005	2050	265	619	1165	327	71
	2006	1900	85	438	1377	369	10
Lower	1987[a]	874	56	571	247	128	
	1995	263	[b]	25	238	50	
	1996	484	[b]	31	453	219	
	1997	1638	25	406	1206	538	
	1998	2258	47	303	1908	731	
	1999	1605	[b]	197	1409	584	
	2000	3337	34	499	2804	673	539
	2001						361
	2002	1219	[b]	169	1050	478	182
	2003	1369	63	872	434	131	122
	2004	1384	88	659	638	50	33
	2005	1500	63	369	1069	138	57
	2006	656	31	113	513	113	136
		Kilograms per hectare					
Upper	1998	141.5	8.8	16.5	116.2	92.3	57.2
	1999	123.8	3.5	15.4	105.0	75.0	83.1
	2000	145.4	5.4	22.7	117.3	92.7	61.6
	2001						21.2
	2002	33.1	[b]	1.9	31.2	14.6	3.4
	2003	44.2	2.3	5.8	36.2	12.7	3.5
	2004	70.0	1.5	17.3	51.2	29.2	7.6
	2005	84.6	8.1	37.7	38.8	30.4	7.5
	2006	88.8	9.2	30.8	48.8	32.3	1.8
Lower	1987	73.7	4.6	35.7	33.4	27.5	
	1995	7.7	[b]	0.5	7.2	2.8	
	1996	23.1	[b]	2.8	20.3	15.6	
	1997	64.1	1.6	9.7	52.8	41.9	
	1998	99.9	2.2	9.7	88.1	70.9	
	1999	95.6	[b]	17.2	78.4	63.7	
	2000	110.9	4.4	19.3	87.3	66.7	55.7
	2001						24.3
	2002	51.9	[b]	9.4	42.5	30.6	13.8
	2003	28.8	1.6	10.9	16.3	9.4	10.6
	2004	29.7	1.6	16.9	11.3	4.4	3.8
	2005	45.0	3.8	17.2	24.1	17.2	6.6
	2006	31.3	2.5	15.3	13.4	7.2	11.6

continued

[a] *Does not include age-0 fish.*

[b] *Too few bull trout were captured to obtain an estimate.*

Table 2. Concluded.

Reach	Year	Trout population estimates: Total	Bull	Cutthroat	Brook: All	Brook: >150 mm	Brook trout harvested
				Number per kilometre			
Upper	1998	754	21	87	646	316	166
	1999	545	11	55	479	211	218
	2000	1152	13	236	903	255	174
	2001						79
	2002	357	[b]	24	333	53	13
	2003	564	26	157	381	58	9
	2004	782	16	243	523	98	17
	2005	533	69	161	303	82	18
	2006	494	22	114	358	95	3
Lower	1987	280 [a]	18	183	79 [a]	41	
	1995	84	[b]	8	76	16	
	1996	155	[b]	10	145	71	
	1997	524	8	130	386	171	
	1998	723	15	97	611	234	
	1999	514	[b]	63	451	189	
	2000	1071	11	160	900	219	266
	2001						178
	2002	390	[b]	54	336	154	90
	2003	438	20	279	139	50	60
	2004	613	28	211	204	16	16
	2005	480	20	118	342	42	28
	2006	210	10	36	164	36	67
				Kilograms per kilometre			
Upper	1998	36.8	2.3	4.3	30.2	24.2	14
	1999	32.2	0.9	4.0	27.3	19.5	21
	2000	37.8	1.4	5.9	30.5	24.1	15
	2001						5
	2002	8.6	[b]	0.5	8.1	3.7	1
	2003	11.5	0.6	1.5	9.4	4.4	1
	2004	18.2	0.4	4.5	13.3	7.8	2
	2005	22.0	2.1	9.8	10.1	7.6	2
	2006	23.1	2.4	8.0	12.7	7.9	0.4
Lower	1987	23.6	1.5	11.4	10.7	8.8	
	1995	2.5	[b]	0.2	2.3	0.9	
	1996	7.4	[b]	0.9	6.5	5.0	
	1997	20.5	0.5	3.1	16.9	13.4	
	1998	32.0	0.7	3.1	28.2	22.7	
	1999	30.6	[b]	5.5	25.1	21.0	
	2000	35.6	1.4	6.2	28.0	21.8	27
	2001						12
	2002	16.6	[b]	3.0	13.6	9.9	7
	2003	9.2	0.5	3.5	5.2	4.4	5
	2004	9.5	0.5	5.4	3.6	1.4	2
	2005	14.4	1.2	5.5	7.7	5.2	3
	2006	10.0	0.8	4.9	4.3	2.3	6

[a] Does not include age-0 fish.
[b] Too few bull trout were captured to obtain an estimate.

Table 3 – Percent of angler-caught fish by species >250 mm in lower and upper reaches of Quirk Creek, 1998–2006.

	Percent >250 mm		
Year	**Bull trout**	**Cutthroat trout**	**Brook trout**
Upper reach			
1998	25	25	4
1999	30	23	4
2000	38	21	4
2001	42	21	2
2002	100	34	1
2003	0	18	2
2004	25	34	12
2005	38	19	12
2006	25	28	47
Upper total	**32**	**23**	**4**
Lower reach			
2000	20	27	8
2001	36	26	5
2002	17	24	5
2003	8	16	1
2004	27	21	13
2005	46	20	17
2006	32	24	5
Lower total	**25**	**24**	**6**
Grand total	**29**	**23**	**5**

Table 4 – Biomass (kg) of brook trout removed by angling and electrofishing in Quirk and Howard creeks.

Year	Month	Section[1]	Biomass
		Angling Lower Reach	
2004	June to Sep	-6.2 – 0.0	11.4
2005	July to Oct	-6.2 – 0.0	20.3
2006	June to Oct	-6.2 – 0.0	35.2
		Angling Upper Reach	
2004	July to Sep	0.0 – 6.5	12.3
2005	July to Sep	0.0 – 6.5	12.2
2006	July and Aug	0.0 – 6.5	2.9
		One-Pass Electrofishing[2]	
2004	August	0.1 – 2.1	9.6
	and	2.2 – 2.5	1.8
	September	2.6 – 4.7	22.6
		4.8 – 6.6[3]	6.8
2005	August	2.6 – 4.7[4]	27.5
2006	August	2.6 – 4.7[4]	23.0

[1]Denotes the locations of the upper marker of the 100-m sections, relative to the Mac Creek bridge.
[2]Little effort was made to capture fish ≤70 mm during one-pass electrofishing in 2005 and 2006.
[3]Includes seven fish caught on second and third pass in section 4.8.
[4]Includes fish captured in the lower 70 m of Howard Creek.

Table 5 – Angling and one-pass electrofishing brook trout catch-per-unit-effort summary for Quirk Creek.

Year	Angling						Electrofishing[3]		
	Unsupervised		Supervised		Combined				
	Number (BKTR/h)	Biomass (kg/h)	Number (BKTR/h)	Biomass (kg/h)	Number (BKTR/h)	Biomass (kg/h)	Number (BKTR/h)	Biomass (kg/h)	Section[4]
Upper reach[1]									
1998					2.47	0.21			
1999					2.15	0.21			
2000					2.36	0.21			
2001	2.45	0.17	1.86	0.13	1.88	0.13			
2002	1.92	0.16	0.93	0.06	1.01	0.07			
2003	1.53	0.13	0.84	0.09	1.03	0.10	34.00	1.37	3.8 – 4.2
2004	no outings	no outings	1.22	0.14	1.22	0.14	3.97	0.13	0.1 – 2.0
							6.76	0.23	2.1 – 4.2
							2.68	0.16	4.3 – 6.6
2005	no outings	no outings	0.80	0.09	0.86	0.09	6.61	0.31	2.6 – 4.7
2006	no outings	no outings	0.47	0.08	0.47	0.08	6.91	0.23	2.6 – 4.7
Upper total angling	**1.92**	**0.15**	**1.31**	**0.11**	**2.02**	**0.18**			
Lower reach[2]									
2000					1.66	0.17	9.26	0.98	-2.7 – 0.0
2001	2.96	0.17	1.51	0.11	1.78	0.12			
2002	2.06	0.17	1.09	0.08	1.28	0.10			
2003	2.20	0.20	1.63	0.14	1.81	0.16			
2004	1.31	0.17	0.76	0.08	0.88	0.10			
2005	1.85	0.19	1.19	0.15	1.42	0.16			
2006	1.65	0.14	1.52	0.13	1.61	0.14			
Lower total angling	**2.09**	**0.17**	**1.33**	**0.11**	**1.59**	**0.14**			

[1]Upper reach for angling includes from Mac Creek bridge upstream to the headwaters.

[2]Lower reach for angling includes from the mouth to the Mac Creek bridge.

[3] Effort was based on the time expended by an electrofishing crew of three and the number of volunteers on the processing crew, which varied according to day and year. During one-pass electrofishing in 2000 and 2003, no fish were weighed or killed. In 2004, all fish (>70 mm) were weighed and all BKTR were killed. In 2005, no fish were weighed and all BKTR were killed. In 2006, all BKTR were weighed and killed. Little effort was made to capture fish ≤70 mm during one-pass electrofishing in 2005 and 2006.

[4] Denotes the locations of the upper marker of the 100-m electrofishing sections, relative to the Mac Creek bridge.