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AN ASSESSMENT OF THE ABUNDANCE, DISTRIBUTION AND POPULATION STRUCTURE OF ADULT TROUT IN THE MAINSTEM LOWER WAITAKI RIVER, USING DRIFT NETTING

by

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Report to Electricorp

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Servicing freshwater fisheries and aquaculture

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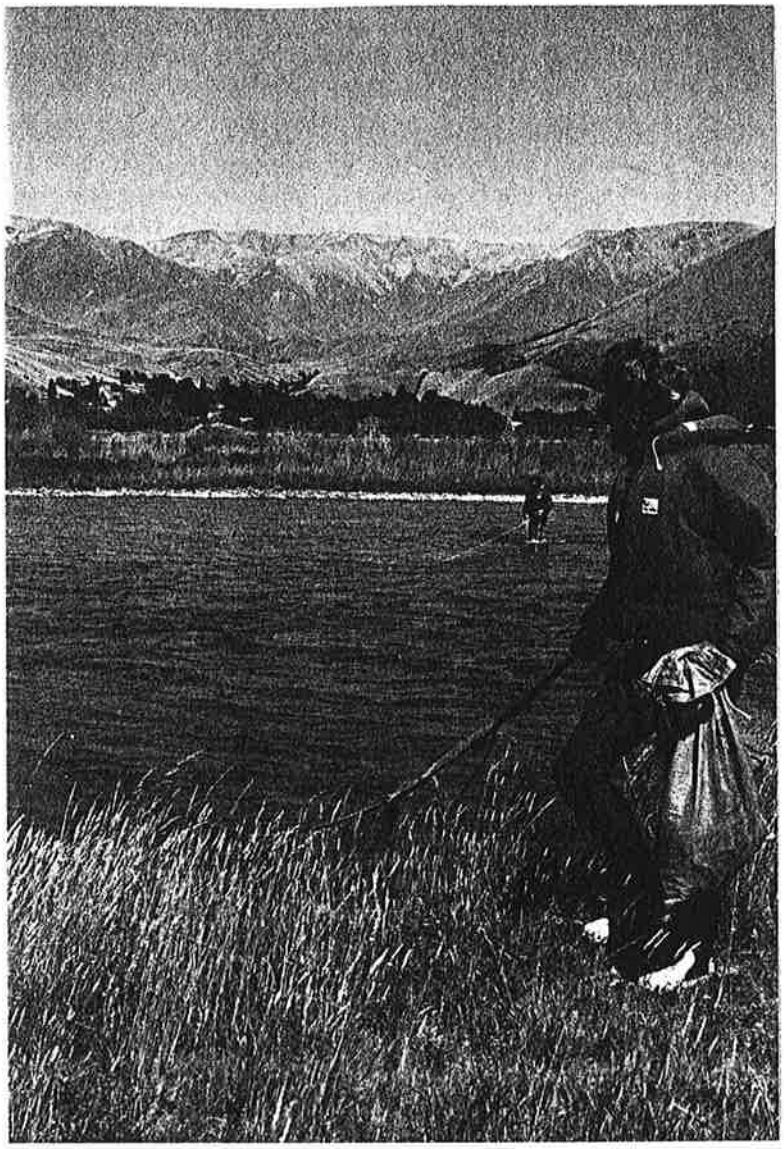
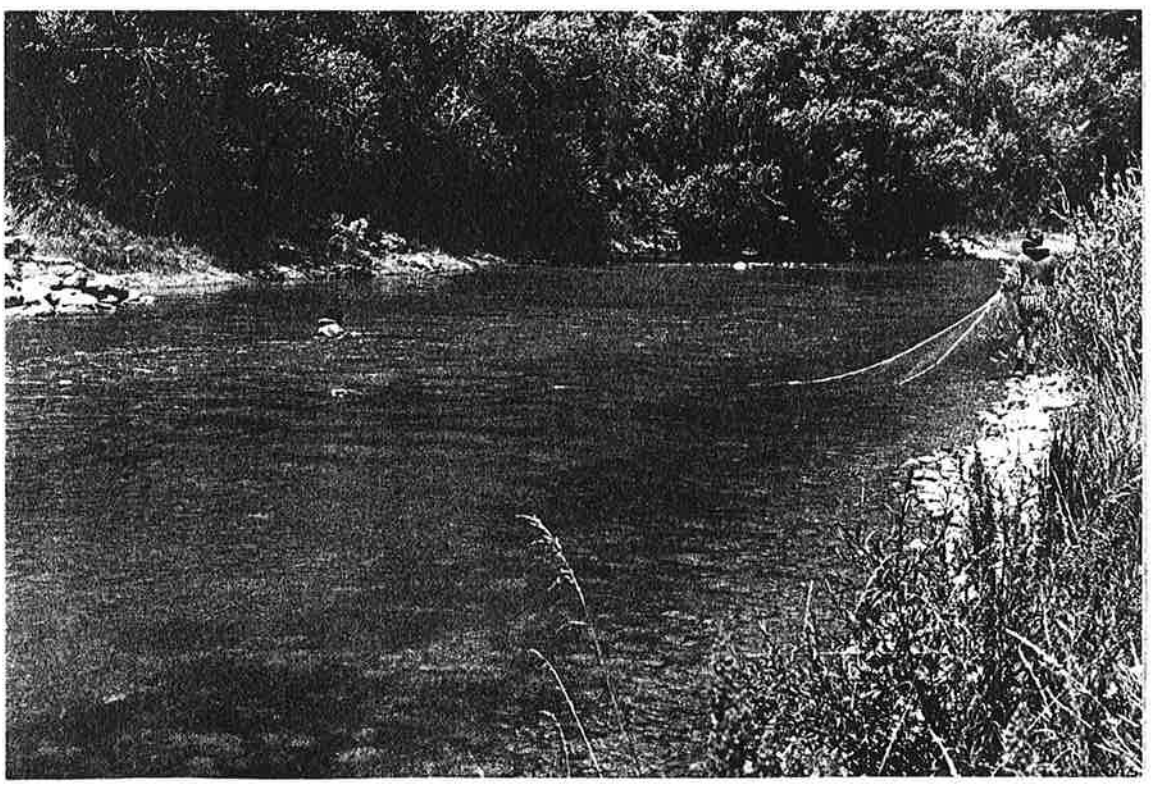


Drift-netting for trout in the lower Waitaki River.



1. INTRODUCTION

The Electricity Corporation plans to develop the lower Waitaki River for hydroelectric power generation. Several development options have been proposed, although those favoured at present each involve separating the river into a power canal, flood channel and residual river. The function of the residual river is to maintain the fish stocks and highly valued recreational fisheries of the lower Waitaki River at their present levels.

The possible effects of the proposed development on the fish stocks and fisheries of the lower Waitaki River, and the role of the residual river, have been described comprehensively in Graybill *et al.* (1988). One of the conclusions of this report was that further studies were needed to better understand the reproductive ecology of rainbow trout in the lower Waitaki, and to determine how stocks of these fish could be maintained. The maintenance of rainbows is considered extremely important, because the lower Waitaki is the only large coastal river in New Zealand with a successful brown trout, rainbow trout, and quinnat salmon fishery.

It was recognised that in addition to further studies being required on rainbow trout spawning and juvenile recruitment, relatively little was known about the distribution and abundance of medium and large rainbow trout in the mainstem of the Waitaki River. Several studies have investigated brown and rainbow populations in the lower Waitaki River, but these have been limited to particular areas such as the Demonstration Channels opposite Duntroon (Palmer 1987, and Smith and Pierce 1986), or some of the spawning tributaries (Webb, Dungey and Graynoth, in prep.)

Palmer found that adult traps on the channels captured many more brown trout than rainbow trout, and that rainbow trout appeared to have declined in abundance in comparison with brown trout over the four years of the study. This study also showed that netting (using mostly seine and set gill nets) was not an effective capture technique in the channels because of high flows, turbidity, and underwater snags. Drifting gill nets (as used in this study) were not tested. Various biological data were provided on the trout trapped.

Webb, Dungey and Graynoth (in prep.) investigated spawning migrations into two major tributaries, the Hakataramea and Maraewhenua Rivers, and a minor one, the Welcome Stream. These tributaries enter the Waitaki River at sites broadly similar to the three locations established for sampling in this study. The authors estimated numbers of spawning trout migrating into each tributary, described the timing of the spawning runs, and provided biological data on fish captured.

The salmonid fisheries of the lower Waitaki have been described by Pierce (in prep.), while Smith and Pierce (1986) reported on angling studies in the Demonstration Channel area. Both reports include references to trout species composition and distribution in the lower Waitaki River.

The main aim of this study was to assess the distribution and abundance of brown and rainbow trout along the length of the Waitaki mainstem, so as to be able to better predict the effects of the proposed hydro development on trout stocks of the lower Waitaki River. Seasonal changes in the distribution and abundance of trout in the lower Waitaki River have also been documented, together with information on the size, age, and growth of trout.

2. METHODS

2.1 Survey Localities

Three sampling localities along the length of the lower Waitaki River were chosen. (Fig. 1). The uppermost locality included about 3 km of river below the Kurow bridges; whilst the other two localities in the vicinity of Duntroon and Ferry Road each covered about 3 km upstream and 3 km downstream. The Waitaki River at all three localities was extensively braided, with smaller channels both along the margins and sometimes in mid-river. Willows and other scrubby vegetation such as gorse and broom were common on islands and along the margins, and often formed snags in the river channels. We initially attempted to establish one survey locality in the more stable area above Kurow which is highly regarded by anglers, but found the channel was much too large to sample effectively.

2.2 Netting

At the commencement of this study in mid 1988, we experimented with two different methods of using gill nets - set netting and drift netting - to capture trout larger than about 20 cm in the Lower Waitaki River. The set net technique involved setting nets of several different lengths in backwater areas of the river for periods of up to about three hours. With the drift net technique, nets 20 m in length and fitted with bridles on either end, were used to drift through smaller channels with flows up to about 25 cumecs. No method was found which appeared effective in flows greater than about 25 cumecs. Water velocities in these larger channels were usually too high to allow the net to fish the bottom effectively.

Set nets used were of monofilament nylon of 70 or 75 mm stretched mesh, and were between 7 m and 45 m in length. Because there were few suitable backwater areas that could be sampled, this technique was abandoned after a short period, and the results are not included in this report. During 36 hours of set net sampling, 16 trout (six rainbow, ten brown) were caught.

Drift nets were 20 m in length but were of two slightly different mesh sizes. Initially 75 mm fine gauge monofilament similar to that in the set nets was used. As this gauge was not strong enough to withstand frequent snagging on submerged rocks or logs, it was replaced with a heavier gauge monofilament of 70 mm mesh size. Given the other variables encountered, it is not considered that the results obtained with these different meshes are measurably different, and so the results have been combined.

2.3 Drift Net Sampling Strategies

Drift net sampling was undertaken quarterly on five occasions between June 1988 and June 1989 at each locality. On each occasion we attempted to sample at least 10 separate sites at each locality. Some drifts were described as invalid and were discounted, usually when the net became snagged, did not appear to fish properly because it was too far off the bottom, became clogged with weed, or the flow was too great. It quickly became apparent that to achieve some comparability between the same sites on different occasions, river flows had to be similar. Thus drift sampling was only undertaken and the results included when flows did not exceed the mean flow of 350 cumecs by more than about 30 cumecs.

Initially, one end of the net was often set from a jet boat as we tried to sample larger flows. However, it became obvious that the net could not be worked adequately in larger flows, and in smaller flows we concluded the boat tended to disturb fish. Thus except for rare occasions, the boat was not used and we relied instead on stealth.

On several occasions during clear water conditions, a snorkel diver followed the net through a drift sequence to ascertain how the net was fishing. The diver confirmed that when the net handlers thought the net was working well, it was doing so and there was little opportunity for fish to escape under the leadline.

Records were kept for each drift of the following physical parameters: flow type, length drifted, estimated flow and whether a boat was used or not. Flow type was recorded as run, riffle or pool or some combination thereof.

Sampling dates, together with information on locality, river flow and underwater visibility (by secchi disc) are given in Table 1. We tried to keep sampling dates for each quarter close together, but occasionally this was not possible e.g. sampling at Kurow in spring 1988 could not be completed for a month because of continuing high flows. Flow records were obtained from Electricorp staff at Waitaki power station and are derived from generator loadings. The flow figures for the dam were adjusted for the three localities, using the following approximate times for a crest of water to travel from the dam to these localities: 1 hour to Kurow, 4 h to Duntroon, and 9 h to Ferry Rd. (Graybill *et al.* 1990).

To permit comparisons between localities and sites, catch rate data have been transformed and are expressed as numbers of fish caught per standard 100 m drift.

2.4 Biological Data and Analysis

Biological data on fish caught were recorded. Species, length, and weight were noted, scales collected, and fish over 300 mm tagged with a serially numbered Floy anchor tag, before release.

Fish scales collected during trapping were mounted on acetate, and examined under 40x power using a micro-projector. Scales were aged, (See Tesch 1968 for a description of scale ageing technique) and measurements were made along the anterior axis from the focus to each annulus, and to the edge of the scale. Where possible five scales from each trout were examined and their measurements averaged to minimise variation in the shape of scales taken from one trout. Replacement scales, and scales which could not be positively aged, were disregarded because they were considered unreliable for use in analysis of trout age and growth.

Lengths at age were back-calculated from scales using the formula (Fraser 1916, Lee 1920):

$$L_n\text{-}c = \frac{S_n}{S} * (L\text{-}c)$$

Where L_n = length of fish when annulus n was completed;
L = length of fish at time scale was obtained;
S_n = radius from scale focus to completed annulus n;
S = scale radius;
c = correlation factor for allometric growth, which is equal to the y intercept of the regression line of trout length on scale radius.

The c values used were 24.5 mm (r = 0.98) for rainbow trout, and 24.6 mm (r = 0.97) for brown trout, as derived by Bloomberg (in prep).

2.5 Drift Diving

Several attempts at drift diving the main channels were made, but quantitative observations proved impossible, because of unfavourable water conditions. One attempt with several divers below the Kurow bridges during poor visibility (2.5 m secchi disc), emphasised the unlikelihood of seeing very much in the main channels, because of the high water velocity and poor visibility. Another drift dive for about 1 km in good visibility (about 4 m), whilst accompanied by a jet boat, provided some interesting observations, but confirmed the impossibility of undertaking quantitative dives in the main channels, even under conditions of good visibility. No trout were seen away from the margins of the main channels because the water velocity is too great, and the substrate is too small to provide any shelter. A few trout were seen along the margins near undercut banks, behind obstructions such as willow stumps or logs, and in a gut where the only cover was depth. In all these situations the water velocity would have been much less than out in the open main channel. We concluded that keeping a group of divers in line even along the margins of the main channels and around obstructions, which is where the few fish observed were seen, would be impossible.

3. RESULTS

3.1 Sample Effort

The distribution of sampling effort by locality and date is given in Table 2. Of the 190 valid drifts, 55 were in the vicinity of Kurow, 74 near Duntroon, and 61 near Ferry Road.

3.2 Species Composition

Rainbow trout were usually less abundant in the catches than brown trout, comprising between 0% and 55% of the catch at any one locality and date (Table 2 and Fig. 2). For all localities and sampling periods combined, the proportion of rainbows in the trout catch was

35%. The proportion of rainbows was greater at Kurow and Duntroon (44% and 46% respectively) than at Ferry Road (28%).

The proportion of rainbows appeared to follow an annual cycle at Kurow (Fig 2), being lowest in spring when mature fish are known to be spawning in the tributaries, and relatively constant for the remainder of the year. At other locations, the relative abundance of rainbows over time appeared to be much more variable. The complete absence of rainbows at Duntroon during the first two sampling periods, and at Ferry Road during summer 1989, is thought to be a result of generally low fish numbers at these localities combined with sampling variability. On no occasions were there zero catches of brown trout, as sometimes occurred with rainbow trout.

3.3 Rainbow Trout

3.3.1 Catch Rate

Catch rates (expressed as numbers per standard 100 m drift) are given by sampling locality and date in Table 3. The mean rainbow catch rate for all sampling periods combined was highest at Kurow (0.91 fish/100 m drift), followed by Duntroon (0.52) and Ferry Road (0.43). There was considerable variation in catch rates between drifts, and this is reflected in the high standard deviations obtained for the catch rate data. There was some variation in catch rate between sampling periods at each locality, but the variability decreased in a downstream direction. This is probably related to decreasing variability in size composition as one moves downstream.

Changes in catch rates at Kurow appeared to follow an annual cycle, with values being lowest in spring during the rainbow trout spawning season. Lower catch rates in the mainstem during this period are consistent with trapping data which show that mature rainbows migrate into tributaries such as the Awakino at this time to spawn.

3.3.2 Length Composition

Analysis of length composition by locality showed that larger rainbow trout were most abundant near Kurow, and that the proportion of larger fish decreased markedly in a downstream direction (Fig. 3 and Table 4). At the furthest downstream locality (Ferry Road), rainbow trout were consistently of small size. The mean lengths for all sampling

periods combined, were tested by analysis of variance, and were found to differ significantly between locality ($F = 4.749$, $DF = 2$, $p = 0.005$).

Too few trout were captured to permit a statistical comparison of mean lengths by sampling period, although the data in Figure 4 and Tables 5 and 6 suggest that at Kurow there were some seasonal changes. There was a higher proportion of smaller rainbow trout (< 350 mm) present in summer and autumn, than in winter and spring when trout 350 to 500 mm in length were more numerous.

There appeared to be a relationship between length composition and variability in catch rate, by locality. Thus at Kurow where larger fish were more abundant, catch rate varied most. At Duntroon both factors were less variable, whilst at Ferry Road which is the furthest locality downstream, there was little variation in catch rate and larger fish were uncommon.

3.3.3 Weight and Condition Factor

Mean weight declined in a downstream direction, and was found to differ significantly between the three localities (ANOVA, $F = 6.508$, $DF = 2$, $p = 0.01$).

Condition factor also differed significantly between localities (ANOVA, $F = 4.245$, $DF = 2$, $p = 0.05$), being higher at Kurow and Ferry Road and lower at Duntroon (Table 4). The high condition factors recorded at Ferry Road may be slightly misleading because trout netted in this area are relatively small, and studies have shown that condition factor is inversely related to fish length (Cone, 1989). However, the high condition factor at Kurow was not unexpected because of the abundant food supply (especially the net-spinning caddisfly *Aoteapsyche*) in the upper reaches of the lower Waitaki River.

3.3.4 Age and Growth

Most rainbow trout captured were 2 years of age, with lesser numbers of 3 year, and very few 4 year and 5 year old fish (Table 7). The oldest rainbow aged was 5 years. In common with length composition, older (and larger) fish were only found in the Kurow area (Fig. 5). Catches at Duntroon and Ferry Road contained only fish aged 2 years and 3 years, except for one rainbow aged 1 year. Several 1 year old rainbows were also taken near Kurow.

Only 2% of rainbow trout had scales which were completely unreadable, and both were large fish from the Kurow area. (Scales were lost from another small rainbow from the Duntroon area.) Another 12% of rainbows could be aged (and the data are included in Table 7), but because the scales had some replacement material, they could not be used for back-calculation purposes. Although relatively few rainbows were unable to be aged, it is still misleading to interpret the age data as representing the age composition of rainbow trout in the lower Waitaki River, because of the limitations of the sampling technique which almost certainly produced underestimates of the numbers of large and very small trout.

Growth of rainbow trout is shown in Table 8 and Figure 6 as mean lengths at age. Two sets of data are provided in Table 8. The first are mean lengths at age for all fish with readable scales, and includes those fish with scales containing replacement material but which could still be aged. The second set are mean back-calculated lengths at age derived from all age groups combined. Scales with any replacement material were excluded from these data, because one or more annuli were missing. Ages in the first set are described as 1+, 2+ etc., and the mean lengths are unadjusted for sampling date. These mean lengths are markedly larger than those in the second set, where length is adjusted back to that at the end of each year of growth, and where ages are described as 1, 2, etc. It is these latter data with much larger sample size which were used to plot Figure 6.

3.4 Brown Trout

3.4.1 Catch Rate

Catch rates by locality (Table 3) were usually considerably higher at Kurow (mean of 1.96 trout/100 m drift) than at Duntroon (0.49) or Ferry Road (0.77). The only exception was in winter 1989, when the catch rate of brown trout at Ferry Road was higher than usual, and that at Kurow was lower than usual. This is the spawning season for brown trout and it is possible that the larger mature fish which normally made up a significant proportion of the catch at Kurow were spawning in the tributaries at that time. Again, there was considerable variation in catch rates between drifts, and this is reflected in the high standard deviations obtained for the catch rate data.

Catch rate did vary seasonally at Kurow, with catch rates being highest in spring and autumn (Table 3). The high autumn value is a result of increased catches of smaller fish (see length composition). The catch rate of 3.25 brown trout /100 m drift in spring was the highest obtained on any sampling date or at any locality. Apart from Kurow, the only other

interesting rise in catch rate was at Ferry Road in winter 1989. This was also comprised of small fish, 79% of the catch being brown trout <36 cm in length.

3.4.2 Length Composition

Analysis of length composition by locality showed that larger brown trout were most abundant near Kurow (Fig. 7 and Table 4), and that the proportion of larger fish decreased in a downstream direction. At Ferry Road very few large brown trout were present. The mean lengths for all sampling periods combined, were tested by analysis of variance, and were found to differ significantly between localities ($F = 12.592$, $DF = 2$, $p = 0.005$).

Length composition by sampling period for the Kurow area (Fig. 8), showed that there was a higher proportion of small brown trout (< 350 mm) present during autumn. At other localities too few trout were captured to permit meaningful comparisons.

3.4.3 Weight and Condition Factor

Mean weight declined in a downstream direction, and was found to differ significantly between the three localities (ANOVA, $F = 17.383$, $DF = 2$, $p = 0.01$).

Condition factor (CF) was also found to differ significantly between localities (ANOVA, $F = 4.787$, $DF = 2$, $p = 0.05$). Mean CF at Kurow (Table 4) was noticeably higher than at Duntroon and Ferry Road. This is most likely the result of an abundant food supply in this upstream area, as noted for rainbow trout, and explained in the Discussion.

3.4.4 Age and Growth

Brown trout 2 years of age were most common, with lesser numbers of 3 year, 4 year, and 5 year old fish (Table 7). Fish aged 1 year, 6 years, and 7 years were uncommon. As with length composition, older (and larger) fish were mostly found in the Kurow area, with catches at Duntroon and Ferry Road comprising fish between 2 years and 5 years of age (Fig. 5). Brown trout aged 1 year were not captured at the latter two sites, although a few were taken near Kurow.

Sixteen percent of browns had scales which were completely unreadable. Almost half of these fish were large (over 500 mm) and from the Kurow area. Another 14% of browns could be aged (and the data are included in Table 7), but because the scales had some replacement material, they could not be used for back-calculating lengths at age. It is misleading to interpret these age data as representing the age composition of brown trout in the lower Waitaki River. This is because there was a significant proportion of fish that could not be aged and the length distribution of aged and unaged fish was different. In addition the limitations of the sampling technique almost certainly produced underestimates of the numbers of large and very small trout.

Growth of brown trout is shown in Table 8 and Figure 9. Two sets of mean length at age data are provided in Table 8 as explained above for rainbow trout. There was considerable overlap between the ranges of length at age for most age groups.

4. DISCUSSION

4.1 Species Composition

Previous studies have estimated that rainbow trout comprised between 29% and 43% of the total angler catch of brown and rainbow trout from the lower Waitaki River (Graybill *et al.* 1988). It was concluded that because rainbow trout were more easily caught, the stock size of takeable brown trout was undoubtedly greater than that of rainbow trout.

Results from the present drift netting study are very similar, with rainbow trout comprising 35% of all trout captured, for all localities and seasons combined. This could still be an underestimate of relative rainbow trout abundance, however, because we were unable to sample in some areas with higher flows and velocities, where rainbows might be expected to be more common than brown trout (Gatz *et al*, 1987). In spite of this, it seems reasonable to conclude that stocks of brown trout in the lower Waitaki River are generally greater than those of rainbow trout, perhaps by as much as a factor of two.

Pierce (in prep) suggested that brown and rainbow trout may have different distributions within the mainstem Waitaki, based on an analysis of angling diaries which showed different catch ratios in different areas. She found that during the 1970s, proportionally lower numbers of rainbows were captured in the areas from the Dam to the Kurow road bridges, and from

SH1 to the sea. Unfortunately, no comparable data were collected during the early to mid 1980s, when river conditions had changed and angling was considerably poorer.

Data were not collected from above the Kurow bridges and below SH1 during this study, so direct comparisons cannot be made with Pierce's angling diary data. However, our data do show that the proportion of rainbows captured was usually considerably less at Ferry Road, than further upstream at Duntroon and Kurow.

4.2 Trout Distribution and Abundance

Earlier studies showed that catch rates by diarists during three seasons in the 1970s, were considerably higher in the area from Waitaki Dam to Kurow (0.65 trout/hour), than in other sections of the river (0.30 to 0.43), (Pierce, in prep.). This study also concluded that trout catch per km, considering the different lengths of the areas, was probably greatest from the dam to Kurow and SH1 to the sea.

Catch rate data in this report support the observations of Pierce that trout abundance is highest in the Kurow area. We found that for both rainbow and brown trout, catch per standard drift at Kurow was usually at least double that at Duntroon and Ferry Road.

The higher catch rates of both species of trout obtained at Kurow during this study, reflect the view commonly held by anglers that trout angling on the Lower Waitaki River is best in this area. It seems likely that the Kurow area is presently relatively more important to trout anglers than in the 1972 - 1982 period, when Pierce (in prep.) estimated that about 15% of trout angling effort on the river, took place between the Dam and Kurow bridges. This is because trout angling in the middle and lower reaches of the Waitaki has been considered of low quality throughout the 1980s (Waitaki Valley Acclimatisation Society Annual Reports; and G. Hughes, pers. comm.).

4.3 Trout length, age, and condition factor

As well as being more abundant, trout were generally larger, older, and better conditioned at Kurow than further downstream.

The proportion of larger, older fish of both species decreased markedly in a downstream direction. There are no other data from the lower Waitaki River to support this conclusion,

but it does agree with fishermen's observations that the best trout angling is in the Kurow area.

For comparison with the Waitaki results, relative abundance data on different size groups of trout in the Tekapo River, are given for two drift dives in February 1989 and 1990 (Appendix). It was envisaged that these surveys could provide comparative information on the longitudinal distribution and abundance of different size groups of trout, in a river with some features in common with the Waitaki. Both rivers are in the same catchment, and contain both brown and rainbow trout. The advantages of the Tekapo River are that it is clear, and of a size where the entire river could be surveyed by drift diving.

It was recognised that the presence of a lake below the Tekapo River was likely to be a significant difference between the two rivers, perhaps making comparisons difficult. We chose the Tekapo River, however, because in an earlier investigation of the Rai and Pelorus system in Marlborough which contained both species and had no associated lake, we had only been able to find occasional rainbow trout juveniles.

There appear to be some major differences between the trout populations in the Tekapo and Waitaki Rivers. The most obvious is the much higher proportion of small trout of both species present in the Tekapo River. In 1989 most of the medium-sized rainbow trout were less than about 25 cm in length. Consequently most rainbows present in February in both years were less than about 25 cm, and aged 0+ or 1+. Fish between about 25 cm and 45 cm were relatively few, and based on netting results in Lake Benmore (McCarter, 1987), many had probably moved downstream into the lake to rear. Similar-sized fish in the Waitaki River were much more abundant than large trout in the middle and lower reaches, and these areas may fulfill an important rearing role for medium-sized trout.

Mean condition factors of trout captured in this study, were markedly greater than those recorded by Palmer (1987) during trapping studies in the early 1980s in the Demonstration Channel area. Although some areas we sampled were different e.g. Kurow and Ferry Road, the area we sampled near Duntroon is likely to have been reasonably similar to the Demonstration Channel area, and even included some sites within the channels. However, our netting technique captured smaller trout than were trapped, and this would have caused some bias (Cone, 1989). Excluding from our data fish smaller than those trapped by Palmer, produces mean condition factors for the Duntroon area of 120 (rainbow) and 111 (brown), compared with 116 (rainbow) and 110 (brown) calculated from Palmer's data. It does not appear that condition of trout in the Duntroon area has changed between the early and late 1980s.

Our data on condition are also consistent with published information on the so-called "lake effect", where food and fish production may be considerably enhanced for some distance below a lake or reservoir. The increased production is considered to result from the large numbers of filter feeding zoobenthos (usually hydropsychid caddisflies) which feed upon lake-derived seston, and are in turn fed upon by fish (Haraldstad et. al., 1987). Such an area is obviously of considerable importance to anglers.

Condition factors of smaller fish are normally greater than those of larger fish (Cone,1989). This study showed that larger trout were relatively more abundant in the Kurow area than further downstream. Our finding that mean condition factors were as high in the Kurow area as further downstream, suggests that food supply in these upper reaches of the river must be sufficiently abundant, to compensate for the lower expected condition factors of larger fish.

6. ACKNOWLEDGEMENTS

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TABLE 1. Sampling data associated with the drift netting studies on the lower Waitaki River. Flow records are from the Waitaki dam with adjustment for travel times between the dam and the sampling locality, and are rounded off to the nearest 10 cumecs.

Sampling date	Locality	Flow cumecs	Underwater visibility (m)
21.06.88	Ferry Road	300	-
22.06.88	Ferry Road	250	-
24.06.88	Duntroon	320	-
30.06.88	Duntroon	260	-
01.07.88	Kurow	250	-
04.07.88	Kurow	240	-
05.07.88	Duntroon	270	-
27.09.88	Ferry Road	360	-
28.09.88	Duntroon	410	-
29.09.88	Kurow	450*	-
27.10.88	Kurow	340	-
17.01.89	Ferry Road	280	3.5
19.01.89	Kurow	370+	2.0
20.01.89	Duntroon	340	2.9
23.01.89	Kurow	280	4.0
18.04.89	Kurow	370	3.4
19.04.89	Kurow	370	3.5
20.04.89	Ferry Road	370	1.6
21.04.89	Duntroon	370	1.9
27.06.89	Ferry Road	370	0.8
29.06.89	Duntroon	370	1.0
30.06.89	Kurow	370	1.5

* = Flows were too high and all drifts this day were omitted.

\+ = Flow increased suddenly by about 70 cumecs as sampling began. Large quantities of drifting algae clogged the net. After about two hours the water cleared and sampling resumed.

TABLE 2. Number of drifts made and catch of rainbow and brown trout at three lower Waitaki River localities. (BT = brown trout; RT = rainbow trout).

Sampling period	Kurow					Duntroon					Ferry Road					Total				
		RT		BT			RT		BT			RT		BT			RT		BT	
	Drifts	N	%	N	%	Drifts	N	%	N	%	Drifts	N	%	N	%	Drifts	N	%	N	%
Winter 1988	13	9	32	19	68	32	0	0	4	100	19	3	23	10	77	64	12	27	33	73
Spring 1988	10	3	10	28	90	12	0	0	1	100	10	6	55	5	45	32	9	21	34	79
Summer 1989	13	6	35	11	65	8	10	67	5	33	11	0	0	5	100	32	16	43	21	57
Autumn 1989	8	26	41	38	59	10	3	33	6	67	9	1	17	5	83	27	30	38	49	62
Winter 1989	11	12	46	14	54	12	10	48	11	52	12	7	27	19	73	35	29	40	44	60
Total	55	56	44	110	66	74	23	46	27	54	61	17	28	44	72	190	96	35	181	65

TABLE 3. Catch rate (numbers/100 m standard drift) by drift net at three lower Waitaki River localities. (CR = catch rate, SD = standard deviation)

Sampling period	Kurow						Duntroon						Ferry Road					
	Rainbow trout		Brown trout		Total trout		Rainbow trout		Brown trout		Total trout		Rainbow trout		Brown trout		Total trout	
	CR	SD	CR	SD	CR	SD	CR	SD	CR	SD	CR	SD	CR	SD	CR	SD	CR	SD
Spring 1988	0.39	0.65	3.25	3.17	3.64	3.46	0.0	0.0	0.14	0.48	0.14	0.48	0.65	1.33	0.34	0.56	0.99	1.81
Summer 1988	0.51	0.79	1.09	1.51	1.60	1.42	1.35	2.24	0.63	1.19	1.98	2.61	0.0	0.0	0.48	0.71	0.48	0.71
Autumn 1989	2.13	1.98	2.71	3.42	4.84	4.37	0.18	0.43	0.40	0.70	0.58	1.10	0.56	1.67	0.63	1.32	1.19	1.93
Winter 1989	1.10	1.28	0.99	1.48	2.09	2.28	0.82	1.11	0.86	1.06	1.68	1.94	0.54	0.92	1.51	1.53	2.05	2.35
Mean	0.91	1.30	1.96	2.70	2.87	3.13	0.52	1.21	0.49	0.88	1.01	1.74	0.43	1.11	0.77	1.18	1.20	1.85

TABLE 4. Length, weight, and condition factor of rainbow and brown trout captured by drift-net at three locations on the lower Waitaki River in 1988-89. All sampling periods are combined.

Species	Location	No. measured	Length (mm)			Weight (g)			Condition factor		
			Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
Rainbow	Ferry Road	17	313	31	270-416	416	140	250- 900	133	11	108-152
	Duntroon	23	342	50	286-465	515	248	250-1200	122	15	100-171
	Kurow	57	376	95	262-600	823	595	240-2850	133	17	71-165
Brown	Ferry Road	44	347	57	281-530	522	298	260-1900	117	9	98-140
	Duntroon	27	398	85	284-540	789	441	250-1600	115	14	91-151
	Kurow	114	426	100	211-625	1078	624	125-2500	122	16	76-177

TABLE 5. Lengths (mm) of rainbow trout captured during the drift-netting surveys on the lower Waitaki River in 1988-89, listed by location and sampling period.

Sampling period	Ferry Road				Duntroon				Kurow			
	N	Mean	SD	Range	N	Mean	SD	Range	N	Mean	SD	Range
Winter 1988	3	344	67	285-416	0	-	-	- -	9	399	52	349-490
Spring 1988	6	314	11	302-327	0	-	-	- -	4	416	68	342-476
Summer 1989	0	-	-	- -	10	370	41	293-438	6	318	73	267-444
Autumn 1989	1	270	-	- -	3	351	99	286-465	26	353	105	262-600
Winter 1989	7	305	12	280-318	10	311	19	290-343	12	422	94	287-543

TABLE 6. Lengths (mm) of brown trout captured during the drift-netting surveys on the lower Waitaki River in 1988-89, listed by location and sampling period.

Sampling period	Ferry Road				Duntroon				Kurow			
	N	Mean	SD	Range	N	Mean	SD	Range	N	Mean	SD	Range
Winter 1988	10	341	49	281-440	4	459	66	360-495	19	438	62	348-594
Spring 1988	5	307	23	290-342	1	328	-	- -	32	475	80	211-602
Summer 1989	5	410	52	342-477	5	361	68	296-460	11	459	119	276-576
Autumn 1989	5	376	99	300-530	6	405	90	294-518	38	360	96	280-625
Winter 1989	19	337	42	293-442	11	395	95	284-540	14	452	92	315-550

TABLE 7. Number of trout of different ages captured at three localities during the drift-netting surveys on the lower Waitaki River in 1988 - 1989, all seasons combined. Fish with replacement scales which could still be aged are included. (U/R = unreadable)

Species	Locality	(Age y+) 1	2	3	4	5	6	7	U/R	Total
Rainbow trout	Kurow	4	30	15	4	2	0	0	2	57
	Duntroon	1	13	8	0	0	0	0	1	23
	Ferry Road	0	14	3	0	0	0	0	0	17
	Total	5	57	26	4	2	0	0	3	97
Brown trout	Kurow	4	35	21	22	11	2	1	18	114
	Duntroon	0	11	6	9	1	0	0	0	27
	Ferry Road	0	17	13	2	0	0	0	12	44
	Total	4	63	40	33	12	2	1	30	185

TABLE 8. Mean length at age (mm ± 1 S.D.) for trout captured during the drift-netting surveys on the lower Waitaki River in 1988 - 1989, all sites and seasons combined. (The first set of data includes fish with replacement scales which could still be aged, while the second data set does not; hence the different totals).

Species	Age	N	Mean length	Age	N	Mean back-calculated length (all age groups combined)
Rainbow trout	1+	5	278 ± 13	1	82	106 ± 19
	2+	57	317 ± 36	3	77	263 ± 43
	3+	26	407 ± 67	3	27	368 ± 64
	4+	4	497 ± 27	4	5	460 ± 56
	5+	2	592 ± 11	5	1	565
Brown trout	1+	4	251 ± 4	1	126	119 ± 25
	2+	63	321 ± 35	2	123	263 ± 53
	3+	40	404 ± 57	3	66	367 ± 57
	4+	33	487 ± 53	4	35	440 ± 49
	5+	12	525 ± 20	5	14	500 ± 34
	6+	2	523 ± 39	6	3	523 ± 57
	7+	1	625	7	1	613

APPENDIX I. **Percentage of brown and rainbow trout of different sizes observed during the drift dives in the Tekapo River on 23 February 1989 (upper) and 14 February 1990 (lower). S = small (10-20 cm); M = medium (20-40 cm); L = large (> 40 cm).**

	Brown trout				Rainbow trout			
Site	S	M	L	Total No.	S	M	L	Total No.
Above mouth	37	23	40	138	90	8	2	315
Above steel bridge	34	34	32	71	66	27	7	165
Below Maryburn confluence	55	31	14	365	62	36	2	389
Above Grays confluence	13	12	75	8	56	41	3	70
Below Forks confluence	50	40	10	10	36	64	0	33
Above mouth	44	9	47	45	100	0	0	400
Above steel bridge	13	23	64	39	99	0	1	856
Below Maryburn confluence	69	8	23	101	99	0	1	1360
Above Grays confluence	25	0	75	4	100	0	0	24

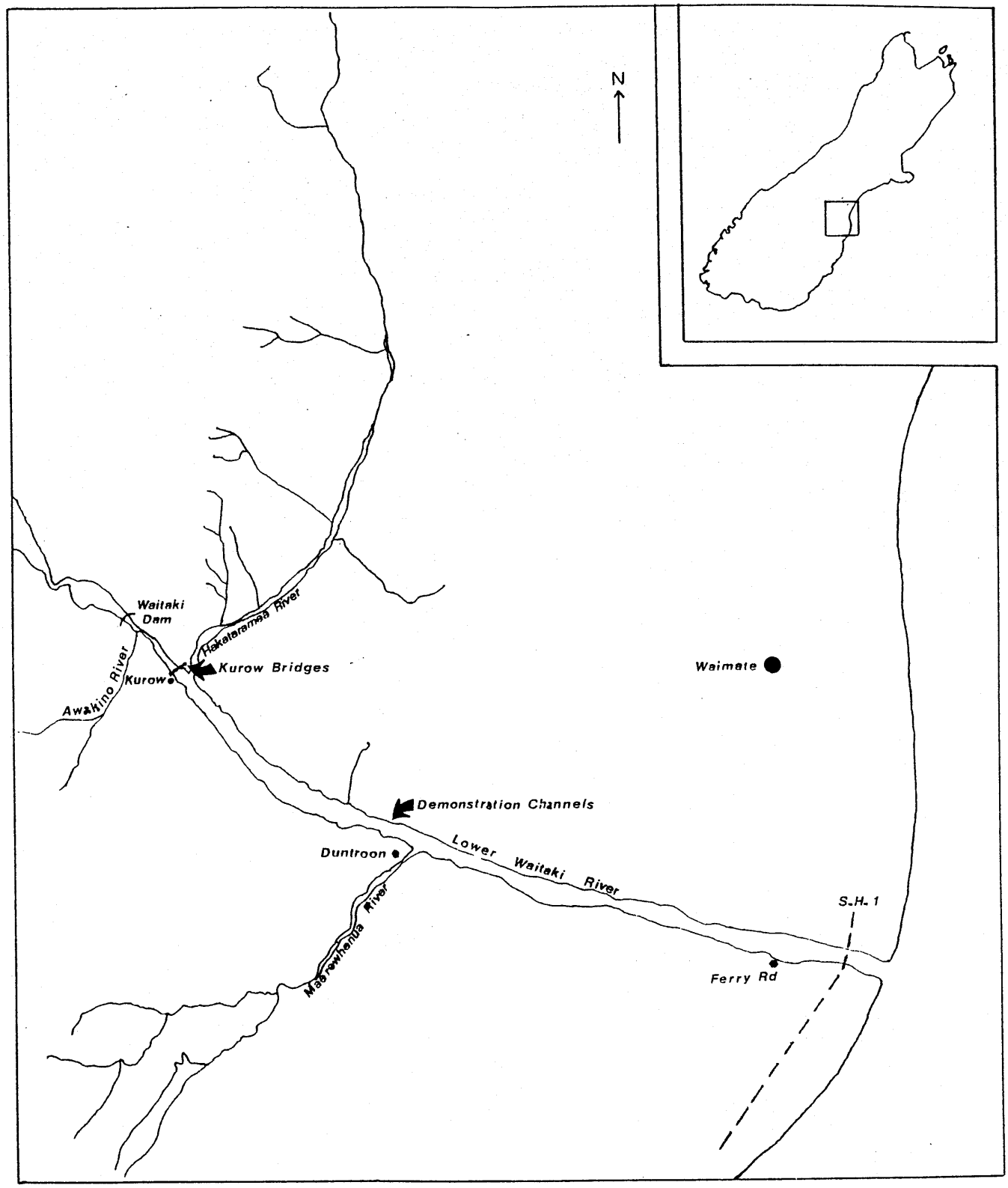

FIGURE 1. The lower Waitaki River, showing places mentioned in the text.

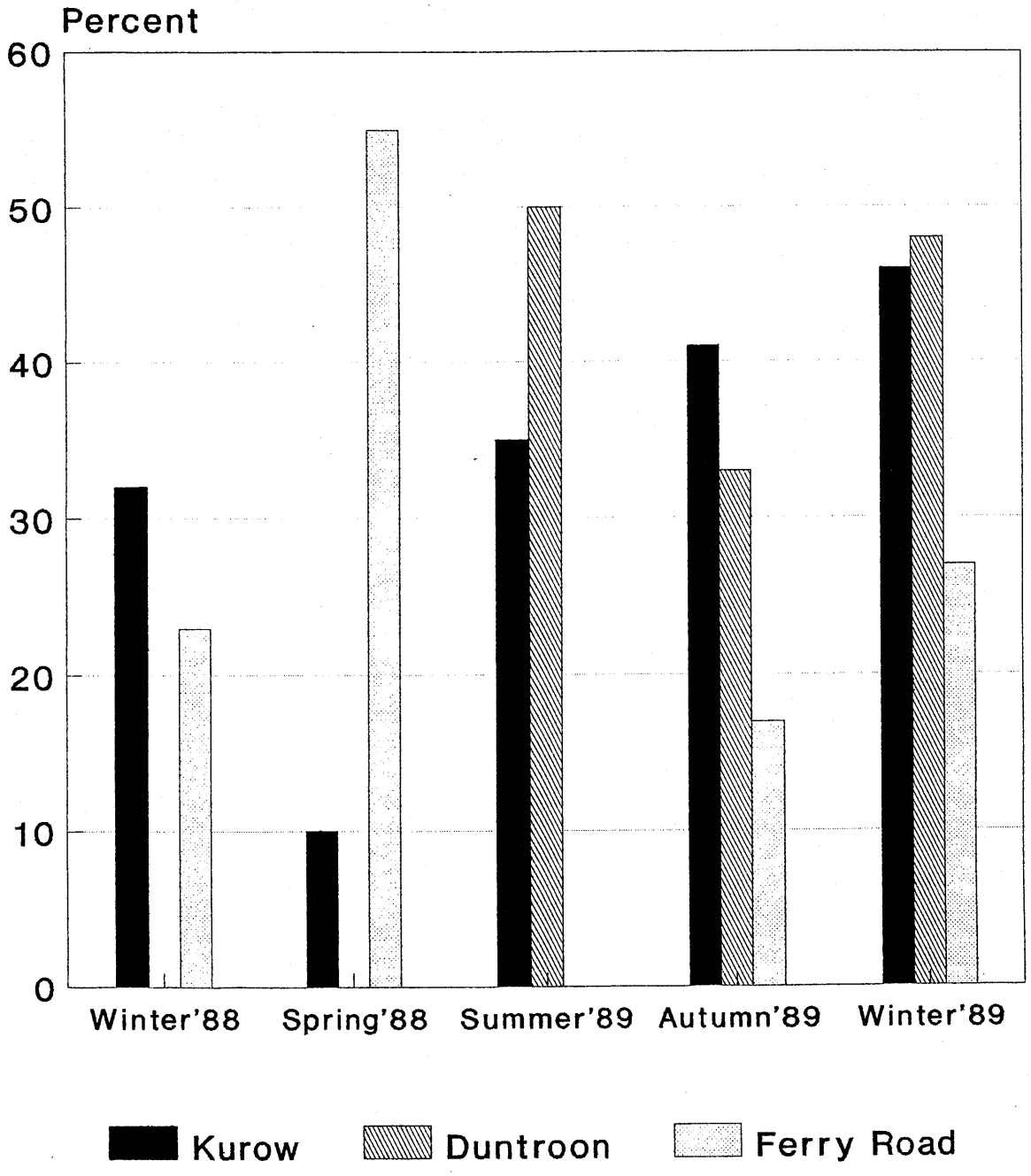

FIGURE 2. Rainbow trout as a percentage of total trout (brown and rainbow) catch, by sampling period and locality.

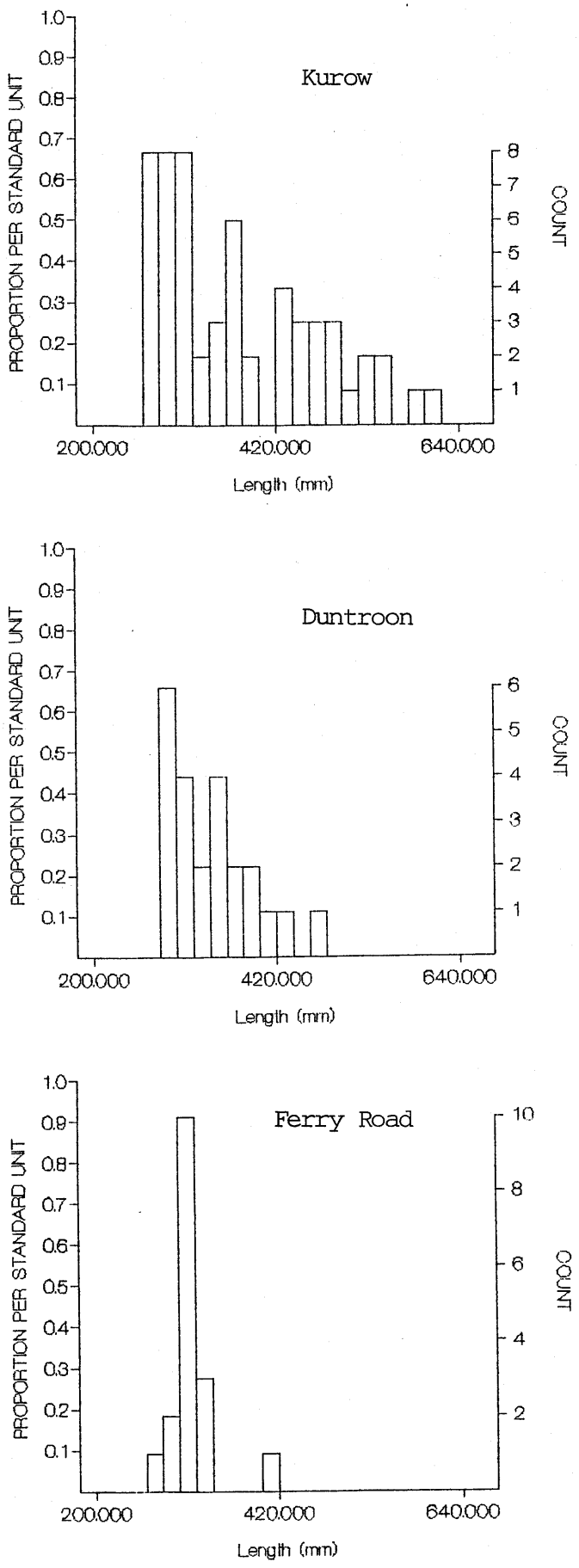

FIGURE 3. Length composition of drift-netted rainbow trout, by locality.

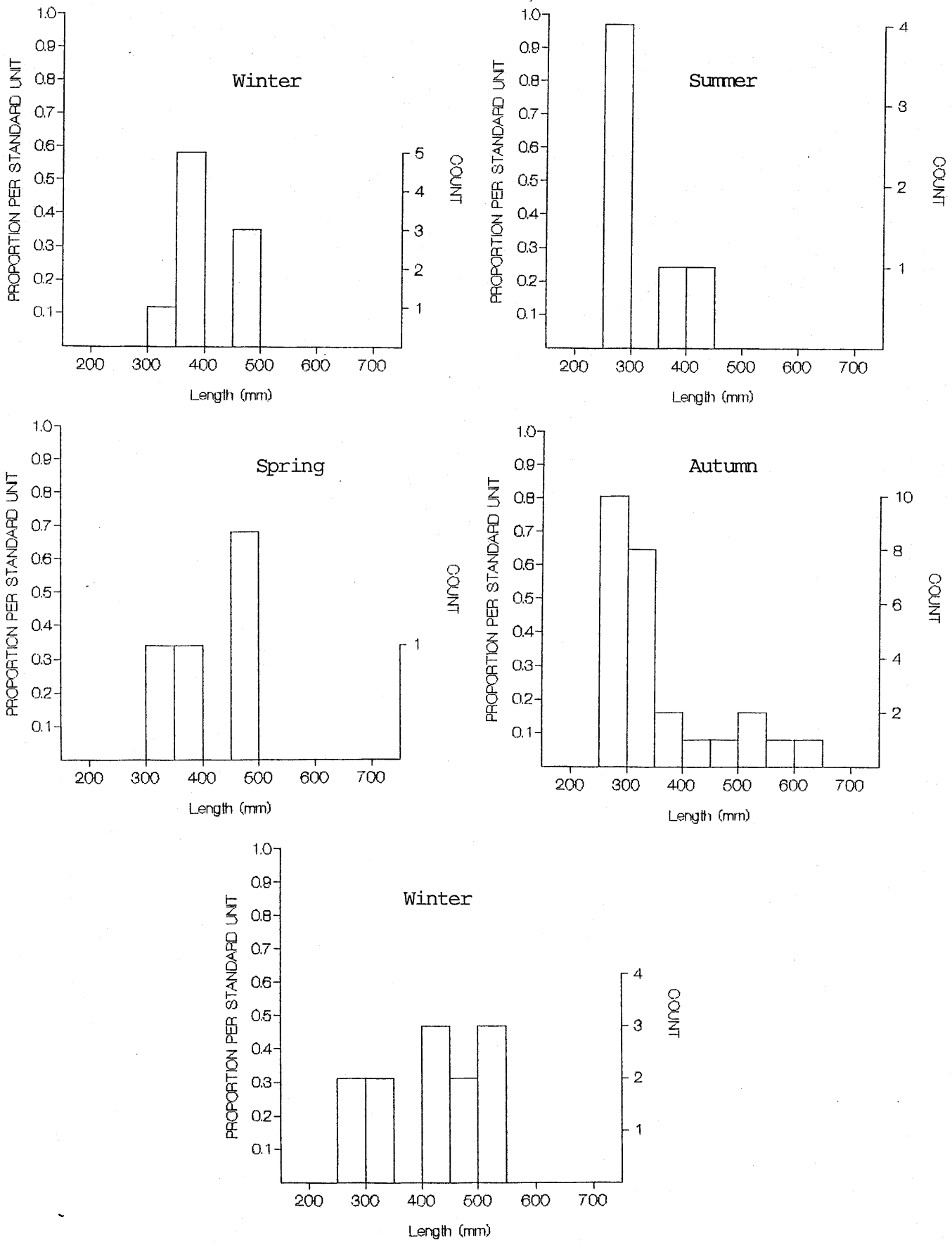

FIGURE 4. Seasonal length composition of rainbow trout taken at Kurow by drift-netting.

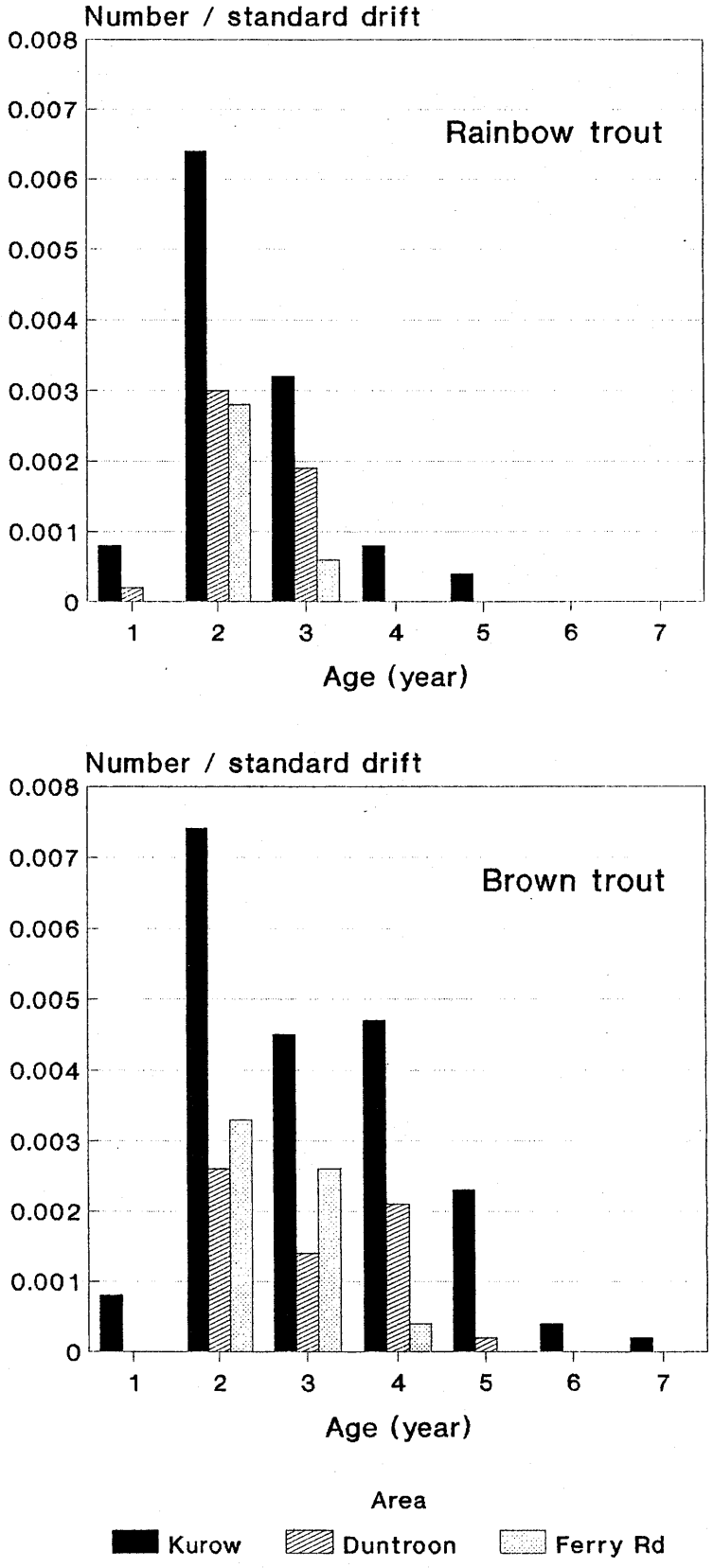

FIGURE 5. Catch rate of drift-netted rainbow and brown trout, by age and locality.

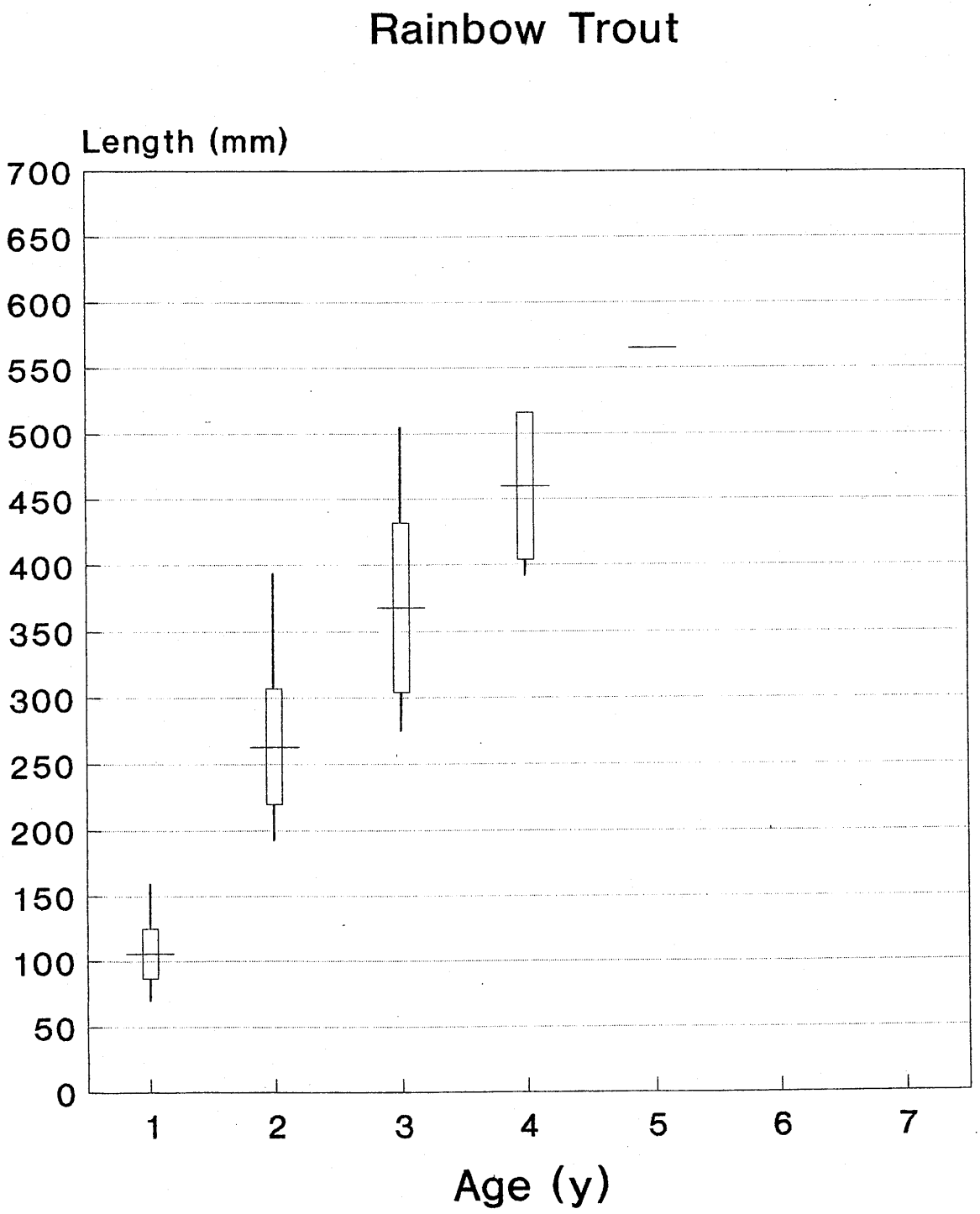

FIGURE 6. Length at age of rainbow trout captured during the drift-netting surveys.

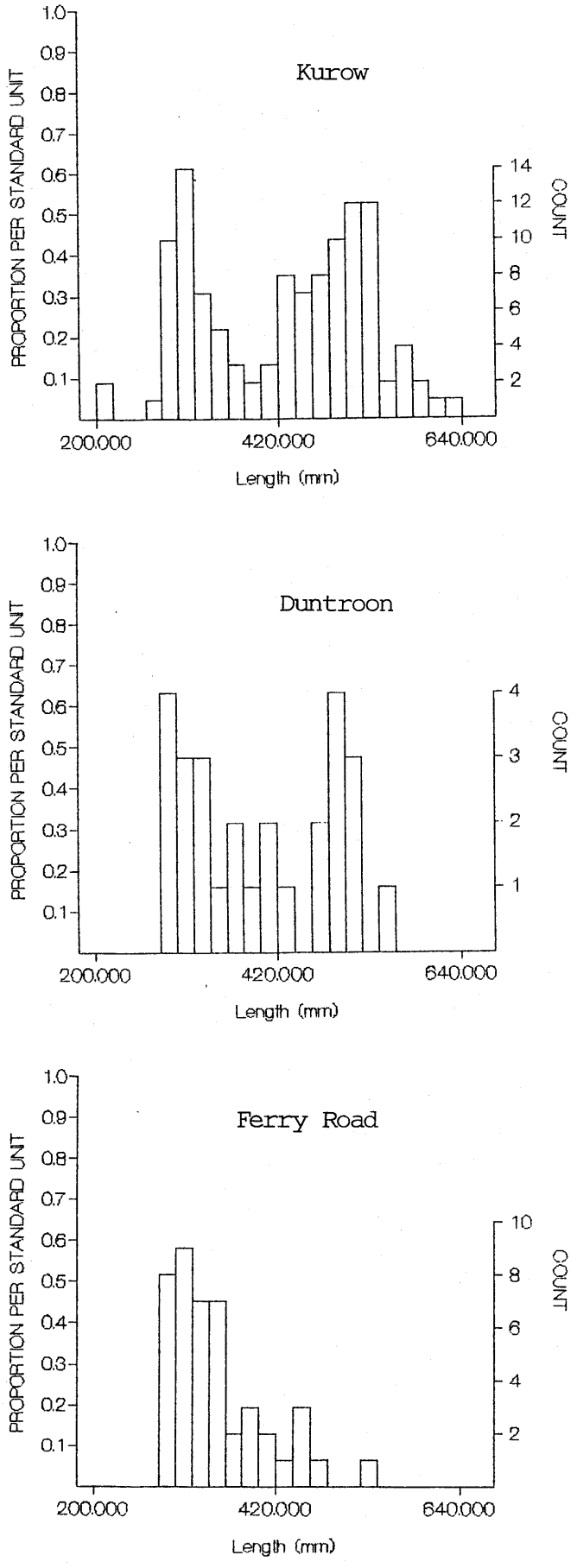

FIGURE 7. Length composition of drift-netted brown trout, by locality.

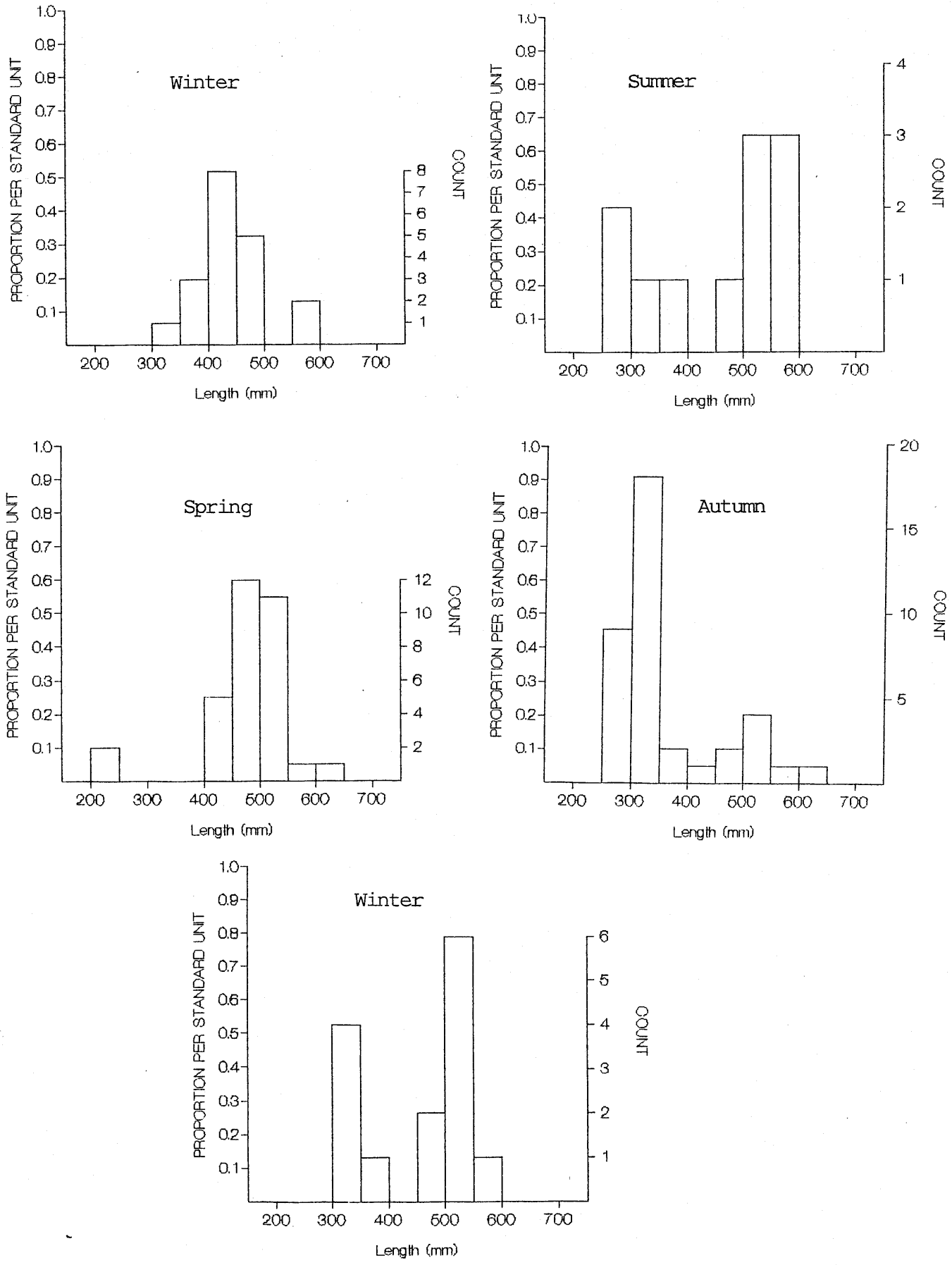

FIGURE 8. Seasonal length composition of brown trout taken at Kurow by drift-netting.

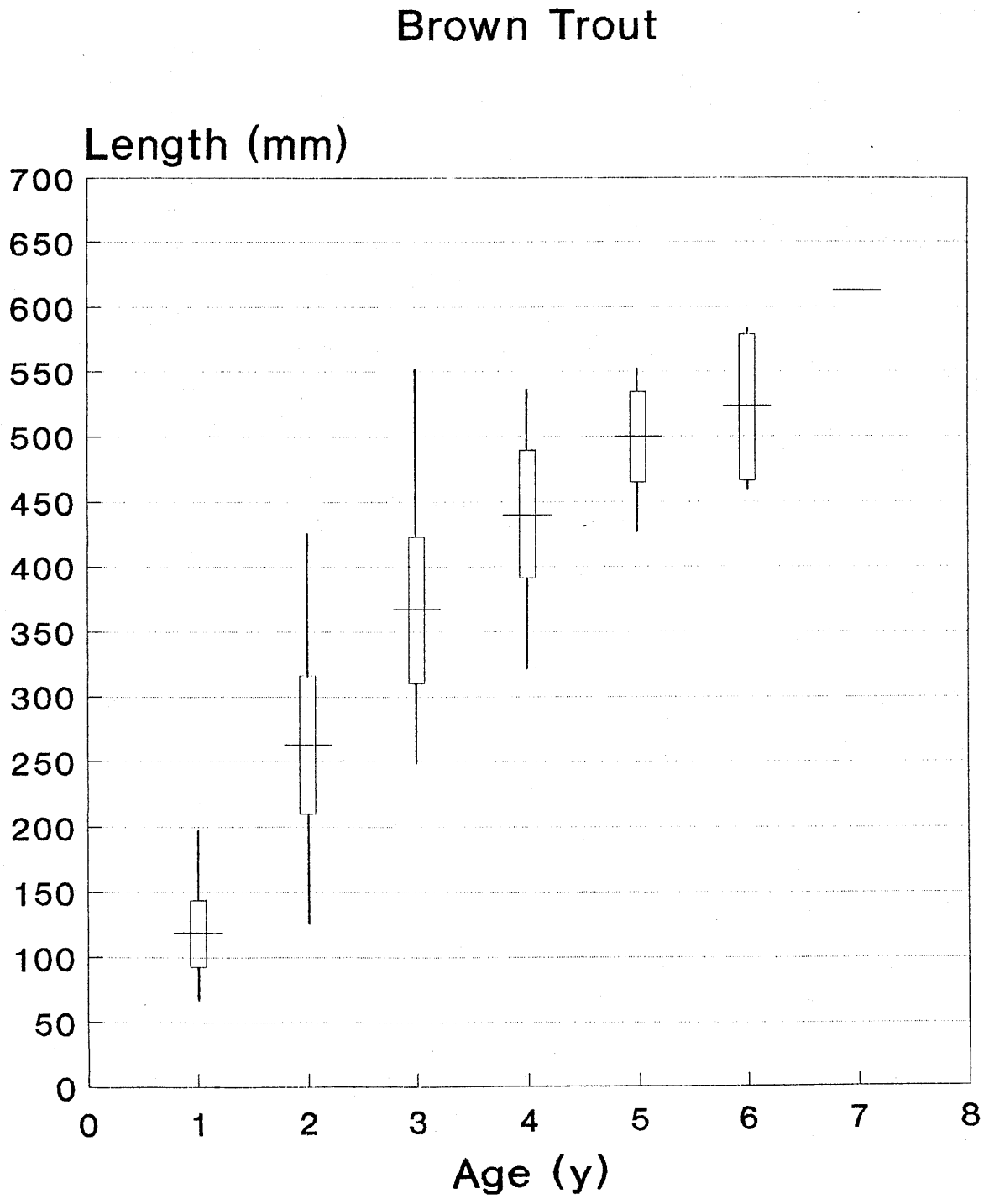

FIGURE 9. Length at age of brown trout captured during the drift-netting surveys.