ISSN 1170-2001

NEW ZEALAND FRESHWATER FISHERIES MISCELLANEOUS REPORT NO. 74

RESULTS OF SECOND PRE-IMPOUNDMENT SURVEY OF TRIBUTARIES OF LAKE DUNSTAN AND THE CLUTHA RIVER, MARCH 1989

by

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Report to: Production Unit of
Electricity Corporation of New Zealand

Freshwater Fisheries Centre

MAF Fisheries

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CHRISTCHURCH

Servicing freshwater fisheries and aquaculture

DECEMBER
1990

NEW ZEALAND FRESHWATER FISHERIES MISCELLANEOUS REPORTS

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ISBN 0-477-08416-8

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RESULTS OF SECOND PRE-IMPOUNDMENT SURVEY OF TRIBUTARIES OF LAKE DUNSTAN, AND THE CLUTHA RIVER
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SUMMARY

1 Compared with the December sampling, there were significant reductions in yearling fish at all sites except Lindis Crossing. Numbers (and densities) of 0+ fish were generally similar to those recorded in December; an exception was 0+ rainbows which were present in only small numbers in the Cluden Stream, where they had previously been relatively abundant.

2 Growth of juvenile fish was rapid. Over three months 0+ fish had grown 2.5-4 cm, while 1+ fish had grown 1-3 cm. Rainbows had grown faster than browns.

3 Very few fish were present in the Cluden water race.

4 There are extensive rearing areas for juvenile fish within the mainstem Clutha. Growth in these areas is rapid, comparable to that in the lower Lindis River.

5 Common bullies were recorded from a backwater above Cromwell. This is the first record of this species from between Lake Roxburgh and Lake Wanaka.

6 Rainbow trout had "fuller" stomachs than brown trout, but had high proportions of weed, sticks, etc.

7 The diets of juvenile browns and rainbows were statistically different, but dominated by small invertebrates - caddis larvae, riffle-beetle larvae, midge larvae, mayfly larvae.

8 Diets of adult brown and rainbow trout were similar, with snails being the most important item (by overall weight) but with caddises and mayflies also occurring in a high proportion of stomachs.

9 During the day, adult brown trout were caught in backwaters and rainbows in runs. At night rainbows also entered backwaters.

10 Condition factors for both species were similar and slightly below "average", and were not related to size.

11 Growth rates for both species were similar to those recorded from rivers and lakes throughout New Zealand.

1 BACKGROUND

An initial survey of tributaries was carried out in December 1988. That survey consisted of electric fishing of sites in the Lindis River, plus other tributaries considered important to Lake Dunstan. The present survey was in part a repeat of the December survey (re-survey of some sites, plus new sites), but also looked at fish stocks within the mainstem Clutha River upstream of Cromwell.

2 OBJECTIVES

The objectives of the survey are:

- To obtain information on the relative abundance of trout fry and yearling fish in selected sites of the Lindis River and tributaries, and also in the Bannockburn, Lowburn, and possibly lower Nevis.

- To obtain information on the relative abundance of trout fry and yearlings in the mainstem Clutha River (at suitable sites from Clyde to Lindis Crossing, and also sites upstream of this).

- To obtain information on the species composition, age, condition, and diet of trout stocks in the mainstem Clutha River.

- To collate and analyse angling data available for the mainstem Clutha River.

- To obtain information on the species and relative abundance of bullies in the mainstem Clutha.

- To assess the suitability of areas of the mainstem Clutha River for a drift diving survey.

3 METHODS

Juvenile fish were principally sampled by a portable battery-operated electric fishing machine. With the exception of the Cluden Stream, a single pass was made at each site - hence abundance estimates (Table 1) are under-estimates of actual abundance. At the Cluden Stream, two passes were made and the progressive removal technique used to estimate numbers.

TABLE 1. Adult brown and rainbow trout caught.

Method	Brown trout No. caught	No. kept	Scales	Guts	Rainbow trout No. caught	Scales	Guts
Angler caught	2	2	2	2	3	3	2
Gill nets							
2 hour sets	12	7*	7	7	-	-	-
overnight	12	12	12	12	21	21	21
drift	1	1	1	1	17	17	17
Total	27	22	22	22	41	41	40

Catch effort data
Gill nets : day sets = 12 fish/38 hr/500 m^2 net = 0.32 fish/hr/500 m^2
overnight = 33 fish/64 hr/500 m^2 net = 0.52 fish/hr/500 m^2

* = 5 trout tagged and released alive.

A seine net (15 m, 1 cm mesh) was used to capture a sample of 1+ fish at Lindis Crossing and samples of 0+ fish within the mainstem Clutha River; seining was generally in a downstream direction.

Adult fish were mainly obtained by gill nets set in backwaters. A summary of results is given in Table 1.

Four sinking gill nets (50 m x 2.5 m) were used (mesh sizes 57, 64, 83 and 102 mm), which were set across backwaters. A drifting gill net (80 mm mesh) was used in selected runs, with the spread of the net maintained by a snorkel diver at either end.

Apart from five brown trout tagged and released (tag numbers 5151-5155), the remaining fish were kept for scale and gut analysis. After fish were measured, weighed and sexed, scales were removed from the area midway between the lateral line and dorsal fin and placed wet on scale books (pages with gummed surfaces). In the laboratory permanent acetate impressions were made from the pages for subsequent aging and measuring. Additional scales were collected and stored in envelopes (in case the scales on the books were all replacement scales and hence unreadable); the left pectoral fin was removed and stored also. Future work will involve the measuring the radius of scale annuli to back-calculate length at previous age (as a check of the validation of scale aging), and also an examination of fin ray cross-sections to further corroborate scale aging.

Stomachs of trout were removed and stored individually in jars containing 10% formalin. For 0+ fish, whole fish were preserved although the body cavity was either slit or injected with formalin. In the laboratory stomachs were opened longitudinally and a fullness index given (after Hunt and Jones 1972) - indices range from 10 (distended) to 0 (empty). After removal, the contents were sorted into species groups and animals then counted. Generally each species group was weighed (wet weight, after removal of water by vacuum and surface drying on filter paper); in instances were stomach contents were small (approximately <0.1 g) the total contents were weighed and species weights apportioned on an estimated proportion basis. Occurrence was calculated from those stomachs which contained food and is expressed as the percentage of fish which contained a particular food item. All feeding data together with length, weight, age, sex, capture technique, and habitat type were stored on computer for analysis.

Condition factors were calculated for adult fish from the length and weight data. The standard metric condition factor, K was calculated from $K = W \times 10^5/L^3$, while the Corbett condition factors (K_c) commonly used by anglers, were calculated from $K_c = W \times 3612800/L^3$, where W = weight in grams and L = length in mm.

4 RESULTS

4.1 Juvenile fish

Summaries of results are contained in Tables 2 and 3.

TABLE 2. Electric-fishing results, March 1989. (December 1988 results in brackets.)

Site	Brown trout Age class 0	Brown trout Age class 1	Brown trout Abundance (no/m^2)	Rainbow trout Age class 0	Rainbow trout Age class 1	Rainbow trout Abundance (no/m^2)	Eels	Upland bullies
LINDIS RIVER								
Tributaries								
Station Creek	88 (29)	44 (57)	1.32 (0.86)	-	-	-	-	-
Camp Creek	17 (11)	72 (26)	0.45 (0.37)	-	- (2)	- (0.02)	2	-
Cluden Stream	153 (128)	5 (20)	0.66 (2.11)	10 (81)	- (4)	0.04 (1.21)	-	11
Mainstem								
At Cluden Stream	53 (2)	4 (36)	0.10 (0.25)	8	-	0.01	-	-
At Lindis Crossing*	44 (51)	17 (2)	0.15 (0.27)	2 (1)	-	<0.01 (0.01)	-	common
CLUTHA								
Mainstem*	28	1	0.10	6	-	0.02	-	-
NEVIS RIVER								
Confluence	-	28	0.10	6	-	0.02	-	-
BANNOCKBURN	16	27	0.14	-	-	-	-	

* = additional seine samples from these sites.

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TABLE 3. Length at age data from March samples.

Site	Species	Age class	Mean length	S.D.	Range	No.
LINDIS RIVER						
Station Creek	BT	0	70.2	6.5	53-83	88
	BT	1	131.0	18.7	96-187	44
Camp Creek	BT	0	61.5	7.5	48-75	17
	BT	1	121.8	16.0	95-174	72
Cluden Stream	BT	0	77.3	12.7	56-110	153
	BT	1	161.4	11.3	146-175	5
	RT	0	66.5	7.6	58-79	10
Lindis at Cluden	BT	0	83.6	11.7	63-113	53
	BT	1	198.4	19.0	178-220	4
	RT	0	71.5	14.4	50-98	8
Lindis at Lindis Crossing	BT	0	94.8	11.2	72-117	48
	BT	1	187.9	20.5	144-254	100
	RT	0	78.0	2.8	76-80	2
CLUTHA						
Below Rocky Point	BT	0	87.3	11.0	66-114	99
	BT	1	184.0	-	-	1
	RT	0	98.9	14.3	75-116	13
Gravelly Gully	BT	0	74.6	7.8	58-93	51
	RT	0	86.0	10.0	76-96	3
NEVIS RIVER						
Confluence	BT	1	107.9	13.1	83-131	28
	RT	0	66.0	12.1	55-79	3
BANNOCKBURN	BT	0	69.2	7.4	58-83	16
	BT	1	143.2	23.8	116-209	27

BT = brown trout.
RT = rainbow trout.

4.1.1 Repeat sampling of sites in Lindis River

Station Creek - Maintained a high overall density but with a reversal in the relative proportions of age classes 0 and 1. Being a shallow stream with cover provided largely by algae and broken water rather than depth, it has limited rearing opportunities for fish as they grow. Hence a decrease in age class 1 and slow growth of this age group.

Camp Creek - Generally similar numbers of fry but a big increase in the number of yearling fish either due to yearlings entering the section fished from further upstream or from the mainstem Lindis River. Being a bushed catchment may result in lower water temperatures than in the mainstem; apart from that, rearing conditions for 1+ fish do not seem favourable as growth is poor.

Cluden Stream - For brown trout, an overall reduction in 0+ fish but a much larger reduction in 1+ fish. Slow growth of 0+ may reflect high densities. Few 0+ and no 1+ rainbows. Thus an overall tendency for out-migration into mainstem, especially 0+ rainbows and 1+ of both species.

Lindis mainstem at Cluden - Much lower density than in tributaries but marked increase in 0+ fish (both species) and reduction in 1+ (browns). Two large brown trout were also caught (500 mm and 570 mm).

Lindis mainstem at Lindis Crossing - Similar numbers of fry to December but an increase in 1+. As 1+ fish accummulated in areas too deep for effective electric fishing, a seine netted sample was collected.

Overall then there were significant reductions in the numbers of yearling fish from those present in December - the exception was the downstream site of Lindis Crossing where yearling fish had accummulated, presumably in an attempt to migrate to the Clutha itself. As with the December samples, there was an increase in size of fish within both year classes with progress downstream (largest fish at lowermost sites).

Growth during the 11 weeks between surveys varied considerably. Table 4 shows the increase in mean length for repeat surveys (larger samples only with n>=5). The numerically stronger data are for age class 0 - these indicate that tributary growth ranged from 24-31 mm, while mainstem growth was both faster and more consistent (36-38 mm). Growth of 1+ fish in both Station Creek and Camp Creek was slow (13.3 mm and 8.6 mm respectively) compared with Cluden Stream (29.7 mm). Sample sizes at Lindis mainstem sites were inadequate for comparison between the two sampling periods but, as these were the largest of the 1+ fish sampled, growth rates could be expected to be relatively rapid, certainly exceeding those of the tributaries. Over a similar period, growth of 0+ brown trout in tributaries of the Clutha River below Roxburgh (23-44 mm) (Pack and Jellyman 1988) was similar to that in the present study but growth of 1+ fish was more rapid (16-27 mm) probably indicating better rearing opportunities for these larger fish in the lower Clutha tributaries.

TABLE 4. Growth of juvenile brown trout from December 1988-March 1989.

Location	Age class	Sample sizes (Dec, Mar)	Increase in mean length (mm)
Station Creek	0	29, 88	31.0
	1	38, 44	13.3
Camp Creek	0	11, 17	29.4
	1	26, 72	8.6
Cluden Stream	0	53, 153	24.4
	1	20, 5	29.7
Lindis River at Cluden	0	36, 53	35.9
Lindis River at Lindis Crossing	0	51, 48	37.9

No trout were captured by electric fishing in the Cluden water race. A foot survey of 0.8 km indicated only two age class 1 fish, despite the presence of large macrophyte beds and marginal emergent vegetation. Although the entrainment of fish into this race is strongly suspected and has been reported by local anglers, there was no evidence from either sampling period. However, it is likely that directed downstream migration of juvenile fish occurs over a short period of time and hence the likelihood of intercepting this during a one-off survey is slight.

4.1.2 Sampling of other tributaries

The Lowburn was dry for much of its bed and was not sampled. The Nevis River at its confluence with the Kawarau, was tramped into and electric fished. Results indicated a relatively low density of juvenile fish, dominated by brown trout (whereas no rainbow trout were found in tributaries of the Nevis River during December). Growth of Nevis fish was markedly slower than at other sites. The Bannockburn contained only brown trout; growth was comparable to that within the Lindis tribuaries. Anglers talk of infrequent but large fish kills within the Bannockburn during summer, thought to be associated with low flows and high water temperatures.

4.1.3 Sampling of mainstem Clutha

Sampling for juvenile fish was carried out at four sites, ie. the mainstem at sites S133 046755, S124 085816 (side braids below Rocky Point), a backwater at Gravelly Gully (S124 102881), and a site at the upstream end of Maori Point Road (S124 136982). Data for the first site (electric fished) are given in Table 2, while data for sites 1 and 2 are combined for inclusion in Table 3. Only three fish were captured in approximately 300 m^2 of electric fishing at the Maori Gully Road site - these fish were two brown trout (84 and 92 mm) and a single rainbow trout (70 mm).

Fish density in the mainstem is relatively low, although there are very extensive areas of habitat available. Fish size below Rocky Point was comparable with that at Lindis Crossing, and greater than the size at Gravelly Gully. Interestingly, the mean length of rainbow trout of both samples in Table 3 exceeded that of brown trout. Thus, although juvenile rainbow trout are initially at a size disadvantage relative to brown trout due to later spawning and hatching, they grow more rapidly than browns and are typically larger by the end of their first years growth. (Note: Similarly, the average growth of 0+ brown trout in the Cluden Stream was 24.4 mm, while that of 0+ rainbow trout was 29.6 mm.)

4.1.4 Native fish

Within the Lindis River, native fish were again conspicuous by their virtual absence, with the exception of upland bullies at Lindis

December to March, eg. Lindis River at Cluden - December length = 61.3 ± 5.9 (n = 8) versus March length = 74.3 ± 9.7 (n = 9). A significant observation was the recording of common bullies within the Clutha River itself; of a sample of 33 bullies collected in a backwater 12 km upstream of Cromwell, 30 were common bullies (length = 57.9 mm ± 14.1) and only three were upland bullies (length = 60.0 ± 7.0). This is the first recording of common bullies between Lake Roxburgh and Lake Wanaka. It is important because it means that common bullies already occur within the area to be occupied by Lake Dunstan. Had they not been present there would have been some delay while they colonised and became established.

It is anticipated that common bullies will increase rapidly in number at lake-fill. In common with lakes elsewhere, the lake populations will grow to a larger size than adjacent riverine populations. Within the lake they will form a very important part of the food chain, being consumed directly by trout, especially brown trout, but also harvesting small benthic invertebrates like chironomids, which are relatively unavailable to trout. Upland bullies have not demonstrated the same ability to colonise lakes and become an important food item.

Longfinned eels are uncommon in tributary streams although local anglers (Cromwell Rod and Gun Club) speak of large numbers still being present in backwaters. Although eels were not fished for within the main river on this occasion, only one trout of the 33 caught in gill nets set overnight in backwaters had been attacked by eels - had large numbers of big eels been about, the incidence of fish damage would have been much higher. The installation of Roxburgh Dam has interrupted the annual upstream migration of juvenile eels; the dam acts as a barrier but not a complete impasse to elvers, and some limited upstream recruitment still occurs (Pack and Jellyman 1988).

4.2 Stomach contents

Summaries of stomach contents are contained in Tables 5 and 6 while more detailed information is given in Appendices 1 and 2. It was anticipated that fish from overnight set gill nets would have a smaller quantity of food in their stomachs than fish caught by 2 hour sets/drift

TABLE 5. Summary of stomach contents - brown trout. (< = less than 1%; na = not applicable).

Food item	Juveniles (n = 15) $\bar{l}$ = 85 mm Av. fullness index = 7.6			Adults (n = 22; 4 empty) $\bar{l}$ = 433 mm Average fullness index = 1.8		
	No. %	Weight %	Occurrence %	No. %	Weight %	Occurrence %
AQUATIC						
Snails	<	<	13	83	74	56
Stonefly larvae	-	-	-	<	1	6
Dobsonfly larvae	<	6	7	-	-	-
Mayfly larvae	2	6	67	2	1	39
Caddis larvae	46	20	87	9	9	44
Beetle (Coleoptera)	26	40	87	<	<	11
Bugs (Hemiptera)	<	<	7	-	-	-
Flies (Diptera)	21	8	80	<	<	6
Fish	-	-	-	<	1	6
Vegetation	na	-	-	na	1	6
Unidentified fragments	na	-	-	na	-	-
Total	95	80		94	87	
TERRESTRIAL						
Flies	2	6	40	<	2	11
Bees, wasps	-	-	-	6	5	11
Beetles	-	-	-	<	2	6
Bugs	2	3	27	-	-	-
Grasshoppers	<	10	7	-	-	-
Spiders	1	1	20	-	-	-
Earwigs	-	-	-	<	2	6
Feathers	na	-	-	na	2	6
Total	5	20		6	13	
Average no. animals/stomach	44			48		

TABLE 6. **Summary of stomach contents - rainbow trout. (< = less than 1%; na = not applicable).**

Food item	Juveniles (n = 7) $\bar{l}$ = 99 mm Av. fullness index = 8.4 No. %	Weight %	Occurrence %	Adults (n = 40; 1 empty) $\bar{l}$ = 375 mm Average fullness index = 4.2 No. %	Weight %	Occurrence %
AQUATIC						
Snails	-	-	-	58	42	36
Stonefly larvae	-	-	-	<	<	3
Dobsonfly larvae	1	6	14	<	1	13
Mayfly larvae	25	35	100	3	3	69
Caddis larvae	12	4	100	29	21	79
Beetle (Coleoptera)	15	6	86	1	<	38
Bugs (Hemiptera)	1	<	14	-	-	-
Flies (Diptera)	34	3	100	1	1	41
Fish	-	-	-	-	-	-
Vegetation	na	13	14	na	25	77
Unidentified fragments	na	1	14	na	1	21
Total	89	68		92	94	
TERRESTRIAL						
Flies	5	9	57	<	1	23
Bees, wasps	1	1	14	7	4	26
Beetles	1	<	14	<	<	21
Bugs	-	-	-	<	<	5
Grasshoppers	4	21	29	-	-	-
Spiders	-	-	-	<	<	3
Earwigs	-	-	-	<	<	3
Feathers	na	-	-	na	<	21
Total	11	31		7	5	
Average no. animals/stomach	19			122		

nets/angling. However, 't' tests of the fullness indices for both groups of fish (separated by species) indicated that differences were not significant; differences between the species were significant though ($P<0.01$), meaning that rainbow trout stomachs were significantly fuller than those of brown trout.

Juvenile brown trout: Stomachs were generally full (index of 8 = "full"), and dominated by aquatic organisms. Main species were caddises (especially Oxyethira, a small pursed caddis), the larvae of riffle beetles (elmids, Hydora) and larval chironomids (midges). These three groups comprised 68% of total weight of food eaten.

Juvenile rainbow trout: Fewer fish, but very full stomachs; a higher terrestrial component than in juvenile brown trout. Mayflies (Deleatidium) were the most important species. A test of diet overlaps (Schoener 1970) gave an index of 0.44 indicating different diets between juvenile browns and rainbows.

Adult brown trout: Snails, (Potamopyrgus and Physa) dominated the diet, with caddis (Aoteapsyche) being the next most important component by weight. Diet was generally mixed with little evidence of selective feeding on a particular organism to the exclusion of others. Average fullness was low, ie. 1.8 (index of 2 = ¼ full).

Adult rainbow trout: A significantly higher overall fullness index (4.2) than brown trout although the diet was generally similar. Snails again dominated diet with the maximum number in single stomach being 667. Large quantities of vegetation (Elodea) were also present, often associated with snails, but sometimes with willow grubs. Although 'tufts' of periphyton might well occur in the drift and be taken along with such other inedible items as sticks, seeds, and feathers, it is unlikely that large sections of Elodea (up to 5 cm) would drift significantly. Presumably such pieces of macrophyte are ingested accidentally in the course of capturing snails or while surface feeding on willow grubs.

Differences between diets of adult brown and rainbow trout were not significant (Schoener index 0.62) and so diets overlap. The presence of large quantities of snails in the diets of both species tends to indicate feeding in backwater areas, while species like Aoteapsyche, a net building caddis, indicates mainstem feeding. Yet results from gill netting during the day and drift netting indicated brown trout present in backwaters and rainbow trout in the runs of the main river. However, overnight set gill nets caught large numbers of rainbow trout, almost always on the downstream side of the net, indicating that rainbow trout enter backwater areas at night to feed. While backwater areas may be the preferred habitat for adult brown trout, their diet indicates some movement into the mainstem for feeding - this may also principally occur at night. If so this could provide some partitioning of the habitats between the two species, so, although diets are generally similar the two species feed in different areas at different times.

4.3 Adult fish - Condition and growth

Conditions factors for both species are given in Table 7. Condition of rainbow trout slightly exceeds that of brown trout, although brown trout were more variable. (Note: exclusion of a single very well conditioned brown trout where K = 1.68, reduces the average K for brown trout to 1.07). Overall, condition can be considered to be slightly below average as 36-49 on the Corbett scale is regarded as average. Neither species showed any relationship between condition factor and size, ie. smaller fish were not in "better" condition than larger fish and vice versa.

TABLE 7. Condition factors of adult trout. (K = metric condition factor; K_c = Corbett condition factor.

Species	No.	mean	Range	S.D.	Mean	Range	S.D.
Brown trout	18	1.10	0.73-1.68	0.20	39.9	26.5-60.8	7.4
Rainbow trout	37	1.13	0.96-1.31	0.08	40.8	34.7-47.2	3.0

The length-weight relationships for both species were:

Brown trout $l_nW = 2.9618(l_nL) - 11.2008$ ($n = 18$, $r^2 = 0.94$)

Rainbow trout $l_nW = 2.9854(l_nL) - 11.3076$ ($n = 37$, $r^2 = 0.97$)

To investigate growth rates, the samples of fish electric fished and seine netted at Lindis Crossing were included with the adult fish from the mainstem Clutha. Results of aging given as length characteristics of each age class are given in Table 8 and Figure 1. No mathematical equation for the respective growth curves are given in Figure 1 although fitting procedures are reviewed in Appendix 3. (Note: equations allow lengths at various ages to be predicted).

TABLE 8. Length at age data.

Age class	Brown trout No.	$\bar{T}$	Range	S.D.	Rainbow trout No.	$\bar{T}$	Range	S.D.
0	34	89	66-106	10	14	97	76-116	16
1	56	194	148-252	23	3	297	270-315	24
2	7	342	275-398	47	20	346	310-415	27
3	1	365			10	413	367-465	28
4	4	487	431-535	45	2	443	405-480	53
5	5	504	472-535	23	-			
6	1	490			-			
7					1	575		

Growth of both species is relatively fast. The growth rate for brown trout exceeds the rate in Lake Roxburgh (Pack and Jellyman 1988), Lake Benmore (McCarter 1987) and the Mataura River (Witherow and Scott 1984) but is slightly below that of Lake Coleridge (Webb 1984), while growth of rainbow trout is faster than in Lakes Roxburgh and Benmore, similar to Lake Coleridge but slower than in Lakes Tarawera and Alexandrina (Hayes in McCarter 1987).

A number of scales examined from larger fish of both species were found to be replacement scales and hence no use for aging. Additional scales (presently stored in scale envelopes) will be examined and mounted for future examination. Also, 10 diaries and packets of scale envelopes have been distributed to members of the Cromwell Rod and Gun Club, and it is hoped that additional scale samples will become available from this exercise. Participating anglers should also record catch and hours fished, enabling some catch-per-unit-effort data to be generated. However, since the removal of willows from the area upstream of Cromwell, anglers report that there are few remaining fish; they postulate that with the removal of cover the fish have moved upstream to undisturbed areas.

Although the radii of annual checks in the scales has not yet been measured, a measurement of all scales read was taken to see whether there were any apparent differences between tributary reared juveniles (0+ fish) and mainstem juveniles. For this, the distance to the 15th circulus (ring) of the first year's growth was measured - as there was almost always more than 15 circuli within the first year, choice of this number ensured that almost all 0+ fish were included. A series of t-tests of the frequency distributions were done and showed that there were no significant differences between the mean measurements for Lindis River tributary and Lindis mainstem fish, so these samples were combined. When tested against mainstem Clutha fish, there was a statistical difference ($P < 0.01$) but there was such an overlap in distributions that the difference was irrelevant in practical terms. This meant that from the growth patterns recorded in the scales of 0+ fish, it is not possible to distinguish between those fish reared in the Lindis River and those reared in the mainstem Clutha. (This exercise assumes that 0+ fish in the mainstem Clutha are <u>not</u> of Lindis River origin - this is reasonable given the extent of rearing available within the Lindis and the fact that from approximately mid-December 1988 until mid-March 1989, the lower Lindis River was dry downstream of Lindis Crossing, preventing any outmigration.)

5 ACHIEVEMENT OF OBJECTIVES

It is considered that all the objectives set have been achieved, with the exception of analysis of historical angling data - this objective awaits arrival of the data or results from DOC. The final objective (suitability for drift diving) requires some comment. Although visibility within the study area is extremely good, drift diving has not been carried out and is not planned. A number of reasons are given:

- Logistically, drift diving would be extremely difficult, requiring a minimum of ten divers and at least one large jet boat.

- The velocity and width of the river would mean that divers would have great difficulty staying in formation and could only dive selected reaches.

- Local anglers report that fish stocks have diminished markedly since willows were removed.

- Given the preference of brown trout for backwater areas, mainstem diving would under-estimate browns.

- Given the above, extrapolation of results to calculate fish densities and even species proportions would be unwise.

6 FUTURE STUDIES

The next phase of studies is monitoring of trout spawning with the Lindis River and selected tributaries; inclusion of the Bannockburn and Lowburn need consideration. A separate draft proposal has previously been prepared and sent to DOC Queenstown for comment.

A decision will need to be made within the next few months, about the fate of the rainbow trout currently being reared at the Wanaka Hatchery and if they are to be released, how they should be tagged. A proposal about tagging was drawn up (13 February 1989) and circulated.

Filling of the Lake Dunstan is scheduled to commence in late August-early September and be completed by mid-November.

It is tentatively suggested that three summer trips be carried out. The first would be to observe any particular response by resident fish to inundation of the Clutha Arm - opportunity would be taken to collect some trout stomachs for feeding analysis (most of these could come from anglers?) The second trip would be a repeat electric fishing of the Lindis River/tributary sites to provide some additional baseline data on juvenile rearing. Some limited sampling of lake juvenile fish would be done together with zooplankton tows for larval/juvenile bullies. The third trip would be late summer and involve Lindis River/tributary electric fishing, plus some sampling of lake fish (principally scale samples but some gut samples as available).

It is suggested that, if available, a field officer from the newly formed (?) Regional Fish and Game Council maintain regular visits, preferably weekly, to monitor angler use and catches throughout the summer. Most of the scale and gut samples could then be obtained by this means.

7 LITERATURE CITED

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Appendix 1. Stomach contents - brown trout. (< = less than 0.1%; na = not applicable).

Taxa	Juvenile (n = 15) No. %	Juvenile Weight %	Juvenile Occurrence %	Adult (n = 18) No. %	Adult Weight %	Adult Occurrence %
AQUATIC						
Mollusca						
Potamopyrgus	0.3	0.2	13	53.0	42.0	28
Physa	-	-	-	26.3	30.3	50
Gyraulus	-	-	-	3.4	1.8	11
Megaloptera						
Archichauliodes	0.2	5.7	7	0.1	0.6	6
Ephemeroptera						
Deleatidium	2.1	5.8	67	1.4	0.7	39
Coloburiscus	-	-	-	0.7	0.7	17
Trichoptera						
Pycnocentria	1.8	2.0	33	0.1	0.1	6
Oxyethira	42.2	16.6	80	-	-	-
Aoteapsyche	-	-	-	6.6	7.0	39
Olinga	-	-	-	1.7	1.3	17
Hydrobiosis	2.1	1.1	27	0.1	<	6
Hudsonema	-	-	-	0.1	0.1	6
Paroxyethira	0.3	0.2	13	-	-	-
Coleoptera						
Lancetes	-	-	-	0.1	0.1	6
Hydora	25.5	40.4	87	0.2	0.2	11
Hemiptera						
Microvelia	0.2	0.1	7	-	-	-
Diptera						
Chironomidae	20.7	7.9	80	0.2	<	6
Austrosimulium	0.2	0.1	7	0.1	0.1	6
Pisces	-	-	-	0.1	1.4	6
Vegetation						
Sticks	na	-	-	na	0.1	6
Seeds	na	-	-	na	0.9	6
TERRESTRIAL						
Hymenoptera						
Willow grub (Pontania)	-	-	-	5.9	5.4	11
Diptera	1.8	6.3	40	0.3	1.8	11
Coleoptera	-	-	-	0.2	1.8	6
Dermoptera	-	-	-	0.2	1.8	6
Hemiptera	1.8	2.9	27	-	-	-
Orthoptera	0.3	9.6	7	-	-	-
Arachnida	0.5	1.1	20	-	-	-
Aves (feathers)	na	-	-	na	1.8	6

Appendix 2. Stomach contents - rainbow trout. (< = less than 0.1%; na = not applicable).

Taxa	Juvenile (n = 7) No. %	Weight %	Occurrence %	Adult (n = 39) No. %	Weight %	Occurrence %
AQUATIC						
Mollusca						
Potamopyrgus	-	-	-	46.6	34.0	31
Physa	-	-	-	11.1	7.9	18
Gyraulus	-	-	-	0.3	0.1	5
Plecoptera						
Stenoperla	-	-	-	<	0.1	3
Megaloptera						
Archichauliodes	0.8	6.2	14	0.1	0.7	13
Ephemeroptera						
Deleatidium	24.4	31.5	100	2.4	1.6	51
Coloburiscus	0.8	4.0	14	0.6	1.4	23
Trichoptera						
Pycnocentria	0.8	1.3	14	5.1	5.0	36
Oxyethira	5.3	0.2	43	0.1	<	5
Aoteapsyche	2.3	2.0	43	20.5	13.4	79
Olinga	-	-	-	2.5	2.4	33
Hydrobiosis	3.8	0.7	29	0.6	0.4	41
Pycnocentrodes	-	-	-	<	0.3	3
Coleoptera						
Lancetes	-	-	-	<	<	3
Hydora	15.3	5.9	86	1.3	0.5	38
Hemiptera						
Microvelia	0.8	0.3	14	-	-	-
Diptera						
Chironomidae	34.3	2.9	100	0.3	<	23
Austrosimulium	-	-	-	1.0	0.1	31
Eriopterini	-	-	-	<	<	3
Unidentified (fragments)	na	0.7	14	na	0.9	21
Vegetation						
Macrophyte	na	-	-	na	21.8	41
Periphyton	na	13.3	14	na	2.1	33
Sticks	na	-	-	na	2.1	13
Seeds	na	-	-	na	<	3
TERRESTRIAL						
Hymenoptera						
Bees, wasps	-	-	-	0.3	1.9	10
Willow grub (*Pontania*)	0.8	1.3	14	6.4	1.8	23

Appendix 2 (cont'd).

Taxa	Juvenile (n = 7)			Adult (n = 39)		
	No. %	Weight %	Occurrence %	No. %	Weight %	Occurrence %
Diptera	5.3	8.7	57	0.3	1.0	23
Coleoptera	0.8	0.3	14	0.2	0.3	21
Dermoptera	-	-	-	<	0.1	3
Hemiptera	-	-	-	0.1	0.1	5
Orthoptera	3.8	20.6	29	-	-	-
Arachnida	-	-	-	<	<	3
Aves (feathers)	na	-	-	na	0.5	21

APPENDIX 3. Curve fitting for age and length relationships.

The age/length relationship for both trout species (Fig. 1) is obviously curved and some non-linear expression is needed to describe it. However, as most data points occur along the lower values (ages 0-2) a linear relationship provides a surprisingly good overall 'fit' (brown trout, n = 107, r^2 = 0.92; rainbow trout, n = 52, r^2 = 0.85), although the predicted line departs markedly from a line drawn by eye at higher values.

Because the x-axis involves a value of zero (age class 0) a normal log transformation could not be done so a log (x + 1) transformation was carried out. As the resulting line had only a fair agreement with the expected line, a number of other transformations were tried.

A summary of results is:

Transformation	Species	r^2	Comparison with expected line
log (age + 1), log length	BT	0.94	fair
log (age + 1), log length	RT	0.93	fair
log (age + 1), length	BT	0.90	very good
log (age + 1), length	RT	0.96	very good
square root age, square root length	BT	0.92	good
square root age, square root length	RT	0.96	good
square root age, length	BT	0.85	reasonable
square root age, length	RT	0.97	good

All relationships gave very highly significant correlation coefficients ($P < 0.01$), and all except the log-log transformation fitted the data reasonably well. The best 'fits' were given by log (age + 1) x length for both species.

Resulting expressions were:

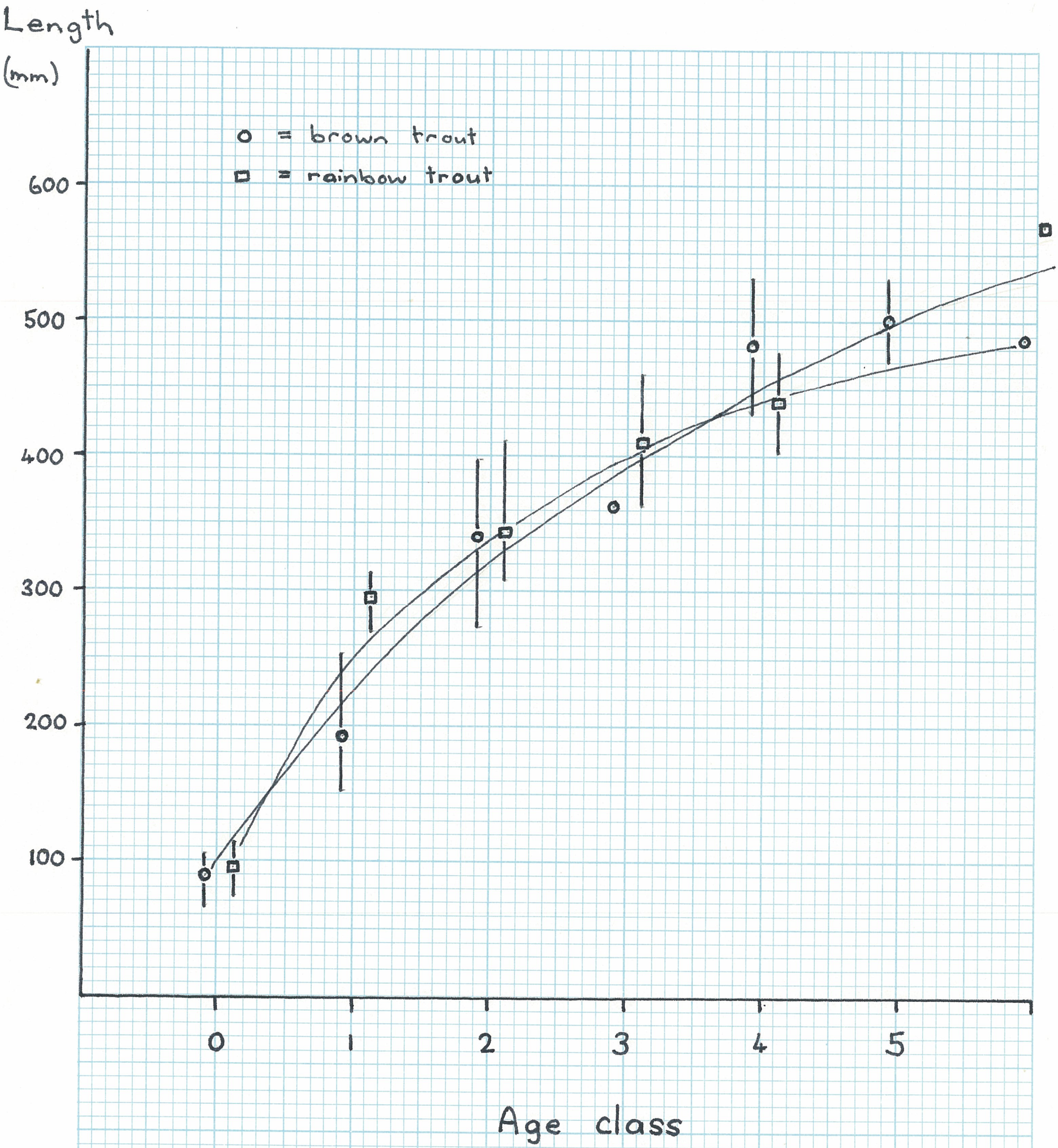
Brown trout: $L = 219.80\ [l_n\ (A + 1)] + 67.12$ (n = 107, r = 0.95)

Rainbow trout: $L = 221.41\ [l_n\ (A + 1)] + 101.54$ (n = 52, r = 0.98)

where L = length in mm, A = age class in years.

Addition of further data will mean these relationships will need to be recalculated. However, for the present the equations do allow lengths at particular ages to be predicted with reasonable certainty.

Fig. 1.


Length
(mm)
o = brown trout
□ = rainbow trout
600
500
400
300
200
100
0
1
2
3
4
5
Age class