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River Don and Colden Water fisheries surveys: initial survey

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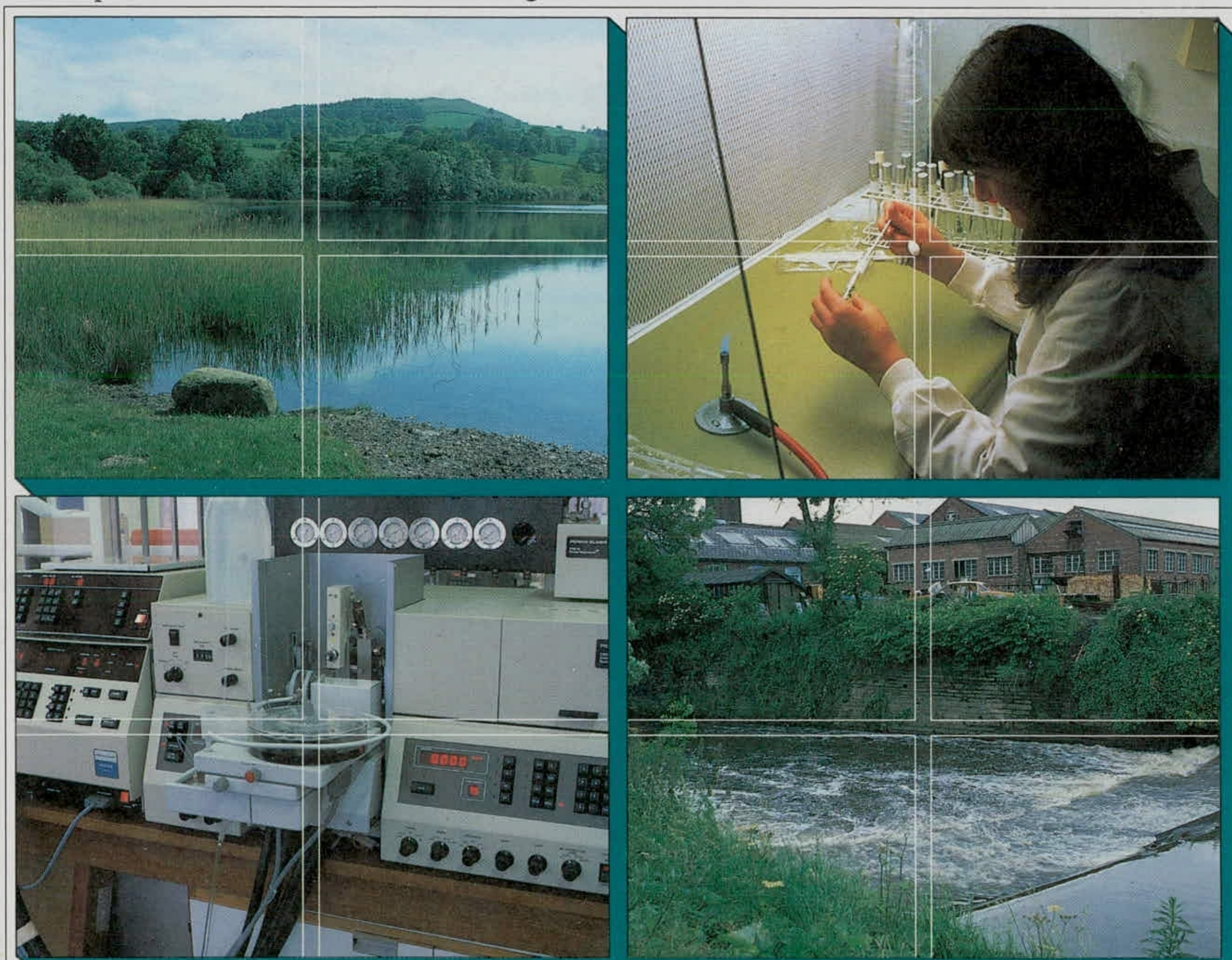

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1. EXECUTIVE SUMMARY

1. As a condition of drought orders being imposed on several West Yorkshire rivers, eight sites on the River don catchment and one on the Colden Water were surveyed for their fish populations in the first week of April 1996. These sites are intended for repeat survey in October 1996 and April 1997.

2. Over all the sites a total of 12 species of fish were captured, but only brown trout *Salmo trutta* were common to all sites. Electric fishing efficiency, density, biomass, year class strengths and size at each age is presented for each species at each site.

3. There was a small amount of evidence of brown trout stocking in some sites but the vast majority of fish captured appeared to be from natural production. However, this survey was probably conducted before the main stocking period and more stocked fish may be captured in the October survey.

4. Some cautions are given with regard to the accuracy of population estimates and interpretation of the data.

2. INTRODUCTION

As a condition of drought orders being imposed on several West Yorkshire rivers, Yorkshire Water are obliged to carry out fishery surveys on the relevant watercourses. These surveys are intended to take place once in April 1996 and to be repeated in October 1996 and April 1997. This report presents the results of the initial survey.

3. METHODS

Between 1 and 5 April eight sites on the River Don Catchment and one on the Colden Water were surveyed for their fish populations (Table 3.1). Each site comprised a 200 m length of river divided into four equal 50 m sections. The location of each site had been predetermined.

Table 3.1 Dates and National Grid References of sites surveyed.

Site name	Date surveyed	National Grid Reference	
River Sheaf	4 April 1996	SK 327 823	✓
River Don u/s Bullhouse Minewater	2 April 1996	SE 213 032	✓
River Don d/s Winscar Reservoir	2 April 1996	SE 158 024	R
River Don at Oxspring	1 April 1996	SE 278 016	?
Ewden Beck	3 April 1996	SK 293 955	R
Little Don d/s Underbank Reservoir	1 April 1996	SK 255 992	R
River Loxley at Storrs Lane Bridge	3 April 1996	SK 299 895	J
River Rivelin at Rivelin Mill	4 April 1996	SK 289 871	J
Colden Water at Hebden Bridge	5 April 1996	SD 983 277	

On arrival, the sections were first marked out by measuring exactly from a predetermined upstream or downstream limit. Each section was then delimited by use of stop nets. In every case all four sections were stop netted before electric fishing commenced in any section.

Sections were then electric fished using a single anode attached to a 1.9 KVa Honda generator, which was either located on the bank, or pulled behind the anode on a rubber dingy depending on access at the site. Three of the sections were fished once and one of the sections was subjected to a triple shock. The estimated efficiency of capture for each fish species was derived using the catch depletion method (Zippin, 1956) from the triple shock. This efficiency was then used to calibrate the single shocks on the other three sections. Selection of the section for the triple shock estimate took into account its similarity to the other sections. That is, unusual sections were not selected for the triple shock. A period of at least 40 minutes elapsed between each shock on the triple shock sections.

At the end of the survey the area of each section was estimated from its length and five width measurements.

3.1 Brown trout, rainbow trout *Oncorhynchus mykiss*, perch *Perca perca*, dace *Leuciscus leuciscus*, grayling *Thymallus thymallus*, roach *Rutilus rutilus* and pike *Esox lucius*.

Once captured, fish were held in a bin. Each fish was measured to the nearest mm and a sample was weighed and had scales removed for age determination. All fish were then returned alive to the section that they were captured in.

In the laboratory, all scales were examined with the use of an Optical Works projectina. Ages of fish were determined from annual growth rings. The presence or absence of stocked fish at each site was determined by assigning each scale read as belonging to naturally or farmed produced stock. The criteria being unusual growth rates or a preponderance of scarred scales from one fish.

Length weight relationships, density and biomass for each section, year class strengths, mean length and weight for each age class and, for trout, data for use in the HABSCORE model were estimated from the field measurements and estimated electric fishing efficiencies.

3.2 Stickleback *Gasterosteus aculeatus*, stone loach *Barbatula barbatula*, bullheads *Cottus gobio*, minnows *Phoxinus phoxinus* and ruffe *Gymnocephalus cernua*.

Once captured these fish were treated in the same way as those fish in the above paragraph, except that, provided there were sufficient number not to impact on the local population, a sample was killed and taken away from the site for measuring and weighing and if necessary for age determination. If it was not possible to take a sample away, length weight relationships from one of the other sites were used to estimate biomass for that species. In such cases age groups were estimated from the population size distribution.

4. RIVER SHEAF

4.1 Site description

Two anglers had to be moved in order to complete the survey at this site, but the level of angling pressure here was unclear. Visibility was good and the whole site was wadeable. Generally it was all shaded by a high tree canopy.

Section 1:- This comprised a short steep riffle at the bottom end and a deep pool at the top end

Section 2:- This comprised nearly all steep shallow riffle

Section 3:- This comprised nearly all steep shallow riffle with the exception of a shallow glide at the top end.

Section 4:- There was a deep pool at the bottom end with some root cover at this point. There was a small area of riffle at the top end.

4.2 Results

4.2.1 Brown trout

Table 4.1. Electric fishing efficiencies for brown trout calculated from triple shocks of Section 1 of River Sheaf site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	28	19	8	66	43.7

Table 4.2. Number of brown trout captured in each section of River Sheaf site, together with density and biomass, calculated from efficiencies in Table4.5. (* = section fished for triple shock estimate of efficiency). Sections are ordered in an upstream direction. That is Section 1 is the section furthest downstream and Section 4 is the furthest upstream.

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	55	263	0.285	10.2
Section 2	11	290	0.117	2.46
Section 3	19	286	0.224	3.3
Section 4	18	274	0.106	8.2
Total	103	1113	0.181	5.9

Table 4.3. The length weight relationship for brown trout at the River Sheaf site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Brown Trout	- 1.58	2.71	98.8 %

Table 4.4. Number of brown trout captured in each year class, year class strengths and mean lengths and weights at the River Sheaf site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	45	117	57.9	8.0 ± 1.12	7.6 ± 3.1
1994	32	51	25.2	14.8 ± 1.55	39.4 ±11.0
1993	20	28	13.9	19.6 ± 1.60	85 ± 19.4
1992	4	4	2.0	25.9 ± 2.65	187 ± 57
1991	2	2	1.0	33.4 ± 0.50	323 ± 4.2

Table 4.5. Information for HABSCORE from the River Sheaf site. Section 1 provided estimate for triple shock estimate.

	No. of fish captured				Efficiency (%)	Estimated number in each section together with density (n m^{-2}) in brackets				Estimated total biomass in each section (g) together with g m^{-2} in brackets			
	Sect 1	Sect 2	Sect 3	Sect 4		Sect 1	Sect 2	Sect 3	Sect 4	Sect 1	Sect 2	Sect 3	Sect 4
1 year old	10/10/ 5	6	14	0	26.2	41 (0.156)	23 (0.079)	53 (0.185)	0 (0)	312 (1.19)	175 (0.60)	403 (1.41)	0 (0)
Trout <20 cm older than 1	13/9/3	5	5	10	47.2	29 (0.110)	11 (0.038)	11 (0.038)	21 (0.077)	1415 (5.4)	537 (1.85)	537 (1.88)	1025 (3.7)
Trout >20 cm	5/0/0	0	0	8	100	5 (0.019)	0 (0)	0 (0)	8 (0.0292)	957 (3.6)	0 (0)	0 (0)	1228 (4.5)

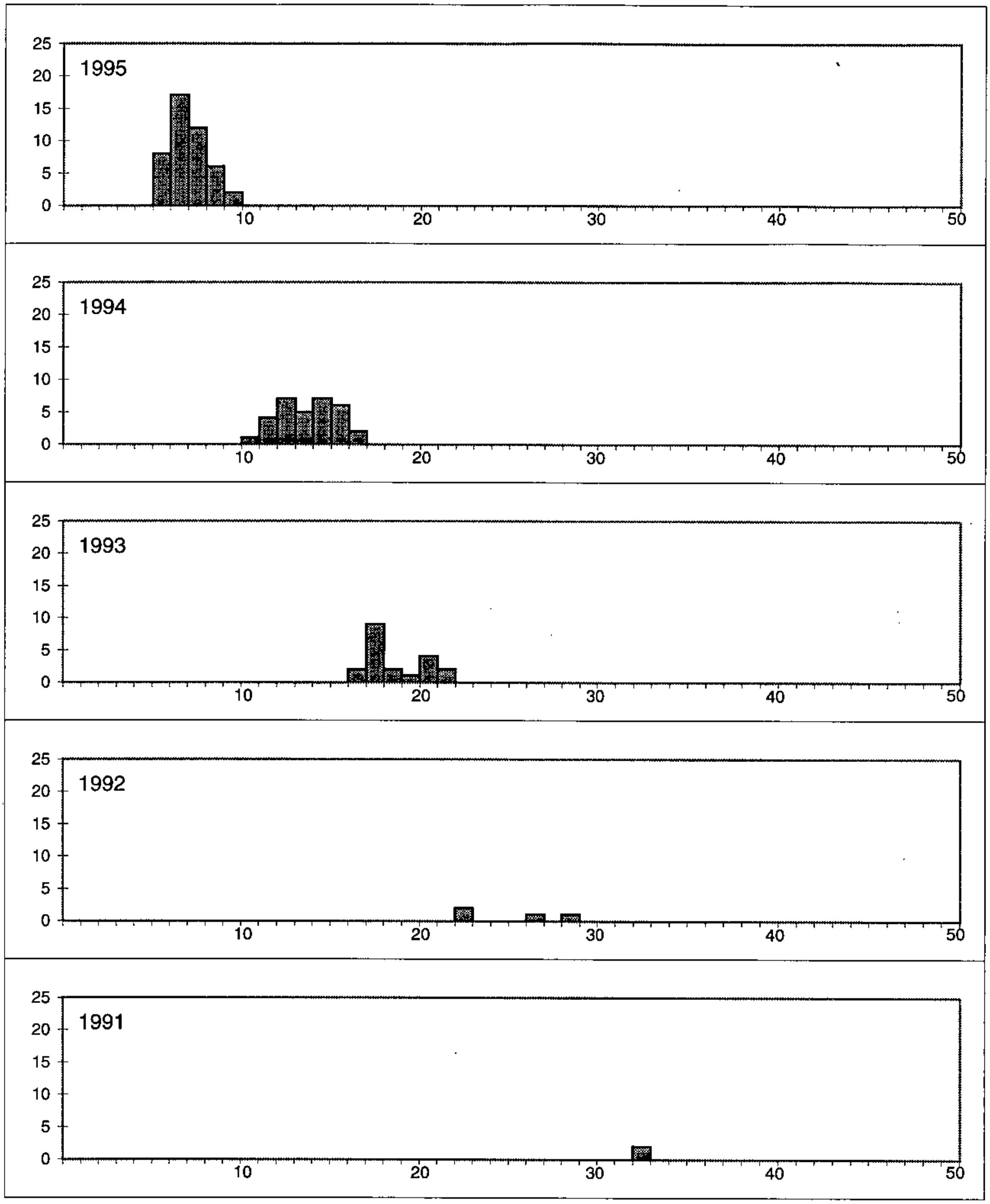

Figure 4.1 Length frequency histogram of each year class of brown trout captured at the River Sheaf site.

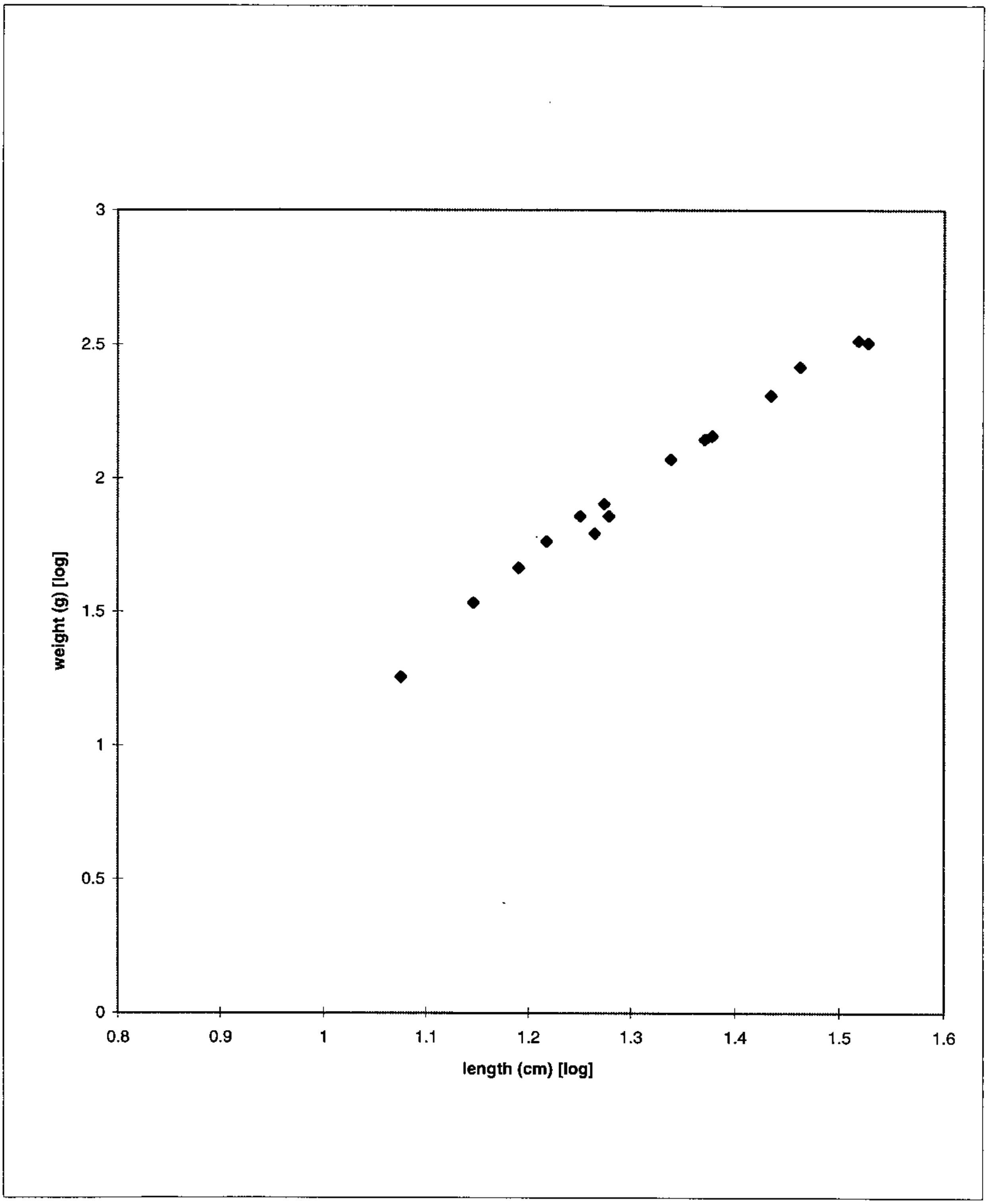

Figure 4.2 Length [log] and weight [log] for brown trout at the River Sheaf site.

4.2.2 Bullheads

Table 4.6. Electric fishing efficiencies for bullheads calculated from triple shocks of Section 1 of River Sheaf site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	22	14	8	56	39.1

Table 4.7. Number of bullheads captured in each section of River Sheaf site, together with density and biomass, calculated from efficiencies in Table 4.6. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	44	263	0.213	1.50
Section 2	12	290	0.107	0.71
Section 3	7	286	0.063	0.46
Section 4	6	274	0.055	0.44
Total	69	1113	0.108	0.77

Table 4.8. The length weight relationship for bullheads at the River Sheaf site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Bullheads	- 2.16	3.39	98.3 %

Table 4.9. Number of bullheads captured in each year class, year class strengths and mean lengths and weights at the River Sheaf site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	8	20	11.4	3.9 ± 0.50	0.76±0.279
1994	60	153	86.9	7.8 ± 0.88	7.7 ± 2.83
1993	1	3	1.7	10.5	20.0

4.2.3 Perch

Table 4.10. Electric fishing efficiencies for perch calculated from triple shocks of Section 1 of River Sheaf site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	6	2	2	11	47.2

Table 4.11. Number of perch captured in each section of River Sheaf site, together with density and biomass, calculated from efficiencies in Table 4.10. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	10	263	0.42	1.00
Section 2	0	290	0	0
Section 3	3	286	0.0210	0.44
Section 4	5	274	0.040	1.72
Total	18	1113	0.114	0.77

Table 4.12. The length weight relationship for perch at the River Sheaf site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Perch	- 2.48	3.57	99.6 %

Table 4.13. Number of perch captured in each year class, year class strengths and mean lengths and weights at the River Sheaf site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	9	19	50	6.5 ± 0.59	2.70± 0.86
1994	8	17	44.7	14.6 ± 1.45	49 ± 15.9
1993	1	2	5.3	18.2	104

4.2.4 Dace

Table 4.14. Electric fishing efficiencies for dace calculated from triple shocks of Section 1 of River Sheaf site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	0	0	0	0	n/d

Table 4.15. Number of dace captured in each section of River Sheaf site, together with density and biomass, calculated from efficiencies in Table 4.14. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	0	263	0	0
Section 2	0	290	0	0
Section 3	0	286	0	0
Section 4	4	274	0.0146**	1.89**
Total	4	1113	0.0036**	0.47**

** represents minimum density and biomass

Table 4.16. The length weight relationship for dace at the River Sheaf site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Dace	n/a	n/a	n/a

Table 4.17. Number of dace captured in each year class, year class strengths and mean lengths and weights at the River Sheaf site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995					
1994					
1993					
1992					
1991	3	3	75	19.1 ±0.115	96 ± 11.0
1990					
1989					
1988	1	1	25	26.1	232

4.2.5 Roach

Table 4.18. Electric fishing efficiencies for roach calculated from triple shocks of Section 1 of River Sheaf site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	0	0	0	0	n/d

Table 4.19. Number of roach captured in each section of River Sheaf site, together with density and biomass, calculated from efficiencies in Table 4.18. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	0	263	0	0
Section 2	0	290	0	0
Section 3	0	286	0	0
Section 4	1	274	0.0036**	0.78**
Total	1	1113	0.00090**	0.192**

** represents minimum density and biomass

Table 4.20. The length weight relationship for roach at the River Sheaf site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Roach	n/a	n/a	n/a

Table 4.21. Number of roach captured in each year class, year class strengths and mean lengths and weights at the River Sheaf site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995					
1994					
1993					
1992					
1991					
1990					
1989					
1988					
1987					
1986	1	1	100	23.4	214

4.2.6 Stickleback

Table 4.22. Electric fishing efficiencies for stickleback calculated from triple shocks of Section 1 of River Sheaf site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	0	0	0	0	n/d

Table 4.23. Number of stickleback captured in each section of River Sheaf site, together with density and biomass, calculated from efficiencies in Table 4.22. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	0	263	0	0
Section 2	0	290	0	0
Section 3	1	286	0.0035#	0.0126**#
Section 4	0	274	0	0
Total	1	1113	0.00090#	0.0032**#

** Estimates of biomass derived from stickleback length weight relationship for fish captured in upper Frome (Log_{10} W (g) = -1.93 + 3.14 Log_{10} L (cm).
# represents minimum density and biomass

Table 4.24. The length weight relationship for stickleback at the River Sheaf site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Stickleback	n/a	n/a	n/a

Table 4.25. Number of stickleback captured in each year class, year class strengths and mean lengths and weights at the River Sheaf site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d. *
1995					
1994	1	1	100	6.2	3.6*

* Estimates of biomass derived from stickleback length weight relationship for fish captured in upper Frome (Log_{10} W (g) = -1.93 + 3.14 Log_{10} L (cm)

4.3 Discussion

4.3.1 Brown trout

There was no evidence of any stocking having taken place at this site this year. All the scales taken from one 17.6 cm trout were scarred, but this was the exception and all other trout scales exhibited growth rates that are typical of naturally produced fish.

Two anglers were disturbed on this site, both of whom were using bait for angling. When the electric fishing team had arrived the anglers had already removed one brown trout at least 30 cm in length. This type of fishing in a small river, such as the Sheaf, will very quickly result in the over exploitation of a natural trout population. This may have already occurred with only 4 fish over 25 cm being captured. In the absence of stocking, it might be expected that even less large fish will be captured later in the year.

4.3.2 Other species

It is unlikely that the perch population captured at this site would be self supporting in a water with such a steep gradient as this and is more likely that they were produced and then 'leaked out' of a stillwater nearby.

The only other abundant species to be found were bullheads. Although a catch depletion was observed with this species, it is hard to attach any confidence to the efficiency of capture or the estimated population density or biomass for this species. This is because the habitat of broken water in riffles, large substrate size and deeper water in pools makes visibility and capture of these fish difficult. The unusual population structure with very few of the smaller 1995 year class being captured is a result of this, and does not reflect the true population structure. For quantitative comparisons at a later date it may be possible to use a catch per unit effort value, but this will also be heavily dependent on the electric fishing efficiency, which will change significantly between electric fishing events with temperature, conductivity and water levels. Mean length for each age class may have some use for comparison at a later date.

5. RIVER DON U/S BULLHOUSE MINEWATER

5.1 Site description

This site was altered from the original one chosen because of the depth of water above the weir. The site surveyed extended for 100 m either side of the mill bridge. In general the river was impacted on by the presence of the weir and also the bridge to create extensive ponded areas.

Section 1:- This was entirely ponded, but wadeable where it was still backed up from the weir. It was mostly shaded from a high tree canopy.

Section 2:- This section had more riffle habitat as it approached the bridge, and had some macrophyte growth. It mainly had open banks.

Section 3:- This section comprised riffle at its lower end and some deeper ponded areas at its higher end. The bankside was mainly open with some rubbish on one bank.

Section 4:- This section was mostly ponded again, with some high canopy shading from trees.

5.2 Results

5.2.1 Brown trout

Table 5.1. Electric fishing efficiencies for brown trout calculated from triple shocks of Section 1 of River Don u/s Bullhouse Minewater site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	6	2	0	8	77.9

Table 5.2. Number of brown trout captured in each section of River Don u/s Bullhouse Minewater site, together with density and biomass, calculated from efficiencies in Table 5.1. (* = section fished for triple shock estimate of efficiency). Sections are ordered in an upstream direction. That is Section 1 is the section furthest downstream and Section 4 is the furthest upstream.

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	8	393	0.020	1.34
Section 2	15	299	0.064	2.03
Section 3	10	364	0.036	1.40
Section 4	24	298	0.104	7.7
Total	57	1354	0.052	2.92

Table 5.3. The length weight relationship for brown trout at the River Don u/s Bullhouse Minewater site. Relationship equates to $Log_{10}\ W\ (g) = a + b\ Log_{10}\ L\ (cm)$.

	a	b	R^2
Brown Trout	- 1.70	2.81	98.9 %

Table 5.4. Number of brown trout captured in each year class, year class strengths and mean lengths and weights at the River Don u/s Bullhouse Minewater site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	14	18	24.7	9.3 ± 0.90	10.8 ±2.90
1994	25	32	43.8	13.9 ±1.91*	34 ± 13.0*
1993	12	15	20.5	20.1 ± 1.45	92 ±19.2
1992	6	8	11.0	25.8 ± 2.12	187 ± 44

* excludes stocked fish

Table 5.5. Information for HABSCORE from the River Don u/s Bullhouse Minewater site. Section 1 provided estimate for triple shock estimate.

	No. of fish captured				Efficiency (%)	Estimated number in each section together with density (n m^{-2}) in brackets				Estimated total biomass in each section (g) together with g m^{-2} in brackets			
	Sect 1	Sect 2	Sect 3	Sect 4		Sect 1	Sect 2	Sect 3	Sect 4	Sect 1	Sect 2	Sect 3	Sect 4
1 year old	0/0/0	7	3	4	n/d (77.9)*	0 (0)	9 (0.030)	4 (0.0110)	5 (0.0168)	0 (0)	97 (0.32)	43 (0.118)	54 (0.181)
Trout <20 cm - older than 1	6/0/0	7	6	11	100 (77.9)*	6 (0.0153)	9 (0.030)	8 (0.0220)	14 (0.047)	246 (0.63)	369 (1.23)	328 (0.90)	574 (1.93)
Trout >20 cm	0/2/0	1	1	9	n/d (77.9)*	2 (0.0051)	1 (0.0033)	1 (0.0028)	12 (0.040)	280 (0.71)	140 (0.47)	140 (0.38)	1676 (5.6)

* The numbers of trout captured were so low that individual efficiencies either could not be estimated or were unrealistic for each age and size class. Therefore the efficiencies estimated in Table 1 were used to estimate the numbers and biomass of brown trout in each section, as this was considered to give the most realistic values.

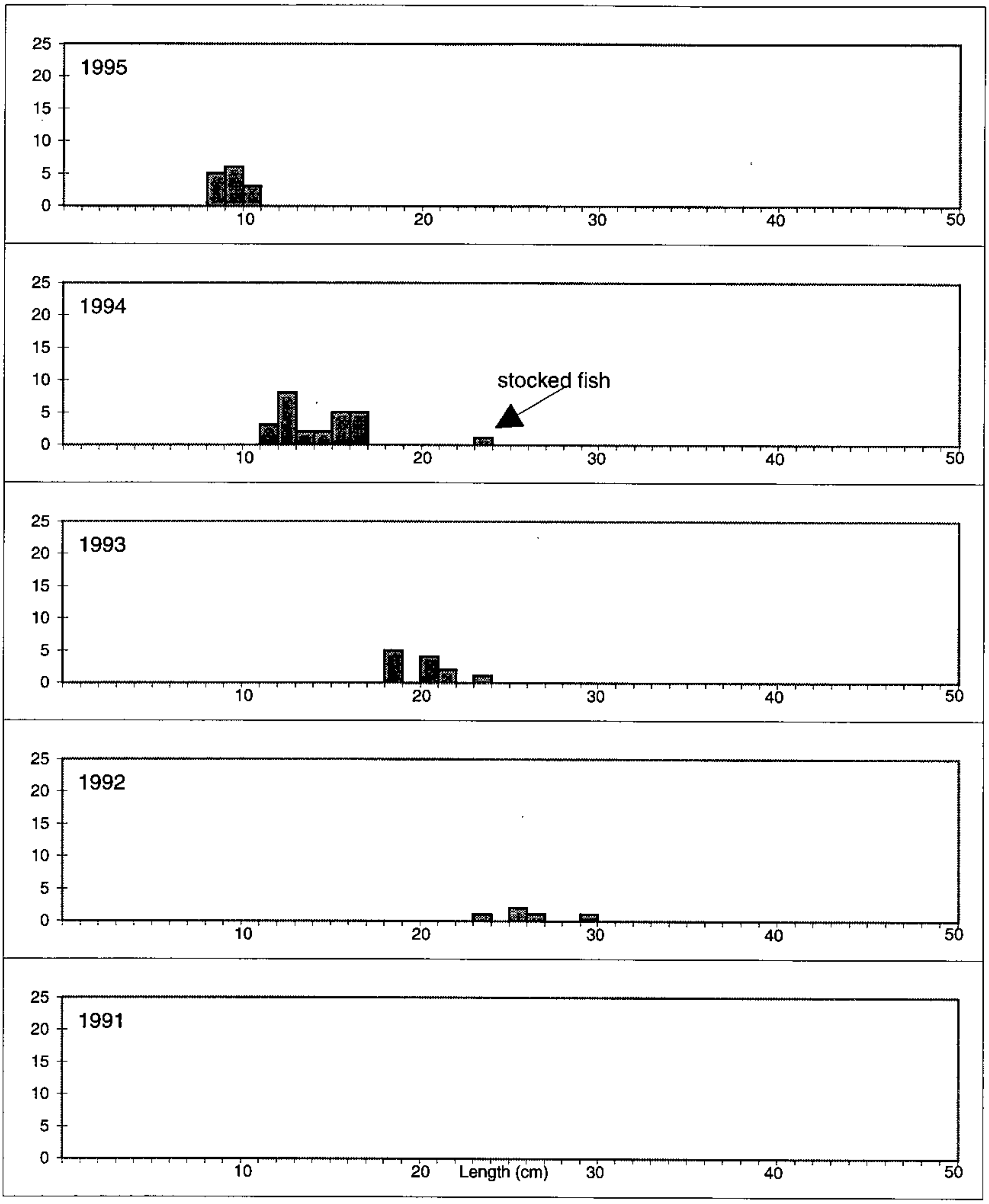

Figure 5.1 Length frequency histogram of each year class of brown trout captured at the River Don U/S Bullhouse Minewater site.

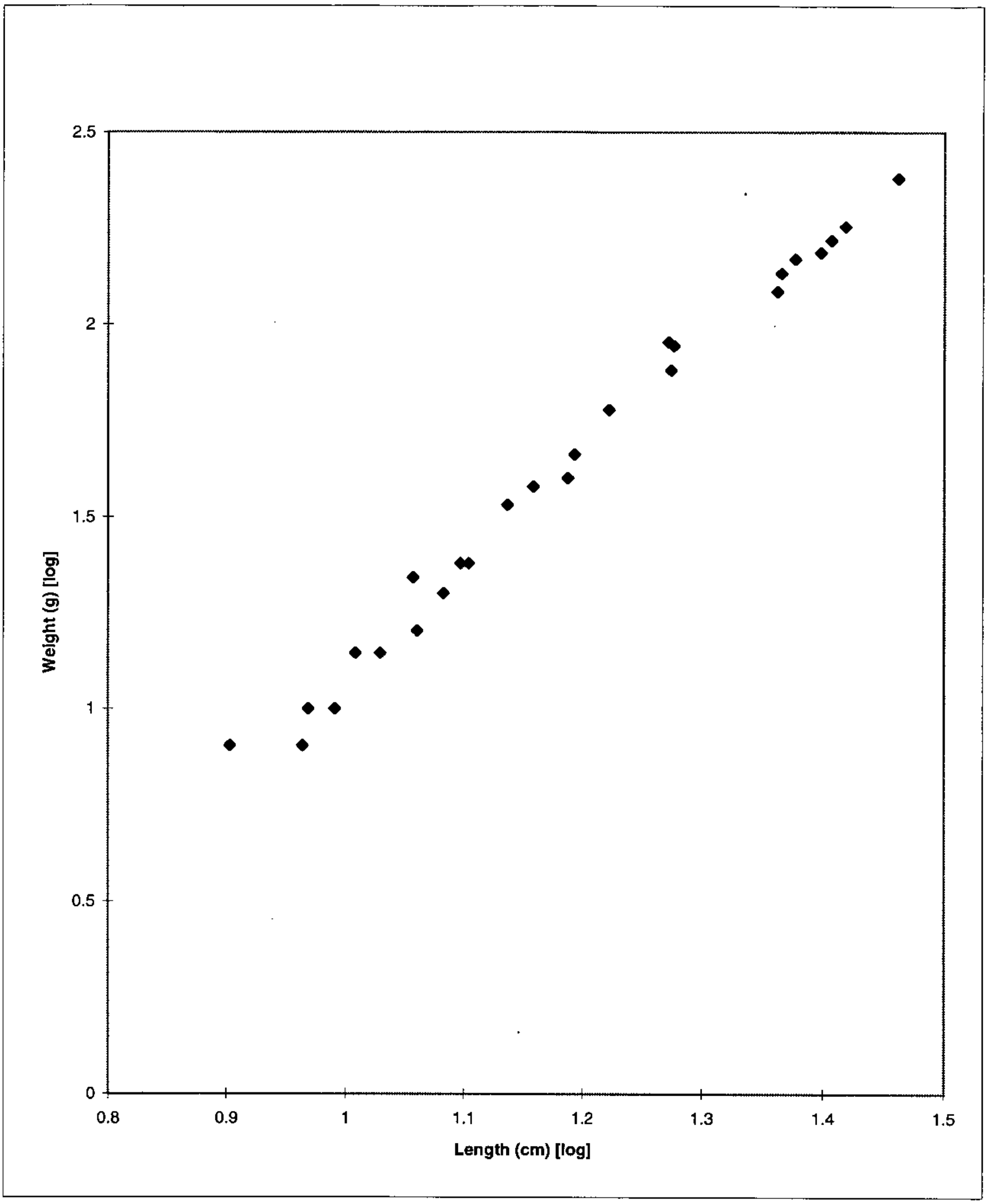

Figure 5.2 Length [log] and weight [log] for brown trout at the River Don U/S Bullhouse Minewater site.

5.2.2 Grayling

Table 5.6. Electric fishing efficiencies for grayling calculated from triple shocks of Section 1 of River Don u/s Bullhouse Minewater site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	1	1	0	2	56.5

Table 5.7. Number of grayling captured in each section of River Don u/s Bullhouse Minewater site, together with density and biomass, calculated from efficiencies in Table 5.6. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	2	393	0.0051	0.173
Section 2	0	299	0	0
Section 3	1	364	0.0055	0.097
Section 4	1	298	0.0034	1.45
Total	4	1354	0.0037	0.40

Table 5.8. The length weight relationship for grayling at the River Don u/s Bullhouse Minewater site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Grayling	-2.09	3.11	99.9 %

Table 5.9. Number of grayling captured in each year class, year class strengths and mean lengths and weights at the River Don u/s Bullhouse Minewater site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	2	4	50	10.5 ± 2.9	13.0 ± 9.9
1994	1	2	25	17.5	62
1993	1	2	25	27.9	244

5.2.3 Minnow

Table 5.10. Electric fishing efficiencies for minnows calculated from triple shocks of Section 1 of River Don u/s Bullhouse Minewater site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	76	38	20	154	48.9

Table 5.11. Number of minnows captured in each section of River Don u/s Bullhouse Minewater site, together with density and biomass, calculated from efficiencies in Table 5.10. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	134	393	0.39	0.70
Section 2	9	299	0.060	0.35
Section 3	18	364	0.102	0.34
Section 4	29	298	0.198	0.45
Total	190	1354	0.140	0.47

Table 5.12. The length weight relationship for minnows at the River Don u/s Bullhouse Minewater site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Minnows	-2.08	3.19	99.8 %

Table 5.13. Number of minnows captured in each year class, year class strengths and mean lengths and weights at the River Don u/s Bullhouse Minewater site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	19	39	10.6	3.1 ± 0.233	0.32±0.071
1994	138	282	76.6	5.2 ± 0.37	1.69 ±0.37
1993	23	47	12.8	7.5 ± 0.76	5.4 ±1.79

5.2.4 Stickleback

Table 5.14. Electric fishing efficiencies for stickleback calculated from triple shocks of Section 1 of River Don u/s Bullhouse Minewater site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	4	2	2	11	31.8

Table 5.15. Number of stickleback captured in each section of River Don u/s Bullhouse Minewater site, together with density and biomass, calculated from efficiencies in Table 5.14. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	8	393	0.0280	0.255**
Section 2	1	299	0.0100	0.0105**
Section 3	1	364	0.0082	0.0114**
Section 4	2	298	0.0201	0.0193**
Total	12	1354	0.0170	0.084**

** Estimates of biomass derived from stickleback length weight relationship for fish captured in upper Frome (Log_{10} W (g) = -1.93 + 3.14 Log_{10} L (cm)

Table 5.16. The length weight relationship for stickleback at the River Don u/s Bullhouse Minewater site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Stickleback	n/a	n/a	n/a

Table 5.17. Number of stickleback captured in each year class, year class strengths and mean lengths and weights at the River Don u/s Bullhouse Minewater site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d. *
1995	4	13	34.2	3.05 ± 0.24	0.40±0.103
1994	8	25	65.8	4.35 ± 0.58	1.25 ±0.55

* Estimates of biomass derived from stickleback length weight relationship for fish captured in upper Frome (Log_{10} W (g) = -1.93 + 3.14 Log_{10} L (cm)

5.3 Discussion

5.3.1 Brown trout

Although no anglers were present on the section being electric fished, neighbouring parts of the river had them and the whole site was obviously run by an angling club. It would be surprising if the natural stock were not supplemented by farm bred brown trout. However, of the brown trout captured during this study only one fish had an obviously fast growth rate in its first year suggesting it was of farm stock origin. So far as it is possible to tell the remainder all appeared to be from naturally produced stock. The one stocked fish was 23.8 cm in length and was approaching the end of its second year. It had been stocked last spring at the end of its first year.

5.3.2 Other species

Although a catch depletion was observed with minnows, it is hard to attach any confidence to the efficiency of capture or the estimated population density or biomass for this species. Minnows are shoaling cyprinids, if a shoal is shocked under a tree root, which is highly likely in this habitat, the greater bulk of the population may not even be seen by the operator and there is no way of knowing what proportion of the population that is. The unusual population structure with very few of the smaller 1995 year class being captured is a result of the greater difficulty in seeing these, and probably does not reflect the true population structure. For quantitative comparisons at a later date it may be possible to use a catch per unit effort value, but this will also be heavily dependent on the electric fishing efficiency, which will change significantly between electric fishing events with temperature, conductivity and water levels. Mean length for each age class may have some use for comparison at a later date.

6. RIVER DON D/S WINSCAR RESERVOIR

6.1 Site description

In general this was a small stream with good visibility. Some overgrowths of vegetation will have reduced efficiency of electric fishing. Would have preferred to use portable battery operated electric fishing gear to increase efficiency.

Section 1:- This section had a large tree in the middle with difficult access and a lot of collected rubbish in the stream. The impact of this on the efficiency made this section unsuitable for the triple shock.

Section 2:- This section was shallow with clear banks and easy access, and was selected as being most typical of the majority of the site. Used for triple shock.

Section 3 & 4:- Both these had banks with over hanging trees and plenty of cover.

6.2 Results

6.2.1 Brown trout

Table 6.1. Electric fishing efficiencies for brown trout calculated from triple shocks of Section 2 of River Don d/s Winscar Reservoir site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	24	17	7	59	42.7

Table 6.2. Number of brown trout captured in each section of River Don d/s Winscar Reservoir site, together with density and biomass, calculated from efficiencies in Table 6.5. (* = section fished for triple shock estimate of efficiency). Sections are ordered in an upstream direction. That is Section 1 is the section furthest downstream and Section 4 is the furthest upstream.

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1	16	100	0.40	6.0
Section 2*	48	90	0.66	7.8
Section 3	19	93	0.49	6.2
Section 4	17	122	0.34	4.7
Total	100	405	0.46	6.0

Table 6.3. The length weight relationship for brown trout at the River Don d/s Winscar Reservoir site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Brown Trout	- 2.31	3.31	98.3 %

Table 6.4. Number of brown trout captured in each year class, year class strengths and mean lengths and weights at the River Don d/s Winscar Reservoir site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	28	42	22.5	5.6 ± 0.95	1.62 ±0.91
1994	63	127	67.9	10.5 ± 1.26	12.4 ± 5.2
1993	9	18	9.6	15.6 ± 1.07	44.6 ±10.2

Table 6.5. Information for HABSCORE from the River Don d/s Winscar Reservoir site. Section 2 provided estimate for triple shock estimate.

	No. of fish captured				Efficiency (%)	Estimated number in each section together with density (n m^{-2}) in brackets				Estimated total biomass in each section (g) together with g m^{-2} in brackets			
	Sect 1	Sect 2	Sect 3	Sect 4		Sect 1	Sect 2	Sect 3	Sect 4	Sect 1	Sect 2	Sect 3	Sect 4
1 year old	2	8/7/1	6	4	50.8	4 (0.040)	18 (0.20)	12 (0.129)	8 (0.066)	6.5 (0.065)	29.2 (0.324)	19.4 (0.209)	13.0 (0.107)
Trout <20 cm older than 1	14	16/10/6	13	13	38.5	36 (0.36)	41 (0.46)	34 (0.37)	34 (0.279)	590 (5.9)	672 (7.5)	558 (6.0)	558 (4.6)
Trout >20 cm	0	0/0/0	0	0	n/a								

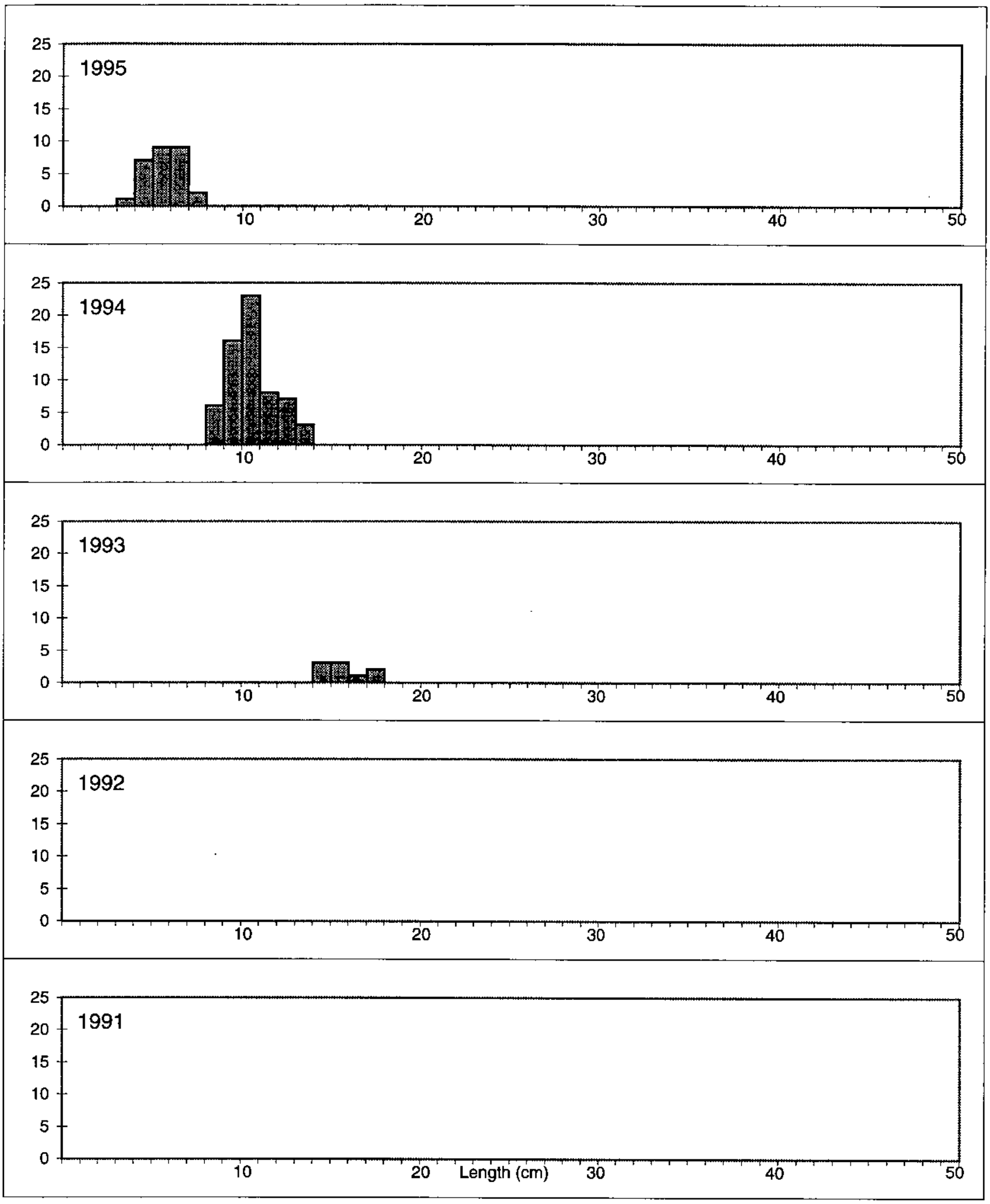

Figure 6.1 Length frequency histogram of each year class of brown trout captured at the River Don D/S Winscar Reservoir site.

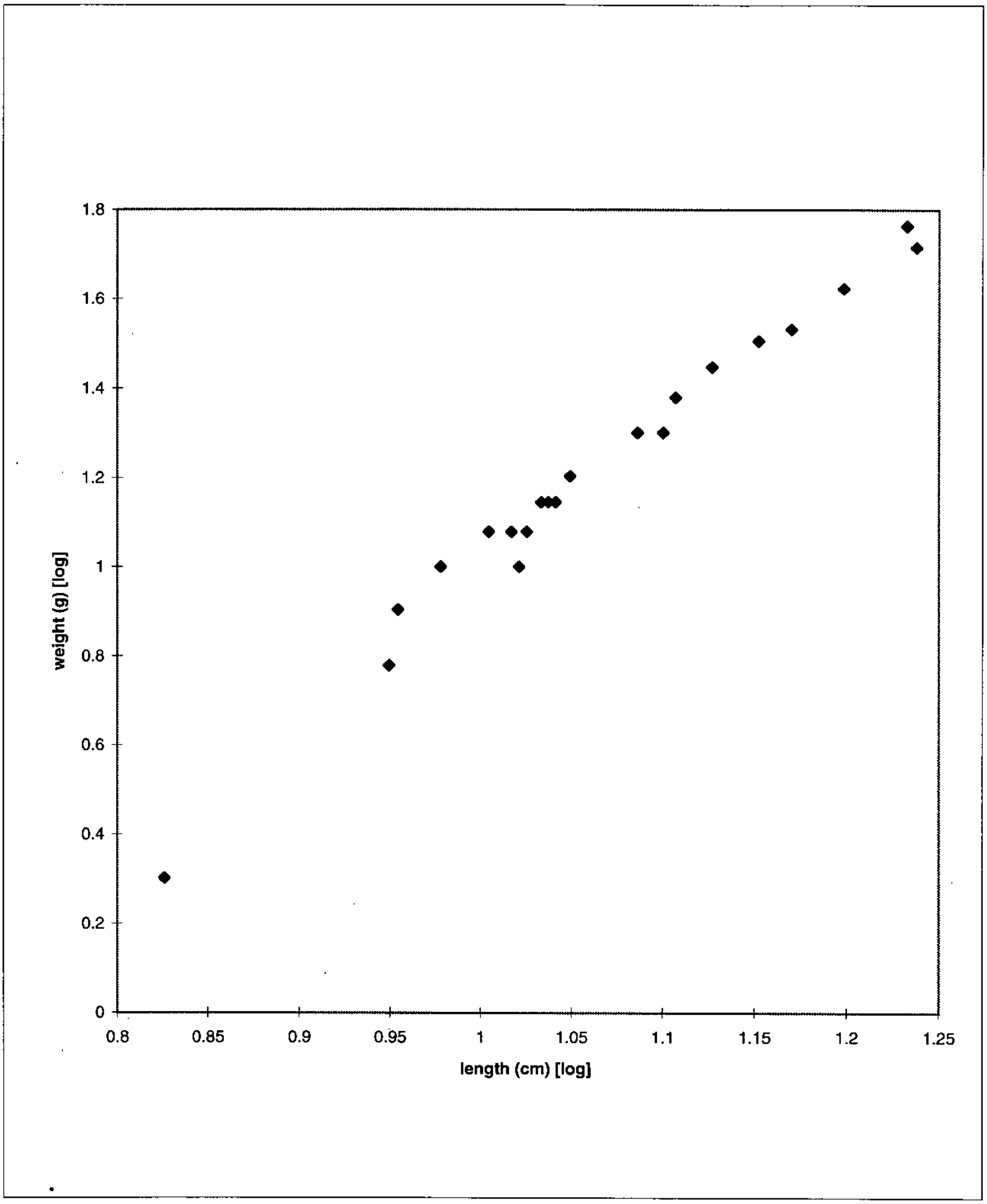

Figure 6.2 Length [log] and weight [log] for brown trout at the River Don D/S Winscar Reservoir site.

6.3 Discussion

This was a very small outflow of a reservoir. The habitat comprised almost entirely of shallow water highly suitable for small brown trout, but unsuitable for larger individuals. Any large fish emerging from the reservoir would have to migrate further downstream or would quickly fall victim to predators. There was no evidence that any of the brown trout captured were of stocked origin.

The electric-fishing efficiency was somewhat impeded by the use of the generator and large anode, better suited to the main river sites downstream, in such a small habitat. Efficiency could be improved by use of battery operated gear with a smaller anode.

7. RIVER DON AT OXSPRING

7.1 Site description

In general the whole site was shaded by a high canopy of trees.

Section 1:- This section was very shallow throughout its entire length.

Section 2:- This section had more deeper water and some areas with submerged tree roots.

Section 3:- This section had some deeper water and the substratum size was large.

Section 4:- Most of this section was shallow, with the exception of a deep part at the top. Again substratum size was large.

7.2 Results

7.2.1 Brown trout

Table 7.1. Electric fishing efficiencies for brown trout calculated from triple shocks of Section 2 of River Don at Oxspring site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	8	2	1	11	68.4

Table 7.2. Number of brown trout captured in each section of River Don at Oxspring site, together with density and biomass, calculated from efficiencies in Table 7.5. (* = section fished for triple shock estimate of efficiency). Sections are ordered in an upstream direction. That is Section 1 is the section furthest downstream and Section 4 is the furthest upstream.

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1	2	392	0.0077	0.61
Section 2*	11	408	0.0270	3.0
Section 3	5	430	0.0186	0.235
Section 4	2	439	0.0068	0.198
Total	20	1669	0.0150	0.99

Table 7.3. The length weight relationship for brown trout at the River Don at Oxspring site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Brown Trout	- 2.27	3.24	98.9 %

Table 7.4. Number of brown trout captured in each year class, year class strengths and mean lengths and weights at the River Don at Oxspring site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	12	17	68	10.7 ± 1.78	12.6 ± 6.0
1994	1	1	4	17.9	61.6
1993	6	6	24	25.2 ± 2.9	194 ± 65
1992	1	1	4	25.6	196

Table 7.5. Information for HABSCORE from the River Don at Oxspring site. Section 2 provided estimate for triple shock estimate.

	No. of fish captured				Efficiency (%)	Estimated number in each section together with density (n m^{-2}) in brackets				Estimated total biomass in each section (g) together with g m^{-2} in brackets			
	Sect 1	Sect 2	Sect 3	Sect 4		Sect 1	Sect 2	Sect 3	Sect 4	Sect 1	Sect 2	Sect 3	Sect 4
1 year old	1	4/0/1	5	1	65.3	2 (0.0051)	5 (0.0123)	8 (0.0186)	2 (0.0046)	25 (0.064)	63 (0.154)	101 (0.235)	25 (0.057)
Trout <20 cm older than 1	0	0/0/0	0	1	n/d (68.4)	0 (0)	0 (0)	0 (0)	1 (0.0023)	0 (0)	0 (0)	0 (0)	62 (0.141)
Trout >20 cm	1	4/2/0	0	0	71.0	1 (0.0026)	6 (0.0147)	0 (0)	0 (0)	216 (0.55)	1166 (2.86)	0 (0)	0 (0)

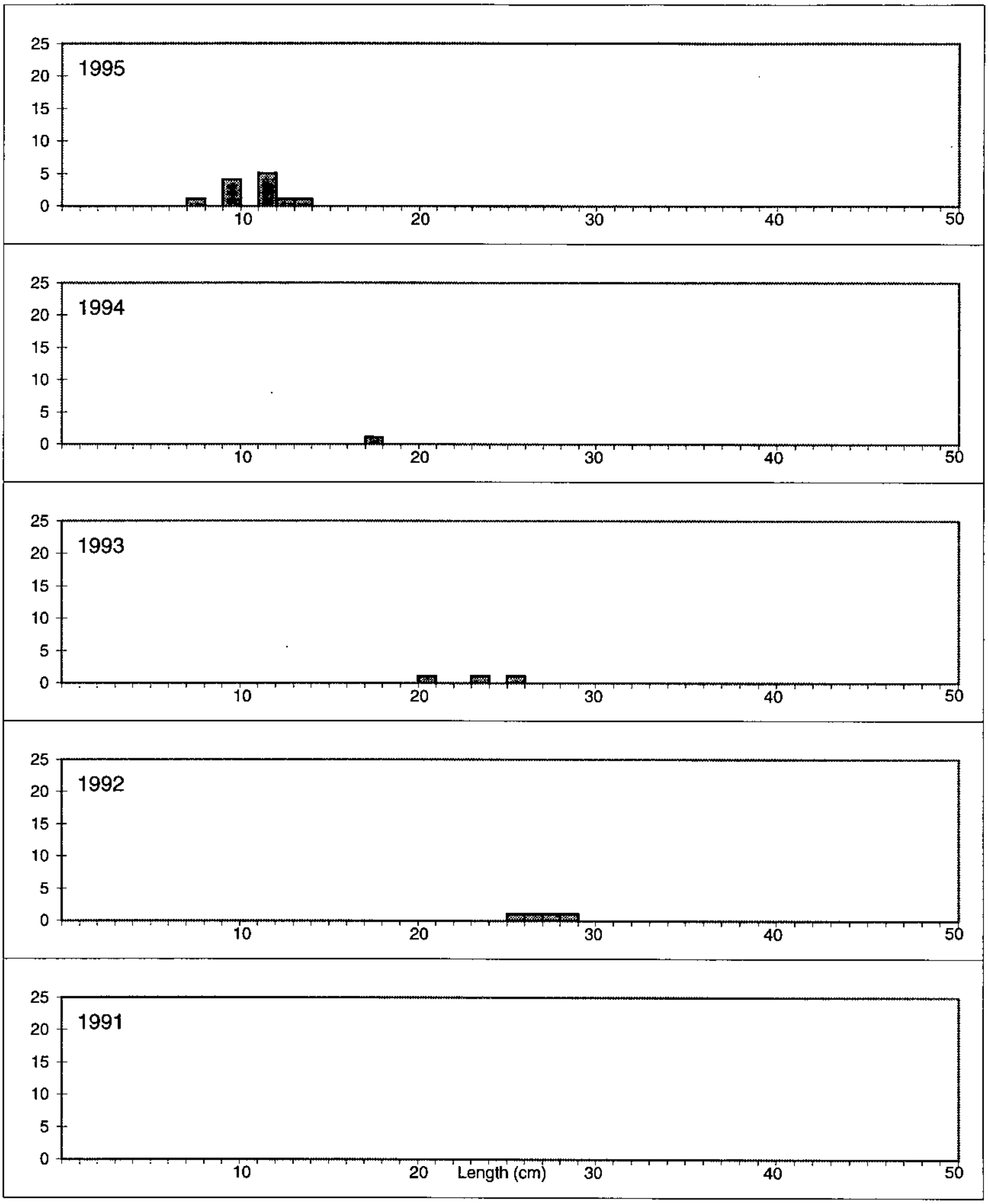

Figure 7.1 Length frequency histogram of each year class of brown trout captured at the River Don at Oxspring site.

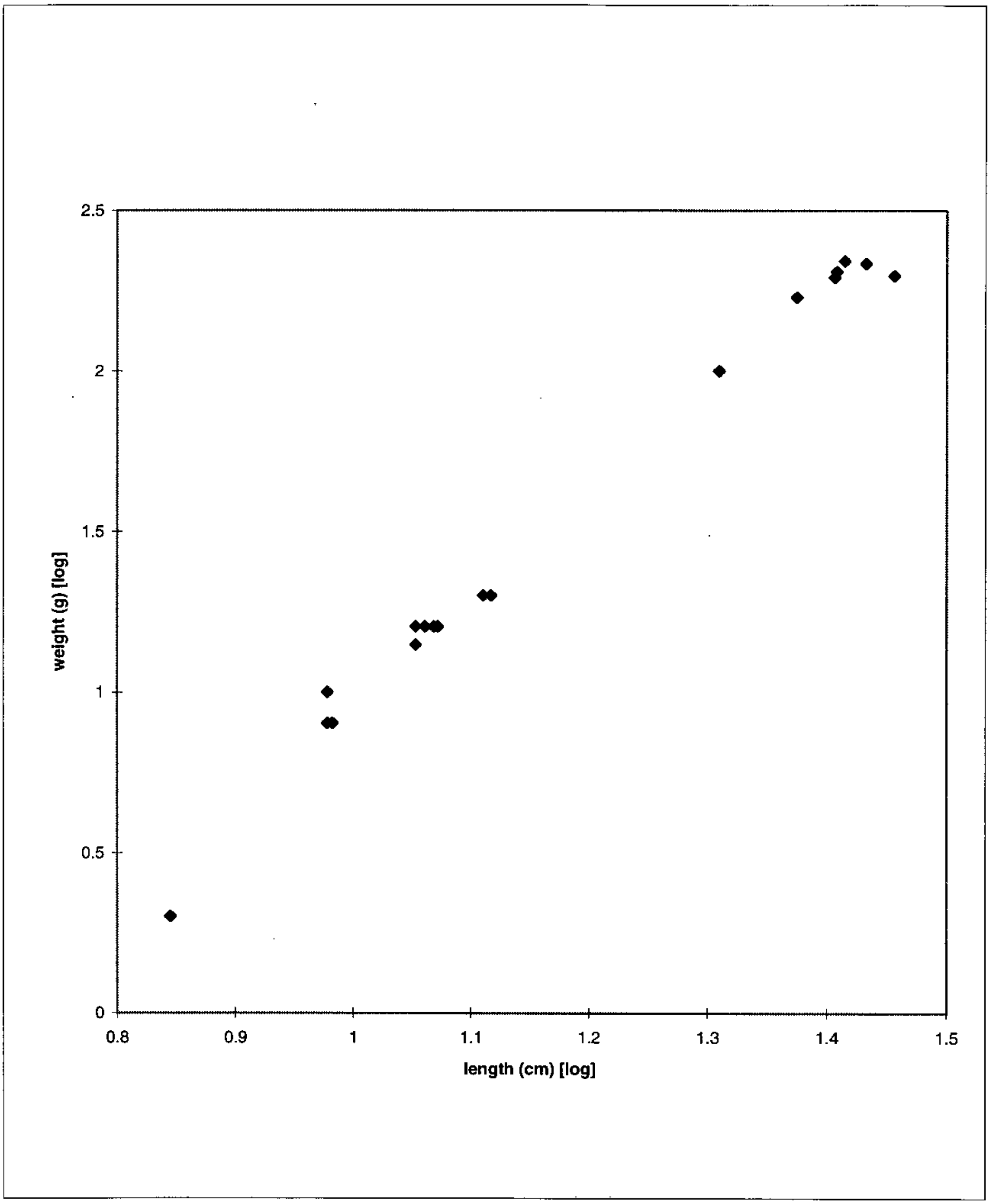

Figure 7.2 Length [log] and weight [log] for brown trout at the River Don at Oxspring site.

7.2.2 Grayling

Table 7.6. Electric fishing efficiencies for grayling calculated from triple shocks of Section 2 of River Don at Oxspring site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	3	3	1	9	35.7

Table 7.7. Number of grayling captured in each section of River Don at Oxspring site, together with density and biomass, calculated from efficiencies in Table 7.6. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1	0	392	0	0
Section 2*	7	408	0.022	1.85
Section 3	2	430	0.0140	0.195
Section 4	1	439	0.0068	0.077
Total	10	1669	0.0108	0.52

Table 7.8. The length weight relationship for grayling at the River Don at Oxspring site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Grayling	- 2.44	3.38	99.1 %

Table 7.9. Number of grayling captured in each year class, year class strengths and mean lengths and weights at the River Don at Oxspring.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	6	17	60.7	11.1 ± 1.52	12.7±4.3
1994	1	3	10.7	18.2	72
1993	3	8	28.6	23.5±0.64	160 ±12.5

7.2.3 Bullhead

Table 7.10. Electric fishing efficiencies for bullheads calculated from triple shocks of Section 2 of River Don at Oxspring site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	26	11	10	58	41.4

Table 7.11. Number of bullheads captured in each section of River Don at Oxspring site, together with density and biomass, calculated from efficiencies in Table 7.10. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1	31	392	0.191	0.35
Section 2*	47	408	0.142	0.56
Section 3	18	430	0.100	0.33
Section 4	9	439	0.050	0.171
Total	105	1669	0.118	0.35

Table 7.12. The length weight relationship for bullheads at the River Don at Oxspring site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Bullheads	- 1.98	3.10	98.1 %

Table 7.13. Number of bullheads captured in each year class, year class strengths and mean lengths and weights at the River Don at Oxspring.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	16	39	15.4	3.3 ± 0.31	0.42±0.123
1994	79	191	75.2	6.0± 0.65	2.86± 0.95
1993	10	24	9.4	8.0 ± 0.41	6.6 ±1.00

7.2.4 Minnow

Table 7.14. Electric fishing efficiencies for minnows calculated from triple shocks of Section 2 of River Don at Oxspring site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	31	14	39	n/a	n/d

Table 7.15. Number of Minnows captured in each section of River Don at Oxspring site, together with density and biomass, calculated from efficiencies in Table 7.14. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1	0	392	0	0
Section 2*	84	408	0.206**	0.60**
Section 3	11	430	0.0256**	0.084**
Section 4	4	439	0.0091**	0.041**
Total	99	1669	0.059**	0.0178**

** represent minimum densities and biomass

Table 7.16. The length weight relationship for minnows at the River Don at Oxspring site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Minnows	- 2.01	3.17	99.1 %

Table 7.17. Number of minnows captured in each year class, year class strengths and mean lengths and weights at the River Don at Oxspring.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	2	2	2.0	3.7 ± 0.14	0.62±0.075
1994	87	87	87.9	5.8 ± 0.29	2.60 ±0.41
1993	10	10	10.1	7.9±0.64	6.9± 1.74

7.2.5 Stone loach

Table 7.18. Electric fishing efficiencies for stone loach calculated from triple shocks of Section 2 of River Don at Oxspring site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	6	3	5	n/a	n/d

Table 7.19. Number of stone loach captured in each section of River Don at Oxspring site, together with density and biomass, calculated from efficiencies in Table 7.18. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1	0	392	0	0
Section 2*	14	408	0.034#	0.30**#
Section 3	2	430	0.0047#	0.039**#
Section 4	1	439	0.0023#	0.0162**#
Total	17	1669	0.0102#	0.088**#

** Estimates of biomass derived from stone loach length weight relationship for fish captured in River Rivelin at Rivelin Mill (Log_{10} W (g) = -2.33 + 3.21 Log_{10} L (cm)

represents minimum densities and biomass

Table 7.20. The length weight relationship for stone loach at the River Don at Oxspring site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Stone loach	- 2.44	3.38	99.1 %

Table 7.21. Number of stone loach captured in each year class, year class strengths and mean lengths and weights at the River Don at Oxspring.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995					
1994	9	9	52.9	8.7 ± 0.64	5.0 ± 1.23
1993	8	8	47.1	11.7±0.81	12.8± 2.92

7.2.6 Stickleback

Table 7.22. Electric fishing efficiencies for stickleback calculated from triple shocks of Section 2 of River Don at Oxspring site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	0	0	0	0	n/d

Table 7.23. Number of stickleback captured in each section of River Don at Oxspring site, together with density and biomass, calculated from efficiencies in Table 7.22. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1	0	392	0	0
Section 2*	0	408	0	0
Section 3	1	430	0.00275#	0.0033**#
Section 4	0	439	0	0
Total	1	1669	0.00060#	0.0006**#

** Estimates of biomass derived from stickleback length weight relationship for fish captured in upper Frome (Log_{10} W (g) = -1.93 + 3.14 Log_{10} L (cm)

represents minimum densities and biomass

Table 7.24. The length weight relationship for stickleback at the River Don at Oxspring site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Stickleback	n/a	n/a	n/a

Table 7.25. Number of stickleback captured in each year class, year class strengths and mean lengths and weights at the River Don at Oxspring site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d. *
1995					
1994	1	1	100	4.6	1.42

* Estimates of biomass derived from stickleback length weight relationship for fish captured in upper Frome (Log_{10} W (g) = -1.93 + 3.14 Log_{10} L (cm)

7.3 Discussion

7.3.1 Brown trout

The numbers of trout captured at this site were low. Although the reasons for this are not clear it may have been because they have been heavily fished. There was no evidence of stocking, with all scales exhibiting natural growth rates. Size at each age was a little greater at this site than those upstream and growth rate appeared to have increased after the first year in those older fish captured at this site. This could be the result of a downstream migration from upstream or out of small feeder streams by juveniles after their first year.

7.3.2 Other species

Although a catch depletion was observed with bullheads, it is hard to attach any confidence to the efficiency of capture or the estimated population density or biomass for this species. Large numbers of minnows and some stone loach were also captured but catch depletions were not achieved supporting the argument that accurate estimates of population densities of these small benthic or shoaling fish is difficult. The apparently unusual population structure with very few of the smaller 1995 year class, in each of these species, being captured is a result of the greater difficulty in seeing these, and probably does not reflect the true population structure. For quantitative comparisons at a later date it may be possible to use a catch per unit effort value, but this will also be heavily dependent on the electric fishing efficiency, which will change significantly between electric fishing events with temperature, conductivity and water levels. Mean length for each age class may have some use for comparison at a later date.

8. EWDEN BECK

8.1 Site description

There were two options for this site. Option 2, the site furthest from the dam was selected. There was good visibility, except in one place where the water was very deep on one bank and not easily accessible and where a tree was lying across the river.

Section 1:- This section comprised almost entirely of shallow riffle and the river was wide here. The river was split by an island at the top end.

Section 2:- This section was nearly all ponded with a very deep section on one bank which was not wadeable. Fishing this part was difficult.

Section 3:- There was a great deal of woody debris in this section associated with a fallen tree. Fishing was difficult in this area.

Section 4:- This section had a typical riffle pool form and was selected for the triple shock.

8.2 Results

8.2.1 Brown trout

Table 8.1. Electric fishing efficiencies for brown trout calculated from triple shocks of Section 4 of Ewden Beck site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	50	17	4	73	69.4

Table 8.2. Number of brown trout captured in each section of Ewden Beck site, together with density and biomass, calculated from efficiencies in Table 8.5. (* = section fished for triple shock estimate of efficiency). Sections are ordered in an upstream direction. That is Section 1 is the section furthest downstream and Section 4 is the furthest upstream.

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1	34	500	0.102	2.27
Section 2	52	345	0.209	7.8
Section 3	32	319	0.150	3.3
Section 4*	71	253	0.289	8.1
Total	189	1417	0.172	4.9

Table 8.3. The length weight relationship for brown trout at the Ewden Beck site. Relationship equates to $\text{Log}_{10}\ W\ (g) = a + b\ \text{Log}_{10}\ L\ (cm)$.

	a	b	R^2
Brown Trout	- 1.74	2.83	99.1 %

Table 8.4. Number of brown trout captured in each year class, year class strengths and mean lengths and weights at the Ewden Beck site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	107	145	59.4	9.1 ± 0.81	9.5 ± 2.41
1994	42	52	21.3	14.9 ± 1.23	39 ± 8.6
1993	38	47	19.3	18.9 ± 1.58	76 ± 18.5

Table 8.5. Information for HABSCORE from the Ewden Beck site. Section 4 provided estimate for triple shock estimate.

	No. of fish captured				Efficiency (%)	Estimated number in each section together with density (n m^{-2}) in brackets				Estimated total biomass in each section (g) together with g m^{-2} in brackets			
	Sect 1	Sect 2	Sect 3	Sect 4		Sect 1	Sect 2	Sect 3	Sect 4	Sect 1	Sect 2	Sect 3	Sect 4
1 year old	23	20	21	28/12/ 3	63.7	36 (0.072)	31 (0.090)	33 (0.103)	45 (0.178)	342 (0.68)	295 (0.86)	314 (0.98)	428 (1.69)
Trout <20 cm older than 1	10	26	11	17/5/1	73.4	14 (0.028)	35 (0.101)	15 (0.047)	23 (0.091)	700 (1.4)	1750 (5.1)	750 (2.35)	1150 (4.5)
Trout >20 cm	1	6	0	5/0/0	100	1 (0.002)	6 (0.0174)	0 (0)	5 (0.0198)	95 (0.19)	630 (1.83)	0 (0)	483 (1.91)

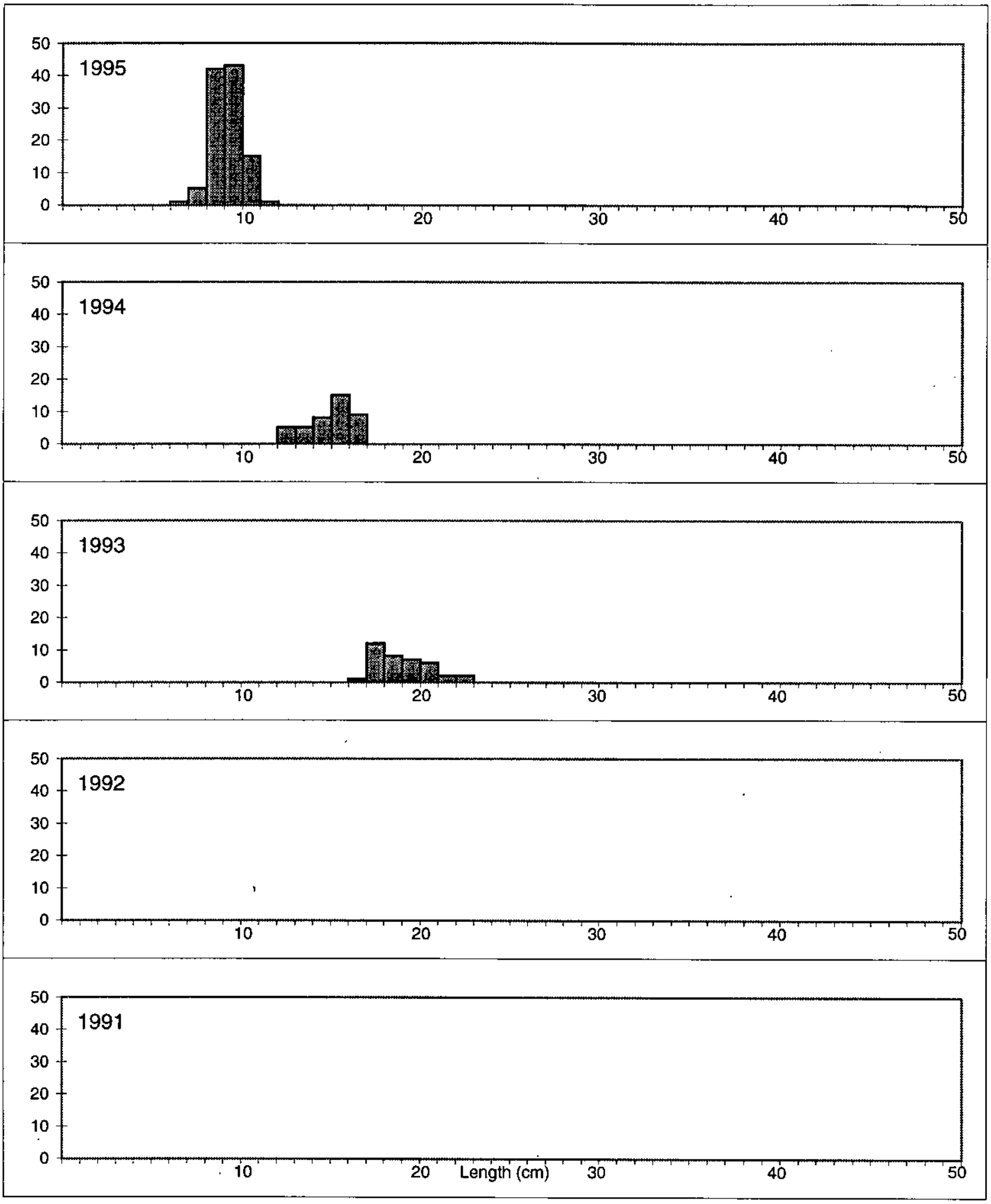

Figure 8.1 Length frequency histogram of each year class of brown trout captured at the Ewden Beck site.

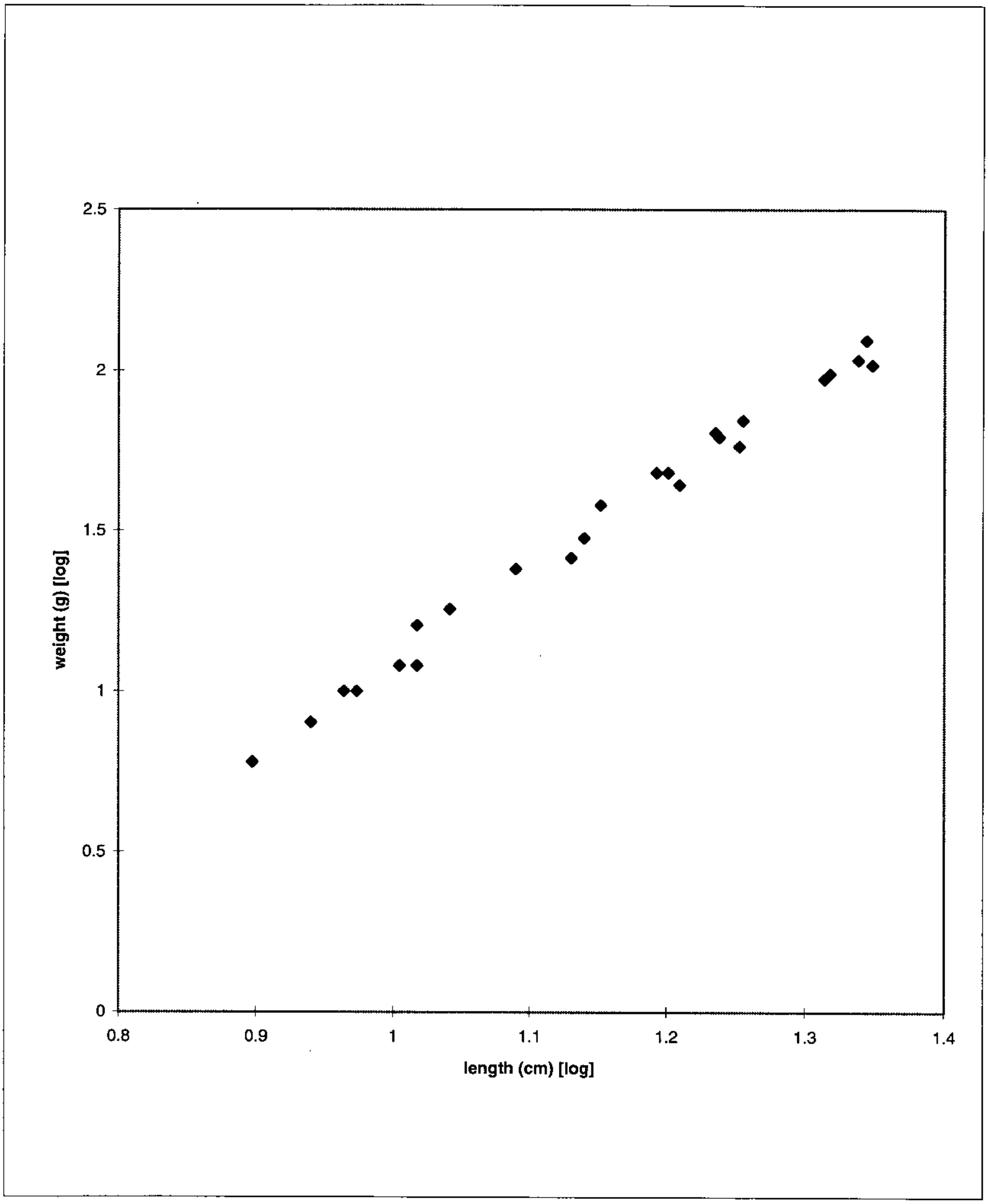

Figure 8.2 Length [log] and weight [log] for brown trout at the Ewden Beck site.

8.2.2 Rainbow trout

Table 8.6. Electric fishing efficiencies for rainbow trout calculated from triple shocks of Section 4 of Ewden Beck site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	10	0	1	11	83.6

Table 8.7. Number of rainbow trout captured in each section of Ewden Beck site, together with density and biomass, calculated from efficiencies in Table 8.10. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1	16	500	0.038	0.55
Section 2	3	345	0.0087	0.41
Section 3	8	319	0.0282	0.52
Section 4*	11	253	0.043	0.63
Total	38	1417	0.030	0.52

Table 8.8. The length weight relationship for rainbow trout at the Ewden Beck site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Rainbow Trout	- 1.51	2.63	98.9 %

Table 8.9. Number of rainbow trout captured in each year class, year class strengths and mean lengths and weights at the Ewden Beck site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	36	40	95.2	10.2 ± 1.28	14.5 ± 4.6
1994	1	1	2.4	16.0	50
1993	1	1	2.4	22.5	112

Table 8.10. Information for HABSCORE from the Ewden Beck site. Section 4 provided estimate for triple shock estimate.

	No. of fish captured				Efficiency (%)	Estimated number in each section together with density (n m^{-2}) in brackets				Estimated total biomass in each section (g) together with g m^{-2} in brackets			
	Sect 1	Sect 2	Sect 3	Sect 4		Sect 1	Sect 2	Sect 3	Sect 4	Sect 1	Sect 2	Sect 3	Sect 4
1 year old	16	2	7	10/0/1	83.6	19 (0.038)	2 (0.006)	8 (0.025)	11 (0.043)	276 (0.55)	29 (0.084)	116 (0.36)	160 (0.63)
Trout <20 cm older than 1	0	0	1	0/0/0	n/d	0 (0)	0 (0)	1* (0.003)	0 (0)	0 (0)	0 (0)	50* (0.157)	0 (0)
Trout >20 cm	0	1	0	0/0/0	n/d	0 (0)	1* (0.003)	0 (0)	0 (0)	0 (0)	112* (0.32)	0 (0)	0 (0)

* Minimum density values

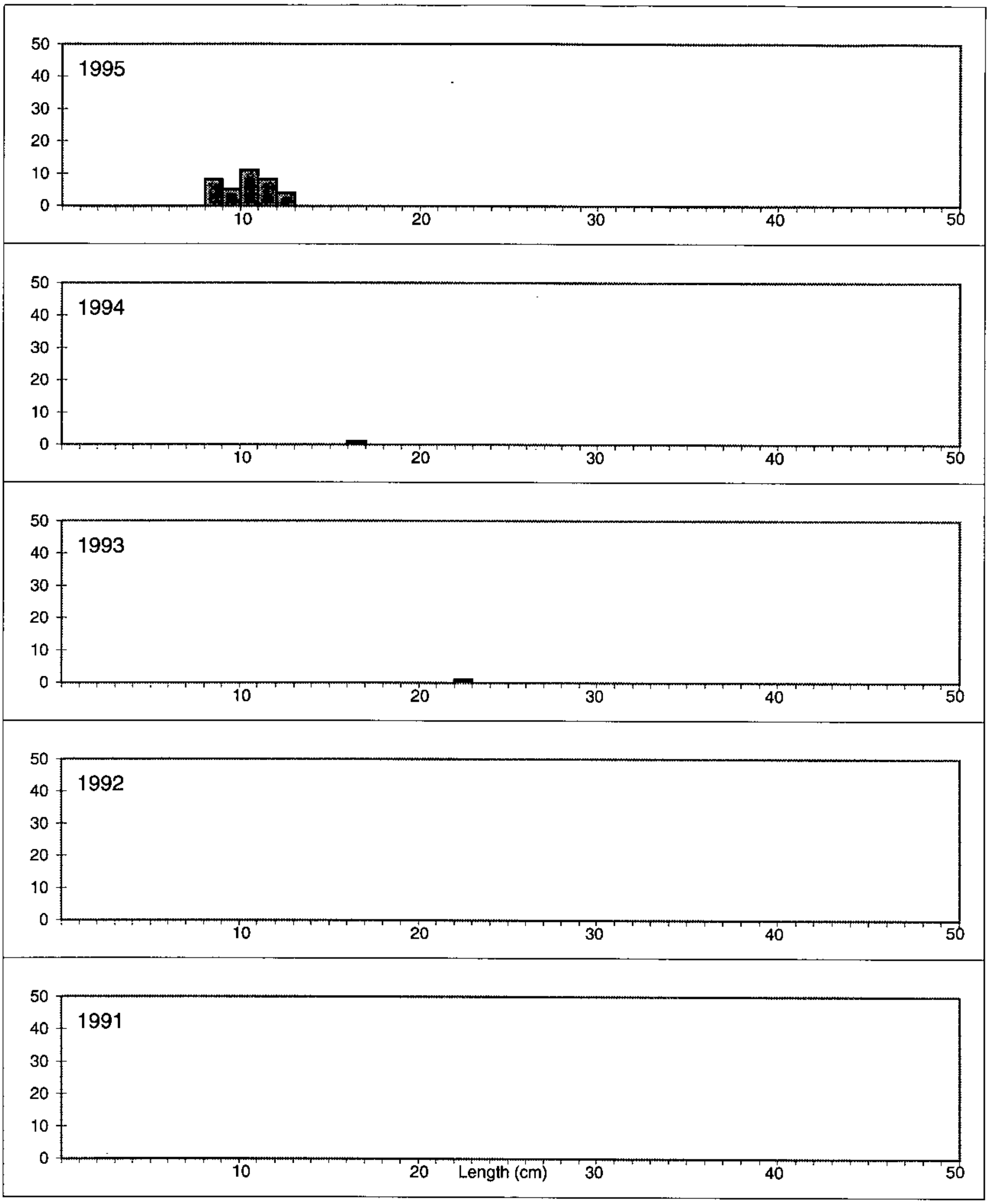

Figure 8.3 Length frequency histogram of each year class of rainbow trout captured at the Ewden Beck site.

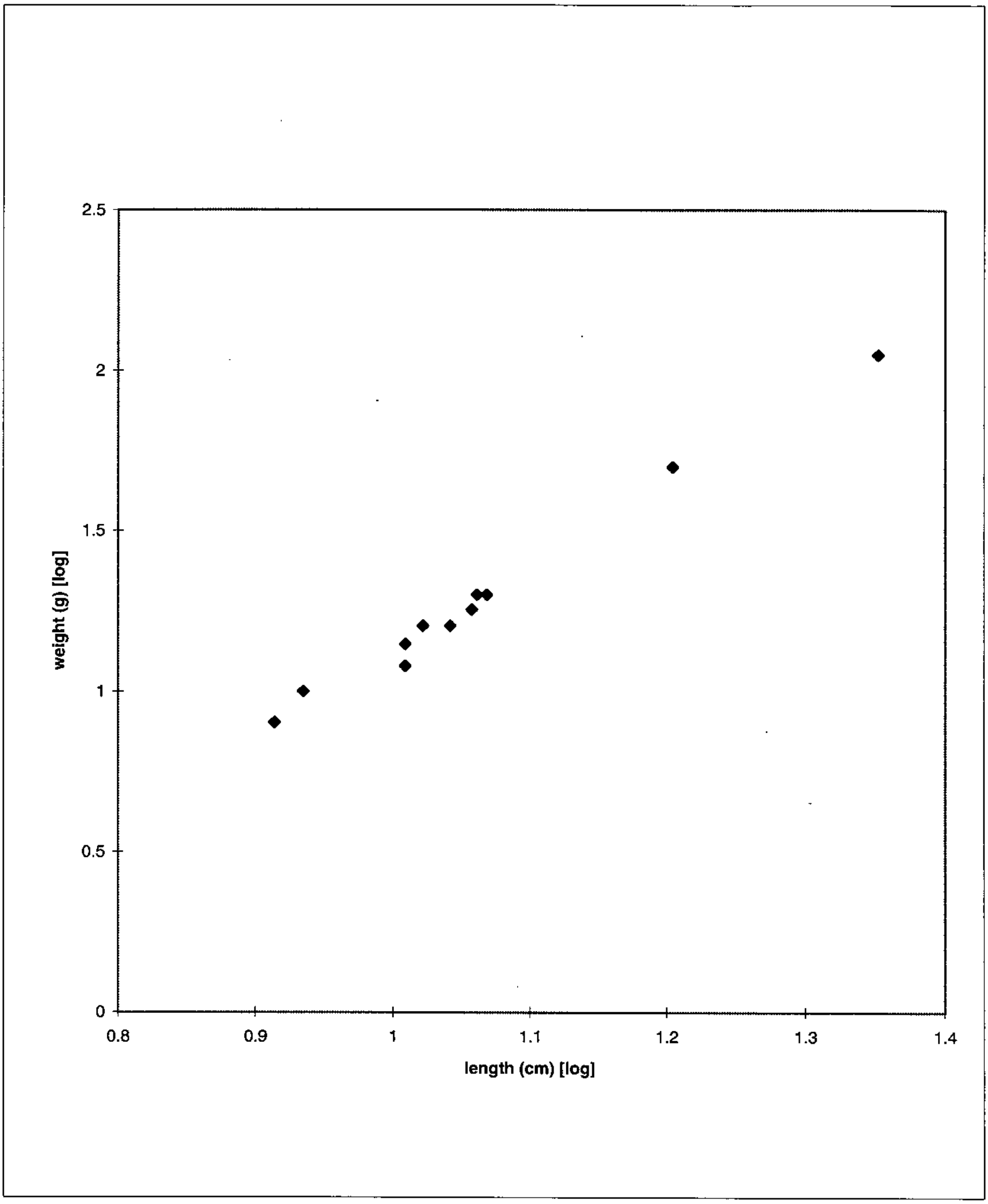

Figure 8.4 Length [log] and weight [log] for rainbow trout at the Ewden Beck site.

8.2.3 Roach

Table 8.11. Electric fishing efficiencies for roach calculated from triple shocks of Section 4 of Ewden Beck site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	0	0	0	0	n/d

Table 8.12. Number of roach captured in each section of Ewden Beck site, together with density and biomass, calculated from efficiencies in Table 8.11. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1	0	500	0	0
Section 2	1**	345	0.00290**	0.139**
Section 3	0	319	0	0
Section 4*	0	253	0	0
Total	1	1417	0.00071**	0.034**

** represents minimum density and biomass

Table 8.13. The length weight relationship for roach at the Ewden Beck site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Roach	n/a	n/a	n/a

Table 8.14. Number of roach captured in each year class, year class strengths and mean lengths and weights at the Ewden Beck site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	0	0	0	n/a	n/a
1994	1	1	100	14.4	48

8.3 Discussion

8.3.1 Rainbow trout

This presence and structure of this population was surprising. Although there were large numbers of juvenile rainbow trout there were only two fish present older than the first year class. Their presence could be due to two reasons; either there is some natural spawning, or they were introduced as stocked fish or farmed escapees. Most of the juveniles had complete and well formed fins indicating that they may have been naturally produced, however one individual had badly formed fins. The scales all exhibited natural growth patterns. There is an impassable weir further downstream, which suggests that any adult rainbow trout must come from the reservoir upstream, but there was no evidence of a spawning population in the river itself. The scales from both of the two larger rainbows captured all had scarring and thus ageing of these was done on the basis of their size, although the scarring may indicate that both these fish were of farmed origin.

It is not unusual for rainbow trout to be found spawning in the rivers surrounding reservoirs and this often results in viable juveniles. However, it is unclear why this has not resulted in the presence of some older rainbow trout, unless at the end of their first year these fish migrate downstream below the impassable weir. Thus the source of these fish is unclear, if they were introduced the scales indicate that they entered the river at a very early age as fry. It is recommended that past records of stocking held at the Environment Agency and within Yorkshire Water are checked to see if any fry were introduced in the spring of 1995. The presence of other potential sources such as a hatchery upstream should also be investigated.

8.3.1 Brown trout

As with the rainbow trout the population structure for this species was unusual in that there were no fish from any year classes earlier than 1993. The habitat at this site contained plenty of cover and deep water and was suitable to support fish larger than 23 cm in length but none were present. The reason for this is unclear. Most of the fish exhibited natural growth rates on their scales, although all the scales of one brown trout 20.6 cm in length were heavily scarred, something that is often found in farmed trout.

It is possible that anglers have taken the larger fish, but it unusual for all these to be removed. One possible explanation for the lack of older fish is a past pollution incident and it is recommended that the history of this river is looked at closely.

9. LITTLE DON D/S UNDERBANK RESERVOIR

9.1 Site description

In general the water clarity was poor, with diffuse light and large amounts of ochrous deposits. The substratum size was large, making efficiency of capture of bullheads low.

Section 1, 2 & 3:- These sections were similar in character, mostly shallow riffle flowing over ochrous coated substratum. Shaded by high tree canopy.

Section 4:- This section was very different in character from the others, because of the presence of a weir and a road bridge at the top. Most of the fish from this section came from the weir pool.

9.2 Results

9.2.1 Brown trout

Table 9.1. Electric fishing efficiencies for brown trout calculated from triple shocks of Section 1 of Little Don d/s Underbank Reservoir site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	8	5	4	25	30.2

Table 9.2. Number of brown trout captured in each section of Little Don d/s Underbank Reservoir site, together with density and biomass, calculated from efficiencies in Table 9.1. (* = section fished for triple shock estimate of efficiency). Sections are ordered in an upstream direction. That is Section 1 is the section furthest downstream and Section 4 is the furthest upstream.

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	17	328	0.061	4.1
Section 2	6	416	0.041	1.34
Section 3	1	416	0.0072	0.075
Section 4	8	363	0.033	6.5
Total	32	1523	0.034	2.82

Table 9.3. The length weight relationship for brown trout at the Little Don d/s Underbank Reservoir site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Brown Trout	- 1.90	2.93	99.3 %

Table 9.4. Number of brown trout captured in each year class, year class strengths and mean lengths and weights at the Little Don d/s Underbank Reservoir site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	16	32	61.5	9.6 ± 1.39	10.2 ± 4.4
1994	4	6	11.5	17.3 ± 0.87	53 ± 8.0
1993	6	7	13.5	24.2 ± 1.98	144 ± 35
1992	4	5	9.6	30.2 ± 1.49	273 ± 41
1991	2	2	3.9	39.9 ± 4.7	628 ± 215

Table 9.5. Information for HABSCORE from the Little Don d/s Underbank Reservoir site. Section 1 provided estimate for triple shock estimate.

	No. of fish captured				Efficiency (%)	Estimated number in each section together with density (n m^{-2}) in brackets				Estimated total biomass in each section (g) together with g m^{-2} in brackets			
	Sect 1	Sect 2	Sect 3	Sect 4		Sect 1	Sect 2	Sect 3	Sect 4	Sect 1	Sect 2	Sect 3	Sect 4
1 year old	4/2/4	4	1	1	n/d (30.2)*	13 (0.040)	13 (0.031)	3 (0.0072)	3 (0.0083)	133 (0.41)	133 (0.32)	31 (0.075)	31 (0.085)
Trout <20 cm older than 1	1/2/0	1	0	0	n/d (30.2)*	3 (0.0091)	3 (0.0072)	0 (0)	0 (0)	165 (0.50)	165 (0.40)	0 (0)	0 (0)
Trout >20 cm	3/1/0	1	0	7	77.9	4 (0.0122)	1 (0.0024)	0 (0)	9 (0.0248)	1040 (3.2)	260 (0.63)	0 (0)	2340 (6.5)

* Where the efficiency for individual size groups could not be estimated, because there was no depletion, the estimated efficiency for all sizes of trout was used as this was considered to best represent the estimated numbers of fish and biomass in the site.

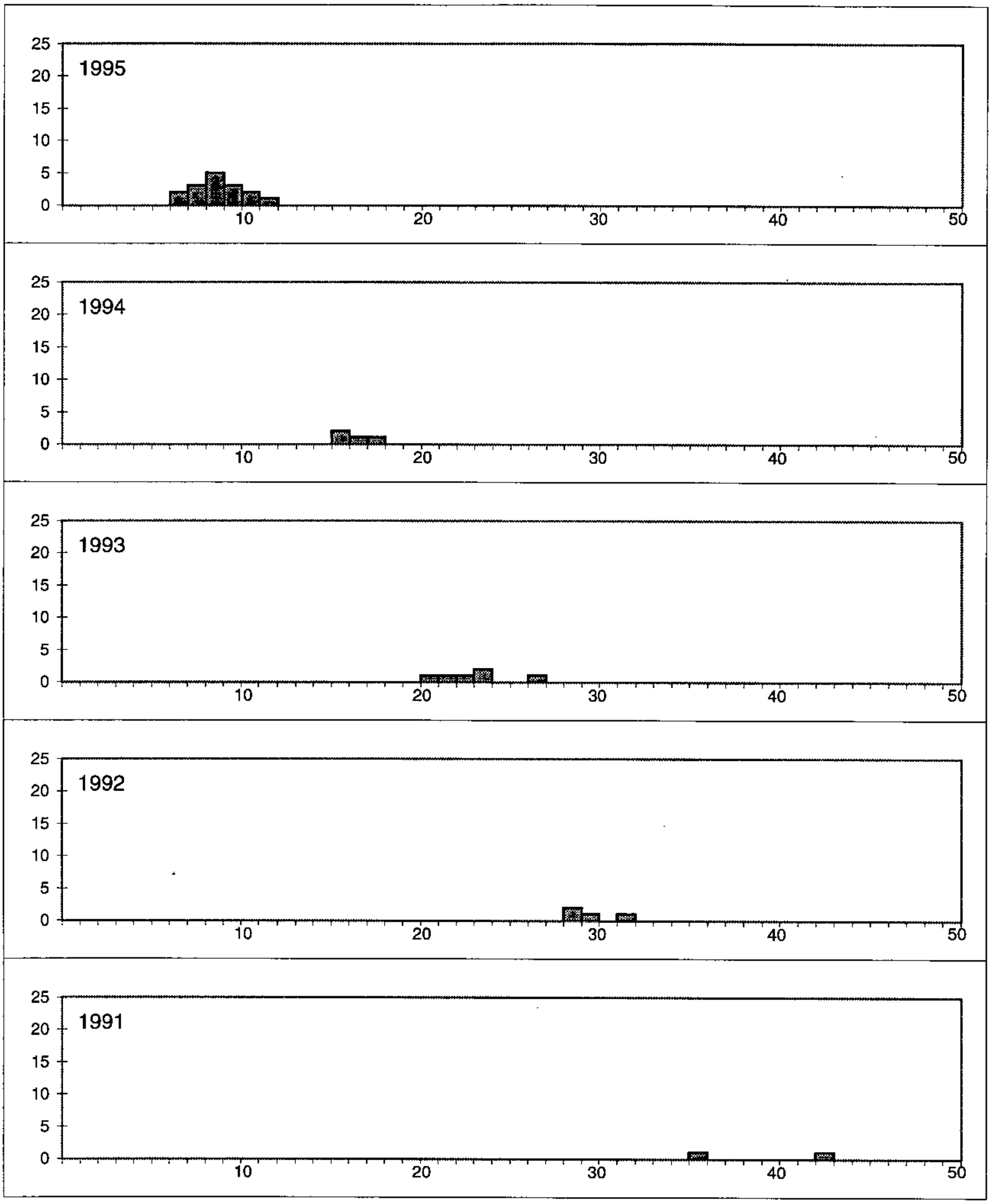

Figure 9.1 Length frequency histogram of each year class of brown trout captured at the Little Don D/S Underbank Reservoir site.

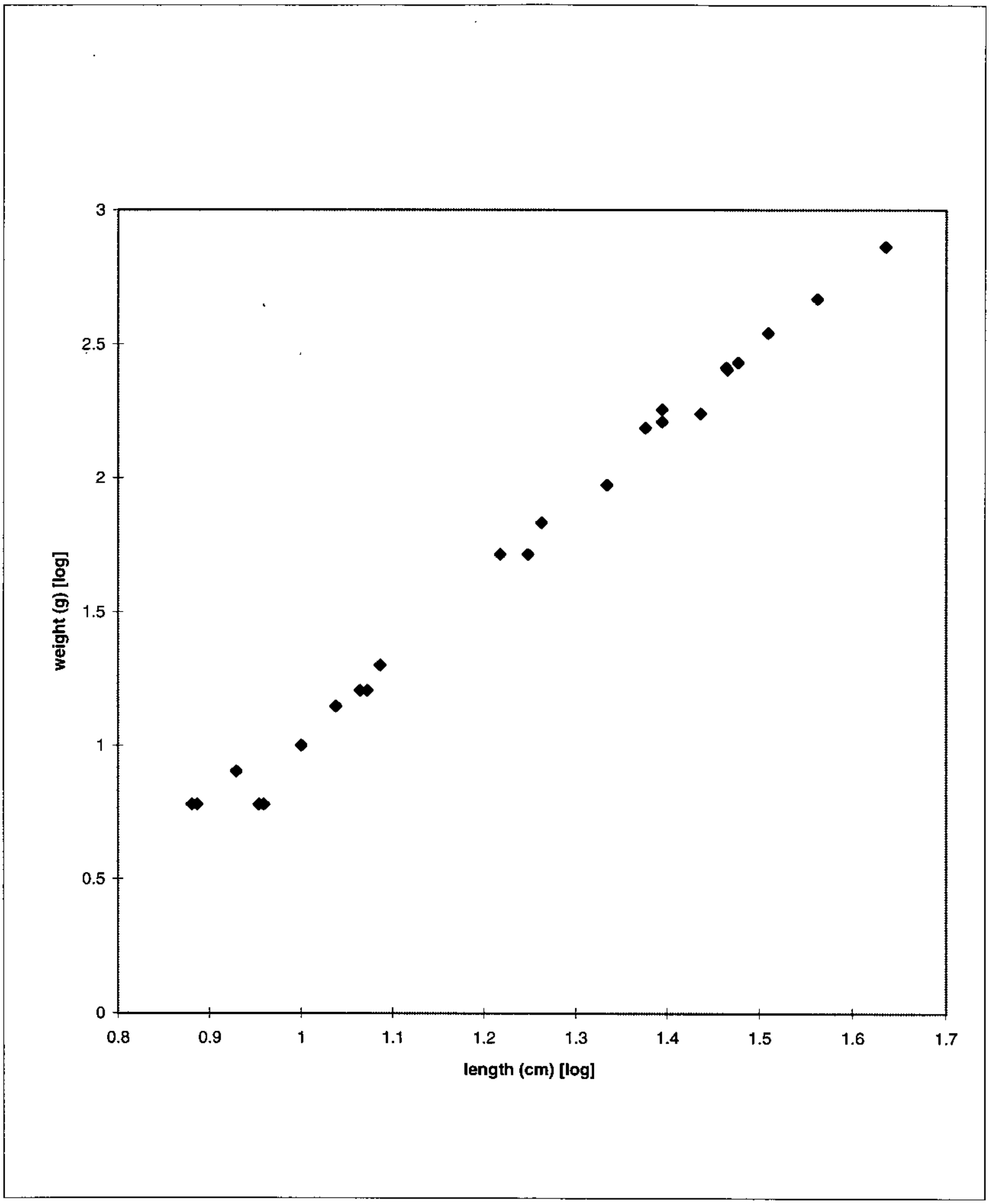

Figure 9.2 Length [log] and weight [log] for brown trout at the Little Don D/S Underbank Reservoir site.

9.2.2 Bullhead

Table 9.6. Electric fishing efficiencies for bullheads calculated from triple shocks of Section 1 of Little Don d/s Underbank Reservoir site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	7	9	4	n/d	n/d

Table 9.7. Number of bullheads captured in each section of Little Don d/s Underbank Reservoir site, together with density and biomass, calculated from efficiencies in Table 9.6. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	20	328	0.061**	0.48**
Section 2	20	416	0.048**	0.37**
Section 3	34	416	0.082**	0.58**
Section 4	11	363	0.030**	0.23**
Total	85	1523	0.056**	0.42**

** represents minimum density and biomass

Table 9.8. The length weight relationship for bullheads at the Little Don d/s Underbank Reservoir site. Relationship equates to $Log_{10}\ W\ (g) = a + b\ Log_{10}\ L\ (cm)$.

	a	b	R^2
Bullheads	- 2.09	3.26	98.4 %

Table 9.9. Number of bullheads captured in each year class, year class strengths and mean lengths and weights at the Little Don d/s Underbank Reservoir site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	11	11	12.9	4.1 ± 0.45	0.81±0.278
1994	15	15	17.6	6.2 ± 0.52	3.1 ± 0.84
1993	59	59	69.5	8.4 ± 0.91	8.9 ± 3.3

9.3.3 Perch

Table 9.10. Electric fishing efficiencies for perch calculated from triple shocks of Section 1 of Little Don d/s Underbank Reservoir site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	0	0	0	0	n/d

Table 9.11. Number of perch captured in each section of Little Don d/s Underbank Reservoir site, together with density and biomass, calculated from efficiencies in Table 9.10. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	0	328		
Section 2	0	416		
Section 3	0	416		
Section 4	11	363	0.030**	2.13**
Total	85	1523	0.0072**	0.51**

** represents minimum density and biomass

Table 9.12. The length weight relationship for perch at the Little Don d/s Underbank Reservoir site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Perch	- 2.54	3.63	99.8 %

Table 9.13. Number of perch captured in each year class, year class strengths and mean lengths and weights at the Little Don d/s Underbank Reservoir site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	1	1	9.1	6.2	2
1994	5	5	45.4	11.7 ± 0.96	23.2 ± 7.3
1993	4	4	36.4	18.0 ± 1.32	104 ± 25.6
1992	1	1	9.1	23.1	242

9.2.4 Ruffe

Table 9.14. Electric fishing efficiencies for ruffe calculated from triple shocks of Section 1 of Little Don d/s Underbank Reservoir site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	0	0	0	0	n/d

Table 9.15. Number of ruffe captured in each section of Little Don d/s Underbank Reservoir site, together with density and biomass, calculated from efficiencies in Table 9.14. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	0	328	0	0
Section 2	0	416	0	0
Section 3	0	416	0	0
Section 4	1	363	0.028**	0.0220**
Total	1	1523	0.00066**	0.0053**

** represents minimum density and biomass

Table 9.16. The length weight relationship for ruffe at the Little Don d/s Underbank Reservoir site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Ruffe	n/a	n/a	n/a

Table 9.17. Number of ruffe captured in each year class, year class strengths and mean lengths and weights at the Little Don d/s Underbank Reservoir site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995					
1994	1	1	100	8.8	8

9.3 Discussion

9.3.1 Brown trout

The population of brown trout captured at this site was heavily influenced by the presence of the weir pool in the top section. Nearly all the larger trout were captured in this section. The growth rates of these fish were slow in their first or first two years and then showed a marked increase in later years. This is interpreted to mean that these fish had recently come from the reservoir upstream and were holding in the deep water provided by the pool. These fish appeared to be in poor condition and struggling to survive in this habitat, resulting in a slight curve in the length weight relationship (Fig 9.2).

9.3.2 Other species

The presence of perch and ruffe is attributed to the reservoir upstream.

Large numbers of bullheads were also captured but catch depletions were not achieved supporting the argument that accurate estimates of population densities of these small benthic fish is difficult. The presence of the ochrous deposit on the substratum and the shading of the trees made visibility difficult, reducing the confidence in population estimates for this species. The apparently unusual population structure with very few of the smaller 1995 and 1994 year class being captured is a result of the greater difficulty in seeing these and probably does not reflect the true population structure. For quantitative comparisons at a later date it may be possible to use a catch per unit effort value, but this will also be heavily dependent on the electric fishing efficiency, which will change significantly between electric fishing events with temperature, conductivity and water levels. Mean length for each age class may have some use for comparison at a later date.

10. RIVER LOXLEY AT STORRS LANE BRIDGE

10.1 Site description

In general there were two section on each side of a stone road bridge. Most of the site was shallow and there was good visibility, except in Section 1 where a small amount of suspended solids made visibility difficult in deep water.

Section 1:- This had two deep parts under a foot bridge and against a stone wall. These provided a lot of cover for trout. There were parts with some large substratum sizes and this will have reduced the efficiency of capture for bullheads.

Section 2:- This comprised a long shallow riffle with a deep pool close to the bridge at the upper end. This was selected for the triple shock.

Section 3:- Mixture of riffles and pools; there was a very deep (1.5 m) scour hole at the top end.

Section 4:- This section consisted of a wider shallower glide for the greater part, with less cover for trout than the other sections.

10.2 Results

10.2.1 Brown trout

Table 10.1. Electric fishing efficiencies for brown trout calculated from triple shocks of Section 2 of River Loxley at Storrs Lane Bridge site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	70	23	16	119	56.1

Table 10.2. Number of brown trout captured in each section of River Loxley at Storrs Lane Bridge site, together with density and biomass, calculated from efficiencies in Table 10.5. (* = section fished for triple shock estimate of efficiency). Sections are ordered in an upstream direction. That is Section 1 is the section furthest downstream and Section 4 is the furthest upstream.

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1	51	340	0.259	12.4
Section 2*	109	319	0.288	15.7
Section 3	69	334	0.383	14.4
Section 4	22	369	0.103	5.2
Total	251	1362	0.254	11.7

Table 10.3. The length weight relationship for brown trout at the River Loxley at Storrs Lane Bridge site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Brown Trout	- 1.96	2.97	96.4 %

Table 10.4. Number of brown trout captured in each year class, year class strengths and mean lengths and weights at the River Loxley at Storrs Lane Bridge site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	32	64	17.0	7.9 ± 1.22	5.4 ± 2.68
1994	124	184	48.9	13.7 ± 1.49	27.2 ± 8.7
1993	83	115	30.6	19.0 ± 1.44	70 ± 16.2
1992	11	12	3.2	24.5 ± 1.39	148 ± 26.5
1991	1	1	0.3	44.1	839

Table 10.5. Information for HABSCORE from the River Loxley at Storrs Lane Bridge site. Section 2 provided estimate for triple shock estimate.

	No. of fish captured				Efficiency (%)	Estimated number in each section together with density (n m^{-2}) in brackets				Estimated total biomass in each section (g) together with g m^{-2} in brackets			
	Sect 1	Sect 2	Sect 3	Sect 4		Sect 1	Sect 2	Sect 3	Sect 4	Sect 1	Sect 2	Sect 3	Sect 4
1 year old	4	10/3/5	8	2	34.9	11 (0.032)	24 (0.075)	23 (0.069)	6 (0.0163)	59 (0.174)	130 (0.41)	124 (0.37)	32 (0.087)
Trout <20 cm older than 1	36	49/20/ 10	55	14	56.0	64 (0.188)	56 (0.175)	98 (0.293)	25 (0.068)	2464 (7.2)	3311 (10.4)	3773 (11.3)	963 (2.61)
Trout >20 cm	11	11/0/1	6	6	84.9	13 (0.038)	12 (0.038)	7 (0.0210)	7 (0.0190)	1703 (5.0)	1572 (4.9)	917 (2.75)	917 (2.49)

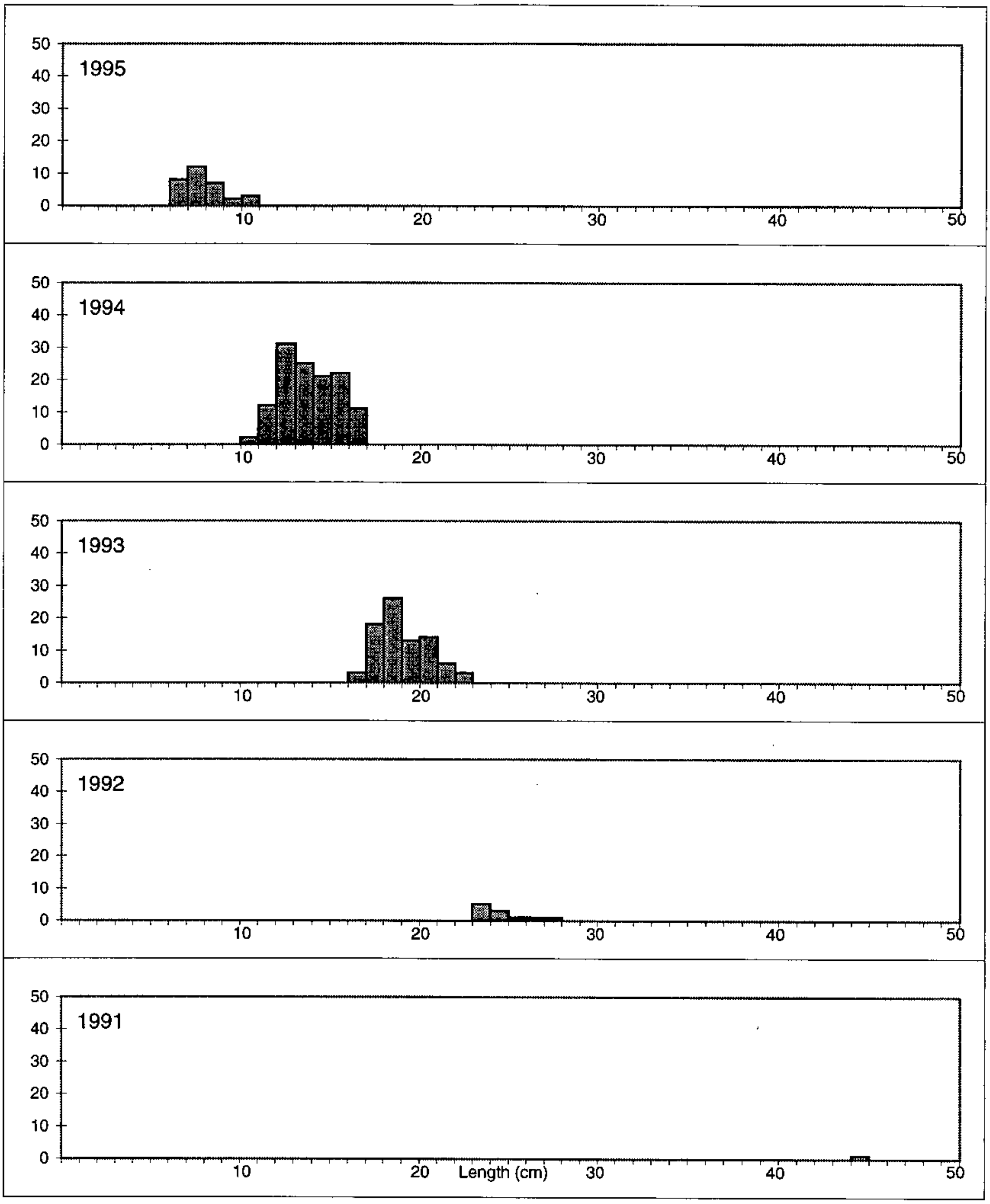

Figure 10.1 Length frequency histogram of each year class of brown trout captured at the River Loxley at Storrs Lane Bridge site.

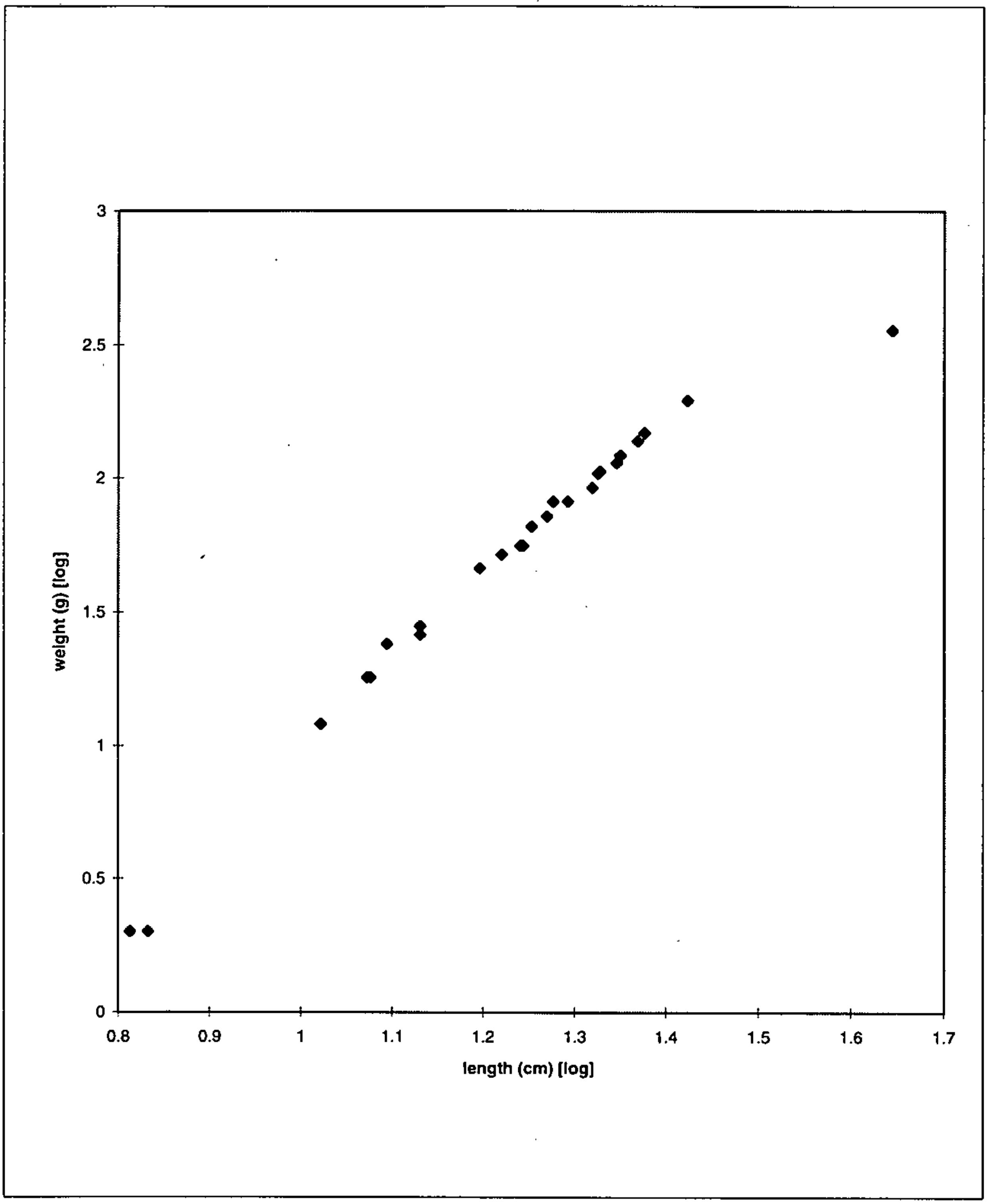

Figure 10.2 Length [log] and weight [log] for brown trout at the River Loxley at Storrs Lane Bridge site.

10.2.2 Rainbow trout

Table 10.6. Electric fishing efficiencies for rainbow trout calculated from triple shocks of Section 2 of River Loxley at Storrs Lane Bridge site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	1	0	0	1	100

Table 10.7. Number of rainbow trout captured in each section of River Loxley at Storrs Lane Bridge site, together with density and biomass, calculated from efficiencies in Table 10.10. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1	0	340	0	0
Section 2*	1	319	0.0031	0.45
Section 3	0	334	0	0
Section 4	0	369	0	0
Total	1	1362	0.00073	0.106

Table 10.8. The length weight relationship for rainbow trout at the River Loxley at Storrs Lane Bridge site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Rainbow Trout	n/a	n/a	n/a

Table 10.9. Number of rainbow trout captured in each year class, year class strengths and mean lengths and weights at the River Loxley at Storrs Lane Bridge site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	0	0	0		
1994	1	1	100	21.6	144

Table 10.10. Information for HABSCORE from the River Loxley at Storrs Lane Bridge site. Section 2 provided estimate for triple shock estimate.

	No. of fish captured				Efficiency (%)	Estimated number in each section together with density (n m^{-2}) in brackets				Estimated total biomass in each section (g) together with g m^{-2} in brackets			
	Sect 1	Sect 2	Sect 3	Sect 4		Sect 1	Sect 2	Sect 3	Sect 4	Sect 1	Sect 2	Sect 3	Sect 4
1 year old	0	0/0/0	0	0	n/d	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Trout <20 cm older than 1	0	0/0/0	0	0	n/d	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Trout >20 cm	0	1/0/0	0	0	100	0 (0)	1 (0.0031)	0 (0)	0 (0)	0 (0)	144 (0.45)	0 (0)	0 (0)

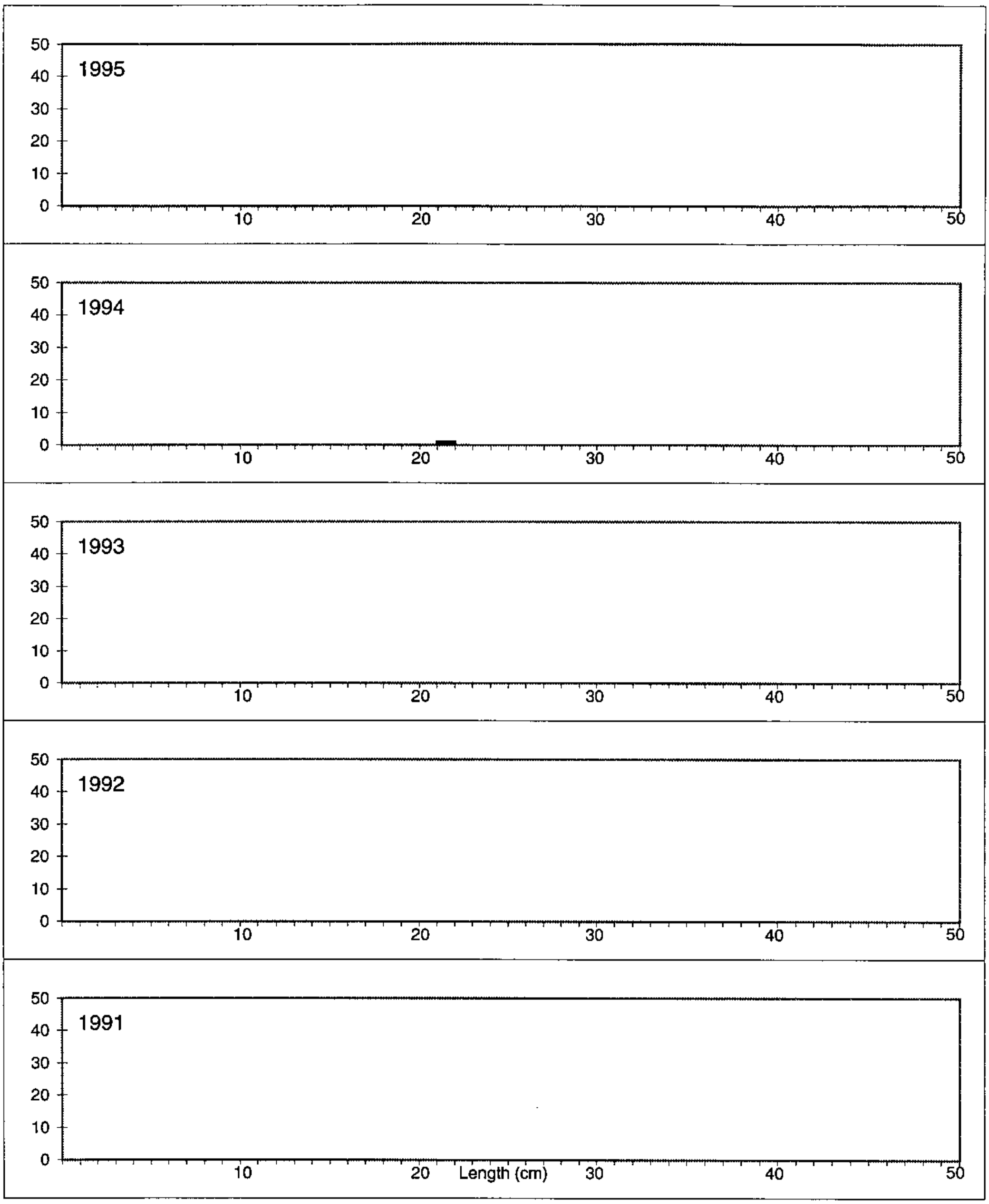

Figure 10.3 Length frequency histogram of each year class of rainbow trout captured at the River Loxley at Storrs Lane Bridge site.

10.2.3 Bullhead

Table 10.11. Electric fishing efficiencies for bullheads calculated from triple shocks of Section 2 of River Loxley at Storrs Lane Bridge site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	10	3	0	13	79.5

Table 10.12. Number of bullheads captured in each section of River Loxley at Storrs Lane Bridge site, together with density and biomass, calculated from efficiencies in Table 10.11. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1	5	340	0.0176	0.192
Section 2*	13	319	0.041	0.279
Section 3	10	334	0.039	0.215
Section 4	26	369	0.089	0.64
Total	54	1362	0.048	0.34

Table 10.13. The length weight relationship for bullheads at the River Loxley at Storrs Lane Bridge site. Relationship equates to $Log_{10}\ W\ (g) = a + b\ Log_{10}\ L\ (cm)$.

	a	b	R^2
Bullheads	- 2.22	3.42	99.6 %

Table 10.14. Number of bullheads captured in each year class, year class strengths and mean lengths and weights at the River Loxley at Storrs Lane Bridge site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	2	3	4.4	3.9 ± 0.64	0.64 ±0.34
1994	48	60	88.2	7.6 ± 0.94	6.6 ± 2.59
1993	4	5	7.4	10.0 ± 0.33	16.0 ±1.86

10.2.4 Pike

Table 10.15. Electric fishing efficiencies for pike calculated from triple shocks of Section 2 of River Loxley at Storrs Lane Bridge site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	0	0	0	0	n/d

Table 10.16. Number of pike captured in each section of River Loxley at Storrs Lane Bridge site, together with density and biomass, calculated from efficiencies in Table 1. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1	0	340	0	0
Section 2*	0	319	0	0
Section 3	1**	334	00030**	0.120**
Section 4	0	369	0	0
Total	1**	1362	0.00073**	0.294**

** represent minimum density and biomass estimates

Table 10.17. The length weight relationship for pike at the River Loxley at Storrs Lane Bridge site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Pike	n/a	n/a	n/a

Table 10.18. Number of pike captured in each year class, year class strengths and mean lengths and weights at the River Loxley at Storrs Lane Bridge site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	1	1	100	16.5	40

10.3 Discussion

10.3.1 Brown trout

This site supported high numbers of brown trout although few of these exceeded 25 cm in length, possibly as a result of angling pressure, since the habitat was suitable for holding large fish. There was no evidence of stocking, with all scales exhibiting natural growth rates.

10.3.2 Other species

The presence of the rainbow trout and the pike are not easy to explain. The rainbow trout was large for its age indicating it had probably had a farmed origin. Both fish may have escaped from a local stillwater fishery.

Although a catch depletion was observed with bullheads, it is hard to attach any confidence to the efficiency of capture or the estimated population density or biomass for this species. The apparently unusual population structure with very few of the smaller 1995 year class, in each of these species, being captured is a result of the greater difficulty in seeing these, and probably does not reflect the true population structure. For quantitative comparisons at a later date it may be possible to use a catch per unit effort value, but this will also be heavily dependent on the electric fishing efficiency, which will change significantly between electric fishing events with temperature, conductivity and water levels. Mean length for each age class may have some use for comparison at a later date.

11. RIVELIN AT RIVELIN MILL

11.1 Site description

In general this river was impacted on by the presence of a number of man made objects including a small dam and outflows from the neighbouring pond.

Section 1:- This was ponded for the greater part of the section, with the exception that towards the top there was a riffle caused partly by water flowing over a small man-made dam wall. It was mostly shaded by a high tree canopy.

Section 2:- This section was ponded for the greater part of its length where it was backed up from the dam wall. This made it deeper than the other sections. The outflow from the raised pond entered this section. It was mostly shaded by a high tree canopy.

Section 3:- This section had a steeper gradient, with primarily riffle habitat. It was mostly shaded by a high tree canopy.

Section 4:- This section comprised riffle habitat at its lower end, where it was also shaded by a high tree canopy. Towards the top of this section the river became slightly wider and shallower and was more open.

11.2 Results

11.2.1 Brown trout

Table 11.1. Electric fishing efficiencies for brown trout calculated from triple shocks of Section 1 of River Rivelin at Rivelin Mill site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	14	8	8	50	26.2

Table 11.2. Number of brown trout captured in each section of River Rivelin at Rivelin Mill site, together with density and biomass, calculated from efficiencies in Table 11.5. (* = section fished for triple shock estimate of efficiency). Sections are ordered in an upstream direction. That is Section 1 is the section furthest downstream and Section 4 is the furthest upstream.

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	30	300	0.120	3.14
Section 2	31	266	0.267	12.0
Section 3	15	218	0.220	4.9
Section 4	15	322	0.146	3.3
Total	91	1106	0.183	5.7

Table 11.3. The length weight relationship for brown trout at the River Rivelin at Rivelin Mill site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Brown Trout	- 1.67	2.78	99.2 %

Table 11.4. Number of brown trout captured in each year class, year class strengths and mean lengths and weights at the River Rivelin at Rivelin Mill site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	40	104	51.5	8.2 ± 0.95	7.6 ± 2.54
1994	18	39	19.3	13.8 ± 0.95	31.7 ± 6.0
1993	32	58	28.7	18.8 ± 1.92	77 ± 22.2
1992	1	1	0.5	24.0	138

Table 11.5. Information for HABSCORE from the River Rivelin at Rivelin Mill site. Section 1 provided estimate for triple shock estimate.

	No. of fish captured				Efficiency (%)	Estimated number in each section together with density (n m^{-2}) in brackets				Estimated total biomass in each section (g) together with g m^{-2} in brackets			
	Sect 1	Sect 2	Sect 3	Sect 4		Sect 1	Sect 2	Sect 3	Sect 4	Sect 1	Sect 2	Sect 3	Sect 4
1 year old	6/8/5	5	8	8	n/d (26.2)*	23 (0.077)	19 (0.071)	31 (0.142)	31 (0.096)	175 (0.58)	144 (0.54)	236 (1.08)	236 (0.73)
Trout <20 cm older than 1	6/0/3	18	7	6	40.6	11 (0.037)	44 (0.165)	17 (0.080)	15 (0.047)	539 (1.80)	2156 (8.1)	833 (3.8)	735 (2.28)
Trout >20 cm	2/0/0	8	0	1	100	2 (0.0067)	8 (0.030)	0 (0)	1 (0.0031)	228 (0.76)	888 (3.3)	0 (0)	88 (0.273)

* It was not possible to estimate an efficiency of capture for 1 year old brown trout. Therefore the efficiency estimated for the capture of all trout was used for this age group instead, because it was felt tat this would be the most realistic option.

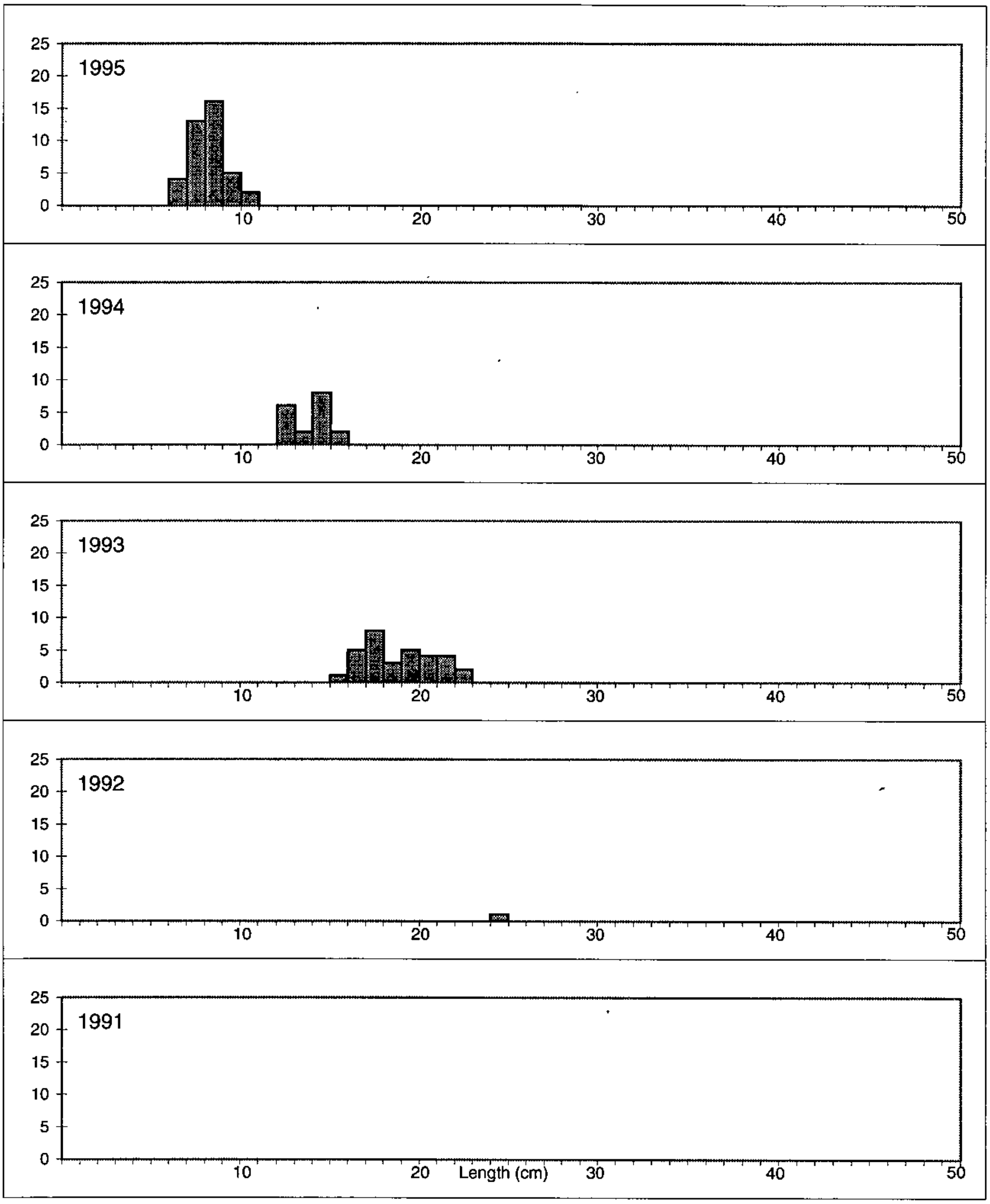

Figure 11.1 Length frequency histogram of each year class of brown trout captured at the River Rivelin at Rivelin Mill site.

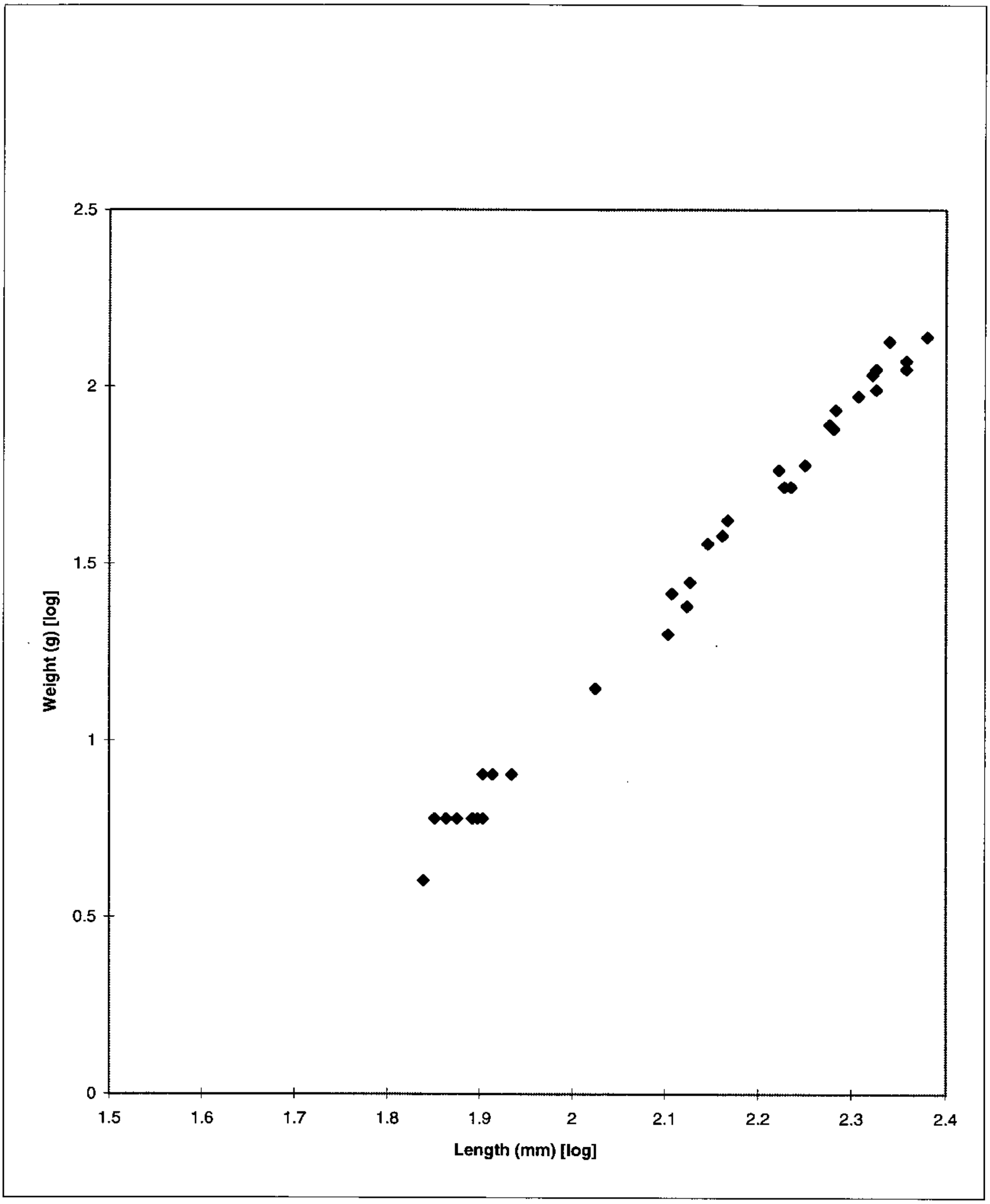

Figure 11.2 Length [log] and weight [log] for brown trout at the River Rivelin at Rivelin Mill site.

11.2.2 Stone loach

Table 11.6. Electric fishing efficiencies for stone loach calculated from triple shocks of Section 1 of River Rivelin at Rivelin Mill site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	7	11	6	n/a	n/d

Table 11.7. Number of stone loach captured in each section of River Rivelin at Rivelin Mill site, together with density and biomass, calculated from efficiencies in Table 11.6. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	24	300	0.08**	0.56**
Section 2	5	266	0.0188**	0.086**
Section 3	11	218	0.050**	0.33**
Section 4	42	322	0.130**	0.76**
Total	82	1106	0.074**	0.46**

** represents minimum density and biomass

Table 11.8. The length weight relationship for stone loach at the River Rivelin at Rivelin Mill site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Stone loach	- 2.33	3.21	98.4 %

Table 11.9. Number of stone loach captured in each year class, year class strengths and mean lengths and weights at the River Rivelin at Rivelin Mill site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	5	5	6.1	5.1 ± 0.37	0.88±0.199
1994	52	52	63.4	8.0 ± 0.75	3.8 ± 1.12
1993	25	25	30.5	11.6 ± 0.89	12.3 ±2.97

11.2.3 Stickleback

Table 11.10. Electric fishing efficiencies for stickleback calculated from triple shocks of Section 1 of River Rivelin at Rivelin Mill site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	0	1	6	n/a	n/d

Table 11.11. Number of stickleback captured in each section of River Rivelin at Rivelin Mill site, together with density and biomass, calculated from efficiencies in Table 1. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	7	300	0.0233#	0.103**#
Section 2	0	266	0	0
Section 3	1	218	0.0046#	0.0061**#
Section 4	6	322	0.0186#	0.0248**#
Total	14	1106	0.0127#	0.036**#

** Estimates of biomass derived from stickleback length weight relationship for fish captured in upper Frome (Log_{10} W (g) = -1.93 + 3.14 Log_{10} L (cm)

represents minimum densities and biomass

Table 11.12. The length weight relationship for stickleback at the River Rivelin at Rivelin Mill site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Stickleback	n/a	n/a	n/a

Table 11.13. Number of stickleback captured in each year class, year class strengths and mean lengths and weights at the River Rivelin at Rivelin Mill site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d. *
1995	1	1	7.1	3.5	0.60
1994	13	13	92.9	4.5±0.187	1.33±0.173

* Estimates of biomass derived from stickleback length weight relationship for fish captured in upper Frome (Log_{10} W (g) = -1.93 + 3.14 Log_{10} L (cm)

11.2.4 Perch

Table 11.14. Electric fishing efficiencies for perch calculated from triple shocks of Section 1 of River Rivelin at Rivelin Mill site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	0	0	0	0	n/d

Table 11.15. Number of perch captured in each section of River Rivelin at Rivelin Mill site, together with density and biomass, calculated from efficiencies in Table 11.14. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	0	300	0	0
Section 2	4	266	0.0150**	0.87**
Section 3	0	218	0	0
Section 4	0	322	0	0
Total	4	1106	0.0036**	0.210**

** represents minimum density and biomass

Table 11.16. The length weight relationship for perch at the River Rivelin at Rivelin Mill site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Perch	n/a	n/a	n/a

Table 11.17. Number of perch captured in each year class, year class strengths and mean lengths and weights at the River Rivelin at Rivelin Mill site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	1	1	25	9.5	10.0
1994	3	3	75	16.4 ± 1.78	74 ± 24.6

11.2.5 Minnow

Table 11.18. Electric fishing efficiencies for minnows calculated from triple shocks of Section 1 of River Rivelin at Rivelin Mill site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	0	0	0	0	n/d

Table 11.19. Number of minnows captured in each section of River Rivelin at Rivelin Mill site, together with density and biomass, calculated from efficiencies in Table 11.18. (* = section fished for triple shock estimate of efficiency)

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1*	0	300	0	0
Section 2	0	266	0	0
Section 3	0	218	0	0
Section 4	1	322	0.0031#	0.0152**#
Total	1	1106	0.00090#	0.0044**#

** Estimates of biomass derived from minnow length weight relationship for fish captured in River don u/s Bullhouse Minewater (Log_{10} W (g) = -2.08 + 3.19 Log_{10} L (cm)

represents minimum density and biomass

Table 11.20. The length weight relationship for minnows at the River Rivelin at Rivelin Mill site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Minnows	n/a	n/a	n/a

Table 11.21. Number of minnows captured in each year class, year class strengths and mean lengths and weights at the River Rivelin at Rivelin Mill site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995					
1994	1	1	100	7.4	4.9

11.3 Discussion

11.3.1 Brown trout

This site supported high numbers of brown trout although none of these exceeded 25 cm in length, possibly as a result of angling pressure, since the habitat was suitable for holding larger fish. There was no evidence of stocking, with all scales exhibiting natural but slow growth rates.

11.3.2 Other species

The presence of perch was attributed to the proximity of a number of ponds.

Large numbers of stone loach together with a few stickleback and one minnow were also captured but catch depletions were not achieved supporting the argument that accurate estimates of population densities of these small benthic or shoaling fish is difficult. The apparently unusual population structure with very few of the smaller 1995 year class, in each of these species, being captured is a result of the greater difficulty in seeing these and probably does not reflect the true population structure. For quantitative comparisons at a later date it may be possible to use a catch per unit effort value, but this will also be heavily dependent on the electric fishing efficiency, which will change significantly between electric fishing events with temperature, conductivity and water levels. Mean length for each age class may have some use for comparison at a later date.

12. COLDEN WATER at HEBDEN BRIDGE

12.1 Site description

In general this stream had a steep gradient and ran over bedrock. There was good visibility. Wading was a little difficult with rocks being extremely slippery. All sections were very similar except that Section 1 had one particularly large deep pool, not found to the same extent in other sections. Because of the presence of this pool in Section 1, Section 2 was used for the triple shock.

12.2 Results

12.2.1 Brown trout

Table 12.1. Electric fishing efficiencies for brown trout calculated from triple shocks of Section 2 of Colden Water, Hebden Bridge site

	Shock 1	Shock 2	Shock 3	Estimated total	Efficiency (%)
Number (n)	10	4	1	15	65.3

Table 12.2. Number of brown trout captured in each section of Colden Water, Hebden Bridge site, together with density and biomass, calculated from efficiencies in Table 12.5. (* = section fished for triple shock estimate of efficiency). Sections are ordered in an upstream direction. That is Section 1 is the section furthest downstream and Section 4 is the furthest upstream.

	No. of fish captured	Area (m^2)	Density ($n\ m^{-2}$)	Biomass ($g\ m^{-2}$)
Section 1	16	283	0.106	2.75
Section 2*	15	254	0.071	3.6
Section 3	14	324	0.077	1.94
Section 4	30	347	0.161	3.9
Total	75	1208	0.107	3.0

Table 12.3. The length weight relationship for brown trout at the Colden Water, Hebden Bridge site. Relationship equates to Log_{10} W (g) = a + b Log_{10} L (cm).

	a	b	R^2
Brown Trout	- 1.91	2.97	98.4 %

Table 12.4. Number of brown trout captured in each year class, year class strengths and mean lengths and weights at the Colden Water, Hebden Bridge site.

Yearclass	No. of fish captured	Estimated number in each year class	Year class strength (% of total fish captured	Mean length (cm) ± s.d.	Mean weight (g) ± s.d.
1995	19	61	47.3	9.3 ± 0.88	9.5 ± 2.52
1994	49	61	47.3	14.0 ± 1.73	32.6 ±12.5
1993	5	5	3.9	21.3 ± 0.82	110 ± 12.2
1992	2	2	1.5	29.3 ± 2.47	283 ± 71
1991	0	0	0	n/a	n/a

Table 12.5. Information for HABSCORE from the Colden Water, Hebden Bridge site. Section 2 provided estimate for triple shock estimate.

	No. of fish captured				Efficiency (%)	Estimated number in each section together with density (n m^{-2}) in brackets				Estimated total biomass in each section (g) together with g m^{-2} in brackets			
	Sect 1	Sect 2	Sect 3	Sect 4		Sect 1	Sect 2	Sect 3	Sect 4	Sect 1	Sect 2	Sect 3	Sect 4
1 year old	4	2/2/1	3	7	26.2	15 (0.053)	8 (0.032)	11 (0.034)	27 (0.078)	143 (0.51)	76 (0.30)	105 (0.32)	257 (0.74)
Trout <20 cm older than 1	10	5/1/0	10	17	84.9	13 (0.046)	8 (0.032)	13 (0.040)	27 (0.078)	424 (1.50)	261 (1.03)	424 (1.31)	880 (2.54)
Trout >20 cm	2	2/0/0	1	2	100	2 (0.0071)	2 (0.0079)	1 (0.0031)	2 (0.0058)	210 (0.74)	567 (2.23)	101 (0.31)	207 (0.60)

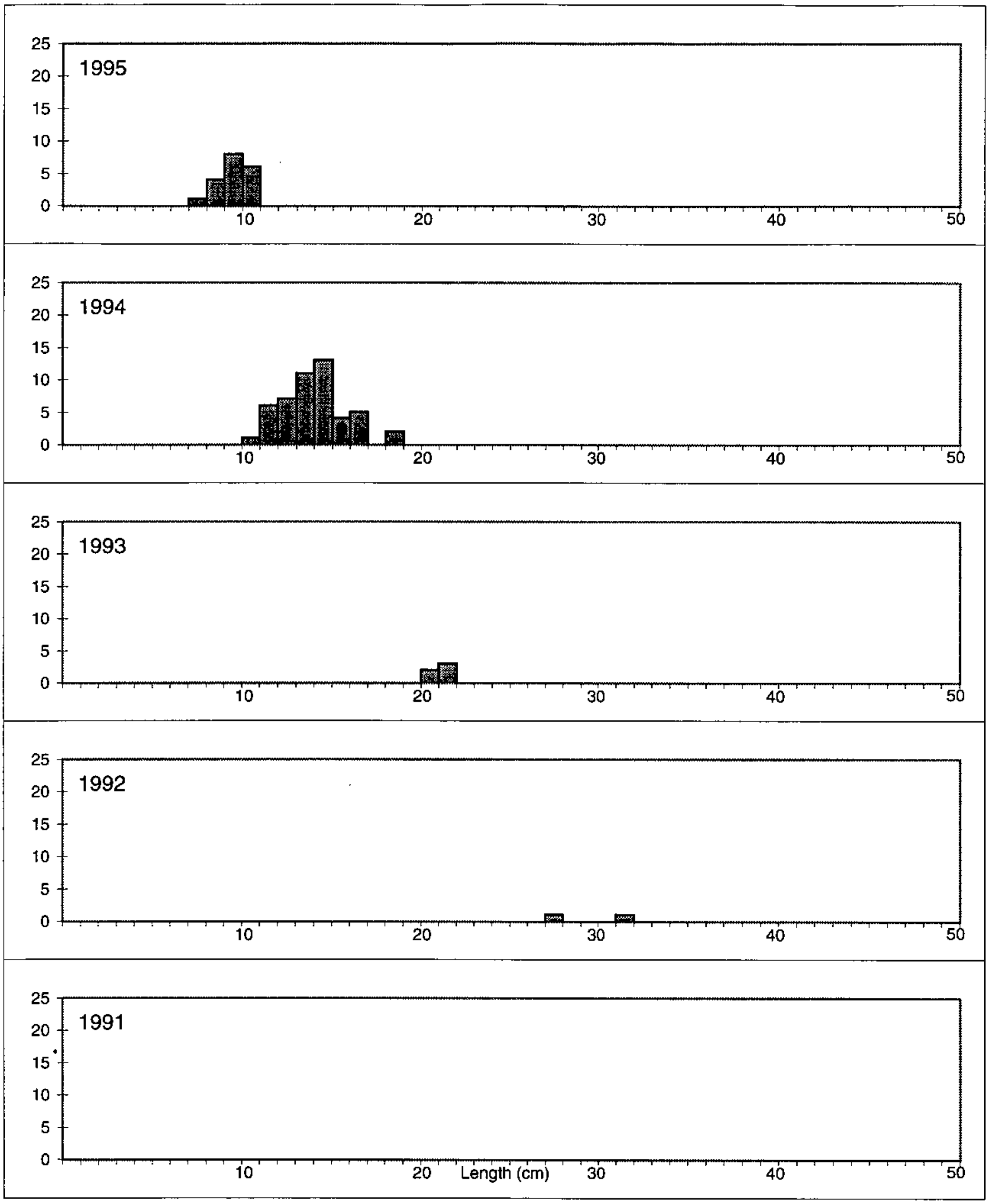

Figure 12.1 Length frequency histogram of each year class of brown trout captured at the Colden Water, Hebden Bridge site.

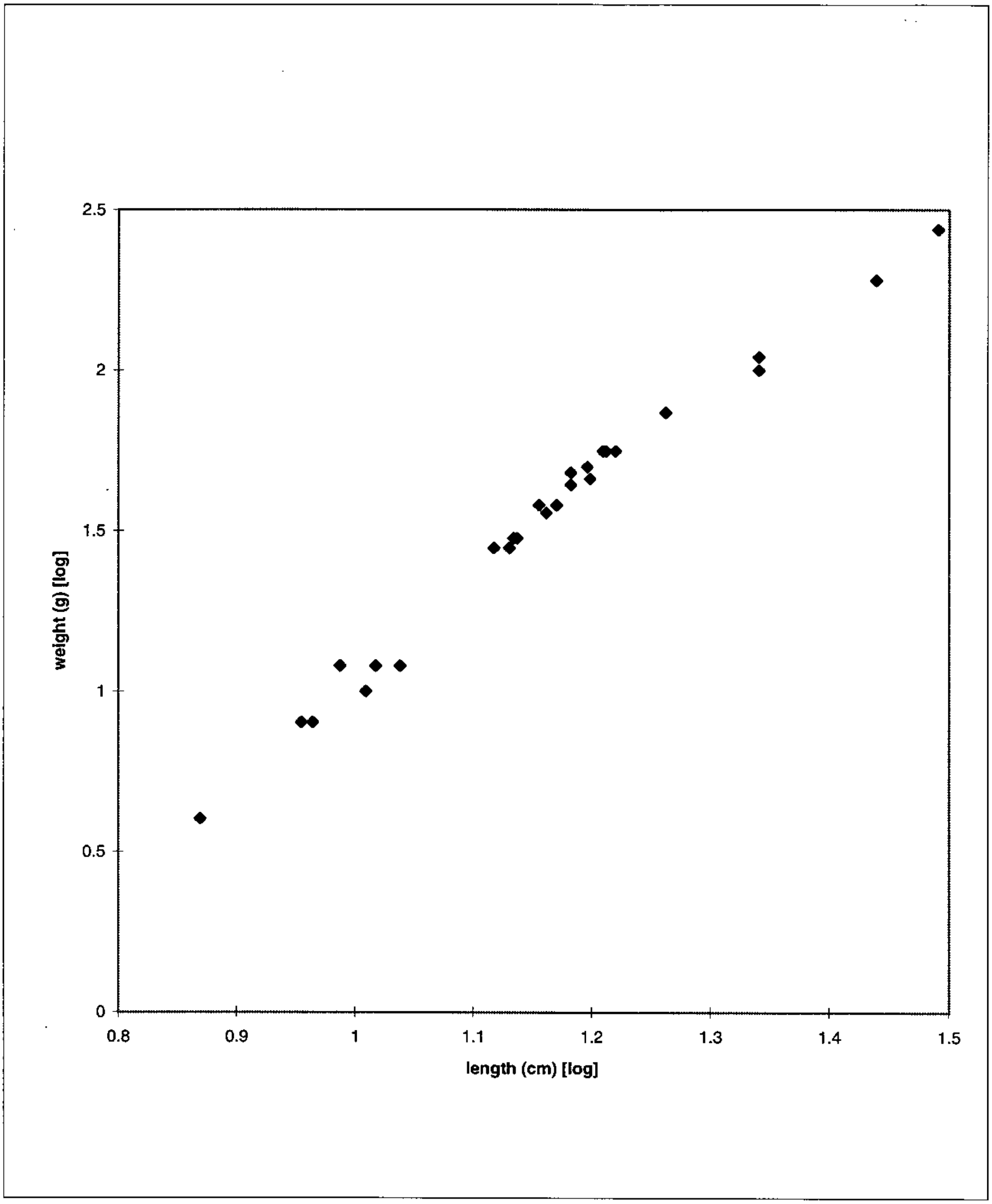

Figure 12.2 Length [log] and weight [log] for brown trout at the Colden Water, Hebden Bridge site.

12.3 Discussion

The population of brown trout here looked natural although it is probable that some of the larger fish have been removed by angling. There was no evidence of any stocking with all the fish exhibiting natural growth rates.

13. SUMMARY RESULTS

Table 13.1. The density (n m^{-2}) of each fish species at each of eight sites surveyed in April 1996

Site Name	Species											
	Brown Trout	Rainbow Trout	Bullhead	Stickle-back	Minnow	Perch	Grayling	Roach	Stone Loach	Dace	Pike	Ruffe
Sheaf	0.181		0.108	0.00090 *		0.114		0.00090 *		0.0036 *		
Bullhse Mnwtr	0.052			0.0170	0.140		0.0037					
Winscar	0.46											
Oxspring	0.0150		0.118	0.00060 *	0.059 *		0.0108		0.0102 *			
Ewden Beck	0.172	0.030						0.00071 *				
Little Don	0.034		0.056 *			0.0072 *						0.00066 *
Loxley	0.254	0.00073	0.048								0.00073 *	
Rivelin	0.183			0.0127 *	0.00090 *	0.0036 *			0.074 *			

* represents minimum density

Table 13.2. The biomass (g m^{-2}) of each fish species at each of eight sites surveyed in April 1996

Site Name	Species										
	Brown Trout	Rainbow Trout	Bullhead	Stickle-back	Minnow	Perch	Grayling	Roach	Stone Loach	Dace	Pike	Ruffe
Sheaf	5.9		0.77	0.00090 *		0.77		0.192 *		0.47 *		
Bullhse Mnwtr	2.92			0.084 *	0.47		0.40					
Winscar	6.0											
Oxspring	0.99		0.35	0.0006 *	0.0178 *		0.52		0.088 *			
Ewden Beck	4.9	0.52						0.034 *				
Little Don	2.82		0.42 *			0.51 *						0.0053 *
Loxley	11.7	0.106	0.34								0.294 *	
Rivelin	5.7			0.036 *	0.0044 *	0.210 *			0.46 *			

* represents minimum biomass

14. GENERAL DISCUSSION

There was little evidence of stocking of brown trout at any of the sites and most of these fish captured at most sites appeared to be naturally produced. It is possible that stocking is more widespread than this survey suggests and that the main period for introductions comes later in the year than the beginning of April. It is recommended that Environment Agency records are checked to determine stocking practices at these sites. This information can be supplemented by contacting the angling organisations responsible for each site.

There was, however, a number of other sources of supplementation for all species, mostly from neighbouring stillwaters. This probably explains the presence of species such as perch, pike, ruffe and in some cases rainbow trout. It is probable that such effects will be independent of manipulation of the water courses, or that the impacts of manipulation on these communities will be difficult to determine. It is recommended that species that are obviously not naturally resident in the sites, but are 'leakage' from other water bodies, should be ignored in estimating the impacts of any manipulation of the rivers.

Division of the sites into four sections often produced sections with widely varying features, which impact both on the electric fishing efficiency and the number and density of different fish species in them. Although as far as possible a typical section was selected each time for the triple shock estimate of catch efficiency, use of that efficiency on other sections may result in some error in estimating density and biomass.

This error may have been compounded because some of the rivers were quite wide in comparison to the 50 m length of the sections and the disturbance of dividing the sites into sections with stop nets could impact a high percentage of the area of the section. This can result in movement of large numbers of fish out of one section into another. So called 'edge effects' have a greater impact on the results the shorter the section in relation to its width.

It is not possible to attach much confidence to the catch efficiencies recorded for the smaller species of fish, even when an apparent fall in catches between shocks was observed. These include bullheads, stone loach, minnows and stickleback. The equipment used, with a large anode and 1.9 KVa generator, are designed for capture of larger fish, and are generally inefficient at capturing smaller fish. Further, many of these species live in crevices or under rocks, and there is no way of determining what proportion was shocked but remained invisible to the fisherman. The most reliable data determined for these species is the average length in each age class. The value of the other data obtained on these species is probably negligible.

15. REFERENCES

Zippin C. 1956. An evaluation of the removal method of estimating animal populations. Biometrics **12**:163-189.

Centre for Ecology & Hydrology
Institute of Freshwater Ecology
Institute of Hydrology
Institute of Terrestrial Ecology
Institute of Virology & Environmental Microbiology

Natural Environment Research Council