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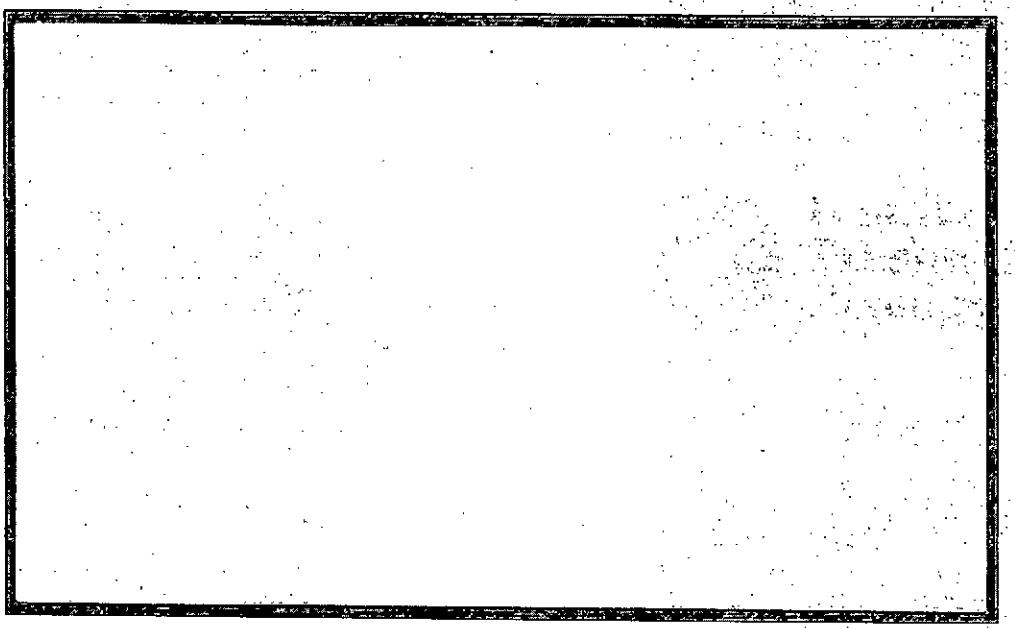
Institute of Freshwater Ecology



Natural Environment Research Council

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A survey of fish populations in Percy and Black Becks, July 1990

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Report date:	July 1990
Report to:	Glaxo Operations U.K. Limited
IFE Report Ref:	WIT/T11050j1/1
TFS Project No:	T11050j1

The Institute of Freshwater Ecology is part of the Terrestrial and Freshwater Sciences Directorate of the Natural Environment Research Council.

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A SURVEY OF FISH POPULATIONS IN PERCY BECK AND BLACK BECK, JULY 1990.

D.T. Crisp, The NERC Institute of Freshwater Ecology, Teesdale Laboratory, c/o Northumbrian Water Ltd., Lartington Treatment Plant, Lartington, Barnard Castle, Co. Durham, DL12 9DW.

SUMMARY

1. A quantitative survey of fish populations at six stations in the Black/Percy Beck system was made on 10 & 11 July 1990.

2. Salmon (Salmo salar L.) parr were found at NZ/046168.

3. 0-group and older trout (Salmo trutta L.) were found in Percy Beck up to NZ/050180 and in Black Beck to just above the confluence of Percy Beck.

4. 0-Group and older bullhead (Cottus gobio L.) were found in Percy Beck up to NZ/050180 and in Black Beck up to NZ/05117.

5. Stoneloach (Noemacheilus barbatulus (L.)) were found in Percy Beck up to NZ/050175 but 0-group loach were found in only one of the three stations which contained loach.

6. The population density of trout varied between stations from 0.265 to 0.448 fish m^{-2} and their biomass was 5.0 to 10.9 g m^{-2}. The proportion of the trout population that was 0-group varied between stations from 26 to 45%.

7. Bullhead population density (excluding 0-group) was 0.056 to 0.138 fish m^{-2} and biomass was 0.2 to 1.0 g m^{-2}.

8. Within the stations where it was found and excluding 0-group, the stoneloach had population densities of 0.021 to 0.185 fish m^{-2} and biomasses of 0.1 to 1.0 g m^{-2}.

9. Total fish populations, excluding 0-group bullhead and stoneloach, had population densities of 0.44 to 0.70 fish m^{-2} and biomasses of 6.9 to 11.1 g m^{-2}. Trout contributed 49 to 87% of total fish numbers and 72 to 98% of total fish biomass. These values compare favourably with published data from other, similar UK streams except that, in 1990 at least, 0 group trout were rather less numerous than might be expected.

I INTRODUCTION

The Institute of Freshwater Ecology was commissioned by Glaxo Operations UK Limited to carry out a brief survey of fish populations in the Black and Percy Becks during the summer of 1990. This survey was part of a larger survey of the water quality and biology of the streams by Durham University.

The present report is intended to be self-contained and self-explanatory. Nevertheless, it should be considered in conjunction with the other elements of the study.

The general aim was to achieve a quantitative description of the fish populations in the two streams in terms of species distribution, fish numbers and fish biomass. The sampling stations, methods and results would be defined and recorded in sufficient detail that the single survey of 1990 could, if required, form the basis of an on-going series of surveys annually or at other regular or irregular intervals.

II STUDY AREA AND SAMPLING STATIONS.

The Black Beck rises c. 2.5 km WNW of Barnard Castle and flows through agricultural land across the back of the Glaxo site. Down to the point where it crosses Harmire Road it is heavily overgrown by aquatic vegetation. Below Harmire Road it flows through Barnard Castle Golf Course and the heavy plant growth is removed from time to time by the greenkeeper and his staff.

The Percy Beck rises near Belle Vue (NZ/045196) to the N of Barnard Castle. It flows through agricultural land and then, on the downstream side of Harmire Road it flows through the golf course where the growth of rank vegetation is controlled by the greenkeeper and his staff.

Percy and Black Becks join at NZ/050178 and their combined flow, known as the "Percy Beck", enters Flatts Wood. The stream flows through the wood and enters the R. Tees at NZ/046168. Within the wood the stream has few macrophytes, but lopped tree branches provide some cover for fish and an appreciable hindrance to electrofishing.

A preliminary survey in December 1989 showed that fish were absent from Black Beck above Harmire Road and scarce in the portion adjacent to the Golf Course. Therefore, the fish survey concentrated on the stream system downstream of Harmire Road and the sampling stations were placed at six strategic points within the system. The streambed in this part of the system was composed of fine gravel and occasional bedrock but there were appreciable deposits of fine silt amongst the gravel.

The approximate positions of the sampling stations are shown in Figure 1 and details of their dimensions are given in Table 1. The following points should be noted:

(a) Stations 1, 2 & 3 correspond, approximately, to Durham University stations 13, 12 and 8, respectively.

(b) Station 4 encompasses the junction of the Black and Percy Becks. Three separate lengths and mean widths are given in Table 1 and these refer to the appropriate portions of Black Beck, Percy Beck and the combined flow, respectively.

(c) Sketch maps to aid in precise location of the sampling stations are given in Appendix I.

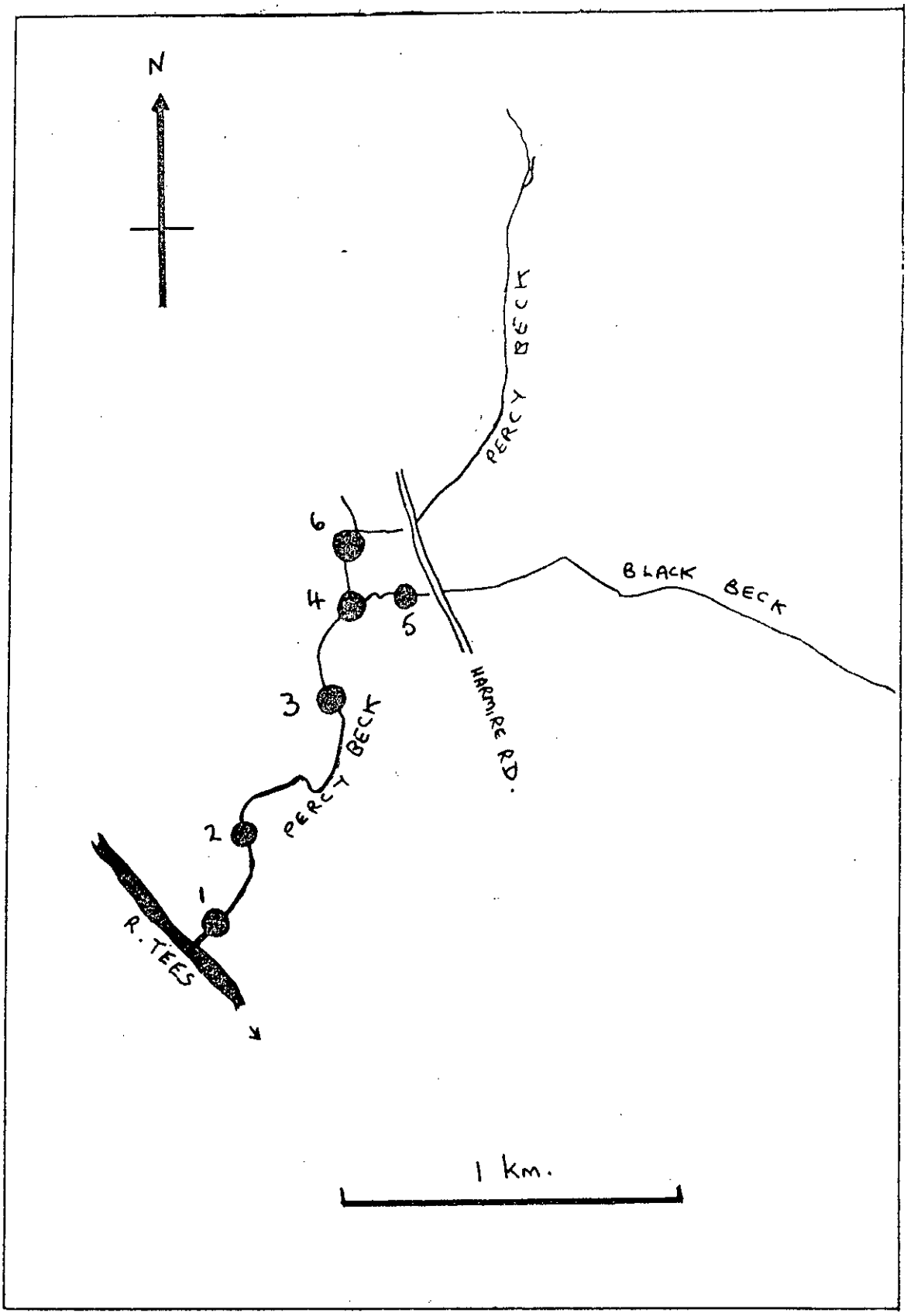

Fig. 1 Map to show approximate positions of fish sampling stations in Percy and Black Becks.

Station	Nat. Grid Ref.	Length (m)	Mean width (m)	Area (m^2)
1	NZ/046168	39.2	3.31	130
2	NZ/047172	40.8	3.52	144
3	NZ/050175	39.6	3.70	147
4	NZ/050178	6.6+13.7+15.8	1.74+1.37+2.25	.66(11.5+18.8+35.4)
5	NZ/051179	34.1	1.55	53
6	NZ/050180	38.7	1.83	71

TABLE 1. Positions, dimensions and areas of fish sampling stations. For further details see Appendix I. An additional station a little downstream of station 5 was fished on 11 July 1990. It had length c. 22 m, width c. 0.9 m and area c. 20 m^2.

III METHODS

1. Station definition and measurement.

As far as possible the position of the upstream and downstream limit of each station was defined in terms of its distance from a reasonably permanent and readily recognisable landmark within or close to the stream. The length of each reach was measured, with due allowance for sinuosity of the channel. The mean width was taken as the average of five measurements of water surface width at regular intervals along the length of the station. As noted, Station 4 was "Y" shaped, and each limb of the "Y" was measured separately.

2. Electrofishing.

Each reach was electrofished in an upstream direction on two occasions, with an interval of 30-45 min between the two successive fishings. The equipment was a lightweight pulsed D.C. outfit operated at 300v and 60 pulses s^{-1}.

The catches from the first and second fishings in each station were kept separate. All the fish caught were identified to species and their lengths measured to the nearest 0.1 cm. Bullheads and stoneloach are very small during July of their first year of life (Age-group 0 - see Appendix II) and not amenable to quantitative census by electrofishing. No attempt was made to collect all the 0-group bullheads or stoneloach which were seen. However, a small sample was taken for measurement. After measurement all fish were returned to the stream.

3. Census by the "removal method".

It is assumed that the same amount of effort is put into each of the two successive fishings of a station. All the fish caught in the first fishing (C_1) are retained until after completion of the second fishing (C_2) and each fishing is assumed to remove a high and relatively constant proportion of the fish present. Therefore, C_2 is less than C_1 and the total population (P)

can be estimated as:

$P = C_1^2 / C_1 - C_2$. The standard error of P is given by:

$$\text{S.E. of } P = \sqrt{\frac{C_1^2 \times C_2^2 \times (C_1 + C_2)}{(C_1 - C_2)^4}}$$ (Seber & Le Cren, 1967).

The following points should be noted:

(a) Each species within a station is treated separately.

(b) Within a given species, large specimens are more efficiently captured by electrofishing than small ones. Experience has shown that, for this reason, it is expedient to estimate 0 group trout numbers separately from the numbers of older trout.

4. Approximate estimation of fish weight.

For most species of fish the relationship between weight (W, g) and length (L, cm) can be represented by the equation $W = a L^b$, where a and b are constants and $b \doteq 3$. The values of a and b for any given species will vary between sites and also between different times of year. Estimation of values of a and b for a particular species in a particular stream would require accurate measurement and weighing of a large sample of fish at the time or times of year which were of interest. This is time-consuming and can cause damage to the fish. In the present survey no attempt was made to weigh any fish. Instead, all fish were accurately measured and then approximate weights were attributed on the basis of length:weight relationships from other waters (Table 2). This gives ample accuracy for present purposes.

5. Age determination.

The ages of trout can be determined from their scales and the ages of bullheads and stoneloach (which lack scales) from their otoliths (ear bones).

Species	Age	a	b
T	O-Group	0.0021	3.4952
T & S	Older	0.0154	2.8903
B	O-Group	0.0126	2.9449
B	Older	0.0111	3.0958
L	Older	0.00647	3.1658

TABLE 2. Values of the constants a and b in the equation $W = aL^b$, where L = length (cm), W = weight (g). The constants refer to the length:weight relationship in July/August and are based on data from populations as similar as possible to those in the Black and Percy Becks. T = trout, B = bullhead, L = stoneloach, S = salmon.

A small sample of scales can be removed from a trout without harming it. Therefore, scale samples were taken from all of the older trout caught in Stations 1 and 4 (Appendix III). The preparation and reading of scales is lengthy and expensive and has not been attempted as part of the present contract. It could be done, if required.

The collection of otoliths requires that the fish be killed. No otoliths were collected during the survey.

For these reasons the present survey gave little solid information about the ages and, hence, the growth, of the fish in Percy and Black Becks. However, some indications can be gained from length-frequency distributions (see below).

IV RESULTS

Four species of fish were found in the Percy and Black Beck system. Young salmon (Salmo salar L.) were found in small numbers in Station 1. Trout (Salmo trutta L.) were found at all stations, except Station 5, and the presence of O-group trout at all stations (except Station 5) suggests that this species breeds successfully over most of the stream system. The bullhead (Cottus gobio L.) was also found in all stations except for Station 5 and an exploratory fishing midway between Stations 4 and 5 yielded bullheads but no trout. The presence of O-group bullheads at Stations 1, 3, 4 and 6 indicates successful spawning at most stations. The stoneloach (Noemacheilus barbatulus (L.)) was found in the lowermost three stations (1, 2 and 3) and O-group were found only at Station 3.

Details of the catches and estimates of population ± 95% confidence limits and of percentage fishing efficiency are given in Table 3. In the last column of the table the results are expressed as numbers of fish m^{-2} of stream. With the exception of older trout, the fishing efficiencies in Station 1 were low (33 - 50%) and the 95% confidence limits of the population estimates were correspondingly high. This largely reflects difficulties in fishing Station 1 as a result of the presence in the stream of large amounts of lopped branches. Nevertheless, the population estimates for Station 1 are similar to those from the other stations. With the exception of bullheads at Station 2 and 0-group trout at Station 4, all other estimates are based on high efficiencies (67 - 100%) and have small confidence limits (± 20%, or less). The estimated population densities from Table 3 have been used, in conjunction with fish weights calculated from observed lengths, to estimate the biomass of each species at each station (Table 4).

Note that, for bullhead at Stations 1, 3, 4 and 6 and for stoneloach at Station 3, the estimates of population density and biomass will be depressed through omission of the 0-group fish.

Excluding 0-group bullhead and stoneloach, the population density of fish varied between stations from 0.44 m^{-2} at Station 6 to 0.70 m^{-2} at Station 1. The majority of these fish were trout (49% at Station 1, 87% at Station 6) and the percentage of the trout which were in their first year of life (0-group) varied from 45% at Station 1 to 26% at Station 6. The estimated biomass of fish, excluding 0-group bullhead and stoneloach, varied from 6.9 g m^{-2} at Station 1 to 11.1 g m^{-2} at Station 6 and trout contributed most of this biomass (from 72% at Station 1 to 98% at Station 6).

Station	Species	Age (S)	C_1	C_2	C_1+C_2	P±95% C.L.	% Eff.	No. m^{-2}	
1	S	I-Grp	2	1	3	4±7	50.0	0.031	
1	T	O-Grp	9	5	14	20±21	45.0	0.154	0.346
1	T	Older	20	4	24	25±2	80.0	0.192	
1	B*	Older	6	4	10	18±38	33.0	0.138	
1	L	Older	12	6	18	24±17	50.0	0.185	
1	TOTAL	-	-	-	-	-	-	0.700	
2	T	O-Grp	17	4	21	22±4	77.0	0.153	0.448
2	T	Older	38	4	42	42±2	90.5	0.295	
2	B	Older	6	3	9	12±12	50.0	0.083	
2	L	Older	1	2	3	3	-	0.021	
2	TOTAL	-	-	-	-	-	-	0.552	
3	T	O-Grp	11	3	14	14±4	73.0	0.102	0.265
3	T	Older	19	4	23	24±3	79.0	0.163	
3	B*	Older	14	3	17	18±3	78.0	0.122	
3	L*	Older	14	3	17	18±3	78.0	0.122	
3	TOTAL	-	-	-	-	-	-	0.509	
4	T	O-Grp	5	2	7	8±6	60.0	0.121	0.318
4	T	Older	10	2	12	13±2	77.0	0.197	
4	B*	Older	6	2	8	9±4	67.0	0.136	
4	TOTAL	-	-	-	-	-	-	0.454	
6	T	O-Grp	6	1	7	7±1	86.0	0.099	0.381
6	T	Older	19	1	20	20±1	95.0	0.282	
6	B*	Older	4	0	4	4	100.0	0.056	
6	TOTAL	-	-	-	-	-	-	0.437	

TABLE 3. Population estimates for trout (T), salmon (S), bullhead (B) and stoneloach (L). No attempt was made to estimate the numbers of O-group bullheads or loach but presence of O-group in each station is indicated by an asterisk. No fish were seen at St. 5, but a reach of c. 20 m^2 a little downstream contained bullheads at a population density of at least 0.25 m^{-2}.

Station	Species	Age(s)	Biomass (g m^{-2})
1	S	I-Grp	0.4
1	T	O-Grp	0.3
1	T	Older	4.7
1	B	Older	0.8
1	L	Older	0.7
1	TOTAL	-	6.9
2	T	O-Grp	0.4
2	T	Older	9.7
2	B	Older	0.4
2	L	Older	0.1
2	TOTAL	-	10.6
3	T	O-Grp	0.3
3	T	Older	5.1
3	B	Older	0.6
3	L	Older	1.0
3	TOTAL	-	7.0
4	T	O-Grp	0.3
4	T	Older	6.9
4	B	Older	1.0
4	TOTAL	-	8.2
6	T	O-Grp	0.4
6	T	Older	10.5
6	B	Older	0.2
6	TOTAL		11.1

TABLE 4. Estimates of biomass (g m^{-2}) in each station for different species and ages of fish and for all fish species. T, S, B & L as in Table 2.

The percentage frequency distribution of the trout between 1.0 cm length ranges is shown in Figure 2. The O-group trout form a distinct group about a modal length of c. 5.5 cm. Subsequent age-groups show considerable overlap. It is likely that the I-group has a mode of c. 11 cm and the II-group has a mode of c. 15 cm. However, scale reading would be required in order to confirm or refute this suggestion.

Figure 3 shows the frequency distributions, between 0.5 cm length ranges of older bullhead and stoneloach. The length ranges covered by the O-group fish are also indicated. For both species the O-group fish can be clearly distinguished from the older fish. The bullhead distribution suggests a I-group mode of 6 - 6.5 cm and a II-group mode of 8 - 8.5 cm, but otolith readings would be required to confirm this. The pattern for stoneloach is irregular and difficult to interpret, even tentatively. In contrast to the trout and bullhead distribution, the stoneloach distribution for I-group and older does not suggest an exponential reduction in numbers as length (hence, age) increases. This and the fact that O-group loach were found at only one station suggests that loach recruitment in Percy Beck may be very variable from year to year.

V DISCUSSION

1. Salmon:

The size of the salmon parr in Station 1 indicates that they were I-group i.e. they were O-group in 1989 and arose from eggs laid in the autumn of 1988 or the winter of 1988-9. There are six possible explanations of their presence:

(a) They were hatchery fish placed in the lower reaches of Percy Beck by the NWA/NRA as O-group during 1989.

(b) They were hatchery fish placed in the lower eaches of Percy Beck as I-group during 1990 by the NRA.

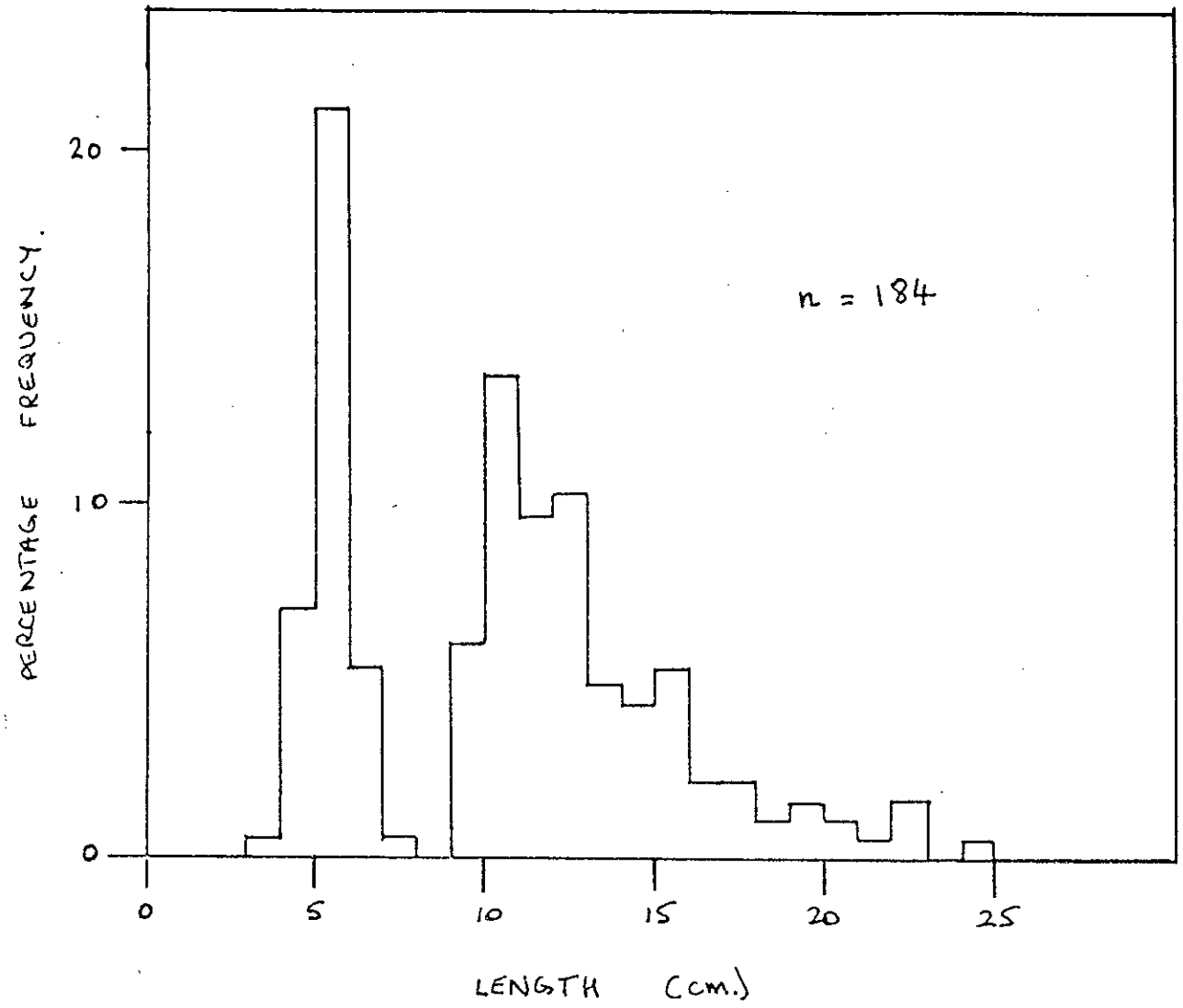

Fig. 2. Percentage length frequency distribution of trout examined in Percy and Black Becks on 10 and 11 July 1990.

n = Number of trout in sample.

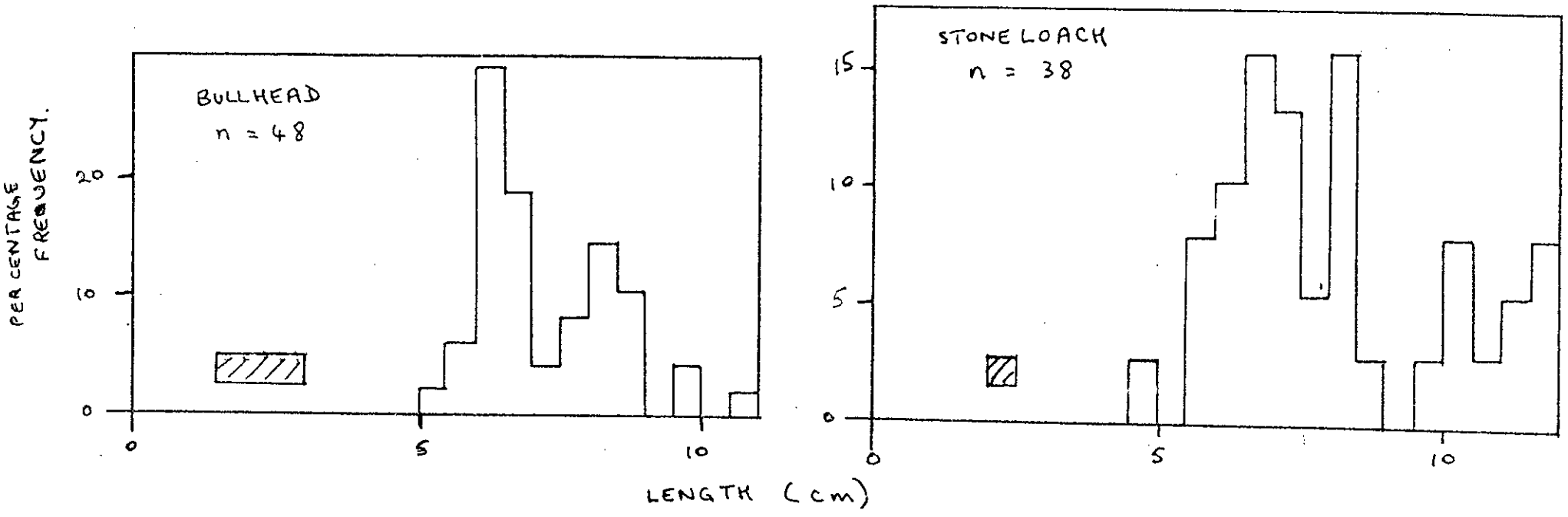

Fig. 3. Percentage length frequency distributions of bullhead and stoneloach of age-groups I and older examined in Percy and Black Becks on 10 and 11 July 1990.

n = Number of fish in each sample. The hatched bars indicate the observed length ranges of 0-group fish.

(c) They were hatchery fish which were placed in the R. Tees as O-group in 1989 and have subsequently moved into Percy Beck.

(d) They were hatchery fish which were placed in the R. Tees as I-group in 1990 and have moved into Percy Beck.

(e) They were progeny of wild fish spawning in the R. Tees.

(f) They arose directly from the spawning of wild salmon in the lower reaches of Percy Beck.

Enquiries are being made by NRA to see whether their records cast any light on the first four possibilities.

2. Fish age and growth.

The length frequency distributions suggest that the approximate mean lengths in July of age-groups 0, I and II will be 5.5 cm, 11 cm and 15 cm for trout and 2.5 cm, 6 - 6.5 cm and 8 - 8.5 cm for bullheads, respectively. Values based on scale readings for trout in the Tees below Cauldron Snout (Crisp et al., 1974) in August were 4.8 cm, 10.7 cm, 15.3 cm. Comparable values for bullheads at the same site were 1.5 cm, 5.0 cm, and 7.0 cm. These values from Cow Green are sufficiently similar to the speculative values from Percy Beck to give some plausibility to the latter, but validation would depend upon rigorous analysis of age determination material.

3. Population density and biomass.

Information on midsummer population densities and biomasses of fish species in 10 English streams are given by Le Cren (1965) (see Appendix IV). The first five streams listed by Le Cren are in northern England, the last five in the south. Amongst the northern streams, Nether Hearth Sike (550 m.O.D.) is exceptional in that it is at high altitude (550 m.O.D.) and in a harsh climate in the northern Pennines. Le Cren's data show O-group trout populations of 0.2 to 2.4 m^{-2}, and population densities of older trout of 0.1 to 0.5 m^{-2}

and trout biomasses of 0.6 to 16.2+ g m^{-2}. Viewed within this context, the population density of 0-group trout in Percy Beck (0.099 - 0.154 m^{-2}) is on the low side, the population density of older trout (0.16 - 0.30 m^{-2}) is unexceptional and the biomass (5.0 - 10.9 g m^{-2}) is normal. Le Cren's northern streams lacked stoneloach and had few, if any, bullheads. The population densities and biomasses of bullheads observed in Percy Beck (0.056 - 0.138 fish m^{-2} and 0,2 - 1.0 g m^{-2}) are low compared with the high values observed in three southern chalk streams.

4. The upper limits of fish distribution.

Preliminary studies during December 1989 indicated that, in Black Beck, fish were absent or very scarce upstream of Harmire Bridge and that the uppermost detectable limit of fish distribution was somewhere between Stations 4 and 5 of the present survey. The present survey has confirmed this. The presence of trout and bullheads in the lower reaches of Black Beck at Station 4 and of bullheads between Stations 4 and 5 suggests that this does not indicate any problem with regard to the chemical quality of the Black Beck water. Rather the absence of fish from the uppermost reaches is likely to reflect decreasing stream size and the choking of the channel by dense growths of macrophytes. It may also be related to suspended solids (see 5 below).

In Percy Beck a thriving trout population, which included 0-group fish (indicative of successful spawning), was found at the uppermost station (St. 6). It might be useful to ascertain the upper limit of fish distribution in this stream.

5. Inputs from Harmire Road.

The upper reaches of Black Beck were visited on 14 December, 1989. There had been a modest overnight snowfall, the roads had been salted and road effluent was flowing into the beck from Harmire Road via two pipes under the road bridge.

This effluent was very turbid and probably also very salty. The turbidity was caused by fine, clayey particles in suspension and, whereas the water was clear upstream of the road, it was sufficiently discoloured downstream that the streambed was difficult to see. The presence of relatively large amounts of fine silt in the bed material of the whole length of Black/Percy Beck in July 1990 has already been noted. Such material can infill the interstices in the gravel in which the young stages of trout develop during the period from October/November to April/May. This infilling reduces the water flow through the gravel and, hence, reduces the supply of oxygen to the intragravel stages of trout and may lead to reduced survival of these young stages. It is not clear whether or not the Percy Beck receives similar effluent at the point where it crosses Harmire Road. If it does not, then this is one possible reason for the presence of more fish in the upper reaches of Percy Beck than in the upper reaches of Black Beck.

VI FUTURE DEVELOPMENTS.

The survey has shown that the fish populations in the Black and Percy Becks are in a generally healthy state and the next step may be simply to retain the data and take no further action, unless at some time in the future, there are indications of a possible change. It might then be appropriate to institute another survey.

Most fish populations show some year-by-year variations in recruitment and to establish a really sound base-line for future comparisons it is necessary to make repeat surveys over a period of 5-10 years. Glaxo UK may wish to consider seeking tenders for repetition of the survey for, say, another four years.

As a result of this work we have a fairly clear knowledge of the upstream limit of fish distribution in the Black Beck. We lack such information for Percy Beck. It would be worthwhile to make a quick, non-quantitative survey of Percy Beck upstream of Harmire Road to gain such information. This might lead to the addition of one or more routine census stations in any future quantitative surveys.

It is unlikely that it would be cost-effective to attempt to read scales from Percy Beck trout. However, this would be possible, if desired. The scale samples will be kept and they will then be available should future circumstances require that they be read.

ACKNOWLEDGMENTS

The study was funded by Glaxo Operations UK Limited. We are grateful to Raby Estates and Mr John Bell for access to the stream and to Mr John Hinton and his staff for being so helpful with regard to access to the stream reaches within the golf course.

Miss R.L. Davey helped with the fieldwork and Mrs D.C. Crisp made the typescript.

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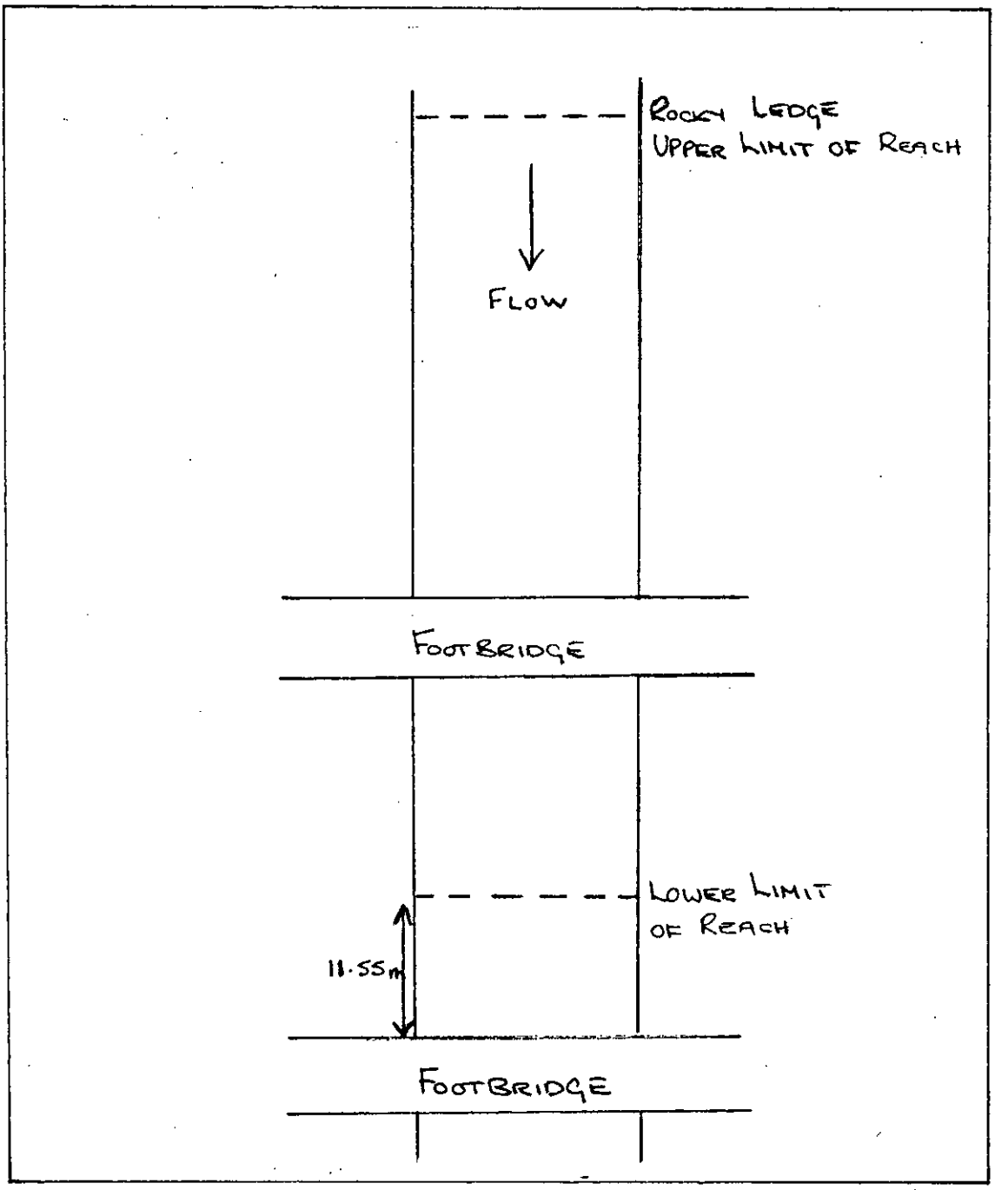
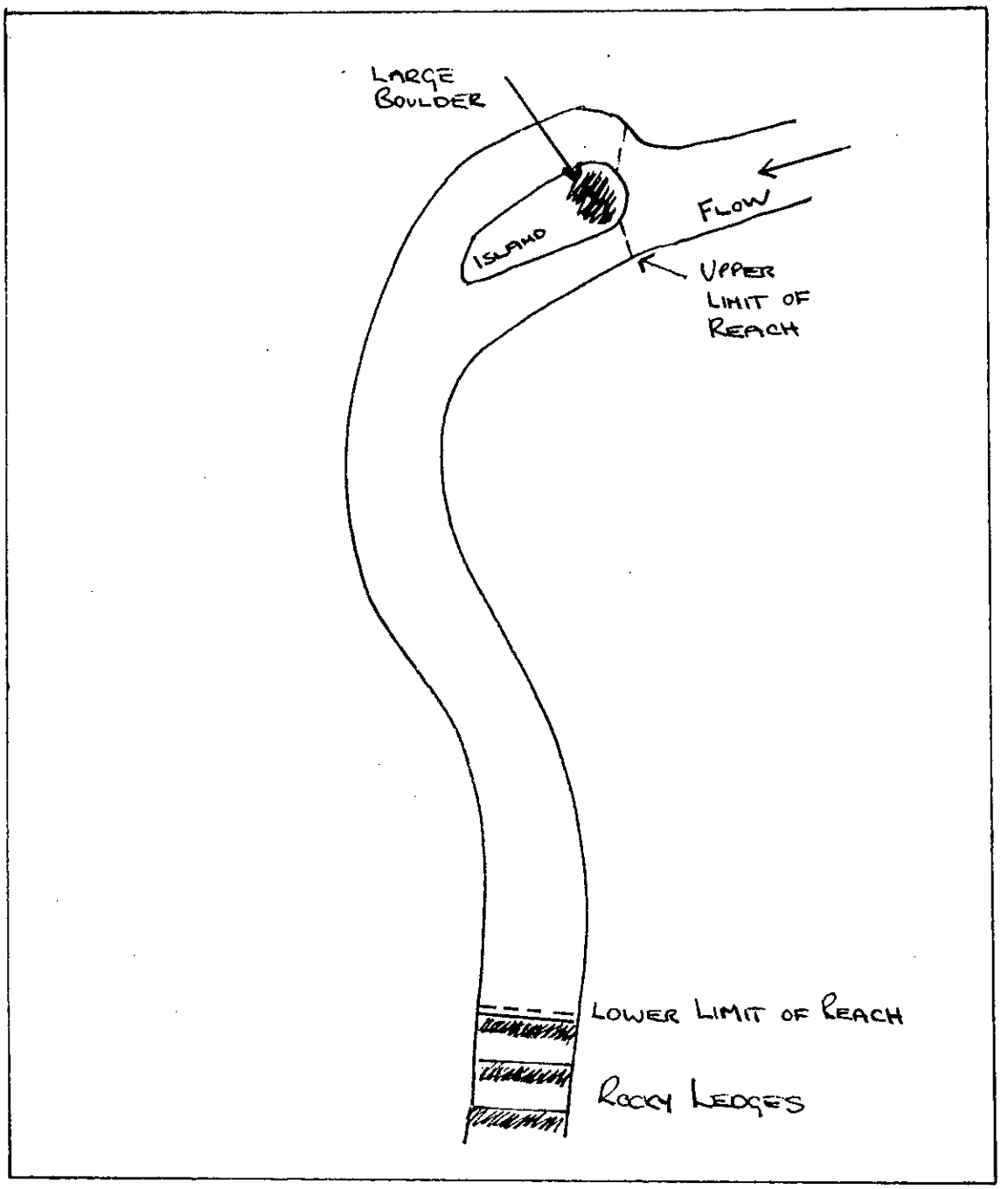
APPENDIX I. SKETCH MAPS AND NOTES TO FACILITATE IDENTIFICATION OF SAMPLING STATIONS.

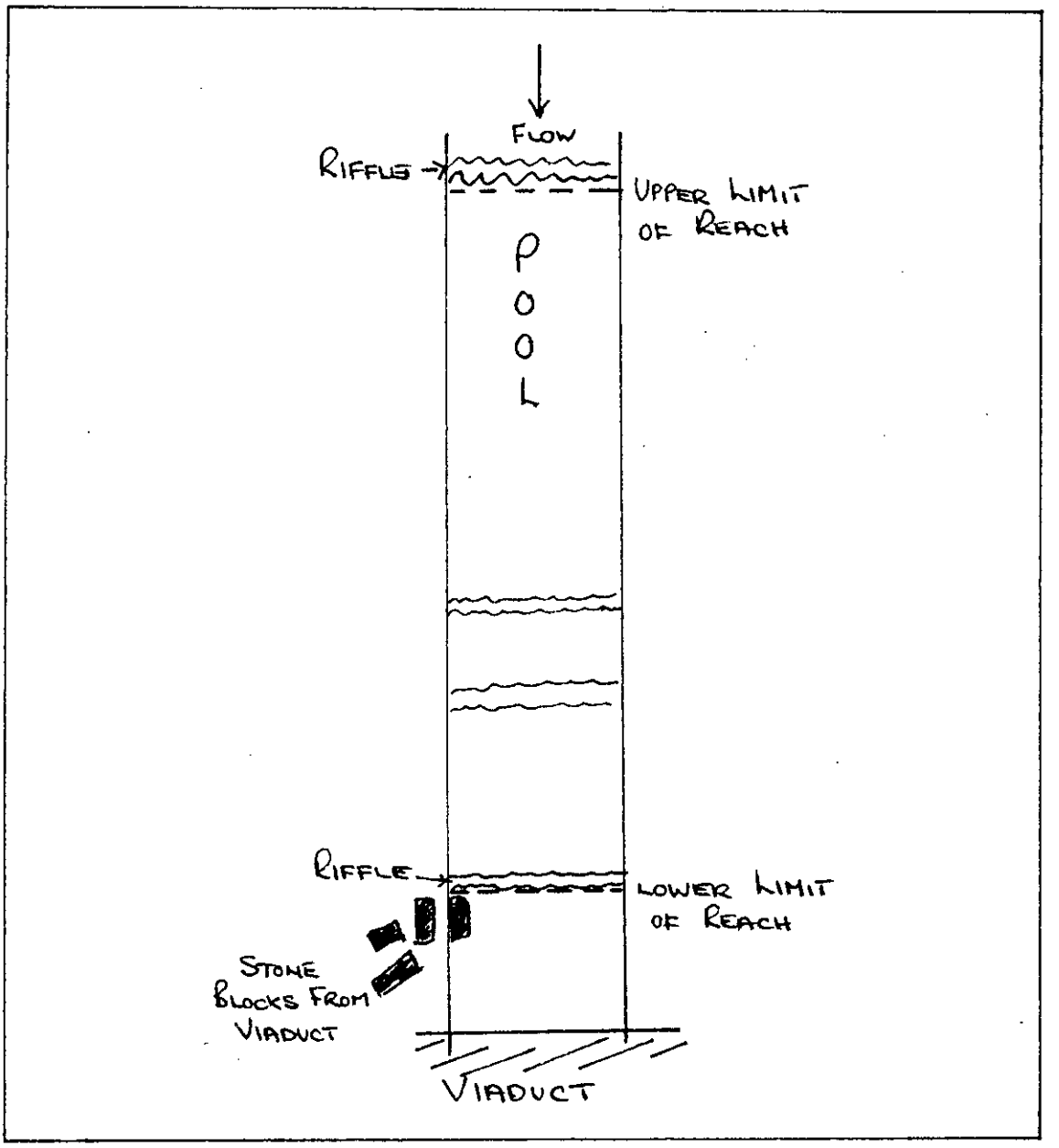
The approximate positions of the stations are indicated in Figure 1 and Table 1. The following maps identify the upper and lower limit of each reach relative to one or more fairly permanent landmarks. Where only one end of the reach can be located in this way, the other can be located by use of the measured length of the station (see Table 1 and legends of sketch maps).



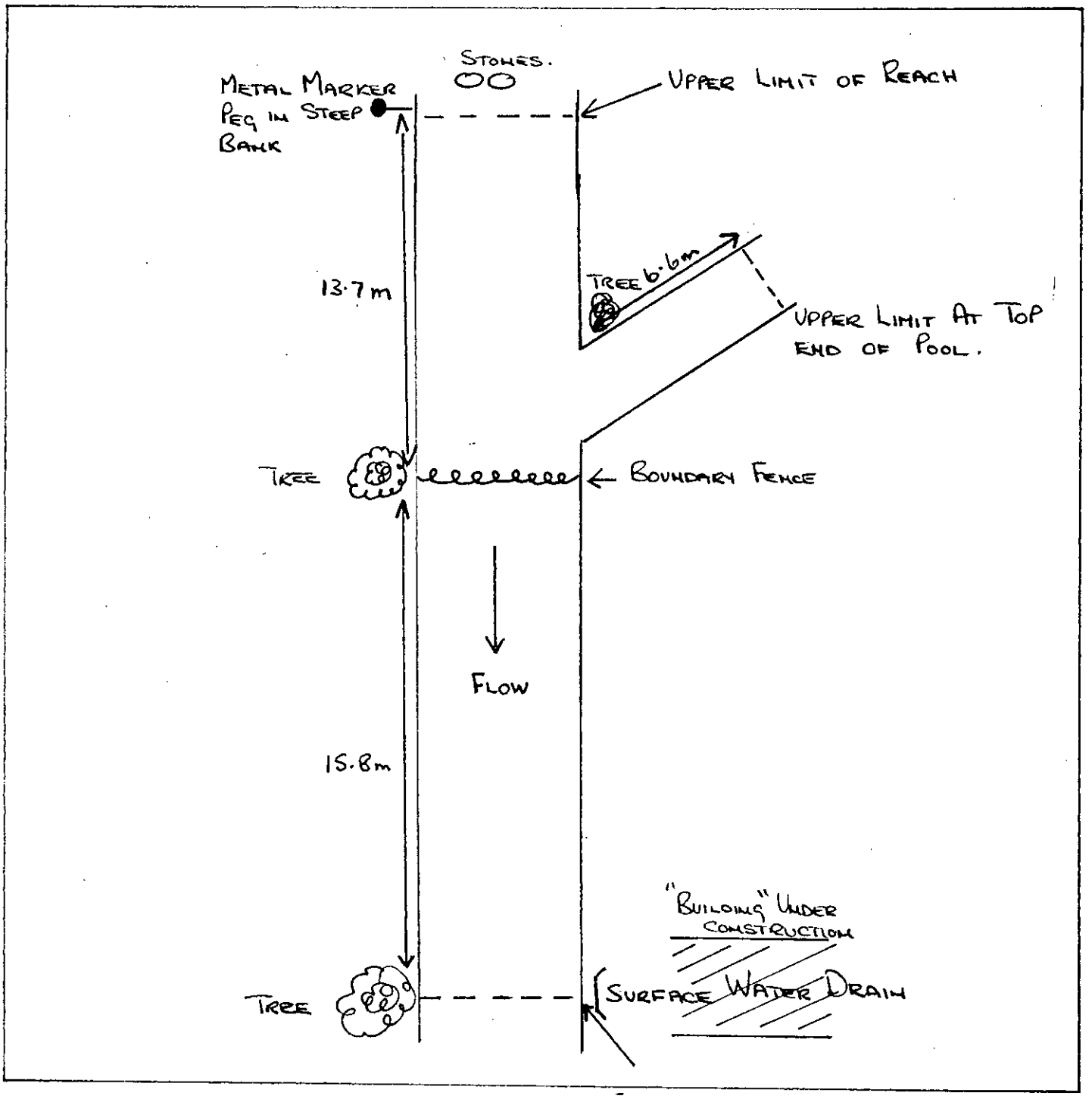
STATION 1. Reach is easily identifiable from 2 permanent footbridges upstream of the junction with the R. Tees. The reach is 39.2 m in length. Gravel bed with some large stones, silt and tree fellings.



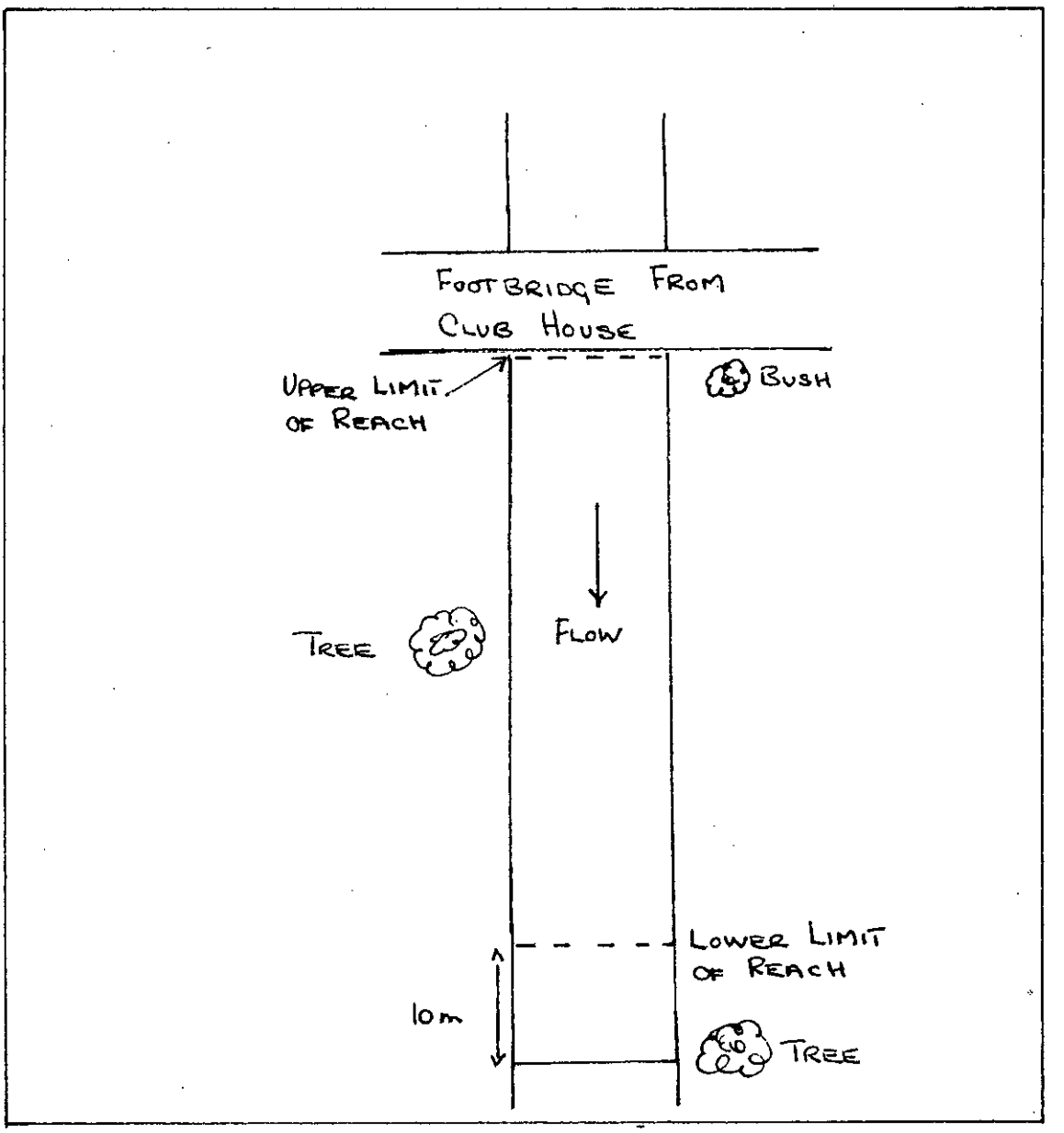
STATION 2. "Island" and boulder mark the upper end of the reach. A series of rocky ledges marks the lower end. Overall length is 40.8 m. Streambed comprises large areas of bedrock with some gravel. Silt in upper end of reach.



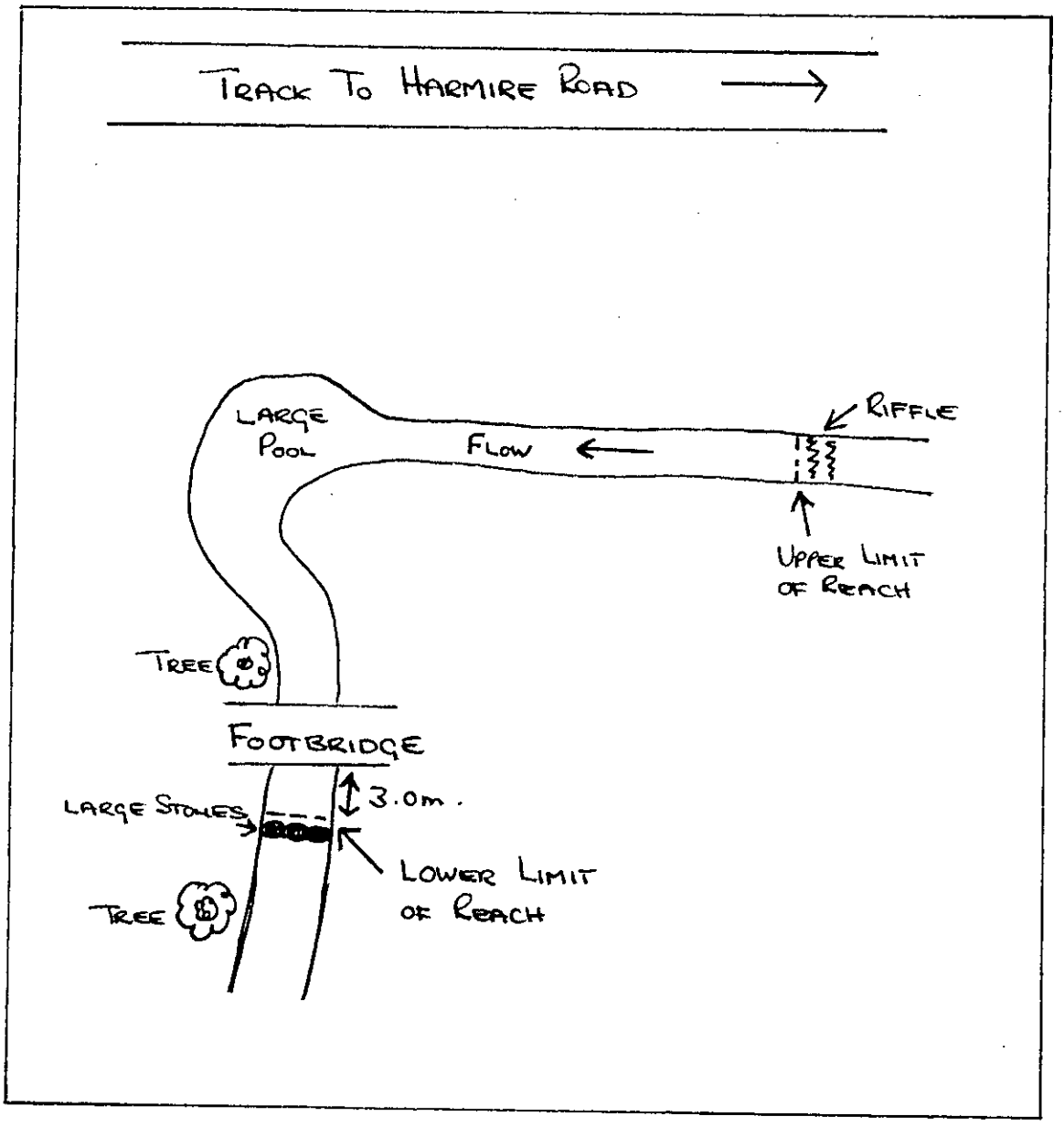
STATION 3. Stone blocks from the viaduct mark bottom end of reach and riffle at top end of a long pool marks the top end. Length of reach is 39.6 m. Reach has a series of riffles and a long deep pool with stony bottom. Appreciable silting in pool.



STATION 4. Measurements together with identification marks are shown on the plan of the reach. The streambed is made up of fine gravel riffles with appreciable deposits of silt at the lower end.



STATION 5. Upper end of reach is marked by the footbridge from the Club House. Length is 34.1 m. Stony bed with algal cover.



STATION 6. Lower end of reach is 3 m below footbridge. Length 38.7 m. Gravel bed with some algal cover and weed bed at lower end of large pool.

APPENDIX II DESCRIBING THE AGES OF FISH.

The manner in which biologists describe the ages of fish can be confusing and a brief explanation of the convention used in this report may be a help to the reader. We will take the trout as an example, though similar principles apply to the other fish species.

Trout lay their eggs in gravel beds in the autumn or winter. The egg develops and hatches to give an "alevin". The alevin remains in the gravel and subsists upon its yolk sac. The following spring, when the yolk sac is almost exhausted, the alevin (now termed a "fry") leaves the gravel and becomes a free-swimming fish which takes external foods. This time of emergence from the gravel (not the time of oviposition) is regarded as the birthday of the fish. The precise birthdays of trout in a given stream will vary from fish to fish. However, for convenience, a single birth date is arbitrarily applied to all the fish of a given species . In Teesdale streams it is convenient to take 1 April as the birthday of all trout. From its date of birth to its first birthday a trout is described as "Age-group 0" or "0-group". During the following year it is described as "Age-group I" or "I-group". Similar terminology applies to later years of life. A particular cohort of fish is usually identified according to its year of birth. For example, trout which were "Age-group 0" in 1989 would be described as the "1989 Year Class".

Similar principles apply to such fish species as bullhead and stoneloach. These fish spawn in Spring and their young become free-swimming in the early Summer. It is, therefore, appropriate to assume a birthday of 1 June for these species.

APPENDIX III. Listing of fish from which scales were collected on 10 July 1990 by station, species and length. S = salmon, T = trout. During the survey of 10-11 July 1990 a total of 3 salmon and 121 trout of I-group and older were handled. Scales were collected from 28 trout older than I group and from 2 salmon.

Station	Species	Length (cm)	Station	Species	Length (cm)
1	S	10.3	4	T	10.4
1	S	10.8	4	T	10.8
1	T	10.1	4	T	12.6
1	T	10.1	4	T	12.7
1	T	10.2	4	T	12.8
1	T	10.7	4	T	12.8
1	T	10.8	4	T	13.1
1	T	10.8	4	T	13.2
1	T	11.3	4	T	14.2
1	T	12.7	4	T	14.4
1	T	13.7	4	T	15.6
1	T	14.7	4	T	22.5
1	T	14.8			
1	T	15.1			
1	T	15.8			
1	T	18.8			
1	T	20.6			
1	T	26.1			

APPENDIX IV. DATA FROM LE CREN (1969).

TABLE II

MIDSUMMER POPULATION DENSITIES OF FISH IN TEN STREAMS (NUMBERS / m^2) + = SMALL NUMBER NOT ACCURATELY DETERMINED, - = SPECIES NOT RECORDED AS PRESENT.

Stream	*Black Brows*	*Kingswell*	*Hall*	*Appletreeworth*	*Nether Hearth*	*Bere*	*Tarrant*	*Devil's*	*Dockens*	*Walla*
Trout 0	1.9	0.6	0.2	0.2	?	?	?	?	1.0	2.4
I	0.5	0.2	0.2	0.1	?	?	?	?	0.1	0.2
Older	+	0.1	0.3	0.1	?	?	?	?	+	0.1
Total	2.4	0.9	0.7	0.4	0.1	0.2	0.8	0.1	1.1	2.7
Salmon	-	-	-	-	-	+	+	-	+	+
Sculpin (Bullhead)		+	-	-	0.5	10.3	45.2	5.3	-	?
Minnow	-	-	-	-	-	0.8	1.5	+	2.2	?
Stickleback	-	-	-	-	-	1.3	-	1.0	+	?
Stone Loach	-	-	-	-	-	+	0.5	+	+	?
Eel	+	-	-	-	-	+	+	+	+	?
All species	2.4+	0.9+	0.7	0.4	0.6	12.6+	48.0+	6.4+	3.3+	2.7+

TABLE III

MIDSUMMER BIOMASSES OF FISH IN TEN STREAMS (g/m^2). + = SMALL AMOUNT NOT DETERMINED; - = SPECIES NOT RECORDED AS PRESENT.

Stream	*Black Brows*	*Kingswell*	*Hall*	*Appletreeworth*	*Nether Hearth*	*Bere*	*Tarrant*	*Devil's*	*Dockens*	*Walla*
Trout 0	1.6	1.1	0.2	0.3	?	?	?	?	2.8	?
I	3.7	1.9	1.1	1.0	?	?	?	?	2.9	?
Older	0.6 ?	2.1	11.6	4.9	?	?	?	?	0.8	?
Total	5.9	5.1	12.9	6.2	0.5	6.5	4.4	0.5	6.5	9.3
Salmon	-	-	-	-	-	+	+	-	+	+
Sculpin (Bullhead)		+	-	-	0.1	6.1	19.9	8.6	-	?
Minnow	-	-	-	-	(+)	0.4	1.8	+	2.5	?
Stickleback	-	-	-	-	-	0.2	-	0.5	+	?
Stoneloach	-	-	-	-	-	+	0.1	+	+	?
Eel	+	-	-	-	-	+	+	+	+	?
All species	5.9+	5.1+	12.9	6.2	0.6	13.2+	16.2+	9.6+	9.0+	9.3+