ECOLOGICAL STUDY OF CHALK STREAMS

LAMBOURN PROJECT

Interim Report
October 1977 to April 1979

Freshwater Biological Association
River Laboratory

CONTENTS

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1. INTRODUCTION

1.1 OBJECTIVES

The aims of the present phase of the project may be divided into two broad aspects. The first involves collecting further information in the field and includes three objectives: a continuation of studies on the Lambourn sites at Bagnor; comparative studies on other chalk streams; and a comparative study on a limestone stream. The second involves detailed analyses of data previously collected to document the recovery of the Lambourn from operational pumping and to attempt to develop simple conceptual and predictive models applicable over a wide range of physical and geographical variables.

1.2 PROGRESS

The programme of field observations is progressing according to plan and seems likely to be completed on schedule. Macrophytes are being mapped each month at the two Lambourn sites at Bagnor. Quantitative samples of invertebrates are being taken and examined in June and December each year and samples of trout and grayling have been examined each winter. These observations maintain the long-term records which extend continuously from early in 1971 and are described in section 2.1 of this report.

Full consultations have taken place with the Steering Committee over the selection of sites for the comparative studies. A site near Fairford on the River Coln was used for the study of a limestone stream. This began in March 1978 and is being continued beyond the twelve months originally planned in order to observe a second year's growth of the macrophytes. The results to date are reported in section 2.2, A survey of macrophytes and invertebrates at 25 sites on the Rivers Test, Itchen and Meon started in March 1979 and will continue until January 1980. This will facilitate comparisons between these large southern chalk streams and the ones previously studied by the project. The first results are presented in section 2.3.

A major effort has been directed to statistical analyses of the accumulated results of the project. The various approaches that have been developed and applied are outlined in section 3 of the report. These analyses will include the observations, that are available on the effects of operational pumping and will place them in context with the observations under natural flow conditions. Several manuscripts are in an advanced state of preparation and abstracts of these are given in section 4. Collaboration has been established with the Institute of Terrestrial Ecology to explore the possibility of developing mathematical models and this should grow during the remaining part of the programme.

A report on the 1973-77 phase of the project has been largely written but still awaits proper drawing of the figures and adequate checking before being submitted.

An approximate division of effort by the team during the period of this report is:

Field work and processing samples collected	37%
Computer analyses and writing manuscripts	43%
Writing 1973-77 report	15%
Other activities	5%

1.3 STAFF

On 1 October 1977 Dr A. P. Mackey took over responsibility for the day-to-day management of the current programme of work. This has allowed Dr J. F. Wright to concentrate on the analysis of data collected previously. Mr J. P. Cropper left in December 1977 to take up a research studentship in Florida after being with the project since October 1975. Miss Helen M. Brown was recruited in January 1978 to fill the additional post made possible in the team by the NCC participation in the project. She graduated in Biology at the University of York and had worked at the Durban Laboratory of the National Institute of Water Research in South Africa. At the same time Mrs Jessica M. Winder replaced Mr Cropper. She graduated in Zoology at University College, Swansea and had worked at the Grosvenor Museum, Chester and with the Faunal Remains Project at the University of Southampton.

1.4 LABORATORIES AND EQUIPMENT

The move from the University of Reading raised several problems. No laboratory space was immediately available at the. River Laboratory and a former school building in East Stoke had to be leased. The team moved into a large classroom which provided adequate space but few of the facilities normally found in laboratories. In March 1979 the team moved into two small laboratories in an old house which had just been renovated and converted for research at the River Laboratory. These are better suited for the work and closer to the library and computing facilities.

The capital equipment which had been provided during the previous contracts belonged to the University of Reading. New microscopes had to be purchased by the FBA and delays in delivery caused some problems. An additional vehicle was purchased for the Laboratory and this has meant that a selection of vehicles has been available suitable for the various needs of the project. An Olivetti P6060 minicomputer was purchased by the Laboratory soon after the project moved there and a second has since been added. These are used extensively by the team as is the telephone link to the ICL 4-70 computer at the Atomic Energy Establishment at Winfrith.

1.5 ACKNOWLEDGEMENTS

We are again grateful to The Piscatorial Society and Mr J. Gladstone for allowing us continued access to the sites at Bagnor on the River Lambourn, We are indebted to The Ernest Cook Trust for access to the River Coln at Fairford. We are also grateful to the following for access to sites on the Rivers Test, Itchen and Meon:

Mr M. Atkinson, Commander R. B. Cooper, Dr J. Couchman, Lord Denning, Mr R. S. Button, Mr R. Harrison, The Houghton Club, Mr A. Humbert, Hon. J. S. Kirkwood, Laverstoke Estates Limited, Mr Leaman, Leckford Estate, Sir Richard Levinge, Mr S. R. Martin, Sir Denis Mountain, Mr E Parish, Messrs Pink, Donger & Lowry, Mr P. Silk, Sir Thomas Sopwith, Mr J. G. St G. Syms, The Trustees of the Tichborne Estate, Mr J. Watson, Captain A. A. Wills and Winchester College.

We have also been helped in locating suitable sites and identifying owners by Mr I. McDonald (Thames WA), Mr P. Soulsby and Mr J. R. Chandler (Southern WA) and Mr C. R. Tubbs((NCC). Dr C. Milner (Institute of Terrestrial Ecology) has provided valuable liaison on mathematical modelling.

2. FIELD STUDIES

2.1 RIVER LAMBOURN

2.1.1 The study sites

Two contrasted sites, each 50 m in length, are being studied . at Bagnor. Both sites are located on the northern branch of the Lambourn below the confluence with the Winterbourne.

The upper site is partially shaded by a continuous line of trees on the south-west bank and varies in width between 6.5 and 9.5 m. A high proportion of the substratum is covered by macrophytes, of which *Berula erecta* is the dominant species, although *Ranunculus* sp., *Callitriche obtusangula, C.stagnates* and *Apium nodiflorum* are also well represented.

At the lower site the river flows through open meadowland unshaded by trees and the volume of water is augmented by a pair of adjustable hatches which connect the south and north branches of the river upstream of this site and allow the passage of water into the north channel. The upstream limit of this site is 7 m wide and has a deep fast-flowing channel dominated by gravel and *Ranunculus* beds, although limited amounts of *Berula erecta* occur. Downstream the river widens to 13m, the current decreases and a slightly greater diversity of macrophytes is found, including *Berula erecta, Callitriche obtusangula* and *C.stagnalis.* The upper and lower sites are referred to as the shaded and unshaded sites, respectively.

2.1.2 Macrophytes

The macrophytes on the two sites at Bagnor have been mapped monthly using the rectangles method although the April 1979 mapping at the unshaded site could not be carried out due to high discharge in the river. An extra mapping took place on both sites at the end of May 1978 to assess the growth of *Ranunculus prior* to a weedcut.

On the unshaded site in 1978 *Ranunculus* grew particularly well, increasing from 27% cover at the beginning of March to 77% by the end of May. The increase in area (50%) was higher than the value of 30% which was predicted from previous data showing the relationship between discharge and growth of *Ranunculus.* Manipulation of hatches between the north and south channels may have increased the proportion of water in the north channel, thus artificially increasing discharge over the site. Berula and *Callitriche both* grew well -in the autumn of 1978 although the maximum values of 11% cover for *Callitriche* in November and 14% cover for *Berula* in December were not unusual for this time of year. Extensive loss of *Ranunculus* occurred during the winter so that by March 1979 it covered only 17% of the river bed. Large areas of silt which had previously been beneath *Ranunculus* beds were exposed, increasing the area of silt to 37% in March 1979, the highest value which has so far been recorded at this site.

On the shaded site in 1978 cover of *Ranunculus* increased from 1% in March to 27% at the end of May, which is also greater than might have been expected from previous data. Cover of *Berula* remained around 40% until November 1978 when the percentage cover was reduced due to overgrowing of *Berula* by *Callitriche.* The percentage cover of C*allitriche* of 48% in November 1978 was the highest value recorded in the eight years run of data. Extensive rip-out of *Berula* and *Callitriche* occurred in November and December 1978, so that total Macrophyte cover decreased from 75% in November 1978 to 1% in February 1979 and remained particularly low in the early part of 1979. Large areas of silt were exposed increasing the total area of silt at the site to 49% in January 1979. This rapidly declined to 21% by March 1979. Changes in macrophyte cover on the shaded site do not show any pattern and in an attempt to understand the changes on the site three different types of analyses have been undertaken.

a) Measurement of current speed and sediment depth: *Berula* has been observed to rip-out on a large scale several times during the study on the shaded site and it is postulated in the 1973-77 report that current speed and sediment depth are responsible for controlling the timing of this rip-out.

   From April 1978 measurements were taken of current speed and sediment depth within the *Berula* carpet and these observations continued until December 1978 when extensive rip-out of *Berula* took place. No significant differences could be detected either by use of 't' test, or discriminant function analysis between measurements made where *Berula had* ripped out and those taken where the *Berula* bed had remained stable. The cause of the rip-out of *Berula* in December 3 978 is uncertain but was suspected to. have been unnatural since sediment as well as *Berula* disappeared but current velocities remained largely unchanged.

b) Stability of weed beds: *Ranunculus* and *Callitriche* on the shaded site both have an annual cycle of growth, whereas the cover of *Berula* has been observed to remain stable over several years followed by a sudden decline. To assess whether a time factor is important in determining the duration of macrophyte cover on . the site, the stability of each species has been studied using the specially written computer program. The mean time in months taken to reduce a weed bed by 50% is very short for both Ranunculus (1.2 months) and *Callitriche* (1.1 months) (Table .1) as would be expected for species with an annual pattern of growth. The values for *Berula* are higher than the other species but even so it appears that a Berula bed has a half life of only four months. At times when % cover of Berula remains stable, an equal amount of 'gain and loss must be taking place so that although cover remains unchanged, the positions of *Berula* beds within the river are slowly moving.

c) Time series analysis: This type of approach has been used to determine if any periodicity exists in the pattern of changes on the shaded site. Periodograms for the percentage cover of the three Macrophytes have been calculated and, as expected, *Ranunculus and Callitriche* show a periodicity of 12 months. A periodicity of 32 months is indicated for cover of *Berula* although the significance of this is not yet certain. Gains and losses of *Berula* have been examined only for transitions with non-macrophyte substrata in order to eliminate any competition effects or periodicity imposed by the other two species. Gain of *Berula* showed no periodicity, whereas loss of *Berula* to gravel and silt showed a 12 month periodicity. An attempt will be made to link this periodicity to environmental variables.

TABLE 1 Stability of macrophytes on the shaded site at Bagnor showing the time in months by which different proportions of the plants are lost.

PERCENTAGE LOSS

		10	20	30	40	50	60	70	80	90
BERULA	Mean	0.5	1.1	1.8	2.8	4.0	5.3	7.1	10.2	15.1
	Max.	1.5	3.0	4.5	6.1	9.4	10.8	13.2	14.8	21.7
	Min.	0.2	0.4	0.7	0.8	1.2	1.8	2.8	4.7	7.8
CALLITRICHE	Mean	0.2	0.4	0.6	0.9	1.1	1.5	2.1	3.0	4.3
	Max.	0.6	1.2	2.0	2.3	3.2	4.5	6.2	8.8	11.8
	Min.	0.1	0.2	0.4	0.5	0.6	0.7	0.8	0.9	1.1
RANUNCULUS	Mean	0.2	0.5	0.7	0.9	1.2	1.6	2.2	3.2	4.7
	Max.	1.7	2.6	3.1	3.4	3.8	4.4	5.6	8.0	11.1
	Min.	0.1	0.2	0.3	0.4	0.5	0.7	0.8	0.9	1.4

2,1.3 Invertebrates

Twice yearly quantitative sampling, of invertebrates has been continued on both Bagnor sites so three sets of samples have been taken during the scope of this report. Since no *Ranunculus* samples could be taken on the shaded site in December 1977 and 1978 and no *Berula* samples on the unshaded site in June 1978, a total of 135 samples were taken. Laboratory processing of these samples is nearly complete and has taken up a substantial amount of time. Table 2 summarizes the findings for

TABLE 2 Summary of invertebrate densities (N/m^2) oil the two Bagnor sites from December 1977 to December 1978

SHADED SITE

SUBSTRATUM	DECEMBER 1977	JUNE 1978	DECEMBER 1978	5 YEAR MEAN 1971-1975	JUNE 1976
GRAVEL	15720	8900	21220	11760	59660
SILT	15640	14040	27860	11760	157060
RANUNCULUS	N.S.	46080	N.S.	31340	180120
BERULA	42520	35540	43880*	35000	182120
CALLITRICHE	37800	36860	67120	42140	88560

UNSHADED SITE

SUBSTRATUM	DECEMBER 1977	JUNE 1978	DECEMBER 1978	5 YEAR MEAN 1971-1975	JUNE 1976
GRAVEL	10820	7060	24080	18690	41480
SILT	7400	3400	31540	19480	48360
RANUNCULUS	50680	50760	68880	36880	194640
BERULA	36220	N.S.	62200	45140	175400
CALLITRICHE	47520	32500	80620*	42949	39040

N.S. No samples taken

* four sample mean since some samples remain to be processed

the period December 1977 to December 1978. To place these figures in perspective the five-year mean for 1971 to 1975 inclusive and the mean for June 1976 (the period of peak densities) are also given. The densities for December 1977 and June 1978 are similar to the five-year means and the river seems to have returned to normal quite quickly after the drought of 1976. The figures for December 1978 appear a little higher than average and suggest that an increase in population densities may be occurring. It will be interesting to see if this trend is continued in the June 1979 samples.

The Mann-Whitney U test has been applied to the Bagnor invertebrate data *it* an attempt to give some statistical basis to conclusions drawn from these data. The immediate concern has been to highlight any substratum preferences different invertebrate taxa may have and explore between, site differences. The U test has also been used to test for significant between-year differences in abundance, but this has been hampered by the pooling of samples in 1972 and 1973. The results have not yet been finally collated.

2.1.4 Fish

Electric fishing has been carried out at Bagnor on two occasions to obtain data on the size and age structure of the fish each winter. On 13 February 1978 the catch was 48 brown trout, 6 rainbow trout and 32 grayling and on 15 January 1979 it was 65 brown trout, 13 rainbow trout and 28 grayling. The data will provide a useful comparison with earlier years when more intensive fish studies were carried out. It seems that rainbow trout, presumably from the adjacent fish farm, are now becoming a significant component of the fish community.

2.2 RIVER COM

The study of a limestone stream was started in March 1978 with the. laying out of a site on the River Coln near Fairford and the installation of a thermograph. Monthly mapping of the macrophytes has been carried out and two sets of quantitative invertebrate samples have been taken, one in June 1978 and the, other in December 1978. In addition, a species list of invertebrates has been compiled by sampling for five minutes with a pond net each month.

2.2.1 Macrophytes

The Macrophyte programme will continue until August 1979 when two seasons' growth will have been documented. In March 1979 a flood occurred and mapping could not be carried out. The flood also submerged - the thermograph and two months' temperature records are missing. The mapping has shown that Ranunculus is the dominant macrophyte, with the cover of the other species present always totalling less than 5%. The most common species after *Ranunculus penicillatus* var. *calcaneus* are *Callitriche* sp., *Fontinalis antipyretica, Rorippa nasturtium-aquaticum, Veronica beccabunga, Myosotis scorpioides* and *Mentha aquatica.* The pattern of *Ranunculus* growth at Fairford is similar to that at Bagnor although in 1978 peak cover (62%) occurred one month later at Fairford, in July.

2.2.2 Invertebrates

The quantitative invertebrate programme is now complete. Ranunculus and gravel were the only two extensive substrata and consequently only these were sampled. In both June and December 1978 there were slightly higher mean densities of animals on gravel than *Ranunculus,* and on both substrata December densities were about twice those found in June (Table 3). This situation is largely due to the preponderance of *Potamopyrgus jenkinsi* in gravel samples and its larger populations in December. When tested with the Mann-Whitney U test these differences were not significant, due to the very large between sample variation.

TABLE 3 Invertebrate densities (N/m^2) on the River Coln site.

	June 1978	December 1978
RANUNCULUS	39800	96460
GRAVEL	53560	111080

A comparison of the Fairford samples with each other, and with the Bagnor samples taken at the same time, has been started but the comparison with Bagnor has been restricted to June samples as December ones are not completely processed. Table 4, presents information on the mean number of individuals and the means for three calculated indices: taxon richness, exponential H' and evenness. The five sample medians for these have been tested with the Mann-Whitney U test.

TABLE 4 Community indices for the Fairford and Bagnor sites. The figures are means per sample based on five samples.

			No. Taxa	No. Individuals	Taxon Richness	Exp H'	Evenness
Fairford	*RANUNCULUS*	June	27.4	1989.6	3.51	9.58	0.67
"	"	Dec.	30.6	4823.0	3.65	8.29	0.60
"	GRAVEL	June	25.0	2678.0	3.08	7.31	0.61
"	"	Dec.	30.8	5554.0	3.63	4.55	0.39
Bagnor Shaded	*RAN.*	June	22.8	2304.4	2.96	7.29	0.61
"	" GRAV.	"	24.6	445.2	3.91	10.86	0.74
Bagnor Unshaded	*RAN.*	June	21.8	2537.6	2.75	5.41	0.49
"	" GRAV.	"	23.6	352.8	3.85	10.08	0.73

In June taxon richness on *Ranunculus* was significantly greater than on gravel, but in December there were no significant differences between the substrata. *Ranunculus* showed no significant differences between June and December but on gravel both the number of taxa and taxon richness were greater in June than December. The comparison between Fairford and Bagnor showed some interesting but slightly unexpected differences. When considering gravel, on both Bagnor sites, the densities of individuals were significantly higher at Fairford, but exponential H', taxon richness and evenness were all significantly greater at Bagnor. On *Ranunculus,* densities were similar, but the number of taxa, exponential H' and taxon richness were all significantly greater at fairford. This reversal may, in part be understood by reference to the diversity index exponential H'. This is a dominance index and reflects the trends of the most abundant taxa. *P.jenkinsi* is the most abundant species at Fairford and is especially abundant on gravel. It was not abundant at Bagnor in June 1978. The higher densities of *P.jenkinsi* at Fairford would depress both exponential H' and evenness, although, of course, it would not affect taxon richness.

Clearly, *Ranunculus* at Fairford in June supports a richer community than at Bagnor. The qualitative data tend to support this as some species guilds appear' slightly richer at the Fairford site than at the Bagnor sites gastropods (Bagnor 12 spp., Fairford 17 spp.), *Caenis* (Bagnor 1 sp., Fairford 3 spp.), *Leuctra* (Bagnor 1 sp., Fairford 2 spp.), *Sialis* (Bagnor 1 sp., Fairford 2 spp.), *Atherix* (Bagnor 0 spp., Fairford 1 sp.). The cumulative effect of these small differences could be quite significant.

The qualitative invertebrate programme will be completed in August 1979. To date, 133 taxa have been identified, 113 of these being at species' level. For comparison with the comparative chalk stream survey, the taxa found in the March sample have been included in Table 6 later in the report.

2.3 COMPARATIVE SURVEY OF CHALK STREAMS

2.3.1 Sampling strategy

An investigation into the utility of taking invertebrate samples with a pond net for obtaining species lists was undertaken, mostly using data collected in the 1972 Winterbourne survey and the 1976-77 Lambourn survey.

Sampling with a pond net is often carried out on a timed basis, but this may not necessarily be the optimum way of taking a sample. A series of five, three-minute samples and a series of five samples which each covered a five-metre strip of" river bed the width of the pond net, were taken. The latter type of sample yielded *9%* more species, both in terms of the average number of species per sample and the total number of species in five samples. Furthermore, although the operator was allowed. to sample the strip of river bed as fully as was felt necessary, the 'strip' samples were taken in less time. A larger area was covered in timed samples but less species were produced, suggesting that these took a less intensive and less efficient sample. The "strip' samples were more variable than the timed samples in terms of the number of species per sample and so were less desirable from this viewpoint. Clearly, the almost traditional timed sample may not be the best way of using a pond net but more extensive work is required before any method can be recommended.

Table 5 summarizes some of the information available on the use of sample replication when taking samples with a pond net. Since the Winterbourne can be considered to have two sections, one being species rich and the other species poor, information is given for one site in each. These data were calculated using the combinatorial method of Gaufin et *al.* By fitting a logarithmic modal to the data, predicted species increments may be found which would be useful figures to have in an invertebrate survey.

TABLE 5 **The effect of different sources of sample replication on taxon yield using data obtained during the 1972 Winterbourne survey.**

Site	3		3		1-5		7		7		6-10	
Source of Replication	OPERATOR*		MONTH		SITE		OPERATOR*		MONTH		SITE	
No. of Replications	N	%	N	%	N	%	N	%	N	%	N	%
1	40		40		40		24		24		23	
2	52	30	54	37	57	44	32	34	35	48	37	61
3	58	47	62	58	67	69	38	60	42	77	45	95
4	63	58	69	75	74	87	42	79	47	101	51	119
5			74	87	79	101			51	118	55	137
6			78	97					54	130		

N = number of taxa

% = increase in number of taxa as a percentage of the one sample case

* i.e. sample replication at the same site at the same time

Table 5, in which the three sources of replication are independent, reveals that for a given number of samples, the maximum taxon yield results from site replication, even though on the Winterbourne the sites are as close as 0.5 km. Replication by month or operator (sample) also gives marked increases in taxon yield over the one sample case. Increasing the number of sites rapidly increases environmental heterogeneity and hence the size of the species pool, whereas sampling on a series of different dates only increases the species pool by those taxa which show marked seasonality of occurrence (such species are few in the Winterbourne). Increasing the number of samples taken on one date includes neither of these components.

Replication by date,, or by samples taken on a particular date enables more complete species lists to be derived for individual sites, allowing better interpretation of distributional trends in the fauna. In consequence, whilst replication by site may optimize the construction of species lists (and hence faunal classification) for whole rivers, or river zones, replication at individual sites is necessary if sites or species are to be the functional units of study.

2,3.2 Rivers Test, Itchen and Meon

Several days were spent looking at potential sites for the survey of these rivers. Finally 10 sites on the chalk section of the Test, 8 on the Itchen and 7 on the Meon were chosen for study. Four sites on the Itchen from Chilland to Eastleigh are also being studied by the River Communities Project at the River Laboratory and this will provide a useful comparison of the results obtained by two different sampling programmes. Access to the sites was negotiated and in general owners and tenants have been very helpful and friendly. Only one riparian owner on the Meon refused access and the 'spare site' was redeployed in the winter-'bourne section of the Test.

As a result of the assessment of sampling methods described above a sampling programme was selected which involves taking two, five-minute samples with a pond net at each site, in alternate months, for a year. Samples are also being taken from the Lambourn at Bagnor and the Coln at Fairford to compare these well-documented sites with the others.

The first samples were taken in March 1979 and a total of 150 taxa have been identified. The results for this series of samples are given in Table 6. The species recorded so far are those commonly found in chalk streams in the previous surveys, although some differences from the Lambourn have already been noted, The record of *Bdellocephala, punctata* from the Itchen is interesting as this is a local species, often scarce and generally recorded from lakes. It has not been found in the Lambourn. *Potamothrix hammoniensis, Batrachobdella paludosa, Erpobdella testacea, Glossiphonia heterocita, Bithynia leachii, Planorbis crista, Agrion splendens,* Plecoptera spp. and *Aphelocheirus montadohi* are all species that have been recorded rarely or never from the Lambourn. In some cases, such as *A.montadoni* and *P.hammoniensis,* the reason for this is probably that they are characteristic of larger chalk rivers, whilst *P.crista* is a pond and ditch species.

Species lists of macrophytes will be obtained by Visiting each site once in both late spring and late summer. Flowering times of *Ranunculus* will be followed by making flower counts at each site three times during the flowering period; a photographic record will be made of each site at each visit.

TABLE 6 Species of invertebrates collected from each

	RIVER LAMBOURN	RIVER TEST										
	BAGNOR	WINTERBOURNE	QUIDHAMPTON	LYNCH	FREEFOLK PRIORS	WHITCHURCH	MIDDLETON	WHERWELL PRIORY	LONGSTOCK	HOUGHTON FORD	LOWER BROOK	MOTTISFONT
Bdellocephala punctata												
Dendrocoelum lacteum								+	+			
Planarian sp.				+								
Polycelis sp.												
Polycelis felina						+						
Polycelis nigra				+							+	
Polycelis tenuis				+					+	+		
Acanthocephala	+				+	+		+		+	+	
Nematoda		+	+	+	+	+	+	+		+		
Eiseniella tetraedra												
Enchytraeaidae		+										
Haplotaxis gordioides	+				+							
Limnodrilus claparedianus												
Limnodrilus hoffmeisteri				+			+	+			+	
Lumbriculus variegatus			+	+	+			+	+	+	+	+
Peloscolex ferox					+					+		
Potamothrix hammoniensis				+			+				+	+
Psammoryctides barbatus	+			+	+	+	+	+	+		+	+
Rhyacodrilus coccineus											+	
Stylodrilus heringianus				+	+	+		+	+	+	+	+
Tubifex ignotus												
Tubifex tubifex		+		+					+			+
Batrachobdella paludosa										+		
Erpobdella octoculata	+	+	+	+	+	+	+	+	+	+	+	
Erpobdella testacea				+								
Glossiphonia complanata			+	+	+	+		+		+		
Glossiphonia heteroclita					+							
Haemopis sanguisuga												
Helobdella stagnalis	+		+	+	+	+	+	+			+	
Hemiclepsis marginata				+								
Piscicola geometra	+		+		+			+	+	+	+	+
Theromyzon tessulatum	+										+	
Bithynia leachii											+	
Bithynia tentaculata	+							+		+	+	+
Potamopyrgus jenkinsi	+							+				+
Theodoxus fluviatilis									+	+	+	+
Valvata cristata		+	+		+						+	
Valvata macrostoma			+									
Valvata piscinalis			+	+		+				+		+
Ancylus fluviatilis	+								+	+		
Lymnaea palustris	+		+									
Lymnaea peregra		+	+						+	+		

site during **the** comparative survey in March 1979

	RIVER MEON						RIVER ITCHEN								RIVER COLN
	SOUTH FARM	EAST END	MEON STOKE	MISLINGFORD	GREAT FUNTLEY FARM	CROFTON HOUSE	HINTON MARSH	CHERITON MILL	OVINGTON	CHILLAND	WINCHESTER	TWYFORD	EASTLEIGH	SWAYTHLING	FAIRFORD
Bdellocephala punctata									+						
Dendrocoelum lacteum															
Planarian sp.															
Polycelis sp.					+										
Polycelis felina															
Polycelis nigra								+						+	
Polycelis tenuis							+		+					+	
Acanthocephala		+	+	+				+				+			
Nematoda	+					+	+		+	+	+	+	+		+
Eiseniella tetraedra							+					+			
Enchytreaidae						+									
Haplotaxis gordioides											+				
Limnodrilus claparedianus						+									
Limnodrilus hoffmeisteri					+	+		+						+	
Lumbriculus variegatus		+	+	+		+		+	+	+		+	+		
Peloscolex ferox									+						
Potamothrix hammoniensis						+								+	
Psammoryctides barbatus	+		+	+				+	+	+	+				+
Rhyacodrilus coccineus	+		+	+									+		
Stylodrilus heringianus	+	+	+	+		+	+	+	+	+	+	+	+		+
Tubifex ignotus													+		
Tubifex tubifex	+			+	+	+									
Batrachobdella paludosa															
Erpobdella octoculata				+	+		+	+	+	+	+	+	+	+	
Erpobdella testacea				+											
Glossiphonia complanata	+	+	+	+	+		+	+	+	+	+	+			+
Glossiphonia heteroclita															
Haemopis sanguisuga				+											
Helobdella stagnalis				+				+	+	+	+	+		+	
Hemiclepsis marginata															
Piscicola geometra			+	+	+			+	+		+	+		+	
Theromyzon tessulatum								+		+		+			
Bithynia leachii															
Bithynia tentaculata						+							+	+	
Potamopyrgus jenkinsi					+	+				+	+	+	+		+
Theodoxus fluviatilis													+	+	
Valvata cristata								+					+		
Valvata macrostoma															+
Valvata piscinalis					+			+	+		+			+	+
Ancylus fluviatilis									+		+		+		
Lymnaea palustris	+						+								
Lymnaea peregra						+	+		+						

	RIVER LAMBOURN	RIVER TEST										
	BAGNOR	WINTERBOURNE	QUIDHAMTPON	LYNCH	FREEFOLK PRIORS	WHITCHURCH	MIDDLETON	WHERWELL PRIORY	LONGSTOCK	HOUGHTON FORD	LOWER BROOK	MOTTISFONT
Physa fontinalis	+		+		+	+		+	+	+	+	+
Planorbis albus			+	+	+							
Planorbis carinatus			+			+						
Planorbis contortus	+		+		+	+		+				
Planorbis leucostoma		+										
Planorbis vortex	+		+		+	+		+		+		+
Planorbis crista												
Sphaeriidae												
Pisidium amnicum												
Pisidium casertanum				+					+	+		+
Pisidium milium												+
Pisidium nitidum				+	+			+	+		+	+
Pisidium personatum											+	
Pisidium subtruncatum				+		+	+	+		+		+
Sphaerium corneum									+	+	+	+
Asellus aquaticus	+		+	+	+	+	+	+	+	+	+	+
Asellus meridianus			+	+	+	+		+				
Cyclopoid copepod												
Crangonyx pseudogracilis												
Gammarus pulex	+	+	+	+	+	+	+	+	+	+	+	+
Niphargus aquilex		+										
Ostracoda	+	+	+	+	+	+	+	+	+		+	
Baetis muticus							+	+				
Baetis niger												
Baetis vernus												+
Baetis rhodani	+		+	+	+	+	+	+	+	+	+	+
Caenis sp.												
Caenis macrura												
Caenis moesta							+			+	+	+
Caenis rivulorum					+	+						
Centroptilum luteolum												+
Ephemera danica	+							+	+	+	+	+
Ephemerella ignita			+		+		+	+				
Heptagenia sulphurea	+					+	+	+		+	+	
Paraleptophlebia submarginata	+										+	+
Sialis lutaria					+			+			+	+
Agrion splendens												
Hydracarina	+		+	+	+	+	+	+		+	+	+
Isoperla grammatica										+	+	+
Nemoura cambrica												
Nemurella picteti			+		+							
Perlodes microcephala											+	
Adicella reducta									+			
Agapetus fuscipes	+		+		+	+	+	+	+	+	+	
Agapetus ochripes			+					+	+	+	+	+
Anabolia nervosa												+

	RIVER MEON						RIVER ITCHEN								RIVER COLN
	SOUTH FARM	EAST END	MEON STOKE	MISLINGFORD	GREAT FUNTLEY FARM	CROFTON HOUSE	HINTON MARSH	CHERITON MILL	OVINGTON	CHILLAND	WINCHESTER	TWYFORD	EASTLEIGH	SWAYTHLING	FAIRFORD
Physa fontinalis					+	+		+	+	+	+	+	+	+	
Planorbis albus						+					+				
Planorbis carinatus															
Planorbis contortus								+	+						
Planorbis leucostoma							+								
Planorbis vortex	+	+		+				+	+	+	+				
Planorbis crista	+														
Sphaeriidae								+							
Pisidium amnicum														+	
Pisidium casertanum	+	+	+	+	+	+				+	+	+		+	
Pisidium milium				+											
Pisidium nitidum				+											
Pisidium personatum							+								
Pisidium subtruncatum	+			+		+			+		+	+	+	+	
Sphaerium corneum			+										+		
Asellus aquaticus	+	+	+		+	+		+	+	+	+	+	+	+	
Asellus meridianus					+								+	+	
Cyclopoid copepod	+														
Crangonyx pseudogracilis						+									
Gammarus pulex		+	+	+	+	+	+	+	+	+	+	+	+	+	+
Niphargus aquilex							+								
Ostracoda	+	+		+		+		+	+		+		+	+	
Baetis muticus													+		
Baetis niger									+			+		+	
Baetis vernus												+			
Baetis rhodani	+		+	+		+			+	+	+	+	+	+	+
Caenis sp.								?							
Caenis macrura													+		
Caenis moesta														+	
Caenis rivulorum									+		+				+
Centroptilum luteolum						+			+					+	
Ephemera danica				+	+					+		+			+
Ephemerella ignita			+					+	+	+	+	+			+
Heptagenia sulphurea			+	+	(+				+	+	+	+			+
Paraleptophlebia submarginata					+				+	+				+	
Sialis lutaria					+	+			+	+				+	
Agrion splendens					+	+								+	
Hydracarina		+	+	+	+	+		+	+	+	+	+	+	+	+
Isoperla grammatica											+	+	+		
Nemoura cambrica					+										
Nemurella picteti									+						
Perlodes microcephala															
Adicella reducta															
Agapetus fuscipes			+	+	+			+	+	+	+	+	+		
Agapetus ochripes					+				+			+			
Anabolia nervosa														+	

	RIVER LAMBOURN	RIVER TEST										
	BAGNOR	WINTERBOURNE	QUIDHAMPTON	LYNCH	FREEFOLK PRIORS	WHITCHURCH	MIDDLETON	WHERWELL PRIORY	LONGSTOCK	HOUGHTON FORD	LOWER BROOK	MOTTISFONT
Athripsodes 'bilineatus' type						+		+				
Athripsodes cinereus	+			+								+
Brachycentrus subnubilus												+
Drusus annulatus	+		+			+		+	+		+	+
Goera pilosa								+	+			+
Halesus sp.	+							+		+	+	+
Hydropsyche pellucidula										+	+	
Hydropsyche siltalai	+					+	+	+		+	+	
Hydroptila sp.			+									
Ithytrichia sp.	+						+	+	+			
Ithytrichia lamellaris										+		
Lepidostoma hirtum	+				+		+	+	+	+	+	
Limnephilus extricatus												
Limnephilus lunatus	+	+	+	+	+		+	+	+	+	+	+
Limnephilus rhombicus												
Melampophylax mucoreus			+		+	+		+		+		+
Metalype fragilis							+					
Molanna angustata												+
Mystacides sp.											+	
Mystacides azurea					+							
Notidobia ciliaris												
Odontocerum albicorne						+	+	+	+	+		+
Oxyethira sp.			+									
Polycentropus flavomaculatus					+					+	+	+
Potamophylax - Chaetopteryx sp.	+				+	+			+	+	+	+
Rhyacophila dorsalis	+					+	+	+	+	+	+	
Sericostoma personatum	+				+	+		+		+	+	+
Silò nigricornis	+		+		+		+		+	+		+
Anacaena sp.												
Agabus paludosus			+									
Brychius elevatus		+										
Deronectes elegans				+							+	+
Dryopidae		+										
Elmis aenea	+		+		+	+	+	+	+	+	+	+
Haliplus sp.		+	+									
Haliplus lineatocollis			+									
Helophorus aquaticus												
Limnius volckmari	+		+			+	+	+	+	+	+	+
Orectochilus villosus					+	+		+				
Oulimnius tuberculatus										+	+	
Oreodytes sanmarki	+											
Platambus maculatus												
Riolus subviolaceus								+			+	
Aphelocheirus montandoni									+			
Callicorixa praeusta												

	RIVER MEON						RIVER ITCHEN								RIVER COLN
	SOUTH FARM	EAST END	MEON STOKE	MISLINGFORD	GREAT FUNTLEY FARM	CROFTON HOUSE	HINTON MARSH	CHERITON MILL	OVINGTON	CHILLAND	WINCHESTER	TWYFORD	EASTLEIGH	SWAYTHLING	FAIRFORD
Athripsodes 'bilineatus' type									+						+
Athripsodes cinereus												+	+	+	
Brachycentrus subnubilus													+		
Drusus annulatus			+	+	+		+	+	+	+					
Goera pilosa															
Halesus sp.				+	+				+	+		+		+	
Hydropsyche pellucidula					+					+		+	+	+	+
Hydropsyche siltalai			+		+				+	+	+	+	+	+	+
Hydroptila sp.												+			+
Ithytrichia sp.			+						+	+	+	+		+	
Ithytrichia lamellaris															
Lepidostoma hirtum					+				+	+		+			
Limnephilus extricatus					+	+									
Limnephilus lunatus		+	+	+		+	+	+	+	+		+		+	
Limnephilus rhombicus					+	+									
Melampophylax mucoreus									+		+				
Metalype fragilis															
Molanna angustata															
Mystacides sp.						+									
Mystacides azurea											+				
Notidobia ciliaris			+												
Odontocerum albicorne			+	+					+	+	+		+		+
Oxyethira sp.									+						
Polycentropus flavomaculatus												+		+	
Potamophylax - Chaetopteryx sp.			+	+	+				+	+	+	+	+		+
Rhyacophila dorsalis				+					+	+	+		+	+	+
Sericostoma personatum			+	+					+	+	+	+	+		
Silo nigricornis				+				+	+	+	+	+			+
Anacaena sp.								+							
Agabus paludosus															
Brychius elevatus					+										+
Deronectes elegans					+	+								+	
Dryopidae															
Elmis aenea		+	+	+	+	+	+	+	+	+	+	+	+	+	+
Haliplus sp.						+									
Haliplus lineatocollis					+										
Helophorus aquaticus						+									
Limnius volckmari		+	+	+	+					+	+	+	+	+	+
Orectochilus villosus					+				+				+		+
Oulimnius tuberculatus						+								+	
Oreodytes sanmarki									+						
Platambus maculatus									+						
Riolus subviolaceus												+			
Aphelocheirus montandoni													+		
Callicorixa praeusta						+									

	RIVER LAMBOURN	RIVER TEST										
	BAGNOR	WINTERBOURNE	QUIDHAMPTON	LYNCH	FREEFOLK PRIORS	WHITCHURCH	MIDDLEHAMPTON	WHERWELL PRIORY	LONGSTOCK	HOUGHTON FORD	LOWER BROOK	MOTTISFONT
Corixidae nymph									+			+
Hesperocorixa sahlbergi												
Sigara dorsalis												
Sigara falleni												
Sigara venusta												+
Atherix ibis												
Ceratopogonidae	+	+	+	+	+	+	+	+	+	+	+	+
Chironomidae	+	+	+	+	+	+	+	+	+	+	+	+
Apsectrotanypus trifascipennis					+		+			+	+	
Prodiamesa olivacea				+	+	+	+	+			+	
Empididae											+	
Limnophora sp.				+							+	
Psychodidae			+					+				+
Simulium equinum										+	+	+
Simulium lineatum												
Simulium ornatum			+		+	+	+	+	+	+	+	
Simulium vernum			+									
Simulium lundstromi				+	+	+	+			+	+	
Stratiomyidae		+										
Tabanidae												
Tipulidae sp.		+						+				
Tipula montium												
Dicranota sp.			+			+	+	+		+		
Pilaria filata	+											
Totals	41	18	43	33	45	40	34	54	39	54	58	52
River Totals		123										

Grand Total 150

	RIVER MEON						RIVER ITCHEN								RIVER COLN
	SOUTH FARM	EAST END	MEON STOKE	MISLINGFORD	GREAT FUNTLEY FARM	CROFTON HOUSE	HINTON MARSH	CHERITON MILL	OVINGTON	CHILLAND	WINCHESTER	TWYFORD	EASTLEIGH	SWAYTHLING	FAIRFORD
Corixidae nymph						+			+						
Hesperocorixa sahlbergi														+	
Sigara dorsalis						+								+	
Sigara falleni						+								+	
Sigara venusta															
Atherix ibis															+
Ceratopogonidae	+	+		+	+	+	+	+	+	+	+	+	+	+	+
Chironomidae	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Apsectrotanypus trifascipennis					+	+		+	+		+				
Prodiamesa olivacea					+	+			+		+				
Empididae															
Limnophora sp.															
Psychodidae	+	+					+								
Simulium equinum			+									+	+	+	
Simulium lineatum													+		
Simulium ornatum			+	+	+		+	+	+	+	+	+	+	+	+
Simulium vernum															
Simulium lundstromi			+	+					+	+		+			
Stratiomyidae					+		+								
Tabanidae						+									
Tipulidae sp.						+	+		+						+
Tipula montium															+
Dicranota sp.		+	+	+	+			+	+		+	+			+
Pilaria filata															
Totals	19	18	32	39	43	43	21	34	60	40	43	43	41	46	30
River Totals	92						111								

3. COMPUTING

3.1 GENERAL

Computing at the River Laboratory may be carried out on two systems, the remote 1CL 4-70 at UKAEA Winfrith, or on in-house Olivetti P6060 minicomputers. In the case of the former, large data sets may be readily manipulated and run times are short, but access and Job Control relatively complex. The in-house facilities provide simple job entry but restricted machine size can cause programming problems and long run times. The most economical solution is to use the in-house facilities wherever possible, and only use Winfrith where their facilities are desirable, or where it is easier to adapt an imported package to work on their hardware. Jobs with long run times can be run overnight on the in-house facilities.

The use of these facilities has necessitated the development of several types of program. Firstly, a series of interfacing programs has had to be written in order to actually input data on paper tape, to exchange data between the P6060S and the ICL 4-70, and to obtain permanent printed output. Programs were then developed in order to establish a data-base containing all the data the project has accumulated, but in standard format. This has had to be broadly split into three compartments: quantitative invertebrate data, qualitative invertebrate data and macrophyte data. Once the data-bases were established, programs were needed to provide summary statistics (totals, means, confidence limits, maps, transition matrices, etc.). Programs to carry out standard statistical tests were then required. The information obtained from these programs then guided the development of programs for specific, specialized analyses or the import of more complex programs for specific purposes. Detailed below are summaries of some aspects of the programs that have been developed,

3.2 DATA HANDLING PROGRAMS

3.2.1 Interfacing programs

Because of the hardware configuration it has been necessary to develop a series of programs to interface the P6060s to other equipment. Examples include interfacing to the IGL 4-70 at Winfrith via telephone connections, mainly for the exchange of data files, to paper tape devices for tape production and the inputting of tapes produced off-line, and connection to a remote printer for high quality printed output. With minor modifications these programs can function with magnetic tape peripherals and VDUs available at the laboratory.

3.2.2 Data-bases

Careful design was necessary for the establishment of data-bases for the P6060s to provide ready access to stored data whilst avoiding excessive core utilization and run times. Programs were required to input,, edit, check and output the data from files and to provide hard copy output of selected items of data on demand.

a) Bagnor and comparative quantitative studies: Since it may be desirable to compare any set of these samples with any other, a standard format was chosen for all these data. The samples were always taken as sets of 5 replicates, and following the conventions established within the project, counts for 72 selected taxa are incorporated. In addition, each file is provided with a security code, the column totals (= no individuals/sample) and a hash total to check against file corruption. An additional file contains the taxon names for tabulated output.

b) Qualitative files: Qualitative surveys have been carried out on 3 rivers (2 occasions at the Bagnor Winterbourne) and are currently in progress on 3 more. These files can only contain presence/absence records and the most efficient means of storage is as string characters; the P6060 having extremely good character handling facilities. Each record in each file contains the taxon name followed by a series of characters indicating presence or absence in each sample taken. Programs are also available for producing summaries of these files for output or preparation for more complex analysis as required.

c) Macrophytes: Information from the monthly mapping program is stored in standard format in data files for use on the ICL 4-70.

3.3 SUMMARY PROGRAMS

3.3.1 Macrophyte general program

This was developed to process the monthly macrophyte maps obtained at the two Bagnor sites and at the River Coln and is run on the ICL 4-70. The program calculates the percentage cover of each habitat type and has the option of printing a map of the dominant sub-strata for the site. A comparison with the previous month's map is made to calculate changes that have occurred on the site. These are printed put in tabular form and a recent modification calculates a summary of these transitions. When measurements of sediment depth and current speed were taken on the shaded site, the program was amended to produce print out of the values of sediment depth and current speed where *Berula* had ripped-out, and for comparison those values where the *Berala* bed had remained stable.

3.3.2 Sample summaries

Quantitative data files can be output to the remote printer in a summarized form, containing both actual counts, arithmetically and logarithmically derived means and confidence intervals for each taxon. Qualitative data files can be summarized by the output of presence/ absence of the whole file, selected sites, months or operators. In addition, it is possible to bulk samples in any of these combinations and output the frequencies of occurrence. In all these cases it is possible to store the summarized data for further analysis.

3.4 STANDARD STATISTICAL PROGRAMS

A number of statistical programs are commonly needed for routine analyses: for comparing data sets (U-test, ANOVA) and correlating between variables (Spearman Rank Correlation and linear regression). Where possible, non-parametric methods have been used to avoid problems of non-normality of data.

3.4.1 Mann-Whitney U Test

This is a very powerful non-parametric approximation to a 't' test, but use of the U statistic avoids the necessity of performing transformations to normalize data; a common problem with quantitative ecological data. A series of programs have been developed culminating in the current version which is designed for analysis of the quantitative data files, or other files constructed in a broadly similar manner. Long series of analyses can be entered to the program for extended overnight runs. Tables of U values and data summaries are output direct to a remote high quality printer. Analyses are performed for each taxon in each file using the 5 sample counts as replicates,

3.4.2 Spearman lank Correlation

Correlation matrices are useful as inputs to multivariate analyses, and as an analysis in their own right. Again, in order to avoid problems with non-normality of data, a powerful non-parametric test was chosen in preference to an equivalent parametric correlation coefficient. The correlation matrix is produced from a standard multivariate data file and can be stored for further analysis or output to printer, or both.

3.4.3 ANOVA

Several programs are available to produce analysis of variance tables from general multivariate data files. It is often necessary to use a logarithmic transformation to normalise data for analysis. The most commonly used analyses are 2-way ANOVA with replicates and 3-way ANOVA without replicates. To avoid problems of transformation a program which performs the non-parametric Friedman 2-way ANOVA is available.

3.4.4 Linear regression

A general purpose linear regression program has been developed outputting both regression parameters and those necessary for comparison of regression lines. Since this method requires normality of data, facilities are provided for transformations (particularly logarithmic) during the analysis. The plotting option available on the P6060 has not yet been implemented in this package due to lack of demand. Other regression programs available at the laboratory have this facility.

3.5 SPECIALIZED PROGRAMS

Large data sets are difficult to comprehend without the use of a model to re-organize, reduce and summarize the data. Cluster analysis and reciprocal averaging are two methods that have been used for this purpose, primarily on the survey data obtained from studying the River Lambourn and its tributary, the Winterbourne. Both techniques suffer from disadvantages and to try and overcome these, programs for tabular analysis and non-metric multi-dimensional scaling have been imported.

The uses to which other specialized programs are being put are described in the relevant section.

3.5.1 Species accretions

A suite of programs has been developed to produce species accretion curves using the method of Gaufin *at al.* (1956) for selected subset® of sites/operators/dates from the qualitative type data files. This technique uses a combinatorial method to calculate the most likely number of taxa in a given number of samples. It is possible to use the technique to predict the probable number of species in more samples than have actually been taken.

This package has been used in the analysis of information on sampling programs for chalk streams and has been most useful in studying the effects of replicating samples.

3.5.2 Diversity package

Diversity measures have been increasingly used to describe community structure despite controversy over their utility. Two programs are available. The first computes several commonly used measures *vizi* Simpson's Index, the reciprocal of Simpson's Index, the Shannon-Wiener Index (H')and its variance, exponential H', Hill's Ratio, species richness, evenness and the summary statistics; number of species per sample and number of individuals per sample. Two standard format quantitative data files are used as input and the. program also computes the between file Mann-Whitney U-statistic for each index. This can be used to test the significance of between file differences. The second program is for use with data obtained over a series of sampling events but where only one sample has been taken on each occasion. The Shannon-Wiener Index is calculated using natural logarithms (H') or logarithms to base 2 (H_2'). The variance of H' is also computed and used as the basis for a 't' test of significance of between event differences. If two series of data are available, the program will also compute 't' values for between series comparisons.

3.5.3 Reciprocal averaging

A limited scale program is now available to perform this promising multivariate analysis on relatively small data files. The technique has advantages over many other multivariate techniques both in its performance and by providing a scaling for both sets and records in a single analysis. It is unfortunately a technique requiring the handling of relatively large matrices and, if extended on the P6060, would become very time-consuming since these matrices would have to be stored between manipulations, rather than retaining them in core. In view of this, it may be preferable to transfer this to the ICL 4-70 if a version for larger data sets is required.

3.5.4 CLUST

This is the largest package developed to date and, although fully functional, is still undergoing development and improvement. The technique of cluster analysis provides a realistic and readily assimilable interpretation of many of the data sets encountered, although none of the multivariate techniques evaluated to date provides an adequate representation in all instances.

CLUST can accept data in matrix format from either standard format quantitative data files or from standard multivariate data files and produces an association matrix and dendrogram diagram on either the P6060 integral printer or the remote high quality printer. It is capable of reversing data matrices and transforming the data logarithmically. Two association measures are currently available (Czekanowski and Euclidean metric) and 3 clustering methods (Group Average, Nearest Neighbour and Furthest Neighbour). Facilities are also available for inputting set names to provide a fully finished output. Current developments will incorporate a binary transformation, other association measures (including Jaccard, Canberra metric) and Lance & Williams flexible clustering, as well as a simplified and more flexible job control input. Furthermore, it will be substantially easier to incorporate additional methods as required. Although run time can be considerable, the program is capable of handling relatively large data matrices, containing up to 100 sets of data, each containing up to several hundred parameters.

3.5.5 Stability of weed-beds

The factors controlling the growth and recession of *Berula* on the shaded site are uncertain and in an attempt to assess whether a time factor was important in the system a program was developed to calculate hoy long Berula remained in the river.

Starting with March 1971, the map for this month is compared with the map for each subsequent month, so that initially the number of squares which remained *Berula* dominated between March 1971 and April 1971 are calculated. Only these squares are then compared with May 1971 and the number of squares remaining *Berula* dominated calculated. This is expressed as a percentage of the area of Berula in the starting month. The process is repeated until there are no squares of *Berula* remaining and a new starting month is then selected. By interpolation, the time taken to reach e.g. 50% removal of the Berula bed from any starting point can be calculated and the program evaluates the percentile points by interpolation from 95% to 0% at 5% intervals.

Although this program was originally designed for *Berula* it has been easily modified to calculate stability of Ranunculus and *Callitriche* beds.

3.5.6 Spectral Analysis

Although functional, this program is not yet complete and it is hoped that further sections will be added in the future. Spectral analysis is a technique capable of detecting periodicity in data and has been used in an attempt to understand the pattern of changes shown by Berula on the shaded site.

The program calculates the periodogram for different frequencies and prints these and the mean square values for the periodogram at each frequency. The cumulative periodogram is then plotted with the appropriate 95% confidence limits.

3.5.7 Tabular Analysis

The program of Ceska and Roemer has been modified slightly to enable it to run on the ICL 4-70 computer. Using a simple percent similarity measure this program simultaneously performs normal (grouping of sites) and inverse (grouping of species) analyses on a species site matrix. It is therefore useful for a preliminary sorting of' large amounts of data and quickly focuses attention on between site similarities and those species important for site groupings. The degree of similarity required for inclusion in a group can be altered and by successively increasing the stringency of these rules some insight into community structure can be obtained.

This program has been used in the analysis of data from the River Coln and the Lambourn longitudinal survey and is likely to prove most useful in the preliminary analysis of data from the current com-parat'ive survey of chalk streams.

3.5.8 Non-metric multidimensional scaling

It is well established that most ordination methods produce curvilinear distortions of environmental gradients due to the assumptions inherent in the models used. These distortions commonly lead to mis-interpretation of the resulting ordinations. Non-metric multidimensional scaling overcomes many of these problems as it assumes only a monotonic increasing relationship between inter-sample ordination distance. To perform this type of analysis Kruskal's program M-D-SCAL version 5 MS has been imported. This is a large, complex program and besides the above analysis it can also perform metric multidimensional scaling, metric and non-metric unfolding and polynomial regression. After some modi-fication it is now running on the ICL 4-70 but is still being debugged.

It is hoped this program will be of use in the analysis of invertebrate data from Bagnor and of information from the current com-parative survey of chalk streams.

4. ANALYSIS OF DATA AND PRESENTATION OF RESULTS

4.1 GENERAL

The analytical techniques described in the previous section are being applied to the data that have been gathered during the project. The mapping and sampling techniques worked out in the early stages of the project and modified by subsequent experience have been fully described. The results obtained in the first phase of the project have been analysed in detail and attention has also been concentrated on the longitudinal surveys carried out previously so that the results could be used for planning the strategy of the current surveys of the Test, Itchen and Meon.

Nine manuscripts have been completely written so far and several more are in earlier stages of preparation. Of the nine, one has been submitted and accepted for publication and two more have already been approved by the sponsors. At the other extreme are those which still need substantial modification before reaching these stages. This section continues with abstracts of the nine completed manuscripts which should give a clear impression of the present position with regard to analysing and writing up the data.

4.2 A COMPARISON OF THREE MAPPING PROCEDURES DEVELOPED FOR RIVER MACROPHYTES

Three methods of mapping macrophytes on sites which are being studied intensively are described and compared. Each method involved setting up a temporary 1 metre grid of tapes over the surface of the water whilst mapping. The first method (detailed mapping) generated a map of the macrophytes and substrata but was very time consuming and objectivity in mapping was difficult to achieve despite the development of conventions to describe changes across the river beds, The second method (points method) involved the recording of the macrophyte and substratum below each of the cross-wires of a ! metre grid system covering the entire study site. The method was fast, capable of giving estimates of percentage cover for the different substrata on the river bed and could be used as a basis for the selection of stratified random sampling points for macrophytes and/or invertebrates. However, it did not produce a map of the study area. The third method (rectangles method) was regarded as both the most efficient and also the most objective of the three mapping procedures. The substratum or macrophyte dominating each 50 x 100 cm rectangle of river bed was recorded together with additional substrata/macrophytes present. The procedure was rapid to use in the field, provided a simplified map of the study site and was more amenable to detailed analysis than the two previous methods. All 3 mapping methods are best suited to rivers less than 20 m wide where safe wading and good visibility can be guaranteed.

4.3 THE GROWTH AND RECESSION OF AQUATIC MACROPHYTES ON AN UNSHADED SECTION OF THE RIVER LAMBOURN FROM 1971 TO 1976

A mapping procedure was used to document the growth and recession of the macrophytes in an unshaded section of the Lambourn from March 1971 to December 1976. The physico-chemical variables of the Lambourn are similar to those of other chalk streams and remained stable throughout the study period. The seasonal pattern of change in cover of the five major substrata (*Ranunculus,* gravel, *Berula, Callitriche* and silt) was generally influenced by the annual growth and recession of the dominant macropbyte *Ranunculus. Ranunculus* grew vigorously during the summer and typically covered at least 70% of the site during its summer peak. The increase in area of *Ranunculus* between March and the beginning of June was positively correlated with mean discharge in the river during this period ($r = 0.903$ $p < 0.03$) and it is postulated that discharge is the most important factor controlling growth of *Ranunculus* in the river. Dredging in 1971 resulted in turbid water during the spring and caused very poor growth of *Ranunculus* despite average discharge. This is attributed to deposition of silt on the *Ranunculus* leaves with a concomitant reduction in photosynthesis and production.

Discharge was also important in regulating the deposition of silt within weed beds, with a high accumulation of silt at low discharges and little deposition of silt at high discharge. This could be of importance to the invertebrate community of the river since the type of habitat available for colonisation changes between years. Other factors thought to influence *Ranunculus* growth are water temperature and solar radiation and these have been combined with discharge into a conceptual model which illustrates how growth of *Ranunculus* may be determined. Discharge is considered the most important regulator of *Ranunculus* growth and may act by influencing the rate of cargon uptake and the accumulation of epiphytic photosynthesis and production.

4.4 SEASONAL CHANGES IN THE BIOMASS OF MACROPHYTES ON TWO CONTRASTED CHALK STREAM STUDY SITES

Monthly changes in the biomass of *Ranunculus* spp., *Berula.* erecta and Callitriche spp. are recorded on two 50 *m* study sites between March 1971 and October 1973. Although each Macrophyte occurred on each site *Berula* dominated a site partially shaded by trees whilst *Ranunculus* dominated an unshaded site. Ranunculus showed the most substantial increase in biomass per unit area each summer and a higher maximum biomass was achieved on the unshaded site compared to the shaded site. There was a significant positive relationship between increase in biomass per unit area and increase in total area of Ranunculus on each site in most years. In contrast, Berula and *Callitriche* failed to show a consistent relationship between area of macrophyte and mean biomass. Their strategies for growth did not appear to include substantial phases of increase in both area and density at particular seasons. A comparison of the seasonal growth pattern of each macrophyte on the two sites using regression analysis revealed a highly significant relationship between the growth of *Berula* on each site but no significant relationship in the case of *Callitriche.*

4.5 A NEW SAMPLES FOR STREAM BENTHOS, EPIPHYTIC MACROFAUNA AND AQUATIC MACROPHYTES

A new sampler is described combining the advantages of both box and Surber samplers. The sample area is 200 x 250 mm (0.05 m^2) and the device has been used to sample the benthos of rivers to a depth of approximately 60 mm where the substratum consists of particles with diameters of 50 mm or less. The basic design may be used in water up to 0.5 m in depth, but with an optional top unit this depth may be increased to 1 m. Aquatic Macrophytes can also be sampled either on their own or together.

with the underlying substratum. Results from sampling programmes designed to estimate macrophyte biomass, the biomass of the macro-invertebrate community and the density of *Gammarus pulex* are given as examples of the flexibility of the sampler on a variety of biotopes.

4.6 THE INVERTEBRATE COMMUITIES OF THE RIVER LAMBOURN AT BAGNOR, MARCH 1971 - FEBRUARY 1972

The invertebrate communities at 2 sites on a chalk stream were sampled quantitatively each month for one year. Each site was 50 m in length and one was' partially shaded by trees and dominated by the micro-phyte *Berula erecta,* whereas the other site was in open meadowland and *Ranunculus* spp. was the dominant Macrophyte present.

On each site the lowest mean number of families occurred on silt while gravel typically supported higher numbers of families. The three macrophytes *Berula, Callitriche* and *Ranunculus* each supported still higher numbers of families than the 2 non-macrophyte substrata. Gravel and silt also had lower densities and a lower dry weight biomass of invertebrates than the Macrophytes.

Calculation of crude estimates of total invertebrate biomass for each site gave similar values despite the fact that the two sites were very different in character. In each case there were 2 periods of peak biomass. It is postulated that the lower peak, in May/June was associated with the exploitation of the spring diatom bloom whilst the main peak in November/December reflected exploitation of leaf fall and decay of Macro-phytes in autumn and early winter..

Both cluster analysis and principal components analysis were used for summarizing and comparing the numerical data on the invertebrate communities of each biotope and gave similar results. As in previous analyses the invertebrate communities on gravel and silt could be disting-uished in most months and were normally discrete from those found on macro-phytes.

Although fresh Macrophytes do not appear to be an important food source for the invertebrate community, the role of macrophytes is important to invertebrates. They provide diverse living space and also food, by acting as a surface for epiphytic algae, decaying in situ, and by trapping both autochthonous and allochthonous organic matter.

4.7 A COMPARISON OF THE DISTRIBUTION AND ABUNDANCE OF BENTHIC INVERTEBRATES IN FIVE BIOTOPES AT TWO CONTRASTED SITES ON THE RIVER LAMBOURN

Between March 1971 and February 1972 a monthly quantitative sampling programme for benthic macroinvertebrates took place on 5 biotopes of each of two 50 metre site® on the River Lambourn. The physical structure of the substratum and the composition of the invertebrate community suggested that the sequence of biotopes gravel - *Ranunculus Berula - Callitriche* - silt formed an overlapping series which experienced decreasing exposure to current velocity.

During the 12-month period 62 families of invertebrates were recorded and monthly variation in the number of families present followed a similar pattern on each study site. Most families had a statistically significant preference for all the Macrophytes as a group and few families preferred gravel or silt. In general there appeared to be *a* lack of strong discrimination between the Macrophytes. Comparison of the biotope preferences of families on the two study sites indicated that significant differences in preferred biotopes were of a minor nature and that most families gave similar results on both sites. However, the highest annual mean density of invertebrates tended to occur on the dominant Macrophyte at each site.

There was limited evidence of a small movement onto silt by some families in response to leaf fall in autumn but little indication of major seasonal movements in the fauna between gravel, the macrophytes and silt. The biotope preferences of *Ephemera danica* and *Gammarus pulex,* were examined in detail month by month and both showed some minor differences between sites in response to the differing character of the two study sites.

It is suggested that the major strength of the biotope approach for the description of invertebrate communities is in the practical application of results for river management. The significance of the results of this study are briefly reviewed as they apply to the management of a chalk stream for game fishing.

4.8 A LONGITUDINAL SURVEY OF MACROPHYTES AND MACROINVERTEBRATES IN THE THE RIVER LAMBOURN 1976-77

Thirteen sites at approximately 2 km intervals along the River Lambourn were examined each month from May 1976 to June 1977 and again in August 1977 to determine changes in the flora and fauna. Flow was intermittent at the upper 5 sites and these were dry throughout 1976 and until February 1977. At each site aquatic macrophytes were surveyed by visually estimating the cover and invertebrates were sampled by collecting for five minutes with a pond net to obtain a species list.

The macrophytes showed no longitudinal pattern of distribution using presence or absence as a measure. However, *Callitriche* and *Berula* were more abundant at sites with permanent flow whereas *Apium* was more frequently recorded in the intermittent section. The number of invertebrate species present generally increased downstream. Low numbers of species recorded at sites in the intermittent section were probably due to the influence of the drought in 1976.

Cluster analyses showed a distinction between the faunas of sites in the intermittent zone and those of sites in the permanent zone of the river and indicated three groups of species which appeared to have biological significance:

1) Species limited in distribution to the temporary stream;
2) Species limited in distribution to the permanent flow section of the river;
3) Ubiquitous species which were recorded at most or all sites.

A conformity test confirmed that there was a marked change in the fauna between the intermittent and permanent zones and that a gradual transition occurred downstream within the permanent *zone.*

4.9 THE MACBOINVERTEBRATE FAUNA OF A SHALL CHALKSTREAM AND THE INFLUENCE OF INTERMITTENT FLOW

A winterbourne tributary of the River Lambourn was sampled : throughout 1972, during the drought of 1976 and the recovery period up to August 1977. Analysis of the invertebrate community revealed 3 major zones; a zone of permanent flow up to the perennial head, a middle section of intermittent flow and an upper gone of intermittent flow comprising a series of ponds connected by ditches.

These zones were characterised by 3 faunal groups:

1) species typical of permanently-flowing chalk streams, some of which may be dependent on recolonization from the River Lambourn ' for their continued presence in the winterbourne.
2) species typical of permanently-flowing chalk streams with the ability to recolonize rapidly upstream when water is present in the intermittent zone.
3) Species restricted to the intermittently-flowing zones, some of which were adapted to life in winterbournes, surviving dry periods either by resistant stages or by entering the groundwater, while others were apparently opportunistic invaders of pond and ditch situations.

During the drought of 1976, the faunal richness of the sites which, remained wet was dramatically reduced. While members of the permanent water fauna were observed migrating downstream to avoid the drought, this was not observed for the intermittent zone fauna. On the return of water, several of the intermittent zone species reappeared almost immediately and a few permanent zone species showed very rapid upstream recolonization. By summer 197? most species had returned to their 1972 distributions, if not abundances, although many of the opportunist component had not had time to recolonize.

4.10 AN EVALUATION OF SAMPLING STRATEGIES FOR QUALITATIVE SURVEYS OF MACROINVERTEBRATES IN RIVERS, USING POND NETS

The efficiency of pond net samples as a means of obtaining a list of invertebrate species was investigated using data collected during surveys of two chalk streams. Comparisons between pond net, Surber sampler and Maitland core samples showed that pond nets produced more species in a given time than either of the other samplers. There was no evidence of particular species being recorded in the quantitative samples but not in the pond net samples. A series of samples taken with a pond net showed that sampling for a given time produced slightly fewer species than sampling over a given distance. The area covered per unit time was greater for the timed sample than for the distance samples, suggesting that timed samples produce a less intensive and less efficient sample.

In one survey four operators each took a sample at each site on each visit. Samples from different operators differed in both the number of species captured and the species composition, although no obvious selectivity for particular taxa was detected. Differences between. operators were increased when a range of sites was considered together.

Substantial increases over the number of taxa recorded from a single sample could be achieved by replication. Increasing the number of sites sampled produced the largest increase in. the species list, but replication in time, or ,even at the same time, also produced a considerable increase in yield.

Evaluation of the. number of replicates necessary to produce a representative species list confirmed that a single strategy could produce satisfactory results at all the sites for which data were available. Furthermore, the strategies required for whole river surveys on both streams were similar.

In chalk streams two sections are clearly recognizable; one of intermittent flow and one of permanent water flow. An adequate sampling programme for a general survey of a chalk stream is concluded to be two sites in each of the stream sections, sampled six times per year with sample replication at each visit.