An Investigation of Ecological Change in the Rivers Kennet and Lambourn

R&D Technical Report W6-104/TR

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Statement of Use
This report describes a survey of invertebrates and plants on the Rivers Kennet and Lambourn between 1997 and 2001. It provides information on the sites, the methods used and the basic results. Also included are synopses of five scientific publications based on the current dataset. Some of these publications include information collected on the same study sites in the 1970s. The report is intended for use by the Agency's staff and others interested in the ecology and management of chalk rivers and the effects of both low and high flows.

Keywords
Chalk streams; discharge; drought; flood; ecological change; macrophytes; macroinvertebrates; management.

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This study would not have been possible without the active cooperation and help of riparian landowners and river keepers. The team was allowed access to each study site in each of the five years and for this we are most grateful. At Bagnor, we were granted access to the River Lambourn by the Donnington Grove Country Club (now the Parasampia Golf and Country Club), at the Littlecote Estate we received help and advice from Head Keeper Mr P Woolnough and at Savernake we received similar assistance from Head Keeper Mr J Hounslow.

EXECUTIVE SUMMARY

The Kennet and Lambourn catchments are important regionally for water supply, fisheries and conservation. Reliable long-term data on the ecology of these chalk streams is essential to ensure effective management and to fulfil the UK Biodiversity Action Plan. Between 1971 and 1979, a major study of the macrophytes, macroinvertebrates and fish took place on the River Lambourn at Bagnor, resulting in a unique dataset and numerous publications. Between 1974 and 1976, further studies were undertaken at two sites on the River Kennet downstream of Marlborough (Upper and Lower Savernake) and at Littlecote, just upstream of Hungerford.

In 1997, the Environment Agency (Thames Region) commissioned the Institute of Freshwater Ecology (IFE) to re-examine these four sites in summer (June/July) and winter (December) using the 1970s protocols in order to obtain information on long-term ecological change and to examine the impact of the 1996-97 drought. Winter 1997/98 marked the end of the drought and phosphate stripping commenced at Marlborough STW in autumn 1997. Hence, there was a need to document any long-term consequences of the drought and/or changes in water quality. In addition, because management practices had changed on some sites between the 1970s and 1990s, a long-term study could shed light on this important topic.

The Environment Agency drew up a contract for a 5-year collaborative project (April 1998 – March 2003) between the Agency and the IFE (now the Centre for Ecology and Hydrology, Dorset). This provided for repeat macrophyte mapping and macroinvertebrate sampling at the four study sites in summer 1999 - 2001. The basic results of the annual macrophyte mapping and macroinvertebrate sampling were to be reported to the Agency each year without any detailed analysis. In this collaborative project, CEH Dorset, would produce one scientific paper on a different aspect of the results in each of the five years. The final year of the contract (April 2002 – March 2003) was devoted to the production of this final report, which summarises the project, and includes synopses of the major findings from the scientific papers, some of which include analyses which incorporate data from the studies in the 1970s.

The first four chapters of the report provide an introduction, information on the flow regimes for both rivers, a detailed description of the four sites and the field and laboratory methods used in mapping and macroinvertebrate sampling. Chapter five presents information in tables plus a brief commentary on the percentage cover of the major habitats at each site during the 5-year study, with additional summary data for the 1970s sampling period. Spreadsheets containing the detailed maps for each site in 1997-2001 have been made available to the Environment Agency. Chapter six gives summary data on the macroinvertebrate sampling programme. This includes family richness (derived from 5 sampling units combined) on each habitat of each site between 1997 and 2001, and further information for the 1970s, accompanied by brief comments. Additional tables give family composition and abundances expressed as numbers per 0.05 m^2 for each habitat, site and sampling occasion. Raw data on family composition and abundance in each of the five sampling units for each habitat, site and sampling occasion has been made available to the Agency as an Access Database.

Chapter seven presents synopses of the five scientific papers written as the CEH Dorset contribution to this collaborative project. The first two papers deal with the impact of

drought conditions on the habitats and macroinvertebrate assemblages of the R. Lambourn at Bagnor. In the first of these, it was shown that important families of chalk stream macroinvertebrates such as Baetidae (mayflies) and Simuliidae (blackflies) show a positive relationship to discharge regime, with available habitat as another relevant factor. Thus, their numbers were very low in June 1997 due to the drought conditions, and this was compounded by the poor growth of macrophytes due to heavy shading on the site. A further analysis of the macroinvertebrate assemblages in the drought years of 1976 and 1997, based on quantitative family data, revealed an extreme response to the drought itself, mainly in terms of changes in faunal abundance, but rapid recovery after each drought, whether the site was managed as a trout fishery (1976) or left unmanaged (1997).

Another study at Bagnor examined the impact on the flora and macroinvertebrate fauna of changes in management between 1975-79, when the river was managed as a trout fishery and 1997-2001 when the river was unmanaged. Throughout the 1970s, the river keeper undertook selective weedcutting, mowed the north riverbank and controlled the growth of overhanging trees on the south bank. After fishing and the associated management ceased in the 1980s, the river slowly reverted to an unmanaged state with encroaching marginal vegetation on the north bank and shading by trees on the south bank, thus limiting the light reaching the river surface. Between the two study periods the area of instream macrophytes decreased by 50% but overall macroinvertebrate family richness increased slightly, possibly due to the appearance of marginal vegetation. Because the heavy shading impacted on instream habitats and food resources, there were substantial changes in the abundance of many families. Mayflies such as Ephemerellidae and Baetidae, whose subimagos and imagos are mimicked by dry fly fishermen, became less abundant under the no management regime. It appears that management for trout fishing promoted both primary production and secondary production, including the fly life taken by trout and mimicked by fishermen.

The next study involved three sites on the R. Kennet which had been sampled in the mid-1970s and resampled from 1997 onwards. The lowest site (Littlecote), near Hungerford had changed little between sampling periods but two other sites (Savernake Upper and Lower), just downstream of Marlborough, suffered progressive loss of macrophytes during the 1990s and attempts at promoting re-growth failed. In autumn 1997 the drought came to an end, phosphate stripping commenced at Marlborough STW, and there was heavy rainfall the following spring. Regrowth of *Ranunculus* on both Savernake sites was spectacular and it became and remained the dominant macrophyte. Although there were minor changes in macroinvertebrate family composition on the three sites between the 1970s and 1990s, there was no evidence of loss of family richness. Further analyses highlighted important differences in family abundance at Savernake between 1997 and 1998/99, whereas only minor differences were apparent at Littlecote. The relative importance of low flows, poor weed growth, siltation and enrichment from Marlborough STW as contributory factors to changes in faunal abundance at Savernake requires further study.

The final paper examines faunal response at all four study sites to the low and high flow events which occurred during the 1997 to 2001 study. In these perennial sections of high quality chalk streams drought events do affect the abundances of many macroinvertebrates, but recovery in the aftermath of the drought is rapid. The unusually high discharge event of winter/spring 2000/2001 had no immediate adverse effects on the fauna. In fact, family richness peaked on each of the three Kennet sites in summer 2001 and overall family abundances on the major habitats of all four sites reached their highest or second highest values in 2001.

The report ends with a series of conclusions and recommendations before providing an appendix with a full listing of all scientific papers published on the R. Lambourn and R. Kennet within this project as a result of the studies in the 1970s and in 1997-2001.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1 Background

In 1997, the Environment Agency, Thames Region, commissioned the Institute of Freshwater Ecology River Laboratory (now the Centre for Ecology and Hydrology, Dorset) to undertake studies on the macrophytes and macroinvertebrate assemblages at a total of four sites on the Rivers Lambourn and Kennet. They included one site on the River Lambourn at Bagnor (the 'shaded' site of the 1970s), two sites in close proximity on the River Kennet downstream of Marlborough ('Savernake Upper' and 'Savernake Lower'), and a further location on the Kennet upstream of Hungerford ('Littlecote'). Each one of these sites had been the focus of detailed ecological studies by a team of freshwater ecologists in the 1970s, in connection with a proposed groundwater pumping scheme. Hence, valuable historical data were available for each location.

The low flows experienced in the late 1980s/early 1990s coupled with the developing drought conditions in 1996 and spring 1997 provided the impetus for a re-examination of these sites. Only by detailed studies over a number of years would it be possible to determine whether the latest sequence of droughts had resulted in long-term changes at these sites. With this in mind, a contract was drawn up as a collaborative project between the Agency and the Institute of Freshwater Ecology. This included a mapping and macroinvertebrate sampling programme at all four sites in June/July of 1997-2001, thereby providing a five-year run of data. In 1997 only, a further set of samples were collected in December at each site.

For each year of sampling, an annual report was prepared for the Agency, giving information on the condition of the sites, together with basic data on the cover of macrophytes and macroinvertebrate family densities. The CEH contribution to this collaborative project has been the production of five scientific papers by the CEH Dorset team, based on the data collected at these research sites. This final report includes synopses of the major findings from each of these scientific papers. Some of them include comparisons between the biotic condition of the sites in 1997-2001 and their condition in the 1970s.

1.2 Objectives

The overall objective of the contract is:

'*to improve the Environment Agency's knowledge of chalk stream ecology in order to increase our ability to manage chalk streams in a sustainable manner'*

The specific requirement for this final report is:

'to produce a technical report on the project, including an overall analysis of the results and comparison with conditions in the 1970s'.

As previously indicated, the analyses which include comparisons with conditions in the 1970s are reported in the five scientific papers, the main findings from which are summarised within this report.

In addition to this technical report, the following information has also been made available to the Agency:

1. A series of spreadsheets containing the cover maps generated for Savernake Upper and Lower (1997-2001), Littlecote (1997-8) and Bagnor (1997-2001).

2. An Access Database which holds the raw data (i.e. information from the individual sampling units) collected during the macroinvertebrate sampling programme on each of the four sites between 1997 and 2001

2 FLOW REGIME

2.1 R. Lambourn at Shaw

Discharge data for the River Lambourn has been supplied by Thames Region of the Environment Agency. The nearest gauging station to Bagnor is at Shaw, approximately 2 km downstream of the study site. Note that whereas the river occupies a single channel at Shaw, it is divided into two channels at Bagnor. In the 1970s, two study sites were chosen on the northern channel at Bagnor because it was of wadeable depth and was more typical of the river. The Winterbourne stream also discharges into the northern channel at Bagnor, ~ 100 m upstream of the shaded site. Hence, when examining the discharge regime at Shaw it should be borne in mind that discharge through the shaded site at Bagnor is substantially lower than at Shaw, but the seasonal regime in any given year will mimic the regime at Shaw.

The discharge regime at Shaw from January 1990 to December 2001, together with the 20-year monthly mean for the period 1970-1989 is presented in Figure 2.1. This sets the context for the resumption of mapping and macroinvertebrate sampling at Bagnor between June 1997 and June 2001. It also indicates the extent to which the discharge regime departs from the mean regime observed between 1970 and 1989. A drought in 1991-92 was followed by three years (1993-95) when a high but more characteristic discharge regime resumed with peak flows early in the year. Then followed another two-year drought (1996-97) with no high flows in the winter of 1996/97. This ended with high rainfall through the winter of 1997/98, but peak flows remained well below those experienced between 1993 and 1995. A wet spring resulted in a mean discharge in May 1998 (prior to sampling) approaching the monthly means recorded in 1993-96 and over twice the discharge recorded in May 1997. In 1999, the characteristic discharge regime was observed once more, as in 1993-95. However, in 2000, discharge increased each month between January and May, resulting in a monthly mean discharge of 3.3 cumecs in May 2000, the highest discharge observed prior to June sampling in the 1990s or in the 1970s. However, even this was exceeded in 2000/01 when heavy autumn rains in 2000 resulted in the mean monthly flow exceeding 5 cumecs between December 2000 and April 2001. In May 2001, the mean monthly discharge was 3.81 cumecs, exceeding the record value of the previous year.

2.2 R. Kennet at Knighton

Figure 2.2 presents the discharge regime on the R. Kennet at Knighton between January 1990 and December 2001, together with the corresponding 20-year monthly mean for the period 1970-1989. Although this is a separate subcatchment, it is immediately apparent that the major discharge events observed for the R. Lambourn at Shaw are also displayed in the hydrograph for the R. Kennet at Knighton. For example, the drought events of 1991-92 and 1996-97 are apparent, separated by 1993-95 when a high but characteristic discharge regime prevailed. As noted on the River Lambourn, winter rains in 1997/98 marked the end of the drought but peak discharge fell short of that recorded in the mid-1990s. In spring 1998, high rainfall resulted in a monthly mean discharge in May 1998 exceeding values recorded in the same month in the earlier years. In fact, mean discharge in May 1998 was almost four times the mean discharge recorded in May 1997. By 1999, a more characteristic (1993-95) seasonal discharge regime had resumed. However, in 2000, monthly mean discharge increased progressively from

February to May, and the monthly mean value of 7.2 cumecs for May exceeded all previous values for this month in either the 1990s or the 1970s. As on the R. Lambourn, the winter/spring discharge remained exceptionally high between December 2000 and April 2001 with mean monthly discharge exceeding 7 cumecs in each of these five months. By May 2001, mean monthly discharge (6.75 cumecs) was a little lower than the previous year and thereafter, mean monthly discharge decreased rapidly through the summer and autumn.

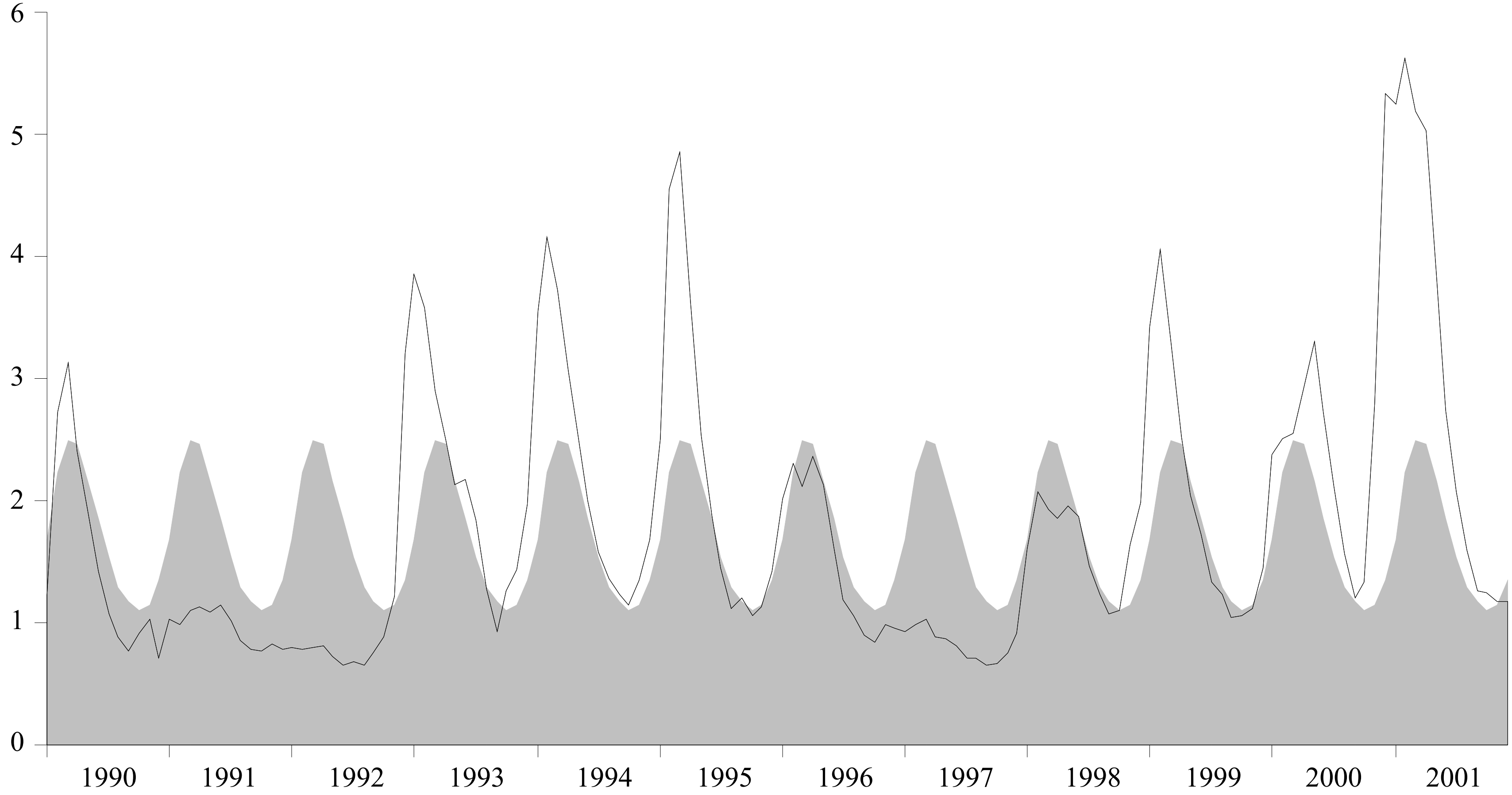

Figure 2.1: Monthly mean discharge (in cumecs) for the R. Lambourn at Shaw over the period January 1990-December 2001, together with the monthly means for the previous 20-year period 1970-1989 superimposed

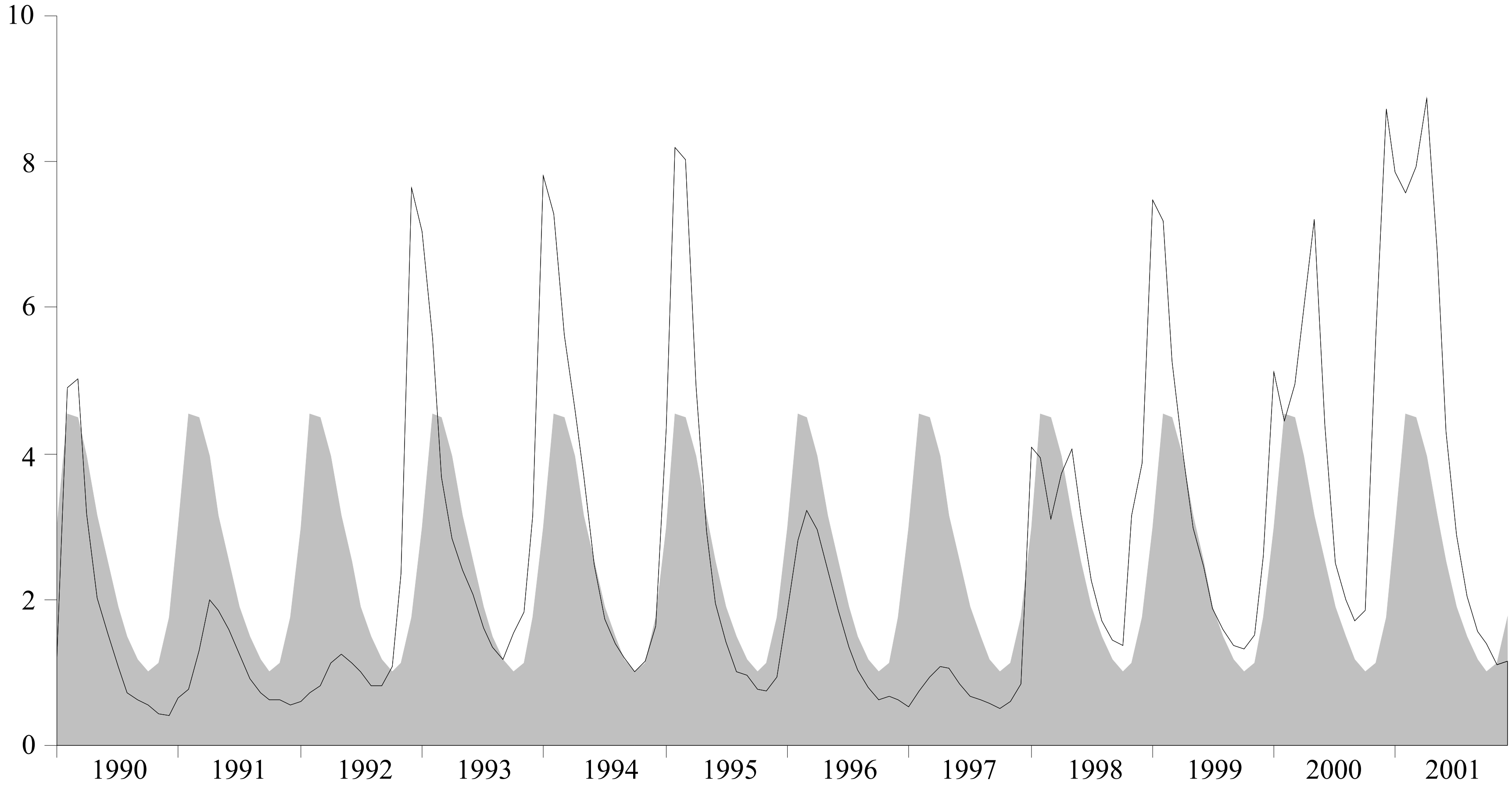

Figure 2.2: Monthly mean discharge (in cumecs) for the R. Kennet at Knighton over the period January 1990-December 2001, together with the monthly means for the previous 20-year period 1970-1989 superimposed

3. THE STUDY SITES

The three study sites on the R. Kennet (Savernake Upper, Savernake Lower and Littlecote) plus the Bagnor site on the R. Lambourn are shown in relation to major towns in Figure 3.1. The location of the Knighton gauging station on the R. Kennet and the Shaw gauging station on the R. Lambourn are also given.

3.1 R. Lambourn at Bagnor

The River Lambourn drains the Cretaceous chalk of the Berkshire Downs and flows for 25 km before its confluence with the River Kennet at Newbury. The 50 m long study site at Bagnor (referred to as the 'Bagnor shaded' site during the 1970s) was established in the lower perennial section of the river at the village of Bagnor, just downstream of the confluence of the Lambourn with its only tributary, the Winterbourne stream. At Bagnor, the river is in two channels, and hatches at the Watermill Theatre regulate the proportion of water flowing in the north (shallow and swift flowing) and south (deeper and slower flowing) channels. The Bagnor study site (Nat. Grid Ref: SU 453 692) is located on the north channel approximately 100 m downstream of the point of entry of the Winterbourne stream, and was originally chosen because it was shallower and more characteristic of the lower perennial section of the river. At that time, the Piscatorial Society fished the R. Lambourn at Bagnor.

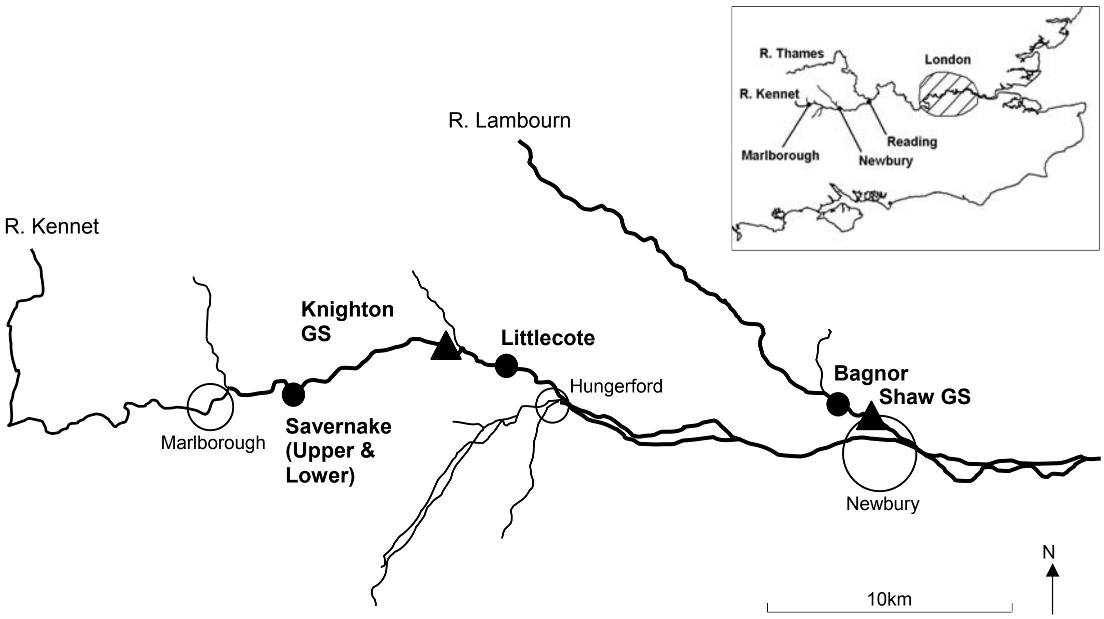

Figure 3.1: Map showing the location of the four study sites on the R. Kennet and R. Lambourn, together with the position of the gauging stations (GS) at Knighton and Shaw

In the 1970s, the site varied from 6.5 to 9.5 m in width and was normally 0.2-0.4 m in depth. A line of trees and shrubs on the south bank resulted in some shading of the water surface, particularly in summer. However, they were pruned back by the river keeper to minimise entanglement of fishing lines. The north bank was mown for the benefit of the trout fishermen, except for a narrow strip of bankside vegetation which was left for emerging insects. The river banks were approximately vertical and the keeper ensured that no marginal vegetation encroached into the river-bed itself. The dominant macrophyte was lesser water parsnip, *Berula erecta* (Huds.) Coville, which grew as a spreading carpet. The site also supported water crowfoot, *Ranunculus penicilatus* var. *calcareous* (Butcher) C D K Cook and starwort, *Callitriche obtusangula* Le Gall. Weed cutting was undertaken by the Piscatorial Society keeper during the summer in line with his normal practice. The research team undertook the monthly mapping of the instream habitats between 1971 and 1979 and, on average, over 60% of the river-bed was colonised by macrophytes during this period.

When the study resumed in June 1997 the site looked very different from the 1970s. The Piscatorial Society ceased fishing during the 1980s and since that time very little management has been undertaken. Marginal emergent vegetation has encroached into the river from the north bank and unhindered growth of trees and shrubs on the south bank has resulted in a higher level of shading than in the 1970s. As a consequence, the percentage cover of instream macrophytes is substantially reduced. It is also noticeable that the south bank, which was essentially a soil bank in the 1970s, has broken down to produce a silty margin below the tree cover. The gravelly north bank is also less steep than in the 1970s, probably due to the invasion of marginal vegetation and the fact that there is no river keeper to remove the marginal vegetation and maximize the fishable area.

Figure 3.2 shows the Bagnor shaded site in June 1999 with trees overhanging the south bank and a variety of marginal emergents invading from the north bank.

3.2 R. Kennet at Littlecote

The 100 m study site chosen at Littlecote in 1974 was ca. 3 km upstream of Hungerford (Nat. Grid Ref: SU 312704). The river was free flowing, and was dominated by water crowfoot, Ranunculus penicillatus var calcareus (R W Butcher) C D K Cook with occasional patches of R. peltatus Shrank. The dominant substratum was gravel, but it ranged from unstable pebbles towards the upstream limit of the site where the central channel was narrow and deep to fine flints embedded in sand towards the wider downstream limit of the site. Water depth varied with location and season but was typically less than 1m, except in the central channel near the upstream limit during periods of high discharge. A few trees occurred on the north bank, but shading of the site was minimal because the mean river width was 13.3m. Ranunculus normally displayed rapid growth from spring onwards, necessitating regular cutting (Ham et al., 1982a) in order to maintain suitable conditions for trout fishing. However, in spring 1976, with the onset of a major drought, Ranunculus failed to grow because it became smothered by epiphytic algae and associated detritus.

The study recommenced in summer 1997, during the height of the 1996/97 drought. Although growth of Ranunculus was poor and marginal emergent vegetation was growing well, it was apparent that instream and bankside management practices closely followed those used in the 1970s. Between 1998 and 2001, after the drought was over, the character of the site was similar to that observed under normal flow conditions in the 1970s.

Figure 3.3 shows the R. Kennet at Littlecote in June 2000, with Ranunculus breaking the water surface.

Figure 3.2: R. Lambourn at Bagnor (shaded site), June 1999. View upstream from the bottom of the site showing beds of *Ranunculus*

Figure 3.3: R. Kennet at Littlecote, June 2000. View downstream from the top of the 100 m site

3.3 R. Kennet at Savernake (lower and upper sites)

In 1974, two 50 m sites were chosen upstream of Stitchcombe Mill and *ca.* 4 km downstream of the town of Marlborough, on a section of river under the control of Savernake Flyfishers.

These sites were referred to as Savernake Lower (SU 224693) and Savernake Upper (SU 222693). Despite being further upstream, this section of the river differed from Littlecote because it was normally deep and slow-flowing as a result of the manipulation of hatches at Stitchcombe Mill. This canal-like section of river had a relatively even depth, and was heavily stocked with trout. On each site the substratum included large pieces of flint, some gravel plus fine sediment. In the 1970s, the lower (downstream) site was *ca.* 13.2 m wide with a central channel typically >1 m deep. It was dominated by common clubrush, *Schoenoplectus lacustris* (L.) Palla, with *Ranunculus* subdominant, particularly in the shallower margins. On the upper site, mean water width was 15.6 m, depth did not normally exceed 1 m and *Ranunculus* was dominant with *Schoenoplectus* subdominant. There was only limited tree cover alongside each site and vertical wooden boarding replaced natural marginal vegetation on the north bank.

By 1997, when mapping and sampling recommenced, the character of the river at Savernake was very different from the 1970s. This was due to active management by the river keeper in an attempt to encourage the regrowth of *Ranunculus*, which had been failing for a number of years. The reason for this problem was unclear but concern focused on low flows and water quality. The keeper allowed the river to run free in the belief that increased water velocities would promote the growth of *Ranunculus*. He also removed the vertical bankside boards, planted native marginal vegetation to narrow the channel and installed current deflectors at strategic locations to increase current speed and promote growth of *Ranunculus*. Despite this the area of macrophyte, both *Ranunculus* and *Schoenoplectus*, was substantially lower in 1997 than at any time during the two-year study in the mid-1970s. However, following the end of the drought in winter 1997/98 and implementation of phosphate stripping at Marlborough STW in autumn 1997, *Ranunculus* recovered strongly in spring 1998 and both sites have supported vigorous growth of this macrophyte in subsequent years.

Photographs of the two Savernake sites in early July 2001 are shown in Figure 3.4 (Savernake Lower) and Figure 3.5 (Savernake Upper).

Figure 3.4: R. Kennet at Savernake, early July 2001. Lower Savernake site looking upstream

Figure 3.5: R. Kennet at Savernake, early July 2001. Upper Savernake site looking upstream

4. FIELD AND LABORATORY METHODS

4.1 Macrophyte Mapping

4.1.1 Field procedures

An account of the field procedures involved in mapping each site (the ‘rectangles’ method) was first published in Wright *et al.* (1981). A detailed description of the technique, including further comments relevant to each study site, was also given in each of the earlier reports on this project (Wright *et al*. 1999a*,* 1999b, 2000a, 2001 and 2002). A brief synopsis of the technique is repeated here for completeness.

Prior to mapping for the first time, a straight baseline is established on one bank using a series of permanent stakes at 5 m intervals. Additional stakes are also required at 5 m intervals on the opposite bank at known distances from the baseline. When mapping, a temporary grid of mapping strings is set out in order to create a 1 x 1 metre grid over the water surface. First, a 5 m tape, with numbered tags at 1 m intervals is placed between the 0 and 5 m stakes on the baseline, with a similar tape on the opposite bank. Next, a series of longer tapes with numbered tags at one metre intervals are positioned across the river at one metres intervals and checks are made that all the 1 m tags on the mapping strings are aligned.

When mapping, one person (the caller) stands in the river in order to describe the river-bed whilst a second (the recorder) stands on the baseline bank and marks the prepared mapping sheet with information provided by the caller. A third person may help with repositioning the cross-river tapes when they are moved upstream. Prior to mapping, it is essential to define all the habitats to be distinguished. Note that all habitat categories are as determined visually, irrespective of the composition of the substratum under the visible surface.

At the start of mapping, the caller enters the river downstream of the cross-river tape connecting 0 m on the baseline with 0 m on the opposite bank. The position of the nearside bank is determined to the nearest 0.5 m and relayed to the recorder who marks the position of the bank on a blank map consisting of 0.5 x 1 m rectangles representing the full 50 m length of river to be mapped. The caller then views the 1 m strip of river between cross-river tapes at 0 and 1 m upstream. The tapes with their numbered tags form a 1 m grid across the river, and each square of the river-bed below can be divided longitudinally, by eye, into two 0.5 x 1 m rectangles. The dominant substratum or macrophyte is then determined for each rectangle, but where a macrophyte and a non-macrophyte each occupy 50%, the macrophyte is given dominance. The substratum underlying the macrophyte is also determined.

Information on each rectangle is passed to the recorder until the location of the opposite bank is given. The caller then moves one metre upstream and continues the mapping process towards the baseline for the strip of river between the tapes positioned 1 to 2 m upstream. This process continues with periodic repositioning of the baseline and cross-river tapes until the entire site has been mapped.

This mapping procedure was used on the River Lambourn at Bagnor, where the river is narrower than the River Kennet. An experienced team of three could map the Bagnor site in approximately half a day. On the three Kennet sites (a 100 m site at Littlecote and two 50 m sites at Savernake), the greater river width coupled with the fact that the habitats on the river-bed were less complex allowed the mapping grid to be increased to 1 x 1 m squares, as used in the 1970s. Only at the bank did the mapping regime revert to 0.5 x 1 m rectangles where necessary, in order to document with greater accuracy the position of the bank and the habitats at the waters edge. Mapping took a full day for a team of three at each of Savernake (2 x 50m sites) and Littlecote (one 100m site).

At Littlecote, although maps were made in June and December 1997, from June 1998 onwards, the decision was taken to draw a sketch–map of the weed beds using mapping strings at 5 m intervals across the river for guidance in order to estimate the approximate cover of the major habitats. This circumvented the need for three people to spend an entire day mapping a site on which *Ranunculus* was always the dominant macrophyte and where the percentage cover of weed largely depended upon the weed-cutting regime that year.

4.1.2 Laboratory procedures

In the laboratory, EXCEL spreadsheets were prepared to represent each of the four mapped sites. The baseline was numbered 0-50 m (0-100 m for Littlecote), whilst rectangles at right-angles to the baseline were numbered 0-0.5, 0.5-1, 1-1.5 m and so on, allowing sufficient space to include the full distance from the baseline to the river, the width of the river itself and the far bank for the full length of the site. Each spreadsheet was then populated with mapping information on the dominant habitat within the river for each 0.5 x 1 m rectangle. In the case of the Kennet sites, where 1 x 1 m squares had been designated within the river, pairs of rectangles were substituted on the map, although single 0.5 x 1 m rectangles were recorded at the river margins where these had been mapped at the site. An automated procedure was then employed for counting the number of rectangles of each habitat, and from this the total area (m^2) and the percentage cover of each habitat was derived.

4.2 Macroinvertebrate Sampling

4.2.1 Field procedures

The Lambourn sampler (Hiley *et al*. 1981) was used to obtain samples of macroinvertebrates on each of the four study sites, as in the 1970s. The dimensions of the sampler were 20 x 25 cm, resulting in a sampling unit of 0.05 m^2. For each habitat, five sampling units were taken in each season. In general, the choice of habitats to be sampled on each site was made with a view to maximising the comparisons which could be made with samples taken in the 1970s. There was one exception to this general rule on the River Lambourn at Bagnor. Lack of management through the 1990s resulted in the development of marginal emergent species, at a time when submerged macrophytes were poorly represented. Although no comparisons would be possible with the 1970s, the marginal emergents represented a potentially important habitat and therefore they were also sampled.

Quantitative sampling for macroinvertebrates on the major habitats took place after the mapping operation. Potential locations for the five sampling units on each habitat were chosen using a series of four digit random numbers. The first two numbers represented distance along the baseline and the second two digits represented distance at right angles from the baseline.

The field procedure for taking macroinvertebrate samples started at the downstream limit of the site and mapping tapes were positioned to locate sampling positions. The Lambourn sampler was lowered over the chosen location and forced into the substratum to a depth of 6 cm using hand and foot pressure. The removal of all plant material and substratum to a depth of *ca.* 6 cm was carried out by hand, with further help from a trowel or sometimes a small spade for cutting through weed and removing the substratum into the collecting net attached to the sampler. The net was then removed from the frame and by carefully dipping the net in the current, the contents were concentrated prior to transfer to a labelled polythene bags.

In June/July and December 1997, no water or formalin was added to the samples in the labelled polythene bags because they were subjected to an initial clean-up in the laboratory the following day, prior to preservation. All samples were kept cool throughout the period before preservation. This procedure was particularly relevant to the December 1997 samples in which there were large numbers of small stone-cased caddis larvae in the family Glossosomatidae in some samples that needed careful removal from larger stones. However, from June 1998 onwards, the decision was taken to fix and preserve each sample in the field in 5% formalin, in order to eliminate the additional step of an initial clean up of each sample in the laboratory. Any large stones were carefully examined and leeches, molluscs and caddis etc. carefully removed and retained with the sample before the stones were discarded.

4.2.2 Laboratory procedures

Each preserved macroinvertebrate sampling unit included macrophyte, mineral material, detritus and macroinvertebrates, except for those taken on gravel and silt, which lacked the macrophyte component. The sorting and identification procedure for each sampling unit was as follows. The sample was placed in the upper of a pair of 12 (1.65mm) and 45 (0.355mm) mesh sieves and the formalin removed by thorough washing. The coarse and fine mesh fractions were then processed separately.

The coarse fraction was put into a series of trays and, on the basis of the amount of material and abundance of the macroinvertebrate fauna, a decision was reached on the proportion of the coarse fraction to be sorted and identified. This varied from the entire coarse fraction to a half or sometimes a quarter of the fraction. All specimens in the designated fraction were removed and identified to family level. The results were entered on a standard data sheet and a multiplication factor applied to estimate the total number of each family in the fraction.

The fine fraction was subjected to a similar procedure, except that the proportion sorted and identified normally varied from one half to one eighth of the total. Again, the number of individuals in each family were determined and entered on the same data sheet before an appropriate multiplication factor was applied. The totals from the coarse and fine fractions were then added to obtain the estimated number of macroinvertebrates in each family within the sampling unit. Approximately 60 days were required for the laboratory processing of the total of 60 macroinvertebrate samples (30 at Bagnor, 10 at Littlecote and 20 in total at the Savernake Upper and Lower sites) when the work was undertaken by someone with several years of experience. All sheets were then independently checked for accuracy before the information was entered into a Microsoft Access database and verified.

5. RESULTS OF MACROPHYTE MAPPING

This section gives basic mapping information on the total area and the percentage cover of each of habitat on each mapping occasion at the four study sites. Spreadsheets containing the detailed maps have been made available to the Environment Agency. Further information on the maximum, minimum and mean percentage cover of the major habitats at each site for the available period of mapping in the 1970s is also given.

5.1 R. Lambourn at Bagnor (shaded site)

Ham *et al.* (1982b) provide a detailed account of the growth and recession of aquatic macrophytes on the shaded site at Bagnor from 1971 to 1980. Table 5.1 indicates that in the 1970's, *Berula* was the dominant macrophyte (mean percentage cover 38.3%) and that *Ranunculus* and *Callitriche* were also important components of the instream flora. Gravel and smaller areas of silt accounted for most of the remaining area of riverbed. Whereas the site was managed as a trout fishery in the 1970s with instream weed cutting and control of bankside trees and marginal vegetation, these activities ceased in the 1980s and by the time of the 1997-2001 repeat survey, the character of the site had changed. Tree cover on the south bank together with the ingrowth of marginal vegetation on the north bank resulted in less light reaching the water surface.

From the information provided in Table 5.1, it is apparent that in the 1997-2001 survey, the area of each of the three instream macrophytes was normally much lower than the mean value for the 1970s (single exception was 24.9% *Callitriche* during the drought of 1997). Also, the importance of marginal vegetation within the wetted perimeter of the stream (listed under 'other') between 1997 and 2001 was typically much higher than observed in the 1970s. Again, the mean percentage cover of gravel and silt recorded during the 1970s was almost always exceeded in the recent five-year survey. A detailed account of the changes in the habitats at this site, with a consideration of their consequences for the macroinvertebrate fauna was published in a recent paper (Wright *et al.* 2003).

Table 5.1: R. Lambourn at Bagnor (shaded site). Total wetted area of the 50 m site and the % cover of the major habitat types in June and December 1997, plus June 1998 - 2001. Historical data for January 1971 - December 1979 is presented as maximum, minimum and mean values

Date(s)	Total Area m^{-2}	Percentage Cover					
		Berula	Call	Gravel	Ran	Silt	Other
June 2001	454.5	18.8	3.9	19.5	4.0	37.4	16.4
June 2000	475.5	12.8	2.7	30.2	7.5	23.7	23.1
June 1999	397	20.0	3.5	35.8	7.7	22.0	10.9
June 1998	439	9.6	2.3	51.7	1.9	26.8	7.8
Dec 1997	372	9.3	1.6	44.2	2.6	31.2	11.1
June 1997	387	5.8	24.9	29.3	6.2	17.6	16.2
71-79: Max	454	65.9	48.1	79.0	44.2	48.8	16.5
71-79: Min	336	0.5	0.0	5.7	0.1	2.8	0.0
71-79: Mean	409	38.3	10.3	26.3	13.7	9.7	1.5

5.2 R. Kennet at Littlecote

In the 1970s, this 100 m site was mapped most months between April 1974 and June 1976 and detailed information on the percentage cover of the habitats during this period is given in Wright *et al.* (2002b). Table 5.2 presents the maximum, minimum and mean values for total area and percentage cover for this period, together with the equivalent data for June and December 1997 plus estimates for June 1998-2001.

The site was free-flowing and was dominated by *Ranunculus* growing on a gravel substratum with limited areas of silt and marginal vegetation (‘others’). The character of the site has hardly changed between the mid-1970s and the recent study and, as a consequence, *Ranunculus* remains the dominant macrophyte. In June 1976, during the historic drought, the area of *Ranunculus* was very limited (16.2%) and during the recent 1997 drought, the area of *Ranunculus* in July (44.2%) was below that observed in later years. In July and December 1997 marginal emergents (‘others’) were providing an important habitat for macroinvertebrates although the plants were later washed away in late winter/spring. From June 1998 onwards, *Ranunculus* dominated the site each summer with between 60 and 80% cover.

Table 5.2: R. Kennet at Littlecote. Total wetted area of the 100 m site and the % cover of the major habitat types in July and December 1997. Estimated values for June 1998 - 2001 are given within brackets. Historical data for April 1974 - June 1976 is presented as maximum, minimum and mean values

Date(s)	Total Area m^{-2}	Percentage Cover			
		Gravel	Ran	Silt	Others
June 2001	(1383.5)	(34.8)	(60.0)	(2.1)	(3.2)
June 2000	(1363)	(18.6)	(77.5)	(0.1)	(3.8)
June 1999	(1362)	(37.9)	(61.2)	(0.5)	(0.4)
June 1998	(1245.5)	(27.7)	(71.5)	(0.0)	(0.7)
Dec 1997	1310	30.5	38.9	0.9	29.7
July 1997	1244.5	35.9	44.2	3.1	16.8
74-76: Max	1395	71.7	84.0	11.6	3.4
74-76: Min	926	12.2	16.2	0.3	0.0
74-76: Mean	1225	38.8	57.2	2.4	1.6

5.3 R. Kennet at Savernake (lower and upper sites)

5.3.1 Savernake (Lower site)

In the 1970s, this 50 m site was mapped between April 1974 and April 1976 and again, detailed information on the percentage cover of the habitats during this period is given in Wright *et al.* (2002b). Table 5.3 presents the maximum, minimum and mean values for total area and percentage cover for this period, together with equivalent data for 1997-2001. Unlike Littlecote, this site and also the Upper site at Savernake underwent marked changes between the mid-1970s and the recent five-year sampling period. In the 1970s this site was the deeper of the two Savernake sites and was dominated by *Schoenoplectus* (mean cover 60%) with limited additional cover of *Ranunculus* on a gravel substratum, plus some areas of silt. During the 1990s, attempts were made to encourage the growth of *Ranunculus*. These included allowing the river to run freely, removing vertical boarding from the north bank and narrowing the channel by planting marginal emergent vegetation. In July and December 1997 there was little evidence of the recovery of *Ranunculus* (Table 5.3) and *Schoenoplectus* was also failing to maintain itself. Much of the riverbed was dominated by gravel or silt and in summer 1997 growths of *Cladophora* were apparent on these substrata.

However, following the end of the drought in the winter of 1997/1998 and the start of phosphate stripping at Marlborough STW in late autumn 1997, the growth of *Ranunculus* was spectacular and it became the dominant macrophyte in this and subsequent years, which were all marked by high flow regimes. In contrast, *Schoenoplectus* continued to decline in area, probably as a result of heavy shading by the vigorous growth of *Ranunculus*. The changes in habitats at this site between the mid-1970s and 1997-1999 are discussed in some detail in Wright *et al.* (2002b), as are the consequences for the macroinvertebrate fauna.

Table 5.3: R. Kennet at Savernake (Lower). Total wetted area of the 50 m site and the % cover of the major habitat types in July and December 1997, plus June 1998 – 99 and July 2000 - 01. Historical data for April 1974 - April 1976 is presented as maximum, minimum and mean values

Date(s)	Total Area m^{-2}	Percentage Cover				
		Gravel	Ran	Schoen	Silt	Other
July 2001	674.5	33.7	44.0	3.0	9.8	9.5
July 2000	676	28.9	43.6	5.2	3.0	19.3
June 1999	653.5	23.6	53.7	6.3	9.3	7.2
June 1998	617.5	26.8	43.6	7.3	5.6	16.7
Dec 1997	536.0	53.6	0.2	11.8	14.1	20.3
July 1997	569.5	61.2	0.9	17.4	18.2	2.5
74-76: Max	686.0	38.6	19.3	66.5	23.5	3.2
74-76: Min	553.0	14.5	0.0	55.0	1.0	0.0
74-76: Mean	661.3	25.9	4.3	60.0	8.6	1.2

5.3.2 Savernake (Upper site)

Detailed information on the percentage cover of the major habitats at this site between April 1974 and April 1976 can also be found in Wright *et al.* (2002b). *Ranunculus* was co-dominant with *Schoenoplectus* in the mid-1970s (Table 5.4), probably because it was shallower and faster-flowing than the Lower site at Savernake. By 1997, small patches of *Ranunculus* were surviving, thanks to current deflectors placed within the river, but the area of *Schoenoplectus* was minimal. Following the end of the drought, the area of *Ranunculus* increased substantially and was maintained through the subsequent years of the study. *Schoenoplectus* remained within the study site but remained at a very low level.

Note that the area of this site decreased in the final two years (2000 and 2001) as a consequence of a separate river rehabilitation demonstration project which was undertaken in autumn 1999 and largely funded by Thames Water. This resulted in some modifications to the site including channel narrowing and the creation of underwater berms.

Table 5.4: R. Kennet at Savernake (Upper). Total wetted area of the 50 m site and the % cover of the major habitat types in July and December 1997, plus June 1998 – 99 and July 2000 - 01. Historical data for April 1974 - April 1976 is presented as maximum, minimum and mean values

Date(s)	Total Area m^{-2}	Percentage Cover				
		Gravel	Ran	Schoen	Silt	Other
July 2001	528	29.8	57.5	1.1	6.4	5.1
July 2000	513	33.4	41.4	1.8	5.0	18.4
June 1999	605	23.1	56.5	2.1	15.0	3.2
June 1998	604.5	36.2	48.8	1.7	4.1	9.2
Dec 1997	541.5	52.5	8.1	2.2	19.2	17.9
July 1997	551.0	64.5	6.5	2.7	22.0	4.4
74-76: Max	806.0	70.9	45.2	28.5	28.3	9.1
74-76: Min	597.0	23.4	0.0	12.5	1.4	0.0
74-76: Mean	766.0	49.5	19.1	21.8	7.0	2.5

6. RESULTS OF MACROINVERTEBRATE SAMPLING

Formation on the composition and abundance of macroinvertebrate families in each of the five sampling units for each habitat, study site and sampling occasion between 1997 and 2001 is held in an Access Database. This has been made available to the Environment Agency. Basic information on family richness, as the total number of families present in the five sampling units for a given habitat and sampling occasion, is presented here in a series of tables, together with a very brief commentary. Further tables present the data on family composition and mean abundances expressed as numbers per 0.05 m^2, without further commentary. The major findings from detailed analyses undertaken for a series of scientific papers are summarised in section 7.

Note: In the tables which present information on abundance, Oligochaeta and Lumbricidae are listed separately because they were distinguished in this sampling programme. Lumbricidae are the earthworms and for the purposes of these tables 'Oligochaeta' include all the other families of true worms. However, in the tables which report on the number of families, Oligochaeta and Lumbricidae are combined and reported as a single 'family'.

6.1 R. Lambourn at Bagnor (shaded site)

6.1.1 Family richness

The number of families of macroinvertebrates recorded on each habitat type (i.e. total number of families from 5 sampling units) in June 1997-2001 is shown in Table 6.1. The table also gives information on the maximum, minimum and mean number of families recorded per habitat during the detailed studies undertaken in the 1970s. (**Note**: the 1970s data-set is restricted to seven years data comprising 1971 plus 1974-79 when the laboratory processing technique was the same as that used in the 1997-2001 surveys. That is, the five sampling units for a given habitat were processed separately before deriving the total number of families present). No macroinvertebrate samples were taken from emergent macrophytes during the 1970s because they rarely occupied a significant area of the river-bed at that time due to the management practices adopted by the trout fishery.

Table 6.1: R. Lambourn at Bagnor (shaded site). Number of families of macroinvertebrates recorded on each habitat in June 1997 to June 2001 plus December 1997 (total from 5 sampling units in each case). Maximum, minimum and mean values for June in the 1970s derived from 7 years data (1971+1974 to 1979) based on the same protocols

Month/Year	Ber	Call	Grav	Ran	Silt	Emerg.
June 2001	36	27	27	32	24	27
June 2000	34	33	31	21	24	25
June 1999	40	34	24	31	28	35
June 1998	37	32	24	26	27	34
Dec 1997	***42***	***32***	***33***	***33***	***27***	***32***
June 1997	30	32	25	31	24	33
June 1970s: Max	41	39	36	41	33	No data
June 1970s: Min	22	30	27	29	23	No data
June 1970s: Mean	33.1	33.0	31.9	33.9	28.2	No data

In the 1970s, June mean family richness on *Berula*, *Callitriche* and *Ranunculus* was higher than on gravel and silt. In each of the five years 1997-2001, June family richness on the macrophytes normally exceeded that on the non-macrophyte substrata, although there were one or two exceptions. Whereas family richness remained high on *Berula* and *Callitriche* in the recent five year survey, family richness on each of *Ranunculus*, gravel and silt was frequently lower than observed during the 1970s.

An estimate of overall family richness on the site may be obtained by pooling the information from all the habitats listed in Table 6.1. The total number of families recorded on all six habitats sampled between 1997 and 2001 (or alternatively, on the five habitats also sampled in the 1970s) varied as follows:

June	Families on 6 habitats	Families on 5 habitats
1997	46	42
1998	52	45
1999	48	47
2000	45	43
2001	46	44

When both the six habitat and the five habitat options are considered, it would appear that the number of families captured is lower under both drought (1997) and high discharge (2000 and 2001) conditions. Note that in the seven years 1971 plus 1974-79, the total number of families from five habitats varied from 42 to 47. Hence, the values obtained in the last five years have not varied beyond these boundaries.

6.1.2 Family composition and abundance

Information on the family composition and mean densities of macroinvertebrates (as number per 0.05 m^2), derived from five sampling units per habitat on the Bagnor shaded site is provided in the next few tables. Information for *Berula* and *Callitriche* in June 1997-2001 is given in Table 6.2, for *Ranunculus* and emergent vegetation in Table 6.3 and for gravel and silt in Table 6.4. Finally, information on the family composition and densities of macroinvertebrates on all six habitats in December 1997 is given in Table 6.5

Table 6.2: R. Lambourn at Bagnor (shaded site), June 1997-2001. Mean densities of families (nos. 0.05 m^{-2}) on *Berula* and *Callitriche*

	Berula					Callitriche				
Family name	**1997**	**1998**	**1999**	**2000**	**2001**	**1997**	**1998**	**1999**	**2000**	**2001**
Planariidae	2.8	2	7.4	4	10.2	1.6	0	0.8	0.4	12.4
Dendrocoelidae	0.4	0.4	2.6	1.2	2.8	0	0	0.8	0	1.2
Valvatidae	0.8	0	1.6	0	4.8	0	0	0.8	0	1.6
Hydrobiidae	13.2	12	29.8	57.4	87	14.4	81	40.6	81.6	100.4
Physidae	0	0	0.6	0	4	0.8	0.4	0	0	0.4
Lymnaeidae	0	0	0.6	0	0.4	0	0	0	0.4	0
Planorbidae	0	4.8	7.8	1.6	10.6	1.4	1	5.8	0	0
Ancylidae	0.4	0.2	9.6	16.2	4.8	0.4	0	1.2	0.8	1.2
Sphaeriidae	12.8	8.2	1.4	4	11.2	7.4	18.4	29.6	14.8	28
Oligochaeta	178.4	197.6	58.6	193.4	677.6	122	100.8	168.4	222	866.4
Lumbricidae	6.8	3.2	4.6	6.8	3	0	0.4	0.8	0.4	0
Piscicolidae	0.4	0	1	0.4	1	0	0.4	0.4	0	2
Glossiphoniidae	5.6	2.6	1.6	2.8	1.2	3	1	0.8	1.6	1.2
Erpobdellidae	2.8	2.6	0.2	0	0.8	0.4	0.2	2.4	1.2	0.4
Hydracarina	25.6	0.8	1.4	40.2	33.6	14.4	0.4	0.4	9.6	52
Astacidae	0	0	0	2.4	0	2	0.6	0	0.6	0.4
Asellidae	2	6	4.4	1.6	1.8	10.8	4.6	5.6	2.8	8
Gammaridae	260	301.2	392.2	246.6	319.6	128.8	114.2	298	82.8	155.2
Niphargidae	0	0	0	0	0	0	0	0.8	0	0
Baetidae	5.2	86.6	91	87.2	86.2	1.6	20.4	41.2	32.4	91.2
Heptageniidae	0	0	0	0.2	0	0	0	0	0	0
Leptophlebiidae	0	0	0.2	0	0	0	0	0	0	0
Ephemeridae	78	5	7.4	0.8	10.2	11.2	1.8	2.4	1.6	3.2
Ephemerellidae	73.6	30.8	27.8	16.2	43.4	38.8	43.2	28.2	50	105.2
Caenidae	14.8	8	27.4	31.6	10.4	4.4	4.4	3.8	17.6	4.4
Nemouridae	0	0.2	0	0	0	0	0	0	0.8	0
Leuctridae	0.8	10.2	11.6	3.2	1.8	3.6	0.4	0.4	0.4	0
Corixidae	0	0	0	0	0	6.8	0	0	0.8	0
Dytiscidae	0	0	0	0	0	1	0.4	0.4	0	0
Scirtidae	0	0	0	0	0	0	0	0.4	0	0
Elmidae	8	9.8	5.8	11.6	0.8	6.6	4.6	0.8	4	1.6
Rhyacophilidae	0	0.8	0	0.4	0.8	0.4	0	0.4	1.2	0
Glossosomatidae	6	12.8	29	27.2	7	1.6	1.6	2	1.6	0
Hydroptilidae	2.8	0	0	0.6	0.4	1.8	0.4	0	1.6	0
Psychomyiidae	0	0	0	0	0	0	0.2	0	0	0
Polycentropodidae	0.8	2.2	0.6	1.6	0.2	0.4	0.8	0.6	2.8	0
Hydropsychidae	0	0	0.2	0	0	0	0	0	0	0
Lepidostomatidae	1.6	0.6	0.6	0	0.2	0.8	0.2	0	0	0
Limnephilidae	6	21.8	7.8	5.8	8.8	7.2	5.8	2.8	5.6	3.2
Goeridae	0.4	0.4	0.2	0.8	0	0	0	0	0.4	0
Beraeidae	0	0.4	0.4	0	0	0	0	0	0	0
Sericostomatidae	0	2.4	0.8	0.4	0	0	0.4	0.8	0	0
Leptoceridae	9.6	37.4	8.6	5	3.2	2.4	5	2	0.8	0.4
Tipulidae	1.6	5.4	3	2.8	1.8	0.8	1.4	1.6	3.2	4.8
Psychodidae	0	0	0.4	0	0.2	0	0	0	0	0
Ptychopteridae	0	0	0.4	0	0.8	1.8	0	0.4	0	0
Dixidae	0	0.4	0	0.4	0	0	0	0	0.4	0
Ceratopogonidae	50.4	63.8	52.8	18.8	44	21.4	8.6	18	14	38.4
Simuliidae	0	1078.6	54.4	206.4	53	0	73.8	5.2	20.8	22.4
Chironomidae	257.6	248	191.6	277	162.2	227.6	373.6	61	196.4	160.8
Stratiomyidae	0	0.4	0	0	0	0	0	0	0	0
Empididae	0.4	4.8	2.4	9	1	0	0.6	0	0.8	0.4
Syrphidae	0	0.4	1.6	0	0	0	0	0	0	0
Muscidae	0	0.4	0	0	0	0	0	0	0	0

Table 6.3: R. Lambourn at Bagnor (shaded site), June 1997-2001. Mean densities of families (nos. 0.05 m^{-2}) on *Ranunculus* and emergent vegetation

	Ranunculus					Emergents				
Family name	**1997**	**1998**	**1999**	**2000**	**2001**	**1997**	**1998**	**1999**	**2000**	**2001**
Planariidae	0.8	0.8	1.8	0	2.4	0.2	0	0.8	0.8	2.4
Dendrocoelidae	0	0	0	0	0.8	0	0	0	0	1.2
Valvatidae	0	0	0	0	2.8	0	0	0.4	0	0
Hydrobiidae	11.2	2	12.4	13.8	58.4	34	8	23.8	69.6	22.4
Physidae	0	0	0.2	0	0.4	0.6	0	0	1.6	6.8
Lymnaeidae	0	0	0.2	0	0	0	0.8	0	0	0
Planorbidae	0	0	6.8	0	2	3.6	0.2	0.8	0	1.6
Ancylidae	0.8	0.2	2.6	1.8	3.6	2.4	0.4	1.4	0.4	3.2
Sphaeriidae	2.4	0.6	0	0	3.6	0.4	1.2	2.4	9.6	19.2
Oligochaeta	70	34.2	26.2	57.4	81.6	16.2	45	59.4	159.2	203.6
Lumbricidae	9.4	3.4	0.6	3.8	3.6	0	1.2	1.2	1.6	0
Piscicolidae	0	0	1.6	0	0.8	0.6	0	0.4	0	0
Glossiphoniidae	7.2	0	0	0	2	1.6	0	1.6	0	0
Erpobdellidae	0.4	0.2	0	0	0.4	1.6	0.2	0.2	0.8	0.8
Hydracarina	11.6	0.8	9.6	35.4	50.4	9	0.2	1.4	7.6	28.8
Asellidae	1.6	0	0.4	0.2	3.6	22.2	17	7.2	20	3.2
Gammaridae	129	208.6	235.6	144.8	172.4	185.2	39.4	216.8	60.8	334.4
Niphargidae	0	0	0	0	0	0	0.2	0	0	0
Baetidae	15.6	56	164	144.8	82	0	1.6	4.4	8.8	8
Heptageniidae	0.4	0	0	0	0	0	0	0	0	0
Leptophlebiidae	0	0	0.2	0	0	0	0	1.2	0	2.8
Ephemeridae	64	3.4	2.6	0	3.2	15.8	0.4	19.6	0.8	4.4
Ephemerellidae	89.4	12.8	48.6	31.6	112	12.6	0.4	4.8	14	25.6
Caenidae	6.8	0.2	17.4	10.6	8	4	1	25.6	8.8	6.8
Nemouridae	0.8	0	0	0	0	0	0	0	0	0
Leuctridae	12	2.8	6.6	1.2	0	5.6	0.2	0.8	0	0
Veliidae	0	0	0	0	0	1	1	1.6	0.4	0.4
Corixidae	0	0	0	0	0	1.6	0.8	0	0	0
Dytiscidae	0	0	0	0	0	1.4	0.2	0.4	0	0
Scirtidae	0	0	0	0	0	0	0.4	0	0	0
Elmidae	4.4	6.6	5.2	8	3.2	8.6	1	1.6	2.8	2
Sialidae	0	0	0	0	0.4	0.4	0	0.2	0	0
Rhyacophilidae	0.8	1.6	0.8	2.2	0.8	0	0	0	0	0
Glossosomatidae	34	79.4	38.4	15.8	7.6	1.2	0.4	4.4	0.8	0
Hydroptilidae	3.2	0	0	0	1.2	2.8	0	0	0	0
Psychomyiidae	0	0.4	0	0.4	0	0	0	0	0	0
Polycentropodidae	0	0	0.6	0	0	0	0.2	4.4	0.8	0
Hydropsychidae	0.4	0.2	0.4	0	0	0	0	0	0	0
Lepidostomatidae	0.4	0	0	0	0	0	0	0	0	0
Limnephilidae	3.2	0.2	1.4	0.8	5.6	11.2	9.8	4.6	7.2	5.2
Goeridae	2	1	0	0	0	0.4	0	0	0	0
Beraeidae	0	0	0	0	0	0	0	0.4	0	0
Sericostomatidae	0	0	0	0	0	0	0.4	0.4	0	0
Leptoceridae	13.2	10.8	4.2	1	3.2	1.4	0.2	0	0	0
Tipulidae	0.4	4.2	0.8	4.6	2	0.4	4.4	0.8	2.4	2.8
Psychodidae	0	0	0	0	0	0	0.8	0.4	0	0.4
Dixidae	0	0	0.6	0	0.4	1.6	5.2	3.4	3.2	0.4
Ceratopogonidae	32.8	0.4	3.8	2.4	14	9.4	14.4	14.6	12	34.4
Simuliidae	8.2	618	124	248.8	13.6	0	5.6	4.8	9.6	2
Chironomidae	112.2	80.2	132.2	389.6	205.6	80.2	322.6	191	245.2	310.8
Empididae	1.2	1.2	0.8	3.4	2.4	1.2	0.4	1.6	0.8	0.4
Syrphidae	0	0	1.6	0	0	0.4	0	0	0	0
Ephydridae	0	0	0	0	0	0	0.8	0	0	0

Table 6.4: R. Lambourn at Bagnor (shaded site), June 1997-2001. Mean densities of families (nos. 0.05 m^{-2}) on gravel and silt

	Gravel					Silt				
Family name	**1997**	**1998**	**1999**	**2000**	**2001**	**1997**	**1998**	**1999**	**2000**	**2001**
Planariidae	1.4	2.2	0.6	2.4	4.2	0.8	0.4	0.8	0.4	0.6
Dendrocoelidae	0	0	0	0	0	0	0	0.4	0	0.2
Valvatidae	0	0	0	0	0	0	0	0	0	1.2
Hydrobiidae	7.6	1.6	25.8	33.6	61.4	6	2.4	15.6	29.6	66
Planorbidae	0	0	1.6	0.2	1	0	0.4	4.8	0	0
Ancylidae	1	0	2	6.6	9.8	0	0	0.4	0	0.2
Sphaeriidae	4.6	0.2	0.4	0.8	1	18	3	22.8	12.4	11.6
Oligochaeta	44.4	34	5.4	37.6	52	53.8	26.6	64.8	43.6	173.4
Lumbricidae	4.8	2.4	0.8	2.6	1	2.6	0.2	0	1	0
Piscicolidae	0	0	0	0	0.6	0.4	0	0.8	0	0
Glossiphoniidae	3	0	0	0.2	0	2.8	0	1.2	0	0.2
Erpobdellidae	0.4	0	0	0.2	0	1.2	0.4	0.4	0	0
Hydracarina	3.6	0	0.8	5.4	2.4	4.4	0	0	0.8	1.2
Asellidae	1.2	0	0	0.8	0.6	1.2	14.6	1.2	0.4	0.2
Gammaridae	202.6	120.8	276.4	143.2	331.4	474.8	103.6	184.2	65.2	74.6
Niphargidae	0	0	0	0	0.4	0	0	0	0.4	0
Baetidae	0.2	41.2	17.8	18.6	44.4	0.8	9	4.8	2.2	1.6
Leptophlebiidae	0	0	0	0	0	0	1.6	0	0.8	0
Ephemeridae	36.2	3.6	4.2	0.4	1.6	43.8	1.4	4	1	8.2
Ephemerellidae	13.2	2.6	1.2	1	5.6	10.6	4.4	5.6	3.6	0.4
Caenidae	1	0.4	0	2.6	1.2	3.2	1	4.4	1.8	1.4
Leuctridae	14.4	2.6	0.4	1	2	2.8	1.2	0	0	0
Corixidae	0	0	0	0	0	0	0	0	0.4	0
Dytiscidae	0	0	0	0	0	0	1.2	0	0	0
Elmidae	5.2	2	2	7.8	2.4	3.8	1	1.6	1.8	0
Sialidae	0	0	0	0	0	0	0	0.4	0	0
Rhyacophilidae	0	0	0.4	1	1.8	0	0.2	0	0	0
Glossosomatidae	56	115.8	202.4	105.2	30.6	2.8	6.2	14.8	21	0.2
Hydroptilidae	0	0.2	0	0	0	0	0	0	0	0
Psychomyiidae	0.2	1.8	0.4	0.4	1.2	0	0	0	0	0
Polycentropodidae	0	0.2	0	0	0	0	0.4	0.4	0	0
Lepidostomatidae	0	0	0	0	0	0.8	0	0	0	0
Limnephilidae	1.6	1.2	0.6	1.2	1.8	5.8	0.8	3.2	1.8	0
Goeridae	1	0.8	1.8	4.6	7.8	0	0	0	0.4	0
Beraeidae	0	0	0	0.2	0	0	0	0	0	0
Sericostomatidae	0	0	0	0.6	0	0	0	0	0	0.2
Odontoceridae	0	0	0	0.4	0	0	0	0	0	0.2
Leptoceridae	9.8	15.6	12.8	12.2	5.2	4.2	3.4	0.4	6.8	4.2
Tipulidae	2.8	2.4	6.4	9	2.2	1.4	3	3.2	2.8	4.2
Dixidae	0	0.4	0	0	0	0	0.2	0.4	0	0
Ceratopogonidae	10.8	1.4	1.6	2	1.4	18.6	2.8	6.4	3.4	5.6
Simuliidae	0	19.4	2.8	0.2	1	0	14.8	2	2.4	0.2
Chironomidae	7.4	16.8	4.6	17.4	17	114.2	209.4	35.2	47.6	37.6
Empididae	1.2	0.4	3.2	2.4	0	5.4	1.6	0.8	0.2	1.6

Table 6.5: R. Lambourn at Bagnor (shaded site), December 1997. Mean densities of families (nos. 0.05 m^{-2}) on six habitats

Family name	Berula	Callitriche	Gravel	Emergents	Ranunculus	Silt
Planariidae	2.4	0.0	0.8	0.8	0.8	0.0
Dendrocoelidae	0.8	0.0	0.0	0.0	0.0	0.0
Hydrobiidae	13.2	56.2	87.0	6.0	91.4	49.8
Physidae	0.8	0.2	0.4	0.0	0.2	0.0
Lymnaeidae	1.2	0.8	0.0	1.6	0.0	0.4
Planorbidae	3.6	5.6	2.0	4.4	1.6	0.2
Ancylidae	2.4	2.8	5.2	0.0	6.2	0.0
Sphaeriidae	6.0	3.2	4.8	1.6	0.0	7.2
Oligochaeta	242.8	107.8	79.6	27.6	53.0	47.6
Lumbricidae	4.0	9.2	5.0	0.4	15.6	0.0
Piscicolidae	0.0	0.0	0.0	0.2	1.2	0.0
Glossiphoniidae	5.2	2.4	1.4	1.6	4.0	1.0
Erpobdellidae	2.0	0.2	0.8	0.0	0.4	0.4
Hydracarina	26.4	27.2	11.2	5.2	19.2	10.4
Asellidae	18.4	11.0	9.4	34.0	9.0	35.8
Gammaridae	652.0	217.6	238.4	31.0	257.0	32.2
Niphargidae	2.4	0.0	0.8	0.4	0.0	0.2
Baetidae	5.2	3.4	0.0	0.8	2.6	0.8
Leptophlebiidae	64.8	11.2	4.8	0.8	4.0	5.0
Ephemeridae	64.0	40.2	32.4	6.0	38.0	10.6
Ephemerellidae	2.0	0.0	0.2	0.0	0.0	0.0
Caenidae	28.4	8.4	25.6	0.8	46.4	1.6
Nemouridae	0.8	0.0	0.0	0.0	0.0	0.0
Leuctridae	0.4	0.0	0.0	0.0	0.0	0.0
Corixidae	0.0	0.0	0.0	1.2	0.0	3.2
Haliplidae	1.2	0.0	0.0	0.0	0.0	0.0
Dytiscidae	2.8	1.2	0.0	0.8	0.0	0.4
Gyrinidae	0.0	0.0	0.0	0.0	0.8	0.0
Elmidae	170.0	55.2	51.4	3.8	137.8	4.0
Sialidae	0.0	0.0	0.0	0.8	0.0	0.8
Rhyacophilidae	0.4	0.0	0.0	0.0	0.2	0.0
Glossosomatidae	53.2	118.0	331.8	1.2	986.4	1.8
Hydroptilidae	433.6	263.8	4.2	42.6	171.8	15.2
Psychomyiidae	0.8	0.4	0.2	0.0	0.0	0.0
Polycentropodidae	19.6	4.0	0.8	0.0	3.2	0.0
Hydropsychidae	0.0	0.0	0.0	0.0	0.8	0.0
Lepidostomatidae	5.6	1.6	2.4	0.0	2.4	0.0
Limnephilidae	18.0	6.8	2.6	8.2	8.0	3.2
Goeridae	3.2	1.6	16.4	0.0	3.6	0.0
Beraeidae	0.0	0.0	0.0	0.0	0.0	0.4
Sericostomatidae	1.2	0.0	0.0	0.0	0.0	0.0
Odontoceridae	0.8	0.0	0.0	0.0	0.0	0.0
Leptoceridae	25.6	4.8	4.8	0.0	14.6	0.0
Tipulidae	1.2	2.4	1.8	5.2	1.4	4.6
Psychodidae	0.8	0.0	1.0	0.4	0.0	0.0
Ptychopteridae	0.0	0.4	0.2	0.0	0.8	6.4
Ceratopogonidae	11.6	8.6	7.8	5.8	9.0	4.8
Simuliidae	4.4	13.2	0.2	1.2	73.2	0.0
Chironomidae	85.6	26.4	13.6	47.2	39.8	86.8
Stratiomyidae	0.0	0.0	0.0	0.8	0.0	0.0
Empididae	11.6	4.8	1.2	0.4	8.0	0.0
Ephydridae	0.0	0.0	0.0	1.0	0.0	0.0
Lonchopteridae	0.0	0.0	0.0	0.4	0.0	0.0

6.2 R. Kennet at Littlecote

6.2.1 Family richness

The River Kennet at Littlecote is characterised by *Ranunculus* growing on a gravel substratum and hence the available results for 1974/75 and the more recent sampling programme have been confined to these habitats. Only limited comparisons are possible between the earlier and later sampling periods, although both June and December samples are available for 1975 and 1997. In both years, family richness on *Ranunculus* was higher in December than in June and particularly high family richness in December 1997 may have been due to colonisation of *Ranunculus* by some families also present in marginal emergents (note high percentage cover of 'others' in Table 5.2).

In general, family richness in June/July on *Ranunculus* and gravel was fairly stable from year to year and richness varied little between the two contrasting habitats. Note, however, that on each habitat, the highest family richness occurred in 2001, in the aftermath of the flood event of the winter and spring of 2000/2001. Thus, high discharge was not detrimental to the maintenance of high family richness on each of these two habitats.

Table 6.6: R. Kennet at Littlecote. Number of families of macroinvertebrates on *Ranunculus* and gravel in June/July 1997-2001 and December 1997. Historical data for 1975 (June and December) and 1974 (June only) are also given

Month/Year	*Ranunculus*	Gravel
June 2001	33	36
June 2000	30	32
June 1999	30	34
June 1998	31	29
Dec 1997	***43***	***34***
July 1997	32	31
Dec 1975	***35***	***33***
June 1975	30	33
June 1974	30 (29)*	28

* Figure in brackets refers to data from 5 replicate samples taken on recently cut *Ranunculus*.

6.2.2 Family composition and abundance

Family composition and abundance on gravel and *Ranunculus* for June 1997-2001 is given in Table 6.7, whilst the December 1997 data for these two habitats is provided in Table 6.8.

Table 6.7: R. Kennet at Littlecote. Mean densities of macroinvertebrate families (nos. 0.05 m^{-2}) on gravel and *Ranunculus,* June 1997 –2001

	Gravel					Ranunculus				
Family name	**1997**	**1998**	**1999**	**2000**	**2001**	**1997**	**1998**	**1999**	**2000**	**2001**
Planariidae	1.4	3.4	5.6	13	5.8	13.6	4.4	3	5.2	7.6
Dendrocoelidae	0.2	0.2	0.2	1.2	0.8	0	0.6	0.4	0.4	1.6
Hydrobiidae	0	0	0	0	1.2	0	0	0	0	0.4
Physidae	0	0	1.2	0.4	0.2	0	0.4	1.8	0	4.8
Lymnaeidae	0	0	0	0	0.4	0	0	0	0	0
Planorbidae	0.2	0.2	0.2	1.4	0.8	3.8	0.6	0.2	1.2	2.8
Ancylidae	0.6	2.8	3.2	36.2	41.8	0	5	0	3.2	0
Sphaeriidae	13.4	3.2	2.4	3.4	13.6	28.4	1.8	3.6	13.2	23.6
Oligochaeta	23.2	109.4	71.2	72.4	87.2	32.4	85.4	85.2	52	75.6
Lumbricidae	5.2	1	2.6	0.2	1.2	0.8	1.8	1	2	1.6
Piscicolidae	0	0	0.6	0.2	0.4	0	0.6	3.2	1.2	1.6
Glossiphoniidae	7	1.6	3.2	3.6	5	26.8	2.8	1.2	3.6	15.6
Erpobdellidae	4.2	4.2	1.8	2.2	0.8	7.2	5.6	0.2	0	2.8
Hydracarina	0.8	0	1.6	0	19	6.4	0	0.6	2.8	46
Asellidae	0	0.8	0.2	0.2	0	0.2	1	0	0	1.6
Gammaridae	325.2	1219.4	458	442.2	802.6	908.6	1123.6	816	552.8	840.8
Niphargidae	0	0	0	0.2	0.8	0.4	0	1	2.4	0
Baetidae	53.8	200.4	57.8	95.2	170	56.2	159	209.6	127.6	94
Heptageniidae	0	0	0.2	0.4	0.4	0	0	0	0	0
Leptophlebiidae	0	0	0	0	0	0	0	0.4	0	0
Ephemeridae	0.4	0	0	0	0	0.4	0	0	0	0
Ephemerellidae	13.6	39.8	15	34.6	31.8	305.8	158.6	70.4	161.6	456.4
Caenidae	17.6	30.6	22.8	25.2	0.6	210	54.8	14.4	7.2	26
Leuctridae	17.8	17.8	5.2	6	15	3.4	3.6	4.2	3.2	2.4
Calopterygidae	0	0	0	0	0	0	0.4	0	0	0.8
Corixidae	0.8	0	0	0	0	0	0	0	0	0
Dytiscidae	0	0	0	0.2	0.2	0	0	0	0	0
Elmidae	18.6	19.4	12	22	27.2	28.2	13.6	13.4	10	22
Sialidae	0	0	0	0	0	0.4	0	0	0	1.6
Rhyacophilidae	0.8	2.6	4.6	7	8	0.8	1.4	3.2	9.6	4.8
Glossosomatidae	10.6	0.4	16	12.6	9	2.8	0.4	1.6	3.6	0
Psychomyiidae	4.6	3.6	0.2	0	1.2	0.2	0	0	0	0
Polycentropodidae	0.6	2	0.2	0.4	0.8	3.2	2.6	0	0.8	2
Hydropsychidae	0.4	2.6	2.4	3	5	0.6	1.4	1.6	4.4	0.8
Lepidostomatidae	0.2	0.8	4.2	0.8	0	23.4	0.6	20.2	14	68
Limnephilidae	0.2	0.4	1.8	0.6	3.4	2.2	0.4	3.6	4.4	12.4
Goeridae	1.2	0.6	6.4	4.6	17	1.4	1	0.6	1.6	0.8
Sericostomatidae	1.6	0.2	6.4	0	1.6	9.4	1.6	4.6	1.2	6
Leptoceridae	13	18.8	21.2	8.6	5.2	13.2	10	10	5.6	11.6
Tipulidae	2	2.4	4.2	3.2	9.8	1.2	0.4	1	2	3.2
Ceratopogonidae	1.4	6.8	3.8	2.8	4.6	7.2	15.2	10.2	18.4	24.8
Simuliidae	20.8	6.2	8.6	9	8.4	114.6	249.4	447.2	213.8	563.6
Chironomidae	23.8	6.4	92.8	23.8	52	61.4	51	364.8	244.4	903.2
Empididae	0	0	0.2	0	2.4	0.4	0	0	0.4	1.6

Table 6.8: R. Kennet at Littlecote. Mean densities of macroinvertebrate families (nos. 0.05 m^{-2}) on gravel and *Ranunculus* in December 1997

Family name	Gravel	Ranunculus
Planariidae	15.8	26.8
Valvatidae	0.0	0.8
Hydrobiidae	0.0	0.8
Physidae	3.4	47.6
Lymnaeidae	0.0	0.4
Planorbidae	5.6	10.8
Ancylidae	5.0	0.4
Sphaeriidae	29.2	29.2
Oligochaeta	191.2	122.4
Lumbricidae	0.0	5.2
Piscicolidae	1.6	6.4
Glossiphoniidae	10.6	22.0
Erpobdellidae	12.8	24.8
Hydracarina	4.8	10.4
Asellidae	3.6	5.6
Gammaridae	326.0	678.8
Niphargidae	5.8	0.0
Baetidae	4.0	19.6
Heptageniidae	0.8	1.2
Leptophlebiidae	0.0	3.2
Ephemeridae	0.0	0.8
Ephemerellidae	0.0	2.4
Caenidae	139.4	792.8
Corixidae	0.0	0.8
Haliplidae	0.0	4.0
Dytiscidae	0.8	0.4
Gyrinidae	1.0	0.0
Elmidae	124.4	111.6
Sialidae	0.0	0.4
Rhyacophilidae	0.0	1.6
Glossosomatidae	771.8	42.0
Hydroptilidae	1.2	8.8
Psychomyiidae	3.4	8.8
Polycentropodidae	9.8	14.8
Hydropsychidae	1.6	47.2
Lepidostomatidae	10.0	6.4
Limnephilidae	15.4	0.4
Goeridae	15.8	2.0
Sericostomatidae	6.6	7.6
Leptoceridae	29.2	18.8
Tipulidae	5.4	0.4
Dixidae	0.0	0.8
Ceratopogonidae	4.4	4.0
Simuliidae	3.2	298.4
Chironomidae	29.4	690.8
Empididae	0.2	2.8

6.3 R. Kennet at Savernake (lower and upper sites)

6.3.1 Family richness

At the lower site at Savernake, family richness was observed to be higher in December in both 1975 and 1997, than in June of the equivalent years. Note also that although *Schoenoplectus* was sampled in the 1970s as the dominant macrophyte and this was continued into the late 1990s, in both 2000 and 2001, the new dominance of *Ranunculus* at this site and the scarcity of *Schoenoplectus* necessitated a change to the sampling of *Ranunculus.* In the current five-year study, the highest summer family richness on both macrophyte and gravel occurred in the very high discharge year of 2001. This is believed to be a result of the wash-out of families which normally occupied marginal habitats (see section 7.4 for further details).

Table 6.9: R. Kennet at Savernake (Lower site). Number of families of macroinvertebrates on *Ranunculus, Schoenoplectus* and gravel in June/July 1997-2001 and December 1997. Historical data for 1975 (June + December) and 1974 (June) is also given.

Month/Year	*Ranunculus*	*Schoenoplectus*	Gravel
July 2001	32	-	32
July 2000	25	-	27
June 1999	-	31	31
June 1998	-	26	30
Dec 1997	***-***	***33***	***32***
July 1997	-	31	27
Dec 1975	***-***	***32***	***29***
June 1975	-	27	24
June 1974	-	26	28

Data on family richness for the upper site at Savernake is presented in Table 6.10. Samples taken on *Schoenoplectus* in December 1975 and on *Ranunculus* in December 1997 had higher family richness than the equivalent samples taken in June/July of the same year. Whereas this feature also applied to the gravel sampling in 1975, this did not apply to samples taken on gravel in 1997. Once again, family richness on *Ranunculus* and on gravel in July 2001 was higher than in all earlier summer samplings, as previously observed at the lower site at Savernake and at Littlecote.

Table 6.10: R. Kennet at Savernake (Upper site). Number of families of macroinvertebrates on *Ranunculus* and gravel in June/July 1997-2001 and December 1997. Historical data for 1975 (June + Dec) and 1974 (June) on these habitats and on *Schoenoplectus* is also given

Month/Year	*Ranunculus*	*Schoenoplectus*	Gravel
July 2001	30	-	33
July 2000	28	-	29
June 1999	28	-	29
June 1998	27	-	23
Dec 1997	***32***	***-***	***27***
July 1997	28	-	29
Dec 1975	***31***	***32***	***31***
June 1975	-	29	29
June 1974	29	-	27

6.3.2 Family composition and abundance

Family composition and abundance data for June/July on the Lower site at Savernake is given in Table 6.11 for gravel (1997 – 2001), *Schoenoplectus* (1997-1999) and *Ranunculus* (2000-2001). Equivalent information relating to December 1997 for gravel and *Schoenoplectus* is provided in Table 6.12.

The family composition and abundance data for gravel and *Ranunculus* in June/July 1997-2001 on the Upper site at Savernake may be found in Table 6.13 whilst the equivalent information for gravel and *Ranunculus* in December 1997 is listed in Table 6.14.

Table 6.11: R. Kennet at Savernake (Lower site). Mean densities of macroinvertebrate families (nos. 0.05 m^{-2}) on gravel, *Schoenoplectus* and *Ranunculus,* June 1997 –2001

	Gravel					Schoenoplectus			Ranunculus	
Family name	**1997**	**1998**	**1999**	**2000**	**2001**	**1997**	**1998**	**1999**	**2000**	**2001**
Planariidae	1.2	4.2	3.8	0	1.6	5.4	3	3.4	2.4	1.6
Dendrocoelidae	0	0.2	0	0	0.6	0	0.2	0.2	0	0.8
Valvatidae	0	0	0	0	0.2	0	0	0	0	3.2
Hydrobiidae	1	0	0	0.8	0	0.4	0	0	0	0
Physidae	1.2	0	0.4	0	1.6	0.4	0	0.4	0	6
Lymnaeidae	0	0	0	0.2	0.8	0	0	0	0	0.8
Planorbidae	0.8	0	0.2	0	0.2	0.4	0.2	0	0.8	0
Ancylidae	1.2	0.4	15.8	12.8	345.6	0.4	0.2	1	6.8	72
Sphaeriidae	1.6	1.4	3.6	4.2	4	1.6	4.4	5.8	12.8	8.4
Oligochaeta	134.2	69	107.6	18.8	35.6	147.2	116.8	325.8	44.4	102.8
Lumbricidae	2	1.4	4.8	0	0	0	0.6	0.6	0	0
Piscicolidae	0	0.2	0.4	0.8	3.8	5	0.2	1.2	4.4	6.8
Glossiphoniidae	22.8	0.2	0.4	0.4	10.4	53.6	1.2	0.8	7.6	9.6
Erpobdellidae	8.8	5.2	2.2	0.6	2.6	13.6	5.6	4.4	2.4	2.8
Hydracarina	4.8	0.2	0.8	3.2	13.4	7	0.2	5.4	9.6	76
Astacidae	0	0	0	0	0	0	0	0	0	0.6
Asellidae	17.6	14.2	10.6	0.8	1.4	46.2	2.2	12.4	1.6	7.2
Gammaridae	223.6	265.4	228.2	256.8	419.4	146	609	146.4	315.2	342.4
Niphargidae	1.2	4	1	1.8	0	0	0.2	0.4	2	0
Baetidae	0.8	87.8	157	35.2	32	37.6	215.6	266	167.6	182.8
Ephemerellidae	14.6	70.4	16.8	40.6	63.4	62	18.8	35	158.8	275.2
Caenidae	1.6	4.6	1.6	0	0	1	0.8	0.4	2.8	1.6
Leuctridae	0	0	0	1	0.4	0	0	0	0	0
Corixidae	0	0.2	0	0	0	0	0	0	0	0
Haliplidae	0.4	0	0	0	0	1.4	0	0	0	0.4
Dytiscidae	11.2	0.6	0.4	2	14.6	2.6	0	0	1.2	6
Hydrophilidae	0	0.2	0	0	0	0	0	0	0	0.4
Elmidae	2.2	1.6	4	5.2	19	3.6	4.4	6.4	4.8	18.8
Sialidae	2.4	0.2	0	0	0	4.2	0	0.8	0	4
Rhyacophilidae	0	0	1.8	2.2	4.2	0	1	1.8	0.8	8.4
Glossosomatidae	0	0	2.6	0	2.8	0.4	0	1.6	0.8	0
Hydroptilidae	0	0	0	0	0	0.4	0	0	0	0
Polycentropodidae	0	3.4	1.2	1.8	6	0.6	1.4	0.2	5.2	0
Hydropsychidae	0	0.2	0.2	0	1.8	0	0	0	0	0
Lepidostomatidae	0	0	0	0	0	0	0	0.4	0	0
Limnephilidae	0.2	1.2	4.8	1.6	3.8	2	0.6	2	2	8.8
Goeridae	0	0.2	1.2	0	0	0.4	0	0.2	0	0
Sericostomatidae	2.4	0.4	1.4	0.2	0.6	3.2	1.4	1.2	0	2
Leptoceridae	4.4	8	8.2	0.2	0.2	3.4	6.2	1	0	0.4
Tipulidae	0.2	3.8	2	1.6	0.8	0	4.4	3.4	0.8	4
Ceratopogonidae	3.2	2.2	2	2.8	8.2	2.4	0.2	12.2	3.6	23.2
Simuliidae	2.8	3	8	8.2	5.4	169.4	210	434.2	228	197.6
Chironomidae	595	84.2	97.8	83.4	307.8	791	801.2	239.4	389.2	458.4
Empididae	0	0	0.4	0.8	2.8	0.2	0	0.2	0	7.2

Table 6.12: R. Kennet at Savernake (Lower site). Mean densities of macroinvertebrate families (nos. 0.05 m^{-2}) on gravel and *Schoenoplectus*, December 1997

Family name	Gravel	Schoenoplectus
Planariidae	28.6	97.0
Dendrocoelidae	2.4	3.4
Valvatidae	0.4	8.4
Hydrobiidae	0.0	0.4
Physidae	0.8	3.6
Planorbidae	1.2	2.8
Ancylidae	0.4	1.6
Sphaeriidae	1.8	10.4
Oligochaeta	25.2	115.2
Lumbricidae	4.4	1.2
Piscicolidae	3.0	3.2
Glossiphoniidae	12.6	26.4
Erpobdellidae	15.2	46.2
Hydracarina	16.2	48.2
Asellidae	23.4	153.4
Gammaridae	244.6	422.4
Niphargidae	1.0	0.0
Baetidae	5.2	9.8
Ephemerellidae	0.4	2.0
Caenidae	14.4	85.4
Corixidae	3.2	0.0
Haliplidae	0.2	0.0
Dytiscidae	5.0	5.0
Elmidae	9.6	34.4
Sialidae	0.2	2.0
Rhyacophilidae	0.0	0.2
Glossosomatidae	1.2	1.6
Hydroptilidae	0.0	5.6
Polycentropodidae	1.2	14.0
Hydropsychidae	1.0	9.2
Goeridae	0.2	0.4
Sericostomatidae	4.0	2.8
Leptoceridae	35.8	21.2
Ceratopogonidae	2.6	12.2
Simuliidae	0.8	51.2
Chironomidae	53.8	302.0
Muscidae	0.0	0.8

Table 6.13: R. Kennet at Savernake (Upper site). Mean densities of macroinvertebrate families (nos. 0.05 m^{-2}) on gravel and *Ranunculus,* June 1997 –2001

Family Name	Gravel					Ranunculus				
	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001
Planariidae	8.8	2.8	4	6	7.6	1.6	4.6	3.8	5.2	0.4
Dendrocoelidae	1.2	0.2	0	0.8	2.8	0.4	0	0.4	1.6	2
Valvatidae	0.2	0.2	0	0	0	0	0	0	0	0.4
Hydrobiidae	0	0	0	0	0	0	0.2	0	0	0
Physidae	0.4	0	0	0	1	0.4	0	0.4	0	0.4
Lymnaeidae	0	0	0	0.8	0.2	0	0.2	0	0	0
Planorbidae	0	0	0	0	0	2.4	0.4	0	0	0
Ancylidae	5.6	0	8	41.4	88.4	3.6	0	3.8	4.8	2.4
Sphaeriidae	0.4	0	1.8	0.4	1.8	2	0.2	0	0	3.2
Oligochaeta	30.4	45	73.8	101.4	65.8	26.4	11	261.6	69.6	50
Lumbricidae	16.6	0.4	0.8	2.6	2.2	9.2	0.2	5.8	1.2	0.4
Piscicolidae	0	0.6	0.4	0.4	0.2	2	1.2	1.8	2.4	7.2
Glossiphoniidae	16.6	2.2	0.2	2.4	2.2	17.2	1.2	2.4	1.6	1.2
Erpobdellidae	6	11	2.2	6.2	1.4	11.6	2.6	4.4	4	3.2
Hydracarina	2.8	0	2	0	0	4.4	0.2	11.6	12	17.6
Astacidae	0	0	0	0	0.2	0	0	0	0	0
Asellidae	9.6	12.6	5.2	2	1	34.4	4.4	22.4	2	1.6
Gammaridae	196.4	319.4	155.4	136.6	256	165.6	202.8	125.4	250.2	317.6
Niphargidae	0	0.8	0.2	0	1.8	0.4	0	0.4	3.2	0
Baetidae	2.8	99	53.6	88.6	36.2	10.8	133.8	218	207.2	284.8
Ephemerellidae	17.6	67.6	26.8	75.8	73.6	67.2	271.8	95.4	190.4	346.8
Caenidae	1.6	7.4	2.2	0	0	3.6	5.6	3.2	2.4	0
Nemouridae	0	0	0	0	0	0	0	0	0	0
Leuctridae	0	0	0	0.2	0.2	0	0	0	0	0
Corixidae	0	0	0	0	0	0	0.2	0	0	0
Haliplidae	0	0	0.2	0	0	0	0	0	0	0
Dytiscidae	2.8	0.8	1.4	0.8	4.6	0.4	0.2	0.2	0.4	3.6
Hydrophilidae	0	0	0	0	0	0	0.2	0	0	0.8
Elmidae	3.8	4.2	6	12.8	14.2	8.4	1.6	4.4	3.6	11.2
Sialidae	0	0	0	0	0.2	0.8	0	0	0.4	1.2
Rhyacophilidae	0.2	0.6	2.2	1.2	5.8	1.2	0.2	3.2	3.2	5.2
Glossosomatidae	0.6	0	0.6	0.2	1.6	0	0	0	0	0
Hydroptilidae	1	0	0	0	0	0	0.4	0.4	0	0
Polycentropodidae	0	0	0.4	3.4	3.4	0	0.4	0	3.6	4.8
Hydropsychidae	0	0	0	0.2	0	0	0	0.4	0.4	0
Lepidostomatidae	0	0	0	0	0.2	0	0	0.8	0	1.2
Limnephilidae	3	0.4	1.6	3.2	4	0	1.2	5.4	4.4	6
Goeridae	0.4	0	0.4	3	2.8	0.4	0	0	0.8	0.8
Sericostomatidae	7	0.8	1.2	1	3	4.4	0.4	1.2	2	5.2
Leptoceridae	6.2	4.6	1.2	1.2	3.2	1.6	1.2	1	0.4	0.8
Tipulidae	0.4	0.2	3.8	0.4	1.8	0	0	0	0	0
Ceratopogonidae	4	0.4	3.6	2.8	5.2	4	0	2.6	2	4
Simuliidae	0.2	9	1.8	12.4	20.2	120.8	230.8	197.6	426	356.4
Chironomidae	160.4	19	27.4	67.6	126.8	254.8	45.6	156.8	195.6	378.8
Empididae	0.4	0	2	1.8	7.2	0.8	0	1.2	0.8	3.6

Table 6.14: R. Kennet at Savernake (Upper site). Mean densities of macroinvertebrate families (nos. 0.05 m^{-2}) on gravel and *Ranunculus*, December 1997.

Family name	Gravel	Ranunculus
Planariidae	27.2	5.0
Dendrocoelidae	0.2	0.0
Valvatidae	0.0	0.4
Hydrobiidae	0.0	0.4
Physidae	0.0	0.4
Planorbidae	0.4	1.8
Ancylidae	1.6	3.6
Sphaeriidae	0.4	3.2
Oligochaeta	16.2	11.6
Lumbricidae	2.2	4.8
Piscicolidae	3.2	1.2
Glossiphoniidae	7.2	10.0
Erpobdellidae	9.8	18.2
Hydracarina	30.4	28.4
Asellidae	20.2	83.8
Gammaridae	294.8	303.6
Baetidae	4.4	23.0
Ephemerellidae	1.6	7.6
Caenidae	34.8	27.6
Haliplidae	0.8	0.0
Dytiscidae	0.4	1.2
Elmidae	20.8	87.4
Sialidae	0.8	0.2
Rhyacophilidae	0.0	0.4
Glossosomatidae	0.4	4.0
Polycentropodidae	0.4	1.2
Hydropsychidae	0.0	1.6
Lepidostomatidae	0.8	0.8
Goeridae	0.0	0.4
Sericostomatidae	2.4	7.2
Leptoceridae	18.0	63.6
Tipulidae	0.0	0.8
Ceratopogonidae	1.2	1.8
Simuliidae	2.4	41.2
Chironomidae	99.4	70.8

7. SYNOPSES OF THE FIVE SCIENTIFIC PUBLICATIONS

7.1 Impact of Droughts on the R. Lambourn at Bagnor (1 and 2)

7.1.1 Publication No. 1

Wright J F, Gunn R J M, Winder J M, Blackburn J H and Wiggers R. (2000b) The Response of Chalk Stream Macroinvertebrates to a Prolonged Drought – The Value of a Long-term Dataset; *Verhandlungen der internationalen Vereinigung fur theoretische und angewande Limnologie*; **27**, 912-915.

Study site and datasets

R. Lambourn at Bagnor (shaded site)
Percentage cover data of major habitats in the 1970s.
Macroinvertebrate data (family level with abundance). All available habitats, June 1971-79.
Macroinvertebrate data (family level with abundances) for all available habitats, June and December 1997 only.

Aim of study

Evaluation of the response of the macrophytes and macroinvertebrate fauna to the 1997 drought, using detailed information available in the 1970s dataset.

Background information

During the 1970s the R. Lambourn experienced a minor drought in 1973 and a major drought in 1976. In 1996-97 the river experienced a prolonged drought and habitat mapping and quantitative sampling of the macroinvertebrates each habitat was restarted in summer 1997. However, an additional factor was also relevant. Whereas in the 1970s the site was managed as a trout fishery, these activities ceased in the 1980s and in 1997 the site was unmanaged.

Major results

In 1997 the area of instream macrophyte was lower than in the 1970s, but marginal emergent macrophytes were now in evidence. These changes were thought to be due to a combination of the prolonged low flows and lack of control of bankside vegetation, which then caused shading of the river and poor weed growth. In general, family richness on each of the habitats was found to be lower in both June and December 1997 than the mean values for the 1970s, based on 7 years data. However, a total of 52 families were recorded on the five core habitats in June and December 1997 compared with a range of 46-53 families recorded over seven years in the 1970s. Six additional families were restricted to emergent vegetation in 1997. Thus, there was no evidence to suggest an overall loss of family richness on the site as a result of the drought or lack of recent management. The grand total of 58 families included 18 'families' of non-insects and 40 'families' of insects, representing a very rich assemblage for a 50 metre section of river.

Four families whose densities in the low flow year of 1997 differed significantly from those in a high flow year (1975) on both *Berula* and gravel were examined in more detail. Densities of Baetidae and Caenidae (Ephemeroptera) and also Simuliidae (Diptera) were significantly lower during the drought of 1997 than in June 1975, whilst Ephemeridae (Ephemeroptera) occurred in significantly higher densities in June 1997. Weighted mean densities of each family on the site in June throughout the 1970s and for 1997 were plotted against the mean monthly discharge for the three-month period (March –May) which preceded sampling. In general, both Baetidae and Simuliidae exhibited high densities when discharge was high and *vice versa*. The densities were low in each of the drought years of 1973, 1976 and 1979. However, they were also low in 1972 (due to loss of water during upstream hatch repairs) and in 1979, when the area of suitable habitat in the form of submerged macrophyte was unusually low.

Conclusions

The combined effect of the low discharge regime of 1996-97 and the recent lack of management did not have deleterious effects on site richness at family level. However, two important and characteristic families of chalk streams (Baetidae and Simuliidae) both suffered a catastrophic reduction in the densities of larvae in June 1997, towards the end of the long drought. This response was probably compounded by poor growth of submerged macrophytes, resulting from low discharge but also from a lack of river management, which caused additional shading of the water surface.

7.1.2 Publication No. 2

Wright J F, Gunn R J M, Winder J M, Wiggers R, Kneebone N T and Clarke R T. (2002c) The impact of drought events in 1976 and 1997 on the macroinvertebrate fauna of a chalk stream. *Verhandlungen der internationalen Vereinigung fur theoretische und angewande Limnologie*, **28**, 948-952.

Study site and datasets

R. Lambourn at Bagnor (shaded site)
Macroinvertebrate data (family level with abundances) for *Berula* and gravel in June 1974-1979 plus June 1997-2000.

Aim of study

Recently there has been an increase in the frequency of drought events in southern England and there is now an urgent need to investigate and understand the ecological effects of low flows. The long-term data available in this project enables us to examine the impact on the macroinvertebrate fauna of the historic drought of 1976 and the more recent 1997 drought.

Background information

This study uses a six-year run of June data for *Berula* and gravel (the dominant macrophyte/non-macrophyte habitats) from 1974-1979 together with a recent four-year dataset (1997-2000). The 1970s dataset includes two years before the historic drought of 1976, in order to place the drought in context, plus three post-drought years when the river experienced high discharge. The recent dataset comprises the drought year (1997) and the next three years, which also experienced a higher discharge regime.

Major results

ANOVA demonstrated that on *Berula*, there were no significant differences in average faunal richness between 1974-79 and 1997-2000. In contrast, on gravel there were significant differences between sampling periods, with lower family richness in 1997-2000. This change appeared to be unrelated to drought conditions. When sampling periods were analysed separately, *Berula* exhibited lower family richness in the drought year of 1976 and also in the drought year of 1997. In contrast, no such differences were observed on gravel between individual years when each of 1974-1979 and 1997-2000 were analysed separately.

When sampling units from *Berula* and gravel were combined for a given year, they revealed that a lower number of families were captured in the drought years of 1976 (35 families) and 1997 (31 families) compared to a range of 37-43 families in non-drought years.

Overall, there were significantly higher numbers of individual macroinvertebrates on *Berula* compared to gravel. When the habitats were analysed separately, there were no significant differences in either case between the average number of individuals in the 1970s and the 1990s. In the 1970s, there were higher numbers of individuals on *Berula* in 1976 than most other years and on gravel numbers were significantly higher in 1976 than in 1975. However, in the 1997-2000 dataset for both *Berula* and gravel, there were no significant differences between years.

Community analysis using Principal Components Analysis (PCA) was employed to integrate information on family composition and abundance in order to examine the impact of the drought conditions. In the case of *Berula* the drought years of 1976 and 1997 were distinct from all others. Interestingly, the pre-drought (1974/75) condition was quickly restored after the 1976 drought. A shift in faunal structure between the 1970s and the 1990s was also a notable feature. The analyses using gravel samples also demonstrated the impact of the two drought years and the overall changes between the 1970s and 1990s.

The changes in faunal composition which distinguished the two drought years from the non-drought years in each of the two separate sampling periods were investigated using Mann-Whitney U-tests. It was apparent that a small number of families occurred at lower densities in both droughts. The most important of these were Simuliidae (blackfly larvae) and Baetidae (mayfly nymphs), but Glossosomatidae (cased caddis) and Planorbidae (snails) also occurred in this category. Families that were more abundant during both droughts included Ephemerellidae (mayfly nymphs) and Hydroptilidae (cased caddis). Chironomidae (non-biting midges) were present in very high densities on both *Berula* and gravel during the drought of 1976, but this was not repeated in the drought of 1997.

Conclusions

Although the macroinvertebrate fauna in the lower perennial section of this chalk stream was affected by drought conditions, particularly in terms of faunal abundance, the study site showed rapid recovery, whether it was managed as a trout fishery (1970s) or left unmanaged (late 1990s).

7.2 Comparison of Macrophytes and Macroinvertebrates at Three Sites on the R. Kennet in the Mid 1970s and Late 1990s (3)

Wright J F, Gunn R J M, Winder J M, Wiggers R, Vowles K, Clarke R T and Harris I. (2002b). A comparison of the macrophyte cover and macroinvertebrate fauna at three sites on the R. Kennet in the mid 1970s and the late 1990s. *Science of the Total Environment,* 282-283, 121-142.

Study site and datasets

R. Kennet at Littlecote and Savernake (Upper and Lower sites).
Monthly percentage cover data for Littlecote between April 1974 and June 1976. Additional data for July and December 1997, plus June 1998 and 1999.
Monthly percentage cover data for the two Savernake sites between April 1974 and April 1976. Additional data for July and December 1997, plus June 1998 and 1999.
Macroinvertebrate data (family level with abundances) for Littlecote (*Ranunculus* and gravel) in June 1974, June and December 1975 together with July and December 1997, June 1998 and June 1999. Equivalent data for Savernake Lower (*Schoenoplectus* and gravel) and Savernake Upper (*Ranunculus* and gravel).

Aim of study

To document the long-term persistence of the macroinvertebrate fauna on a major chalk stream, examine the impact of and recovery from the 1996-97 drought and assess the role of *Ranunculus* in shaping the macroinvertebrate assemblages.

Background information

Ecological studies were undertaken on the R. Kennet at the above three sites in the mid-1970s because the Thames Conservancy were planning a groundwater scheme which would take water from the chalk aquifers of the R. Kennet and its tributaries. In the 1990s, protracted droughts occurred in 1991-92 and again in 1996-97. The ecological impact of these low flows could be exacerbated by water abstraction. The Environment Agency, Thames Region, contracted CEH to use the 1970s mapping and sampling protocols from summer 1997 onwards to address the question of the impact of the 1996-97 drought and the rate of recovery from such an event.

Major results

At Littlecote, in spring and summer 1974 and 1975, *Ranunculus* covered a major proportion of the river-bed, but as the historic drought of 1976 took hold in June of that year, it was held back by an accumulation of epiphytic algae and associated detritus.

When mapping recommenced in early July 1997, the area of *Ranunculus*, though lower than 1974-75, was substantially greater than in 1976. In the subsequent years of 1998-99 *Ranunculus* occupied a substantial proportion of the river-bed once again, indicating rapid recovery from the 1996-97 drought.

On the lower site at Savernake in the mid-1970s, *Schoenoplectus* was dominant in all seasons, occupying ~60% of the riverbed with *Ranunculus* not exceeding 20% in summer. By July 1997, although the river was flowing freely in an attempt to promote the growth of *Ranunculus*, the area of *Schoenoplectus* was below 20% cover and *Ranunculus* occupied less than 1% cover. However the following June, after the end of the drought, *Ranunculus* occupied 43.6% of the riverbed and then 53.7% in June 1999, whilst the area of *Schoenoplectus* continued to decrease, probably due to severe shading by *Ranunculus*.

On the Upper site at Savernake which was shallower and faster flowing than the lower site, seasonal growth of *Ranunculus* exceeded the area of *Schoenoplectus* in the summer of 1974 and 1975. In July 1997 it was apparent that this site had suffered similar effects as the lower site with substantial loss of *Schoenoplectus* and *Ranunculus* (now just 6.5%), despite efforts to narrow the channel and increase current speed with current deflectors. However, following the end of the drought, spectacular growth of *Ranunculus* occurred in both 1998 (48.8% cover) and 1999 (56.5%), whilst the area of *Schoenoplectus* remained low.

Fifty-six families of macroinvertebrates were found at the three sites during this study, 52 at Littlecote, 44 at Savernake Lower and 43 at Savernake Upper. Some apparent changes in family composition between the 1970s and 1990s are detailed within the manuscript. ANOVA indicated that there were significant overall differences in family richness between sites and between years, but not between habitats.

Differences in family composition and abundance between sites and also changes over time were examined using PCA. Samples collected at Littlecote were shown to be distinct from those collected at the two Savernake sites. In addition, samples taken in the mid-1970s on each site were separated in ordination space from samples taken on the same site in the late 1990s. Finally, samples taken at each of the Savernake sites in 1997 were spatially separated from the 1998 and 1999 Savernake samples, whereas this clear distinction was not apparent at Littlecote. Whereas the 1996-97 drought had only a limited impact on the growth of macrophyte at Littlecote, both Savernake sites had suffered a major loss of macrophyte when mapping recommenced in 1997. Given that there were relatively minor changes in family richness and composition between 1997 and 1998/99, the major contributory factor to the results obtained in 1997 would appear to be the differences in abundance. Differences in abundance between 1997 and 1998 were investigated using Mann-Whitney U-tests. The results suggested that the fauna in 1997 was affected by low flow conditions and by enrichment. In 1997 some families which favour lentic conditions occurred in high abundance whilst, following the end of the drought in 1998, the fauna demonstrated a rapid response to the new conditions and the assemblages reverted to those expected in a fast-flowing chalk stream. The manuscript discussion also includes a consideration of the possible mechanisms involved in the substantial loss of *Ranunculus* at the Savernake sites in the late 1980s and 1990s.

Conclusions

The two study sites at Savernake, just downstream of Marlborough had experienced a major loss of macrophytes by summer 1997, compared to the mid-1970s. In contrast, further downstream at Littlecote seasonal growth of *Ranunculus*, although delayed by the drought of 1997, remained an important habitat. In autumn 1997 phosphate stripping commenced at Marlborough STW, the drought came to an end and there was heavy rainfall the following spring. Regrowth of *Ranunculus* on both Savernake sites was spectacular and it became the dominant macrophyte.

There were minor changes in macroinvertebrate family composition on the three sites between the 1970s and 1990s. A variety of factors were probably responsible including recent colonisation, crayfish plague, and the impact of recent droughts and enrichment (at Savernake). However, there was no evidence of a major loss of family richness.

Multivariate analysis (PCA) demonstrated differences in faunal composition between sites and between study periods. It also highlighted important differences in family abundance at Savernake between 1997 and 1998/99, whereas only minor differences were apparent at Littlecote. The extent to which low flows, poor weed growth, siltation and enrichment from Marlborough STW and other sources contributed to changes in faunal abundance at Savernake is difficult to unravel. However, other studies suggest a dominant role for the discharge regime in controlling macrophyte growth and, following the end of the drought *Ranunculus* dominated all three sites.

7.3 Impact of Changes in River Management on the R. Lambourn at Bagnor (4)

Wright J F, Clarke R T, Gunn R J M, Winder J M, Kneebone N T and Davy-Bowker J (2003). Response of the flora and macroinvertebrate fauna of a chalk stream site to changes in management. *Freshwater Biology*, 48, 894-911.

Study site and datasets

R. Lambourn at Bagnor (shaded site)
Percentage cover data of the major habitats in June 1975-1979 and also June 1997-2001.
Macroinvertebrate data (family level with abundances) for all available habitats in June 1975-1979 and June 1997-2001.

Aim of study

To examine how changes in river management, from a regime as practised by river keepers on many chalk streams to an essentially unmanaged state, influence the instream and riparian vegetation and hence the macroinvertebrate fauna.

Background information

Throughout the 1970s, the Piscatorial Society operated on the R. Lambourn at Bagnor and their river keeper managed the river by selective weedcutting. He also mowed the banks for ease of access, left uncut vegetation at the water's edge for emerging insects and controlled the growth of overhanging trees and bushes. During the 1980s fishing and the associated management ceased and the river slowly reverted to an unmanaged state. As a consequence, shading markedly increased on the site due to the trees and bushes on the south bank and progressive encroachment of marginal vegetation from the north bank.

Major results

Although the mean area of riverbed at the site was very similar in both study periods, the vertical banks typical of the managed state in the 1970s had broken down by the 1990s and therefore in the second study period, the actual area in a given year was more dependant on the discharge and weed within the channel at that time.

Major changes in habitat composition also took place between 1975-79 and late 1997-2001. The mean area of instream macrophytes (*Berula, Ranunculus* and *Callitriche* combined) decreased by 50% whilst gravel and silt increased. In addition, the invading marginal vegetation formed a new habitat for colonisation by macroinvertebrates.

Changes in macroinvertebrate family richness between the two sampling periods were scale dependant. Thus, although there were on average significantly more families in individual sampling units in 1975-79 as compared to 1997-2001, nevertheless, total family richness for the site in each year did not differ significantly between the sampling periods.

In total, 60 families of macroinvertebrates were recorded during this study, 50 in both sampling periods, 53 in 1975-79 and 57 in 1997-2001. This small increase in overall site family richness in the second sampling period may be due to the invading marginal plants.

However, total macroinvertebrate abundance was significantly lower in the second sampling period. The historic drought of 1976 resulted in significantly higher densities of macroinvertebrates, partly through the exploitation of epiphytic diatoms by chironomid larvae. In contrast, the 1997 drought failed to elicit a similar response because of the limited macrophytes and diatoms under heavy shading by trees and marginal vegetation.

There were significant changes in the importance of some functional feeding groups. For example, there were increases in important shredders and decreases in some scrapers between the early and late sampling periods. These largely reflected changes in the available food resources.

Conclusions

'Chalk rivers' have been designated as a UK Biodiversity Action Plan Habitat and the R. Lambourn has also been scheduled as a Site of Special Scientific Interest. This study indicates that, despite a change from intensive management in the 1970s to the present non-interventionist regime, persistence (constancy of community composition through time) measured at the crude scale of family occurrence has remained high for over 25 years.

However, heavy shading has impacted on the percentage cover of habitats and available food resources and there have been substantial temporal changes in the abundance of many families. For example, when the river was managed as a fishery, Ephemerellidae and Baetidae (mayflies whose subimagos and imagos are mimicked by dry fly fishermen) were more abundant than they are now, under the no management regime. It appears that management for trout fishing promoted both primary production and secondary production, including high populations of the fly life taken by brown trout and mimicked by fishermen.

Fortunately, the lower perennial section of the R. Lambourn includes both shaded and unshaded stretches of river and therefore community persistence, which is an essential requisite for the conservation of biodiversity should be assured if measures in place to maintain water quality and quantity are successful.

7.4 Faunal Response at Four Sites to Low and High Flow Events (5)

Wright J F, Clarke R T, Gunn R J M, Kneebone N T and Davy-Bowker J (to be submitted). Impact of major changes in flow regime on the macroinvertebrate assemblages of four chalk stream sites, 1997-2001.

Study sites and datasets

Three sites on the R. Kennet (Savernake Upper, Savernake Lower and Littlecote) plus the R. Lambourn at Bagnor (shaded site).
Percentage cover data of major habitats in June/July 1997-2001 for the above four sites.
Macroinvertebrate data (family level with abundances) for the dominant macrophyte and also gravel in June/July 1997-2001 on each of the above four study sites.

Aim of study

To document the faunal assemblages at each of these four sites and on two contrasted habitats in terms of family richness, composition and abundance and investigate faunal response to the major changes in discharge regime observed over the study period.

Background information

This study of four chalk stream sites on two subcatchments started in the second year of a major drought (1997) but in subsequent years the discharge prior to sampling was higher, culminating in the exceptionally high discharge regime observed in the winter and spring of 2000/2001. Note that the two study sites at Savernake were suffering from loss of *Ranunculus* at the outset of the study, that the character of the Littlecote site was little changed from the 1970s and that the site on the R. Lambourn at Bagnor differed from the three Kennet sites in being heavily shaded as a result of lack of recent management.

Major results

ANOVA demonstrated that there were significant differences in family richness in relation to site, habitat and year. In fact, family richness at the two Savernake sites was significantly lower than that recorded at Littlecote, further downstream and also on the R. Lambourn at Bagnor. ANOVA also showed that there were significant differences in overall macroinvertebrate abundance between sites, between years and most notably between habitats. Highest overall abundance occurred at Littlecote, the lowest sampling site on the Kennet. The highest discharge year of the study, 2001, had significantly higher abundance of macroinvertebrates than three of the other four years. In addition, macroinvertebrate abundance was higher on macrophytes than on gravel at each of the four study sites.

Multidimensional scaling (MDS) based on Bray-Curtis dissimilarities, which takes account of both family composition and abundance, also demonstrated significant differences between sites, habitats and years. Although the two Savernake sites could not be separated, they were distinct from the samples taken downstream at Littlecote and these were distinct from the samples at Bagnor. In addition, samples on macrophyte were distinct from those on gravel at Bagnor and Littlecote, and separated in most cases at the Savernake sites.

In total, 57 families of macroinvertebrates were recorded during this five-year study. Unexpectedly, in view of the earlier results, 43 families were recorded on each one of the three Kennet sites. Between habitat differences in richness at these three sites were minimal. In contrast, 51 families were recorded at Bagnor, and whereas family richness on *Berula* was substantially higher than on the Kennet macrophytes, richness on Bagnor gravel fell below that on the Kennet sites. Additional information on the families which contributed to these results is provided within the paper.

Further analyses examined, in greater detail, changes in faunal assemblages at each site and habitat between 1997 and 2001. At each of the three Kennet sites and on each of gravel and macrophyte, family richness was highest in 2001, with no clear trend in richness between 1997 and 2000. Changes in family composition and abundance over the five years on each site and habitat were examined separately in a further series of eight (i.e. 4 sites x 2 habitats) MDS ordinations. In all but one of the eight cases, the greatest between-year dissimilarities occurred between the drought year of 1997 and 1998.

Information is presented on the eight most abundant families in the study. These families always represented at least 75% of total family abundance on each site, habitat and year combination, and typically over 85% of total abundance. Taking these eight families on the two habitats of the four sites, the highest densities over the five year study occurred in only 11% of cases in the drought year of 1997 but in 31% of cases in the high discharge year of 2001.

Conclusions

It appears that in the perennial sections of chalk streams of high biological quality there is a high level of persistence of the macroinvertebrate families through both drought and high flow events. Drought events appear to affect the abundances of many macroinvertebrates but recovery is normally rapid. The sampling programme undertaken after the unusually high discharge regime encountered in 2001 demonstrated that there were no immediate adverse effects on the macroinvertebrate fauna resulting from this event. In fact, family richness on both habitats of each of the three Kennet sites peaked in 2001, probably as a result of wash-out of families which normally occupied marginal habitats. In addition, family abundance peaked or reached second highest values on all four sites and both habitats in 2001, indicating that the high discharge regime did not have detrimental consequences for the macroinvertebrate assemblages of these sites.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

This five-year sampling programme (1997-2001) at four chalk stream sites on the R. Kennet and R. Lambourn was initiated during the second year of the 1996-97 drought, when there was concern that a succession of droughts may have had a detrimental impact on the flora and fauna of these chalk streams. This new dataset provides a firm basis from which to compare the current flora/fauna with that recorded using the same procedures in the 1970s. Long-term studies are essential in order to document the extent of between-year variation and interpret biotic response to extreme events including droughts and periods of high discharge. The 1997-2001 dataset has now been used to examine the response of the flora and fauna to the 1996-97 drought. In addition, the discharge regime over the winter/spring period of 2000/01 was unusually high, providing further information on the response of the biota to another extreme hydrological event.

Some sites have provided further insights into the response of the macroinvertebrate fauna to changes in management (Lambourn at Bagnor) or the return of *Ranunculus* as the dominant macrophyte at a site (Kennet at Savernake). In contrast, Littlecote appears to have changed little from the 1970s and has been viewed as a valuable control site.

Thus, the information collected and analysed over the past five years forms the basis for achieving the overall objective of the project. That is, to improve the Environment Agency's knowledge of chalk stream ecology in order to manage chalk streams in a sustainable manner and maintain their biodiversity. This is of increasing importance at a time when there appears to be an increased risk of summer droughts and winter/spring flood events.

In the following sections, some brief conclusions and recommendations are provided for each of the study sites.

8.2 R. Lambourn at Bagnor

8.2.1 Conclusions

The macrophyte and macroinvertebrate studies undertaken on the R. Lambourn at Bagnor throughout the 1970s and more recently between 1997 and 2001 use a unique and very comprehensive dataset. A substantial number of papers have been published in the scientific literature as a result of these studies (see Appendix). They include new sampling apparatus, sampling strategies, studies on the growth and recession of aquatic macrophytes, quantitative studies on the macroinvertebrate fauna of different habitats through the seasons and information on the distribution and ecology of particular species or taxonomic groups. Later studies involving longer datasets have considered the response of the flora and macroinvertebrate fauna to different flow regimes and, in particular, low flow conditions (see section 7.1). The change from the river management regime of the 1970s designed to optimise the trout fishery to an unmanaged state in 1997-2001 provided an invaluable opportunity to document the consequences of this change in management for the macrophytes and macroinvertebrate assemblages (see

section 7.3). Finally, the Bagnor site has been included in the latest series of analyses at four sites which investigate faunal response to flow conditions, including a low flow and also an unusually high flow event (see section 7.4).
In view of the range of detailed studies undertaken on this site over the past thirty years, and the fact that there is an Environmental Change Network (ECN) site just upstream, there are strong arguments for mapping/resampling the site at some point in the future in order to document whether this site, which is within the R. Lambourn Site of Special Scientific Interest (SSSI), has retained its flora and fauna under the prevailing conditions.

8.2.1 Recommendations

1. Ensure that the exact location of each of the sampling sites is defined by existing mapping stakes or, if necessary, by the insertion of new mapping stakes at critical locations to ensure that the sites are defined for future use.

2. Consider a future programme of mapping/sampling. This might involve summer surveys at five-year intervals or be responsive to perceived environmental change. With the second option a series of summer surveys, as undertaken between 1997 and 2001, could be more appropriate.

3. Consider an experimental treatment at the site in which the river management procedures of the 1970s, including the control of marginal vegetation, cutting back of bankside tree and even weedcutting are re-established to determine whether the flora and fauna revert to their status in the 1970s.

8.3 R. Kennet at Littlecote

8.3.1 Conclusions

The visual appearance of this site in 1997-2001 was very similar to that in the 1970s, and the same regime of bar-cutting and bankside maintenance has continued with the interests of the trout fishery in mind. Scientific papers dealing with the effects of weed cutting on *Ranunculus* and also a study of the population structure, growth and biomass of the brown trout may be found in the Appendix.

The long-term stability of this site within the R. Kennet SSSI has been of particular help when evaluating the substantial changes observed between the mid-1970s and late 1990s on the two Savernake sites further upstream (see section 7.2). For example, in the drought summer of 1997, although the growth of *Ranunculus* was slower than normal, nevertheless, it covered 44.2% of the site in July 1997 and in subsequent years growth of *Ranunculus* was good. In addition, changes in family composition and abundance on *Ranunculus* and gravel between the 1970s and late 1990s were relatively low under a range of different discharge regimes. Information on this and three other sites has also been used in a further manuscript which examines faunal response to the low and high flow events of 1997-2001 (see section 7.4).

8.3.2 Recommendation

1. This site would be of potential value as a 'control' site in any future studies undertaken upstream at the Savernake sites in connection with low flows, water quality or the effect of particular management practices. Hence, retention of information on the precise location of this site would be useful.

8.4 R. Kennet at Savernake

8.4.1 Conclusions

The two sites at Savernake, which are also within the R. Kennet SSSI, have proved to be of considerable ecological interest, not only because of the changes which occurred on this section of river downstream of Marlborough between the mid-1970s and the 1990s but also because of further changes which have taken place during the 1997-2001 study. Several papers on the chironomid fauna at Savernake plus a paper on the brown trout populations at both Savernake sites have been published, based on data for the mid-1970s (see Appendix).

The substantial reduction of macrophyte cover at both sites between the mid-1970s and the 1990s, and the spectacular recovery of *Ranunculus* from 1998 onwards, following the end of the 1996-97 drought and the start of phosphate stripping at Marlborough STW in autumn 1997 have already been documented (see section 7.2). The underlying reasons for these changes need further study. However, at sites on the R. Lambourn, there is observational evidence that in years of low discharge, growth of *Ranunculus* is restricted by the accumulation of epiphytic algae and associated detritus on the surface of the plants (Ham *et al*. 1981, Wright and Berrie 1987).

At Savernake, the potential for this problem to be compounded in low flow years by the presence of nutrients from Marlborough STW, plus diffuse sources resulting from agricultural activities is apparent. Faunal changes between 1997 and 1998 in the aftermath of the changes in water quality, quantity and habitat (*Ranunculus*) were also examined. On both Savernake sites the fauna underwent a notable change between summer 1997 and 1998, mainly due to changes in faunal abundance. In 1997 there were high densities of three families of leeches, Asellidae and Chironomidae, all normally associated with slow flow/eutrophic conditions. In 1998, under high flow conditions, these families normally occurred at significantly lower densities but in contrast, there were high densities of mayflies in the family Baetidae which favour high discharge conditions. Despite this, the relative importance of flow regime, water quality and available food resources, as influences on the density of particular macroinvertebrates need careful consideration.

Finally, the two Savernake sites are also part of the four site study of faunal response to the low and high flow events which occurred between 1997 and 2001 (see section 7.4).

In addition to the research undertaken by CEH Dorset and reported here, there are a number of other studies underway on the R. Kennet below Marlborough. CEH Wallingford and the University of Reading have a substantial research interest in the hydrology, water chemistry and biological interactions between the algae and macrophytes on this section of the R. Kennet and a series of scientific publications covering many of these topics can be found in volume 282-283 of the *Science of the Total Environment* which was published in 2002.

8.4.2 Recommendation

1. It would be valuable to undertake a mapping and macroinvertebrate sampling operation through a future drought event at Savernake, to document the impact of low flows on the flora and fauna now that phosphate stripping is in place and some river restoration measures have been put in place. Hence, retention of information on the precise location of these sites would be useful.

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APPENDIX

LIST OF SCIENTIFIC PUBLICATIONS RESULTING FROM ECOLOGICAL STUDIES ON THE R. LAMBOURN AND R. KENNET DURING THE 1970s AND BETWEEN 1997 AND 2001 (IN CHRONOLOGICAL ORDER)

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