Utilisation of off-river habitats by lowland river fishes

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Utilisation of Off-River Habitats by Lowland River Fishes

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Thesis submitted for the degree of Doctor of Philosophy

University of Durham
School of Biological and Biomedical Sciences

May 2006

Declaration

The material contained in this thesis has not previously been submitted for a degree at the University of Durham or any other university.

All work in this thesis was that of the author, unless acknowledged otherwise.

Abstract

This study assessed the importance for fish of lateral connectivity of river side-channels to the River Frome, a lowland chalk stream in Southern England. Lateral connectivity and habitat complexity is under threat in many floodplain river systems due to human disturbance. A holistic approach was used to investigate fish communities in seven side-channels (including drainage ditches, natural streams and a millstream) and to assess the functionality provided by these habitats to fish species. Seasonal electric fishing over three years was used to monitor fish assemblages in each channel in relation to biotic and abiotic variables. Fish movements between the main channel and lateral habitats were monitored continuously in five locations with PIT (passive integrated transponder) telemetry. In total over one hundred pike (*Esox lucius*) and dace (*Leuciscus leuciscus*) were radio tracked to monitor the movements of individual fish with increased sensitivity.

Each side-channel provided a distinct habitat and supported a different fish community. Flow was the main discriminating factor between channels and their assemblages. General linear models of biotic and abiotic variables did not predict abundances of individual species effectively. In contrast, habitat stability was a good indicator of species diversity and may prove a useful management tool. Side-channels were used for different functions by different species. A single fish species used a range of habitats within the river system, each for different functions with functional differences in use between seasons.

The River Frome dace population exhibited a structured population with individuals exhibiting different uses of the main river and side-channels. The structure of the population is based upon the availability of both lateral and longitudinal connectivity, with dace moving between the main river and side-channels and also making excursions over 10 km along the main river channel. Drainage ditches are a particularly important pike spawning location, with males arriving earlier onto this distinct habitat. Protandry (early arrival strategy of some males) was exhibited by slow-growing male pike which arrived as early as December. Growth was also related to home range size in males, with faster growing males inhabiting larger, home ranges.

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Acknowledgements

I am grateful to the Natural Environment Research Council (N.E.R.C) for funding this LOCAR tied studentship.

Very special thanks to my supervisors Rodolphe Gozlan and Martyn Lucas. Rudy (CEH Dorset) for the inspiration and guidance provided during the course of this Ph.D. and helping me see the "bigger picture". Martyn (University of Durham) for being so involved despite the long distance and for constructive and profitable discussions on many subjects.

I am grateful to Michael Bone for his willingness to help building and trouble-shooting the PIT detectors…together we beat them! Thank you to the Fish Department for their involvement in the LOCAR project. My appreciation goes to the CEH library staff for their willingness and speed to respond to even the most obscure of requests and to the computing staff for keeping me up and running. I am grateful to Ralph Clarke for useful statistical chats and to Robert Kenward and Sean Walls for many interesting and profitable discussions on all things to do with animal movements. Chapter 7 is taken largely from a multi authored paper in which Robert was greatly involved. Thank you to all CEH staff, particularly the volleyball team who endured my poor skills over the years!

My gratitude also goes to all the students that helped during and before my Ph.D. Jerome Masters, Silvia Fernandes, Mike Smith, Laure Arbogast, Jack Cutler, Kate Hawley, Simon Hately, Rob Hinks, Tom Bernard and Jessie Baeten all added their own energy and enthusiasm to the project and helped me keep track of all those fish on the move.

Last, but not least…A great appreciation goes to my dad for writing the macros used for the PIT data and to both my parents for their endless support. Thank you for letting me keep that goldfish I won at the school fete when I was seven, it all started there! Finally, to Ian for his support, his great belief in me at times when even I thought all may be lost and for listening to the endless 'fishy' thoughts. Time to rediscover life outside a Ph.D.!

Chapter 1

General Introduction

1.1 River Floodplain Habitats: Functionality of a Declining Fish Habitat

Some of the first conceptual models of the principles of river systems focussed primarily on longitudinal (main river channel) processes and functions (Chorley 1962, Cummins 1974, Huet 1954, Leopold and Maddock 1953, Vannote et al. 1980). Subsequent work soon showed that focussing only on the longitudinal main river corridor was too limited for understanding the ecology of lowland freshwater fishes and that the ecological integrity of floodplain rivers depends on the ecological connectivity acting across their floodplains (Amoros and Roux 1988, Ward and Stanford 1995). In the four-dimensional concept of running water systems (Ward 1989) the four dimensions are the longitudinal dimension, latitudinal dimension, the vertical dimension consisting of interactions between the channel and contiguous groundwater and finally the temporal scale. In this model the ecological integrity of temperate floodplain rivers is largely due to hydrological features, such as the flood pulse, which seasonally forms a moving littoral traversing the floodplain surface across the aquatic/terrestrial transition zone (ATTZ) (Junk et al. 1989). Temperate river systems class into two types; montane snow-fed systems and oceanic non-montane rain-fed systems, with snow-fed systems tending to be more susceptible to flash flooding due to snowmelt. Chalk rivers in particular tend to respond relatively slowly to rainfall due to the buffering effect of aquifers. Thus hydrology plays a primary role, inducing disturbances, controlling dynamic processes and connections/disconnections, differentiating and structuring habitats, which ultimately provides a variety of habitats for fish communities (Niaman and Decamps 1990, Ward and Stanford 1995). Such floodplain habitats are important factors in the ecology of lowland river fishes.

For fishes, spatial patterns of assemblages and longitudinal zonations, as well as lateral movements, are strongly influenced by connectivity features. Fish species through their life-stage specific requirements, exploit the longitudinal and lateral dimension of the river over different time scales. Good longitudinal and lateral connectivity is important for the ecology of many fish communities (Bayley 1995, Gore and Shields 1995, Ross and Baker 1983).

Lateral floodplain habitats include small natural flowing side-streams (small tributaries), agricultural drainage channels which tend to be slow-flowing and highly vegetated, oxbows which are also low-flow vegetated habitats and the inundated floodplain itself. They provide an important role in the ecological functioning of lowland rivers by providing a mosaic of habitats used by fish for feeding, spawning, sheltering and as a residential location (Gore and Shields 1995). Many organisms living in or near the floodplain exhibit characteristic adaptations to enable them to exploit this resource. Floodplain habitats are important for some species of fish, while providing supplementary habitat for other fish (Bayley 1995, Borcherding et al. 2002, Ross and Baker 1983). They support major concentrations of fish (Fraser et al. 1999) because they offer important habitat for a wide variety of activities such as feeding, shelter and spawning (Bell et al. 2001, Neumann et al. 1996, Sommer et al. 2001). Lateral connectivity diversifies the species composition of the whole river system. Ross and Baker (1983) caught 33 species of fish from the Black Creek Stream, Mississippi and its floodplain during spring floods. Of those 33 species, 26 were caught on the floodplain, 17 of which were caught only on the floodplain, illustrating the importance of the floodplain to the fish community in the Mississippi River. It is also true for small floodplain systems such as the River Garonne (Gozlan et al. 1998)

Floodplain systems have been shown to support greater numbers of fish than those without lateral aquatic habitats (Bayley 1995). In an investigation into the productivity of floodplains Bayley (1995) compared productivity of river-floodplain systems against that of equivalent stable water-level bodies. He found that all numeric fish yields and biomasses (for both tropical and temperate regions) were higher in floodplain systems than stable systems. Disrupting the complex connectivity system by isolating the main channel from its adjacent floodplains or by blocking longitudinal fish paths results in corresponding declines of fish populations. This ranges from lower catches to the total collapse of a particular species (Jungwirth 1998, Northcote 1998).

In many temperate floodplain systems much of the lateral, as well as longitudinal, connectivity has been lost as a result of human activities. In some systems, such as the Danube, only certain aspects such as the backwaters remain in a few areas, elevating their importance even further. Lateral side-channel and marginal habitats have been advocated as relatively more important for rehabilitation than in-stream structures in low gradient rivers (Bayley et al. 2000). The importance of off-river habitat creation and restoration is highlighted by Pretty *et al.*, (2003) who recommend the creation of off-channel, marginal and floodplain habitats as a better strategy for rehabilitating lowland rivers, than restoration attempts in the main river channel.

In unaltered areas a rich mosaic of habitats remains on the floodplain, although little work has yet been carried out into the significance and functioning of a range of these habitats within a single catchment. With increasing threats to floodplain habitats from anthropogenic sources it is essential to understand the value of these habitats for river communities both in terms of specific individual habitat functions and as lateral habitat more generally.

1.2 Aims and Structure of Thesis

This study set out to generate an overview of the fish communities of lateral side-channel habitats and the functionality of these habitats within the river system. With lateral off-river habitats increasingly threatened (Gore and Shields 1995, Olson and Dinerstein 1998) a scientific basis for management and conservation of lateral connectivity is necessary. The aim of this study was to provide this information in terms of:

- the diversity of side-channels in both their habitat and fish assemblages,
- their functionality for fish populations,
- their contribution to the recruitment of fish populations,

so that recommendations could be made to managers and conservation bodies.

The River Frome in Dorset, Southern England, is a relatively unaltered river system, although like many British rivers it suffers from relatively high water abstraction.

Still, it provided a semi-natural system within which to investigate the importance of lateral connectivity; something that is increasingly rare nowadays in temperate locations.

The overall aim of this thesis is to investigate whether:
"lateral habitats significantly contribute to the fish populations of the river system."
Specific aims are to examine whether:

- *off-river habitats can be classified into types such as natural flowing streams, flowing millstreams and non-flowing drainage ditches by their habitats and fish species assemblages.*
- *Fish use side-channel habitats for a variety of different functions such as spawning, sheltering and feeding.*
- *Fish populations are adapted to the presence of off-river habitats in the river system.*

A holistic approach was used to achieve these aims and test the hypotheses, which allowed for the investigation of the side-channel habitats at several levels. First, an overview of the habitat characteristics of each side-channel is presented with defining features highlighted (Chapter 4). The assemblages of different channels were characterised and attempts made to predict them according to habitat variables, a potentially useful technique if successful for designing and prioritising floodplain habitat management (Chapter 4). Deeper investigation into the functionality of side-channels for fishes, and the specific functions that individual species use side-channels for, was made by detailed analysis of movements between main river and lateral habitats (Chapter 5). Two species were then considered in detail as case studies. First, connectivity is discussed in respect to a rheophilic prey species, the dace (*Leuciscus leuciscus*), (Chapter 6). A methodological chapter (Chapter 7) then precedes the second species specific case study, introducing and examining home range estimation in riverine environments as this technique formed an important component of the following chapter. Then the importance of longitudinal and lateral connectivity within different life history strategies were considered with respect to a limnophilic predator, the pike (*Esox lucius*) (Chapter 8). These examples were selected to explore further the role that connectivity plays for various processes acting at different scales and levels. Finally the wider implications of this work, particularly in terms of management and maintenance of lateral connectivity are discussed (Chapter 9).

It had been intended to also consider fish response to flooding and use of the inundated floodplain. Unfortunately a particularly dry period resulted in virtually no over-bank flooding during the course of the study. This issue was addressed to some extent by a large scale high flow experiment included in Appendix 14.

This thesis was carried out as part of a larger Natural Environment Research Council (NERC) thematic LOCAR (Lowland River Catchment) project, number NER/T/S/2002/00229. All radio- and PIT- tagging was carried out under UK Home Office licence.

Chapter 2

Study Area

2.1 Characteristics of the River Frome Catchment

2.1.1 GEOLOGY AND HYDROLOGY

The River Frome rises near Evershot (NGR ST047576), and flows south east through Dorset in the South of England for approximately 65 km, entering the English Channel at Poole Harbour. The Frome catchment covers 300 km^2 and is comprised mainly of agricultural land (Casey 1969). The catchment is underlain throughout by chalk and this is exposed at the surface over the majority of the catchment. The river is described as a typical medium-sized chalk stream (Crisp et al. 1982).

Chalk is a soft, permeable, calcareous rock that readily absorbs and transmits water. Rainwater rapidly percolates into the chalk and accumulates in aquifers, which may be up to 80 m deep and may retain water for 20 years or more (Ladle and Westlake 1995). Aquifers help to regulate flow; damping the effects of heavy rainfall and releasing water continuously even during spells without precipitation. Water temperature is also buffered with groundwater being cool in summer and warm in winter, relative to air temperatures. Mean monthly water temperatures in the Frome range from 6.5°C in January to 17.4°C in July (Crisp et al. 1982). Similarly, the chemical composition of the water is more consistent than on rivers with a lower input from aquifers. The pH of the River Frome is slightly alkaline, between 7.5 and 8.5, due to the influence of the chalk (Anonymous 2005).

Discharge in the River Frome at East Stoke was much lower during the study period than usual (Figure 2.1 shows discharge during the study period and the 3 years previously which represent typical discharge over a much longer period). This was due to a very dry spell during the study with very little rainfall. Groundwater accounts for a large proportion of the river discharge, but this may also have been drained due to the long period without rain. Seventy four percent of the total River Frome discharge at East Stoke was found to have originated as groundwater by Paolillo (1969). The mean annual current velocity upstream of East Stoke was estimated to be

25 cm s^{-1} by Crisp *et al* (1982). However, a high local variability may be observed with mean velocities of 4-15 cm s^{-1} inside dense weed beds, compared to velocities in excess of 50cm s^{-1} between them (Ladle and Westlake 1995).

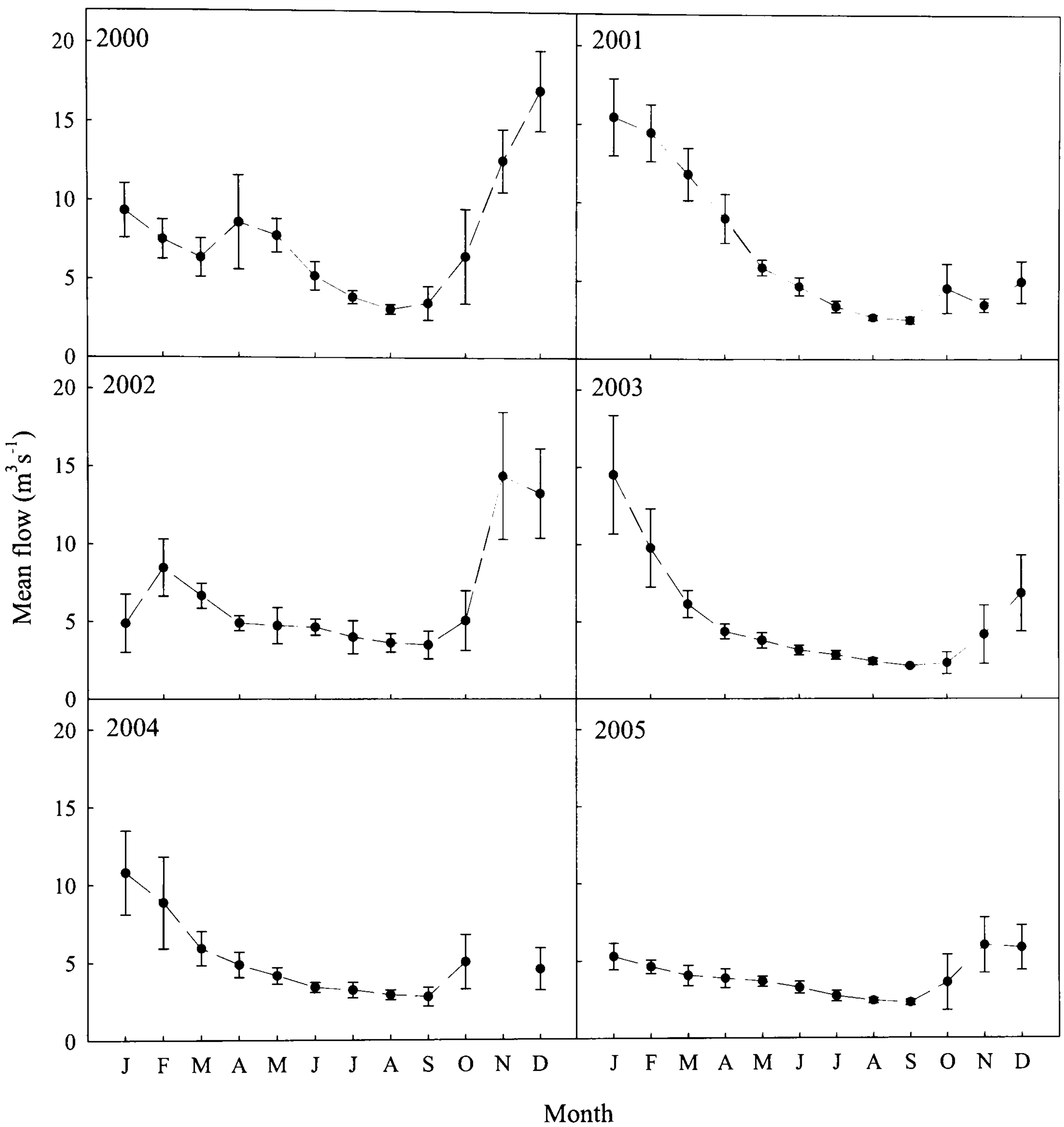


Figure 2.1 Mean monthly flow over East Stoke gauging weir from 2000 to 2005 showing the much lower flows during this study in 2004 and 2005. Error bars represent monthly standard deviation (Source CEH unpublished data). No flow data was available for November 2004.

2.1.2 WATER QUALITY

The overall water quality of the River Frome is good with over 97% of the catchment demonstrating good or very good water quality (River Ecosystem classification 1 or 2) (Anonymous 2005). The river is predominantly calcium bicarbonate bearing, the source of which is weathering processes within the chalk aquifer (Howden 2004). Elevated levels of phosphate (predominantly from point source sewage inputs) are found in the river and its major tributaries the Tadnoll Brook and the River Cerne (Howden 2004) reflecting a eutrophic watercourse.

The EC Nitrates Directive (91/676/EEC) requires Nitrate Vulnerable Zones (NVZs) to be established in catchments where high or rising levels of nitrate have been identified and measures be implemented to reduce nitrate pollution. Approximately 90% of the Frome Catchment is designated as an NVZ. Nitrogen sources are both diffuse agricultural runoff and point sources of sewage effluent.

2.1.3 ABSTRACTIONS

There are currently 308 abstraction licences held within the Frome Catchment and a total of 58 Ml day^{-1} of water is abstracted from the Frome (Anonymous 2005). While these abstractions are spread throughout the whole area, large groundwater abstractions are concentrated on the chalk aquifer. The end use of the water abstracted determines the impact the abstraction has on the river. For example, water abstracted for use in fish farms is eventually returned to the river causing a lesser effect on water volume than water abstracted for spray irrigation, which results in a total loss to the system. However, water that has passed through fish farms is more prone to be of lower quality with high nutrient loading. The largest abstractor by volume on the Frome is aquaculture for fish farming which removes 56.5% of the total volume abstracted. Water abstracted for agriculture is only 1.4% of the total abstraction.

2.1.4 LANDSCAPE AND LAND USE

Dorset is predominately rural and relatively free from heavy industry. Existing industry on the Frome catchment is light and mostly related to agriculture and the two major towns of Dorchester and Wareham, which have populations of 15,000 and 8,000 residents respectively. The majority of the countryside is used for animal pasture or arable farming, interspersed with small villages, woodlands and heathlands towards the south. Aquaculture for fish farming and watercress beds feature in some areas of the Frome. The floodplain of the River Frome features extensive historic water meadow systems. River management includes an annual mechanized weed-cut by the Environment Agency to improve summer water drainage. Excessive sedimentation is also an issue in the Upper Frome catchment. This is believed to be due to poor land management practices, causing runoff of soil into the river (Heywood and Walling 2003).

2.1.5 CONSERVATION DESIGNATIONS

The Frome catchment area contains one of the highest concentrations of designated areas for nature conservation in England (Anonymous, 2005). The River Frome is a UK Biodiversity Action Plan (BAP) chalk stream priority habitat. The Dorset Area of Outstanding Natural Beauty (AONB) covers a large proportion of the River Frome. The Environment Agency has a duty to protect and enhance the natural beauty of the AONB under the Countryside and Rights of Way Act.

The Frome and its water meadows downstream of Dorchester are designated as a Site of Special Scientific Interest (SSSI). Between the tidal limit of the Frome to Dorchester is a target area for restoration of floodplain grazing marsh. A Water Level Management Plan will be developed in the future for the Frome SSSI (Anonymous 2005).

2.1.6 RECREATIONAL USE

Angling for both salmonids and coarse fish takes place throughout the catchment, although coarse angling is focused in the lower reaches. There are few places with a public right of access to the river. The main public access to the river is at the tidal reach in Wareham. Here, there is a public right of navigation within the tidal limit, which extends just upstream of Wareham.

2.2 Description of Study Section of River Frome

The river downstream of East Stoke (Figures 2.2, 2.3, and 2.4) is able, under high flow conditions, to over-top its banks and flow freely onto the floodplain with no flood management in place. Winter floods are frequent but summer floods, although common 20 years ago, are now very rare. In the lower reaches of the river there is very little riparian tree cover but there are rich beds of submerged macrophytes, especially *Ranunculus* species.

Figure 2.2 Winter (left panel) and summer (right panel) views of the River Frome at East Stoke

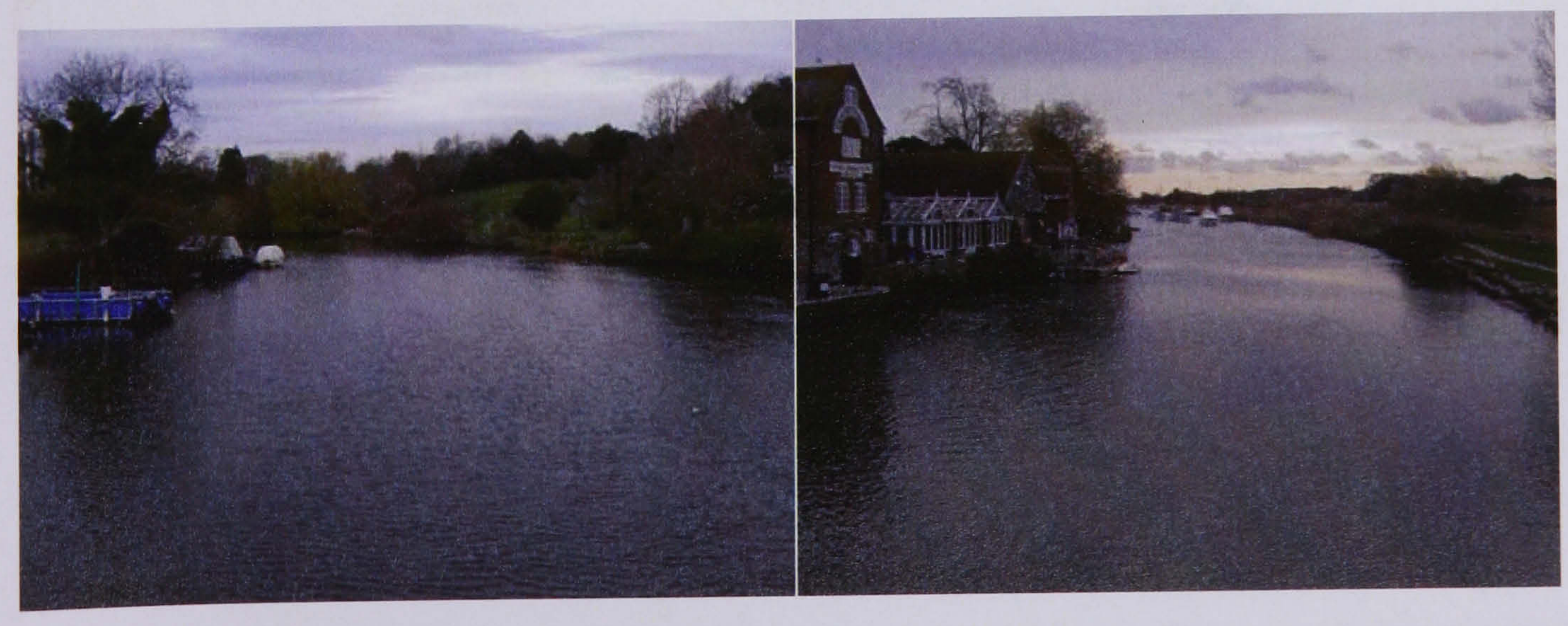


Figure 2.3 Upstream (left panel) and downstream (right panel) views of the tidal River Frome at Wareham.

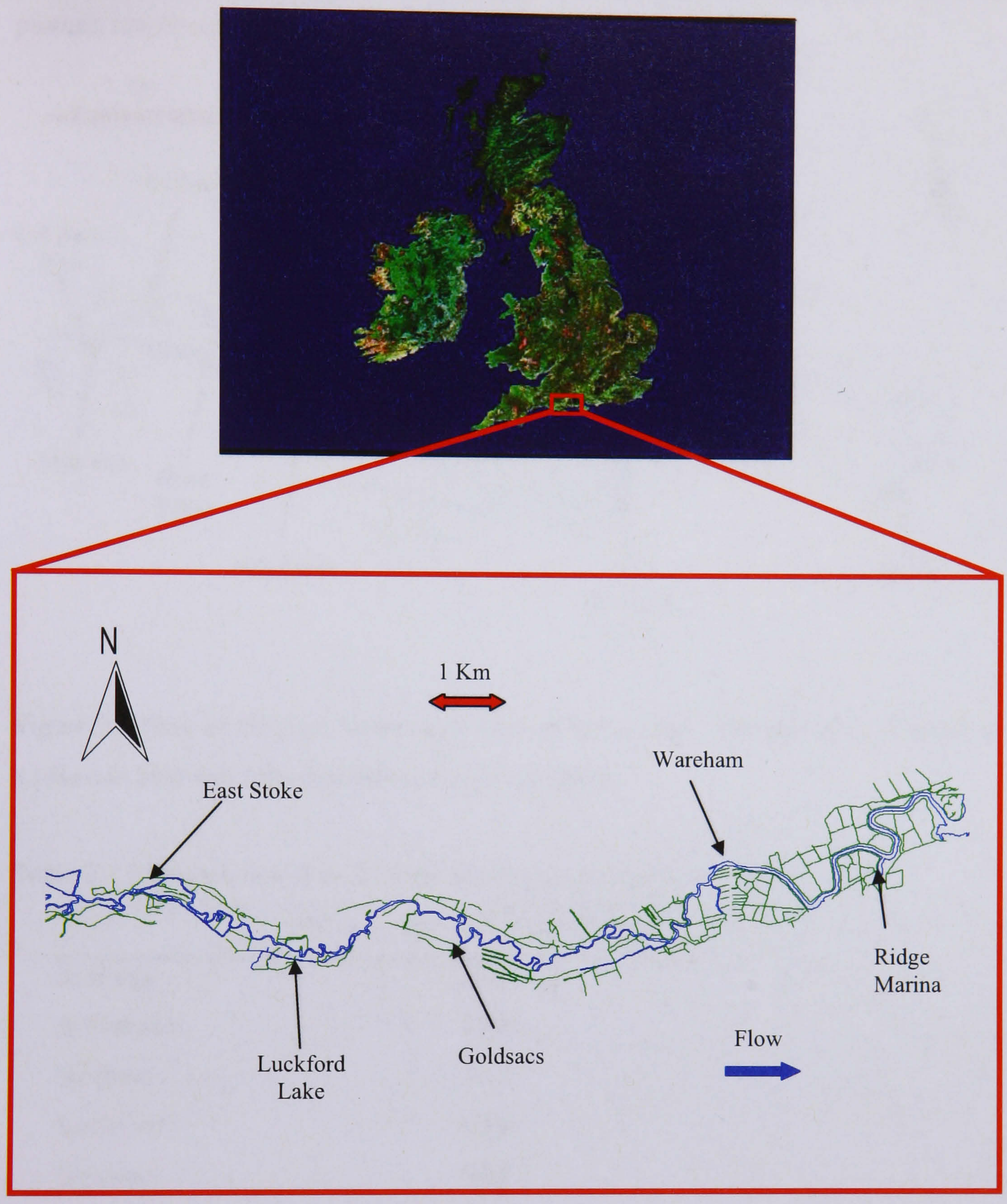


Figure 2.4 Map of the full study area in the Frome catchment and the location of the catchment in the UK. The main river channel is marked in blue and side-channels are coloured green.

The East Stoke reach of the River Frome has a network of river channels (UK national grid references SY867863 to SY898862) (Figure 2.5). Some of these are flood relief channels, man-made millstreams, relics of historic meadow systems and natural streams. The streams vary in surface area from Millstream the largest to Goldsacs the smallest (Table 2.1) In its lowest reach, the floodplain of the Frome widens out into pasture, marsh and some acidic heathland.

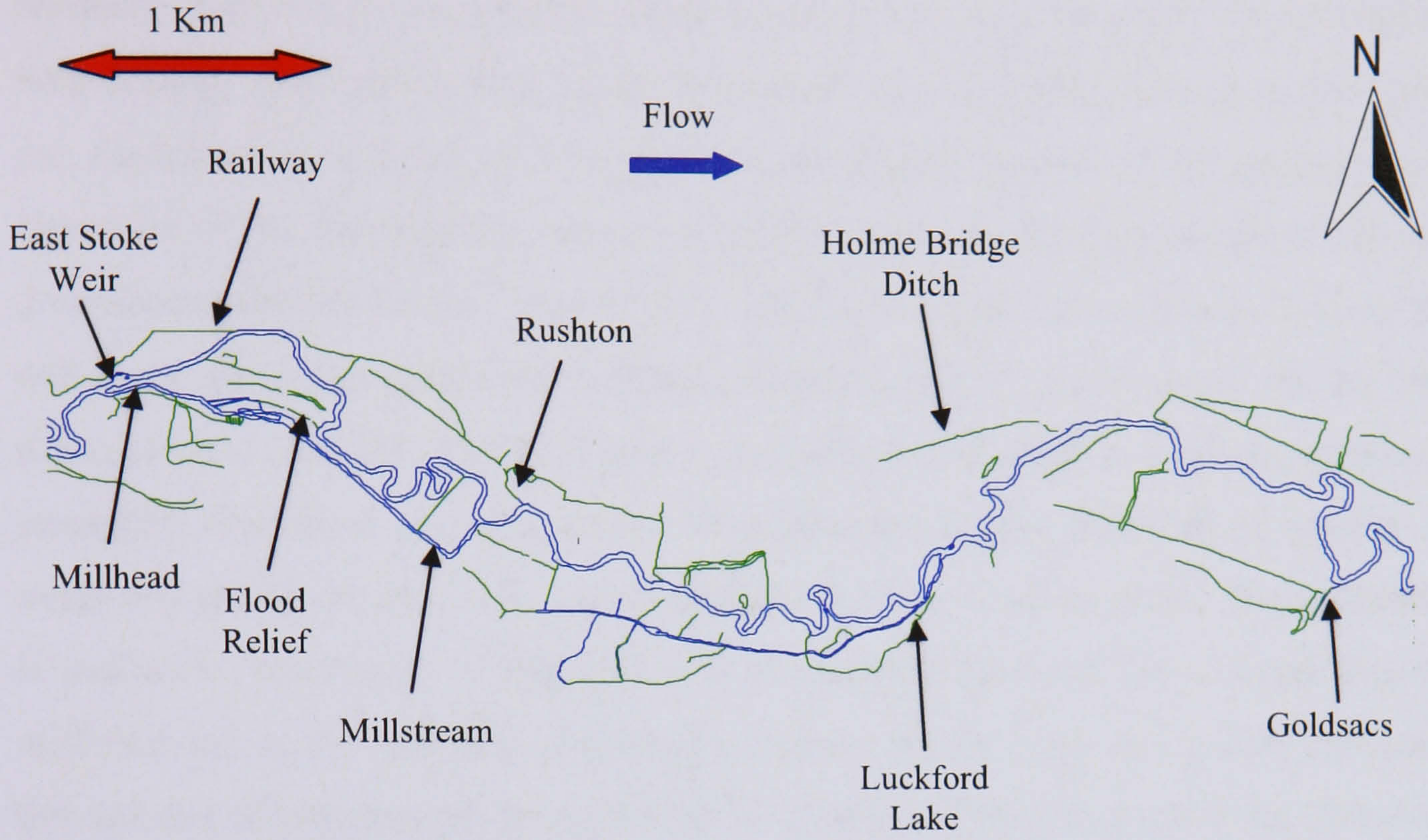


Figure 2.5 Map of the East Stoke study area of the Frome. The main river channel is marked in blue and side-channels are coloured green.

Table 2.1 Surface areas of each of the seven side-channels sampled.

	Surface area of 200m section (m^2)
Railway	573
Millstream	1200
Rushton	613
Luckford	1060
Goldsacs	453
Holme Bridge	820
Flood Relief	633

2.2.1 EAST STOKE MILLSTREAM

The millstream at East Stoke separates from the river and runs for 1.4 km before rejoining (Figure 2.5). Five hundred metres after leaving the main river the millstream runs through a fluvarium, built on the site of the old mill. Fifty metres downstream of the fluvarium is a small (0.5 m high) Environment Agency flow gauging weir. Upstream of the fluvarium the stream is referred to as the Millhead (Figure 2.6), and downstream the Millstream (Figure 2.7). As the Millhead leaves the main river fish will move downstream into the Millhead with the flow of water, unlike all the other side-channels sampled. The Millhead is typically 1-2 m deep with dense patches of emergent vegetation in some areas. The substrate in the Millhead is mostly silt overlying gravel and clay with gravel exposed in faster flowing areas. The millstream is shallower, reaching 1 m depth in only the deepest pools. It flows faster than the millhead and so the substrate is generally coarser, mostly sand and gravel. Discharge through the millstream can be controlled by a series of hatches both in the fluvarium and at the start of three smaller channels along the length of the millstream, which rejoin it further downstream.

Figure 2.6 Winter (left panel) and summer (right panel) views of the East Stoke Millhead.

Figure 2.7 Winter (left panel) and summer (right panel) views of the East Stoke Millstream.

2.2.2 NATURAL STREAMS

Natural streams are varied in type and length along the Frome. Two small tributaries of the Frome in the East Stoke area were included in this study: Goldsacs stream and Luckford Lake (Figure 2.5). Goldsacs stream is the most downstream side-channel that was sampled in this study (Figure 2.8). It is 5.5 km in length and flows across the Bovington army ranges (heathland) before joining the Frome. As a result its predominant substrate is sand. Luckford Lake stream originates from Luckford Lake on Coombe Heath nature reserve and flows for 4.5 km before joining the Frome. It is slow flowing and consequently its dominant substrate is silt (Figure 2.9).

Figure 2.8 Winter (left panel) and summer (right panel) views of Goldsacs stream.

Figure 2.9 Winter (left panel) and summer (right panel) views of Luckford Lake stream.

2.2.3 DRAINAGE DITCHES AND FLOOD RELIEF CHANNELS

Four agricultural drainage ditches and one flood relief channel were sampled during the project. These habitats are known to support a rich invertebrate diversity due to their lower flow and chemically different environment to the main river (Armitage et al. 2003).

Holme Bridge ditch is the furthest downstream ditch in the study area (Figures 2.5 and 2.10). It is shallow (up to 20 cm) in its lower reach with heavy tree cover, but opens up and deepens 150 m upstream of the entrance to the Frome. Its main substrate is silt and it has submerged, emergent and floating vegetation in most unshaded areas. Moving upstream, Rushton ditch is the next agricultural drainage ditch (Figures 2.5 and 2.11). It is 800 m long and flows across grazed fields before joining the river. It is mostly over 1 m deep in the centre, generally heavily silted with some patches of gravel and supports large amounts of emergent vegetation. The furthest upstream agricultural ditch sampled is the Railway ditch (Figures 2.5 and 2.12). This ditch is 1200 m long and runs alongside a rail track for the majority of its length. It is mostly shallow (up to 50 cm) and heavily vegetated along its entire length with emergent vegetation and some tree cover. While most of the substrate is silt there are patches of gravel originating from the railway.

Figure 2.10 Winter and summer views of Holme Bridge ditch.

Figure 2.11 Two summer views of Rushton ditch.

Figure 2.12 Winter (left panel) and summer (right panel) views of Railway ditch.

The flood relief channel (Figure. 2.5 and 2.13) is the shortest of the channels at 200 m. It is the only blind-ending channel, with a sluice gate blocking flows at the top. In its lower stretch it reaches 1.5 m deep and is heavily vegetated, mostly with submerged vegetation. Further upstream it becomes very shallow down to only 10 cm and is heavily shaded, with little in-stream vegetation.

At the start of the study the Flood Relief was very overgrown and heavily silted and had been cut off from the main channel except under very high flows (Figure 2.14). In October 2003 it was reopened and the first 100 m was cleared of all aquatic vegetation to enhance fish access (Figure 2.13).

Figure 2.13 Winter (left panel) and summer (right panel) views of the Flood Relief channel after reopening.

Figure 2.14 Flood relief channel prior to reopening and clearance. Left panel shows the dense emergent vegetation in the flood relief channel and right panel shows the blocked connection with the main river.

Chapter 3

Materials and Methods

3.1 Habitat Monitoring

Seasonal sampling was carried out quarterly in March, June, September and December during 2003, 2004 and 2005. Seven side-streams were sampled including drainage ditches (Railway, Rushton, Flood Relief and Holme Bridge ditches), natural flowing streams (Goldsacs and Luckford streams) and a millstream (see Figure 2.5). The first 200 m of each stream was sampled in 50 m sections, separated by stop-nets, as it was thought this distance would be representative of the habitat and species assemblages throughout each channel.

Habitat surveys were carried out for every 25 m of the 200 m sections to relate to patterns of use by fishes. Dissolved oxygen (mg l^{-1}) and temperature (°C) were recorded at 25 m intervals before the water and sediment were disturbed during fishing. At these locations depth (m) was measured at the centre and 25% and 75% across the channel. The width was also measured as the wetted width (m) at each 25 m interval. Flow type (slack, glide and turbulent), vegetation (submerged, emergent and overhanging), in-stream structures (boulders, tree roots, woody debris) and substrate (silt, clay, sand and gravel) were estimated as a percentage of the 25 m stream area to 5% accuracy for each category.

A hydrolab minisonde (Hydrolab; Colorado, USA) was used to monitor dissolved oxygen, temperature and pH every fifteen minutes for fortnightly periods in side-channels monitored with PIT detectors (see Section 3.6). Every fortnight the hydrolab was collected from the logging location, recalibrated and fitted with a new oxygen membrane and the data downloaded.

3.2 Seasonal Sampling of Assemblages

Fish were sampled by electric fishing each section using 50 MHz pulsed DC at 1-2 Amps with a generator supply (Electracatch International, Wolverhampton, Uk). The 50 m sections were fished once only, except one section per side-stream that was double fished in order to calculate fishing efficiency and population estimates. Triple fishing all sections would have allowed greater accuracy in the results with less variability due to variation in fishing conditions between channels and seasons. However the high silt composition of many of the channel beds would not have permitted three fishing passes to be undertaken during the same day.

Fish were identified to species and the fork length of each fish captured was measured, up to a total of 30 randomly sub-sampled individuals per species per stream section, after which individuals were counted. Where possible the sex of each fish was determined. Scale samples were taken from all pike captured (see section 3.11 for further detail). Fish were returned immediately after they were processed, unless the section was being double-shocked in which case they were held until after all fishing of that section was finished.

3.3 Main River Sampling

The main river from the East Stoke weir to Rushton ditch (Figure 2.5) was sampled with electric fishing once annually in March (2003-2005). It had been hoped that sampling would be carried out during more seasons but it was not possible to obtain a licence from the Environment Agency to do so. As a result, fishing was mainly carried out in order to radio and PIT tag fish and not directed at sampling the full species assemblage.

The fishing was conducted with a boom boat powered by a small diesel engine (designed and constructed by CEH). A series of cathodes trailed from the back of the boat and two circular anodes with droppers hung from the side of the boat. One person stood at each side of the boat ready to net fish and put them in the holding bin in the centre of the boat. Electric fishing was carried out with 50 MHz pulsed DC at approximately 2 Amps. The river was fished in sections with several downstream passes per section in order to maximise fish capture. Fish were processed in the same manner on the river bank as for side-stream sampling and were released near to their capture site.

The main river in the tidal reach was sampled between Ridge and Wareham Pool (Figure 2.4) in January and June during 2004 and 2005 also using a boom boat. This fishing targeted dace and roach large enough to PIT tag in order to monitor upstream migration. Several downstream passes were made and fish were processed (anaesthetised, identified, measured and PIT tagged) in the boat (away from public interference) before being released near to their capture site.

3.4 PIT Tagging

The minimum fish size used for tagging varied between species. Table 3.1 gives minimum tagging sizes. Those individuals large enough to receive a PIT tag were lightly anaesthetised in 2-phenoxyethanol (1:1000) in river water. Scales were removed from above the lateral line just by the dorsal fin in order to age the fish. Fish were then weighed and tagged. To insert the tag a small 4 mm incision was made on the mid-ventral line anterior to the pelvic girdle deep enough to penetrate the peritoneum. The PIT tag was inserted by gently pushing it into the body cavity. PIT tags used were either 23.1 mm long, 3.9 mm in diameter and weighing 0.6 g in air (Texas Instruments, TIRIS) or 12 mm long, 2.2 mm in diameter and weighing 0.1 g in air (UKID systems, Preston, UK) (Figure 3.1). The incision was closed with commercial grade acrylamide gel and the fish was held in a bin for recovery prior to release at the catch location. This procedure is demonstrated in Figure 3.2.

Table 3.1. Minimum size of fish PIT tagged for two different tags. Sources: (A. Pinder and M. Lucas Pers. Comm.) (Skov et al. 2005, Jepsen et al. 2001).

	Minimum fish size (cm)	
Species	TIRIS tags	UKID tags
Pike	12	7
Roach	15	12
Dace	12	10
Eel	30	N/A
Gudgeon	8	N/A
Grayling	15	N/A
Trout	15	N/A

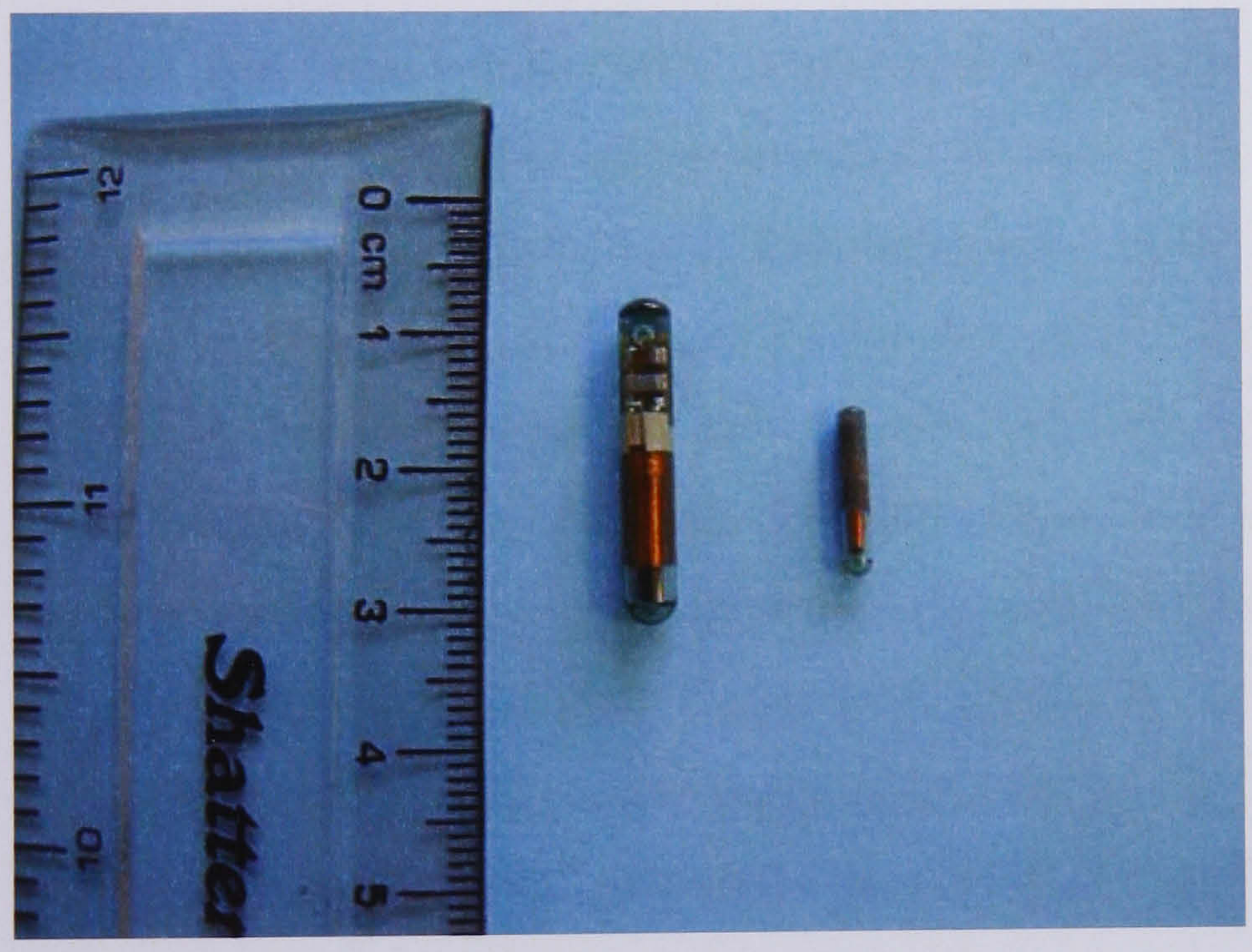


Figure 3.1 PIT tags used in the study, 23 mm Texas Instruments (TIRIS) tag on left and 12 mm UKID tag on right.

Figure 3.2 PIT tagging of a small pike. The tag is inserted through a small incision in the pike, which is then sealed with acrylamide gel.

Initially fish large enough were tagged with both sorts of tags in order to enable detection by the two types of reader used in the main river and side-channels (a UKID detector spanned the main river at East Stoke weir, while TIRIS detectors spanned the side-channel entrances, see section 3.6 for more detail). However, the tags were found to interfere with each other and subsequently fish were tagged with only one. In most cases fish reaching the minimum size were tagged with 23 mm TIRIS tags and only the smallest individuals were tagged with 12 mm UKID tags. However, half the fish caught in the tidal reach were tagged with UKID tags and the other half with TIRIS tags so that both main river movements (detected by the UKID detector at East Stoke weir) and passage into side-channels (detected by TIRIS detectors) following upstream migration could be monitored.

Recaptured fish were identified by scanning with a handheld PIT tag reader (Allflex portable RFID reader and Casper UKID reader). If a tag was recorded the number was noted and the fish weighed and measured. A note of its new catch location was made.

3.5 Management of Assemblage Data

With the large amount of data collected it was deemed necessary to develop an appropriate database. This was achieved through the development of an MS Access database that separated tagged and untagged fish into two separate tables. Data on tagged fish measurements and catch data were separated into two further tables. Two forms were created to enable simple and error free data entry for tagged and untagged fish as illustrated in Figures 3.3 and 3.4. Storing data in MS Access enabled the data to be interrogated more simply and to greater depth.

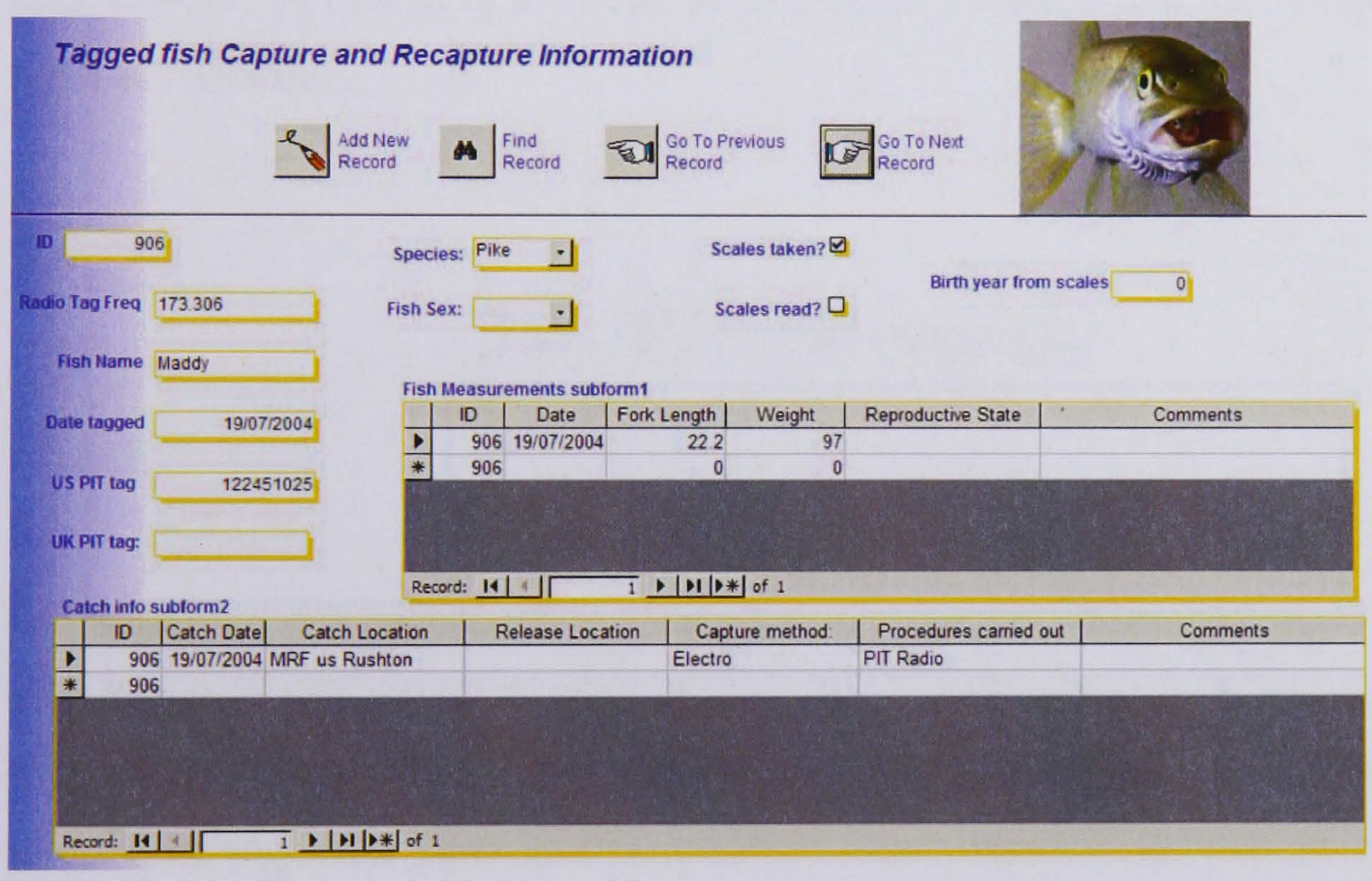


Figure 3.3 Data entry form for PIT- and radio-tagged fish demonstrating easy entry boxes for details of tags and two tables for (1) recording measurements of individual fish and (2) for recording details on capture and recapture. Many fields contained controls on data entered to minimise the possibility for entering incorrect values and so that PIT tag details could not be repeated.

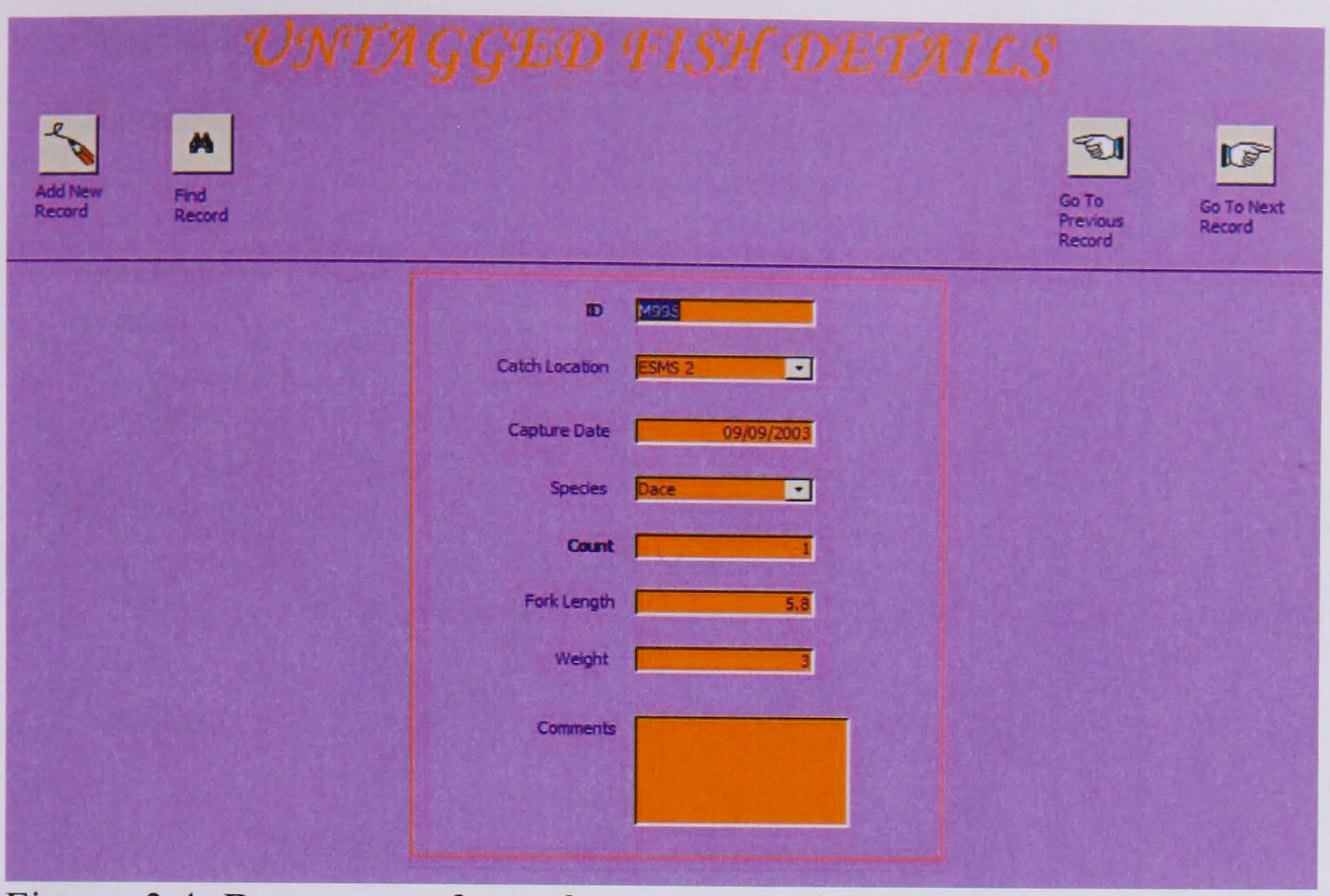


Figure 3.4 Data entry form for non-tagged fish. This form enabled either fish measurements or counts of a species to be entered. Controls were set in fields to limit incorrect data entry.

3.6 PIT Telemetry

PIT telemetry was used in order to continuously monitor movements of fish between side–channels and the main river. It gave finer scale temporal information on fish movements but was more restricted in terms of the species and fish sizes tagged than electric fishing. Five pairs of PIT detectors were installed between 10 m to 20 m upstream of the entrance (so as to be sure fish detected were entering the channel and not just sheltering in the entrance) of five side-channels (Figure 3.5). These detectors were installed at Railway (Figure 3.6a) and Rushton ditches (Figure 3.6b), at Luckford Lake stream (Figure 3.7) and at the in-flowing entrance (Millhead) (Figure 3.8a) and out-flowing exit (Millstream) (Figure 3.8b) of the East Stoke millstream. These sites were selected because all were within reasonably local proximity and provided a selection of different habitats for fish to access. A single UKID PIT detector was installed on the main river (Figure 3.9) as part of a separate study that was also utilised in this study. This main river detector did not give the direction of fish movement and worked only for fish tagged with UKID tags.

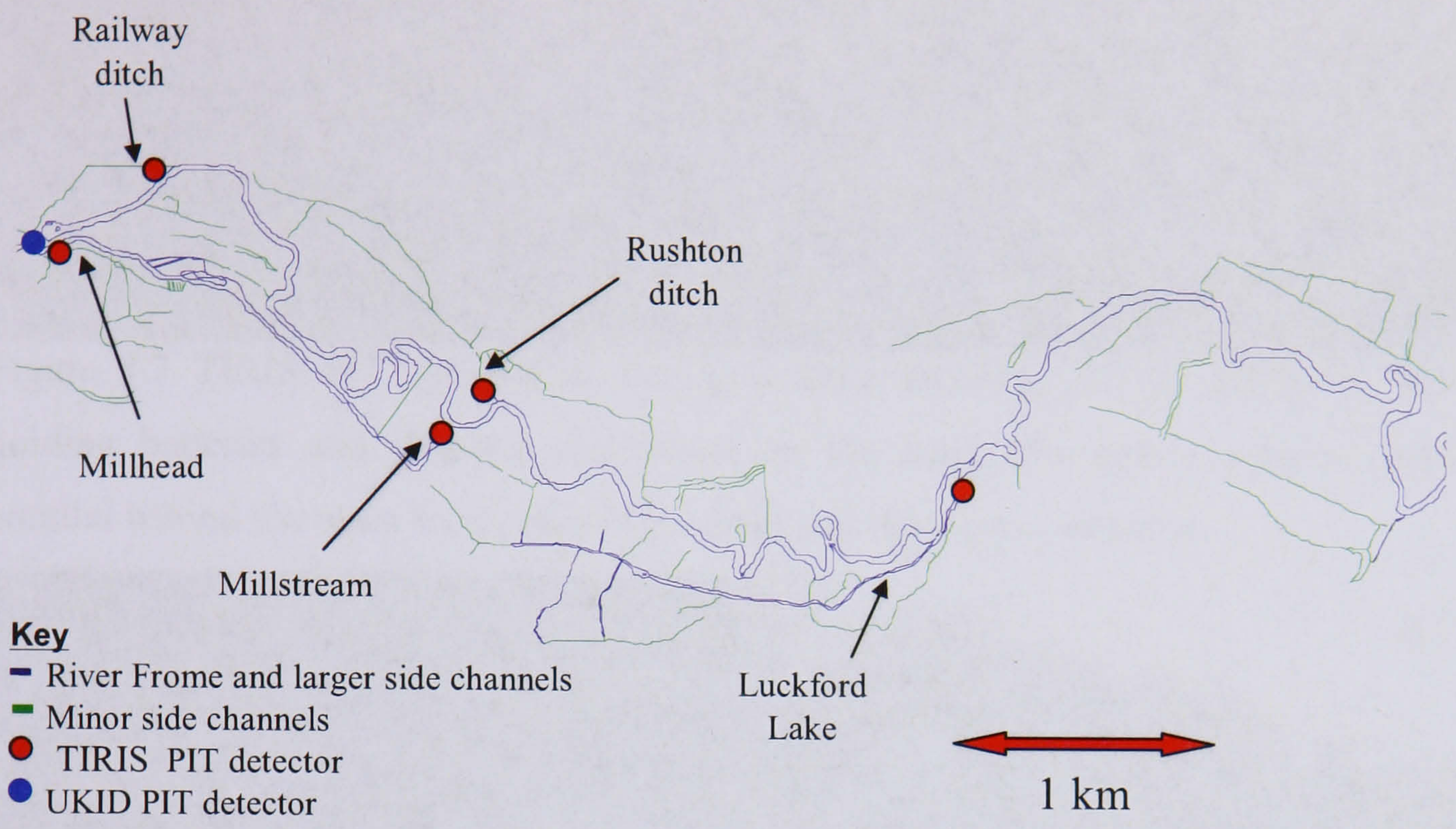


Figure 3.5 Map of the location of PIT detectors in the study area

Figure 3.6 TIRIS PIT detectors at (a) Railway ditch and (b) Rushton ditch. The capacitor array was mounted on the wooden stakes and protected from rain with tape and plastic bags

Figure 3.7 TIRIS PIT detector at Luckford Lake showing (a) the protective box holding batteries and detector electronics on the bank (the stream channel runs parallel behind the main river channel in view) and (b) the two antenna.

Figure 3.8 TIRIS PIT detectors at the (a) Millhead and (b) Millstream. The solar panel supplementing the two 110Ah 12V batteries can be seen by the Millstream detector. The bank of tuning capacitors in protective bags can be seen in both.

Figure 3.9 UKID PIT detector on the main River Frome at East Stoke, comprising 13 multiplexed antennae attached to hydraulic vanes. The vanes lift every four hours to clear any debris caught on them.

Side-channel PIT detectors were constructed using a commercially available radio frequency identification system (Texas Instruments TIRIS S-2000) and were based on the methodology of Zydlewski *et al.,* (2001). The system consisted of a half-duplex (HDX) reader module (TIRIS RI-RFM-008) operating at 134.2 kHz, connected to a control module (TIRIS RI-CTL_MB2A). Power draw was 2-3 Amps depending on the tuning and size of the detector. Power source for the reader/control modules varied. Two units (Railway and Millhead) were powered by mains electricity, one supplied locally and the other through 450m of armoured cable. Each was down-regulated using a 240V – 15V low noise step down transformer. The three remaining detectors (Millstream, Rushton and Luckford) were powered by two 110Ah 12V DC lead-acid batteries connected in parallel. Batteries lasted two weeks on a single charge. The millstream was supplemented by a solar panel (150 cm by 100cm), which supplemented the batteries of this the largest (width and depth) PIT detector. Data was logged onto a Flinka Fiskar logger (Flinka Fiskar, Orkellunga, Sweden) that wrote onto 32 MB compact flash cards.

Reader modules and data logger were housed in a single plastic box 25cm long x 25 cm wide x 15 cm deep (Figure 3.10). The reader module was connected to an open loop inductor antenna that both generated an electromagnetic field to energise the tag and received transmitted signals from the tag. The antenna was constructed using 12-gauge insulated THHN multi-strand wire. One or two loops were wound to form an inductor coil around the banks and bed of the stream, leaving sufficient distance at the surface of the stream for it still to be enclosed in the antenna when water levels rose. Depth and width of the antenna coils varied but reached maxima of 6.5 m wide and up to 80 cm deep. Antenna coils were supported at each bank by a wooden post, across the surface of the stream by a length of rope and were pegged to the stream bed with plastic pegs hammered in at 40cm intervals. The two ends of the antenna were connected to the reading module through the bank of tuning capacitors (TIRIS RI-ACC-008). Selection of combinations of capacitors allowed the antenna circuit to be tuned to the resonant frequency, with fine tuning enabled using a potentiometer.

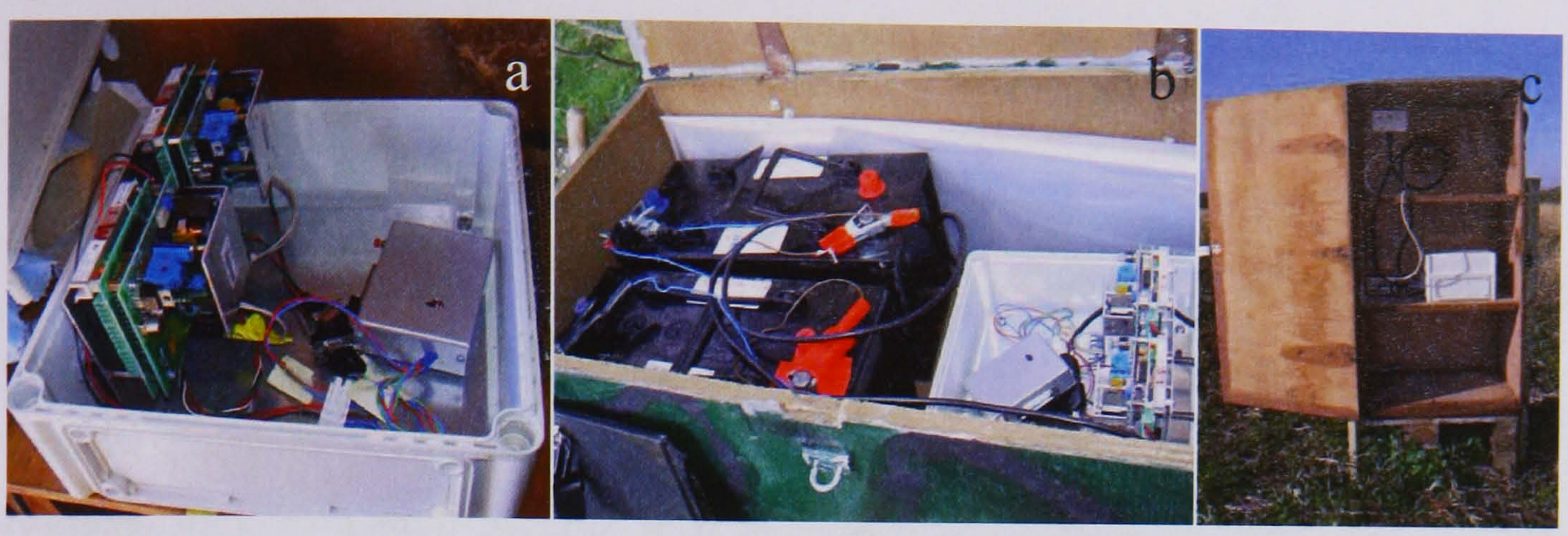


Figure 3.10 (a) Waterproof box with two units (master and slave), each containing a reader module and a control module, on the left and logger box on the right (b) Battery powered detector showing two 110Ah 12V batteries and reader/control box all housed in a protective wooden box (c) Wooden housing of PIT equipment for mains powered reader showing mains power supply, step-down transformer and reader/control box

Each PIT array at each site had two antennae (or gates), each connected to a reader unit (labelled gate 1 and gate 2) to record the direction of travel of fish passing through. Thus, there were two antenna, spaced between 2 m and 5 m apart, each with its own bank of tuning capacitors and two reader/control modules. The reader/control modules were however, housed together in one protective plastic box and both recorded to only one data logger. One detector was assigned as the "master" and the other the "slave" in order that transmit and receive phases were coordinated, to avoid close range interference.

The detection range, measured as the distance between the plane of the antenna loop and the tag, varied with tag orientation. Maximum detection distance of 90 cm was achieved when the tag was horizontal. Minimum detection distance occurred at the centre of the antenna where the field was weakest. Minimum detection distance did not fall below 20 cm on any detector. Detectors scanned four times per second so any transponder entering the antenna field for less than a second was recorded. Such a low read-rate was possible because fish were relatively slow moving in slow flows; this compromise meant that power consumption was lower and enabled batteries to last 2 weeks. The functioning of each PIT detector was tested once a week when flash cards were changed (or more often when necessary) by passing a PIT tag through each gate and noting the time. This tested whether the detector was detecting efficiently and that the logger was recording the correct time.

As a developing technology, problems were experienced with maintaining the continuous running of the PIT detectors. Problems ranged from the equipment itself, such as failed batteries and malfunctioning loggers not logging or producing un-readable files, to natural hazards such as floating trees destroying detectors during floods and damage by cattle to cables or equipment on a number of occasions. As a result there were periods when PIT detectors were not working and data was not collected (Appendix 2).

Problems were encountered if a tagged fish remained within the reader field for an extended period. In this case other tag records could be masked with the reader only capable of detecting one tag at a time, and well in excess of 10000 records could be recorded. The latter proved to be the greatest difficulty with the PIT system as logger files and memory could fill in a matter or days or even hours if a fish was continuously present. The issue of possible masking of other tags by a 'sitter' fish is common to PIT systems and software has been developed to reduce this problem. Such software records a single tag for a short time and then re-records it only at intervals if it is still present. This was not available with the Flinka Fiskar loggers used in this study. Placement of detectors in positions in the channel where fish are unlikely to linger (i.e. with faster flow and little cover) is one possibility to minimise the effect of 'sitters' and this was attempted in this study (although the flexibility was limited by the need to be near the channel mouth in sufficiently shallow water for the reader to be installed).

The main river PIT detector consisted of thirteen antennae, each housed within a fibreglass fin 3.5 cm wide, 48 cm long and 200 cm high across the 4.5 m wide middle section of the East Stoke weir (Ibbotson et al. 2004). Each fin was spaced at 35 cm intervals across the river in staggered formation to reduce the effect of obstruction to downstream river flow. Each antenna was connected to a 24 V DC single point decoder that continually scanned for PIT tags and stored any detections with a date and time stamp on a computer. This detector was of a full-duplex reader operating at

134 kHz for the exciter and 67 kHz for the signal back from the tags. It scanned 5 times per second.

To reduce the accumulation of debris on the equipment due to the river flow each fin was connected to a galvanised steel support structure that housed a pneumatic system. The pressure in the pneumatic system was maintained with a compressor which held the fins in a vertical position using low pressure (138-207 Nm^{-2}). Once debris accumulated on any fin the force was detected by a sensor which triggered the fins to be raised clear of the water under high pressure (689 Nm^{-2}) allowing debris to be washed downstream. The force required to trigger a lift could be adjusted as necessary. Once a lift was completed the fins were lowered back into position. The whole process took approximately 20 seconds. A timer operated system ensured an automatic lift every 4 hours.

The active PIT detector within the fins was 150 cm deep and 40 cm long. The maximum range of the PIT tags was 20 cm so the staggered array of PIT detectors 35 cm apart provided detection across the entire central channel. Two side-channels, either side of the central channel were not instrumented, but flow only passes through these side-channels at very high flows reducing the likelihood of missing fish. The detector was set up on the downstream face of the gauging weir where the bed was uniform and flow was fast (~2 $m\ s^{-1}$). This discouraged the occurrence of 'sitters'.

3.7 Management of PIT data

As each TIRIS detector interrogated the antennae and potentially stored data four times per second it was possible for a huge amount of data to be created. The logger created a text file, which was converted to Excel format. Macros written in Visual Basic for Applications (VBA) were utilised to compress and analyse the data files produced by PIT detectors (Peter Knight, www.PITsoftware.co.uk). A number of macros were run. The first, "Standardise", removed the hourly time marker records and sorted the file into fish order. It merged repetitive records, to leave only one record for each occasion that a fish was detected at one antenna, giving the arrival and departure times of the fish from the antenna. This reduced the number of records for the file by a factor of between 10 and 100. Finally it looked up species codes in the Access database and recorded the species of each PIT tagged fish. A second macro, "Join", was then used to join consecutive files from the same PIT reader together to form a continuous dataset where applicable.

Three further macros were used to provide preliminary analysis. The first, "Movement", reported the transits of each fish through the detector and the direction in which it passed. The second, "Location", gave the location of each fish detected, whether it was on the main river or side-channel side of the detector. These macros also highlighted when a fish apparently spent an extended time between the two antennae, which would suggest that they had passed undetected through the detector. The third macro, "Count", provided (for one or more specified species) the number, over time, of fish that had been detected and were known to be in the side-channel. These three macros were only carried out on continuous data sets.

Another macro, "Overview", was used to give a pictorial representation of fish movements, based on the Combined Positions Record. In the Overview spreadsheet, each fish in the data set was given one line representing each PIT tag reader. Within each such line, each character represented one day. For each fish, each reader and each day, if the fish was detected at the reader or if its position relative to the reader was known (for continuous data runs), this was represented by an appropriate symbol. The total history of the interaction of each fish with each reader was thus shown in one line of symbols, and each fish's activity throughout the project was shown in its group of lines, one for each reader. This pictorial representation simplified events within any one day, showing the position of fish at the end of each day. It thus contained less information than the Combined Positions Report. However the overview was used for looking at initial patterns.

A final macro added and organised each new batch of PIT data into the "Combined Positions Record" (CPR). This was a fish centred file which brought together, for each fish, every movement through all of the five TIRIS readers. This large Excel file was the main TIRIS PIT data library, and the starting point for any analysis of particular fish. The complete CPR contained 32753 individual location records of 1808 individual fish.

Examples of the standardised PIT data, the Combined Positions Report and the Overview are given in Appendices 3, 4 and 5.

3.8 Radio Tagging

Radio tagging was carried out on the river bank under as aseptic, sterilised conditions as possible and using sterilised instruments. Large pike (> 55 cm) were anaesthetised in 2-phenoxyethanol (1:1000 dilution in river water) to a level at which they no longer responded to external stimuli and did not attempt to maintain an upright position in the water. Throughout the procedure a constant flow of water containing 1:5000 2-phenoxyethanol was washed over the gills to maintain oxygen and anaesthesia levels. A gas sterilised Biotrack TW-5 radio tag (Biotrack Ltd., Wareham, UK) of dimensions: 8.0 cm long, 1.6 cm diameter and 22g weight in air, with an internal coil antenna was used (Figure 3.11). As only pike over 50 cm were tagged the tag constituted a very small percentage of the fish's weight (range 0.08-0.5 %).

The tag was interfaced to a micro-controller to increase pulse rate when tilted and thus indicate periods of activity. The tag was implanted into the body cavity through an incision anterior to and just above the pelvic fin. The incision was closed with soluble Vicryl 2 mm sutures (Johnson & Johnson Intl, Brussels, Belgium) and covered with commercial grade cryanoacrylate adhesive. A prophylactic intramuscular injection of Baytril (Bayer plc, Bury St. Edmonds, UK) (1 mg per 5 kg of fish) a broad spectrum antibiotic was administered to each fish before release. Pike were transferred to recovery tanks immediately after tag implantation and remained there until they had regained full consciousness (approximately 15 minutes). They were released soon after recovery from anaesthesia, as it was considered that a swift release provided the fish with the least stressful form of recovery (Crossman 1977).

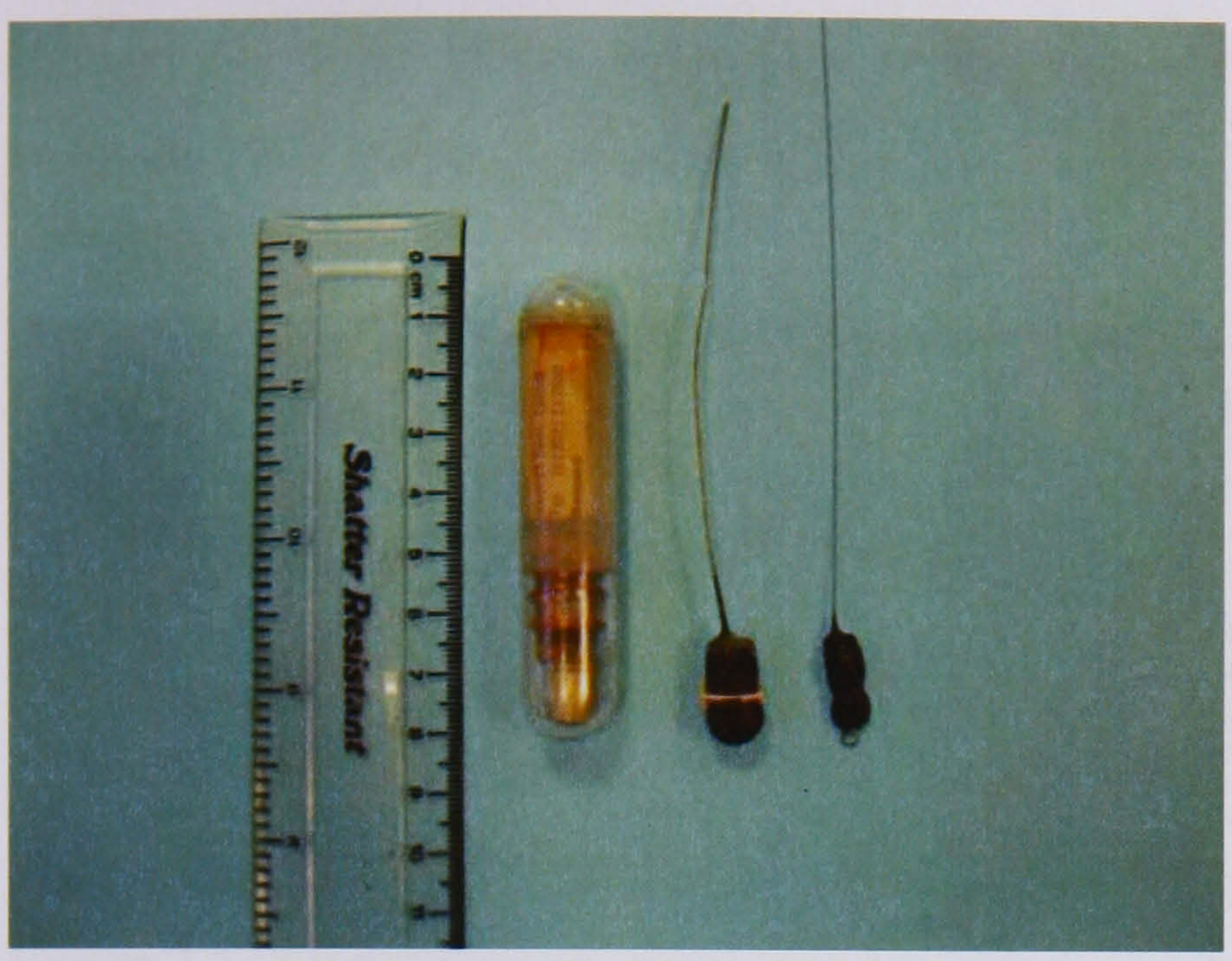


Figure 3.11 Example of radio tags used during the study. From left TW-5, TW-4 and PIP 3 tags.

Small pike (25 < FL < 55 cm) were anaesthetised in 2-phenoxyethanol (1:1000 dilution in river water) to a level at which they no longer responded to external stimuli and did not attempt to maintain an upright position in the water. External tags were used for these fish as maximum battery life was 3 months due to the smaller weight these fish could carry. By attaching tags externally with dissolvable sutures the tag could be removed or would drop off at the end of the study period. A Biotrack TW-4 radio tag of dimensions 10 x 8 x 6 mm and 0.7 g in air with a 10 cm whip antenna and battery life of 2-3 months was used for pike over 25 cm long (percent of body weight range 0.04-0.1 %) (Figure 3.11). Two sutures attached to the tag were passed through the body posterior to the anal fin and a backing plate on the other side of the fish and then tied. Sutures were left loose in order to minimise damage to the fish caused by the tag rubbing (Figure 3.12). A Biotrack PIP 3 radio tag of dimensions 7 x 7 x 4 mm and 0.4 g in air with a 15 cm whip antenna and battery life of 3-4 weeks was used for pike between 10 and 25 cm long (percent of body weight range 0.4-5 %) (Figure 3.11). These were attached with a single loop passed through the body just posterior to the dorsal fin (Figure 3.13). Pike were transferred to recovery tanks until they regained consciousness and were released soon after. This method of tag attachment was preferred because it minimised contact with the body and resulted in no damage to the fish. However, it was only possible with the very smallest tags (with short battery lives) as larger tags would have come free too quickly. Tank investigations showed that 10 to 15 cm pike tagged in this way were able to move freely through vegetation and feed and abrasion effects from tag attachment were minor.

Figure 3.12 Demonstration of the tag attachment of TW-4 tags to pike between 25 and 55 cm.

Figure 3.13 Demonstration of the tag attachment of PIP3 tags to pike between 10 and 25 cm.

Adult dace (> 18 cm) were anaesthetised in the same manner as small pike (percent of body weight range 0.2-0.6 %). A Biotrack TW-4 radio tag was attached externally just below and posterior to the dorsal fin (Figure 3.14). Two sutures attached to the tag were passed through the fish and a backing plate on the other side of the fish and then tied. Sutures were left slightly loose in order to minimise damage to the fish caused by the tag rubbing. This improvement to the method of Beaumont *et al.* (1996) was found to cause little damage to the fish. Dace were transferred to recovery tanks until they regained consciousness and were released soon after to minimise stress.

Figure 3.14 Demonstration of tag attachment of TW-4 tags to dace.

3.9 Radio Tracking

Tagged fish were located by walking the river bank whilst listening to tag frequencies until a tag was detected (Figure 3.15). A hand-held radio receiver (Sika, Biotrack Ltd.) connected to a 3-element Yagi antenna was used to locate fish. Frequencies were stored in the receiver and scanned through at 4 second intervals until a tag was located. Tag pulse rates were 0.5 – 1 Hz so the 4 second interval provided an effective compromise in scanning through the necessary range of frequencies with minimal chance of missing a tag. The location of the fish along the length of the river could be ascertained by moving to the position along the river bank receiving the strongest signal. As the distance to the tag reduced, the gain was adjusted to reduce the arc over which the signal could be detected. Once the position longitudinally along the river was found, the tracker moved five or ten metres up- or downstream in order to triangulate the position across the river. Each time a fish location, referred to as a fix, was determined, a standardised set of data were recorded on a form. Data recorded include date and time (in GMT).

Figure 3.15 The author radio tracking

The fish position was recorded as coordinates by referring to a GIS map of the river. The fix was stated as a position relative to marker posts along the bank in addition, for example 8 m upstream of T2 (post T2 in the main river). The exact locations of these marker posts were known, allowing the coordinates recorded in the field to be checked against those calculated from the written description of location. For each fix, the fieldworker recorded an estimate of the accuracy of that fix, based on signal strength, longitudinally and laterally. In general precision was between 0 and 2 m (in some cases the pike was seen) in both directions. In wider sections of river, or with weaker tags and when fish were in dense vegetation weakening the signal precision was lower. At worst it was 8 m.

Sixty eight pike (mean 49.2 cm; range 9.2 – 101 cm) and forty dace (mean 22.7 cm; range 18.9 – 27.1 cm) were tracked during the course of the study. Appendices 6 and 7 give the tracking duration and size of individual pike and dace respectively. Twenty five pike had been tagged during a previous study from 2000 to 2003 and continued to be monitored during this study. Tracking intensity of pike varied according to the specific objectives and is described in later chapters. For instance, pike were tracked intensively once or twice a day during the spawning period (February to June) but weekly to maintain contact during the summer. It was necessary to track dace daily due to their high levels of mobility. A number of tags failed or their frequencies drifted significantly during the study, particularly in spring 2004 causing the tracking duration of some pike and dace to be shortened to up to only a week in some cases.

3.10 Analysis of Animal Movements from Telemetry Data

The most appropriate home range estimation technique for the study was determined during an investigation using data from the radio tracked pike. A summary is given below and details of the optimal method and reasoning behind this conclusion are given in Chapter 7.

Methods used to estimate home ranges in restricted environments (e.g. rivers) are liable to overestimate home range area through the inclusion of unused habitats (e.g. river bank). This reduces the accuracy of management decisions such as habitat management which can be made from the data. Location data from 23 radio-tagged pike were used to examine the efficiency of standard home range estimators, when clipped to include only the area of home range within the river, for determining seasonal changes in habitat use. Cluster analysis demonstrated changes in core area most clearly between seasons, whilst kernel analysis most effectively showed seasonal variation in excursive activity. Range span did not statistically demonstrate any seasonal variation. Cluster analyses, kernel contour estimators and convex polygons round all locations gave progressively greater technique-based variation. Area clipping reduced out-of-river error and hence bias generated by this error, aiding detection of seasonality.

3.11 Scalimetry and Growth

Inspection of the hard structures of a fish can reveal the age and growth rate of that individual. The alternation between rapid and slow growth during the fish's life may be reflected in the scale structure by the spaces between the daily growth rings (Bagenal 1978). This pattern is particularly clear in cold and temperate regions with the slowest growth occurring in the winter. The number of annuli gives the age of the fish and the spaces between them reflect the growth rate.

Scales removed from pike were used to measure pike age and growth. Scale samples were always taken from the same place on the fish's body to ensure that the earliest formed scales were used for analysis. For pike, some of the earliest scales to develop are those just below the dorsal fin and above the lateral line (Figure 3.16). All scales used in this study were taken from this location.

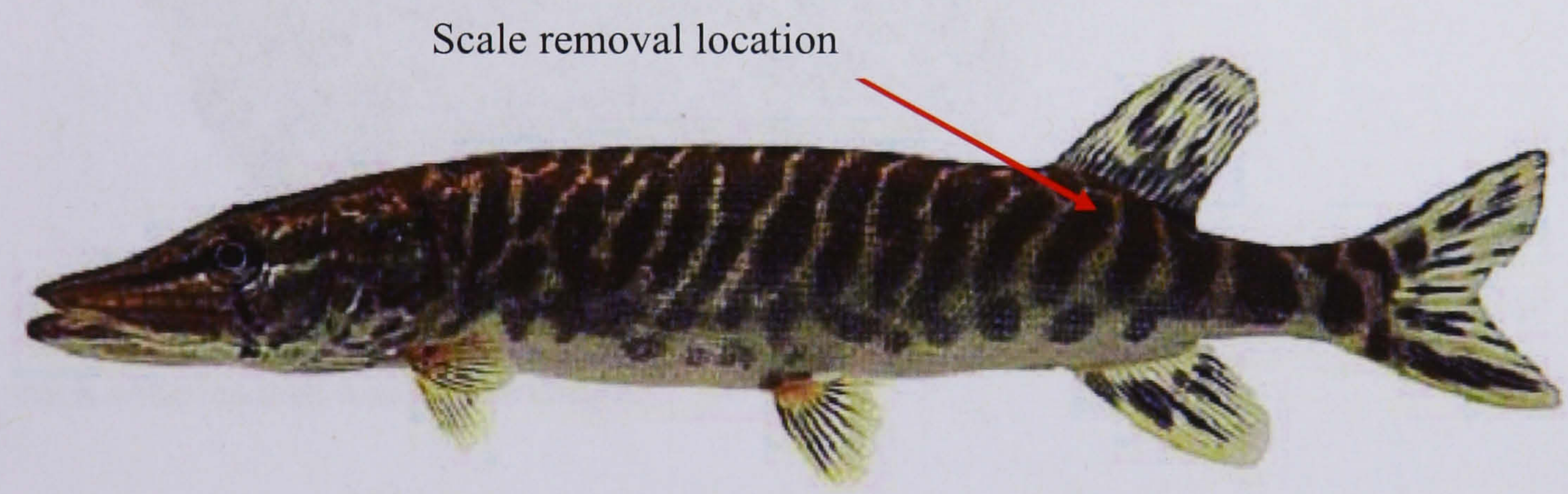


Figure 3.16 Location of scale removal on pike

Approximately ten scales were sampled from each fish using tweezers. Unflawed scales (those without regenerated centres or deformations) were selected and placed in a petri dish containing 4% sodium hydroxide for 5 minutes. Scales were then washed in water and mounted between two microscope slides.

The slides were examined under a Projectina microscope at x10 magnification. The distance from the scale centre to each annulus and the scale edge was measured along the axis demonstrated in Figure 3.17. The clearest three scales of each fish were measured in this way.

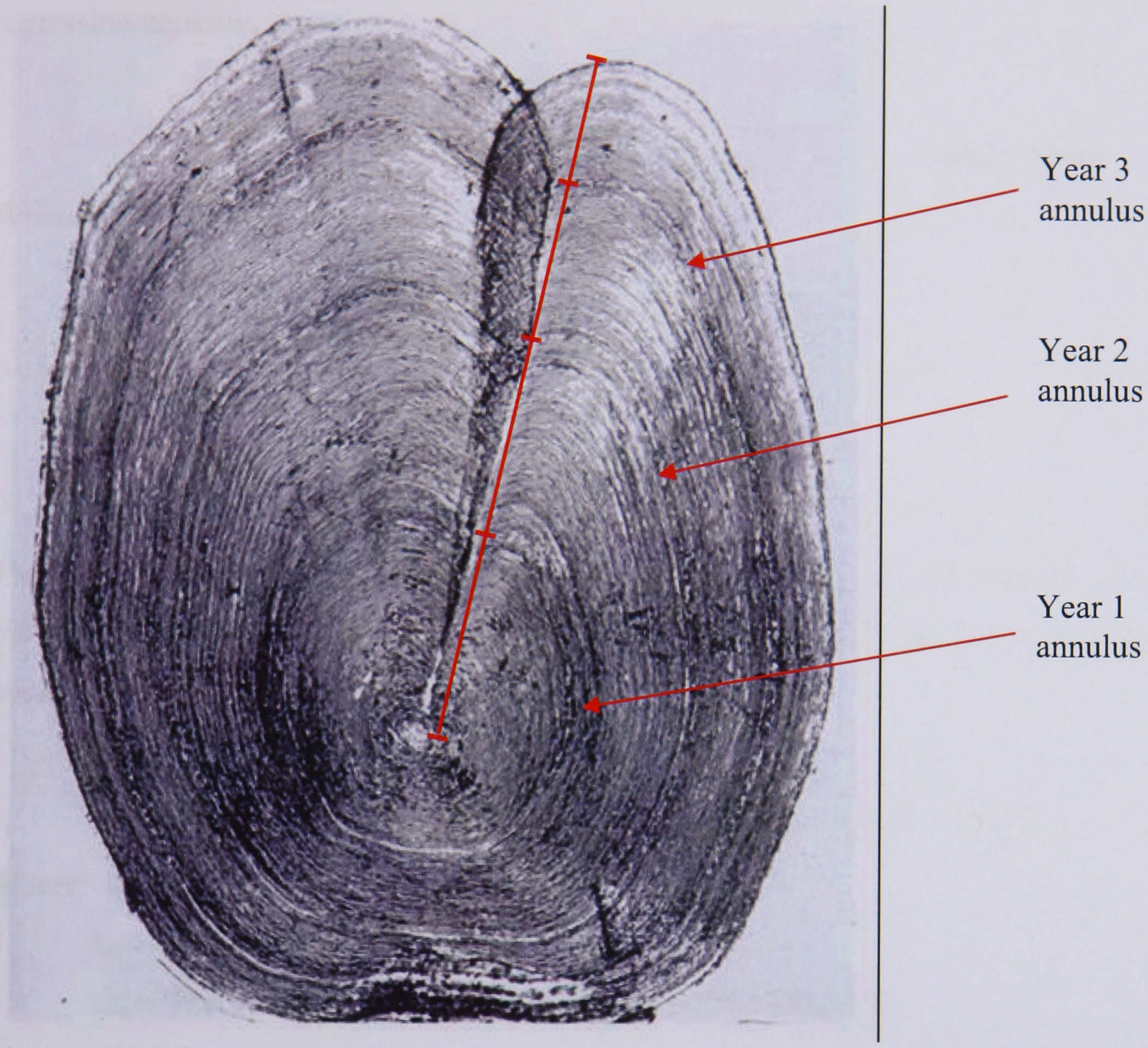


Figure 3.17 Pike scale demonstrating three annuli and the position of measurements of each annulus and total scale length.

3.12 Back-calculation and Growth Estimation

Back-calculation enables the estimation of an individual's growth history from annual growth patterns measured from hard structures (in the case of this study fish scales). It is based on an approximately proportional relationship between the linear growth of the scale and the length of the fish. The length of the fish when captured, the length of the full scale radius and the lengths of the radii at each age permit the length of the fish at each age to be estimated. The linear regression model (Fraser 1916) was used to back-calculate fish length at age as it is a frequently used model (Dauba and Biro 1992, Mann 1974, 1976a) and gave good fit to the data set (R^2 = 90%). The linear regression equation:

$$R_n = a + bL_n \qquad \text{Fraser (1916)}$$

Where:

a = intercept,

b = slope,

R_n = scale radius at age,

L_n = length at age

The Von Bertalanffy growth model (1938) was used to calculate individual growth of pike because it is well adapted to the logarithmic type of growth and has been widely used, allowing for easy comparison.

$$L_t = L_\infty \left[1 - e^{-K(t-t_0)}\right] \qquad \text{Von Bertalanffy (1938)}$$

Where:

L_t = Length at time t

L_∞ = Theoretical maximum size when growth would be nil

K = Constant that characterises growth speed to reach L_∞

t_o = Theoretical time when L = 0 (although size at birth is often > 0)

Thus by using back-calculation it was possible to calculate an individual's growth from birth to capture. The parameters of the Von Bertalanffy equation can be calculated using the Ford-Walford equation (Ford 1933, Walford 1946). Size at L_{t+1} must be plotted on a graph against size at L_t to give the Ford-Walford equation:

$$L_{t+1} = a + bL_t \qquad \text{(Ford 1933, Walford 1946)}$$

Where:

a = intercept

b = slope

L_t = length at age t

The output of the Ford-Walford equation was then used to calculate the parameters of the Von Bertalanffy equation:

$$L_{\infty} = a / (1 - b)$$

$$K = -\ln(b)$$

Chapter 4

Side-Channel Characteristics and Species Assemblages

4.1 Introduction

In rivers interaction between the abiotic and biotic factors affects the distribution and abundance patterns of species and thus community structure (Brown 1984). Both abiotic variability (e.g. dissolved oxygen, temperature, flow) and biotic processes (e.g. predation, competition) affect fish assemblages. Poff (1997) compared abiotic factors to multiple-scale 'filters' that control local occurrence or abundance of species. Assemblages locally reflect species' functional ability to cope with ecological conditions. Within sites, fish abundances vary with the stability or persistence of suitable habitats as well as the interaction between species (Freeman et al. 2001).

A broad means of assessing the value of a particular habitat to the entire aquatic community is to study the species assemblages of organisms using that habitat. Monitoring the community as a whole enables subtle changes in the assemblage diversity and composition to be detected. The suitability of a habitat to a particular species or age-group may vary as the conditions in the habitat fluctuate (Pessanha et al. 2003, Rueda and Defeo 2003). Long term change in species composition may also be symptomatic of anthropogenic alterations such as flood control measures (Bayley 1995, Bunn and Arthington 2002). Thus analysis of species assemblages provides a powerful tool for assessing the significance of a particular habitat within the ecosystem, as well as the functioning of the habitat supporting the community throughout the year.

Fish assemblages of aquatic floodplain systems have great potential to reshuffle during flood events and to vary according to season (Bayley 1995, Hoeinghaus et al. 2003). The underlying objective of this chapter is to compare and contrast the various different off-river habitats available in a typical chalk stream and the fish species assemblages that use them throughout the year. Thus, the importance of both a single side-channel and a network of contrasting off-river habitats within a floodplain river system are addressed. It is hypothesised that although the side-channels of a chalk stream may appear the same at the macro-scale, subtle variation in the habitat and fish community differentiates their contribution to the river system.

4.2 Materials and Methods

4.2.1 SAMPLING

Seven side-channels (Chapter 2) were sampled with electric fishing four times a year during 2003-2005. Side-channel temperature, pH and dissolved oxygen was measured with a hydrolab. Chapter 3 gives further detail on the procedures used.

4.2.2 ANALYSIS

Detrended correspondence analysis (DCA) with detrending by linear segments and nonlinear rescaling of axes was undertaken to confirm that the data were linear before carrying out a principle components analysis (PCA) (ter Braak and Prentice 1988). A partial PCA with year and season controlled for as covariables was completed. Environmental variables were centred and standardised to allow them to be directly comparable.

Population size within a single section of side-channel was estimated for a number of depletion sampled (double or triple fished) sections using the weighted maximum likelihood method (Carle and Strub 1978). While these estimates were unlikely to be accurate measures of population size (especially outside the 50 m section to which they applied) they did provide an indication of fishing efficiency. This allowed the accuracy of abundance and density estimates calculated from single pass fish catches to be gauged and the level of representation of these estimates of population size to be judged.

Two diversity indices were used to investigate the side-channel assemblages. Species richness *S*, the total number of species present, was a simple measure of diversity. Shannon's diversity index *H'* which is influenced by the total number of species and by the evenness of distribution of catch between those species was calculated with the equation:

$$H' = -\sum_{i=1}^{s} p_i \ln(p_i)$$

Where p_i = the proportion of the *i*th species in a sample

Diversity indices were calculated for the total assemblage at each location, seasonal assemblages at each location and also for each sample.

Canonical correspondence analysis was used to investigate the influence of environmental variables on species distribution after DCA. A partial CCA was undertaken with year and season controlled for as covariables so that only the interaction between species and environment factors was presented. To remove the effects of collinearity (the amount of redundancy within the environmental information) in the CCA, only those variables were selected that explained a significantly additional proportion of the variance independent of the other variables. Forward selection was used to identify the smallest subset of variables explaining the most variation in the assemblage data. Each variable was tested through Monte Carlo permutation tests (with 999 unrestricted permutations), with variables added to the model according to Bonferroni corrected *P*-values. Rare species were down-weighted in the CCA ordinations. The first two ordination axes were presented as a triplot of samples, species and environmental variables. Then simple scatterplots of the first two axes with only species on an enlarged scale were made, with each species coloured according to its hydraulic preference.

General linear models were used to predict species diversity and catch from environmental variables. The data set was split randomly into two groups, a first group of 236 samples used to create the model and a second group of 100 samples used to test the model. Variables with an α-value < 0.05 in the full general linear model were selected to include in the final model. Equations were then constructed from the coefficients provided and were used to test on the second data set.

A habitat stability index was created and calculated for each stream. This index used the variability (standard deviation) to give an indication of the stability of a particular side-channel relative to all side-channels. The equation used was:

$$Stability = \sum_{hab\,\mathrm{var}} {SD_{loc}}/{SD_T}$$

Where SD_{loc} = standard deviation of each habitat variable for individual side-channels

SD_T = standard deviation of each habitat variable for all locations

The relationship between this habitat stability index and species diversity was then investigated with a Pearson correlation coefficient. This method was used because of the small sample size.

Ordination methods were carried out in CANOCO 4.5 with ordination figures constructed in CanoDraw. All other graphs were made in SigmaPlot 2000. Statistical analyses were carried out in Minitab 14.

4.3 Results

4.3.1 SIDE-CHANNEL HABITAT CHARACTERISTICS

4.3.1.1 Temporal variation

As with most ecosystems the side-channels were found to be dynamic habitats, showing daily, seasonal and to some extent annual variation in habitat characteristics. Seasonal and annual variations in abiotic factors measured during seasonal sampling are presented in Appendix 8 and Appendix 9. Temperature, dissolved oxygen and vegetation showed the highest amount of seasonal variation. Interannual variation was apparent but at a low level. Daily fluctuations were apparent in side-channel temperature, dissolved oxygen and pH (Figures 4.1 and 4.2). Daily fluctuations in all three variables were stronger in summer than winter. Daily fluctuations in dissolved oxygen were more extreme in Railway than Luckford due to the large amount of macrophytes and very little shade in Railway.

Temperature varied seasonally, peaking in August in most side-channels and generally following the same pattern as the main river (Figure 4.3). Millstream temperatures were similar to the main river as could be expected because Millstream leaves the river and rejoins only 1.4 km downstream. The other side-channels exhibited buffered temperatures compared to the main river (Figure 4.3), suggesting that they are all in part ground water fed. Temperatures peaked at a lower temperature in the summer, were similar to the river in autumn and were slightly lower in winter and spring. There were no significant differences in year-round monthly temperatures between locations, but summer (June, July and August) temperatures were significantly higher in the main river and Millstream than in the other side-channels (*ANOVA*, Tukey test; $F = 7.46$, $P < 0.01$, $df = 6$).

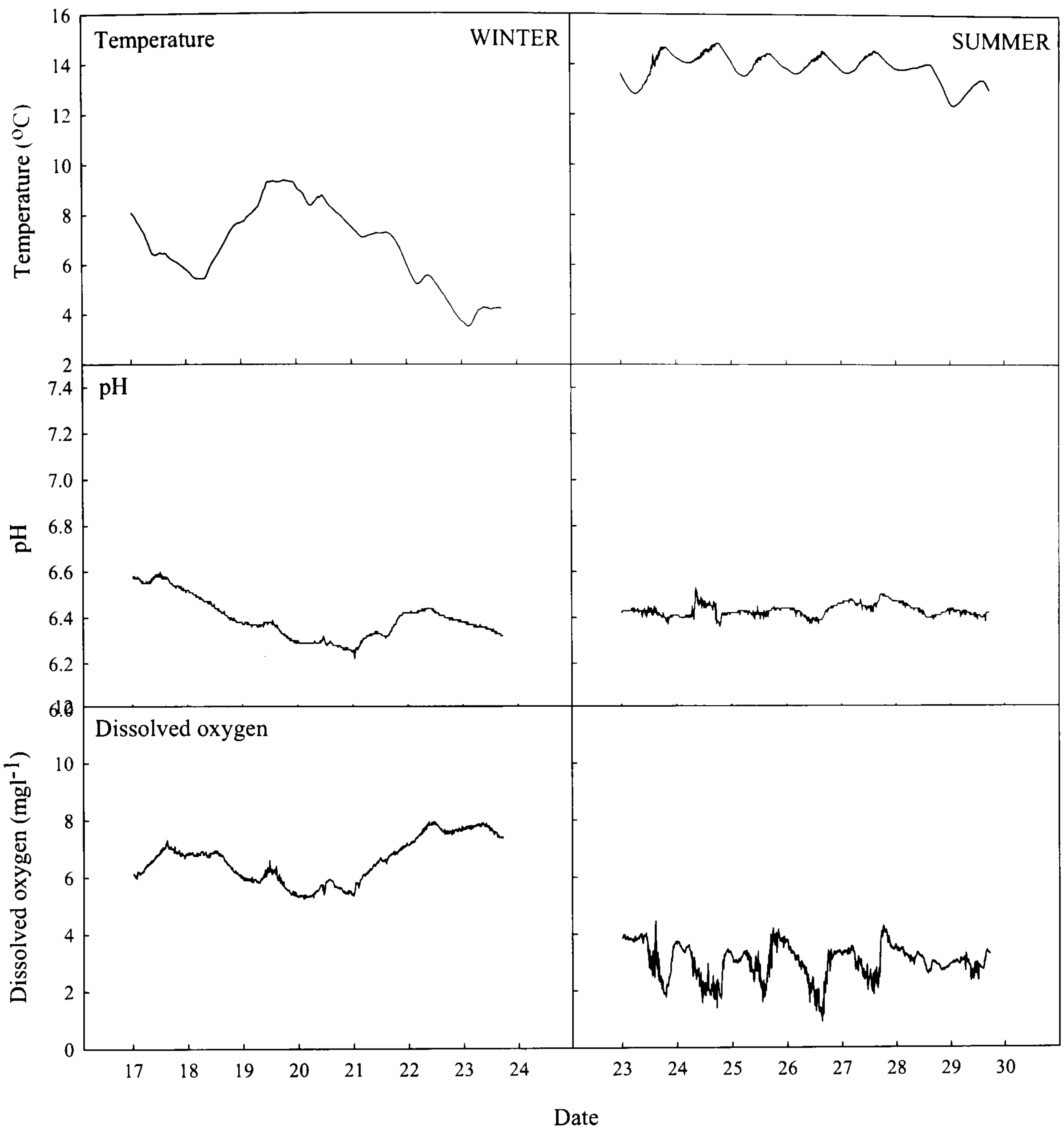


Figure 4.1 Daily variation over 7 days in temperature, pH and dissolved oxygen in the Railway ditch during winter (January) 2005 and summer (June) 2005.

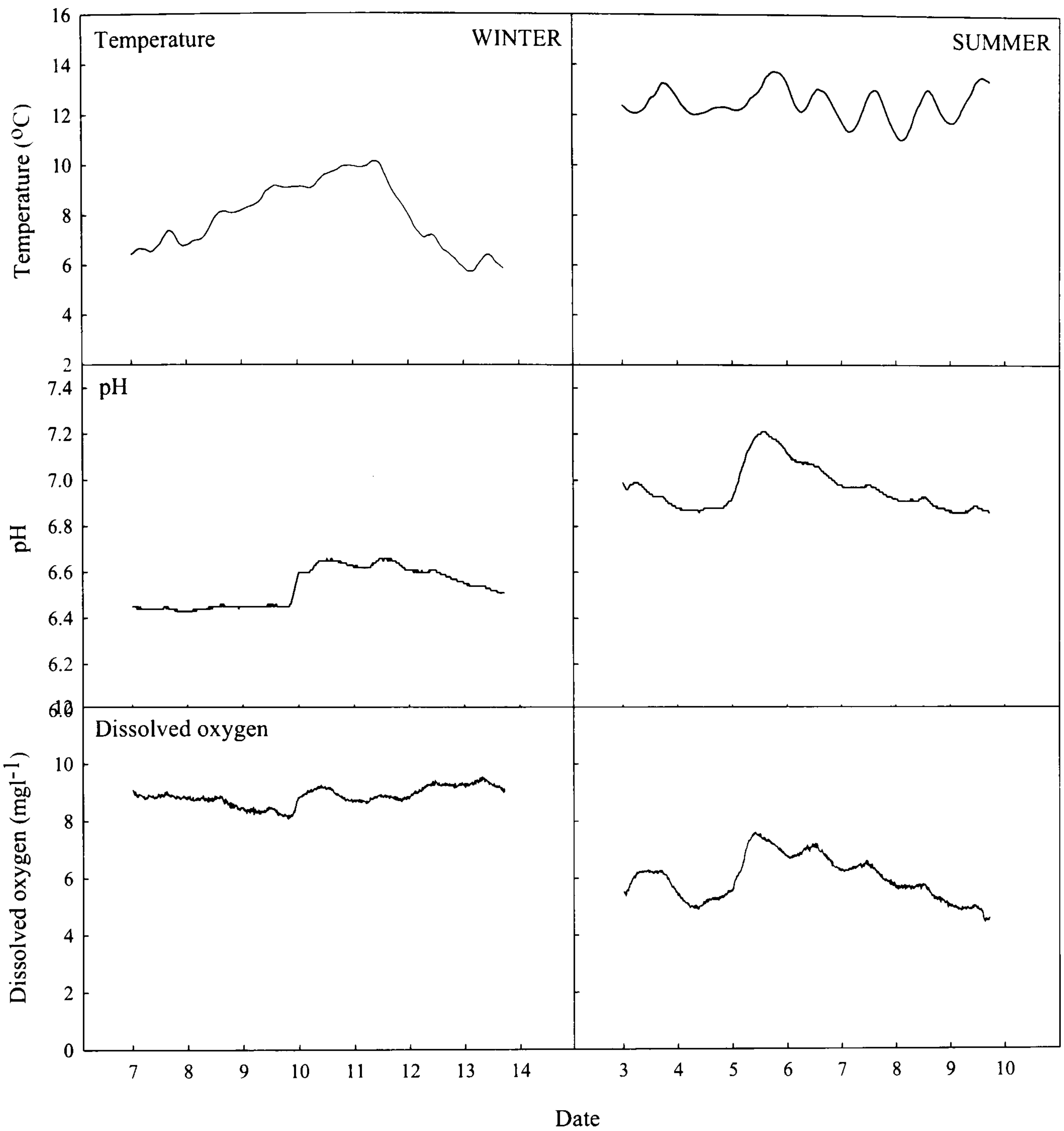


Figure 4.2 Daily variation over 7 days in temperature, pH and dissolved oxygen in Luckford during winter (February) 2005 and summer (June) 2005.

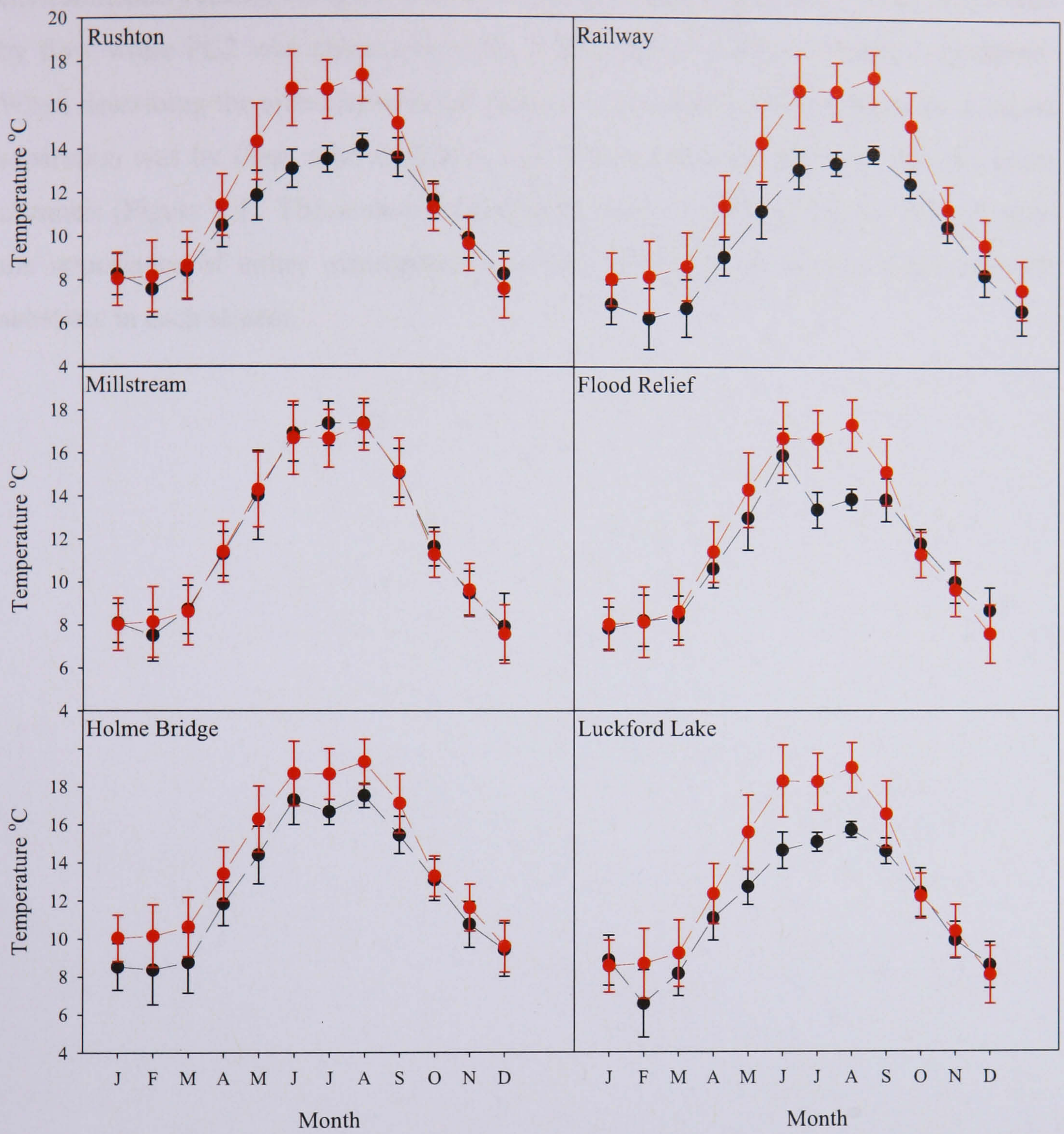


Figure 4.3 Average monthly temperatures in 2004 for each side stream (black line) and for the main river (red line). Error bars represent standard deviation. Temperature data were collected with Tinytalk temperature loggers every 15 minutes. Temperature data for Goldsacs stream was not available. (Source CEH and University of Exeter unpublished data).

4.3.1.2 Side-channel variation

The gradient length of the habitat characteristics was 1.51 standard deviation units, so the data showed a linear response suggesting that principle components analysis (PCA) was appropriate (ter Braak and Prentice 1988). Principle components analysis of the habitat characteristics measured seasonally demonstrated the distribution of environmental variables (Figure 4.4). Principle component axis (PC) 1 was dominated by flow while PC2 was characterised by woody debris and macrophyte vegetation. When describing the side-channels by their environmental characteristics the clearest separation was by flow, with Goldsacs and Millstream faster flowing than the other channels (Figure 4.4). Those slower flowing or slack channels separated according to the importance of either macrophytes and clay substrate or woody debris and silt substrate in each stream.

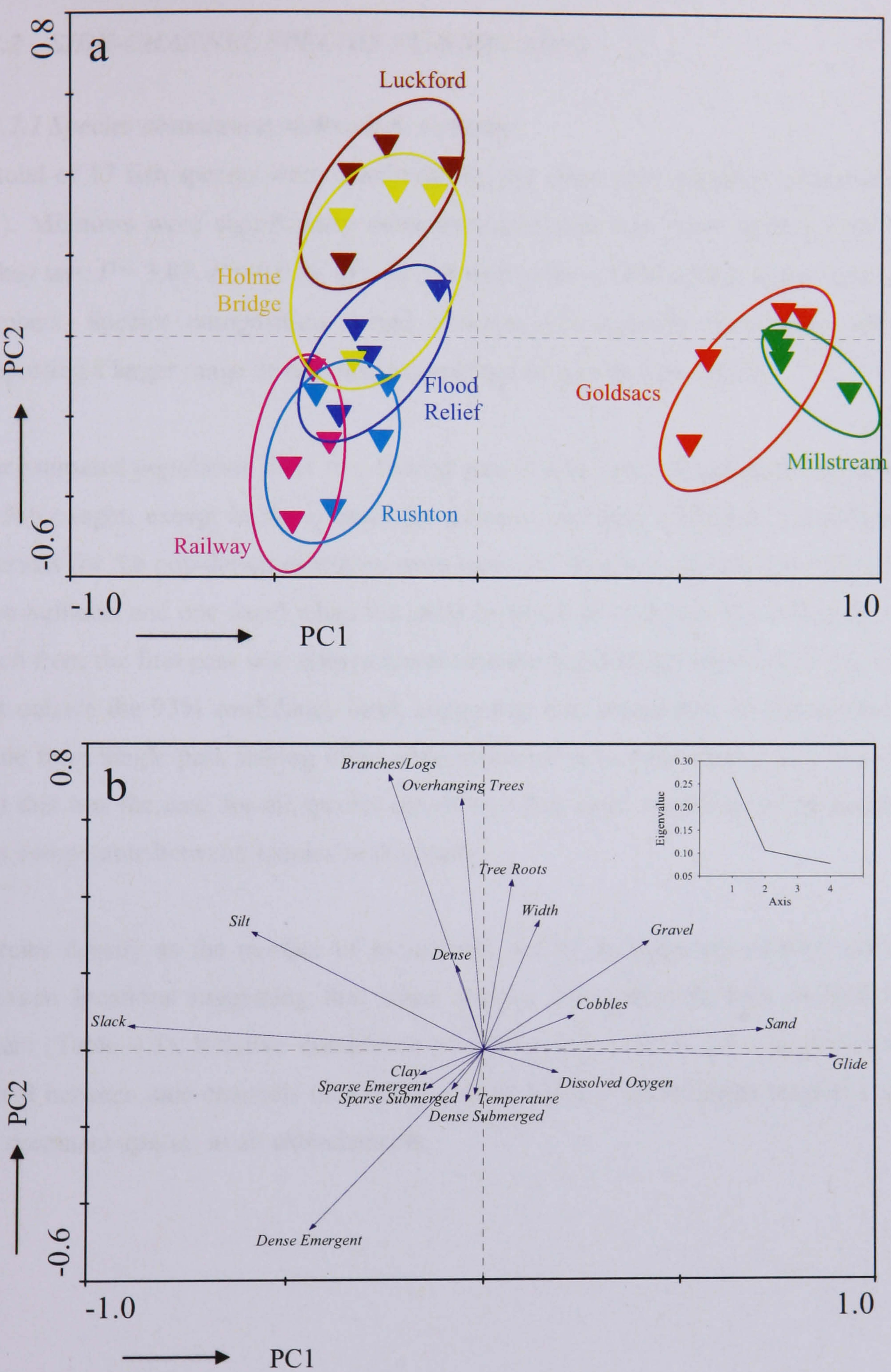


Figure 4.4 Principle components analysis of 18 environmental variables measured during sampling in March, June, September and December 2003 to 2005 with (a) the four 50 m sections for each side-channel grouped and (b) the correlations for variables.

4.3.2 SIDE-CHANNEL SPECIES ASSEMBLAGES

4.3.2.1 Species abundance, richness & diversity

A total of 17 fish species were caught during the three year sampling period (Table 4.1). Minnows were significantly more abundant than any other species (*ANOVA*, Tukey test; $F = 3.07$, $P < 0.014$, $df = 6$) and were often estimated due to the very large numbers. Species composition varied between side-channels with some streams supporting a larger range or different assemblage of species than others.

The estimated population after two fishing passes was generally close to the number of fish caught, except in some cases for minnow and dace (Table 4.2). Confidence intervals for the population estimates were generally small except for three occasions (two bullhead and one dace) when the catch from the second pass was still high. Fish catch from the first pass was always lower than the population estimate and was often just outside the 95% confidence limit, suggesting that calculation of fish abundance made from single pass fishing often underestimated actual population size. The fact that this was the case for all species means that fish catch recorded during sampling was comparable between species in this study.

Species density as the number of individuals per m^2 in each side-channel differed between locations suggesting that some streams were more heavily utilised than others (Table 4.3). Relative dominance of each species within the community also varied between side-channels (see relative catch Table 4.3), although minnows were the dominant species in all side-channels.

Table 4.1 Latin and common names and total number of fish sampled in the side-channels over three years (2003-2005) by individual side-channel (RW, Railway; MS, Millstream; RU, Rushton; LL, Luckford; GS, Goldsacs; HB, Holme Bridge; FR Flood Relief).

Latin name	Common name	Number of fish						
		RW	MS	RU	LL	GS	HB	FR
Cottus gobio	Bullhead	1	970	17	16	331	12	13
Leuciscus leuciscus	Dace	8	564	1	547	123	13	51
Anguilla anguilla	Eel	99	551	102	96	150	201	83
Platichthys flesus	Flounder	-	116	-	-	269	-	-
Thymallus thymallus	Grayling	-	34	-	-	2	-	-
Gobio gobio	Gudgeon	-	45	3	14	-	9	1
Lampetra planeri	Brook lamprey	4	24	27	16	256	2	2
Phoxinus phoxinus	Minnow	6201	7491	3138	50979	1942	16340	126140
Perca fluviatilis	Perch	-	-	4	2	-	1	2
Esox lucius	Pike	153	52	83	52	2	58	73
Oncorhynchus mykiss	Rainbow trout	-	-	-	-	1	-	-
Rutilus rutilus	Roach	-	99	6	385	16	78	15
Salmo salar	Salmon	-	499	-	13	13	1	-
Gasterosteus aculeatus	3 spine stickleback	4	11	3	1	13	2	17
Barbatula barbatula	Stone loach	6	963	25	84	221	23	18
Leucaspius delineatus	Sunbleak	-	-	1	-	-	-	-
Salmo trutta	Brown trout	-	174	-	13	482	1	-

Table 4.2 Population estimates in 50 m side-channel sections calculated from depletion sampling using the weighted maximum likelihood method.

Species	Location	Date	Catch 1	Catch 2	Catch 3	Catch Total	Estimated Population	95% Confidence interval
Bullhead	Goldsacs	Jun 04	5	4	-	9	11	5.2
		Mar 05	15	8	-	23	27	7.8
		Jun 05	8	2	-	10	10	0
		Sep 05	18	16	-	34	60	42
	Millstream	Sep 04	26	13	-	39	47	12.7
		Dec 04	11	5	-	16	17	2.7
		Mar 05	7	1	-	8	8	0
		Sep 05	19	6	0	25	25	0
Dace	Flood Relief	Jun 05	14	4	-	18	18	0
	Luckford	Dec 04	22	2	-	24	24	0
	Millstream	Sep 04	19	18	-	37	71	54
		Sep 05	142	42	-	184	200	14.5
Eel	Millstream	Sep 05	4	2	1	7	7	0
Flounder	Goldsacs	Jun 04	16	2	-	18	18	0
		Mar 05	2	1	-	3	3	0
	Millstream	Sep 04	5	2	-	7	7	0
		Dec 04	3	1	-	4	4	0
Minnow	Flood Relief	Jun 05	6	1	-	7	7	0
	Goldsacs	Mar 05	530	440	-	970	2868	1332
		Jun 05	2	1	-	3	3	0
		Sep 05	16	7	-	23	26	6.4
	Millstream	Sep 04	278	177	-	455	745	180
		Mar 05	8	5	-	13	15	4.8
		Sep 05	470	49	3	519	522	0
		Dec 05	8	2	-	10	10	0
Pike	Millstream	Sep 05	4	1	0	5	5	0
	Railway	Jun 05	4	2	-	6	6	0
Roach	Millstream	Sep 05	54	17	-	71	77	8.5
Stone loach	Goldsacs	Sep 05	11	6	-	17	20	6.7
	Millstream	Sep 04	16	7	-	23	26	6.4
		Sep 05	23	4	2	29	29	0
Trout	Goldsacs	Jun 05	12	2	-	14	14	0
	Millstream	Dec 04	5	1	-	6	6	0

Table 4.3 Common name, code, mean relative catch (in %) and mean densities (in indiv m-^{2}) (based on single pass fishing) of fish sampled in the side-channels over three years (4 quarterly samples per year) (2003-2005) by individual side-channel (RW, Railway; MS, Millstream; RU, Rushton; LL, Luckford; GS, Goldsacs; HB, Holme Bridge; FR Flood Relief).

Common name	Code	Relative catch (% of total capture)							Relative density (indiv/m^2)						
		RW	MS	RU	LL	GS	HB	FR	RW	MS	RU	LL	GS	HB	FR
Bullhead	Cg	0.02	8.37	0.50	0.03	8.66	0.07	0.01	0.00	0.81	0.03	0.02	0.73	0.01	0.02
Dace	Ll	0.12	4.87	0.03	1.05	3.22	0.08	0.04	0.01	0.47	0.00	0.52	0.27	0.02	0.08
Eel	Aa	1.53	4.75	2.99	0.18	3.93	1.20	0.07	0.17	0.46	0.17	0.09	0.33	0.25	0.13
Flounder	Pf	-	1.00	-	-	7.04	-	-	-	0.10	-	-	0.59	-	-
Grayling	Tt	-	0.29	-	-	0.05	-	-	-	0.03	-	-	0.00	-	-
Gudgeon	Gg	-	0.39	0.09	0.03	-	0.05	0.00	-	0.04	0.00	0.01	-	0.01	0.00
Lamprey	L	0.06	0.21	0.79	0.03	6.70	0.01	0.00	0.01	0.02	0.04	0.02	0.56	0.00	0.00
Minnow	Pp	95.75	64.62	92.02	97.63	50.82	97.60	99.78	10.82	6.24	5.12	48.09	4.28	19.93	199.17
Perch	Pef		0.00	0.12	0.00		0.01	0.00	-	-	0.01	0.00	-	0.00	0.00
Pike	El	2.36	0.45	2.43	0.10	0.05	0.35	0.06	0.27	0.04	0.14	0.05	0.00	0.07	0.12
Rainbow trout	Om	-	-	-	-	0.03	-	-	-	-	-	-	0.00	-	-
Roach	Rr	-	0.85	0.18	0.74	0.42	0.47	0.01	-	0.08	0.01	0.36	0.04	0.10	0.02
Salmon	Ss	-	4.30	-	0.02	0.34	0.01	-	-	0.42	-	0.01	0.03	0.00	-
3 Spine stickleback	Ga	0.06	0.09	0.09	0.00	0.34	0.01	0.01	0.01	0.01	0.00	0.00	0.03	0.00	0.03
Stone loach	Bb	0.09	8.31	0.73	0.16	5.78	0.14	0.01	0.01	0.80	0.04	0.08	0.49	0.03	0.03
Sunbleak	Ld	-	-	0.03	-	-	-	-	-	-	0.00	-	-	-	-
Trout	St	-	1.52	-	0.02	12.62	0.01	-	0.00	0.14	0.00	0.01	1.06	0.00	0.00

No difference was found across the 50 m stream sections using Bonferroni corrected two-way ANOVA (F and P values provided in Appendix 10). Thus the four 50 m stream sections were used as replicates in subsequent analyses. A wide range of species diversity occurred between side-channels with the two faster flowing streams Goldsacs and Millstream exhibiting significantly higher diversity (ANOVA, Tukey test; $F = 34.08$, $P < 0.01$, $df = 6$) (Figure 4.5). Species richness was also significantly higher in the two flowing streams (ANOVA, Tukey test; $F = 102.88$, $P < 0.01$, $df = 6$). Diversity was significantly higher in side-streams in summer and autumn than spring and winter (ANOVA, *Tukey* test; $F = 12.45$, $P < 0.05$) and only remained high in spring and winter in Goldsacs and Millstream (Figure 4.6). Species richness varied less seasonally but was significantly higher in spring and winter (*ANOVA*, *Tukey* test; $F = 21.38$, $P < 0.05$), contrary to species diversity. Relative diversity was more variable between side-channels during the more diverse seasons, for example Rushton exhibited the lowest diversity in summer.

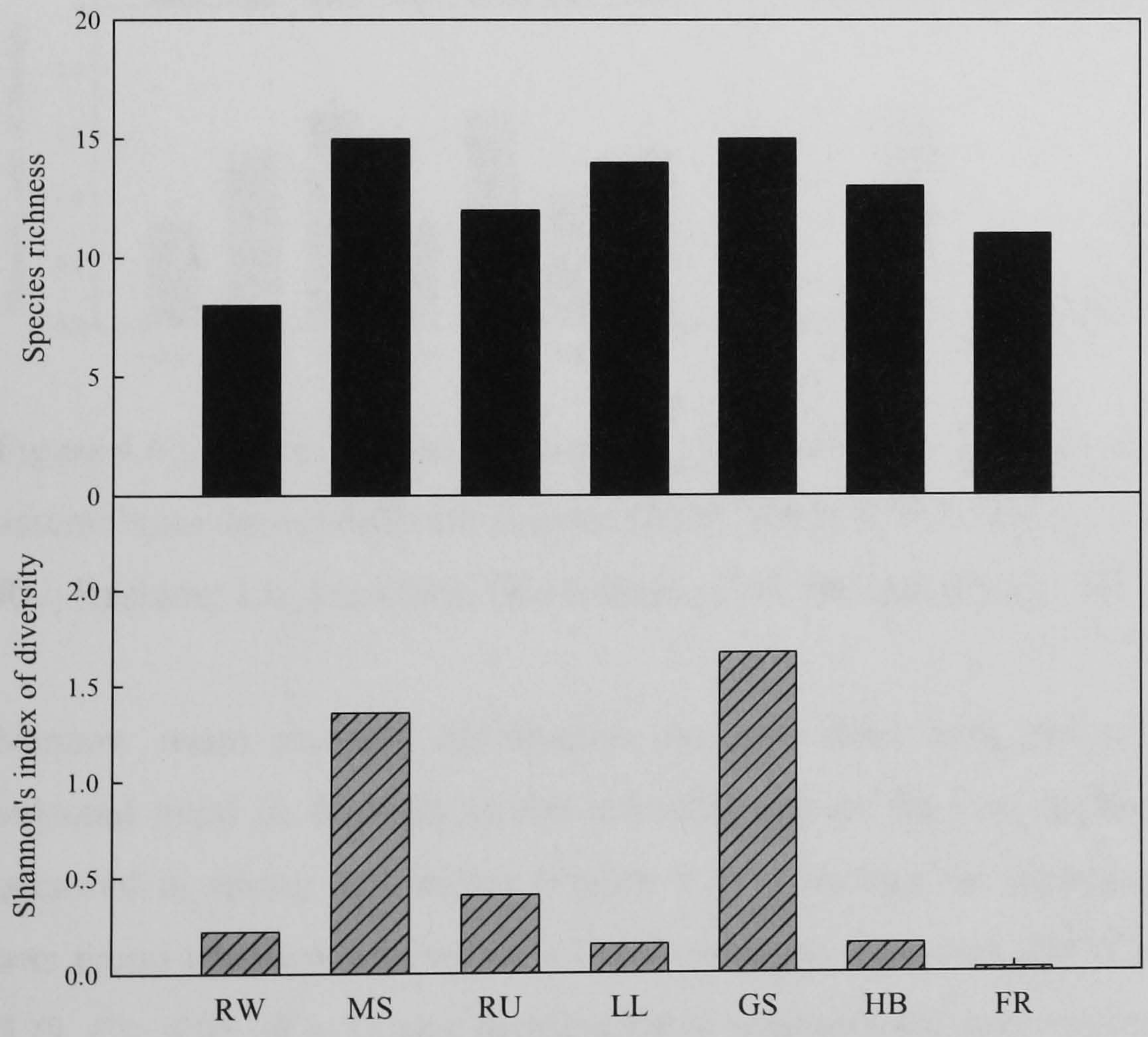


Figure 4.5 Species richness ■ and Shannon's index of diversity ▨ for the full period of sampling in the side-channels (2003-2005). RW, Railway; MS, Millstream; RU, Rushton; LL, Luckford; GS, Goldsacs; HB, Holme Bridge; FR, Flood Relief.

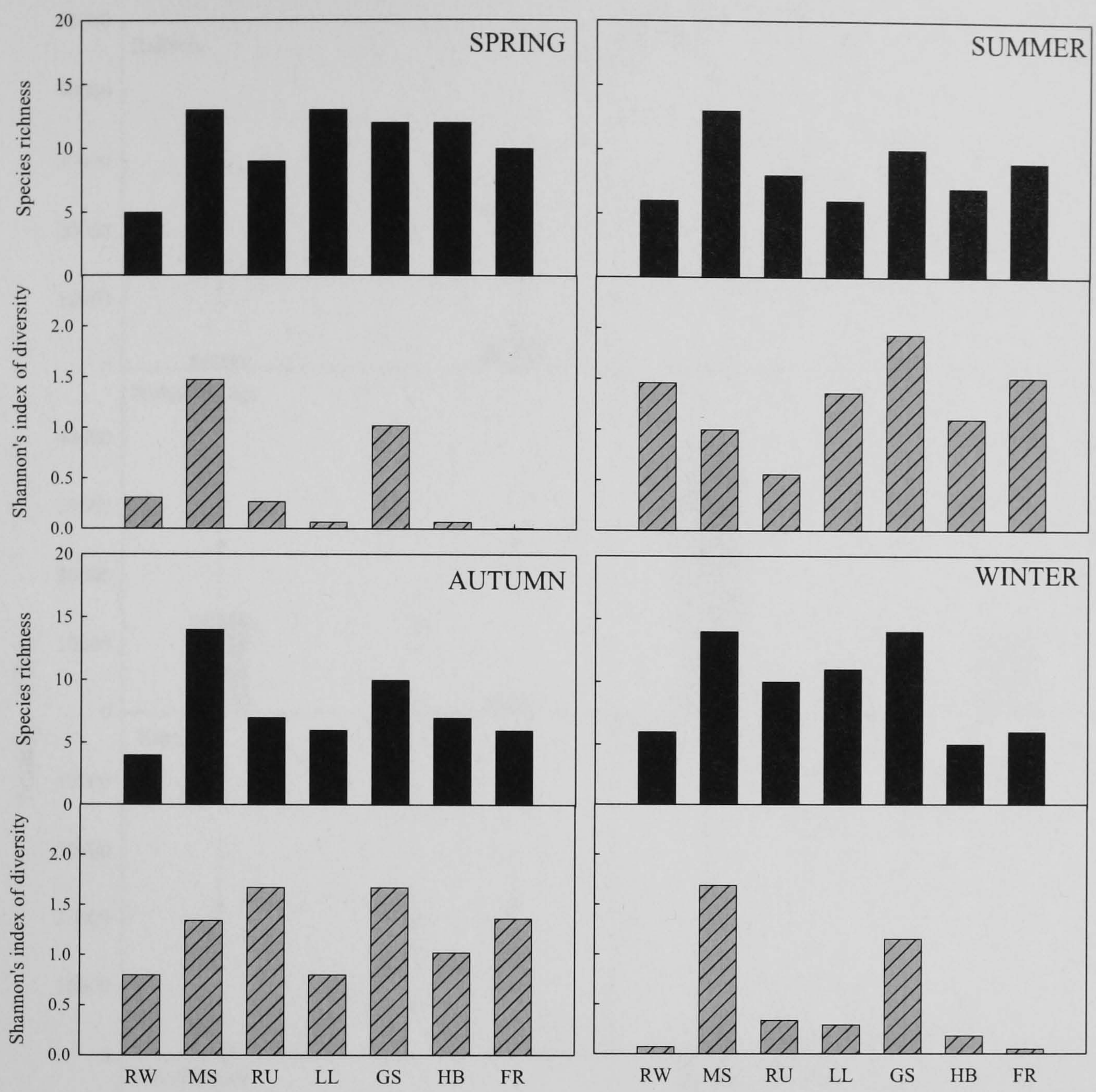


Figure 4.6 Species richness ■, Shannon's index of diversity ▨ for side-channel fish assemblages during different seasons (2003-2005). RW, Railway; MS, Millstream; RU, Rushton; LL, Luckford; GS, Goldsacs; HB, Holme Bridge; FR, Flood Relief.

Minnow mean seasonal distribution over the three year period may explain the seasonal trend in diversity in the side-channels as the very high catch of minnows occurred in spring and winter (Figure 4.7). Although no significant size difference was found between seasons for all side-channels (two-way *ANOVA*, Tukey test; $F = 0.79$, $P > 0.05$, $df = 3$), size distribution of minnows did vary between channels (two-way *ANOVA*, Tukey test; $F = 3.70$, $P < 0.05$, $df = 6$). Significantly younger (smaller size classes) minnow used Luckford and Railway than Goldsacs and Millstream. However, when considering these patterns it must be kept in mind that fishing efficiency was likely to be lower for smaller fish of all species.

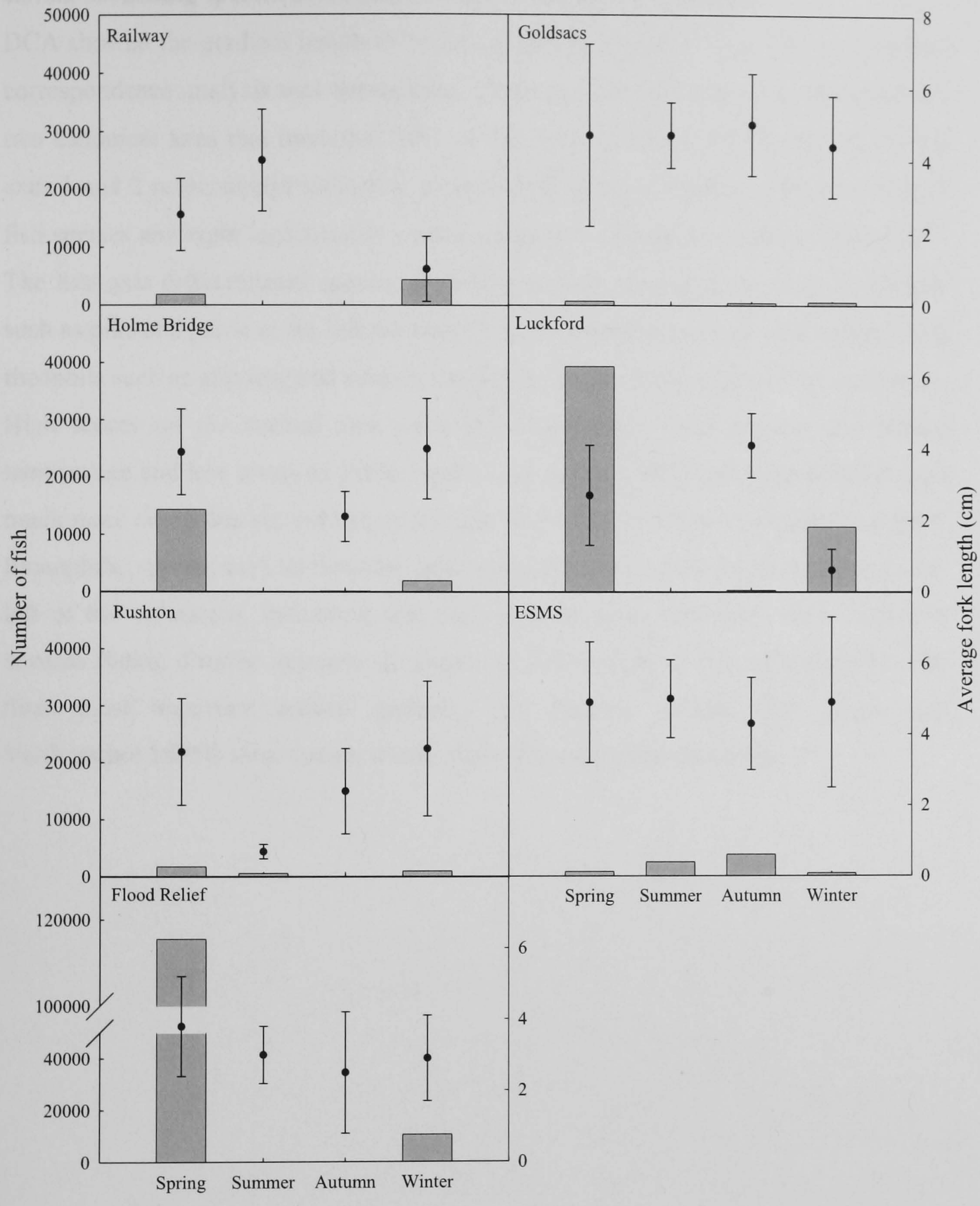


Figure 4.7 Seasonal catch from electric fishing (bars) and size variation (points and standard deviation error bars) of minnow (*Phoxinus phoxinus*) in River Frome side-channels (Mean of 2003-2005).

4.3.2.2 Modelling species assemblages with environment variables

DCA showed the gradient length to be 2.15 standard deviation units and so canonical correspondence analysis was appropriate. Canonical correspondence analysis yielded two canonical axes that modelled 80% of the total variation (58.9% and 21.1% for axes 1 and 2 respectively) indicating a reasonably strong relationship between the 15 fish species and eight significantly contributing environmental variables (Figure 4.8). The first axis differentiated species according to flow requirements, with limnophils such as pike and perch at the left extreme of the axis favouring slack flow habitats and rheophils such as grayling and salmon tending to cluster on the right of the ordination. High scores on the second axis were associated with wider streams and higher temperature and low levels of shade. Species favouring high flows were differentiated much more along this second axis than those favouring low flow environments. Some limnophilic species such as flounder, bullhead and stoneloach were also placed on the left of the ordination, indicating that they may be more associated with shallower streams (being directly opposite the depth vector) than slow flow (Figure 4.8). The three most important habitat variables (i.e. longest vectors; (Ter Braak and Verdonschot 1995)) were stream width, slack flow and sandy substrate.

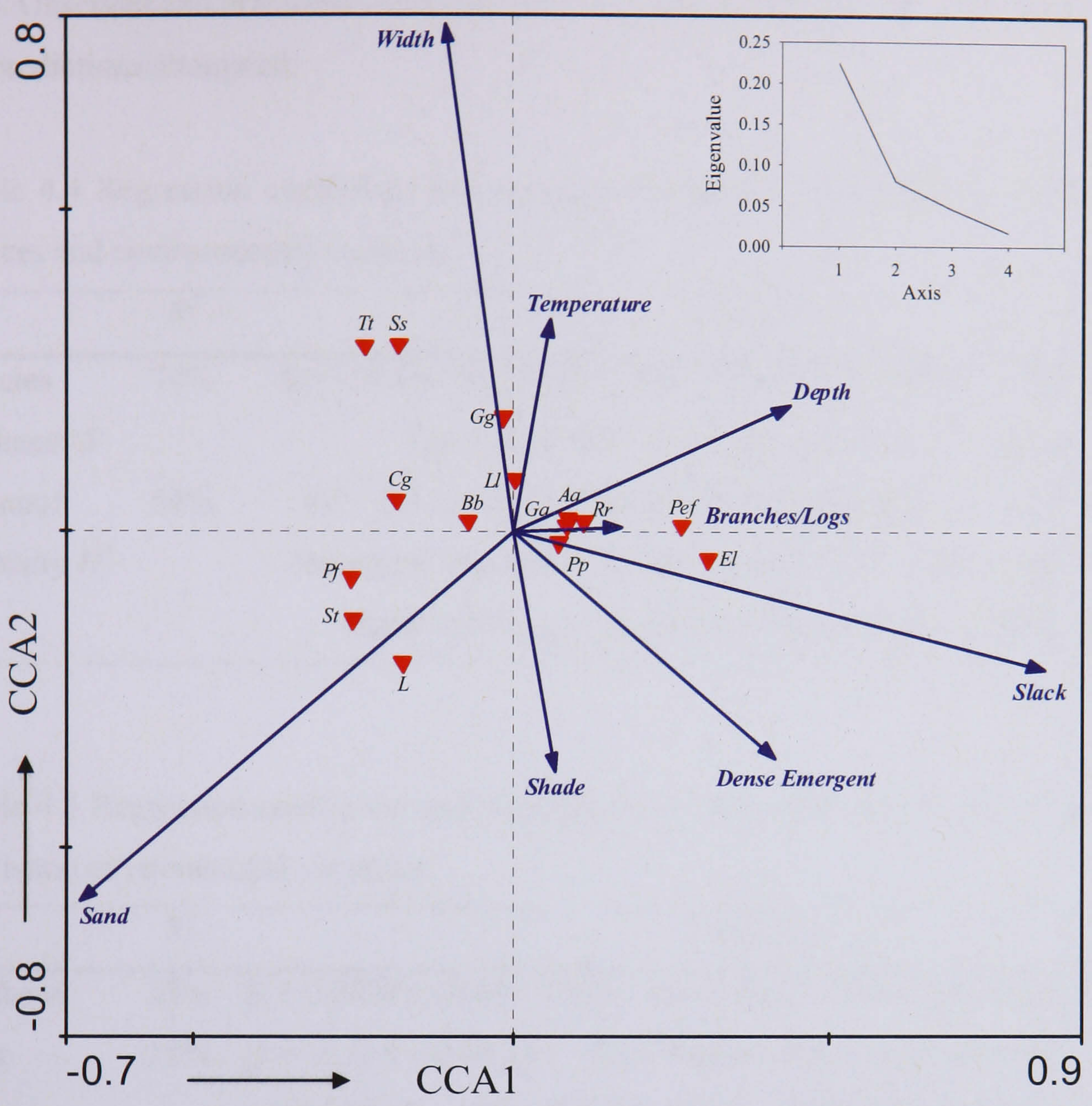


Figure 4.8 Axes 1 and 2 of canonical correspondence analysis of the influence of environmental variables on fish assemblages sampled in March, June, September and December 2003 to 2005. Only those environmental variables that make a significant contribution are presented. (Cg, bullhead; Ll, dace; Aa, eel; Pf, flounder; Tt, grayling; Gg, gudgeon; L, brook lamprey; Pp, minnow; Pef, perch; El, pike; Rr, roach; Ss, salmon; Ga, 3 spine stickleback; Bb, stone loach; St, trout).

General linear models gave mixed success at predicting species richness metrics and individual species catches (Tables 4.4 and 4.5). Species diversity could not be successfully described by habitat diversity indices (Table 4.6). It was possible to predict species richness and diversity with habitat variables (Table 4.4; Figure 4.9) but species diversity more weakly related to the environmental variables recorded (Table

4.4). Observed and predicted values of species richness presented the closest match of all predictions attempted.

Table 4.4 Regression coefficient and equation of general linear models of diversity indices and environmental variables.

	R^2	Equation
Species Richness S	74%	S = -21.95 + 0.22 DO + 0.28 Glide + 0.25 Slack -0.03 Clay - 0.02 Sand -0.03 Silt + 0.02 Branches/logs + 2.0 Pike
Shannon diversity H'	54%	H' = 0.121 + 0.47 Pike -0.005 Overhanging tree -0.005 Dense Emergent vegetation + 0.04 Temperature – 0.005 Depth – 0.004 Dense submerged vegetation + 0.04 Width + 0.006 Glide

Table 4.5 Regression coefficient and significance of general linear models of species catch and environmental variables.

	R^2	Equation
Bullhead	53%	B = 0.04205+ 0.009 Glide – 0.001 Sand – 0.001 Dense Emergent Veg
Dace	28%	D = -4.515 + 0.04 DO + 0.05 Temp + 0.006 Branches/logs + 0.04 Glide + 0.04 Slack + 0.006 Branches/logs – 0.002 Overhanging tree
Eel	44%	E = 0.3424 + 0.005 Sand - 0.007 Clay + 0.02 Temp
Flounder	52%	F = 0.29 -0.003 Depth -0.001 Dense Emergent Veg + 0.004 Glide – 0.002 Overhanging tree
Lamprey	18%	L= 0.06 + 0.003 Glide – 0.01 Cobbles – 0.002 Dense Submerged Veg
Minnow	14%	M = 0.22 + 0.01 DO
Pike	18%	P = - 1.22 + 0.01 Glide + 0.02 Slack + 0.02 Width -0.004 Branches/logs
Roach	9%	R = - 0.23 + 0.01 Temp + 0.22 Pike + 0.007 Branches/logs
Stone loach	30%	S = 0.13 + 0.005 Glide – 0.002 Dense Emergent Veg
Trout	60%	T = - 0.21 + 0.01 Sand + 0.04 DO

Table 4.6 Regression coefficient and significance of the correlation between species and habitat diversity for richness *S*, Shannon diversity *H'*.

	Species *S*		Species *H'*	
	R^2	*P*-value	R^2	*P*-value
Habitat *S*	3.1%	0.004	0.4%	0.171
Habitat *H'*	0.7%	0.098	0%	0.406

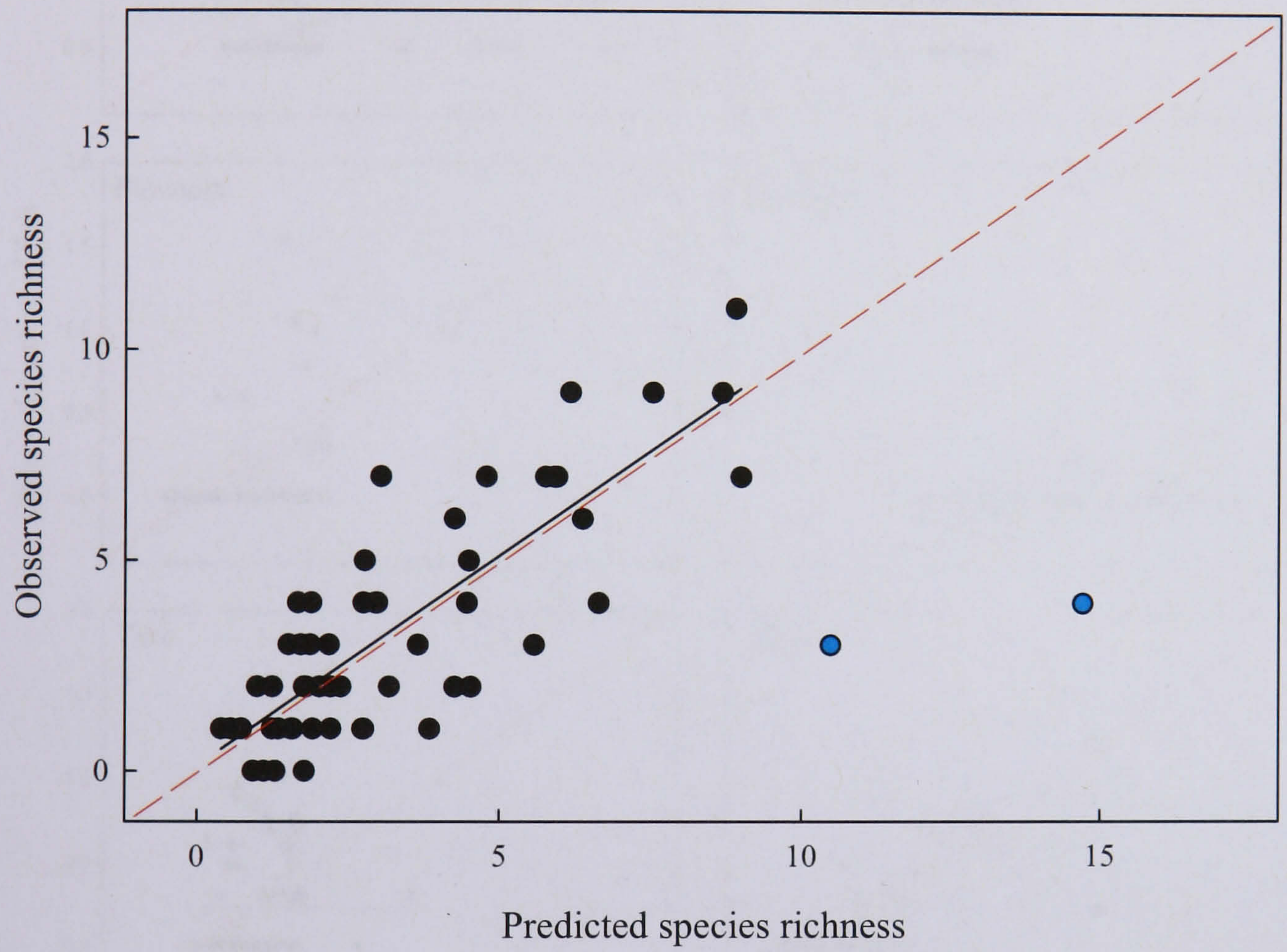


Figure 4.9 Observed and predicted species richness for each assemblage sample (each point represents a single channel by season and year) taken, predicted from habitat variables. Results are shown for a "testing" sample after model development on a separate sample. The red line indicates the perfect fit line where x = y, the black line gives the actual regression fit. The two blue dots are outliers not included in the regression.

The relationship between species catch and environmental factors was also variable and R^2 values ranged from 9 to 60% (Table 4.5). In general it was the species most strongly associated with faster flow and sand substrate (bullhead, flounder and brown trout see Figure 4.6) that were most successfully predicted with habitat variables (Figure 4.10). In the more successful models created, predicted catches were generally higher than the observed number of fish (Figure 4.10).

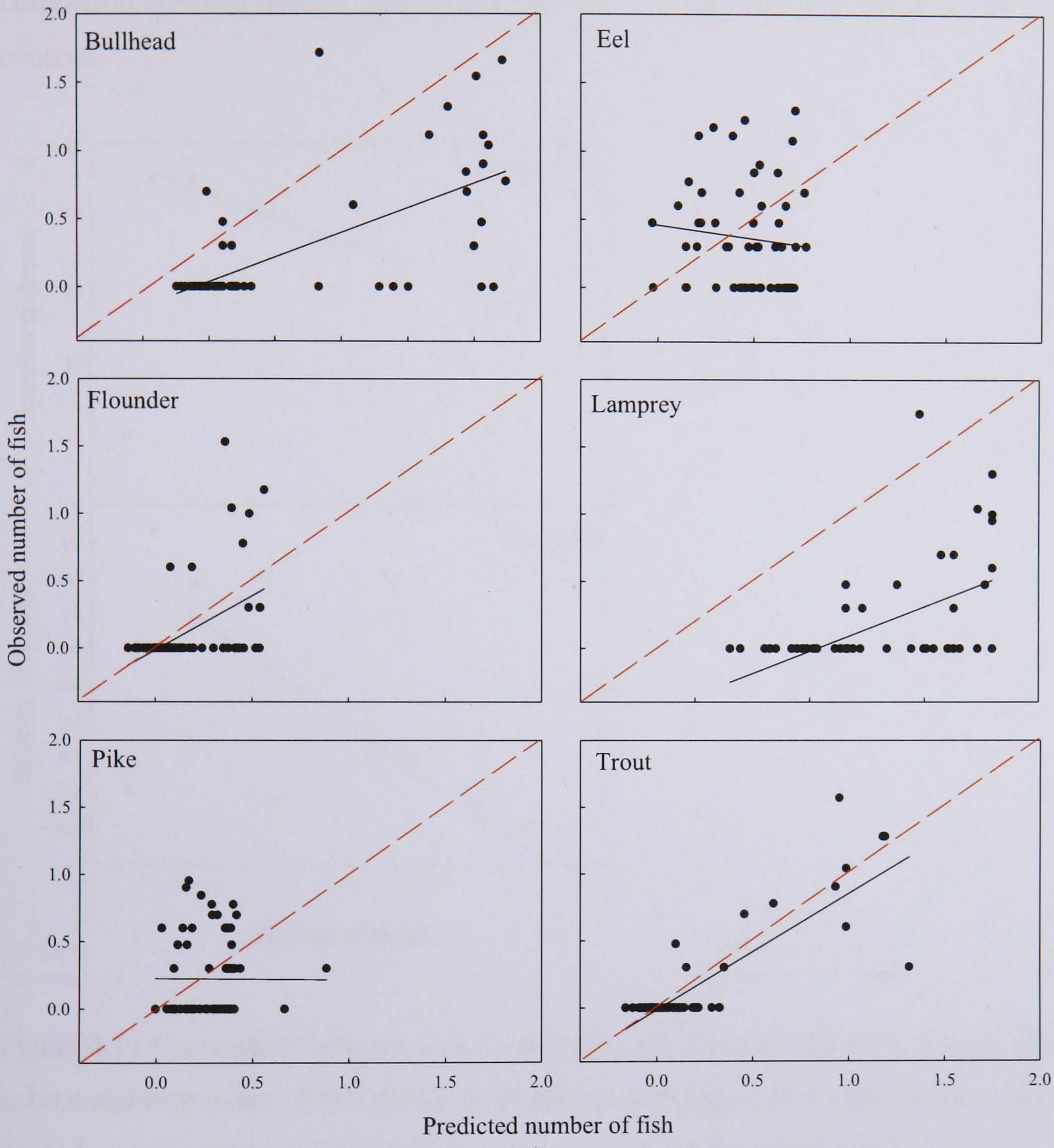


Figure 4.10 Observed and predicted species catch for each sample taken. Results are shown for a "testing" sample after model development on a separate sample. The red line gives the perfect fit where x = y, the black line gives the regression fit.

Species diversity appeared to be correlated with the relative temporal stability of side-channel habitat (Figure 4.11). Diversity and stability relationship in the Railway ditch lay a long way outside the trend of the other streams (details of the habitat stability index and results are given in Appendix 11). While Pearson correlation coefficients were not significant for all channels combined, they were significant following the removal of Railway (Table 4.7). Given the small sample size of only seven locations this suggests that with a larger sample of side-channels there could be a strong correlation between habitat stability and the diversity of fishes supported by the side-channel.

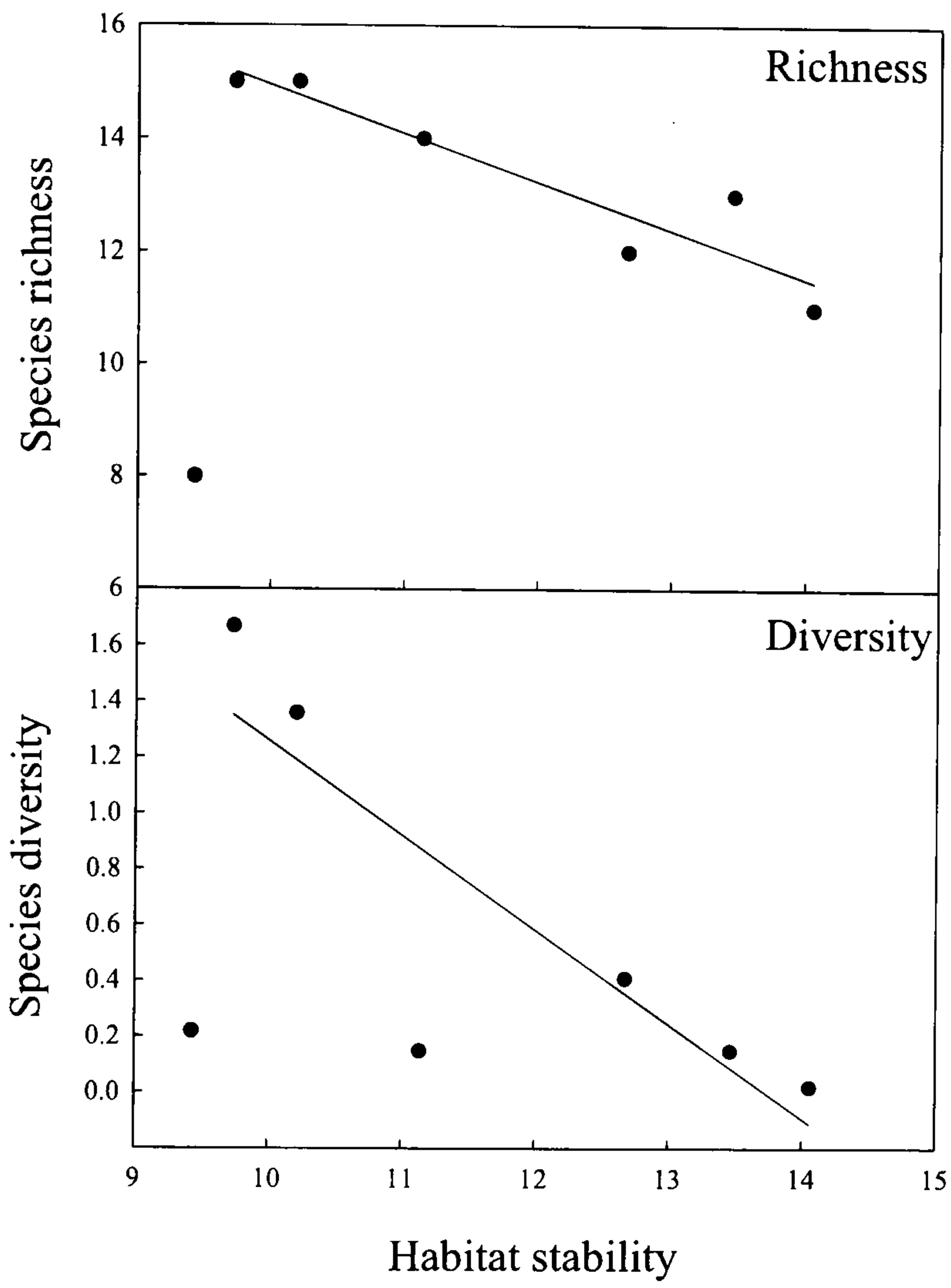


Figure 4.11 Correlation between species richness and Shannon diversity indices and a habitat stability index (2003-2005). Note habitat stability is an inverse metric thus as the index increases stability decreases (see section 4.2.1 for calculation).

Table 4.7 Correlation coefficients and significance for relation between habitat stability and species diversity in all channels and also excluding the outlying Railway ditch.

	All side-channels		Side-channels without Railway	
	Correlation	*P*-value	Correlation	*P*-value
Species Richness *S*	-0.083	0.86	-0.931	0.007
Shannon diversity *H'*	-0.606	0.149	-0.852	0.031

4.3.3 MAIN RIVER ASSEMBLAGES

As fishing in the main river at East Stoke was conducted once annually in March (2003-2005), seasonal comparisons in assemblage and diversity were not possible. Likewise, the efficiency of electric fishing equipment used to sample the main river was inferior for catching small fish and thus direct comparison between main river and side-channel catch and diversity was not possible. A full list of the annual catch in the main river at East Stoke is given in Table 4.8.

Table 4.8 Summary of the annual catch by boom boat electric fishing in the main River Frome from East Stoke weir to Rushton Ditch.

	2003	2004	2005
Dace	18	26	1
Perch	0	1	1
Pike	35	53	18
Roach	2	1	0

4.4 Discussion

Side-channels of the River Frome varied according to habitat variables. In particular flow was the main determining factor, with the two faster flowing streams Millstream and Goldsacs being grouped separately to other side-channels on the PCA ordination. Perhaps not surprisingly the fish composition structure varied between channels with unique assemblages present at each channel and species occurring at different relative densities from one location to another. In a relatively small geographic scale study such as this (side-channels distributed over 4 km of river), these differences are likely due to variation in the habitat available and suitability for each species rather than an upstream/downstream zonation.

As well as seasonal changes in side-channel habitat, daily changes in factors such as temperature, dissolved oxygen and pH altered the suitability of locations to fish, particularly in summer. Buffered summer water temperatures in the side-channels (as shown in Chapter 2) may have made these habitats more suitable to fish during the day, but low levels of oxygen after dark may have rendered them inaccessible at night (Wootton 1990). These daily oxygen variations may have altered the suitability of highly vegetated streams in particular, causing them to be used less by the less mobile species, resulting in an overall reduction in diversity. While diversity indices appeared low in winter and spring in many side-channels, this could be due to the very high catch of minnows in the side-channels. The dominance of minnows (>90% in five of the seven streams) led to a reduction in the apparent diversity of the streams during these seasons compared to summer and autumn. However species richness, unaffected by relative dominance, did not decrease proportionately and was actually higher in winter and spring.

Flow velocity was the most important factor in determining the catch of a fish species in a given location (CCA axis 1). Flow has often been documented as being a very important descriptor of species assemblages (Bartozova and Jurajda 2001, Cattaneo 2005, Junk et al. 1989). This is not only in terms of the flow regime being a major physical habitat determinant in a location as described in this study but also in terms of maintaining connectivity of lateral habitats and supporting the requirements of species which have developed life history requirements to natural flow regimes (Bunn and Arthington 2002).

Predictive power of environmental variables on species catch was low however. This may have come from the fact that many other factors influence fish presence. This may include biotic factors such as competition (Wootton 1990) or more complex abiotic factors that were not measured during the study.

Species richness was successfully predicted from habitat variables. The determinants of species assemblages and diversity that appear most often in the literature are flow, stream order and habitat stability or complexity (Cattaneo 2005, Grenouillet et al. 2004, Jackson et al. 2001). Habitat complexity (diversity) was not correlated with species diversity in this study, but habitat stability was (positively). Species richness in particular was strongly correlated with habitat stability, with the exception of the outlying Railway ditch. According to the habitat stability index Railway ditch was comparatively stable, yet it only supported 8 species. Railway had the highest relative density of pike of the all side-channels and this high predation pressure may have had a limiting effect on species diversity (Wootton 1990). Pike were found to be one of the significant contributing variables for the relationship between environmental variables and species richness and diversity in the general linear models. The results suggest that habitats which undergo less seasonal and annual variability are able to support a wider range of species, which supports existing literature (Grossman et al. 1998, Oberdoff et al. 2001).

The presence of side-channels in the river system increased the range of habitats available to fish over a relatively small area. All side-channels supported a community of fishes illustrating utilisation of the good connectivity to these habitats. Diversity and species presence and relative density varied seasonally according, to some extent, to habitat variables. Understanding the functioning of these habitats within the system and for particular species may help to understand what drives the use of side-channels and thus which are particularly important to preserve and maintain. This is investigated further in Chapter 5.

Chapter 5

Seasonality of Side-Channel Habitats for Lowland River Fishes

5.1 Introduction

The ecological functioning of off-river habitats will change seasonally and ontogenetically (Baade and Fredrich 1998, Grift et al. 2001, Molls 1999). It depends on the functional requirements of the animal communities which are present (i.e. refuge, feeding, spawning and nursery areas) (Baade and Fredrich 1998, Borcherding et al. 2002, Brown et al. 2001, David and Closs 2002). Also, off-river habitats are very variable in annual connectivity. Existing channels may be reconnected during flooding or areas desiccated at other times of year may be inundated.

5.1.1 SPAWNING

Natural and man-made off-river habitats such as abandoned and partially abandoned floodplain channels, the floodplain itself or backwater lakes such as gravel pits are valuable reproductive locations for fish (Hohausová et al. 2003, Neumann et al. 1996, Ross and Baker 1983) and nursery habitats for juveniles (Copp 1997, Garner 1996, Lusk et al. 2001). They provide a potential patchwork of habitat, often harbouring a diverse fish fauna from which fishes can be recruited to populations in the main river (Copp 1997).

Reduced flows in backwaters and floodplains aid smaller fish with lower absolute swimming performance (Muller et al. 2000). Many side-channel and floodplain habitats contain large invertebrate populations (Armitage et al. 2003, Humphries et al. 1999) creating good feeding opportunities for fast growth (Neumann et al. 1996). Predation risk is greatest while at a small size so rapid growth reduces the period of vulnerability (Bayley 1995). Whilst a proportion of some fish populations use river backwaters as additional available spawning habitat, some depend almost exclusively on recruitment from these areas, such as common bream (*Abramis brama*) in the Lower Rhine, Germany (Borcherding et al. 2002, Molls 1999).

Many species in temperate regions respond to rising flows as a cue for spawning, although a combination of the onset of higher flows and temperature is often the driver to stimulate spawning (Gozlan 1998, Lucas 1992, Welcomme 1985). Many freshwater fish species commonly anticipate high flow conditions and make their migration to spawn during or just prior to the rising water (Bayley 1995). Indeed, some species use or compensate for variations in flow by varying migration distances to compensate for the river discharge at the moment of spawning (Humphries et al. 1999). Rising water levels that inundate floodplain habitat or provide access to lentic, vegetated habitat are also important for phytophilic spawners such as pike and roach.

Ontogenetic shifts in floodplain habitat use have frequently been reported. While many fish begin their early life in these habitats and migrate to the main river channel only returning to spawn (Humphries et al. 1999, Neumann et al. 1996), more complicated use has also been revealed (Molls 1999). A proportion of the adult bream population in the Rhine river do not leave after moving to and spawning in oxbow lakes (Molls 1999). Thus, these fish demonstrated a dual use of the oxbows. First as a nursery habitat, leaving at 0+ or 1+ and then again as a resident habitat for adults over 4+ having returned from the juvenile phase in the main river. A similar pattern was also found in the sofie (*Chondrostoma toxostoma*) in the Garonne River and its tributaries, France (Gozlan 1998).

5.1.2 FEEDING

There is increased recognition that floodplain habitats play a major role in the productivity of riverine communities (Bayley 1995). Use of the floodplain for feeding has frequently been reported (Borcherding et al. 2002, Humphries et al. 1999, Ross and Baker 1983, Sommer et al. 2001, Welcomme 1985) with many different feeding strategies catered for on the floodplain from plant and detritus feeders to top predators. A wide range of niches may be exploited within the rich, often seasonal environment of the floodplain.

Aquatic invertebrate prey density tends to be higher in river backwaters than in the main channel (Armitage et al. 2003, Hohausová et al. 2003, Neumann et al. 1996). Some individuals may take advantage of this high prey abundance and potentially reduced predation by moving into these areas to feed. Borcherding *et al.*, (2002) reported segregation in a population of bream with a proportion moving into a side-channel at night to feed. They concluded that there were competitive advantages to these individuals making daily migrations to these highly productive feeding areas.

If all requirements for an individual are catered for in an off-river habitat then some individuals may benefit by being resident. Grift *et al.*, (2001) demonstrated that immigrant bream into a floodplain lake were both smaller and significantly lower in condition than residents. Significantly better growth rates were found in chinook salmon (*Oncorhynchus tshawytscha*) residing on the seasonally inundated floodplain. The floodplain resident salmon increased in size substantially faster than those in the river due to greater availability of drift invertebrates (Sommer et al. 2001). Masters *et al.*, (2002) attributed use of the floodplain by riverine pike during over-bank floods to be due to fish utilising the additional feeding opportunity. However, as almost 80% of fish locations were made within 10 m of the nearest riverbank this behaviour is more likely related to sheltering from high flows.

5.1.3 SHELTER

The provision of shelter is also thought to be an important role of off-river habitats but this function has rarely been investigated. However, while few studies have focused on the use of off-river habitats for shelter, it has been considered as an aside to another study. This may be due to difficulty in demonstrating evidence of sheltering in comparison with the active tasks of feeding or spawning where physiological changes or activities can be quantified.

Off-river habitats are often important shelters from both high flow and predation experienced in the main river channel. Species responses to high flows vary greatly (David and Closs 2002), but many species, for example, threespot tilapia (*Oreochromis andersonni*), pink happy cichlids (*Sargochromis giardi*), coho salmon (*Oncorhynchus kisutch*) and roach undertake some form of sheltering behaviour in side-channels (Baade and Fredrich 1998, Erman et al. 1988, Thorstad et al. 2001).

Side-channels also offer sanctuary from predation. Borcherding et al., (2002) interpreted the fact that 90% of ditch users were 0+ fish to be a result of them sheltering from higher predation risk in the main river. However, as previously mentioned these habitats offer a good, lower flow environment for 0+ fish (Humphries et al. 1999, Muller et al. 2000). This illustrates the difficulty in clarifying the exact function of off-river habitats to visiting fish.

As discussed, species are likely to use side-channels for different functions during different seasons and throughout their lifetime. Also different channel types may differ in the resources available and so may be used for functionally different reasons. The aim of this chapter is to investigate both the seasonal functions of the side streams studied and to assess the functions for which particular species require off-river habitats. It is hypothesised that fish species will vary in their use of side-channels and the functions they for which they use them. Different species will use a different network of side-channels and each side-channel will provide resources for a distinct community of fish. The use of side-channels by pike for spawning is also investigated. It is hypothesised that side-channels are an important spawning habitat for the population. It is also hypothesised that the pike population is structured as a result of the availability of off-river spawning grounds with some individuals exhibiting protandry (early arrival onto spawning grounds).

5.2 Materials and Methods

5.2.1 SAMPLING

Seven side-channels (Chapter 2) were sampled with electric fishing four times a year during 2003-2005. Five side-channels were monitored with PIT detectors during 2004-2005. Adult pike were radio-tracked at dawn, midday and dusk over a 13-day period four times per year to determine their seasonal home range (2002-2005). See Chapter 3 for further detail on the procedures used.

Several abiotic factors were monitored continuously. Daily temperature (°C) was monitored every 15 minutes in each channel with a TinyTag data logger (Gemini Data Loggers, Chichester, UK). Side-channel depth (cm) was monitored every hour with water level loggers (Exeter University, Geography Department). Rainfall (mm) was measured daily at East Stoke. River discharge was monitored at 15 minute intervals at East Stoke gauging weir (Environment Agency data, using Venturi gauging weir). Light levels were monitored every hour with a light meter (Centre for Ecology and Hydrology) at East Stoke gauging weir (Appendix 12 provides a summary of this data).

5.2.2 ANALYSIS

Seasonal catch data (single pass electric fishing of the first 200 m of each side-channel, see Chapter 3 for more detail) are presented as figures of the mean number of fish caught per season (averaged over 3 years) with mean and standard deviation of size on a second axis. The mean number of fish recorded by PIT detectors during each season (averaged over 2004 and 2005) is presented as a figure for each species, separated for each side-channel. Daily movement patterns are presented as the ratio of fish moving in and out of side-channels in hourly groups during each season for each species at each side-channel, with the total number of fish moving on a second axis. In this case the sum and not the mean number of fish was used for each season because once the data was split into 24 hour groups the number of fish was at times small.

The relationship of daily movements to abiotic factors (daily temperature (°C), side-channel depth (cm), change in side-channel depth from the previous day (cm), rainfall (mm), river discharge (m^3s^{-1}), change in river discharge from the previous day (m^3s^{-1}) and maximum light level on a day (lux)) was investigated with linear regression for each species. This was also separated between seasons and side-channels. Change in temperature from previous day was also investigated but is not presented because it was not significant with daily movements of any fish species. Results were Bonferroni corrected for each species to account for the large number of regressions applied.

General linear models (StatSoft.Inc. 2006) were applied for each species to investigate the main drivers of fish movement into the side channels. Included in these were the factors mentioned above as well as season and side-channel.

Seasonal home range was determined for 23 adult pike for which 13-day dawn, midday and dusk locations had been collected (58 – 101 cm FL). Every individual fish is not represented for each season because some fish were not tracked in each season. The mean home range size (using 95% kernels, 95% clusters and range span; see Chapter 7) is presented with standard deviation error bars. Spawning period results are presented for all pike radio-tracking during spring 2004 and 2005.

Von Bertalanffy growth coefficients L_∞ and K were calculated for the full life of each fish (see Chapter 3). The following transformations were applied to normalise the data.

Transformations used were:

L_∞	$Log_{10} (L_\infty)$
K	$Log_{10} (K * 10000 + 1)$

Values of K were multiplied by 10000 because there were zeros and many low values. This allowed the data to be transformed while the proportions between the data points were maintained.

Nominal logistic regression (Sokal and Rohlf 1995) was used to investigate the relationship between individual growth or length and seasonal presence in spawning channels. The correlation was tested for all fish combined and also males and females separated.

A general linear model was constructed with the aim of predicting the number of days an individual pike spent in a spawning channel per month. By using fish ID as the first factor in the model, it was created so that only the variation between individuals was being predicted (and not variation due to environmental factors for example).

Home range analysis was carried out in Ranges7. Statistical analyses were carried out in Minitab 14. Graphs were made in SigmaPlot 2000.

5.3 Results

5.3.1 BULLHEAD

Bullhead were caught in all seven side-channels, although they were only caught in very small numbers in all streams except Goldsacs and Millstream. Highest catches of bullhead were in autumn in both Goldsacs and Millstream (Figure 5.1). There was no significant variation in bullhead size between Goldsacs and Millstream (*GLM Tukey adhoc*; $P = 0.07$, $T = -1.804$, $df = 1$). Bullhead size in spring was significantly larger than autumn (*GLM Tukey adhoc*; $P = 0.003$, $T = 3.469$, $df = 3$), no other seasonal size differences were found.

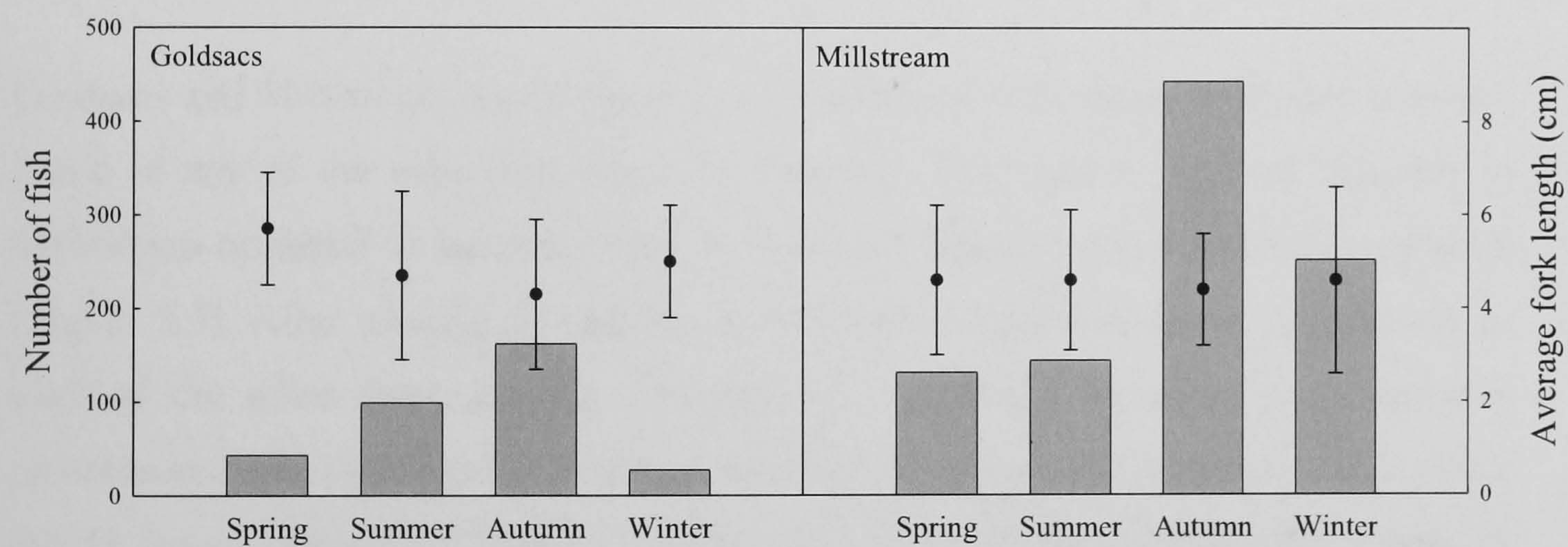


Figure 5.1 Seasonal catch (bars) and size variation (points and standard deviation error bars) of bullhead (*Cottus gobio*) in River Frome side-channels (Mean of 2003-2005).

5.3.2 BROOK LAMPREY

Brook lamprey were caught mainly in Goldsacs although a very small number were caught in all other side-channels. There was no significant variation in size between seasons in Goldsacs (Figure 5.2). Summer was the time of highest catch and winter the lowest, although water clarity in Goldsacs in winter may have reduced fishing efficiency.

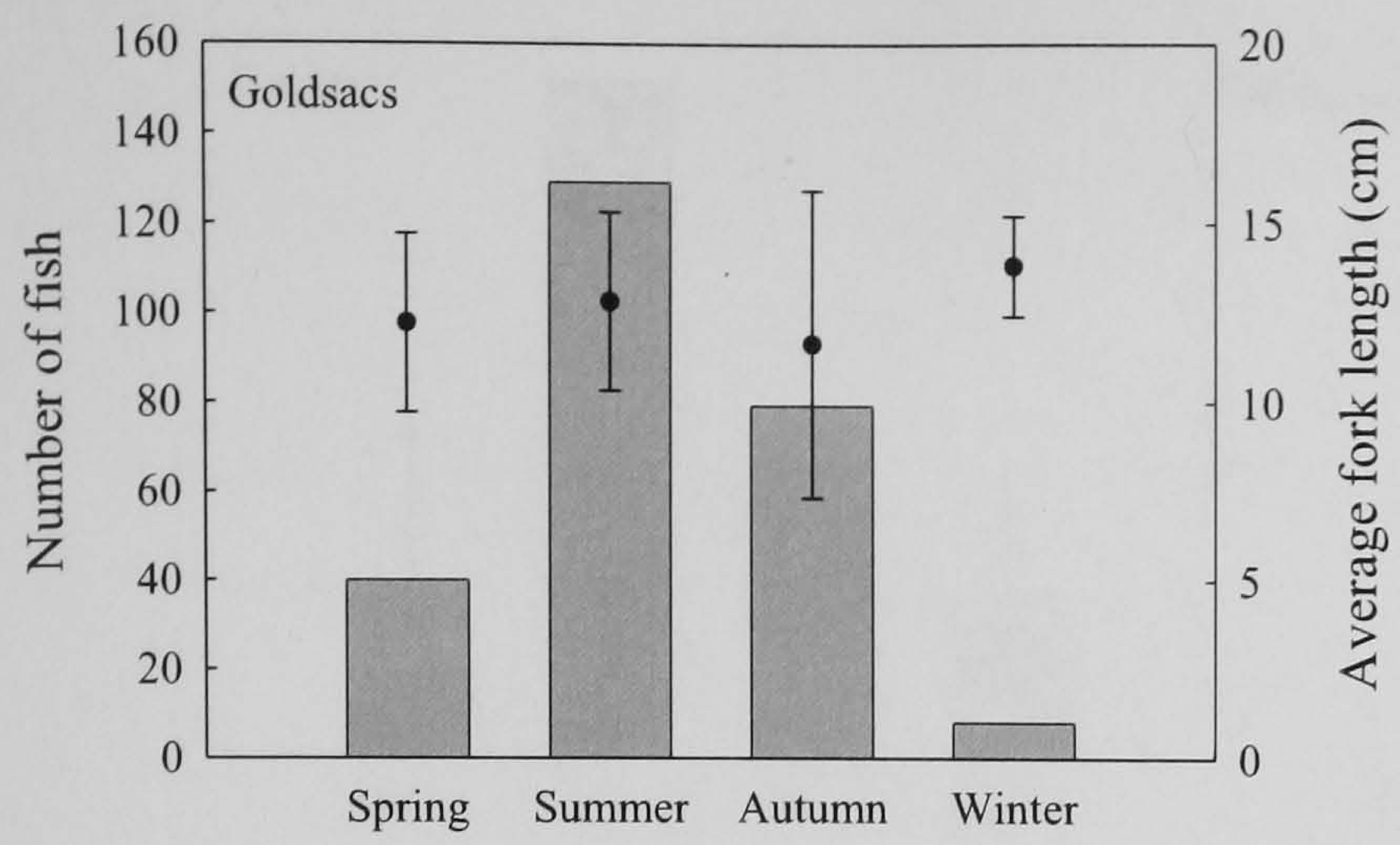


Figure 5.2 Seasonal catch (bars) and size variation (points and standard deviation error bars) of brook lamprey (*Lampetra planeri*) in River Frome side-channels (Mean of 2003-2005).

5.3.3 FLOUNDER

Goldsacs and Millstream also supported large numbers of flounder. Flounder were not found in any of the other side-channels sampled. The highest catch of flounder in Millstream occurred in autumn, while in Goldsacs flounder catch peaked in summer (Figure 5.3). After peaking in summer in Goldsacs flounder decreased in number in each of the other three seasons. Flounder size gradually increased from summer onwards and was significantly different between all seasons except autumn and winter (*GLM Tukey adhoc*; $P < 0.05$, $T > 2.01$, $df = 3$ in all cases). Flounder caught in Millstream were significantly larger than those in Goldsacs (*GLM*; $P < 0.001$, $T = 8.046$, $df = 1$).

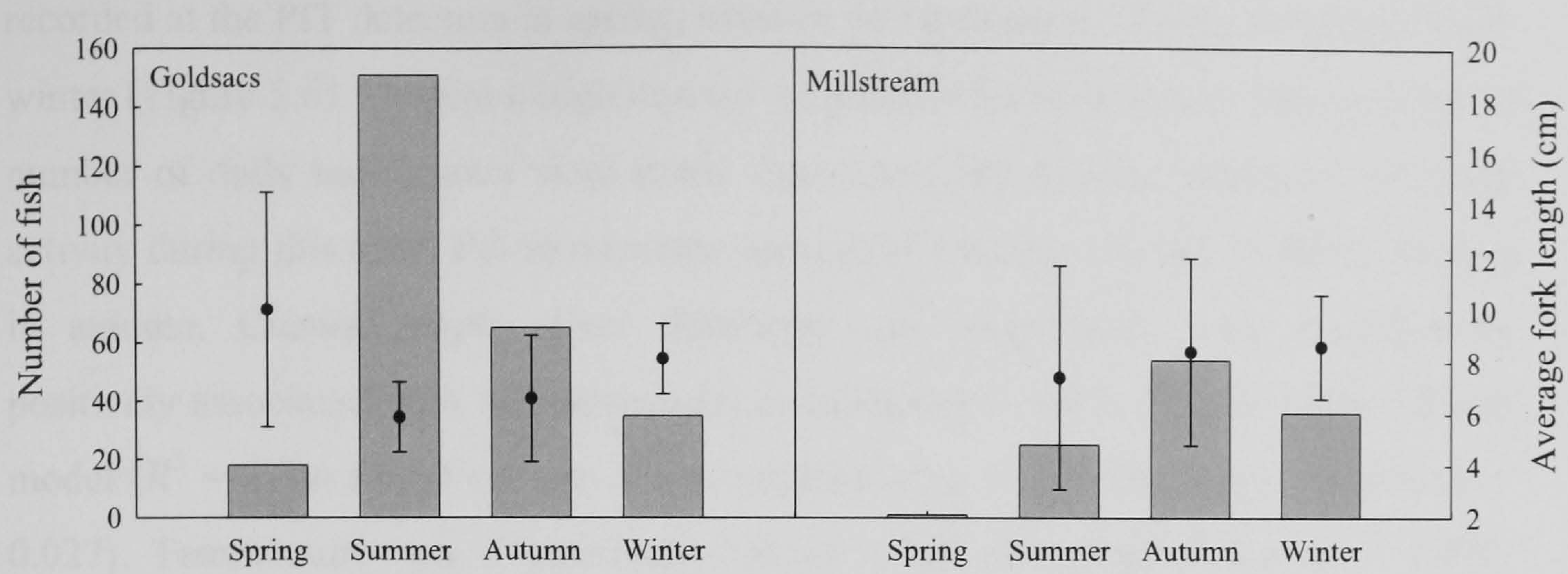


Figure 5.3 Seasonal catch (bars) and size variation (points and standard deviation error bars) of flounder (*Platichthys flesus*) in River Frome side-channels (Mean of 2003-2005).

5.3.4 EEL

Eel used side-channels throughout the year and were present to some extent in every side-channel sampled (Figure 5.4). Recorded catch was generally lowest in winter suggesting this was the period of least use. Highest catch was in summer in Goldsacs, Holme Bridge, Rushton and Millstream, whereas eel catch was highest in spring in Flood Relief and Luckford, suggesting different functional use of these two groups of side-channel (Figure 5.4). There was little variation in the mean size of eel between seasons with only eel in side-channels in spring being larger than summer (*GLM Tukey adhoc*; $P = 0.03$, $T = -2.777$, $df = 3$). Although fishing efficiency of small eel was probably lower than for other species. Eel in Goldsacs were significantly smaller than those in all other side-channels except Railway (*GLM Tukey adhoc*; $P < 0.03$, $T > 3.116$, $df = 6$ in all cases). Eel in Luckford were significantly larger than those in Millstream and Railway (*GLM Tukey adhoc*; $P < 0.003$, $T < -4.097$, $df = 6$ in both cases) and those in Holme Bridge were larger than those in Railway (*GLM Tukey adhoc*; $P = 0.01$, $T = -3.353$, $df = 6$).

Eel demonstrated the strongest nocturnal in/out movements in spring and summer in the Millstream (Figure 5.5). Eel moved out of the Millstream in early morning and back in during the evening and overnight in spring and summer. Small amounts of movement were apparent in autumn, with no real directional gradient and there was almost no movement during the winter (Figure 5.5). Between 20 and 30 eel were recorded at the PIT detectors in spring, summer and autumn with only 8 individuals in winter (Figure 5.6). Despite a high number of individuals recorded in autumn a lower number of daily movements were made throughout the season, indicative of lower activity during this time. Eel movements were most strongly related to abiotic factors in autumn. Channel depth, river discharge and temperature were significantly positively associated with eel movements at Millstream (Table 5.1). A general linear model (R^2 = 27%) found eel use of the Millstream to vary according to season (p = 0.027). Temperature was a positively related to eel side-channel use (p = 0.033, coefficient = 1.137).

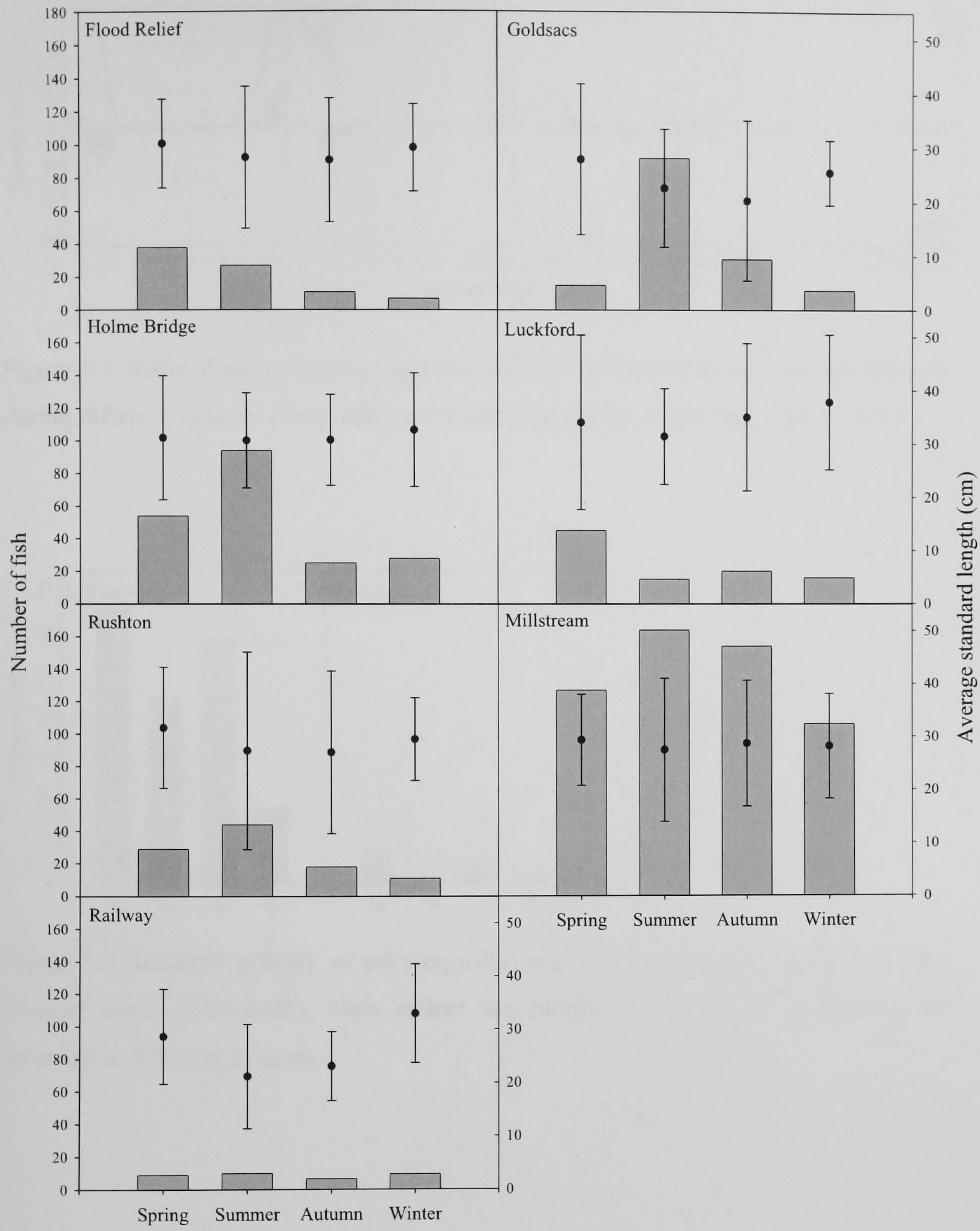


Figure 5.4 Seasonal catch (bars) and size variation (points and standard deviation error bars) of eel (*Anguilla anguilla*) in River Frome side-channels (Mean of 2003-2005).

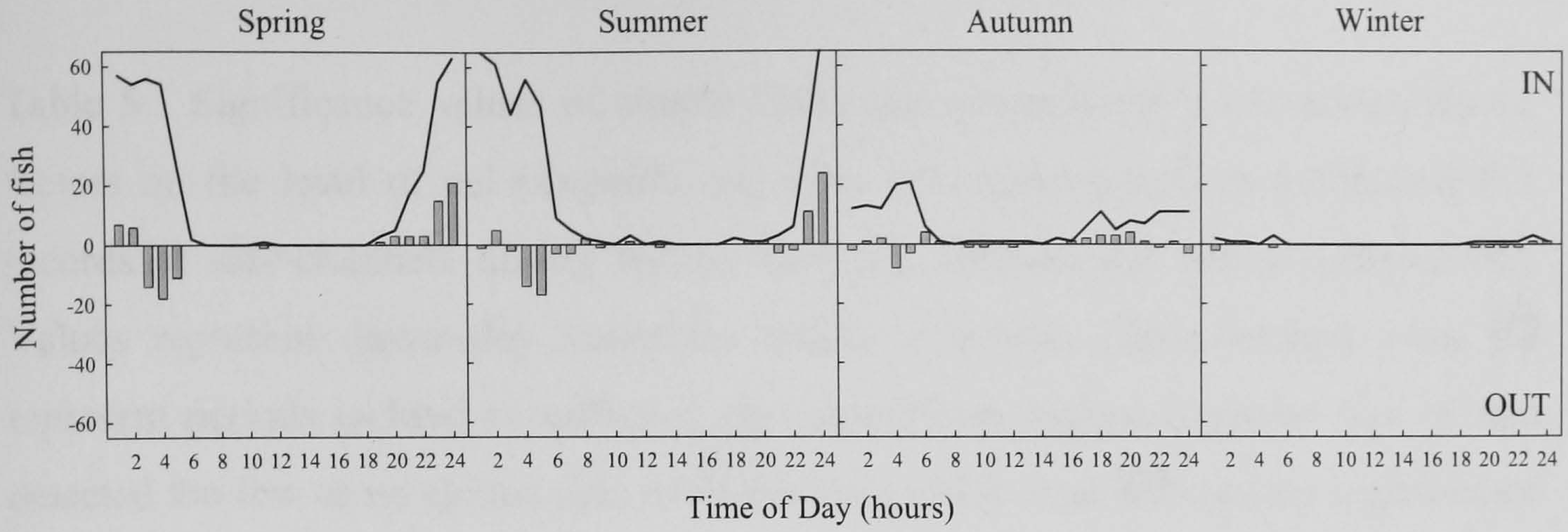


Figure 5.5 Ratio of eel (*Anguilla anguilla*) daily side-channel in and out movements during different seasons (bars) and total number of eel detected (line) (2004-2005).

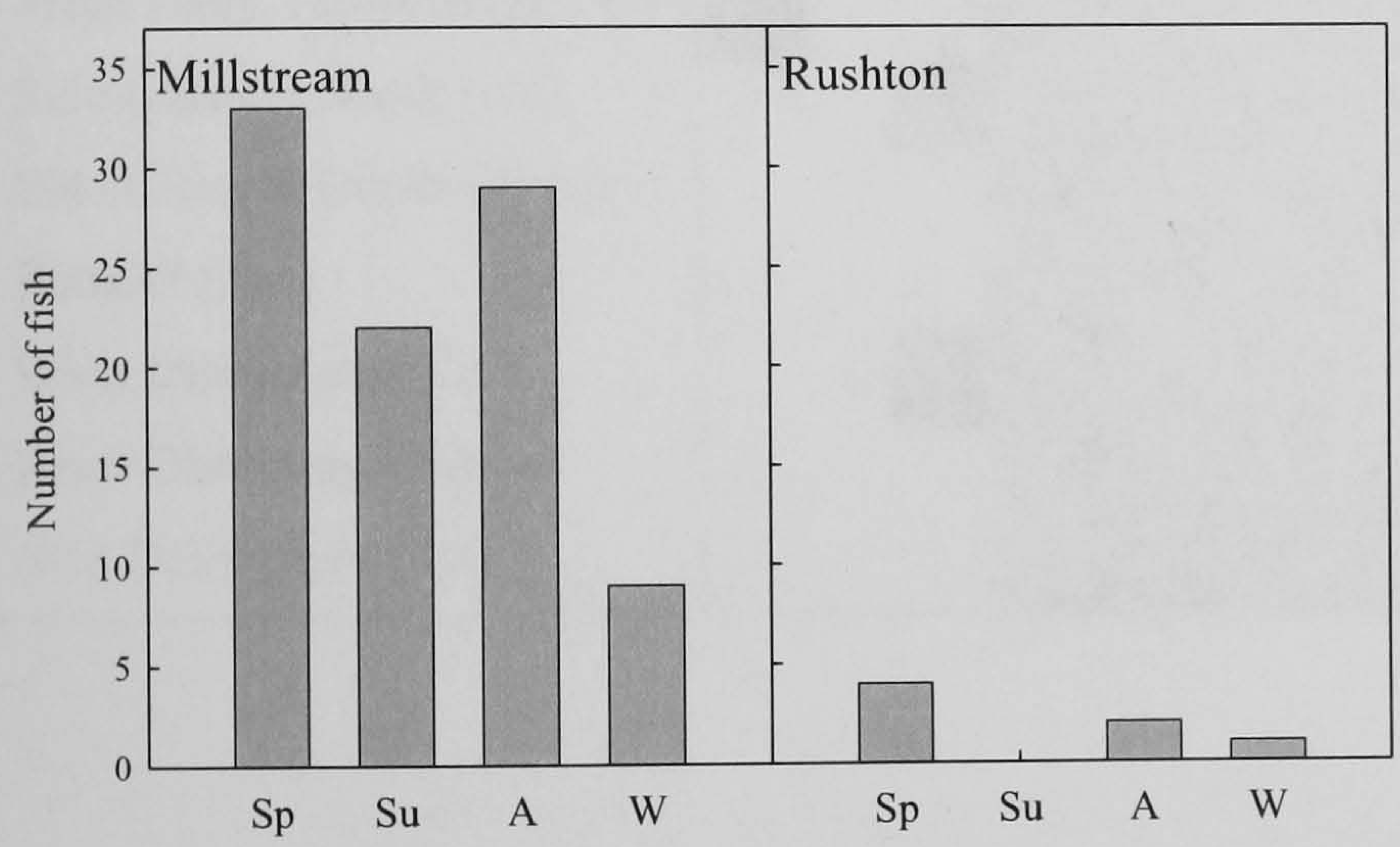


Figure 5.6 Seasonal activity of eel (*Anguilla anguilla*) at each PIT monitored side-channel used (2004-2005). Data reflect the numbers of different individual eel recorded in different seasons.

Table 5.1 Significance values of simple linear regression analysis of various abiotic factors on the level of eel (*Anguilla anguilla*) movement based on automated PIT records at side-channels during spring, summer, autumn and winter (2004-2005). Values represent day-to-day variations within a season. Cross-hatched areas ▨ represent periods lacking in sufficient data to perform analysis (sample size of fish detected too low or no abiotic data available) and black areas ■ indicate significance at an 0.002 Bonferroni corrected α level. Actual R^2, P-values, n and coefficients are given in Appendix 13.

EEL	Millstream				Millhead				Railway				Rushton				Luckford			
	Sp	S	A	W	Sp	S	A	W	Sp	S	A	W	Sp	S	A	W	Sp	S	A	W
Mean Daily Temperature (°C)	■			▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Side-Channel Depth (cm)			■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Side-Channel Depth Change				▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Rainfall (mm)				▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
River Discharge (m^3s^{-1})			■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
River Discharge Change				▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Max Daily Light (lux)				▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨

5.3.5 DACE

Dace showed differential use of side-channels with small dace using the Flood Relief throughout the year and larger dace using Goldsacs and Luckford but mainly during spring and winter (Figure 5.7). Millstream was used throughout the year but by different size classes of fish in different seasons. Different size classes of fish used the side-channels in every season (*GLM Tukey adhoc*; $P < 0.02$, $T > 2.978$, $df = 3$ in all cases). Fish size was different between most side-channels except as mentioned previously between Flood Relief and Holme Bridge, Luckford and both Goldsacs and Holme Bridge (*GLM Tukey adhoc*; $P < 0.02$, $T > 2.914$, $df = 5$ in all cases). No dace were recorded in the Railway ditch.

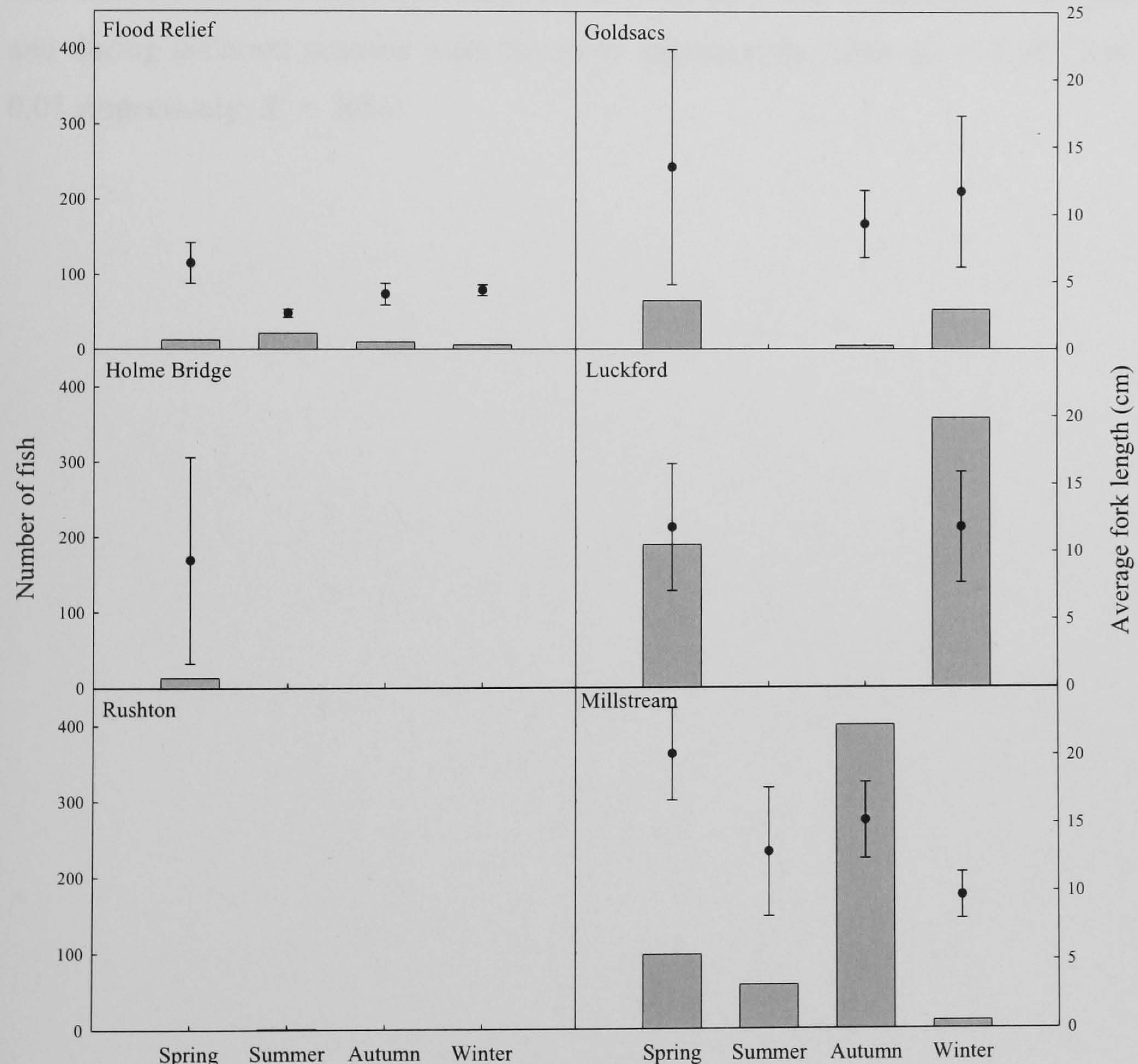


Figure 5.7 Seasonal catch (bars) and size variation (points and standard deviation error bars) of dace (*Leuciscus leuciscus*) in River Frome side-channels (Mean of 2003-2005).

Very little or no movement was recorded at Luckford in the summer and winter with small numbers present during spring and autumn (Figure 5.8). Dace showed a diurnal pattern of movement at the Millhead in spring and summer and Millstream in spring. They moved in during the morning and out in the afternoon/evening (Figure 5.8). Less dace visited Millhead in autumn and winter with no real diel pattern. Dace did not use Millstream appreciably in the winter. While many fish visited Millstream in autumn, there was not a strong directional gradient according to the time of day (Figure 5.8).

No abiotic factors were found to affect the use of side-channels by dace using linear regression. (Table 5.2). A general linear model of all variables and also season and side-channel found a corresponding result. Only dace use of different side-channels and during different seasons were found to significantly differ ($p < 0.001$ and $p = 0.01$ respectively; $R^2 = 26\%$).

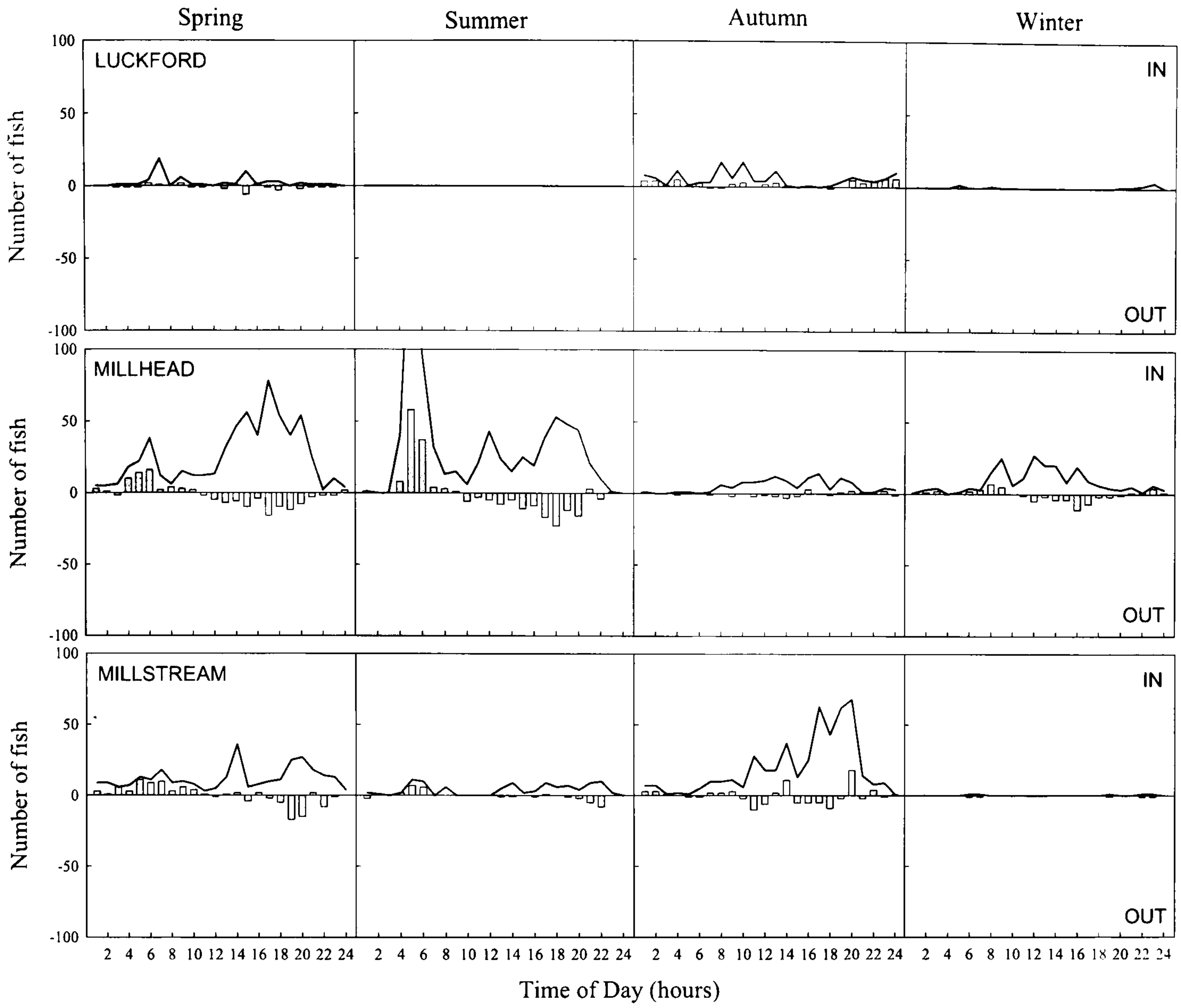


Figure 5.8 Ratio of dace (*Leuciscus leuciscus*) daily side-channel in and out movements during different seasons (bars) and total number of dace detected (line) (2004-2005). The peak of dace detected in the Millhead in summer (peak was 192 dace) is not shown in full to avoid loss of detail in all other seasons/locations.

Table 5.2 Significance values of simple linear regression analysis of various abiotic factors on the level of dace (*Leuciscus leuciscus*) movement at side-channels based on automated PIT records during spring, summer, autumn and winter (2004-2005). Values represent day-to-day variations within a season. Cross-hatched areas ▨ represent periods lacking in sufficient data to perform analysis (sample size of fish detected too low or no abiotic data available) and black areas ■ indicate significance at an 0.001 Bonferroni corrected α level. Actual R^2, P-values, n and coefficients are given in Appendix 13.

DACE	Millstream				Millhead				Railway				Rushton				Luckford			
	Sp	S	A	W	Sp	S	A	W	Sp	S	A	W	Sp	S	A	W	Sp	S	A	W
Mean Daily Temperature (°C)																				
Side-Channel Depth (cm)																				
Side-Channel Depth Change																				
Rainfall (mm)																				
River Discharge (m^3s^{-1})																				
River Discharge Change																				
Max Daily Light (lux)																				

Dace showed a much higher level of movement than was suggested by fish catches in Luckford in autumn (Figures 5.7 and 5.9). Luckford is a long stream and it is possible for fish to move further upstream than the 200 m section fished during the sampling. Radio tagged dace were found up to 800 m up Luckford during this study. Movement at Millstream was also much higher than capture for dace in spring. Millstream also extended a long distance past the 200 m sampled section and potential spawning habitat was located upstream.

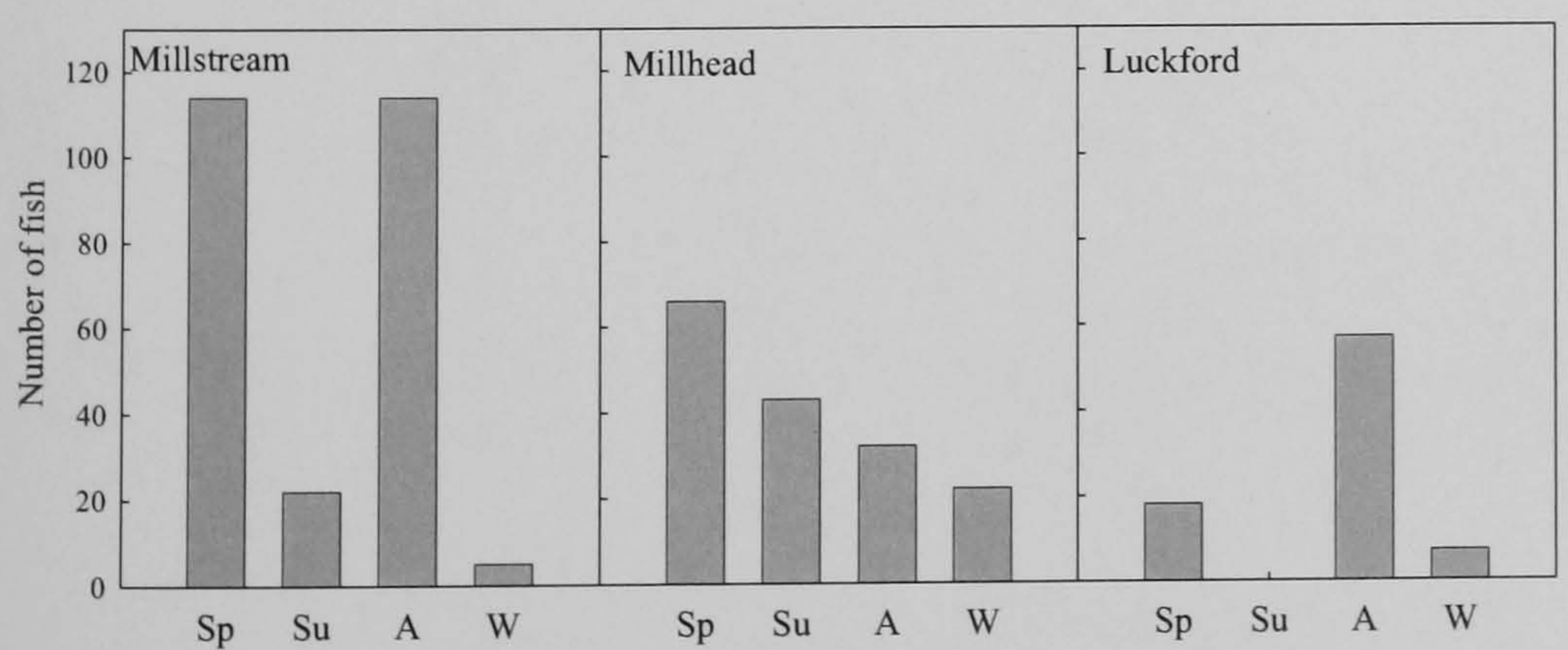


Figure 5.9 Seasonal activity of dace (*Leuciscus leuciscus*) at each PIT monitored side-channel used (2004-2005). Data reflect the numbers of different individual dace recorded in different seasons.

5.3.6 ROACH

Roach showed similar use of side-channels to dace in some cases, for example in their seasonal catch in Goldsacs and Luckford (Figure 5.10). Likewise the peak of roach catch in Millstream occurred in autumn, although at a much lower level then dace and use was only by large roach. Juvenile roach used the low flowing channel Holme Bridge, although the mean size and standard deviation showed high size variation. Roach using side-channels in summer were significantly smaller than during all other seasons (*GLM Tukey adhoc*; $P < 0.01$, $T < -3.089$, $df = 3$ in all cases). Dace using the Millstream were significantly larger than those using all other side-channels, those using Luckford were significantly larger than those using Flood Relief and Holme Bridge (*GLM Tukey adhoc*; $P < 0.003$, $T > 4.270$, $df = 5$ in all cases).

Roach also showed a much higher level of movement than was suggested by fish catches in Luckford in autumn (Figures 5.10, 5.11). This may be for the same reason of a large amount of available habitat upstream of the 200 m sampling section as dace.

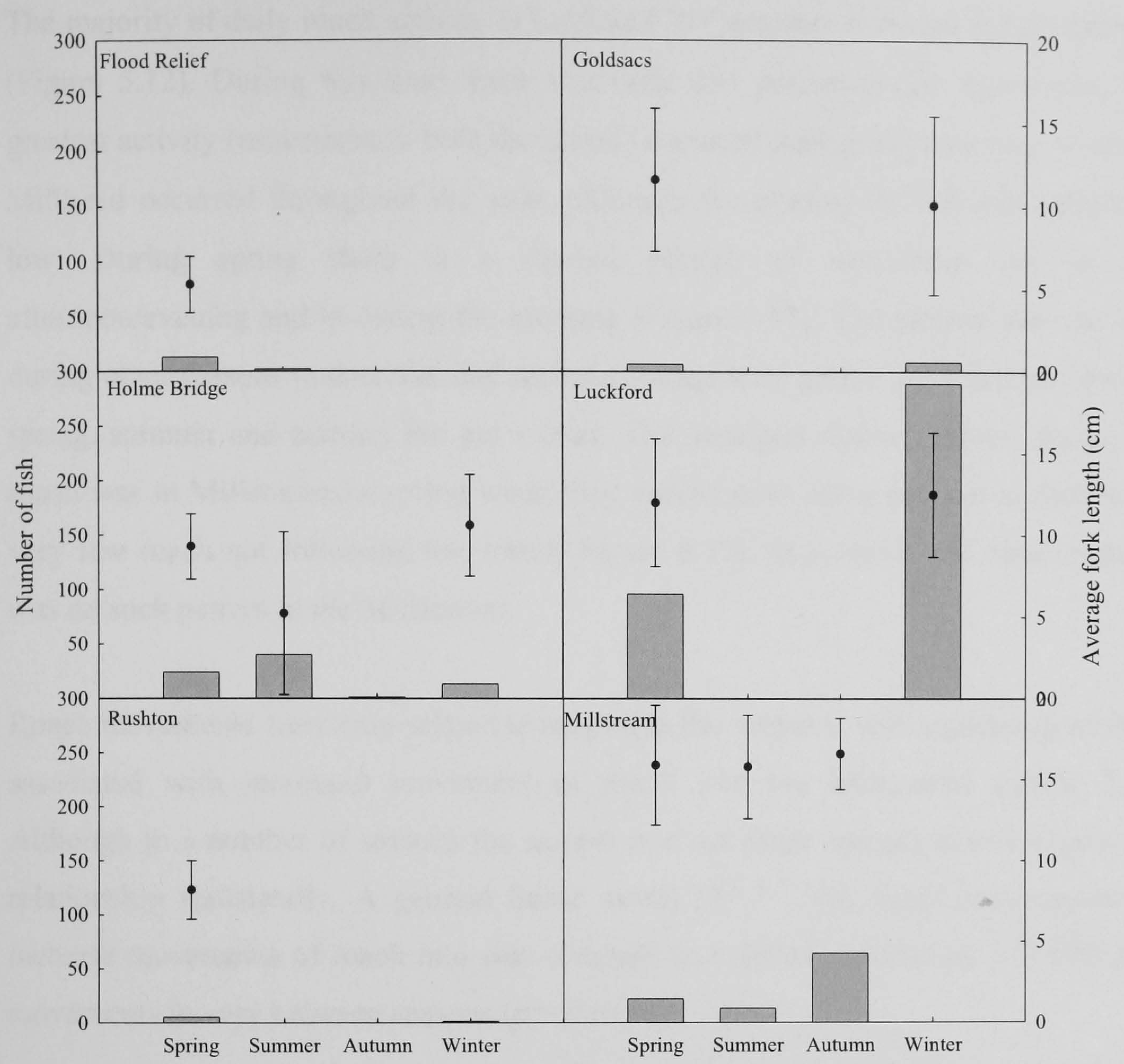


Figure 5.10 Seasonal catch (bars) and size variation (points and standard deviation error bars) of roach (*Rutilus rutilus*) in River Frome side-channels (Mean of 2003-2005).

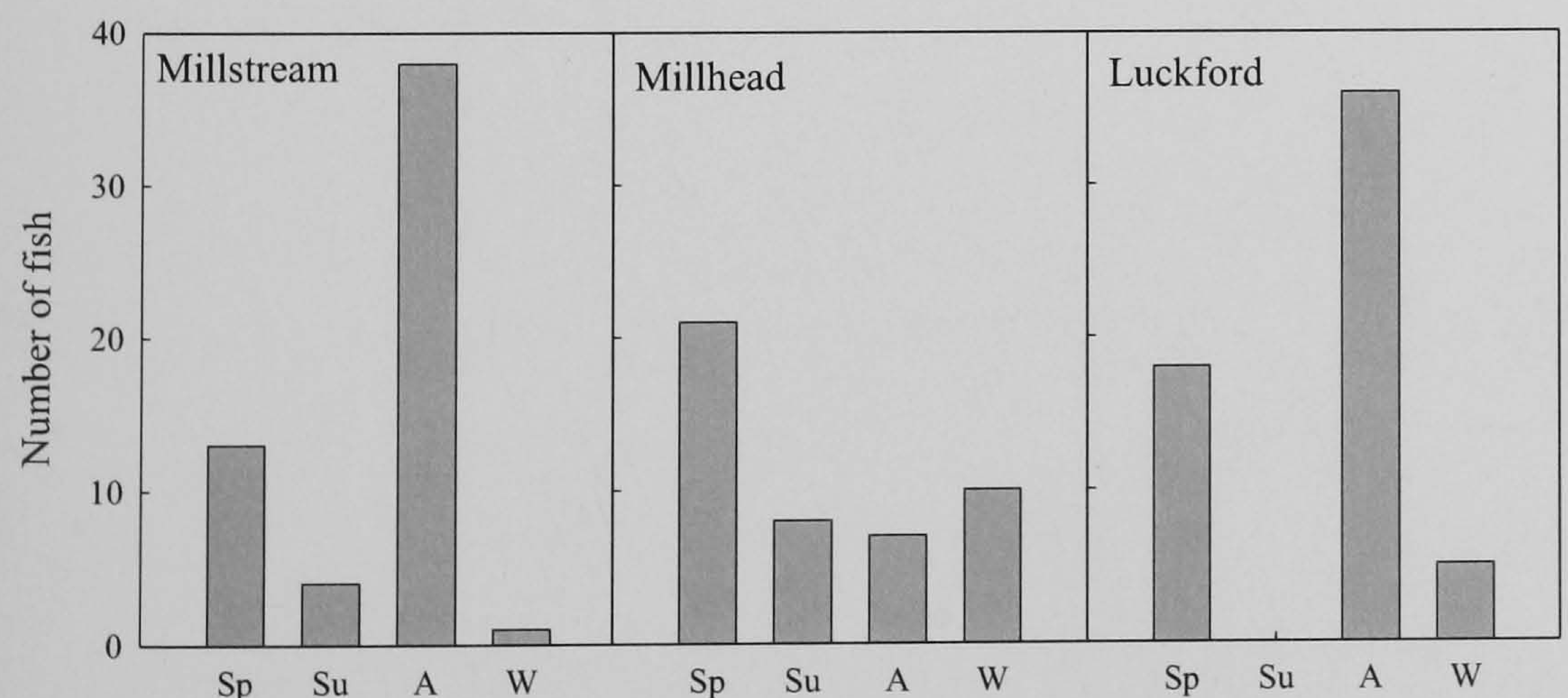


Figure 5.11 Seasonal activity of roach (*Rutilus rutilus*) at each PIT monitored side-channel used (2004-2005). Data reflect the numbers of different individual roach recorded in different seasons.

The majority of daily roach activity at Luckford PIT detector occurred during autumn (Figure 5.12). During this time there was little diel pattern in the movement, but greatest activity (movement in both directions) occurred during late morning. Visits to Millhead occurred throughout the year, although the number of fish was relatively low. During spring there is a diurnal pattern of movement out in the afternoon/evening and in during the morning (Figure 5.12). The sample was too low during other seasons to describe diel activity. Roach were active at Millstream during spring, summer and autumn but not winter. The strongest diurnal pattern shown by roach was in Millstream in spring when they moved in at dawn and out at dusk with very few roach not following this trend (Figure 5.12). In summer and autumn there was no such pattern at the Millstream.

Roach movements were only related to rainfall in the summer, with increasing rainfall associated with increased movement of roach into the Millstream (Table 5.3). Although in a number of seasons the sample was not large enough to investigate the relationship statistically. A general linear model (R^2 = 25%) found temperature to increase movements of roach into side-channels (p = 0.043, coefficient = 0.304) and movements to vary between seasons (p = 0.013).

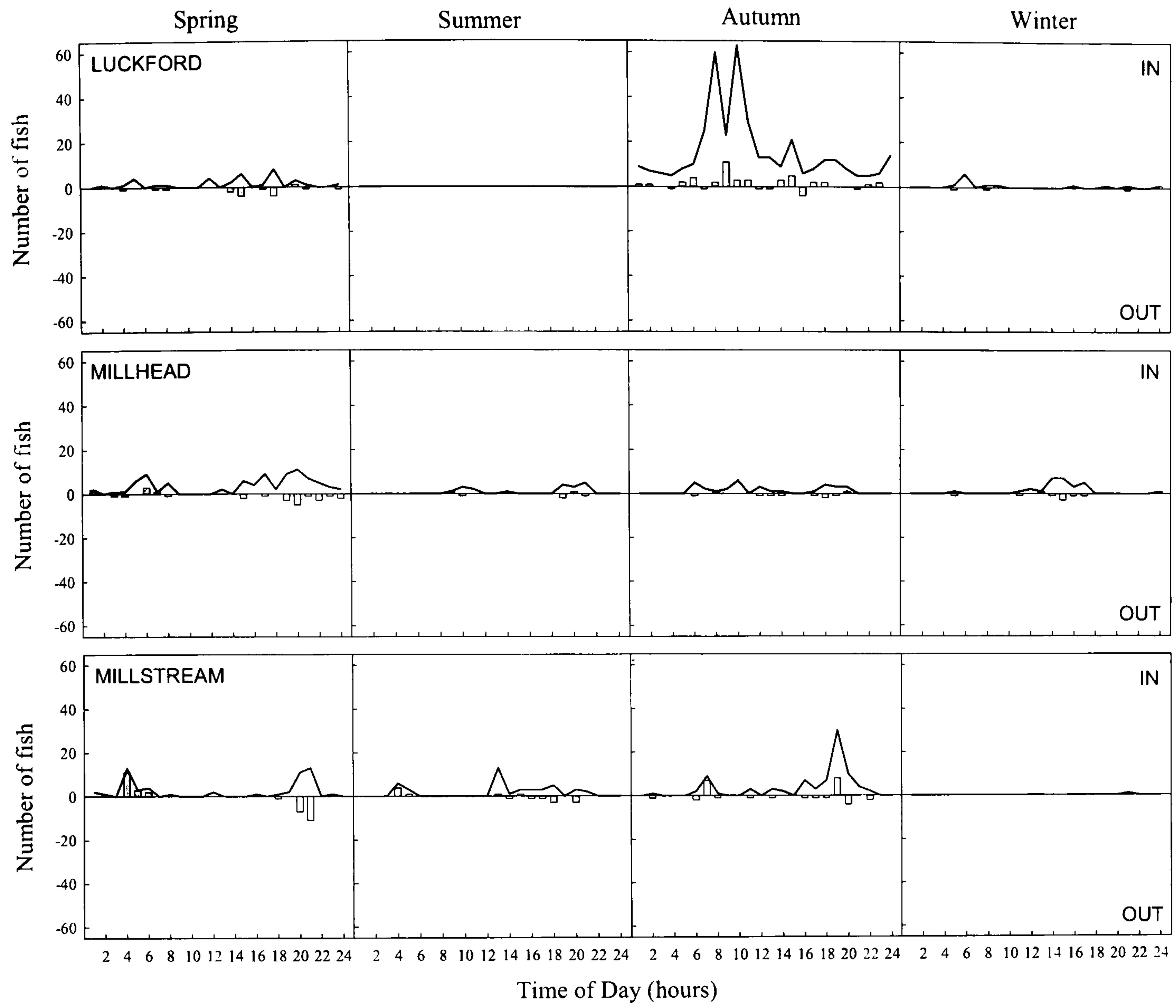


Figure 5.12 Ratio of roach (*Rutilus rutilus*) daily side-channel in and out movements during different seasons (bars) and total number of roach detected (line) (2004-2005).

Table 5.3 Significance values of simple linear regression analysis of various abiotic factors on the level of roach (*Rutilus rutilus*) movement at side-channels based on automated PIT records during spring, summer, autumn and winter. Values represent day-to-day variations within a season. Cross-hatched areas ▨ represent periods lacking in sufficient data to perform analysis (sample size of fish detected too low or no abiotic data available) and black areas ■ indicate significance at a 0.002 Bonferroni corrected α level. Actual R^2, P-values, n and coefficients are given in Appendix 13.

ROACH	Millstream				Millhead				Railway				Rushton				Luckford			
	Sp	S	A	W	Sp	S	A	W	Sp	S	A	W	Sp	S	A	W	Sp	S	A	W
Mean Daily Temperature (^oC)			▨	▨		▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Side-Channel Depth (cm)			▨	▨		▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Side-Channel Depth Change			▨	▨		▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Rainfall (mm)		■	▨	▨		▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
River Discharge (m^3s^{-1})			▨	▨		▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
River Discharge Change			▨	▨		▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Max Daily Light (lux)			▨	▨		▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨

5.3.7 PIKE

Pike were found in all side-channels throughout the year, except Goldsacs (Figure 5.13). Presence in the side-channels appeared to be higher in spring and winter, although it was only found to be significantly larger in spring than summer (*GLM Tukey adhoc*; $P = 0.027$, $T < -3.205$, $df = 3$). Catch in Railway and Rushton ditches, where spawning was observed, was particularly high during spring. Pike using side-channels in autumn were significantly smaller than those in spring or winter (*GLM Tukey adhoc*; $P < 0.001$, $T > 3.724$, $df = 5$ in both cases). Pike in the Millstream were significantly larger than all other side-channels except Luckford, pike in Luckford were also larger than those in Railway (*GLM Tukey adhoc*; $P < 0.002$, $T < -3.753$, $df = 5$ in all cases).

In some cases pike PIT-recorded movement and catch (measured by electric fishing) were the same in a given season, for example in Millstream (Figures 5.13 and 5.14). However, often the point sampling carried out by electric fishing (i.e. one day in a three month period) did not compare well to the pattern of movement shown by PIT-monitoring (Figures 5.13 and 5.14). Peaks in movement into Rushton ditch in spring in particular was missed by catch sampling (Figure 5.13) but highlighted well with PIT telemetry (Figure 5.14).

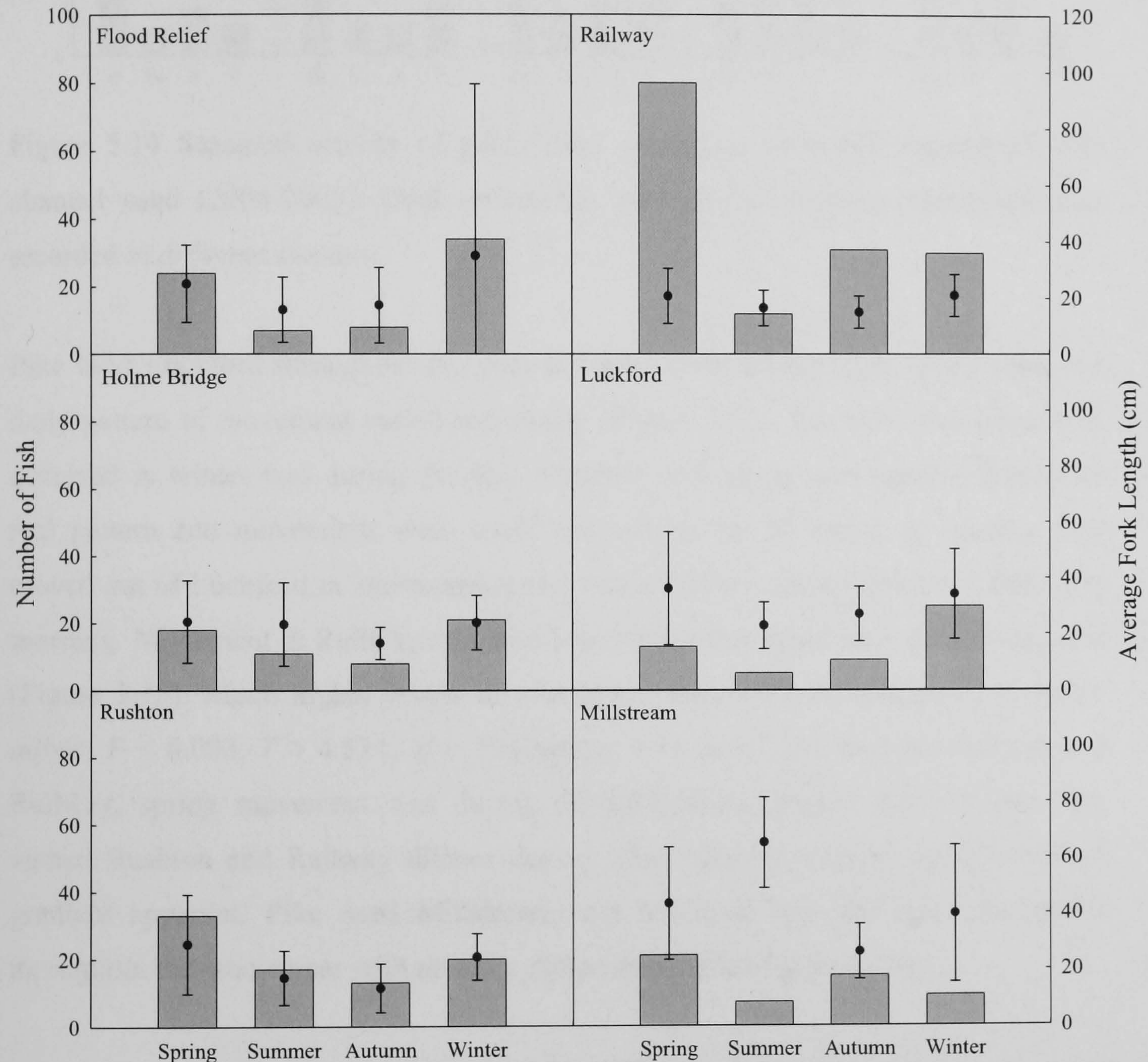


Figure 5.13 Seasonal catch (bars) and size variation (points and standard deviation error bars) of pike (*Esox lucius*) in River Frome side-channels (Mean of 2003-2005).

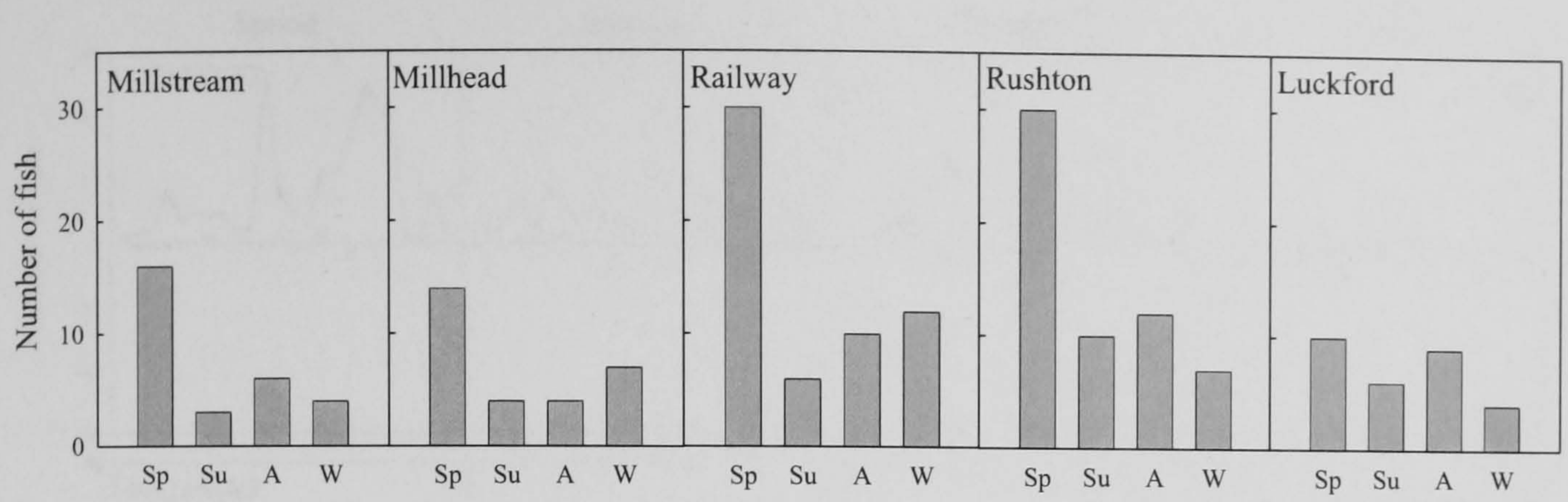


Figure 5.14 Seasonal activity of pike (*Esox lucius*) at each PIT monitored side-channel used (2004-2005). Data reflect the numbers of different individual pike recorded in different seasons.

Pike used Luckford throughout the year but less in the winter time. Once again the daily pattern of movement varied seasonally (Figure 5.15). The little movement that occurred in winter was during the day. Summer and spring movements showed no real pattern and movements were made throughout the 24 hours. In autumn pike moved out of Luckford in late morning and into Luckford during afternoon and early morning. Movement at Railway and Rushton ditches was more seasonally structured (Figure 5.15). Much higher levels of movement were seen in spring (*GLM Tukey adhoc*; $P < 0.003$, $T > 4.534$, $df = 3$) (Figures 5.14 and 5.15). In both Rushton and Railway, spring movement was during daylight hours (Figure 5.15). Fewer fish visited Rushton and Railway ditches during other seasons with no real directional gradient apparent. Pike used Millstream and Millhead less and use was spread throughout the whole year with no daily direction pattern (Figure 5.15).

Only movement of pike into and out of the Millstream was found to be associated with abiotic factors. Channel depth and discharge increased activity at the Millstream in spring and rainfall increased movement into the Millstream in autumn (Table 5.4). Both rainfall and discharge were found to influence pike side-channel use with a general linear model ($p = 0.022$ and $p = 0.008$ respectively; $R^2 = 27\%$).

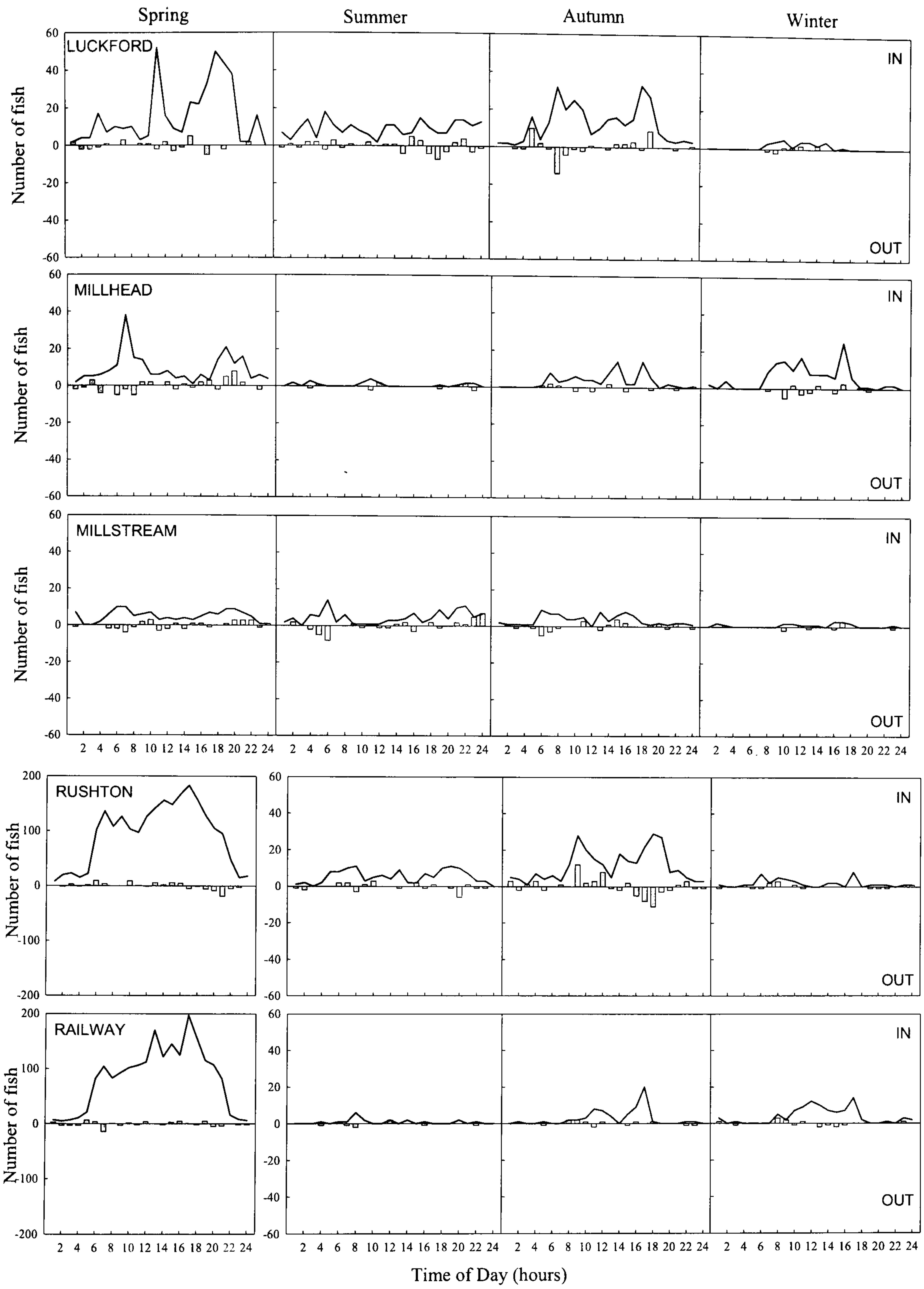


Figure 5.15 Ratio of pike (*Esox lucius*) daily side-channel in and out movements during different seasons (bars) and total number of pike detected (line) (2004-2005). Spring movements are shown on a different scale due to much higher levels of activity

Table 5.4 Significance values of simple linear regression analysis of various abiotic factors on the level of pike (*Esox lucius*) movement at side-channels based on automated PIT records during spring, summer, autumn and winter (2004-2005). Values represent day-to-day variations within a season. Cross-hatched areas ▨ represent periods lacking in sufficient data to perform analysis (sample size of fish detected too low or no abiotic data available) and black areas ■ indicate significance at a 0.0005 Bonferroni corrected α level. Actual R^2, P-values, n and coefficients are given in Appendix 13.

PIKE	Millstream				Millhead				Railway				Rushton				Luckford			
	Sp	S	A	W	Sp	S	A	W	Sp	S	A	W	Sp	S	A	W	Sp	S	A	W
Mean Daily Temperature (°C)						▨					▨					▨			▨	▨
Side-Channel Depth (cm)	■					▨					▨					▨			▨	▨
Side-Channel Depth Change						▨					▨					▨			▨	▨
Rainfall (mm)			■			▨					▨					▨			▨	▨
River Discharge (m^3s^{-1})	■					▨					▨					▨			▨	▨
River Discharge Change						▨					▨					▨			▨	▨
Max Daily Light (lux)						▨					▨					▨	▨	▨	▨	▨

5.3.8 PIKE POPULATION USE OF FLOODPLAIN HABITATS FOR SPAWNING

Adult pike activity (home range area/range span size per season), monitored by radio telemetry (n = 23; 58 – 101 cm FL), tended towards increasing and became more variable between individuals in spring (Figure 5.16). Both core and outer measurements of home range increased, showing that adult pike both increased their exploratory movements as indicated by an increase in outer home range area and range span and also the area in which they spent most of their time (the core).

Of all confirmed spawning events of radio-tagged pike (active spawning observed; n = 7) 71% occurred in a side-channel, suggesting a high level of side-channel use for pike spawning. This value may be biased as spawning events were harder to confirm in the river because spawning could not be observed in deeper water and only increases in activity noted. However, 15% of the whole PIT tagged pike population sample visited Railway or Rushton (two historical spawning ditches; CEH and Jerome Masters unpublished data) during the 2005 spawning season.

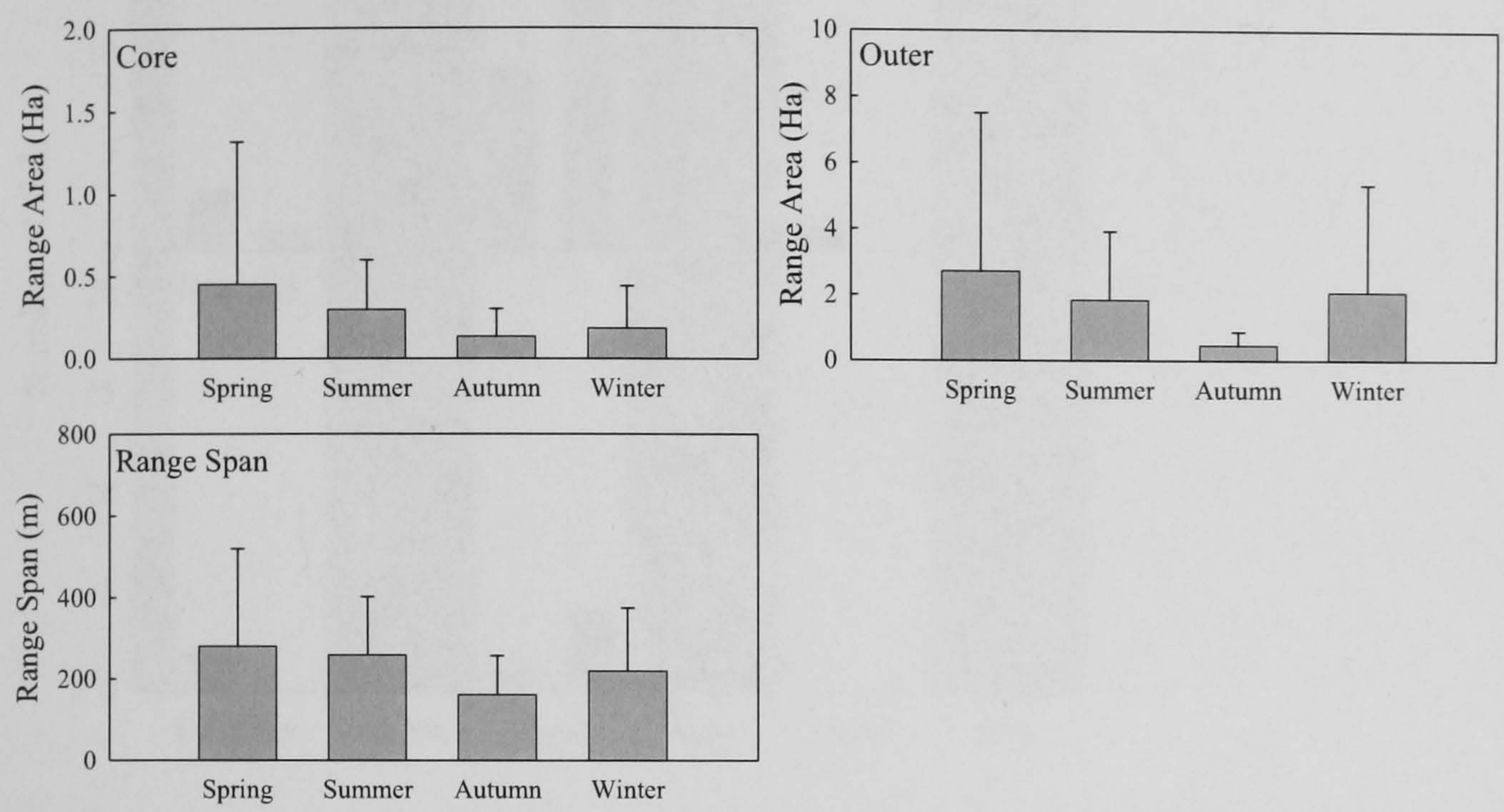


Figure 5.16 Seasonal activity of radio-tagged adult pike (*Esox lucius*) measured in terms of home range for core (95% cluster) and outer (95% kernel) and also range span (2002-2005). Spring n = 16, summer n = 12, autumn n = 14 and winter n = 12. Error bars represent standard deviation.

As well as an increase in radio-tagged pike home range size, visits to side-channels increased during the spawning season (Figure 5.15). Activity at the side-channels began in the first half of February and ended in June (Figures 5.17 and 5.18). Male and female pike entered in early February but in both years females left and did not return until early March, while activity by males continued from early February through the rest of the spawning season. The ratio of total PIT tagged female pike to total PIT tagged male pike was 1 : 1.4. Yet two to four times more males visited side-channels than females (Female to male ratio 2004; 1 : 3.7 and 2005 1 : 2.9, illustrated in Figures 5.17 and 5.18), indicative of the spawning behaviour of pike whereby one female is often joined by between one and four males to spawn (Pictures 5.1, 5.2 and 5.3). Visits started during the same fortnight (early February) in both years and peaked during the same fortnight (late April). However the period of side-channel visits lasted longer in 2005 than 2004 with a small number of pike still making visits in July 2005, while visits ended in early June 2004.

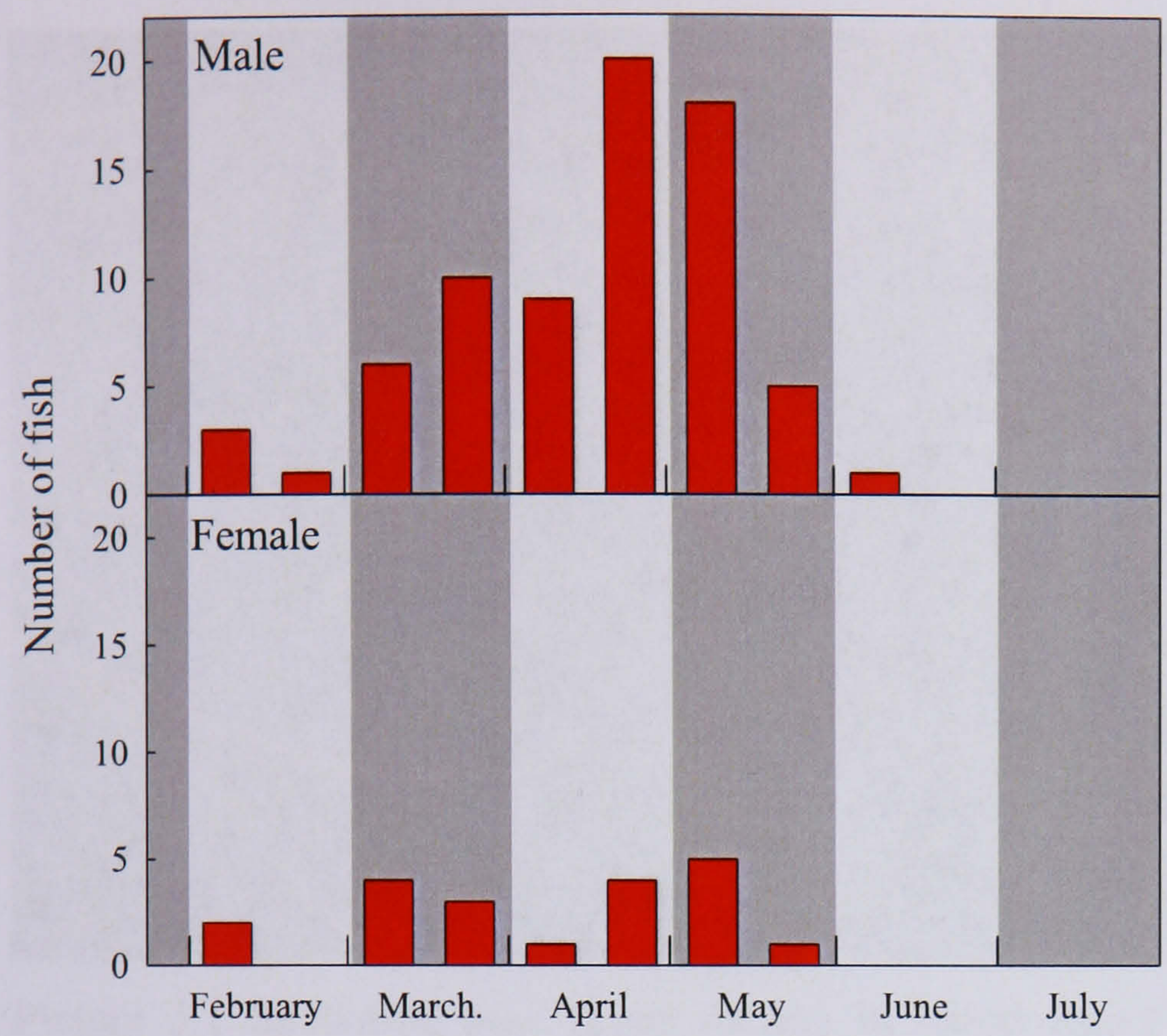


Figure 5.17 Side-channel visits by male and female pike (*Esox lucius*) during the 2004 spawning season. Total number of pike detected by PIT readers in each fortnight is presented. Shading emphasises each month.

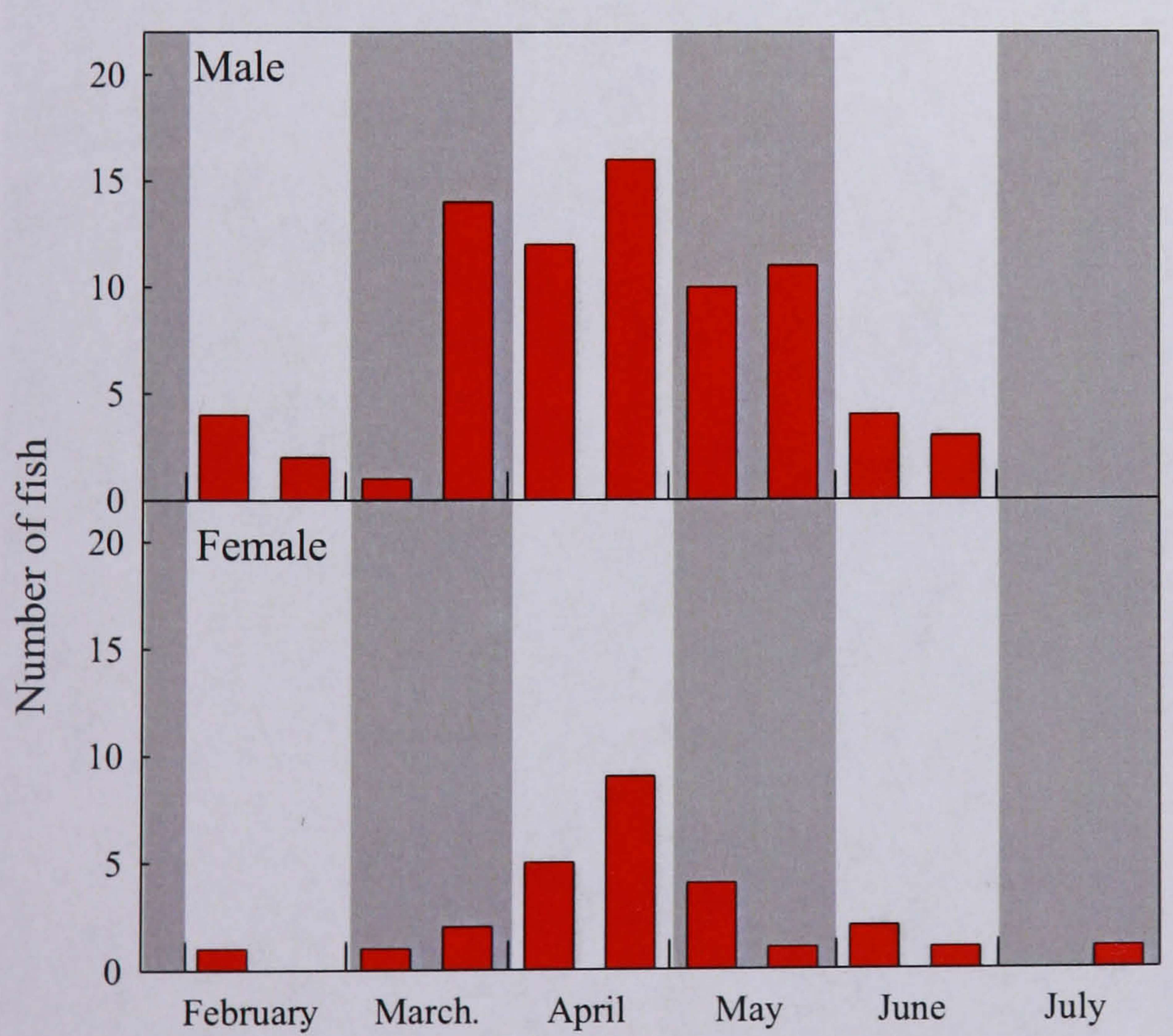


Figure 5.18 Side-channel visits by male and female pike (*Esox lucius*) during the 2005 spawning season. Total number of pike detected by PIT readers in each fortnight is presented. Shading emphasises each month.

Picture 5.1 Spawning pike (*Esox lucius*) in Flood Relief showing a larger female (bottom) being attended by 2 smaller males both on her right (top).

Picture 5.2 Spawning pike (*Esox lucius*) in Railway ditch showing a larger female (bottom) being attended by a smaller male (top).

Picture 5.3 Paired spawning pike (*Esox lucius*) in Railway ditch showing a larger female (bottom) being attended by a smaller male (top).

The number of male and female pike present in the spawning channels varied by season. From electric fishing samples in the lower 200 m of the side-channels, the sex ratio differed seasonally for all three years combined (Figure 5.19). In spring and autumn it was approximately even (59% and 45% male, respectively) while in winter the sex ratio was much more skewed towards males, with 79% of all pike being male.

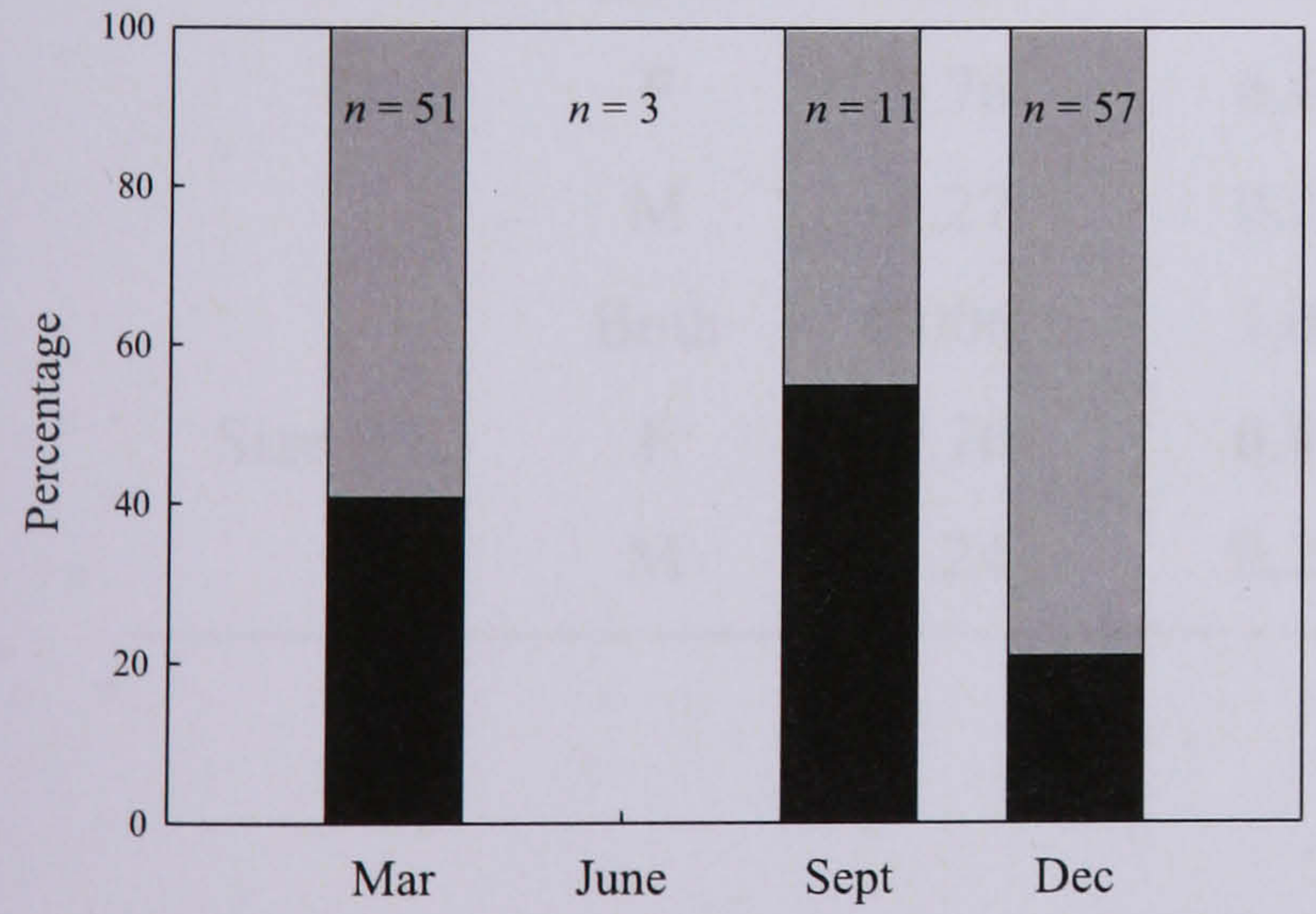


Figure 5.19 Percentage ratio of male ☐ to female ■ pike (*Esox lucius*) in Railway and Rushton ditches (when sex was determined). As only 3 pike of known sex were caught in these ditches in June of all three years this was not deemed an adequate sample to determine a sex ratio. The sample size is given for all seasons.

The results of nominal regression highlighted fork length and growth coefficients (L_∞ and K) as strong predictors of the difference in PIT-recorded side-channel presence of males between winter and spring (Table 5.5). Growth and size of males in Railway and Rushton was lower in winter than spring (Table 5.5). There was no such relationship for females or when sex was not included. All models of fork length and growth constants were found to fit the data significantly (Pearson Goodness of Fit, Table 5.5). Thus males, and not females, in Railway and Rushton ditches were significantly smaller and slower growing in winter than they were in spring.

Table 5.5 Results of nominal logistic regression investigating seasonal differences in growth coefficients by sex. Only pike (*Esox lucius*) caught in the historical spawning channels (Railway and Rushton; CEH and Jerome Masters unpublished data) were included in this seasonal analysis. Results are reported only for the comparison of spring and winter as it is the differences between these that are important to the hypothesis of early arrival.

Predictor	Sex	Coefficient	Odds Ratio	*P*-Value	Goodness of fit (Pearson)
	Both	0.18	1.2	0.52	
L_∞	F	-0.77	0.46	0.239	$P > 0.1$
	M	-1.26	0.28	***0.026***	
	Both	0.49	1.63	0.530	
K	F	-0.76	0.47	0.243	$P > 0.1$
	M	-1.27	0.28	***0.025***	
	Both	0.006	1.01	0.785	
Size (FL)	F	-0.76	0.47	0.244	$P > 0.1$
	M	-1.24	0.29	***0.029***	

A general linear model using the variables K, age and length described 65% of the variation between individuals in time spent in ditches (Coefficients are given in Table 5.6). Railway and Rushton were included in the model as they are historical spawning locations where spawning has been observed, while Millstream, Millhead and Luckford were not.

Table 5.6 General linear model describing individual variation in the number of days per month spent in a side-channel of the River Frome study reach by individual pike (*Esox lucius*) measured by PIT telemetry (2004-2005).

	P-Value	Coefficient
Constant		-0.238
K	***0.02***	5.13
Age	0.06	1.0004
Length	***0.0006***	0.24679

Adult pike monitored by radio telemetry (that usually resided in the main river channel) often did not spawn in the nearest side-channel to their main river home range, but travelled further to another side-channel (Table 5.7). In all but one cases they travelled upstream to spawn. Nine radio tagged fish were observed visiting side-channels during both spring 2004 and spring 2005. All of these nine fish visited the same side-channel in both years.

Table 5.7 Travel distances of pike (*Esox lucius*) to their nearest side-channel and to the side-channel they actually visited. RW, Railway; FR, Flood Relief; LL, Luckford; HD, Hedgemans ditch (2 km upstream of East Stoke).

Fish	Distance home range to nearest side-channel (m)	Nearest channel	Distance home range to spawning location (m) *	Channel visited
E	67	RW	67	RW
Za	102	RW	102	RW
Ab	111	FR	991	None
F	111	RW	1380	HD
H	116	RW	116	RW
O	157	RW	3080	River upstream
Be	161	RW	161	RW
X	201	LL	1409	RU
Fd	280	RW	280	RW
Y	286	RW	286	RW
B	327	RW	327	RW
C	363	RW	938	HD
Ze	401	RU	401	RU
K	494	FR	591	RU
Ka	159	RW	159	RW
J	58	RW	58	RW
L	41	RW	38	River

* Spawning location is classified either as spawning observed (in all cases of river spawning location and some cases of side-channel spawning location) or as side-channel visited and spawning suspected.

5.4 Discussion

Eel demonstrated strongly nocturnal behaviour, supporting existing literature (Baras et al. 1998, Schulze et al. 2004, Tesch 1977). However contrary to Baras (1998) movements extended throughout the night and did not peak soon after darkness and then reduce. Eel generally moved into the Millstream during the evening and to a smaller extent overnight and out in early morning although there was general movement in both directions. This suggests that Millstream may have been used for feeding during nocturnal activity and eel moved out to the main river during daytime inactivity. Daily activity reduced in autumn, while the total number of eel moving during the season did not. Adult eel make their seaward migrations in autumn (Tesch 1977). In autumn on the River Frome many eel only passed through the PIT detectors once in a downstream direction, seemingly on their way to sea. Eel seaward migrations tend to occur on high flows (Behrmann-Godel and Eckmann 2003) and in this study only eel movements in autumn were positively correlated with river discharge and channel depth. As 34% of eel moving through the Millstream PIT detector in autumn had not been detected at any other time these may have been migrating individuals from further upstream in the Millstream that had not made daily nocturnal forays between the millstream and river. Thus it is proposed that the Millstream provided residence habitat for many eel, some of which migrated to sea in autumn.

Some roach activity occurred at dawn and dusk which is in agreement with daily activity recorded in the literature (Baade and Fredrich 1998, Jacobsen et al. 2004), but often sample sizes were too small to show a clear pattern. Autumn was the peak of side-channel use but while this was reflected in daily activity at Luckford, there was not such an increase in daily activity at Millstream. This suggests that roach made frequent trips between Luckford and the river in autumn, while once in the Millstream they remained there. Large numbers of roach collect in the Eel pool (CEH unpublished data), which is a large pool with some flow but many sheltered, slack areas, about 1 km up the Millstream. Baade and Fredrich (1998) also found roach to be located more often in stagnant waters during colder months. It could be suggested from this that Millstream provides shelter and feeding habitat, while Luckford is only suitable for sheltering.

Roach activity increased at Millstream, Millhead and Luckford in spring suggesting that areas of all were used for spawning activity. Roach are known to spawn in side-channels and reed beds (Mann 1973). While Luckford and Millhead provided the vegetated habitat used by roach to spawn (Baade and Fredrich 1998, Wootton 1990) this was not available in the lower sections of the Millstream. However it is possible that roach moved up through the Millstream to spawn in the suitable habitat in Millhead further upstream. Nursery habitat was also provided by the non-flowing side-channels. Holme Bridge appeared to offer a sanctuary away from the higher flows and predation risk of the main river, possibly with a larger supply of invertebrates for feeding (Armitage et al. 2003). Holme Bridge may therefore have also been used for spawning. Although mature roach were never caught there during electric fishing sampling, this side-channel was not monitored with PIT telemetry, which was shown to better reflect transient activities such as spawning, in dace and pike.

Dace use of side-channels was similar in many respects to roach. Dace too used Luckford heavily in autumn, although unlike roach they also were present in spring. This spring use has been described as "resting-up" post-spawning (Clough et al. 1998). Use of tributaries upstream of East Stoke by post-spawning dace in the River Frome had previously been documented by Mann and Mills (1986) by fin clipping of dace spawning in Millstream and recapture in Tadnoll Brook. It was thought that side-channels were used for sheltering and not for feeding during resting-up as 66% of the dace caught in these areas had empty stomachs and the mean fullness was <1 item per fish (Clough et al. 1998). Dace showed diurnal activity patterns with increased movement in both directions at dawn and dusk as has often been described in cyprinids (Clough 1997, Lucas and Baras 2001). Dace exhibited the diel movement patterns out of the side-channel at night, returning in the morning as documented between the Millhead and main river channel by Clough (1997).

Catch data suggested that the Flood Relief was used by young dace (<10 cm) at a low level throughout the year. This is similar to the ditch use by the juvenile roach in this study and the habitat described by Baras and Nindaba (1999). They concluded that these shallow, low flowing and heavily vegetated habitats were selected because they were warmer, provided good cover from predation and better feeding due to a higher abundance of micro-invertebrates (Baras and Nindaba 1999).

Pike were present throughout the year in all side-channels except Goldsacs. In some cases, for example Rushton and Railway in spring, movements were clearly made during the day (in both directions). At other channels pike moved at dawn and dusk, for example Luckford in autumn and Millhead in spring. However, in many cases activity occurred throughout the day and night. Pike have been shown to be flexible in the timing of daily feeding activity in different locations (Cassleman and Lewis 1996, Diana 1980, Jepsen et al. 2001, Lucas et al. 1991). On the River Frome feeding activity has previously been linked to movement at dawn and dusk (Beaumont et al. 2005). It is possible that pike were feeding in Luckford during autumn and Millhead in spring. Here, a strong diurnal pattern of activity was apparent. Combined with the knowledge that large numbers of roach used Luckford in autumn and large numbers of dace used Millhead in spring it may be hypothesised that pike were feeding in these locations, particularly as cyprinids were previously found to form the major component of pike diet on the River Frome (Mann 1976b).

Pike movements at Millstream were made throughout the 24 hours, which may suggest that pike were primarily moving in to Millstream to shelter from unsuitable conditions in the main river, when those conditions arose. The stronger positive correlation between movements into the Millstream and abiotic factors such as rainfall, river discharge and channel depth supports this premise. In many other cases the reason for moving into or out of a side-channel is less clear, perhaps as pike use them for a number of different functions simultaneously. As there was a continued presence of pike in most of the side-channels throughout the year it is probable that some individuals were resident in these areas.

Fifteen percent of the PIT tagged pike population visited Railway or Rushton during the 2005 spawning season. These were the only two side-channels monitored by PIT detectors that radio-tagged pike were observed spawning in. Deaths and emigration since tagging and immaturity of some individuals must be taken into account. Also, the fact that a number of other suitable unmonitored side-channels (known from radio telemetry) were available in the area must be considered. With this in mind the conservative estimate of 15% of the population spawning in these two locations can be considered as a large part of the spawning population.

Male pike were more active and spent longer in spawning channels than females. This behaviour has previously been described in pike and was thought to demonstrate a polygynous mating strategy (Frost and Kipling 1967, Lucas 1992). Slow growing males were present in the spawning ditches even earlier in the season than their faster growing counterparts. No such relationship was found for female pike. A strong sex bias towards males was found in pike in side-channels prior to the spawning season (December). The mature males in the side-channels at this time were small and also slower growing. Thus they had matured at small size and not young age. It is possible that slow growing pike were resident in side-channels, however in most cases different individuals were caught in each season (determined through PIT tagging). It is also possible that slow growing pike moved into the side-channels for shelter in winter when much of the vegetation cover in the main river had died back. However, the strong sex bias toward males and the proportion of these producing milt and ready to spawn already in December suggests an alternative or additional rationale for the increasing number of pike using side-channels in winter. It is suggested that some slow growing males may have been exhibiting protandry; the early arrival of males to spawning grounds to gain spawning opportunities that may not have been available to them after larger males had arrived (Morbey and Ydenberg 2001).

Duration of time spent on the spawning grounds could be successfully predicted by a combination of size, age and growth revealing that slow growing pike remained longer in the side-channels. This may again be due to pike sheltering in the side-channels or it may infer that the males may be using "sneaky behaviour" as a second strategy to maximise their spawning potential. By lingering in the side-channels during the spawning season the slow growing pike may maximise their chances of being present when a female entered. With the present data conclusions cannot be drawn as to which of these possibilities, if any, are the drivers of side-channel use by slow growing male pike. However, hypotheses drawn here can be used as a basis for further research. Clearer understanding could come from radio tracking all individuals utilising a spawning ditch in order to monitor all interactions, which may indicate whether slow growing males were participating in spawning behaviour or merely sheltering away from the main river channel. Further, genetic analysis of offspring would determine which pike and, indeed how many, fathered them.

All male and female radio-tagged pike that spawned in both 2004 and 2005 returned to their spawning location of previous years. Spawning site fidelity has long been acknowledged in pike (Carbine and Applegate 1946, Frost and Kipling 1967, Karas and Lehtonen 1993, Rosell and MacOscar 2002). Recently however it has been suggested that pike return to their natal site to spawn (Miller et al. 2001). In this case there may be large consequences of the destruction or alteration of a spawning area, depending on the obligatory nature of the fidelity. If reproductive success is highly dependent on returning to a particular spawning site, the loss of that site would result in the loss of reproductive output from an entire spawning population. Constructions of levees and draining of the floodplain of the Illinois River caused the pike population to diminish (Starrett 1972). The author attributed this to loss of the spawning grounds.

In many systems, including the present study site, some spawning channels are only available under high flows. Others, following several years without significant flooding, may become blocked and impassable. In this case fish may either spawn elsewhere or skip spawning for a year. Skipped spawning has been reported in a number of fishes including three-spine stickleback (Lam et al. 1978), Atlantic salmon (Schaffer and Elson 1975), and yellow perch (*Perca flavescens*) (Holmgren 2003), although data on skipped spawning is limited due to the difficulties in clearly identifying non-spawning females. Females may retain their eggs if a suitable spawning location cannot be found and energy saved by not spawning in a poor year may lead to increased survival and a higher probability of spawning in subsequent years (Rideout et al. 2005). A number of female pike in this study visited spawning channels (Railway and Rushton) in only one of the two years they were monitored. While it is possible that some spawning events were missed, the large number observed visiting in only one year and the high level of spawning site fidelity exhibited by all pike between years suggests that at least some females skipped spawning. It is likely that in unsuitable years female pike skip spawning until the following year. However if spawning channels are lost through lack of maintenance or destruction the whole pike population will be affected, particularly if pike will not spawn at other locations than their natal site.

All side-channels were utilised by some or all of the fish species investigated during this study. The niche provided by each varied according to the species, season and type of channel and for roach, dace and pike different side-channels were used for different functions. For example, dace used Millstream for spawning, Luckford for resting post-spawning and Flood Relief as a nursery habitat. Thus the full mosaic of habitats available was exploited by the fish community. This corroborates other studies that have shown the benefits of accessible off-river habitats to fishes and the losses as a result of their removal or inaccessibility (Hohausová et al. 2003, Neumann et al. 1996, Penczak et al. 2003, Schiemer 1999, Schmutz and Jungwirth 1999, Scott and Nielsen 1989).

Goldsacs and Millstream supported a number of species that were not present elsewhere in side-channels. Goldsacs in particular supported the only large numbers of brook lamprey, a Biodiversity Action Plan species, in the area sampled, elevating the importance of this habitat within the system. Goldsacs may also be a freshwater nursery ground for flounder which peaked in abundance in summer when they move in from sea (Greenhalgh 1999) and reduced in number thereafter. Flounder were smallest in summer and gradually increased in size during the following three seasons.

The level of contribution of lateral habitats to the survival of the population was considered for pike, but further investigation of population structure and use of side-channels may provide extra information as to the necessity of these habitats within the river system and the functionality for particular species. Two case studies on the functional use of side-channels by pike and dace are described in the following two chapters.

Chapter 6

Population Structure and Side-Channel Use: A Case Study of a Rheophilic Species

6.1 Introduction

Dace are a rheophilic cyprinid found in fast flowing rivers and streams throughout England and E Wales (Wheeler 1969). They congregate in large shoals at all life stages, except the largest individuals which may be more solitary (Bagenal 1973). They attain a maximum size of 20 – 25 cm or up to 600 g (Davies et al. 2004). Dace are opportunistic feeders, feeding on insects and crustaceans and allocanthous material and grazing on algae (Davies et al. 2004). Unlike most other British cyprinids dace are thought to continue to feed opportunistically, at a reduced rate, throughout the winter (Davies et al. 2004). Dace are known to undertake migrations of up to 30 km and are able to osmoregulate in the salinities found in tidal reaches (Cowx 2001).

Dace are the first cyprinids to spawn each year, with spawning taking place between February and early April. Onset of spawning migration is thought to depend on water temperature (Mann 1974, Alabaster and Lloyd 1982) and photoperiod (Brook and Bromage 1989). Dace are lithophilous spawners, spawning communally over gravelly, well oxgenated shallows of rivers and streams (Davies et al. 2004). Females release a single batch of eggs during the two to three week spawning period (Mann and Mills 1986, Mills 1991). Female fecundity is a function of length and varies between 6550 and 9500 eggs for 20 cm females (Cowx, 2001).

Lakes, rivers and streams offer a mosaic of habitats that influence the persistence and structure of fish populations. Over the year, fish move between different habitats, depending on their requirements and activities, such as feeding, spawning or sheltering (Borcherding et al. 2002, Harden Jones 1968, Northcote 1978). These seasonal patterns can be regarded as an attempt to optimise habitat use, for example for spawning, foraging, or as a trade-off between predator avoidance and resource use (Krebs and Davies 1997). Separate age classes of fish or those at different of developmental stages have different resource requirements and thus their ecological needs differ.

A key to understanding spatially structured populations is in the movements of individuals between patches or habitats (Szacki 1999). The extent and scale of movements are of particular significance in understanding mobile populations, yet monitoring these movements is dependent on the method used to obtain measurements and movements are often underestimated (Szacki 1999). Defining population patches and habitats used by riverine fish and monitoring movement between them at the population level is a difficult task due to the difficulty of identifying individuals. So few studies have considered population structure and population scale movement in fishes (but see (Dunham and Rieman 1999, Gotelli and Taylor 1999, Koizumi and Maekawa 2004)). However, now the use of PIT telemetry opens a new possibility in characterising spatial population structure of fish.

The fate of mammal and bird populations fragmented by habitat destruction and isolation has been commonly investigated using theoretical models such as metapopulation theory, attracting interest from conservation managers as well as population ecologists (Hanski 1994, Lindenmayer et al. 2001, Lindenmayer et al. 1995). Yet, although little studied, the effects of habitat fragmentation on the population dynamics of stream-dwelling organisms like fish are arguably even more serious than terrestrial organisms because the colonisation route is restricted linearly. Thus, construction of movement barriers (e.g. dams, thermal plumes or impassable road culverts) may compromise their persistence, particularly in upstream areas, through the destruction of dispersal and migration routes (Jager et al. 2001, Morita and Yamamoto 2002, Reyes-Gavilan et al. 1996).

This study addressed the issues discussed above by using a number of different methods (electric fishing captures, mark-recapture, PIT telemetry and radio telemetry) to monitor dace spatial population structure within the river system. Identification of individual dace with telemetry methods allowed repetitive use of habitats to be monitored at a finer temporal and spatial scale than previous studies. The aims of this chapter were to investigate functional main river and side-channel use by dace and understand the structure of the dace population in the Frome Catchment.

6.2 Materials & Methods

6.2.1 SAMPLING

Seven side-channels (Chapter 2) were sampled with electric fishing four times a year during 2003-2005. Five side-channels were monitored with PIT detectors during 2004-2005. Dace were radio-tracked daily during spring 2004 and 2005 and autumn 2004. See Chapter 3 for further detail on the procedures used.

6.2.2 ANALYSIS

Data presented for dace catch from electric fishing captures in side-channels or the main river use combined data from 2003 to 2005. Data for main river PIT telemetry is presented from July 2004 to June 2005 (after which time sensitivity of this detector decreased and became unreliable). This time period was associated with the availability of a large sample of dace tagged in the main river and side-channels. Results from side-channel PIT telemetry use data from January 2004 to December 2005 except for Luckford as the PIT detector was built in February 2005. Main river (FDX, 12 mm tag) and side-channel (HDX, 23 mm tags) PIT detectors read different tags so in most cases records were mutually exclusive and recorded different fish (except in the instances of double tagged fish – see Chapter 3).

Due to missing weeks in the data one week per month was selected for PIT data from each side-channel (as close to the middle of the month as available data would allow) and all movements during that week noted. Use of one week was necessary because there were occasions when a PIT detector operated successfully for only one week out of the month. This provided a standardised dataset that could be compared across months, seasons and locations. This was done for 2004 and 2005 and averaged for each season, except for Luckford where the reader was only installed for 2005.

The main river PIT detector was not directional i.e. it recorded the presence of a fish but not the direction in which it was travelling. However, all fish were initially tagged and released downstream of the detector. For side-channel PIT telemetry, movements in and out were combined and only one in and one out movement were counted per fish per day to prevent influence of fish loitering in the vicinity of detectors. While numbers of fish moving through PIT detectors are presented it must be kept in mind that only 5% of the population > 12 cm was tagged (see Chapter 5).

Seasons for dace were divided according to the dace spawning season in the Frome (Mann 1974). Thus:

Spring	February - April
Summer	May - July
Autumn	August - October
Winter	November - January

Mature and immature dace were defined by size according to Mann (1974). Mann gave 16.3 cm as the mean size of maturation of males and 17.9 for females. As it was only possible to tell the sex of dace around spawning time an average size at maturity for males and females was taken:

	Size
Immature	0 – 17.09 cm
Mature	17.1+ cm

Statistical analyses were carried out in Minitab 14. Graphs were made in SigmaPlot 2000.

6.3 Results

6.3.1 POPULATION STRUCTURE OF DACE USING SIDE-CHANNELS

Within the side-channels dace fork length was significantly different between all seasons (*ANOVA*, Tukey test; $F = 56.66$, $P < 0.001$, $df = 3$). A wider size range of dace were present in the side-channels during spring and summer than during the latter half of the year (Figure 6.1).

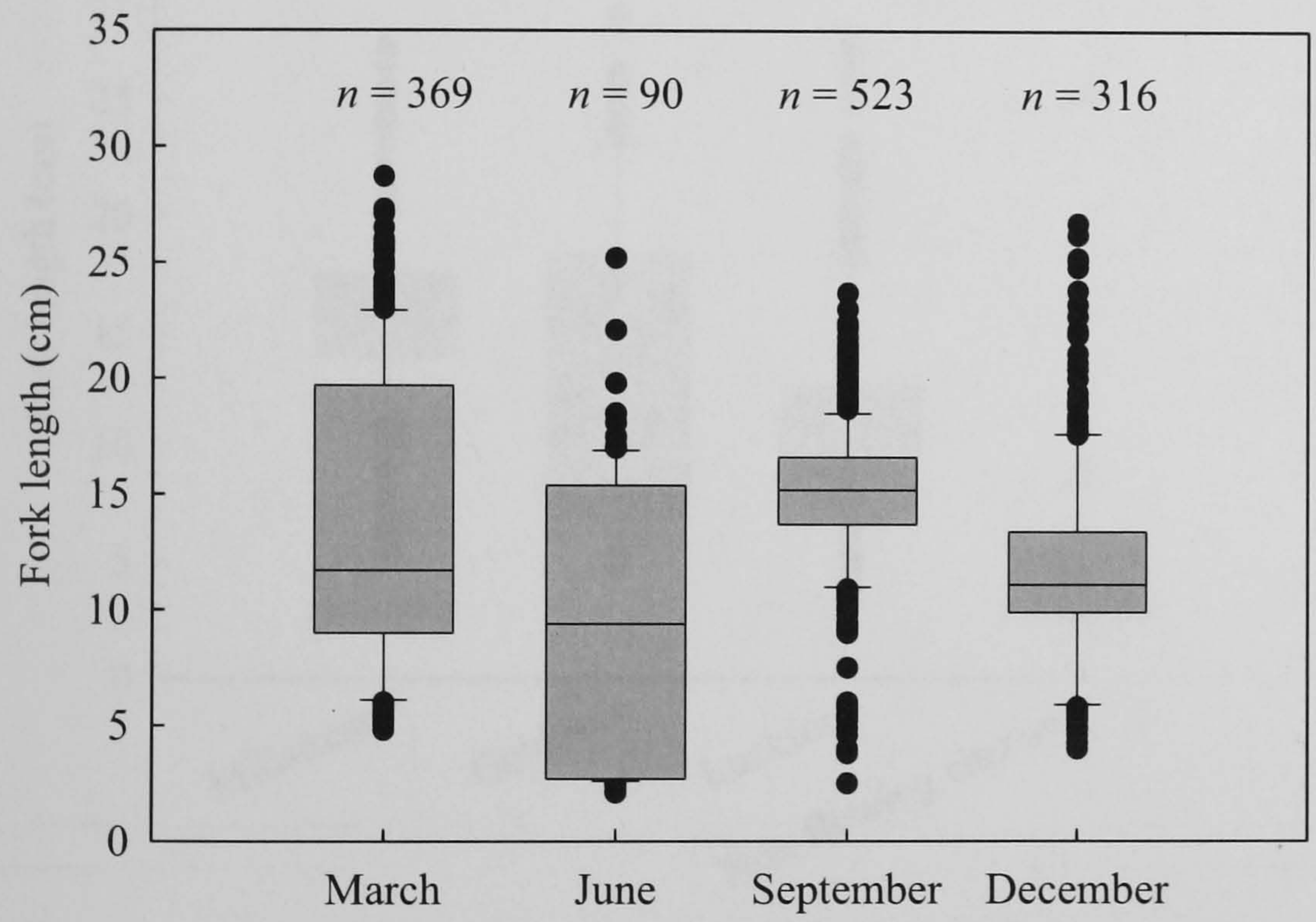


Figure 6.1 Seasonal size distributions of dace (*Leuciscus leuciscus*) in side-channels from 2004 to 2005. Lengths are given as fork length. The box plots show the median, 10^{th}, 25^{th}, 75^{th} and 90^{th} percentiles. Remaining data points are values outside these boundaries.

Of the dace using side-channels only the smallest individuals were captured in the non-flowing channels (Figure 6.2). While the size range of dace in the three flowing channels was less variable, *ANOVA* post-hoc tests show that all were significantly different from each other (*ANOVA*, *Tukey* test; $F = 205.72$, $P < 0.001$, $df = 3$). Dace catch in side-channels varied greatly between seasons, with greatest numbers of dace caught in a single channel peaking in September and reaching a minimum in June (Figure 6.3). Very few mature dace were caught in side-channels in June, while in contrast almost half of the catch in March was mature fish.

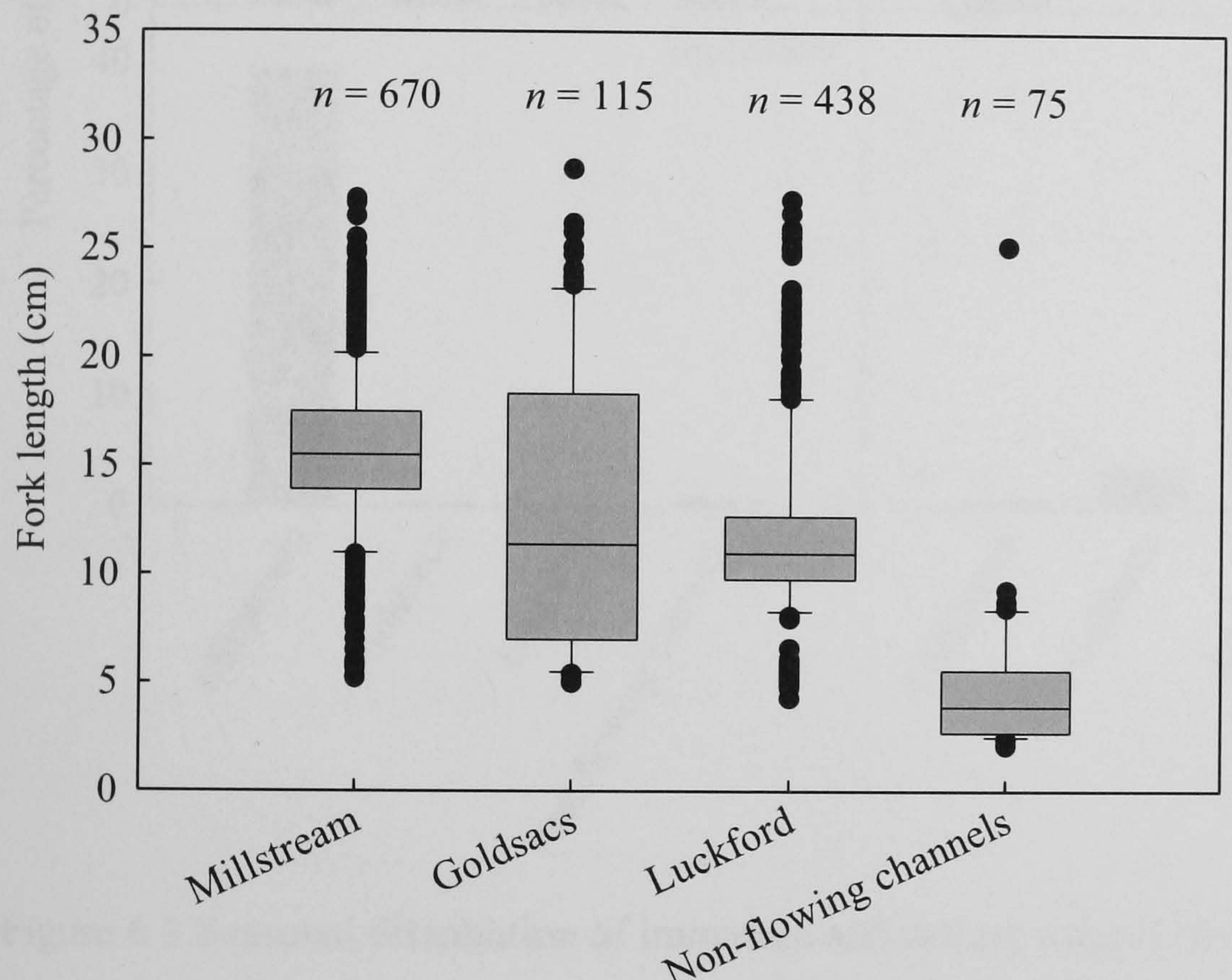


Figure 6.2 Size distribution of dace (*Leuciscus leuciscus*) caught in side-channels (2004-2005). The box plots show the median, 10th, 25th, 75th and 90th percentiles. Remaining data points are values outside these boundaries.

Seasonal side-channel use also varied between channels (Figure 6.3). In March mostly mature fish were captured in the Millstream, with some other mature fish visiting other channels also. Immature dace were present in all side-channels. Lowest use of the side-channels occurred in June and then almost exclusively by immature individuals. Millstream was heavily used by mature and immature dace alike in September. Indeed, in September very few fish were caught in other side-channels. By December the importance of Millstream had diminished and Luckford supported the greatest number of dace. Once again, as in summer, relatively fewer mature fish were caught in the side-channels.

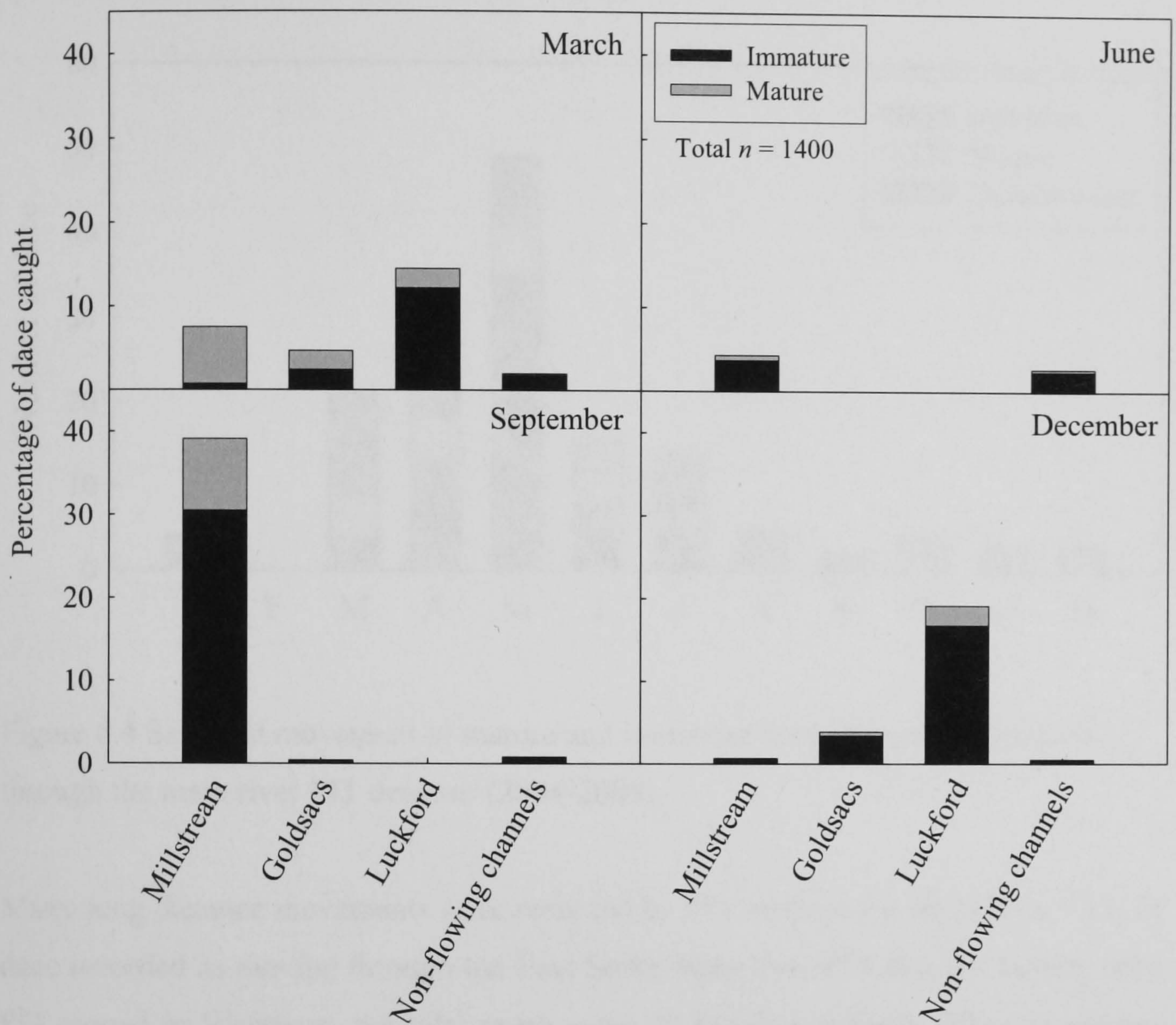


Figure 6.3 Seasonal distribution of immature and mature dace (*Leuciscus leuciscus*) in the side-channels as a percentage of total fish captured (2004-2005). Dace capture for all non-flowing channels has been pooled due to low sample size.

6.3.2 SPATIAL DISTRIBUTION OF THE DACE POPULATION

Movements in the main river measured by the East Stoke PIT detector peaked in May with elevated movement detected between March and July (Figure 6.4). There was little repeat detection of individuals during this time. When separated by maturity, immature fish constituted a larger number of those movements than mature dace (Figure 6.4). While both showed increased activity between March and July the largest peak was of immature and not mature dace. No such peak in May was observed through the Millhead PIT detector which is immediately adjacent to the main river detector.

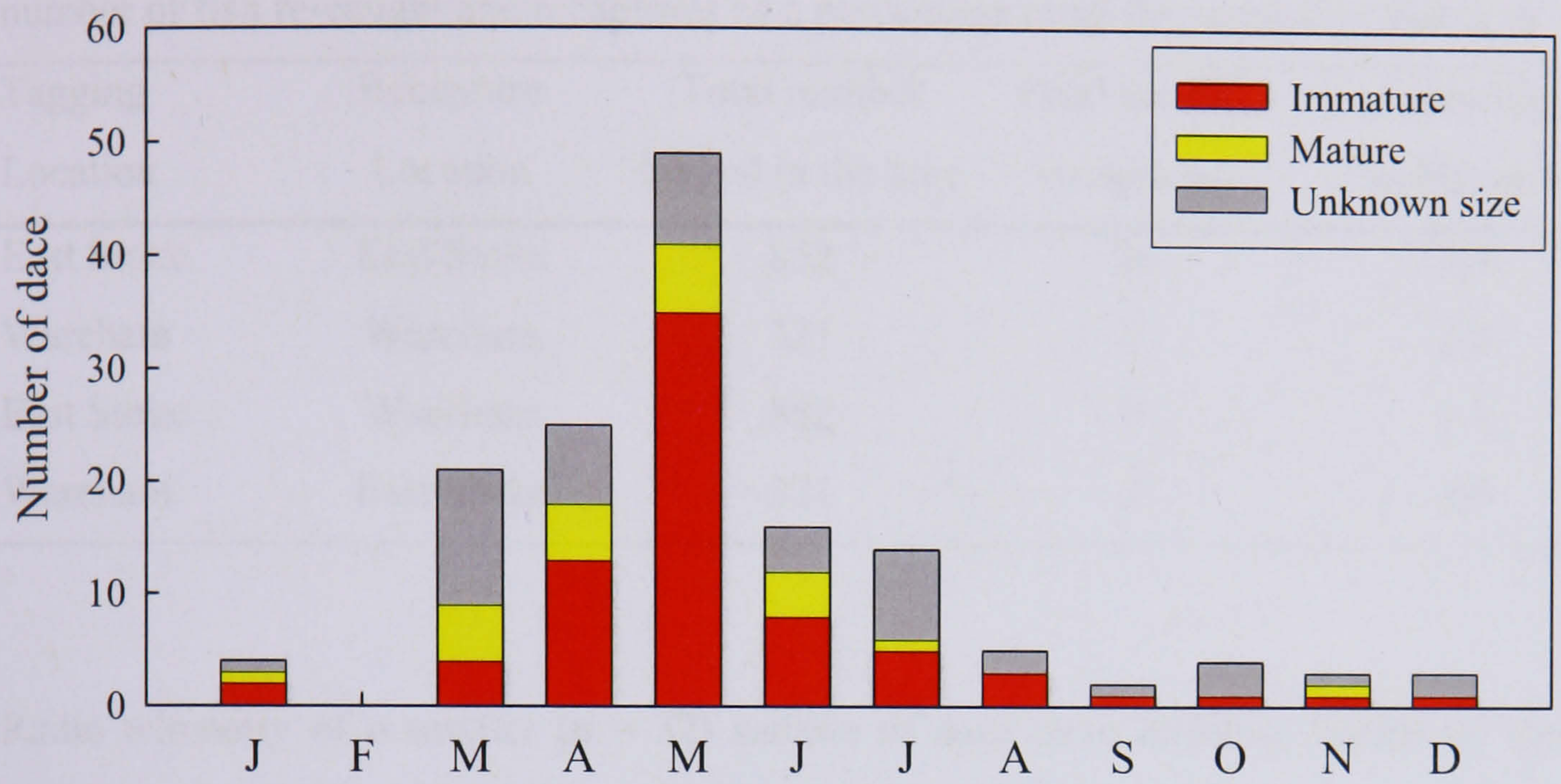


Figure 6.4 Seasonal movement of mature and immature dace (*Leuciscus leuciscus*) through the main river PIT detector (2004-2005).

Many long distance movements were recorded by PIT telemetry with 24% (n = 13) of dace recorded as moving through the East Stoke main river PIT detector having been PIT tagged in Wareham, the tidal reach some 10 km downstream. When recaptures were considered for all locations, 11.5% (n = 3) of all East Stoke (main river reach and side-channel) recaptures were fish that had moved upstream from Wareham (Table 6.1).

Approximately 3% of dace were recaptured in the large scale area (i.e. East Stoke or Wareham) in which they were tagged, and 1% of dace had made the long distance movement between tidal and upstream locations (Table 6.1). There was no difference according to location or direction of movement. Although based on small numbers of recaptures these results suggest that one quarter of all tagged dace move between the tidal and upstream areas of river (Table 6.1).

Table 6.1 Movements of recaptured dace (*Leuciscus leuciscus*), demonstrating those that remained in the general tagging area and those that moved between the upstream and tidal reaches. Three values are given; the total number of fish tagged, the total number of fish re-caught and recaptures as a percentage of all fish tagged in that area.

Tagging Location	Recapture Location	Total number tagged in the area	Total number recaptured	% of total tagged in that area
East Stoke	East Stoke	852	26	3.1
Wareham	Wareham	321	9	2.8
East Stoke	Wareham	852	9	1.1
Wareham	East Stoke	321	3	0.9

Radio telemetry of a smaller (n = 32) sample of dace gave differing results on the mobility of individuals between upstream and tidal sections. During this part of the study 54% of all individuals visited Wareham. In both spring and autumn the same proportion of the radio-tagged population (33%) used side-channels, despite the different number of fish sampled (Table 6.2). However, dace were twice as likely to visit Wareham in spring as in autumn (Table 6.2). Dace that visited Wareham travelled significantly further than those that did not (t-test, $P < 0.001$) (Figure 6.5b). There was no significant difference between distance moved by dace in spring and autumn (t-test, $P > 0.10$) (Figure 6.5a). Dace that used side-channels did not travel significantly further than those that did not (t-test, $P > 0.10$) (Figure 6.5c).

Table 6.2 Number and percentage of radio-tagged adult dace (*Leuciscus leuciscus*) using a side-channel or visiting the tidal reach in spring or autumn (all dace were tagged in the East Stoke area).

	Spring		Autumn	
	n	%	n	%
All fish	15	100	9	100
Use side-channel	5	33	3	33
Visited Wareham	10	67	3	33

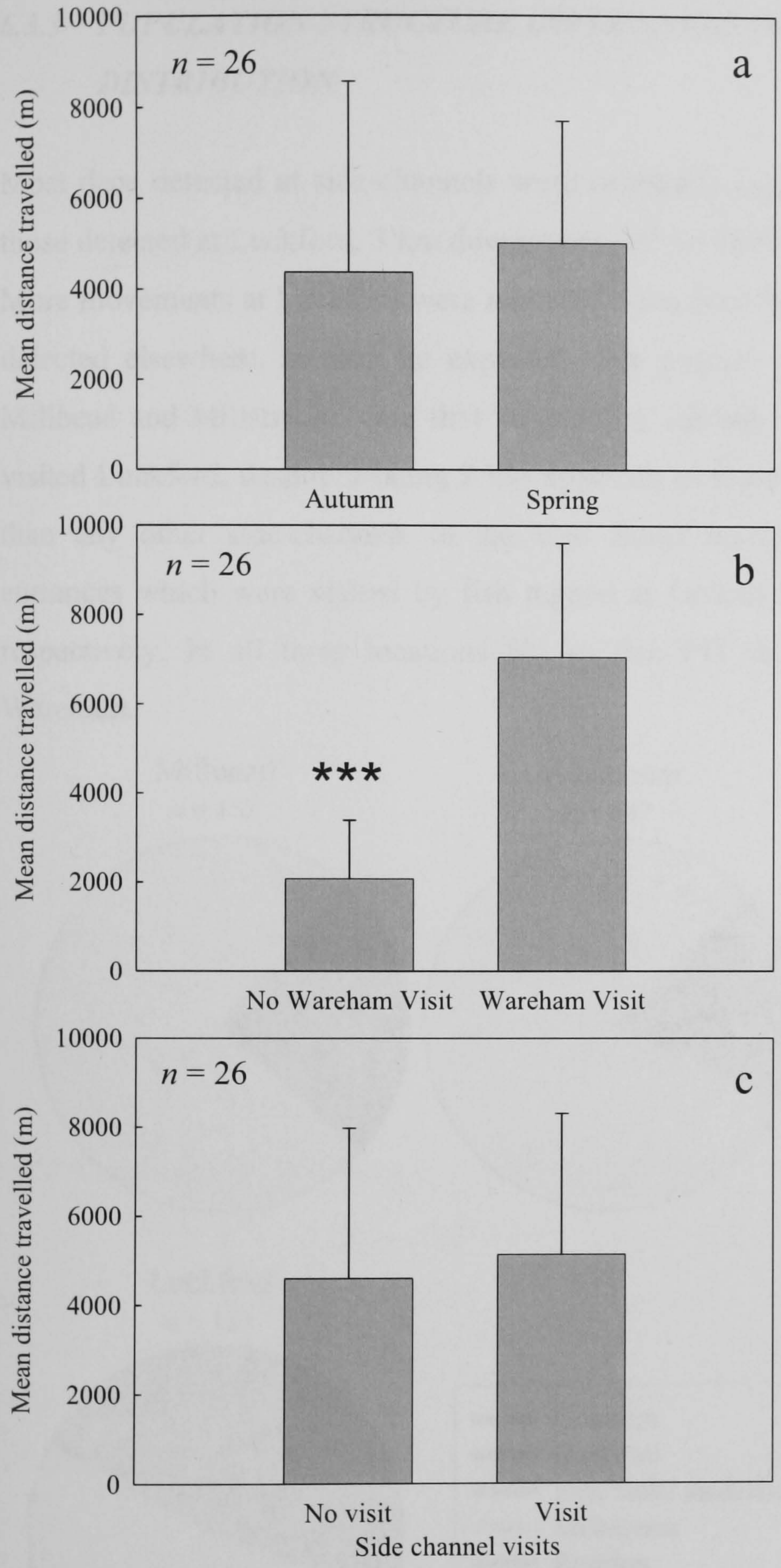


Figure 6.5 Mean distance moved (mean of maximum distance moved by each fish during tracking period) by radio tracked dace (*Leuciscus leuciscus*) (a) during different seasons, (b) by those that visited and did not visit the tidal reach and (c) by those that used side-channels and those that did not (2004-2005). Error bars represent standard deviation.

6.3.3 POPULATION STRUCTURE INFLUENCES ON SPATIAL DISTRIBUTION

Most dace detected at side-channels were originally tagged in Millstream, even for those detected at Luckford, 3 km downstream of the Millstream entrance (Figure 6.6). More movements at Luckford were recorded from dace tagged at Luckford than were detected elsewhere, as may be expected. Ten percent of fish PIT detected at the Millhead and Millstream were first tagged at Luckford. No fish tagged in Goldsacs visited Luckford, despite it being 2 km upstream of Goldsacs and nearer to Goldsacs than any other side-channels in the East Stoke reach. Millstream and Millhead entrances which were visited by fish tagged in Goldsacs are 5 and 8 km upstream respectively. In all three locations 5% of fish PIT detected had been tagged in Wareham.

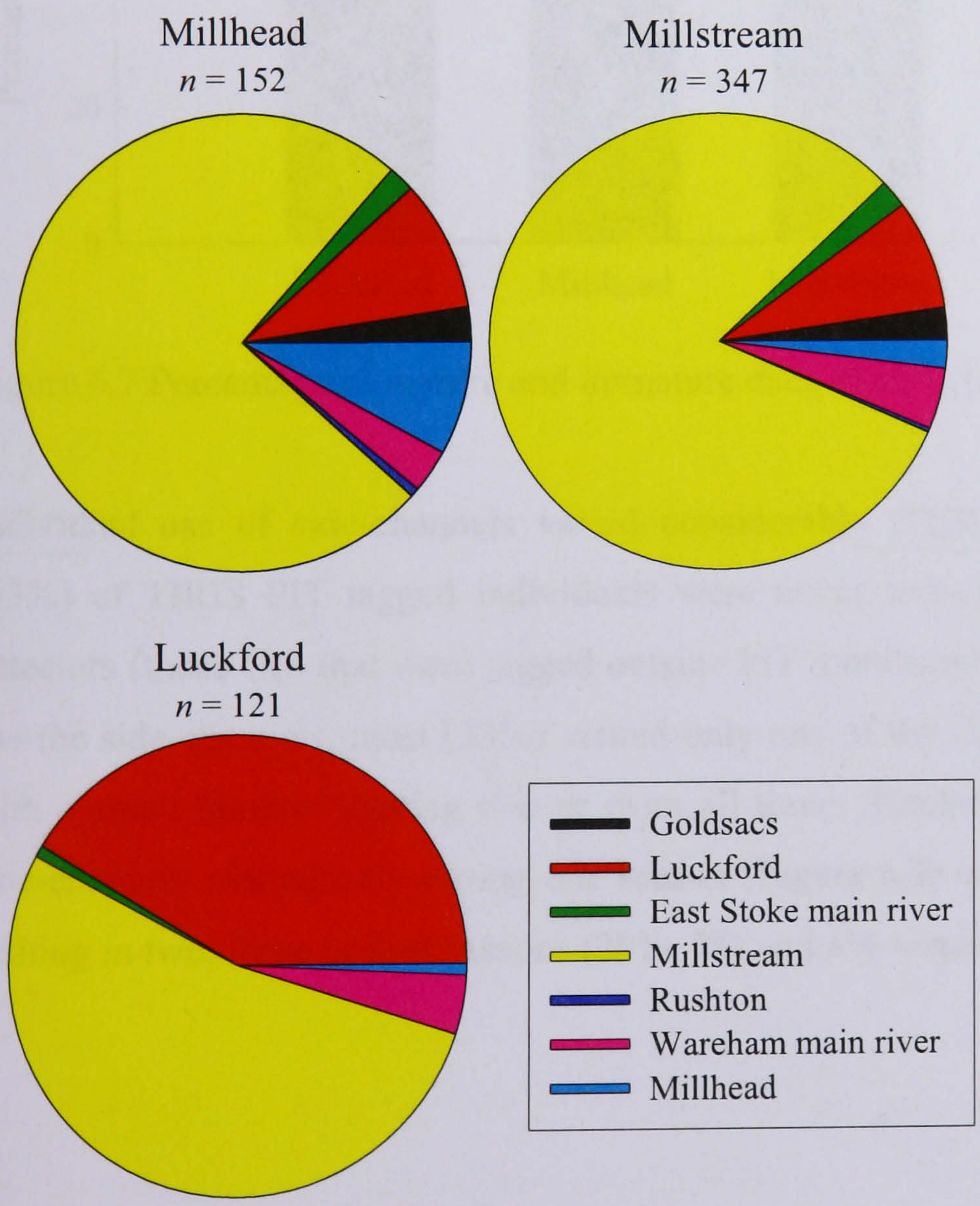


Figure 6.6 Proportions of fish detected at each side-channel PIT detector tagged in different locations. Total numbers of dace are given under each title.

Dace fork length in Luckford was found to be significantly smaller than both Millhead and Millstream when ANOVA was carried out on Log_{10} transformed fork lengths (*ANOVA,* Tukey test; $F = 5.11$, $P = 0.006$, $df = 2$). There was no difference between Millhead and Millstream. A higher proportion of immature dace visited Luckford than Millhead or Millstream (Figure 6.7).

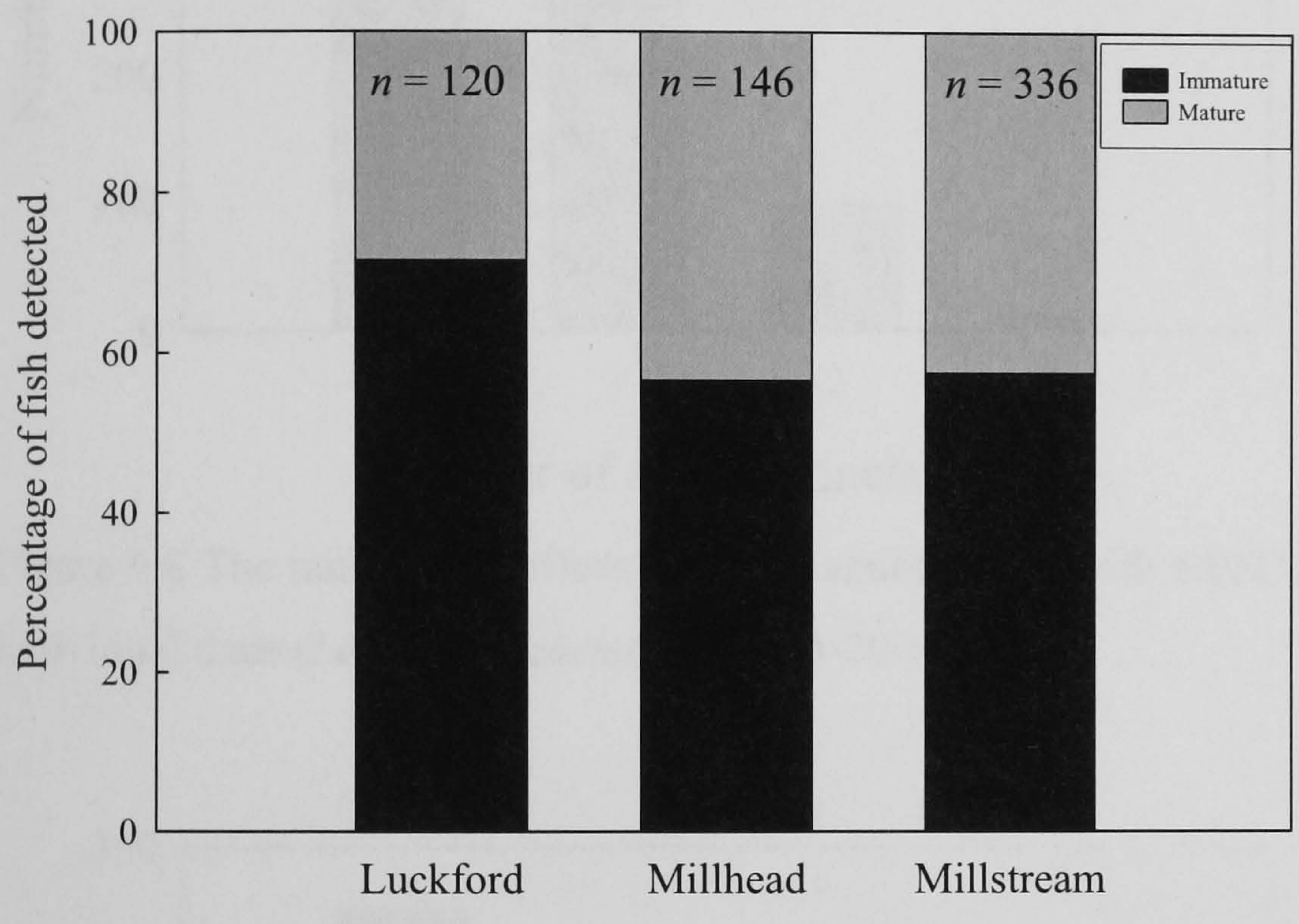


Figure 6.7 Percentage of mature and immature dace visiting each site (2004-2005).

Individual use of side-channels varied considerably (Figure 6.8). More than half (55%) of TIRIS PIT tagged individuals were never recorded on side-channel PIT detectors (those fish that were tagged outside PIT monitored areas). Of those that did use the side-channels, most (33%) visited only one of the three that were monitored, with a small number visiting two or even all three. Similarly 58% of all fish using side-channels visited only during one season (Figure 6.9) with a decreasing number visiting in two, three or four seasons (29%, 9% and 4% respectively).

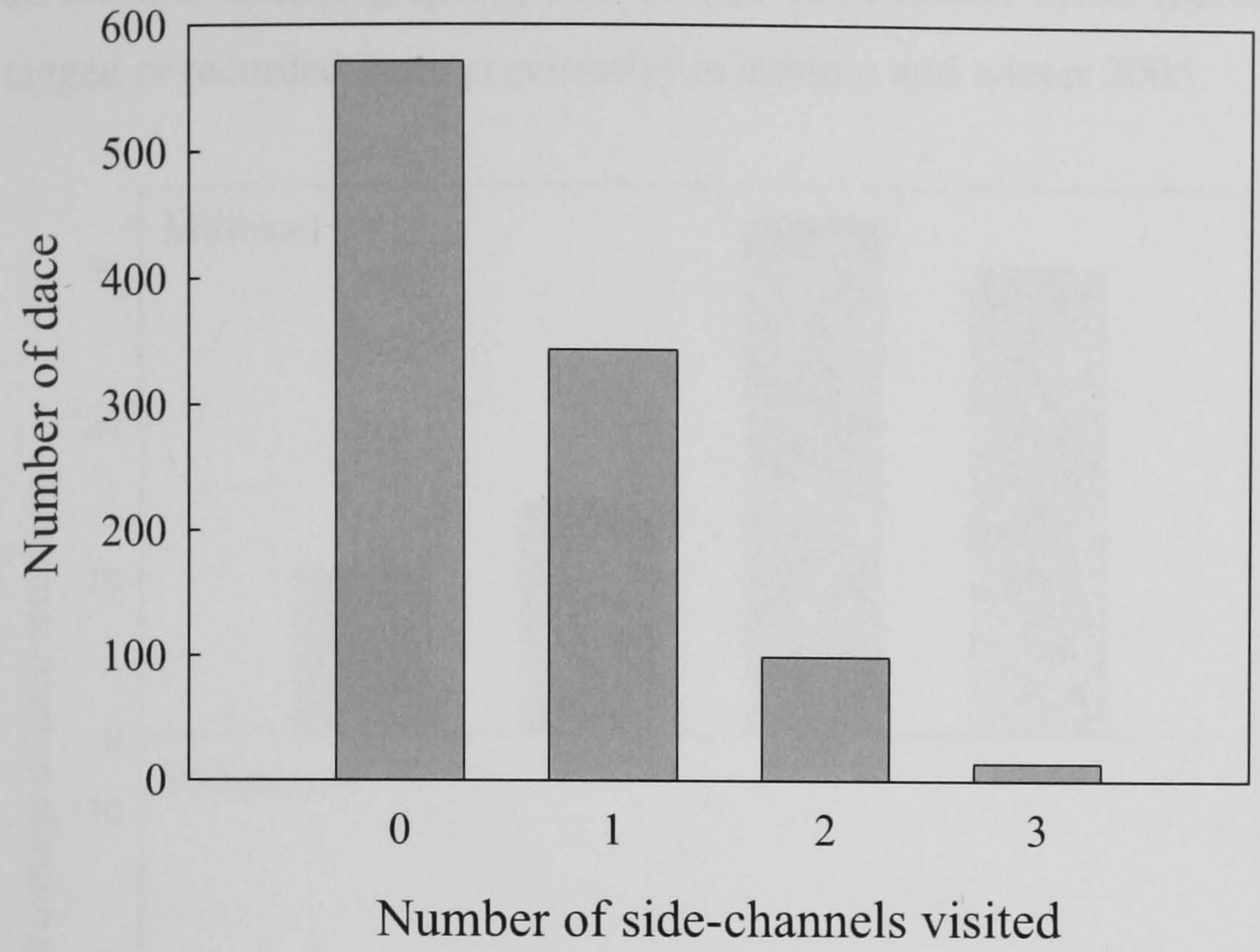


Figure 6.8 The number of different side-channels fitted with a PIT detector visited by individual dace (*Leuciscus leuciscus*) (2004-2005).

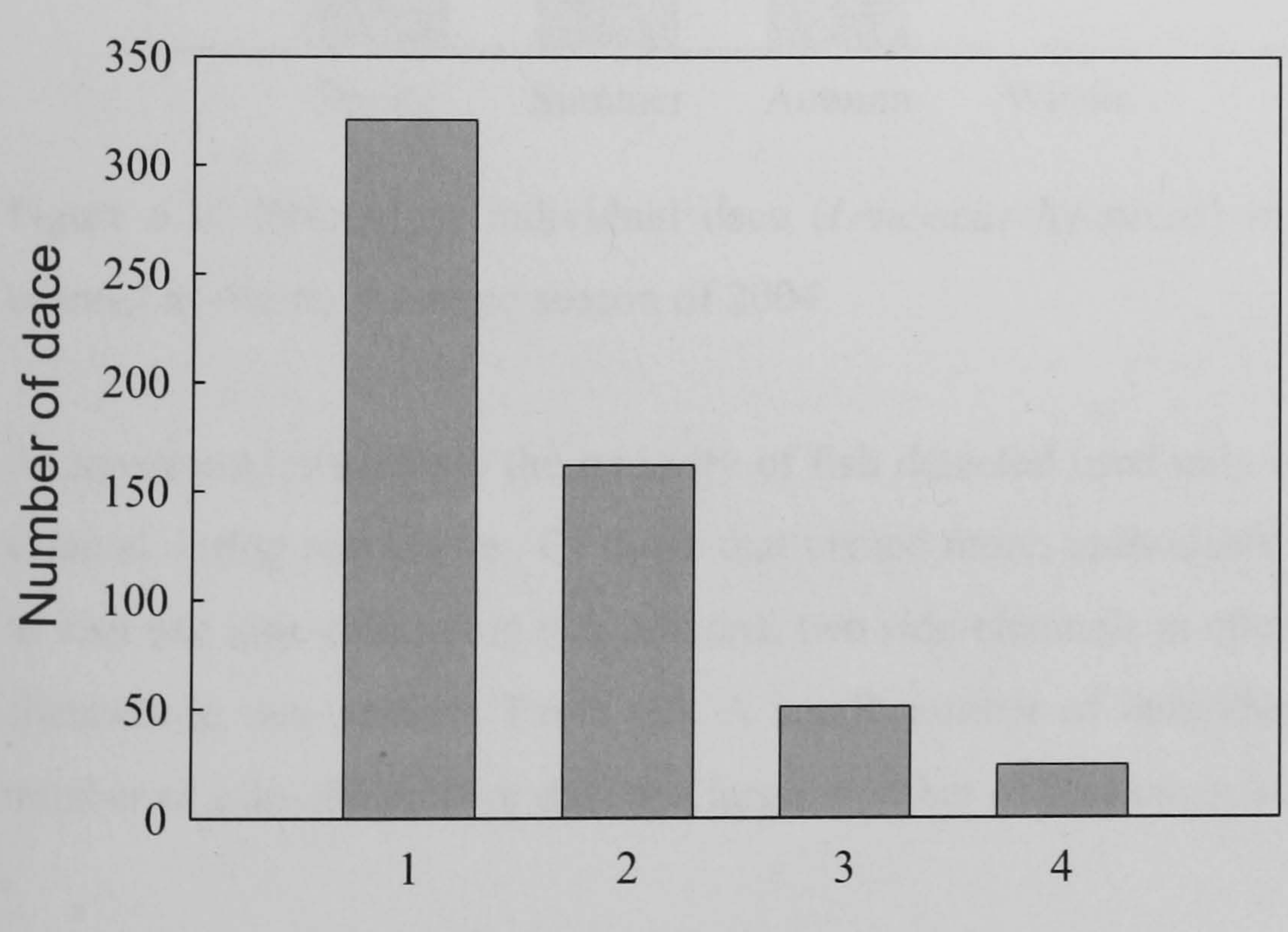


Figure 6.9 The number of different seasons individual dace (*Leuciscus leuciscus*) were recorded visiting side-channels by PIT telemetry (2004-2005).

A number of fish were found to leave a side-channel site, enter the main river and then to return to the same side-channel during the same season the following year

(Figure 6.10). Returns to Millstream, a known spawning location, were much lower in all seasons including spring than returns to Millhead which reached 30% (of all fish tagged or recorded there previously) in autumn and winter 2005.

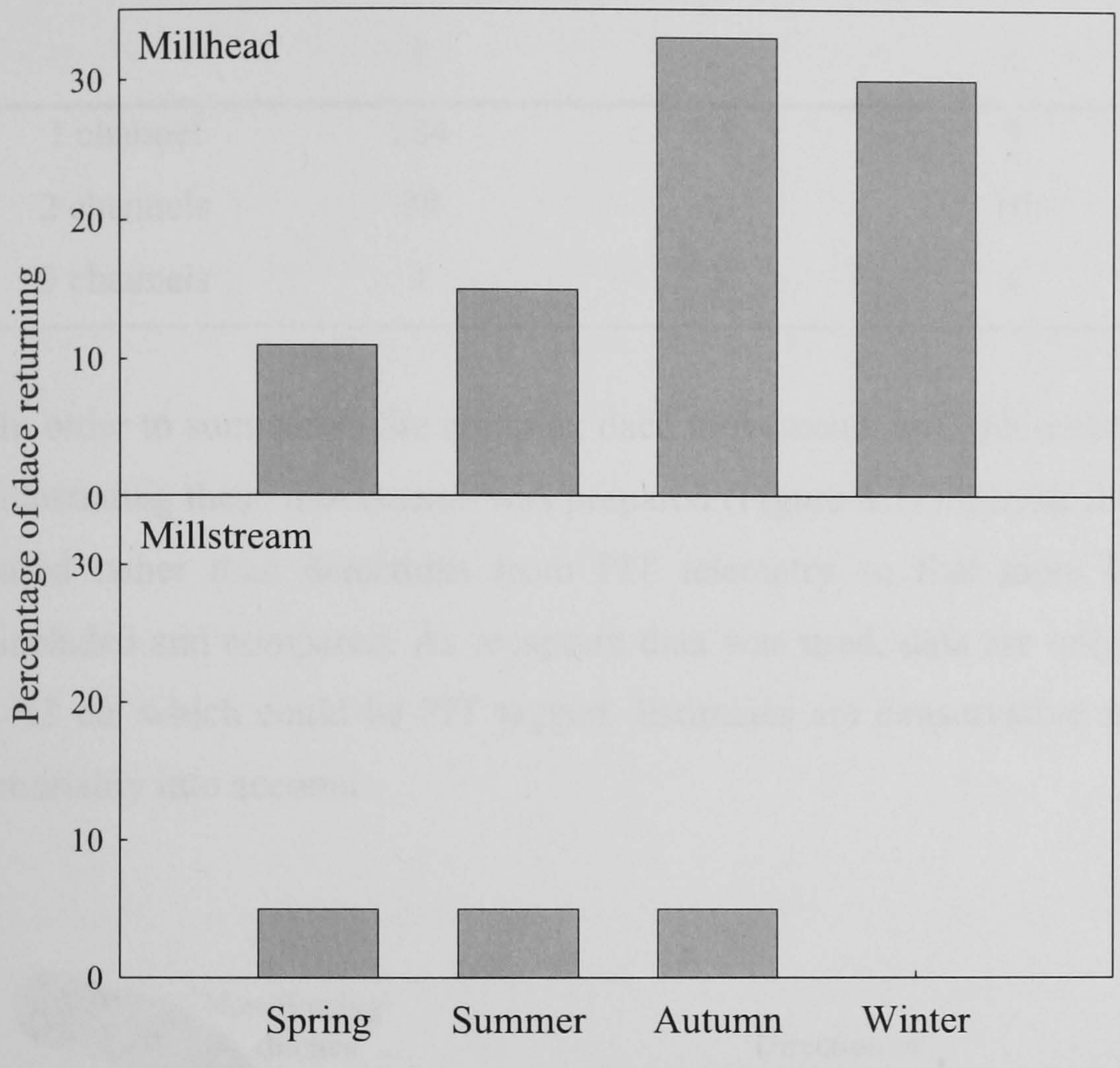


Figure 6.10 Returns of individual dace (*Leuciscus leuciscus*) in 2005 to the same channel as during the same season of 2004.

As mentioned previously the majority of fish detected used only one monitored side-channel during one season. Of those that visited more, individuals were equally likely to visit one side-channel in two seasons, two side-channels in one season or two side-channels in two seasons Table 6.3. A small number of individuals visited a higher number of side-channels or during a larger number of seasons or both.

Table 6.3 The number of PIT-monitored side-channels used by individual dace (*Leuciscus leuciscus*) and the number of seasons in which they visit these habitats (2004-2005).

	No. seasons			
	1	2	3	4
1 channel	284	35	3	1
2 channels	38	43	10	3
3 channels	1	3	4	2

In order to summarise the complex dace movements and side-channel use, a diagram illustrating these movements was prepared (Figure 6.11). Physical recapture data was used rather than detections from PIT telemetry so that more locations could be included and compared. As recapture data was used, data are only presented for fish >12 cm which could be PIT tagged. Estimates are conservative as they do not take mortality into account.

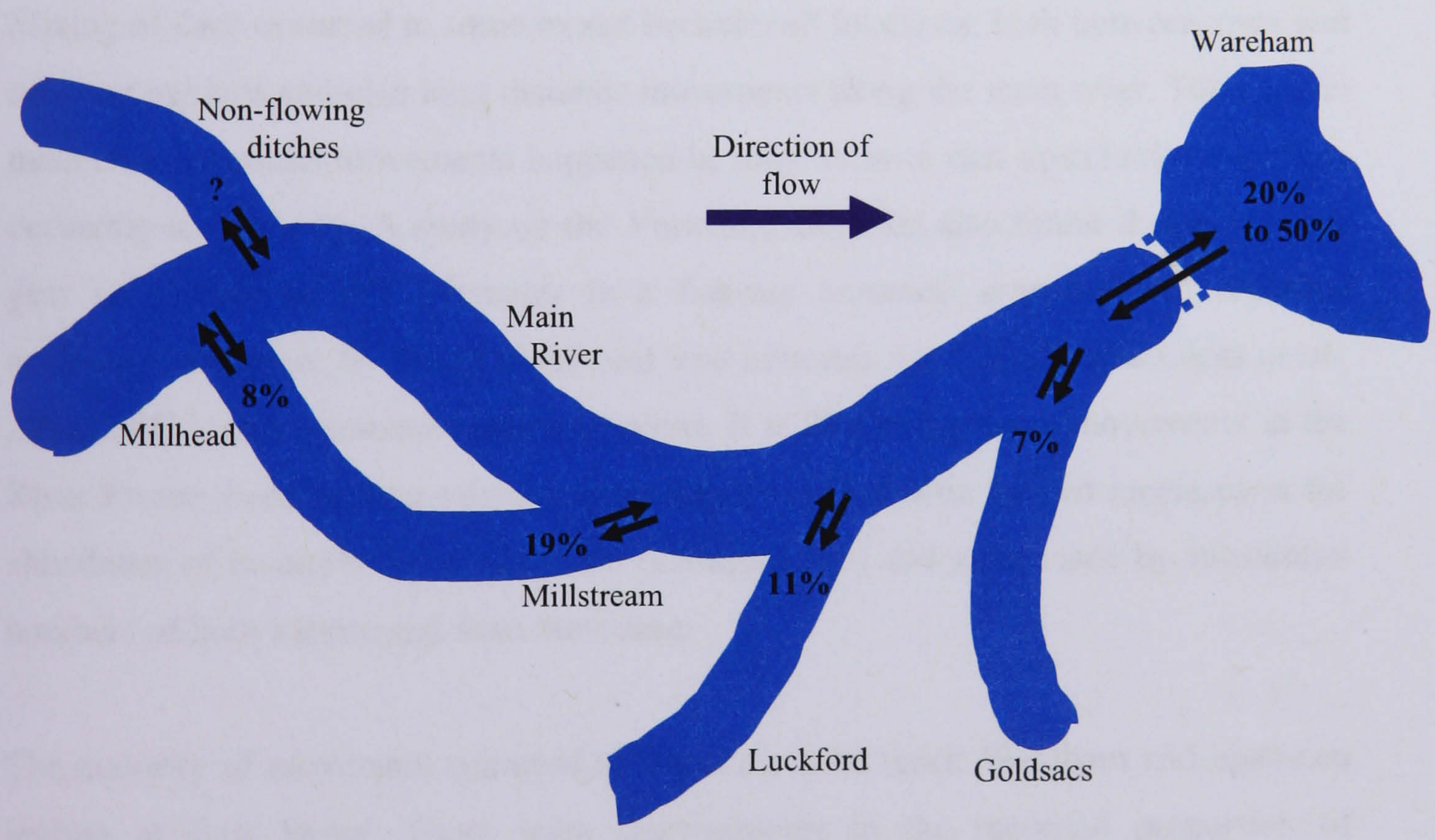


Figure 6.11 Schematic diagram of dace movements between locations. Data are presented for physical recapture of fish to allow inclusion of sites without monitoring by PIT detector. No percentages were available for non-flowing ditches because these fish using these were too small to mark for recapture analysis.

6.4 Discussion

Dace used the entire mosaic of habitats available to them within the river system. Over the year, fish moved between habitats, depending on their requirements and activities. More immature than mature dace were found in the side-channels though the proportion varied seasonally and between side-channels. Lateral side-channels often contain large numbers of juvenile fish (Copp 1997, Garner 1996, Lusk et al. 2001) sheltering from the larger and more abundant predators of the main river channel (Borcherding et al. 2002). Though non-flowing ditches supported low numbers of dace in this study, those that were present were mostly small, 0+ dace. This suggests their significance only as secondary nursery habitats, supporting few fish. Large, primary nursery areas were found in the main river in an oxbow lake out of the main flow (CEH, unpublished data).

Mixing of dace occurred to some extent between all locations, both between river and off-river habitats and also long distance movements along the main river. The peak in main river upstream movements happened in May, despite first upstream movements occurring in February. A study on the Yorkshire Derwent also found that over a full year of continuous PIT telemetry in a fishway entrance, over 80% of recorded upstream movement by dace (12-19 cm) was between April and July (Lucas *et al.*, 2000; M.C.Lucas, personal communication). It is likely that these movements in the River Frome were feeding migrations as they coincided with known increases in the abundance of invertebrates at that time (Clough 1998) and were made by substantial numbers of both mature and immature dace.

The majority of movement occurred between the tidal reach Wareham and upstream section at East Stoke. There were discrepancies in the recorded proportion of individuals between the different monitoring methods used, something that has been acknowledged as an issue with this type of study (Szacki 1999). Estimates of mixing ranged from between 5% to 50% of the population. This is in line with a previous study using passive marking techniques (visible implant alpha-numeric tags, visible implant elastomer and fin clipping) which found that 28% of individuals moved between the two areas (Clough 1998). Substantial variation in estimates of large scale movements was evident. Differences between East Stoke main river (24%) and side-channel (5%) PIT detection may reflect different proportions of fish from Wareham travelling further up the main river or into one of the 5 monitored side-channels. Physical recapture proportions were intermediate to the two PIT detection estimates (11.5%). Radio tracking estimates of the proportion of dace visiting Wareham were by far the highest (67% in spring, but only 33% in autumn). These fish could be constantly monitored so more movements, and thus more long scale travel, were recorded as opposed to the more passive forms of monitoring. However, during the study few radio-tagged dace returned upstream following a downstream migration to Wareham. It is possible that fish moving downstream were unwell and unable to maintain position further upstream. However, many fish made localised upstream movements in Wareham and some were observed shoaling with other dace. Those that did not move following downstream travel to Wareham (implying death) were not included in analysis. Despite the high level of variability between estimates of population mixing, it is most likely that estimates made from radio-tracking were most accurate as this technique enabled a higher proportion of all movements, and particularly long-distance movements to be recorded (Szacki 1999).

While this study has addressed movement between habitat patches, it was over a short time period when considering population scale issues. However, it has gone some way towards establishing the complex spatial and temporal structure of a lowland river dace population. The study provides evidence of a quite structured population with some age structuring. There is also indication of the use of alternative strategies by adults with some mobile individuals travelling between habitats and other less mobile components of the population remaining in one area. A portion of the population utilised the side-channels, whilst others moved to the tidal reach and another group remained solely in the main river channel. Both linear and lateral connectivity were found to be contributory components to the life history diversity of the dace population.

This study concurs with other literature in that small changes in the distribution or accessibility of good and poor habitat may precipitate relatively large changes in species' viability (Doak 1995, Pulliam et al. 1992). If, as suggested, this is the case for dace then destruction of lateral habitats or blockage of movement throughout the system with obstacles such as dams or weirs could have substantial impacts on population characteristics and persistence.

Chapter 7

Home Range Estimation within Complex Restricted Environments: Importance of Method Selection in Detecting Seasonal Change

7.1 Preface

The work presented in this chapter has previously been submitted as a multi-authored paper to Ecological Applications. Those involved in the earlier work have been acknowledged in the acknowledgements section of this thesis. While in the original submitted thesis it was included as an appendix it was felt that it added much to the thesis, particularly as an introduction to the analysis techniques used in Chapter 8. For this reason it has been included in the body of the thesis as an additional chapter. Some of the pike telemetry data used in the manuscript was collected prior to the onset of this project.

7.2 Introduction

For many animal populations, systematic radio-tracking can provide data on spatial behavior and demography more rapidly and with less bias than more traditional methods such as visual observations or mark recapture (White and Garrott 1990). The advantages of such tracking are at their greatest for elusive species, including fish.

Quantitative analysis of home range size, shape and core structure has become fundamental to understanding the movements and behavior of animals (White and Garrott 1990, Fisher 2000, Crook et al. 2001, Broomhall et al. 2003, Fuller et al. 2005). The use of telemetry data to estimate home ranges is now common-place for studies of resource use (Aebischer et al. 1993, Terry et al. 2000, Johnson et al. 2004, Markus and Hall 2004), social interactions (Sliwa 2004, Sunde and Bolstad 2004), activity (Taylor and Skinner 2003), predation (Madsen and Shine 1996, Kraus and Rodel 2004, Yoder et al. 2004). Home ranges can be considered as the spatial expressions of the behaviors carried out by animals to survive and reproduce (Burt, 1943) that may change between seasons or year on year. Thus as spatial and temporal representations of an animal's requirements they are well suited to use investigating applied issues of animal ecology. Home range assessment has helped to answer a wide range of applied ecological questions relating to spatial behavior including reserve design (Wielgus 2002), conservation planning (Locke 1996, Johnson et al. 2004), habitat management analyses (Peach et al. 2004), assessing habitat suitability for reintroductions (Schad et al. 2002), controlling spread of disease (Woodroffe et al. 2006) and interactions of native with non-native species (Kenward and Hodder 1998).

There is a wide choice of possible methods for estimating home range. One group consists of ellipses or contours based on density distributions (Dalke and Sime 1938, Jennrich and Turner 1969, Worton 1989), which are derived from all the locations and hence tend to be influenced by outliers that represent the excursions of an individual. The second group creates polygons (Dalke and Sime 1938, Jennrich and Turner 1969, Worton 1989) that minimize linkage distances between pairs of locations. Polygon methods include an excursive-sensitive minimum convex polygon around the peripheral locations, but can also exclude the influence of outliers by peeling or with cluster analysis to define range cores. The various density and linkage methods differ in their ability to (i) estimate home range outlines that conform to the observed locations; (ii) derive statistics describing the range structure; and (iii) achieve stable estimates with few locations (Harris et al. 1990, Kenward 1992, Robertson et al. 1998).

Methods of estimating home range use were primarily designed for species that move freely throughout the landscape (Dalke and Sime 1938, Calhoun & Casby 1958, Dixon and Chapman 1980). However, many species are tightly associated with restricted and fragmented habitats such as woodland (Redpath 1995, Major and Gowing 2001) or confine their movements to largely linear pathways. Mammals, such as weasels (*Mustela nivalis*), inhabiting field edges in agricultural areas tend to remain confined to these linear corridors rather than venturing far into cultivated fields (MacDonald et al. 2004). Species such as river otter (*Lutra canadensis*) (Blundell et al. 2001), watervole (*Arvicola terrestris*) (Barreto and MacDonald 2000, Fedriani et al. 2002) and bald eagle (*Haliaeetus leucocephalus*) (Harmata and Montopoli 2001) often associate themselves with rivers and shorelines and many freshwater fish are limited to rivers. The use of standard home range methods in these cases may estimate outlines that include large areas of unusable habitat. This is particularly true where narrow corridors of usable habitat are highly convoluted, as occurs for braided river channels and meanders. The result is bias in size and home range structure statistics that indicate foraging movements.

Recently some investigators have attempted to develop new techniques to address this issue using simulated datasets (Burgman and Fox 2003, Matthiopoulos 2003, Getz and Wilmers 2004), however these techniques have not become widely available or used in ecological management. Few applied studies of species with linear patterns of movement maximize the information gained from the data by employing the most appropriate methods to quantify home ranges. Currently, while most work using linear home range estimation has focused on fish in rivers (Bridcut and Giller 1993, Baras 1997, Masters et al. 2002, Bahr and Shrimpton 2004), novel analysis has been applied mainly to river otters (Blundell et al. 2001, Sauer et al. 1999). Despite an increasing number of telemetry studies on river fish species and related management issues, such as interactions between natives and non-natives, most either make no estimates of home range or calculate very basic measures, likely missing much of the ecological or behavioral information (Vokoun 2003). With potentially rapid alteration in habitats and movements of animals through climate change, coupled with strict targets for management through legislation such as the Water Framework Directive (European Commisssion 2000), the need to make best use of hard-won data from radio tracking is now greater than ever.

In this study, we test the effectiveness in a restricted environment of commonly used and widely available home range analysis techniques, including the clipping of range outlines to include only the water usable by an aquatic species. Pike (*Esox lucius* Linnaeus), like many fish species, are known to alter their behavior seasonally (Cook and Bergersen 1988).We postulate that size and internal structure of home ranges of river-dwelling pike, would differ between seasons to reflect differences in behavior, and that these differences would be shown more effectively by some analysis methods than by others.

7.3 Materials & Methods

7.3.1 STUDY AREA

The study was conducted on the lower River Frome, Dorset, UK. The river is largely unmodified, with a meandering main channel in its lower reaches, but also has a man-made millstream within the study site. Most fish locations were collected within a 2 km stretch of river (UK national grid references SY867863 to SY882870), although fish were also tracked outside this stretch.

7.3.2 RADIO TAGGING AND TRACKING

Data from 23 adult pike were used to test the range estimators. Radio tags (TW-5 tags, Biotrack Ltd., Wareham BH20 5AX, UK) were implanted into the body cavity of the pike (58 – 101 cm FL) as described in Beaumont et al. (2002). Fish locations were determined to within 1 m by triangulation from within 10 m on the river bank, using a Sika radio-receiver (Biotrack Ltd.) and a hand-held three-element Yagi antenna.

Data were collected between May 2000 and September 2003, during March, June, September and December to provide home range estimates for each season. Fish were located at dawn, midday and dusk every day over a 13 day period, resulting in standard home range data sets of 39 locations per fish in each season. The timing of dawn, midday and dusk locations was selected as a result of a pilot study that demonstrated the diel activity of pike to be at dawn and dusk (Masters et al. 2002; Hodder et al. in press). In addition, fish were routinely located two or three times per week during the entire study period in order to prevent loss of mobile individuals.

One range was used from each fish per season. If data were collected from an individual in more than one year, the average range area for that season was used. In order to enable direct seasonal comparison of river channel habitat use ranges estimated during flooding were not included as these may have included floodplain habitat not available to fish in all seasons. In total, 16 records were available for spring, 12 for summer, 14 for autumn and 12 for winter (Table 7.1).

Table 7.1 Summary of home range tracks for each individual fish used for estimation of home range area.

	Fish ID Code																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Spring		I		I	I			I	I	I	I	I	I	I	I	I	I			I	I		I
Summer	I		I	I	I	I			I		I	I			I	I	I					I	
Autumn				I	I		I	I	I		I	I	I		I	I	I	I	I	I			
Winter					I			I	I		I	I	I		I	I	I	I		I	I		

7.3.3 *HOME RANGE AND MOVEMENT ANALYSES*

Four methods of area-based range analysis were used. All were methods readily available in commercial software (as reviewed by Larson (2001)) that are widely applied (Kernohan et al. 2001, Walls and Kenward 2001, Fuller et al. 2005) to give trade-offs between precision in conforming to peripheral and core locations (Table 7.2) and sample-size requirements (Robertson et al. 1998). All were estimated with RANGES 6F (Anatrack Ltd., Wareham. BH20 5AX, UK), with abbreviations and classification following Kenward *et al* (2001).

Table 7.2 Summary of home range estimation techniques and their advantages and disadvantages for use in restricted environments.

Home range Technique	Sample size considerations	Periphery/core representation	% locations included	Short name	Original reference
Density methods					
Ellipses	Size can be stable with as few as 12-15 locations (well separated in time).	Outline conforms poorly to locations and is sensitive to outlying locations.	95%	E95	(Worton 1989)
Kernels	Size can be stable with as few as 15-20 locations.	Contours conform to multinuclear data but not to abrupt change in location density and are affected by outlying locations.	95% 50%	K95 K50	(Dalke and Sime 1938)
Link distance methods					
Minimum convex polygon	Sample-size-dependent but often stable with 30+ locations.	Single polygon conforms only to peripheral locations.	100%	X100	(Kenward 1987)
Clusters (core influenced)	Requires 30+ locations for stability.	Polygons fit core location patches and provide internal structure statistics.	85%	CX85	(Kenward et al. 2001)

7.3.4 DENSITY METHODS

Jennrich-Turner ellipses, estimated to include 95% of the density distribution (E_{95}), are least precise in conforming to locations, but can give stable estimates of total range area with 12-15 locations that have low spatio-temporal correlation (Kenward, 2001). Kernel contours containing 95% of the estimated density distribution (K_{95}) were estimated using least squares cross-validation with a fixed smoothing multiplier of 1 and a 40×40 matrix as a total area measure with more flexible conformation. A widely-used estimator of core size (Fuller et al. 2005) is the kernel contour K_{50}, containing 50% of density distribution (Table 7.2).

7.3.5 LINK DISTANCE METHODS

As an estimate of total range size, a single convex polygon around 100% of the locations (X_{100}) provides greatest comparability with other publications (Harris et al. 1990), but its conformation to the range periphery requires large sample sizes to minimize sample-size-dependence. Similarly, core polygons derived by cluster analysis require large samples of locations for stability (Robertson et al. 1998). Cluster polygons were estimated around 85% of the locations in each range (Cx_{85}) as this excluded peripheral locations for 95% of the ranges (Kenward et al. 2001). In addition to area and number of cores, cluster analysis provides an index of range patchiness: the sum of areas of the separate cores as a fraction of the area of a single convex polygon around all the clusters decreases from 1, if locations are all in one nucleus, to a small fraction if nuclei are far apart (Harris et al. 1990).

7.3.6 AREAS AND DISTANCES IN RESTRICTED ENVIRONMENTS

A problem with analyzing movements in restricted environments is that measurement of distances by straight lines may underestimate travel distances for example, in rivers, by cutting across curves, islands and junctions with tributaries. RANGES 6F avoids this problem by estimating inter-location distances along a river midline for travel estimates and the nearest-neighbor distances used in cluster analysis. Similar functions may be performed in widely used software such as ArcView. A more pervasive problem with analyses in rivers is that home range outlines often extend beyond the river banks (Figure 7.1), so that inaccuracy (over-estimation of area) may mask biologically meaningful relationships. Cluster analysis minimizes this error (Hodder et al. in press) but cannot entirely eliminate it. Outlines for all six range area estimators were therefore clipped to a map of the river banks that was imported to RANGES 6F from ArcView GIS 3.2 (ESRI Inc, Redlands, California). An excursion-excluded range span was calculated as the summed midline lengths of 85% cluster cores. The clipped X_{100} measures maximum river area covered by excursions and is equivalent to maximum linear distance at constant river width.

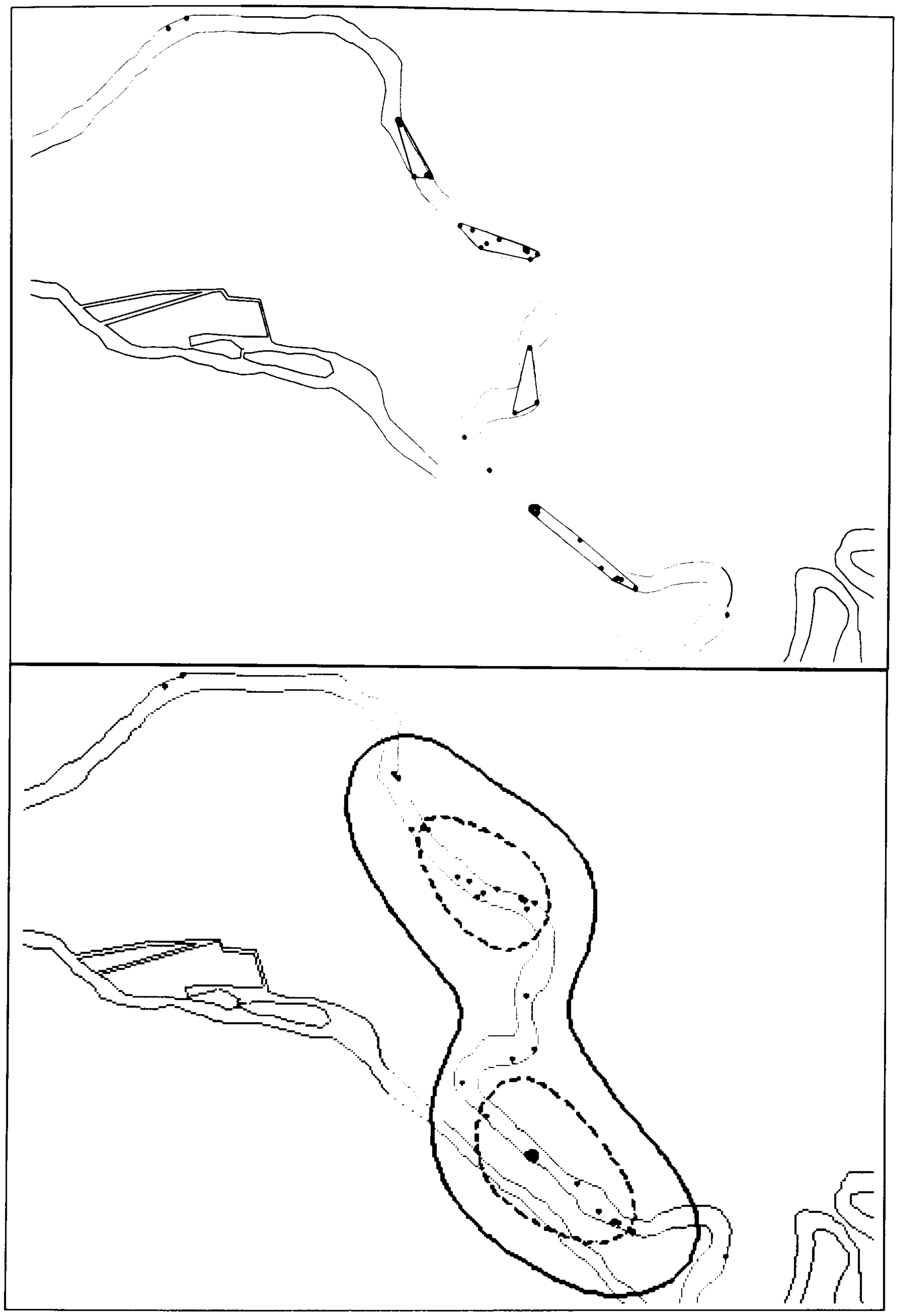


Figure 7.1 Example of out-of-river error from locations of the same fish fitted with (a) 85% clusters and (b) 95% kernels (solid line) and 50% kernels (dotted line).

7.3.7 COMPARING ESTIMATORS

Two approaches were used to compare the performance of different spatial estimators. 'Discrimination testing' compared the ability of different estimators (of area, span, patchiness and distance between consecutive locations) to detect variation between seasons. When testing for seasonal variation with six estimators of range area in the same data set, there was an enhanced probability of Type I error. Therefore a

Bonferroni correction was applied. 'Error testing' compared, for each method, the extent of unusable environment (out-of-river) error, its coefficient of variance and its correlation with range span (as an independent estimate of range size). The index of out-of-river error was total range area divided by clipped area.

Seasonal variation in range areas, patchiness and distances between consecutive locations was investigated with a global test across all seasons, followed by pair-wise comparison of seasons. A Friedman test of overall seasonal variation in range size was used for seven fish that contributed a range in all four seasons, followed by Mann-Whitney U-tests of range size differences between pairs of seasons for all fish. Wilcoxon tests of estimators for each season paired across the same fish gave similar results, albeit at lower significance levels due to reduced sample sizes.

7.4 Results

Friedman tests demonstrated overall differences in area between seasons only when calculated with Cx_{85} and Cx_{85} clipped ($P < 0.01$). However, range area was found also to differ significantly between pairs of seasons for K_{95} and K_{50} using Mann-Whitney U-tests (Figure 7.2). All methods estimated the smallest ranges in autumn. For the kernel estimators, summer range areas were significantly larger ($P < 0.001$) than autumn range areas for both kernel and cluster estimators. These seasonal patterns remained the same after clipping. There were no significant seasonal differences in range span (Figure 7.2g).

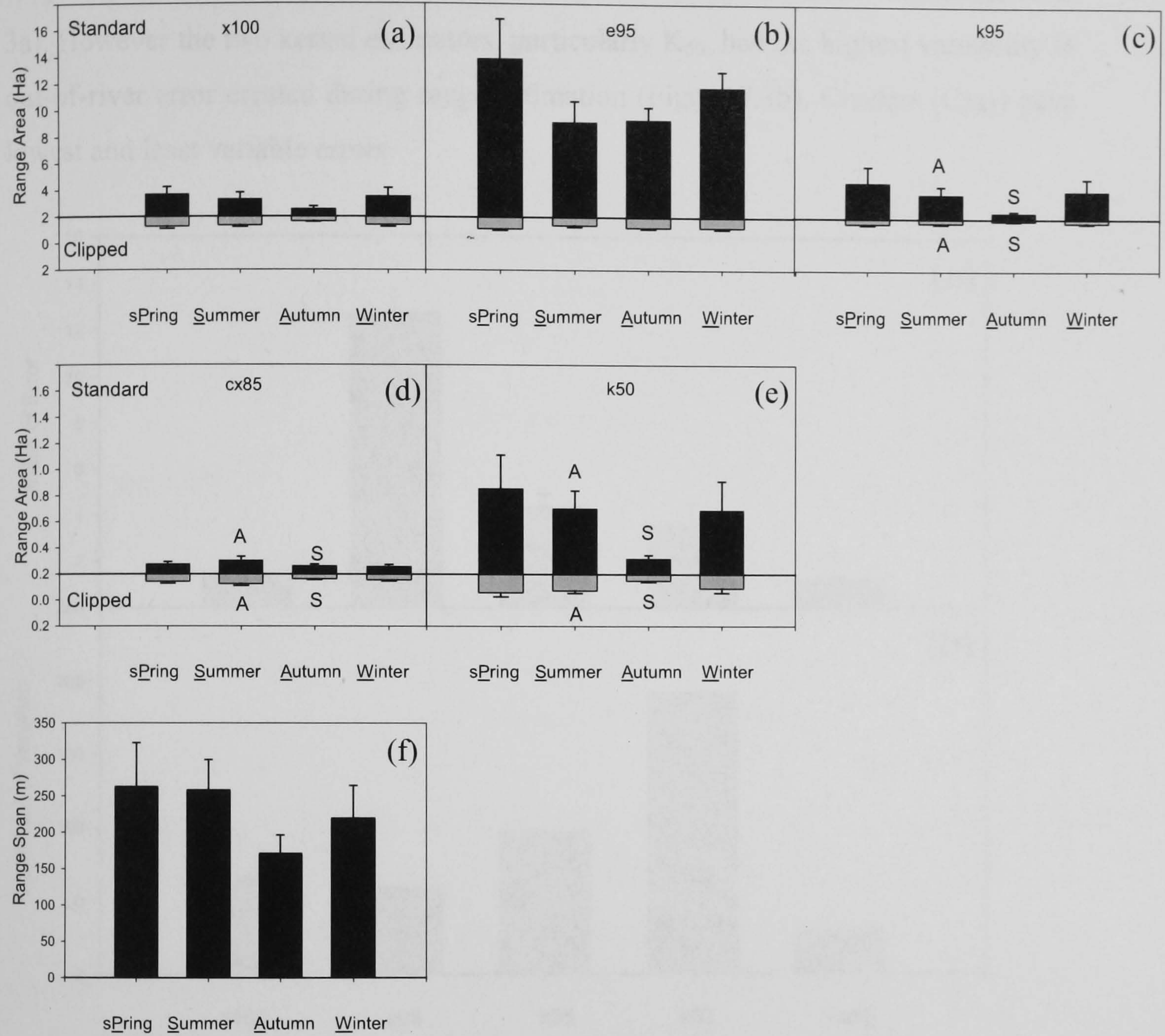


Figure 7.2 Mean home range area (with standard deviation bars) estimated with non-clipped methods (black) and clipping (grey) for three excursion-sensitive range estimation techniques; (a) 100% polygons, (b) 95% ellipses and (c) 95% kernels, followed by two coring methods; (d) 85% clusters and (e) 50% kernels with (f) excursion-excluded range span. Letters, indicate Bonferroni corrected significant differences between the seasons labeled; Spring – P, Summer – S, Autumn – A and Winter – W. Note different scales for the top, middle and bottom plots.

Excursion sensitive range estimators X_{100}, E_{95} and K_{95} gave larger range areas than core estimators Cx_{85} and K_{95}, by a factor of ten (Figure 7.2). However, clipping increased comparability between range cores and excursion-sensitive methods.

Ellipses produced the highest proportion of out-of-river error within each range (Fig. 3a). However the two kernel estimators, particularly K_{50}, had the highest variability in out-of-river error created during range estimation (Figure 7.3b). Clusters (Cx_{85}) gave lowest and least variable errors.

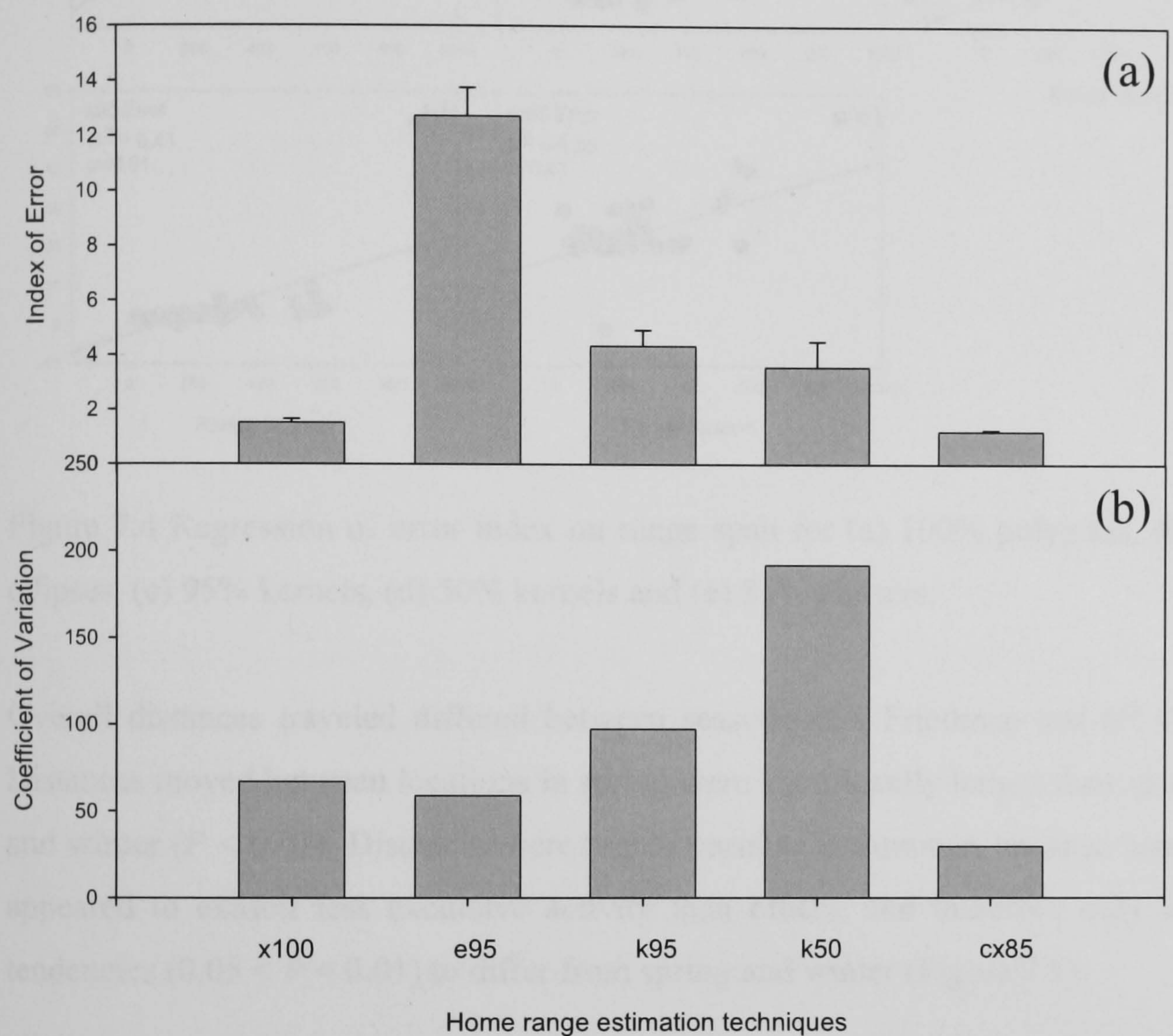


Figure 7.3 (a) Index of out-of-river error, as the proportion of the clipped range area in the total unclipped range area, and (b) its coefficient of variation.

Range span provides an index for investigating the extent to which out-of-river error depends on range size, because the greater the span along a curvaceous river, the more meanders the outline is likely to encompass. The influence of range size on the amount of out-of-river error included into estimation of range size varied greatly between different estimators from 8% to 73% (Figure 7.4). Error of core range estimators was less correlated with range span (maximum R^2 = 44%) than for excursion sensitive kernels and polygons (maximum R^2 = 73%) but not ellipses (R^2 = 8%).

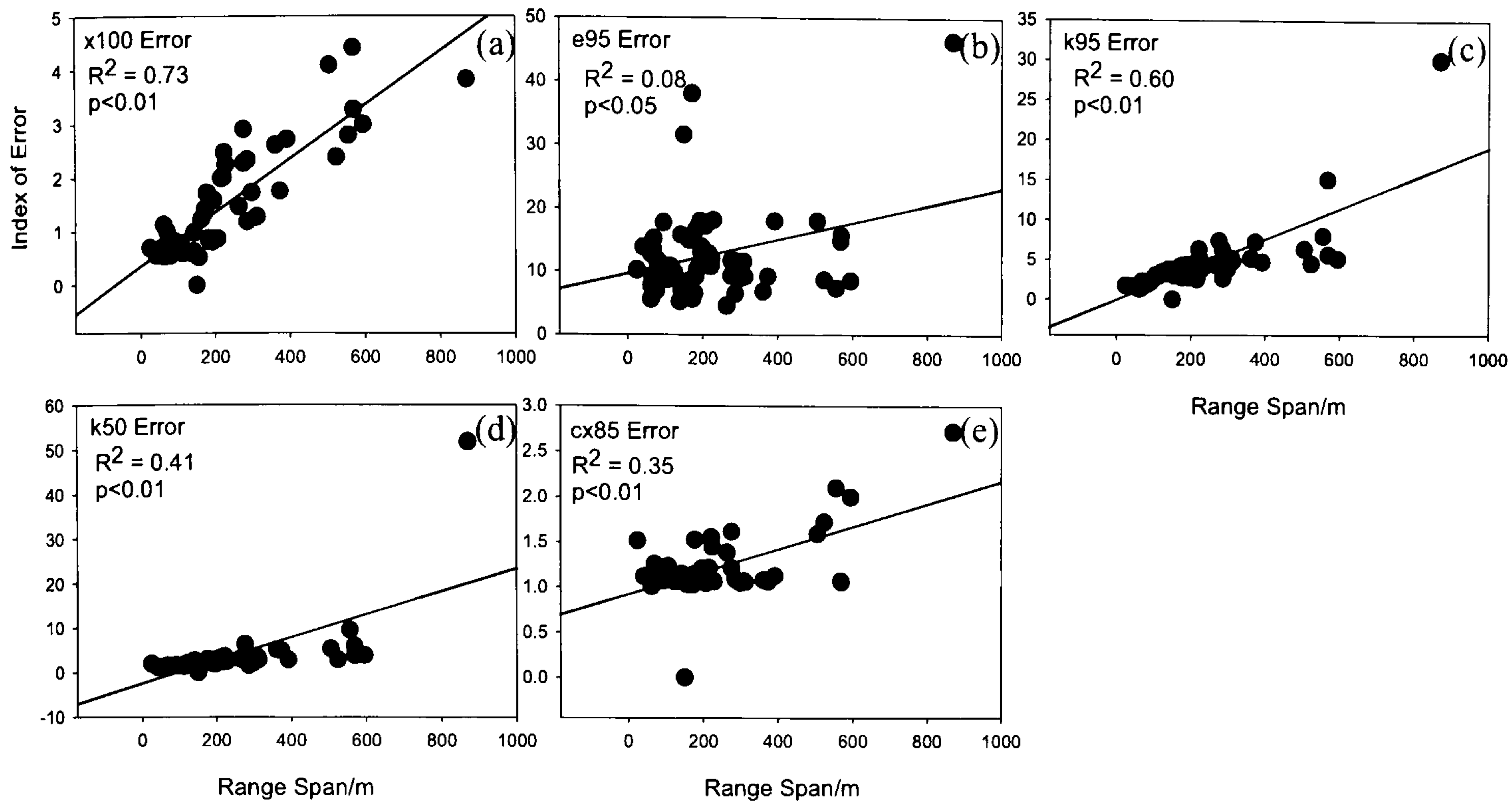


Figure 7.4 Regression of error index on range span for (a) 100% polygons, (b) 95% ellipses, (c) 95% kernels, (d) 50% kernels and (e) 85% clusters.

Overall distances traveled differed between seasons in a Friedman test (P < 0.05). Distances moved between locations in spring were significantly longer than in autumn and winter (P < 0.01). Distances were highly variable in summer, because some pike appeared to exhibit less excursive activity than others, and therefore only showed tendencies (0.05 < P < 0.01) to differ from spring and winter (Figure 7.5).

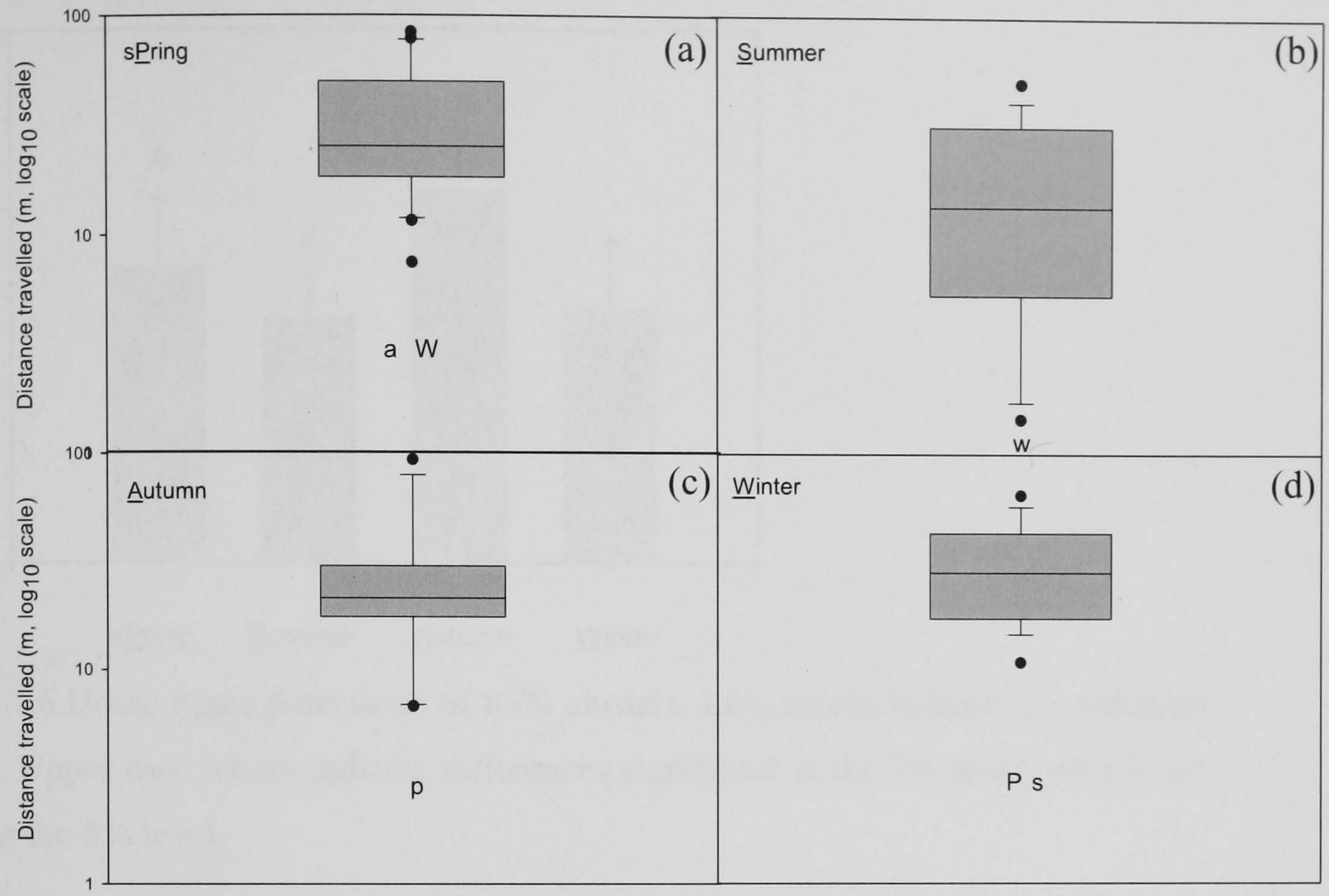


Figure 7.5 Boxes show median, 25th and 75th percentiles, with whiskers at 10th and 90th percentiles (and outliers as dots) for mean midline distances between consecutive locations ($\log_{10}$ transformed). . Upper case letters indicate differences significant at the 1% level, with lower case letters for the 5% level.

Variation in home range patchiness indicated differences in core range structure between seasons (Figure 7.6). Home ranges were significantly less patchy in autumn than summer ($P < 0.01$), when fish activity was less tightly focused in the core areas.

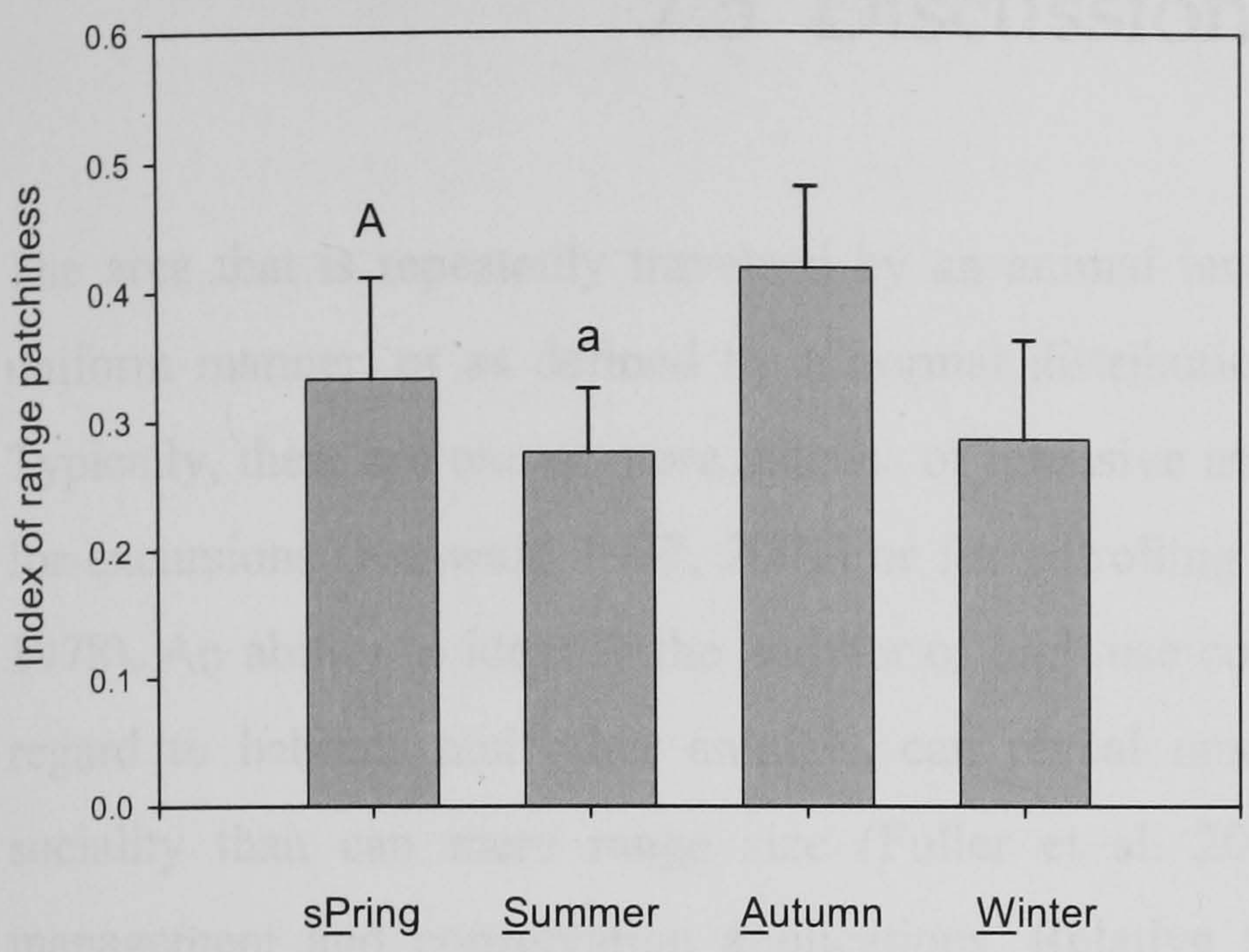


Figure 7.6 Home range patchiness of 85% clusters. Low scores indicate the patchiest ranges. Upper case letters indicate differences significant at the 1% level, with lower case for the 5% level.

7.5 Discussion

The area that is repeatedly traversed by an animal tends not to be used either in a uniform manner, or as defined by a normal distribution (White and Garrott 1990). Typically, there are one or more patches of intensive use surrounded by an area used for excursions (Kenward 1987, 2001) or for patrolling territorial boundaries (Kruuk 1978). An ability to identify the number of high-use cores, and their placement with regard to habitats and other animals, can reveal much more about foraging and sociality than can mere range size (Fuller et al. 2005) and is crucial to many management and conservation applications. Relative size and usage of peripheral areas can indicate the effort directed to exploratory behavior, mating and territoriality, as well as quantifying the habitats and neighbors available to an individual (Allouche et al. 1999).

In this study, cores defined by cluster analysis showed the strongest variation between seasons, the lowest and least variable inclusion of unusable habitat, the second lowest correlation with range span, and also showed seasonal variation in core fragmentation. The least variation due to estimation processes might be expected in cluster cores, because the exclusion of outliers eliminates a small number of locations with very variable placement due to behavior that may differ from core activities (Kenward et al. 2001). Areas of clusters are totally uninfluenced by excluded outliers. In contrast density estimators include effects of all locations in every calculation, although distance functions of harmonic mean estimators (Dixon and Chapman 1980) minimize this effect (Kenward et al. 2001) and peripheral polygons are defined by outliers. With least methodological variance, cluster areas should be best able to show biological variance, in this case due to seasonality. Moreover, their tight definition by polygons minimizes the expansion into unusable habitat that results from smoothing implicit in density estimation. A similar restriction to local nearest-neighbor linkages may give equally good performance from the convex-hull approach of (Getz and Wilmers 2004) if an algorithm becomes more generally available.

For estimating a home-range periphery, a K_{95} contour gave better detection of seasonal variation than either an E_{95} ellipse or a peripheral convex polygon (X_{100}).

This resulted despite the peripheral polygon having least (and relatively invariable) out-of-river error, probably because only the kernel contours could define multinuclear range outlines. The moderate sensitivity to outliers of K_{95}, as opposed to the high sensitivity of E_{95} and total dependence of X_{100} may also have been advantageous.

The extent of unusable-environment error would be expected to depend both on the home range estimator and the behavior of each animal. Expansive estimators and far ranging individuals will tend to cause more unused area to be included in the home range calculation than those that occupy smaller areas. Ellipse estimates tended to be very large (Figure 7.2), such that error was large and relatively invariable (Figure 7.3), which apparently minimized scope for correlation with range span (Figure 7.4). Yet in no cases was there a tendency for seasonal variation to be better defined by clipping of unusable habitat. This poor result from an intuitively attractive analysis approach was surprising. If confirmed for other species, this finding implies that unclipped estimates of range area might serve for fish in both linear and non-linear (e.g. lakes) habitats. Indeed, unclipped kernel and cluster analyses showed significant range expansion of home ranges when the river Frome flooded adjacent fields (Hodder et al. in press). However, clipping might be more necessary for habitat analyses and when range overlaps are used to investigate sociality.

Seasonal differences in range size reflected variation partly in linear distances traveled and partly in the patchiness of range structure. Range span alone however, was not informative in terms of pike behavior. It did not show the significant differences in space use between seasons demonstrated by area based range analysis methods in this study or the spring peak and autumn dip in movement described in Cook and Bergersen's (1988) radio telemetry study in a Colorado reservoir. A high level of range span variation between individuals hindered detection of statistically significant seasonal trends, as it did for peripheral convex polygon areas, with which range span correlated strongly (Figure 7.4). Differences in river width between seasons might also have contributed to area-based methods having greater statistical significance than range span in seasonal differences.

Therefore, although range span has traditionally been the most common analysis technique of animals in restricted habitats (Powell 2000), linear distance measures of movement should be complemented by estimates of home range. For pike in the River Frome, this showed that all range area estimators were smallest in autumn (Figure 7.2), at which time cores were least fragmented (Figure 7.6) and inter-location movements smallest (Figure 7.5). Cluster analysis showed that core ranges were largest and most fragmented in summer, when inter-location distances were at their most variable. However, the largest peripheral range areas, with statistically significant differences from autumn for the most moderately excursion-sensitive methods (K_{95}) were in spring, when inter-location distances were at their largest.

7.5.1 APPLICATION

In a review of how twelve estimators of home range area scored subjectively in seven performance criteria, Kernohan et al. (2001) rated kernels first and clusters second. Our objective comparison of four methods in a complex restricted environment concurs with this result for estimating peripheral outlines, but we rate cluster polygons as the more appropriate for estimating range cores because of their greater ability to eliminate influence of outlying locations and their generation of structure statistics. A multifaceted approach with more than one technique enables the most thorough interrogation of the data and also helps to overcome some of the drawbacks inherent in the different methods of home range analysis. Continued estimation of range span will provide an index that remains comparable with previous studies in restricted environments, such as rivers and hedgerows.

Maximizing data interrogation and comparability of results between studies should aid the application of findings to management situations For example, improved study and analysis of space-use interactions between native and non-native fish species in river systems could contribute usefully to understanding mechanisms of observed declines in native species (e.g. Marchetti et al. 2004). Furthermore, improved data interrogation and comparability of space-use statistics in restricted habitats would enhance their utility for meta-analyses that can give broad ecological insights. Current progress in the analysis of telemetry data (Börger et al. 2006), should permit even greater exploitation of available information and provision of resources for managers.

Management may also require predictive modeling, for which it is important to minimize sources of error and bias.

Chapter 8

Population Structure and Side-Channel Use: A Case Study of a Limnophilic Species

8.1 Introduction

Pike are a limnophilic predator typically found in lakes, slow-flowing rivers and canals with shallow to moderately deep waters and a high density of vegetation (Raat 1988). Pike are found throughout Britain, except Northern Scotland and occur throughout Europe, Asia and North America (Davies et al. 2004). Pike exhibit sexual size dimorphism with females being larger than males (Raat 1988). Females attain sizes of up to 130 cm or 19 kg in Britain (Davies et al. 2004). They are thought to be solitary but not territorial, with some overlap in their range areas (Cowx 2001). Pike are opportunistic predators, with their food type varying according to abundance and seasonal availability (Chapman et al. 1989). They feed on invertebrates, fish and other vertebrates and are known to be strongly cannibalistic, with cannibalism forming a large part of the predation pressure on young pike in some populations (Mann 1982).

Pike spawn in shallow, sheltered, vegetated water between March and May (Cowx 2001). The onset of spawning is controlled by photoperiod and increasing temperature (Lucas 1992). There is some evidence that pike migrate to the same spawning ground each year (Frost and Kipling 1967, Bregazzi and Kennedy 1980). Spawning takes place in daylight with between one and three males accompanying a single female (Raat 1988). Eggs are shed indiscriminately over vegetation over a distance of 50 – 100m (Raat 1988). Female fecundity is approximately 15 -30 eggs per gram of body weight fecundity varies widely (Frost and Kipling 1967, Mann 1976b).

Fish populations are often structured by the environmental pressures that they face. Thus habitat structure and diversity influences the spatial distribution and ecology of fish populations. Different life history stages often use different habitats. For example, sofie (*Chondrastoma toxostoma*) spawn in river tributaries. Juveniles move out into the main river and do not return until they spawn, young mature sofie migrate from the main channel to spawn in the tributaries and then return to the main channel and older sofie remain in the tributaries as residents (Gozlan 1998). Population spatial structure is not just driven by different age groups, but individuals within a population may adopt different space use strategies. This may mean use of segregated habitats such as the main channel and side-channels or it may mean use of different habitats within the main river channel. Habitats differ in their quality for the individuals using them. Individuals in poorer quality habitats exhibit slower growth and lower condition. For instance, some bream are resident floodplain lakes of the Lower Rhine, while other individuals, which are smaller and in lower condition, remain in the river or make trips to the floodplain lakes (Grift et al. 2001).

The floodplain of the River Frome provides a varied network of off-river habitats available to fish. Each of these lateral habitats supports a community of fishes (Chapter 4) and provides different functional uses for many fishes throughout the year (Chapter 5). Dace used a wide range of habitats available on the Frome, but as a rheophilic species largely utilised only flowing side-channels (Chapter 6). As a limnophilic species, pike could be expected use a different range of the side-channels available on the River Frome.

Pike are also a top predator and unlike dace which batch spawn, pike undergo mate selection with one female spawning with between one to three males (Raat 1988). In pike, unlike many fish species, there are no secondary sexual characteristics for females to differentiate between males (Wootton 1990). Instead, as in many other species, a likely selective trait for spawning pike is the size of the fish (Downhower and Brown 1980, Maekawa et al. 1996, Rowland 1989). Thus small male pike are likely to compete less well for spawning than larger males.

This chapter addresses the hypothesis that a limnophilic, top predator population will be spatially structured as a result of habitat variability. This may be applied to use of different areas within the main river channel and also differential use of main river and side-channel habitats. Individual's home ranges will be compared with respect to their growth characteristics to investigate population structure using the common definition of a home range as "the area traversed by an individual in its normal activities of food gathering, mating and caring for young" (Burt 1943). It is likely that the size and quality (availability of feeding and sheltering resources) of an animal's home range will affect the excursions made outside its everyday area (Powell 2000). So the relationship between home range size and an individual's vagility, or inherent tendency to move, was investigated in pike as it has been documented previously in both birds and mammals (Bowman 2003, Bowman et al. 2002). Indeed, Bowman (2002; 2003) was able to predict vagility from home range size. Bowman et al (2002) argued that differences in behaviour and physiology between species affect vagility in mammals, such that home range size and dispersal distance covary proportionately. These previous studies investigated this relationship between species, while this investigation focussed on differences between individuals of a single species. The relationship between an individual pike's growth rate and it's presence in a side-channel was also investigated.

8.2 Materials & Methods

8.2.1 SAMPLING

Seven side-channels (Chapter 2) were sampled with electric fishing four times a year during 2003-2005. Five side-channels were monitored with PIT detectors during 2004-2005. Adult pike were radio-tracked at dawn, midday and dusk over a 13-day period four times per year to determine their seasonal home range (2002-2005) and also 2-3 times per week to monitor excursive activity and maintain contact (2002-2005). See Chapter 3 for further detail on the procedures used.

8.2.2 ANALYSIS

The relationship between seasonal home range size and annual excursions was investigated. The sample size was limited to 14 pike for which both seasonal home range and annual excursions were available. Adult pike (mean FL ± S.D. 69.5 ± 12 cm, range 52-93 cm) were located in December, March, June and September at dawn, midday and dusk every day over a 13 day period, resulting in standard home range data sets of 39 locations per fish. In addition, fish were routinely located two or three times per week during the entire 3.5 year study period.

Annual home range area was calculated using cluster analysis, objectively excluding all excursive activity (see example in Figure 8.1). An iterative process excluded the location with the most extreme linkage distance if it was beyond 1% of the distribution estimated by the remainder, and repeated this process until all distances were within the 1% alpha-level on a normal distribution. Ninety nine percent cluster analysis (Kenward 1987) was used to ensure that only the clearest excursions were excluded. The number of excursions and mean excursion distance (m) outside this home range were calculated along a river midline using the three times weekly tracking data over a full year (Figure 8.1).

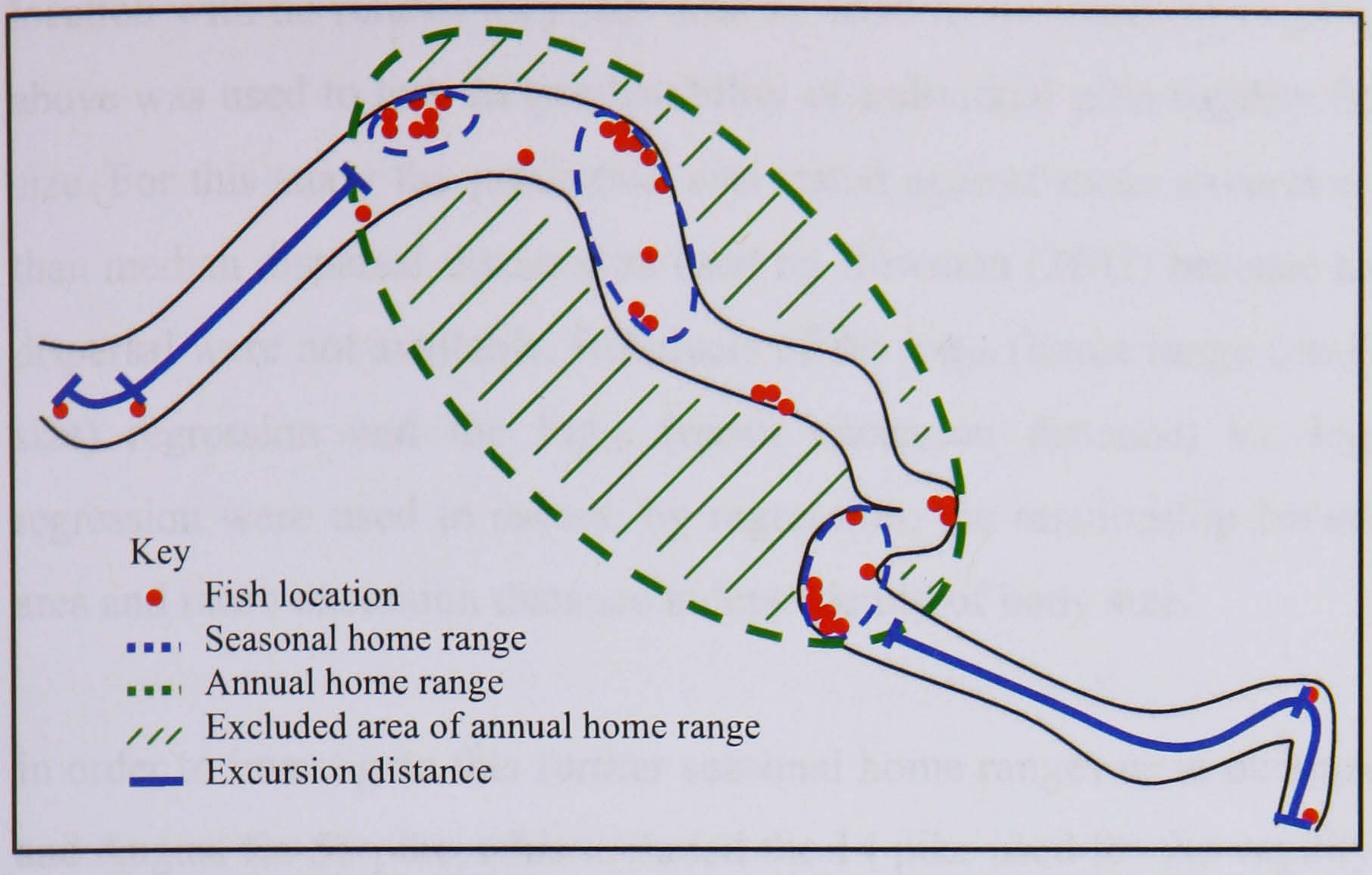


Figure 8.1 Example of the calculation of annual and seasonal home range and of the calculation of excursion distance.

Ninety five percent cluster analysis (Kenward 1987) was used to estimate the seasonal home range areas as it expresses the core structure of a range once excursive movements are excluded (Hodder et al. 1998). Core ranges estimated from the seasonal 13-day tracks for each pike were then compared to their annual number of excursions and mean excursion distance (Figure 8.1).

Home range size for all four seasons was regressed against both mean excursion distance and annual number of excursions. All variables were on a $\log_{10}$ scale to correct for non-normality of the data. The potential for predicting mean excursion distance from seasonal home range area was then investigated. An isometric relationship between the linear dimension of home range (square root of home range size) and median dispersal distance exists in mammals (Bowman et al. 2002) of the form:

$$\text{median dispersal distance} = 7\sqrt{HR}$$

Where:

HR = Home range

Vagility is defined as the tendency of animals to move. While there are clear differences between excursions (long distance movements where the individual returns to its original location) and dispersal (long distance movements away from a location with no return) they can both be used as measures of vagility. The equation above was used to test the predictability of individual pike vagility from home range size. For this study the prediction was tested against mean excursion distance rather than median dispersal distance as used by Bowman (2002) because measures of pike dispersal were not available. Residuals of the $\log_{10}$ (home range area) vs. $\log_{10}$ (body size) regression and the $\log_{10}$ (mean excursion distance) vs. $\log_{10}$ (body size) regression were used to assess, by regression, the relationship between home range area and mean excursion distance independently of body size.

In order to investigate this further seasonal home ranges were obtained between May and August for 51 pike, (this included the 14 pike used for the vagility investigation.) (mean FL ± S.D. 51.4 ± 25.5 cm, range 9.2-105 cm). Between 30 and 39 fixes were included in all home range estimates. In most cases 39 fixes were used (Hodder et al. in press) but for some of the smallest pike fewer were available. Home range size stabilised with fewer locations for small pike. So estimates made from 30-35 fixes for small pike were comparable to 39-fix home ranges estimated for large pike. Sex was known for 36 of the 51 pike radio-tracked (female n = 17; male n = 19) and growth data was available for 45.

Von Bertalanffy growth coefficients L_∞ and K were calculated for each pike (see Chapter 3 and Chapter 5 for further details). Except where specified, 85% clusters were used appropriately as home range estimates (see Chapter 7). The following transformations were applied to normalize the data. It was not possible to totally normalise L_∞ but after transformation the variances were very much reduced and it tended towards normality ($P > 0.05$).

Transformations used were:

Cluster area	Log_{10} (cluster area * 10000+1)
L_∞	Log_{10} (L_∞)
K	Log_{10} (K * 10000+1)

Values were multiplied by 10000 (before adding 1) when there were zeros and many low values in order to transform the data while maintaining the proportions between the data points.

Seasons were defined according to the pike spawning season, so that all spawning months were described together as Spring. Thus:

Spring	March - May
Summer	June - August
Autumn	September - November
Winter	December – February

The condition coefficient of individual fish was calculated with the formula:

$$C = 10^5\,(W/L^3)$$

Where:

C = condition coefficient

W = weight

L = fork length

No pike were caught in Goldsacs stream and Millstream functionality differed from that of the other streams utilised by pike (see Chapter 5 for further detail). Thus for this chapter only (Figures 8.7 and 8.8 and Tables 8.2 and 8.3), side-channels Railway, Rushton, Luckford, Flood Relief and Holme Bridge were grouped as 'ditches' for analyses into condition and growth factors, with Millstream and also the main river channel used for comparison.

Statistical analyses were carried out in Minitab 14. Graphs were made in SigmaPlot 2000.

8.3 Results

8.3.1 PIKE SPATIAL BEHAVIOUR

Winter and spring home range area of the 14 adult pike studied were strongly positively correlated with mean annual excursion distance (R^2 = 0.91, P < 0.0001 and R^2 = 0.74, P = 0.001 respectively), while summer and autumn were not (R^2 = 0.37, P = 0.15 and R^2 = 0.08, P = 0.42 respectively) (Figure 8.2). Seasonal home range areas were not correlated to the number of excursions made throughout the year ($R^2 < 0.22$, $P > 0.18$ in all cases).

No significant differences were found between observed and predicted mean excursion distances (Paired *t*-test: $P > 0.10$ in all cases). So, mean excursion distance of pike was successfully predicted from winter and spring home range area with Bowman's (2002) equation developed for mammals, despite the small sample size of pike.

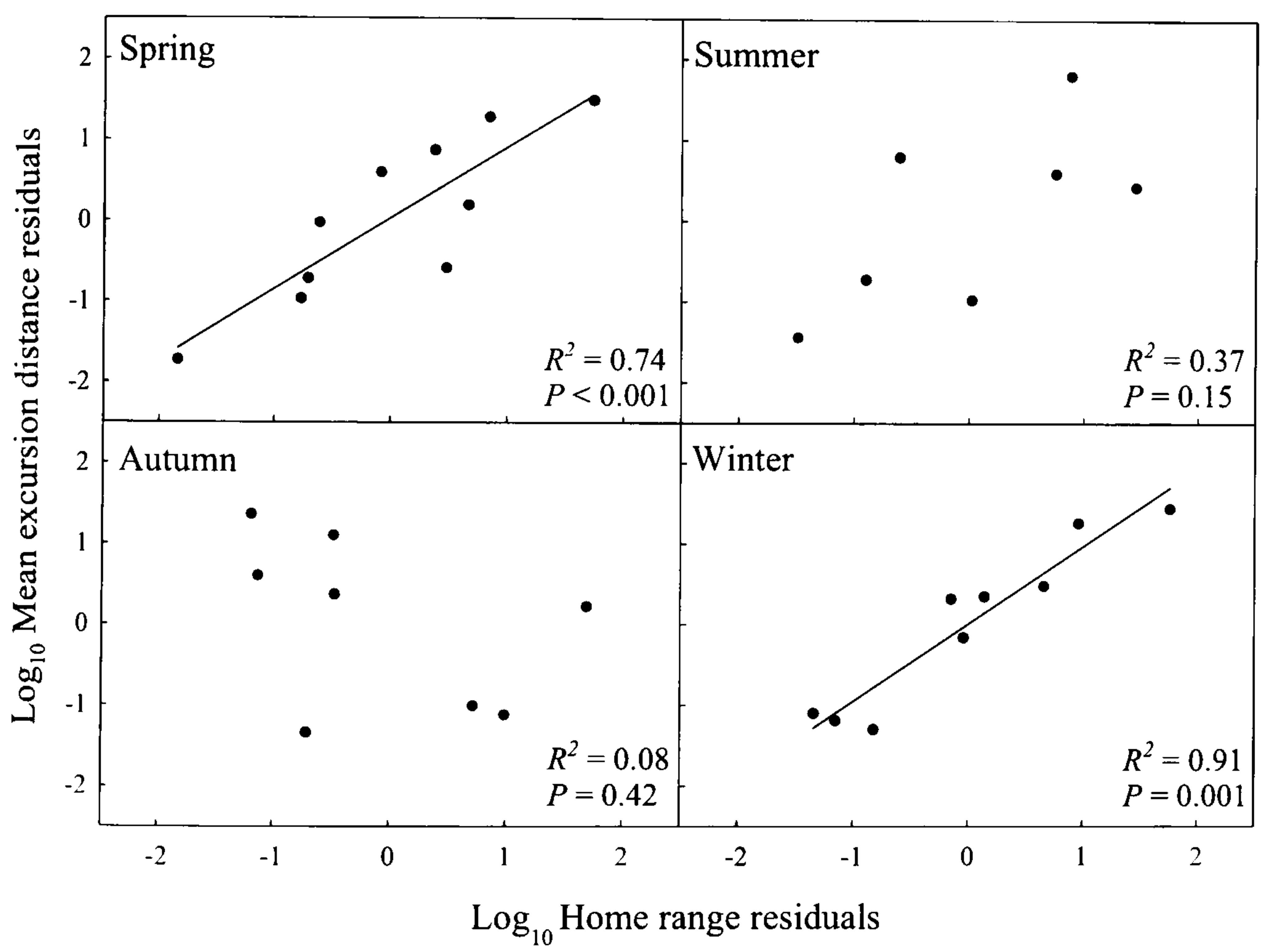


Figure 8.2 Relationship between residuals of seasonal cluster home range areas and residuals of mean annual excursion distance (i.e. after effects of body size were removed) demonstrating the seasonal relationships between home range area and excursion distance.

Pike length was not correlated with either variation in seasonal home range area ($R^2 < 0.01$, $P > 0.34$ in all cases) or mean excursion distance ($R^2 = 0.00$, $P = 0.925$). The relationship between seasonal home range area and mean excursion distance showed no change when the effect of body size was removed (Fig. 8.2), showing that body size did not influence the relationship between home range size and mean excursion distance. No significant difference was found between males (n = 6) and females (n = 9) for either home range size or mean excursion distance (t-test; $P > 0.29$ in all cases), although sample sizes were low. The relationship between individual growth variables and home range size were investigated for a larger sample of pike (including those that did not have information on annual excursion distance).

On a large scale, ranging nearly the full size range of pike, home range size increased with the size and age of pike (Figures 8.3 and 8.4). Home range increased at a faster rate with size increases in smaller/younger pike, slowing to reach a plateau in fish over 80 cm or 9 years of age.

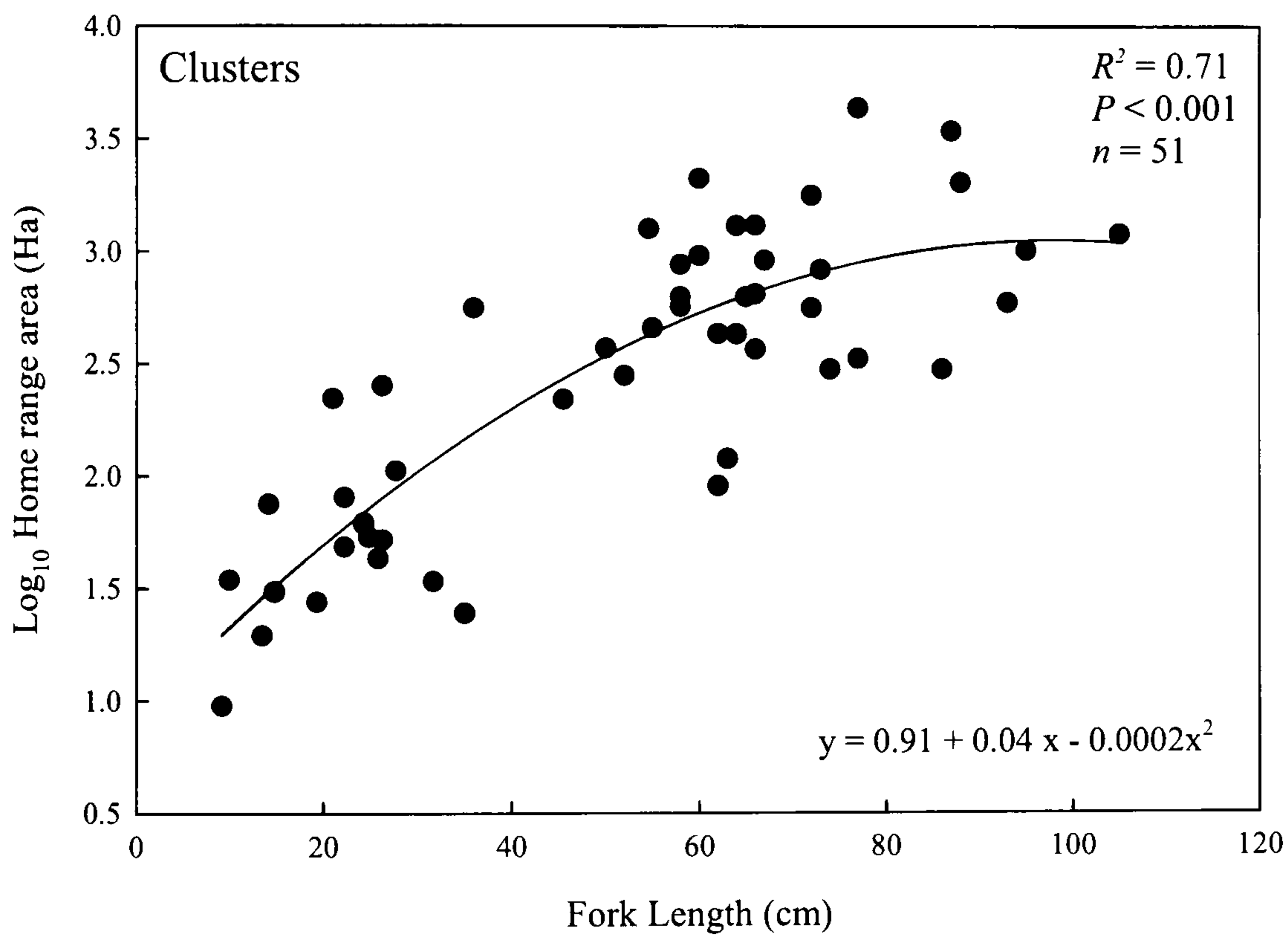


Figure 8.3 Cluster home range size according to individual fish size. Home range is expressed as Log_{10} (Home range size * 10000).

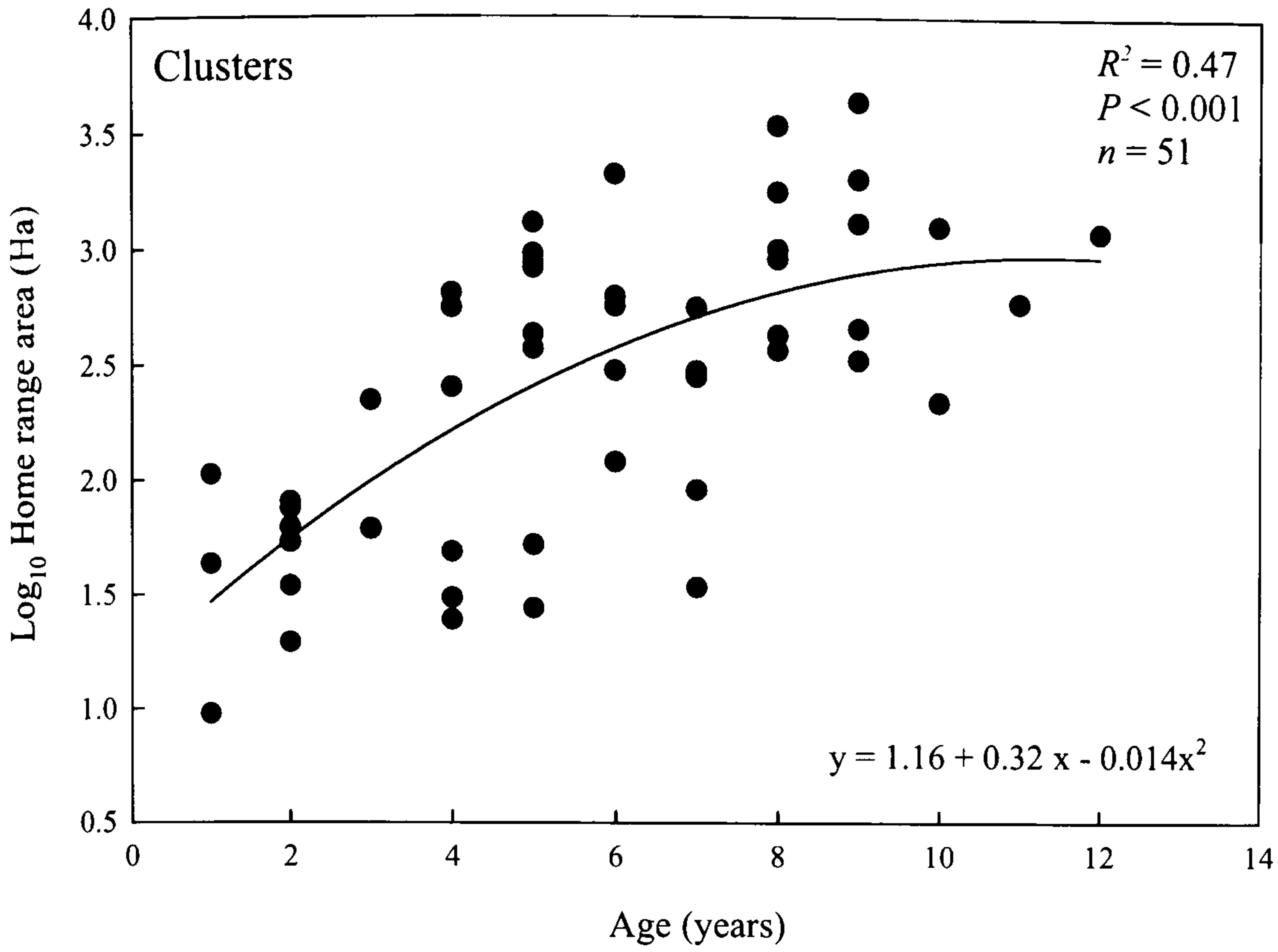
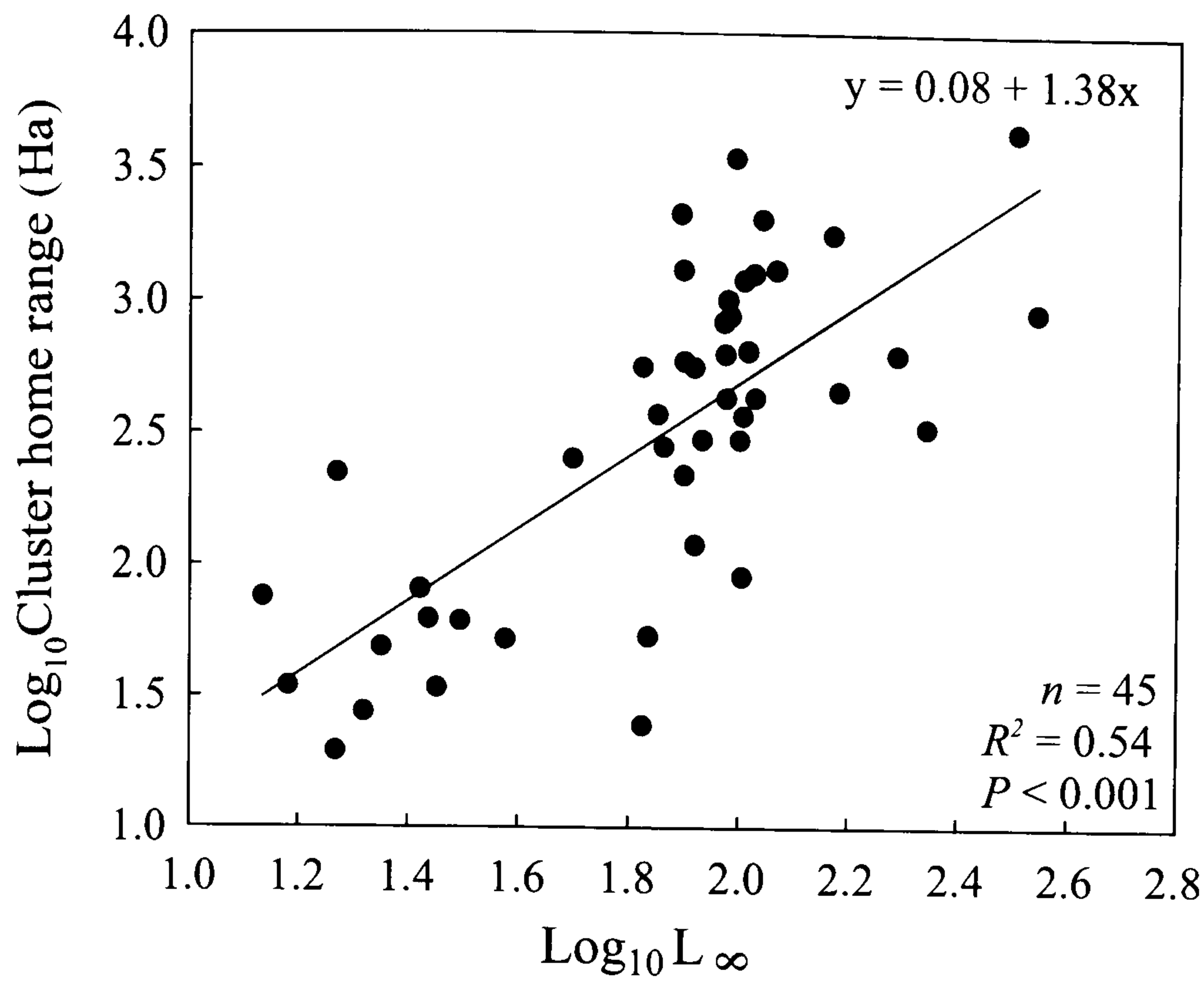


Figure 8.4 Cluster home range size according to individual fish age. Home range is expressed as Log_{10} (Home range size * 10000).

Home range size was correlated with growth throughout a pike's life time (Figure 8.5). This was illustrated by both the growth constant K and L_∞ being positively correlated with cluster home range area (K is inversely proportional to growth rate, hence the apparent negative correlation with home range size in Figure 8.5). The theoretical maximum size of an individual (L_∞) gave a stronger correlation with home range size than growth coefficient K.



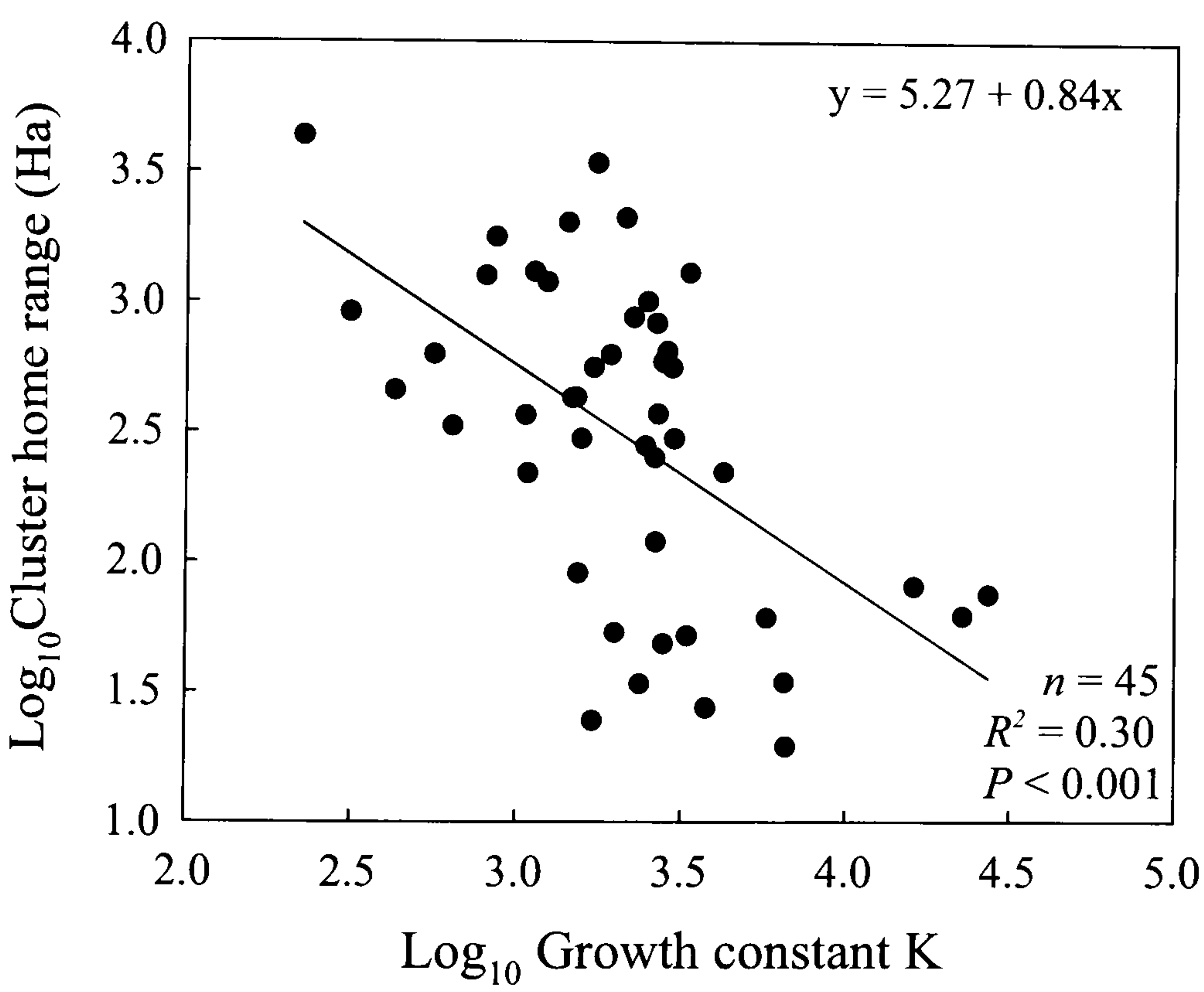


Figure 8.5 Relationship between growth coefficients L_∞ and K (expressed as Log_{10} of the variables) with cluster home range size. Home range is expressed as Log_{10} (Cluster * 10000).

Male and female pike growth rate did not differ significantly (*t*-test, K; $P = 0.708$, L_∞; $P = 0.456$). Male cluster home ranges were significantly smaller than female home ranges (*t*-test; $P = 0.002$). Male home ranges were also more variable in size than females' as illustrated by a higher coefficient of variation (Table 8.1). However, males were generally smaller than females (male mean fork length = 51.5 cm, S.D. = 19.7;

female mean fork length = 70.23 cm, S.D. = 17.84). To account for this, size was added as a covariate in the *ANCOVA* when testing the correlation differences between fish size and home range size. Male home range size was found to be more strongly related to fish size than female (*ANCOVA*; Clusters $R^2 = 0.57$, $P = 0.023$). This was not the case for age (*ANCOVA*; Clusters $R^2 = 0.40$, $P = 0.19$).

Table 8.1 Home range characteristics for male and female pike

	Male	Female
Mean home range size (Ha)	0.0234	0.0724
Coefficient of variation	24.03 %	13.84 %

Incorporation of pike life history parameters (i.e. growth, sex, size and age) by stepwise multiple regression against cluster home range size found that the best (explaining most variance) combination was size, L_∞ and sex ($R^2 = 0.66$, $P < 0.001$; size $P = 0.001$; L_∞ $P = 0.005$; sex $P = 0.069$).

8.3.2 DIFFERENTIAL SIDE-CHANNEL USE

Both mean fork length and mean weight differed according to the location in which the pike was caught between all locations (Figure 8.6a and b). The condition coefficient was significantly lower for fish caught in ditches (excluding Millstream, see section 6.1.2) than those in the river (Figure 8.6c) but no significant differences were found between Millstream and either the ditches or main river. Likewise individual growth indicators varied according to catch location. L_∞ was lower in ditch pike than Millstream and river pike (Figure 8.6d). K indicated lower growth in fish caught in ditches than the main river (Figure 8.6e). Pike caught in the main river and Millstream exhibited similar growth and condition characteristics. Pike caught in the ditches attained a smaller size at age than those in the main river or Millstream (Figure 8.7). Indeed it took pike in the ditches two years longer to reach a given length than those in the main river or Millstream.

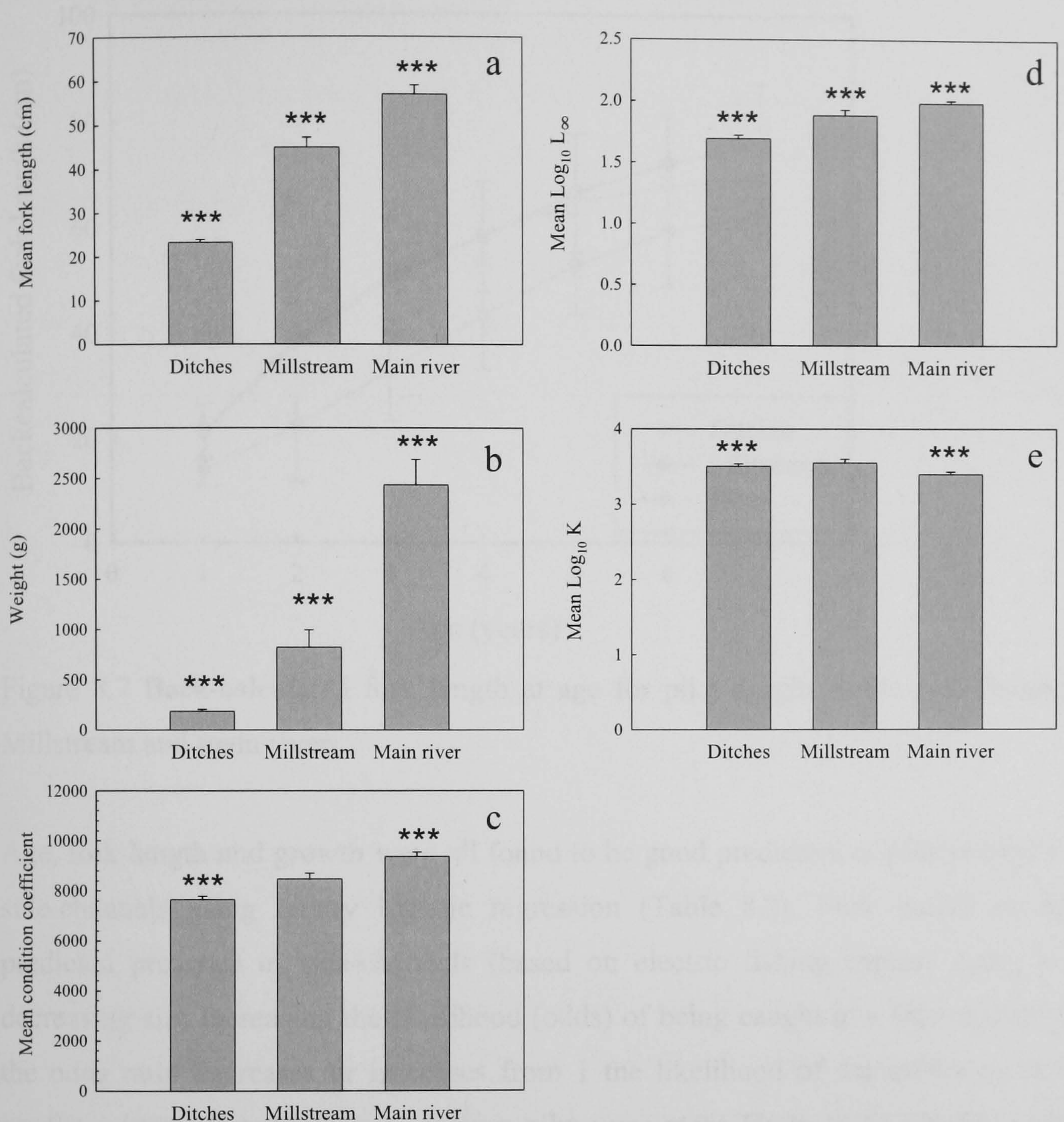


Figure 8.6 Mean (a) length, (b) weight, (c) condition coefficient, (d) L_{∞} and (e) growth coefficient K of fish in the ditches, Millstream and main river with standard deviation error bars. Asterisks indicate significant differences at $\alpha = 0.001$ level (*ANOVA; Tukey* test, $F > 13.23$ in all cases).

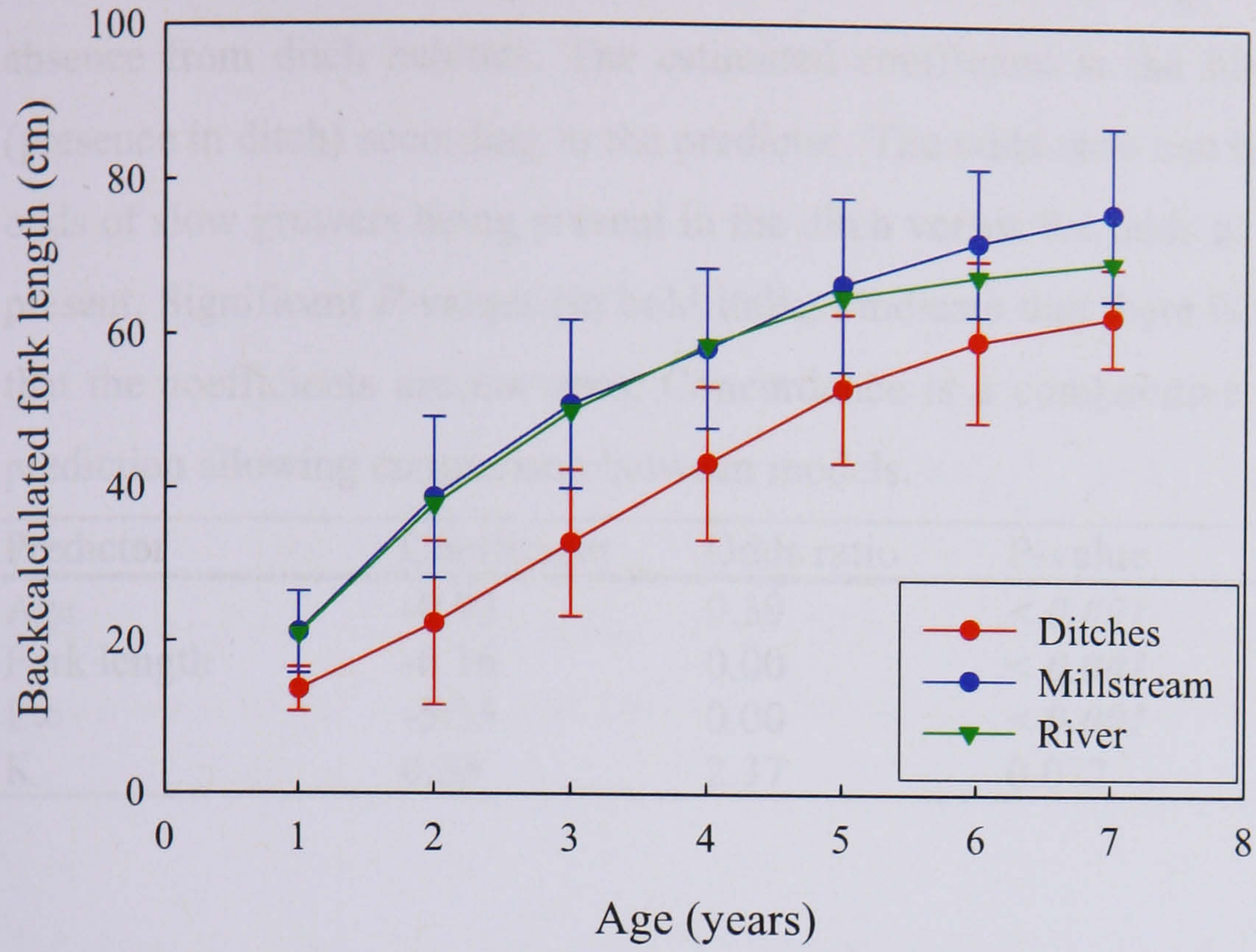


Figure 8.7 Back-calculated fork length at age for pike caught in the side-channels, Millstream and main river.

Age, fork length and growth were all found to be good predictors of pike presence in side-channels using binary logistic regression (Table 8.2). Fork length strongly predicted presence in side-channels (based on electric fishing capture data), with decreasing size increasing the likelihood (odds) of being caught in a side-channel (as the odds ratio decreases or increases from 1 the likelihood of the influence of the predictor increases). Likewise, younger pike were more likely to be caught in side-channels. Odds ratios suggested that the probability of faster growing pike being caught in a side-channel was only 0.39 or less than that of capture elsewhere. A small L_∞ was strongly representative of side-channel caught pike. In the case of the growth constant K, as K is inverse to growth rate the odds ratios were also inverse. In most cases the coefficients were found to differ significantly from 0 and the prediction of most models was high. Growth constant K was a weaker predictor than age, fork length or L_∞.

Table 8.2 Results of binary logistic regression modelling of growth on presence or absence from ditch habitats. The estimated coefficient is the likelihood of success (presence in ditch) according to the predictor. The odds ratio can be interpreted as the odds of slow growers being present in the ditch versus the odds of fast growers being present. Significant *P*-values (in bold italics) indicate that there is sufficient evidence that the coefficients are not zero. Concordance is a comparative measure of model prediction allowing comparison between models.

Predictor	Coefficient	Odds ratio	P-value	Concordance
Age	-0.93	0.39	***< 0.001***	78.8
Fork length	-6.16	0.00	***< 0.001***	84.7
$L\infty$	-5.35	0.00	***< 0.001***	82.3
K	0.86	2.37	0.072	55.5

8.4 Discussion

Like dace (Chapter 6), pike used a wide range of habitats available to them within the river system. Over the seasonal cycle, pike move between different habitats, for feeding, spawning or sheltering (Chapter 5). Individuals have distinct spatial distributions and habitat use along the Frome, either in terms of the time spent in lateral channels or of the size and structure of their home range.

Vagility was related to pike winter and spring home range size. This is similar to bird and mammal dispersal (included in Bowman et al's (2002) study were gray wolf, *Canis lupus*, Eastern chipmunk, *Tamias striatus*, cougar, *Felis concolor* and meadow vole, *Microtus pennsylvanicus*) for which home range size is a reliable predictor of tendency to move (Bowman et al. 2002, Walls et al. 1999). However no relationship was found with the number of excursions. This suggests that while all pike travel outside their home range as frequently, some travel further than others. The strong relation between seasonal home range size and vagility indicates that there are common factors dictating the tendency of an individual to move.

The relationship between home range size and vagility for birds is influenced, at least in part, by social pressures (Walls et al. 1999). Growth rate was faster in pike with larger home ranges, suggesting that these individuals were able to acquire more energy than was expended while using the greater area. Social hierarchy has been noted in pike, with dominant and subdominant individuals (Hawkins et al. 2005). It is possible that fast growing individuals gain advantage over conspecifics early in life and become dominant members of the population. As pike are not territorial, but intimidation between individuals does occur (Eklov and Diehl 1994, Nilsson et al. 2000, Raat 1988), it is possible that faster growing pike gain access to more areas (and thus have a larger home range) through intimidation and as a result encounter more feeding opportunities.

The lack of correlation between mean excursion distance and summer or autumn home range size indicates a difference in activities between winter/spring and summer/autumn periods. In temperate climates highest pike competition for resources occurs during winter and spring. In winter prey productivity in the river is low (Chapman 1968) and availability of cover for these ambush predators is reduced due to die back of vegetation (Dawson et al. 1991). In spring competition increases during the spawning season for access to spawning grounds and mate selection (Billard 1996) with larger pike likely to be more successful spawners. Increased competition between pike during winter/spring is likely to increase the mobility of pike, with more dominant individuals able to travel between more areas (Sutherland 1996). This is supported by the highly significant correlation between home range size and an individuals' tendency to move during these highly competitive seasons.

Growth rate was more strongly linked to male than to female pike home range size suggesting that behaviour differing between the sexes may be the root of the fish size to home range size relationship. It is possible that size may a selective trait for mate selection in pike with bigger males gaining more spawning opportunities. This would suggest that pike which grow faster are better reproductive competitors. Male home range size was also more variable than that of females, suggesting that inter-male competition was more significant in pike than inter-female competition. Inter-male competition is often higher in species where female selection determines male reproductive success (Krebs and Davies 1997). These findings may suggest a reproductive basis to the differences in home range characteristics seen in male and female pike. In the case of inter-male reproductive competition, male pike would likely employ reproductive strategies to maximise their individual spawning success. Male pike arrived earlier onto spawning grounds than females (Chapter 5) which could be suggestive of protandrous behaviour; the early arrival of males onto the spawning grounds to wait for females.

Home range size correlated well with both the age and size of an individual. At the start of life, home range size increased quickly with respect to age/size. This increase in home range size slowed and eventually reached a plateau at about 80 cm or 9 years old. This change in home range size with time closely follows, and probably results from, the pike growth curve. In the exponential phase of growth early in life pike need to increase their home range size quickly as both their body size and energy requirements increase. This allometric relationship has previously been shown in birds (Bowman 2003), mammals (Bowman et al. 2002, Mysterud et al. 2001, Swihart 1986), lizards (Perry and Garland 2002) and other fish (Minns 1995) but has always considered cross-species relationships and not within-species relationships as was the case in this study.

Pike resident in lateral habitats were smaller, slower growing and in poorer condition. Pike caught in side-channels took a full two years longer to reach the same size as pike from the main channel. Indeed the relationship was strong enough that growth characteristics could be used to predict presence or absence in side-channels (Table 8.3) and also described 65% of the individual variation in the time spent in side-channels (Chapter 5). There was less difference in these growth variables between the main river and Millstream probably because in terms of pike habitat, the millstream was closer to being a 'small river' than a slow flowing side-channel.

Like the River Frome dace population, the pike population was structured by the surrounding environment. Side-channel habitats were used by pike for spawning, but were particularly important for slow-growing males which arrived early in the spawning season. The main channel population was also behaviourally structured with faster-growing pike accessing larger areas of the river.

Chapter 9

General Discussion and Conclusions

During the history of the River Frome human alterations have been made which changed the form of this semi-natural system. Changing land-use such as cultivation on the floodplain and bank stabilising has affected the river system and the fish populations it supports. Fish, particularly dace, abundance has declined over the last 15 years (observations from River Frome angler CPUE) with no known cause, though it is likely that human activities have impacted on the populations. Increased water abstraction or farming practises leading to siltation of gravel beds (Heywood and Walling 2003) may have damaged important dace spawning areas for example. Where natural off-river habitats have been lost through bank stabilisation to prevent oxbow lake formation or infilling to create pastureland, man-made creations in the form of drainage ditches have taken their place as low-flow lateral habitats. Now field drainage occurs through underground pipes, drainage ditches no longer function for their original purpose and are not regularly cleared or have been filled becoming inaccessible for fish. This trend of loss of natural and man-made connectivity is occurring in most temperate floodplain river systems and threatens many fish populations (Gore and Shields 1995, Olson and Dinerstein 1998).

Lateral connectivity in the River Frome provides a mosaic of habitats used to different degrees and during different parts of the life-cycle by a wide range of fishes (Chapters 4 and 5). Current literature on riverine habitat ecology and rehabilitation following anthropogenic change ascribes increasing importance of connectivity to lateral habitats for lowland river fish populations (Pretty et al. 2003). Rehabilitated off-river channels lead to increased fish abundance while in-stream structures have much lower effect (Langler and Smith 2001, Pretty et al. 2003). This study characterised the functioning of lateral side-channel habitats of the River Frome by fish communities. This will enable a more rational management of the Frome floodplain and beyond of floodplain rivers generally.

Ideally, due to the diversity of fish species requirements for off-river habitats (Chapters 4 and 5) the total preservation of floodplain systems and the maintenance or restoration of all lateral connection would be possible. However, funds, human resource requirements and the level of degradation that has already occurred in main riverine habitats mean that this is often not possible (Schiemer 1999) and a more realistic and practical approach of rehabilitation must be adopted with the most important habitats being highest priority (Gore and Shields 1995).

Defining which lateral habitat is the most 'important' for the system depends on the criteria selected for the definition. Some habitats support a larger abundance or range of fish than others and could merit protection for this reason. Some authors have found that physical criteria may not be enough to determine ecological need and contribution to the system (Pretty et al. 2003). Yet this study found that species diversity in side-channels was positively correlated with their habitat stability (Chapter 4) and so an index of stability could indicate ecological contribution. This is a potentially useful tool for habitat managers and policy makers who may not have the resources to sample and monitor fish populations. They could determine the significance of a series of lateral habitats by taking simple habitat measurements such as those collected in this study over a period of time to create a stability index to rate each location.

Some lateral habitats support significant species, such as Goldsacs which contained a large population of brook lamprey a Biodiversity Action Plan (BAP) species. As no other side-channel in the study supported such a density of brook lamprey Goldsacs is a notable habitat for that reason. However, conservation solely for individual species may not provide the range of habitats necessary for a healthy riverine ecosystem. A combination of conservation of the most significant habitats to the overall system and those for particular species is therefore recommended. Understanding the functioning of these habitats within the system and for particular species may help to understand what drives the use of side-channels and thus which are particularly important to preserve and maintain.

As mentioned, Goldsacs is an important habitat for brook lamprey and it is also an important nursery habitat for flounder on the Frome. Eel, another BAP species, occur in many of the side streams sampled, particularly Holme Bridge and the Millstream. Eel were resident in the Millstream but moved between here and the main river during nocturnal activity. Dace used Millstream for spawning, Luckford for resting post-spawning and Flood Relief as well as a natural oxbow near Luckford as a nursery habitat. Some dace also moved into both Luckford and Millstream in autumn.

Railway and Rushton provided a great deal of the local spawning habitat for pike. Pike were present at a lower level in most channels (except Goldsacs where they were not recorded) throughout the year.

This study on the River Frome can be used to create an example of a management plan for preserving the most important aspects of the floodplain. The two flowing streams Goldsacs and Millstream were the most stable habitats with the highest species diversity, Luckford was next most stable. Goldsacs also supported the only BAP species in the study, the brook lamprey. Luckford and Millstream were important habitats for dace supporting both spawning and sheltering individuals. Thus these three side-channels must be considered the three most important side-channels monitored during the study. However, this does not take into account the needs of the pike population for which drainage ditches are important spawning areas. So Rushton (more stable and species diverse than Railway) must also be included as an important lateral habitat for conserving. Finally, if preservation of all lateral habitats within the system were not possible Goldsacs, Luckford, Rushton and Millstream would be the most significant to preserve, in that order. A large number of reserve selection algorithms have been developed for application in prioritising relative importance of habitats for preservation or conservation (Nicholls and Margules 1993, Rothley 2006, Van Teeffelen et al. 2006). Further investigation into the relative importance of the side-channels on the River Frome could be continued using these algorithms.

The complex and mobile nature of the dace population structure showed that connectivity (both lateral and longitudinal) is an important element in the preservation of dace populations in the river system (Chapter 6). Habitat diversity and in particular access to certain habitats such as side-channels or oxbows may have disproportionate importance that is not always evident from species' abundance (Hoopes and Harrison 1998). Small changes in the distribution and accessibility of different habitats may precipitate relatively large changes in the species' viability (Doak 1995, Pulliam et al. 1992), an essential consideration for management plans. Should blockages to fish passage or loss of lateral connectivity prevent population mixing or reduce access to habitats necessary for life history requirements, the dace population as a whole is likely to suffer.

The life history strategies shown in pike highlight a variety of different connectivity-related movements and migrations (Chapter 7). Behavioural strategies relating to habitat use and spatial distribution rely on both lateral and longitudinal connectivity. Different spawning strategies developed within the population are based on the nature and availability of lateral spawning sites. Behavioural diversity may enable the pike population to cope better with situations of change (Krebs and Davies 1997). For example, residents in poorer, side-channel habitats provide a source of colonisers should a population crash occur in the main river population. Side-channels are particularly important spawning habitat during unusually high flow years when eggs in the main river would be washed away. As pike appear to exhibit spawning-, and perhaps, natal-site fidelity conservation of a range of spawning habitats for pike is important so that the gene pool is not artificially reduced by lack of spawning areas. If this were to happen those individuals arriving early into the spawning-channels may be more likely to spawn successfully because in the limited habitat available those larvae that hatch early will have a size advantage (and thus lower threat from cannibalisation) to those hatching later in the season. In that case the trade-off between the cost of moving into the poorer feeding habitat (poorer for adult pike) earlier and spending longer there would be repaid by greater successful reproductive output.

Studying the dynamics of the pike and dace populations at the level of an individual within the population provides a much higher level of detail on the use and functionality of the side-channels, as well as the spatial distribution of individuals in the river system. The populations of the two species were structured very differently and had very different requirements from the lateral habitats. The need for a diverse range of habitats to be maintained throughout the river system and for integrated, catchment-wide management has been illustrated. In view of that, the final contribution of this thesis will be to consider practical implications and guidelines for conservation management of lateral connectivity of river systems.

9.1 Practical Implications

Lateral connectivity has been shown to be of importance to the ecology of a floodplain river system both in this study and others (Bayley 1995, Borcherding et al. 2002, Copp 1997, Gore and Shields 1995, Ross and Baker 1983, Slipke et al. 2005). According to several authors, restoration of lateral connectivity holds more benefits to the ecological integrity of lowland river systems than rehabilitation of in-stream structures (Buijse et al. 2002, Pretty et al. 2003, Schmutz and Jungwirth 1999). Human alterations to the ecosystem, such as poor water quality, damming, river regulation or abstraction all contribute to a cumulative negative effect on the communities and species resident in the river system. In particular, flood induced disturbances are a key element for maintaining biodiversity, creating characteristic patch dynamics and spatial heterogeneity (Schiemer 1999), as well as being a necessary part of the life history of some species (Bayley 1995, Gozlan 1998, Lucas 1992, Welcomme 1985). According to the flood pulse concept, seasonal flooding is not a disturbance but a typical and crucial event of floodplain rivers and connectivity (Junk et al. 1989). With so many human requirements on the river system and the associated changes, provision or maintenance of diverse and complex lateral habitats is especially important to enable the persistence of communities or populations which may be impacted by other changes.

The Water Framework Directive (WFD) requires "*prevention of further deterioration and protection and enhancement of the status of water resources*" (2000). The guidance document on the implementation of the WFD to rivers and lakes (WFD CIS Guidance Document No. 10 2003) recommends physical rehabilitation of river habitats, including lateral connectivity, to enable "*recovery to a level of biodiversity and ecological functioning equivalent to unmodified natural water bodies*". Such a recommendation should mean that as the WFD comes into operation the restoration of lateral connectivity will be a frequently used management practice applied in many ecosystems throughout Europe. Merging a system-oriented view with detailed analysis of functional requirements by populations, as approached in this study, will allow the development of the most appropriate management procedures. Creating interdisciplinary teams of ecologists, hydrologists, environmental engineers and local stakeholders and combining the restoration of connected lateral habitats with continued assessment of the success of the management should ensure the greatest benefit to the riverine biota.

Studies such as this can increase knowledge and understanding of the complex interactions between fish communities and the lateral habitats available to them. Investigation of different dimensions of side-channel use, from assemblages through to individual fish, begins to provide an insight into the functionality of these habitats and the mosaic of these habitats provided in a floodplain system upon which management practices can be based. This study provided strong evidence for the need for a variety of different off-river habitats to enable the continuation of a balanced ecosystem and provision for all species habitat requirements to ensure high biodiversity of the sort in natural systems.

Appendices

Appendix 1 Table of PIT tagged fish

ID	US PIT tag	UK PIT tag	Date tagged	Species	Fork length on first capture	First Catch Location
1	94698332	DC001C-B287	16/04/2003	Pike	56	Main River Frome us road bridge
19		DC001B-E4CC	17/03/2003	Pike	12.4	Railway 1
20	124086156	DC001B-E619	17/03/2003	Pike	11.2	Railway 1
65	94698696		19/03/2003	Dace	22.7	Luckford Lake 4
77	94698688		19/03/2003	Dace	19.3	Luckford Lake 4
78	94698689		19/03/2003	Dace	19.4	Luckford Lake 4
79	94698690		19/03/2003	Dace	18.9	Luckford Lake 4
80	94698691		19/03/2003	Dace	22	Luckford Lake 4
81	94698693		19/03/2003	Dace	22.2	Luckford Lake 4
82	94698695		19/03/2003	Dace	25.6	Luckford Lake 4
83	94698699		19/03/2003	Roach	18.8	Luckford Lake 3
84	94698700		19/03/2003	Roach	17.9	Luckford Lake 3
85	94698701		19/03/2003	Roach	19	Luckford Lake 3
86	94698702		19/03/2003	Dace	22.6	Luckford Lake 3
87	94698703		19/03/2003	Dace	21.5	Luckford Lake 3
88	94698704		19/03/2003	Dace	23.1	Luckford Lake 3
107	94698705		19/03/2003	Dace	21	Luckford Lake 2
108	94698706		19/03/2003	Dace	18	Luckford Lake 2
109	94698707		19/03/2003	Dace	21.2	Luckford Lake 2
110	94698708		19/03/2003	Dace	22.8	Luckford Lake
111	94698709		19/03/2003	Dace	16.2	Luckford Lake 2
112	94698710		19/03/2003	Dace	20.2	Luckford Lake 2
113	94698711		19/03/2003	Pike	33.1	Luckford Lake 2
114	94698698		19/03/2003	Pike	34.2	Luckford Lake 3
115	94698692		19/03/2003	Pike	45.5	Luckford Lake 4
117	94698713		19/03/2003	Pike	60.5	Luckford Lake 1
118	94698712		19/03/2003	Pike	65	Luckford Lake 1
135		DC001B-F278	20/03/2003	Dace	9.3	Holme Bridge 3
139		DC001B-EECB	20/03/2003	Roach	11.4	Holme Bridge 3
140		DC001B-E8CD	20/03/2003	Roach	12	Holme Bridge 3
142		DC001B-EEF2	20/03/2003	Roach	12.2	Holme Bridge 3
144		DC001C-0C80	20/03/2003	Roach	11.5	Holme Bridge 3
149		DC001C-0AEE	20/03/2003	Roach	7.5	Holme Bridge 1
150		DC001C-0BB5	20/03/2003	Dace	8	Holme Bridge 1
151		DC001C-085B	20/03/2003	Roach	8.5	Holme Bridge 1
152		DC001C-0198	20/03/2003	Dace	8	Holme Bridge 1
153		DC001B-FAC4	20/03/2003	Dace	9.3	Holme Bridge 1
155		DC001B-ED9C	20/03/2003	Roach	12	Holme Bridge 1
156	94698683		20/03/2003	Pike	18.8	Holme Bridge 4
157	94698682		20/03/2003	Pike	13.5	Holme Bridge 4
158	94698679		20/03/2003	Pike	52.5	Holme Bridge Extra
159	94698681		20/03/2003	Pike	13.5	Holme Bridge Extra
160	94698685		20/03/2003	Pike	14	Holme Bridge 4
161	94698684		20/03/2003	Pike	28.5	Holme Bridge 4
163		DC001B-F450	20/03/2003	Roach	8.5	Holme Bridge 2
165	94698680		20/03/2003	Pike	12.5	Holme Bridge Extra
166	94698653		24/03/2003	Dace	14.6	ESMS

167	94698655	24/03/2003	Dace	22.8	ESMS
168	94698656	24/03/2003	Dace	22	ESMS
169	94698657	24/03/2003	Dace	23.6	ESMS
170	94698654	24/03/2003	Dace	19.8	ESMS
171	94698652	24/03/2003	Dace	18	ESMS
172	94698651	24/03/2003	Dace	20.2	ESMS
173	94698650	24/03/2003	Dace	20.5	ESMS
174	94698658	24/03/2003	Dace	24	ESMS
175	94698662	24/03/2003	Dace	22.7	ESMS
176	94698659	24/03/2003	Dace	23.4	ESMS
177	94698661	24/03/2003	Dace	18.3	ESMS
178	94698660	24/03/2003	Dace	17.4	ESMS
179	94698663	24/03/2003	Dace	18.5	ESMS
180	94698664	24/03/2003	Dace	17.5	ESMS
181	94698666	24/03/2003	Dace	19.5	ESMS
182	94698670	24/03/2003	Dace	21.6	ESMS
183	94698667	24/03/2003	Dace	24	ESMS
184	94698671	24/03/2003	Dace	24.9	ESMS
186	94698672	24/03/2003	Dace	21	ESMS
187	94698647	24/03/2003	Dace	17.4	ESMS
188	94698668	24/03/2003	Dace	19.5	ESMS
189	94698669	24/03/2003	Dace	25.5	ESMS
190	94698665	24/03/2003	Dace	23	ESMS
191	94698620	24/03/2003	Roach	14.1	ESMS
192	94698621	24/03/2003	Dace	19.2	ESMS
193	94698622	24/03/2003	Dace	19.5	ESMS
194	94698630	24/03/2003	Dace	17.1	ESMS
195	94698629	24/03/2003	Dace	19.1	ESMS
196	94698628	24/03/2003	Dace	20.4	ESMS
197	94698627	24/03/2003	Dace	19	ESMS
198	94698626	24/03/2003	Dace	15.8	ESMS
199	94698625	24/03/2003	Dace	19.2	ESMS
200	94698624	24/03/2003	Dace	21.2	ESMS
201	94698623	24/03/2003	Dace	18.4	ESMS
202	94698632	24/03/2003	Dace	20.7	ESMS
203	94698631	24/03/2003	Dace	20.2	ESMS
204	94698633	24/03/2003	Dace	20.9	ESMS
205	94698634	24/03/2003	Dace	18	ESMS
206	94698635	24/03/2003	Dace	18.9	ESMS
207	94698637	24/03/2003	Dace	18.1	ESMS
209	94698639	24/03/2003	Dace	18.9	ESMS
210	94698638	24/03/2003	Dace	17.4	ESMS
211	94698640	24/03/2003	Dace	20.7	ESMS
212	94698641	24/03/2003	Dace	21.2	ESMS
213	94698642	24/03/2003	Dace	24.3	ESMS
214	94698643	24/03/2003	Dace	20.6	ESMS
215	94698644	24/03/2003	Dace	18	ESMS
216	94698646	24/03/2003	Roach	17.8	ESMS
217	94698645	24/03/2003	Roach	18.5	ESMS
218	94698619	24/03/2003	Dace	15.3	ESMS
219	94698618	24/03/2003	Roach	13.6	ESMS
220	94698403	24/03/2003	Dace	20.4	ESMS
221	94698402	24/03/2003	Dace	19.2	ESMS
222	94698648	24/03/2003	Roach	14.5	ESMS

223	94698649		24/03/2003	Roach	14.5	ESMS
224	94698677		24/03/2003	Pike	61.6	ESMS
225	94698674		24/03/2003	Pike	21.3	ESMS
226	94698673		24/03/2003	Pike	59	ESMS
227	94698398		24/03/2003	Pike	34.3	ESMS eel trap
228	94698399		24/03/2003	Pike	44.5	ESMS eel trap
229	94698678		24/03/2003	Pike	77	ESMS Lily Pool
230	94698380		24/03/2003	Roach	13	ESMS eel trap
231	94698381		24/03/2003	Roach	13.7	ESMS eel trap
232	94698382		24/03/2003	Roach	12.8	ESMS eel trap
233	94698383		24/03/2003	Roach	12.3	ESMS eel trap
234	94698384		24/03/2003	Dace	14.6	ESMS eel trap
235	94698385		24/03/2003	Roach	15.3	ESMS eel trap
236	94698386		24/03/2003	Dace	14	ESMS eel trap
237	94698387		24/03/2003	Roach	13.2	ESMS eel trap
238	94698388		24/03/2003	Roach	13.5	ESMS eel trap
239	94698389		24/03/2003	Roach	14.1	ESMS eel trap
240	94698390		24/03/2003	Perch	14.2	ESMS eel trap
241	94698391		24/03/2003	Perch	15.7	ESMS eel trap
242	94698392		24/03/2003	Roach	18.2	ESMS eel trap
243	94698393		24/03/2003	Roach	12.7	ESMS eel trap
244	94698394		24/03/2003	Roach	14.2	ESMS eel trap
245	94698395		24/03/2003	Perch	21.7	ESMS eel trap
246	94698396		24/03/2003	Roach	51	ESMS eel trap
247	94698397		24/03/2003	Roach	17.7	ESMS eel trap
248	94698400		24/03/2003	Roach	16.1	ESMS
249	94698401		24/03/2003	Roach	13	ESMS eel trap
250	94698377		25/03/2003	Pike	60.4	Main River Frome
251	94698379		25/03/2003	Pike	61	Main River Frome
252	94698376		25/03/2003	Pike	72.9	Main River Frome
253	94698375		25/03/2003	Pike	47.1	Main River Frome
254	94698360		25/03/2003	Pike	86.2	Main River Frome
255	94698373		25/03/2003	Pike	65	Main River Frome
256	94698361		25/03/2003	Pike	79.8	Main River Frome
257	94698374		25/03/2003	Pike	18.1	Main River Frome
258	94698359		25/03/2003	Dace	21.1	Main River Frome
260	94698356		25/03/2003	Dace	21.5	Main River Frome
261	94698358		25/03/2003	Dace	18.8	Main River Frome
262	94698366		25/03/2003	Dace	19	Main River Frome
263	94698365		25/03/2003	Dace	18.7	Main River Frome
264	94698364		25/03/2003	Dace	17.3	Main River Frome
265	94698363		25/03/2003		18	Main River Frome
266	94698362		25/03/2003	Dace	21.3	Main River Frome
267	94698367		25/03/2003	Dace	21.5	Main River Frome
268	94698368		25/03/2003	Dace	17.5	Main River Frome
269	94698369		25/03/2003	Dace	19.1	Main River Frome
270	94698370		25/03/2003	Dace	22.6	Main River Frome
271	94698371		25/03/2003	Dace	23	Main River Frome
272	94698372		25/03/2003	Roach	21.2	Main River Frome
273	94698378		25/03/2003	Dace	18.8	Main River Frome
274	94698350	DC001C-9126	26/03/2003	Pike	17.5	ESMS Millhead
275	94698349		26/03/2003	Pike	17.5	ESMS Millhead
276	94698353	DC001C-6FCC	26/03/2003	Pike	59.3	ESMS Millhead
277	94698352	DC001C-7FEB	26/03/2003	Pike	45.4	ESMS Millhead

278	94698351	DC001C-B4FC	26/03/2003	Pike	16.1	ESMS Millhead
279	94698355	DC001C-B331	26/03/2003	Pike	62.8	ESMS Millhead
280	94698354	DC001C-A832	26/03/2003	Pike	62.3	ESMS Millhead
281	94698347	DC001C-B1C0	01/04/2003	Pike	81	ESMS Millhead
282	94698348	DC001C-B7EA	01/04/2003	Pike	56	ESMS
283	94698346	DC001C-77DF	15/04/2003	Pike	55.4	ESMS
284	94698314		14/04/2003	Pike	73.2	Main River Frome
285	94698318		16/04/2003	Dace	17.2	Main River Frome
286	94698319		16/04/2003	Roach	19.2	Main River Frome
287	94698323	DC001C-A06E	16/04/2003	Dace	17.9	Main River Frome
288	94698334	DC001C-AE21	16/04/2003	Pike	63.9	Main River Frome us road bridge
289	94698322	DC001C-9DAA	16/04/2003	Pike	62.1	Main River Frome
290	94698321	DC001C-B8FD	16/04/2003	Pike	58.8	Main River Frome
291	94698320	DC001C-A6C8	16/04/2003	Pike	78.3	Main River Frome Road bridge
292	94698331	DC001C-AB5D	16/04/2003	Pike	51.8	Main River Frome us road bridge
293	94698315		16/04/2003	Pike	64.8	Main River Frome
294	94698317	DC001C-9E28	16/04/2003	Pike	101	Main River Frome
295	94698330	DC001C-7BA4	16/04/2003	Pike	48	Main River Frome us road bridge
296	94698328	DC001C-B604	16/04/2003	Pike	45.5	Main River Frome us road bridge
297	94698329	DC001C-B66C	16/04/2003	Pike	25.7	Main River Frome us road bridge
298	94698327	DC001C-842E	16/04/2003	Pike	21.3	Main River Frome us road bridge
299	94698326	DC001C-77E3	16/04/2003	Pike	23	Main River Frome us road bridge
300	94698325	DC001C-B990	16/04/2003	Pike	21.7	Main River Frome us road bridge
301	94698316		16/04/2003	Pike	22.6	Main River Frome
302	94698313	DC001C-BA53	01/05/2003	Pike	95.5	ESMS Millhead
303	94698307	DC001C-7A21	06/05/2003	Pike	64.5	ESMH above smolt counter
304	94698312	DC001C-BAO7	06/05/2003	Pike	71	Main River Frome T4
305	94698309	DC001B-F3EB	06/05/2003	Pike	58	Main River Frome T9 - T10
306	94698308	DC001C-B64A	06/05/2003	Pike	78	Main River Frome T2
307	94698324	DC001C-BBB9	16/07/2003	Dace	23.2	Main River Frome Roadbridge/Ducks Egg
308	94698305	DC001C-6DEB	20/05/2003	Pike	47.5	ESMH
309	94698303	DC001C-A332	20/05/2003	Pike	22.2	ESMH
310	94698306	DC001C-A355	20/05/2003	Pike	45.5	ESMH
311	94698310	DC001C-A053	20/05/2003	Pike	68.5	ESMH
312	94698300	DC001C-78D7	23/06/2003	Pike	24.8	Rushton 1
313	94698302	DC001C-A24D	23/06/2003	Pike	29.8	Rushton 1
314	94698301		23/06/2003	Perch	25.8	Rushton 1
315		DC001C-B470	23/06/2003	Dace	-9	ESMS 1
316		DC001C-7418	23/06/2003	Dace	-9	
317		DC001C-7297	23/06/2003	Dace	11	
318		DC001C-B865	23/06/2003	Dace	11.5	
319	94698299	DC001C-FDC0	23/06/2003	Pike	19.7	Flood Relief 3
320	94698298	DC001B-E5B3	23/06/2003	Pike	37.1	Flood Relief 2
321	113943627	DC001C-7F6C	24/06/2003	Pike	18.5	Luckford Lake 2
322	94698297	DC001C-7BA3	24/06/2003	Pike	23.9	Railway 2

323	94698296		24/06/2003	Pike	17	Luckford Lake 1
324	94698289	DC001C-898D	24/06/2003	Pike	13.2	Railway 2
325		DC001C-B5B3	25/06/2003	Roach	9.5	Holme Bridge 4
326		DC001C-8BCF	25/06/2003	Roach	9.4	Holme Bridge
327		DC001C-785A	25/06/2003	Roach	14	Holme Bridge 4
328		DC001C-8A73	25/06/2003	Pike	13.6	Holme Bridge 4
329		DC001C-7130	25/06/2003	Roach	10.2	Holme Bridge 4
330		DC001C-A85D	25/06/2003	Roach	9.1	Holme Bridge Extra
331		DC001C-7B92	25/06/2003	Roach	8.5	Holme Bridge Extra
332	94698252	DC0024-EFB3	08/09/2003	Roach	23.7	ESMH
333	94698251	DC0024-DD87	08/09/2003	Dace	20.5	ESMH
334	94698284	DC0024-EEF7	08/09/2003	Dace	16	ESMH
335	94698283	DC0024-E725	08/09/2003	Roach	18.6	ESMH
336	94698282	DC0024-E17F	08/09/2003	Roach	21.6	ESMH
337	94698281	DC0024-CCFE	08/09/2003	Dace	19.6	ESMH
338	94698280	DC0024-DED2	08/09/2003	Roach	18.2	ESMH
339	94698278	DC0024-DDF9	08/09/2003	Dace	17.1	ESMH
340	94698279	DC0024-DACD	08/09/2003	Roach	16.9	ESMH
341	94698277	DC0024-E87F	08/09/2003	Dace	16.3	ESMH
342	94698276	DC0024-EEBB	08/09/2003	Roach	21.9	ESMH
343	94698271	DC0024-CB6D	08/09/2003	Dace	25.6	ESMH
344	94698272	DC0024-CFC9	08/09/2003	Dace	25.7	ESMH
345	94698273	DC0024-CE47	08/09/2003	Dace	14.4	ESMH
346	94698274	DC0024-D2CC	08/09/2003	Roach	17.8	ESMH
347	94698288	DC001B-EE42	17/03/2003	Pike	11.4	Railway 4
348	94698286		08/09/2003	Pike	19.3	Railway 4
349	94698287		08/09/2003	Pike	17.5	Railway 3
350	94698246	DC0024-E965	08/09/2003	Roach	17.3	ESMH
351	94698248	DC0024-F332	08/09/2003	Dace	21.5	ESMH
352	94698250	DC0024-CC8A	08/09/2003	Dace	21.4	ESMH
353	94698254	DC0024-DB26	08/09/2003	Roach	16.4	ESMH
354	94698253	DC0024-E9FC	08/09/2003	Roach	18.3	ESMH
355	94698249	DC0024-E54C	08/09/2003	Dace	19.5	ESMH
356	94698285	DC0024-F32C	08/09/2003	Dace	22.5	ESMH
357	94698247	DC0024-CEFB	08/09/2003	Dace	21	ESMH
358	94698245	DC0024-F030	08/09/2003	Roach	14.3	ESMH
359	94698258	DC0024-E430	08/09/2003	Dace	16.9	ESMH
360	94698257	DC0024-E91F	08/09/2003	Roach	16.5	ESMH
361	94698255	DC0024-ECC1	08/09/2003	Dace	25.8	ESMH
362	94698256	DC0024-EFB0	08/09/2003	Roach	15.5	ESMH
363	94698259	DC0024-E8B4	08/09/2003	Dace	15.4	ESMH
364	94698260	DC0024-D552	08/09/2003	Roach	15.1	ESMS
365	113943601	DC0024-ES34	08/09/2003	Dace	15.2	ESMH
366	94698265	DC0024-E9BC	08/09/2003	Dace	20.5	ESMH
367	94698264	DC0024-E2F7	08/09/2003	Roach	13.9	ESMH
368	11394360	DC0024-F1E7	08/09/2003	Dace	13.6	ESMH
369	113943602	DC0024-CF25	08/09/2003	Dace	19.5	ESMH
370	94698266	DC0024-E602	08/09/2003	Perch	23.5	ESMH
371	113943610	DC0024-EC68	08/09/2003	Roach	13.2	ESMH
372	113943604	DC0024-DCA5	08/09/2003	Dace	14.6	ESMH
373	94698262	DC0024-CBE1	08/09/2003	Roach	15.3	ESMH
374	94698261	DC0024-DFF5	08/09/2003	Roach	13.9	ESMH
375	94698268	DC0024-D649	08/09/2003	Dace	17.2	ESMH
376	113943605	DC0024-CA56	08/09/2003		16	ESMH

377	94698269	DC0024-EFID	08/09/2003	Dace	15.5	ESMH
378	94698267	DC0024-EBB3	08/09/2003	Roach	15.6	ESMH
379	113943606	DC0024-EC90	08/09/2003	Dace	23.2	ESMH
380	113943598	DC0024-EF58	08/09/2003	Roach	18.5	ESMH
381	94698270	DC0024-DGAF	08/09/2003	Dace	24.2	ESMH
382	113943608	DC0024-CBAC	08/09/2003	Roach	18	ESMH
383	113943600	DC0024-D29D	08/09/2003	Roach	16.3	ESMH
384	113943599	DC0024-F19F	08/09/2003	Dace	14.9	ESMH
385	94698342	DC0024-DGAC	08/09/2003	Dace	15.4	ESMH
386	113943609	DC0024-EBF3	08/09/2003	Dace	22.2	ESMH
387	113943607	DC0024-E13F	08/09/2003	Dace	16.5	ESMH
388	113943611	DC0024-DEA6	08/09/2003	Dace	14.9	ESMH
389	94698244	DC0024-ED9B	08/09/2003	Dace	14.6	ESMH
390	94698242	DC0024-E780	08/09/2003	Dace	21.1	ESMH
391	94698243	DC0024-F1C5	08/09/2003	Roach	18.6	ESMH
392	94698238	DC0024-E83B	08/09/2003	Dace	13.9	ESMH
393	94698240	DC0024-EA57	08/09/2003	Dace	14.3	ESMH
394	94698239	DC0024-EFCF	08/09/2003	Dace	16.7	ESMH
395	94698236		09/09/2003	Trout	22.8	ESMS 1
396	94698233		09/09/2003	Trout	21.4	ESMS 1
397	94698234		09/09/2003	Eel	49.7	ESMS 1
398	94698229		09/09/2003	Eel	32	ESMS 1
399	94698232		09/09/2003	Eel	32.7	ESMS 1
400	94698230		09/09/2003	Eel	37.2	ESMS 1
401	94698235		09/09/2003	Trout	28	ESMS 1
402	94698231		09/09/2003	Eel	33.4	ESMS 1
403	94698237		09/09/2003	Eel	41.3	ESMS 1
404	94698177	DC001C-0A92	09/09/2003	Dace	13.8	ESMS 2
405	94698178	DC001B-E867	09/09/2003	Dace	14.3	ESMS 2
406	94698157	DC001B-F6E3	09/09/2003	Dace	12.1	ESMS 2
407	94698179	DC001B-EF00	09/09/2003	Dace	16.5	ESMS 2
408	94698187	DC001C-07BF	09/09/2003	Dace	15.9	ESMS 2
409	94698191	DC0024-D1A3	09/09/2003	Dace	14.3	ESMS 2
410	94698167	DC001B-E3F3	09/09/2003	Dace	13.6	ESMS 2
411	94698192	DC001B-F781	09/09/2003	Dace	14.5	ESMS 2
412	94698188	DC001C-0118	09/09/2003	Dace	14.9	ESMS 2
413	94698149	DC001B-E2DE	09/09/2003	Dace	15.9	ESMS 2
414	94698171	DC001B-F18E	09/09/2003	Dace	13.7	ESMS 1
415	94698174	DC001B-EFEB	09/09/2003	Dace	15.5	ESMS 2
416	94698166	DC001B-F3A6	09/09/2003	Dace	15.1	ESMS 2
417	94698183	DC001B-EF45	09/09/2003	Pike	16.5	ESMS 2
418	94698181	DC001C-038A	09/09/2003	Dace	18.7	ESMS 2
419	94698175	DC0024-E57C	09/09/2003	Dace	14.8	ESMS 2
420	94698184	DC001B-E97C	09/09/2003	Dace	15.6	ESMS 2
421	94698176	DC001C-08B3	09/09/2003	Dace		ESMS 2
422	94698170	DC001B-EE85	09/09/2003	Dace	14	ESMS 2
423	94697175	DC001B-E499	09/09/2003	Dace	14.8	ESMS 2
424	94698165	DC001B-FDE5	09/09/2003	Dace	15.9	ESMS 2
425	94698168	DC001C-055D	09/09/2003	Dace	14.9	ESMS 2
426	94698169	DC001B-E722	09/09/2003	Dace		ESMS 2
427	94698198	DC0024-C90E	09/09/2003	Trout	27	ESMS 2
428	94698208	DC0024-D22C	09/09/2003	Dace	16.1	ESMS 2
429	94698180	DC0024-EAEA	09/09/2003	Dace	14.5	ESMS 2
430	94698193	DC0024-EC34	09/09/2003	Dace	14	ESMS 2

431	94698182	DC0024-D324	09/09/2003	Dace	12.9	ESMS 2
432	94698189	DC0024-D46E	09/09/2003	Dace	19.3	ESMS 2
433	94698186	DC0024-E8FB	09/09/2003	Dace	21.5	ESMS 2
434	94698190	DC0024-D4B7	09/09/2003	Dace	21.5	ESMS 2
435	94698185	DC0024-D993	09/09/2003	Dace	15	ESMS 2
436	94698173	DC00TB-E559	09/09/2003	Dace	16.8	ESMS 2
437	94698199	DC0024-E646	09/09/2003	Dace	16.1	ESMS 2
438	94698194	DC0024-CAE0	09/09/2003	Dace	16.3	ESMS 2
439	94698200	DC0024-D3BB	09/09/2003	Dace	16.7	ESMS 2
440	94698211	DC0024-F3BF	09/09/2003	Dace	15	ESMS 2
441	94698202	DC0024-E910	09/09/2003	Dace	14.8	ESMS 2
442	94698203	DC0024-E132	09/09/2003	Dace	13.4	ESMS 2
443	94698205	DC0024-CFE2	09/09/2003	Dace	15	ESMS 2
444	94698206	DC0024-E5FC	09/09/2003	Dace	14	ESMS 2
445	94698207	DC0024-DC73	09/09/2003	Dace	18.4	ESMS 2
446	94698210	DC0024-CAFF	09/09/2003	Dace	13.9	ESMS 2
447	94698209	DC0024-CEE2	09/09/2003	Dace	14.5	ESMS 2
448	35471119	DC0024-D013	09/09/2003	Dace	15.2	ESMS 2
449	94698197	DC0024-E0A5	09/09/2003	Dace	15.1	ESMS 2
450	94698196	DC0024-DC65	09/09/2003	Dace	14	ESMS 2
451	94698222		09/09/2003	Dace	19	ESMS 2
452	94698223		09/09/2003	Dace	15.2	ESMS 2
453	94698224		09/09/2003	Dace	15.3	ESMS 2
454	94698219		09/09/2003	Roach	13.6	ESMS 2
455	94698215		09/09/2003	Dace	12.8	ESMS 2
456	94698228	DC0024-E25B	09/09/2003	Dace	13.7	ESMS 2
457	94698201	DC0024-DB6F	09/09/2003	Dace		ESMS 2
458	94698204	DC0024-E84F	09/09/2003	Dace	12.5	ESMS 2
459	94698213		09/09/2003	Roach	15.6	ESMS 2
460	94698220	DC0024-D72C	09/09/2003	Dace	15.2	ESMS 2
461	94698212		09/09/2003	Dace	14.4	ESMS 2
462	94698218		09/09/2003	Dace	14.4	ESMS 2
463	94698214	DC0024-C03A	09/09/2003	Dace	13.5	ESMS 2
464	94698221	DC0024-E12A	09/09/2003	Dace	15.2	ESMS 2
465	94698227	DC0024-D05C	09/09/2003	Dace	18	ESMS 2
466	94698226	DC0024-DA72	09/09/2003	Dace	16.8	ESMS 2
467	94698225	DC0024-D21B	09/09/2003	Dace	14.5	ESMS 2
468	94698216	DC0024-CA5F	09/09/2003	Dace	15.4	ESMS 2
469	94698217	DC0024-D913	09/09/2003	Dace	15.3	ESMS 2
470	94698160	DC001C-0540	09/09/2003	Dace		ESMS 2
471	94698144	DC001B-E1BF	09/09/2003	Dace	12.2	ESMS 2
472	94698147	DC001B-F3A3	09/09/2003	Dace	15.5	ESMS 2
473	94698150	DC001B-F8A4	09/09/2003	Dace	14.5	ESMS 2
474	94698156	DC001B-E5FF	09/09/2003	Dace	14	ESMS 2
475	94698158	DC001C-0CF9	09/09/2003	Dace	16.4	ESMS 2
476	94698159	DC001B-E239	09/09/2003	Dace	15.9	ESMS 2
477	94698151	DC0024-E168	09/09/2003	Dace	14.9	ESMS 2
478	94698145	DC0024-DE86	09/09/2003	Dace	15.3	ESMS 2
479	94698155	DC0024-DE05	09/09/2003	Dace	19.9	ESMS 2
480	94698154	DC0024-CA8F	09/09/2003	Dace	15	ESMS 2
481	94698162	DC001B-F59E	09/09/2003	Dace	14.4	ESMS 2
482	94698163	DC0024-DCD5	09/09/2003	Dace	15.5	ESMS 2
483	94698164	DC0024-CB45	09/09/2003	Dace	15.3	ESMS 2
484	94698161	DC0024-CB20	09/09/2003	Dace	14.2	ESMS 2

485	94698172	DC0024-D18B	09/09/2003	Dace	14.3	ESMS 2
486	94698129	DC0024-D586	09/09/2003	Dace	15.5	ESMS 2
487	94698132	DC0024-E3DF	09/09/2003	Dace	13.9	ESMS 2
488	94698131	DC0024-C8CF	09/09/2003	Dace	15.3	ESMS 2
489	94698133	DC0024-C8A0	09/09/2003	Dace	16.4	ESMS 2
490	94698136	DC0024-CD98	09/09/2003	Dace	14.4	ESMS 2
491	94698134	DC0024-E32A	09/09/2003	Dace	13.8	ESMS 2
492	94698138	DC0024-E359	09/09/2003	Dace	17.4	ESMS 2
493	94698139	DC0024-EFA0	09/09/2003	Dace	13.3	ESMS 2
494	94698140	DC0024-E58D	09/09/2003	Dace	23	ESMS 2
495	94698127	DC0024-E4D2	09/09/2003	Dace	14.7	ESMS 2
496	94698128	DC0024-F0DE	09/09/2003	Dace	14.2	ESMS 2
497	94698141	DC0024-F228	09/09/2003	Dace	13.8	ESMS 2
498	94698146	DC0024-D404	09/09/2003	Dace	14.5	ESMS 2
499	94698130	DC0024-E171	09/09/2003	Dace	13.2	ESMS 2
500	94698024	DC0024-C825	09/09/2003	Dace	14.7	ESMS 2
501	94698142	DC0024-D8C8	09/09/2003	Dace	14.6	ESMS 2
502	94698126	DC0024-EF87	09/09/2003	Dace	13.5	ESMS 2
503	94698143	DC0024-CCC4	09/09/2003	Dace	18.2	ESMS 2
504	94698124	DC0024-D9B3	09/09/2003	Gudgeon	12.9	ESMS 2
505	94698010	DC0024-ED3E	09/09/2003	Eel	83.2	ESMS 2
506	94698120	DC0024-CB68	09/09/2003	Eel	43.8	ESMS 2
507	94698123	DC0024-DB77	09/09/2003	Eel	51.5	ESMS 2
508	94698122	DC0024-D5BA	09/09/2003	Dace	16.3	ESMS 2
509	94698052		10/09/2003	Pike	17	Luckford Lake 2
510	94698051		10/09/2003	Pike	23.7	Luckford Lake 2
511	94698048		10/09/2003	Pike		Luckford Lake 4
512	94698720	DC001B-F849	17/03/2003	Pike	36.9	Flood Relief 2
513	94698049		10/09/2003	Pike	38.7	Luckford Lake 4
514	113943625		05/12/2003	Pike	19.5	Luckford Lake 1
515	113943628		05/12/2003	Pike	66.5	Luckford Lake 2
516	113943626		05/12/2003	Pike	63	Luckford Lake 2
517		DC0024-F03B	05/12/2003	Sea trout	38	Luckford Lake 3
518	122451034	DC0024-CA89	05/12/2003	Pike	9.9	Luckford Lake 3
519		DC001C-00CA	05/12/2003	Sea trout	60	Luckford Lake 3
520	94698057		05/12/2003	Dace	21.1	Luckford Lake 4
521	113945695		05/12/2003	Roach	24.9	Luckford Lake 4
522			05/12/2003	Roach	17.9	Luckford Lake 4
523	113945694		05/12/2003	Dace	17	Luckford Lake 4
524	113945692		05/12/2003	Dace	17.7	Luckford Lake 4
525	113945691		05/12/2003	Roach	19.3	Luckford Lake 4
526	113945690		05/12/2003	Dace	16.7	Luckford Lake 4
527	113945689		05/12/2003	Roach	16.2	Luckford Lake 4
528	113945688		05/12/2003	Roach	17.1	Luckford Lake 4
529	113945687		05/12/2003	Dace	15.9	Luckford Lake 4
530	113945686		05/12/2003	Roach	18.2	Luckford Lake 4
531	113945685		05/12/2003	Dace	15	Luckford Lake 4
532	113945684		05/12/2003	Roach	14	Luckford Lake 4
533	113945683		05/12/2003	Roach	14.2	Luckford Lake 4
534	113945679		05/12/2003	Roach		Holme Bridge 3
535	113945678		05/12/2003	Roach	14.5	Holme Bridge 3
536	113945677		05/12/2003	Roach	15.8	Holme Bridge 3
537	113945676		05/12/2003	Pike	22.2	Holme Bridge 4
538	113945675		05/12/2003	Pike	25.4	Holme Bridge 4

539	113945671		08/12/2003	Pike	19.5	Railway 3
540	113945672		08/12/2003	Pike	19.3	Railway 3
541	113945670		08/12/2003	Pike	31.5	Railway 4
542	113945669		08/12/2003	Pike	19	Railway 4
543	113945668		08/12/2003	Pike	18.5	Railway 4
544	113945665	DC0024-E7F9	08/12/2003	Pike	371	Flood Relief 2
545	113945664	DC0024-C982	08/12/2003	Pike	45.2	Flood Relief 2
546	113945667	DC0024-8473	08/12/2003	Pike	27.4	Flood Relief 2
547	113945663		08/12/2003	Roach	17.3	Goldsacs
548	113945662		08/12/2003	Roach	22.5	Goldsacs 4
549	113945661		08/12/2003	Dace	20.4	Goldsacs 4
550	113945659		08/12/2003	Eel	31.5	ESMS 1
551	113945660		08/12/2003	Eel	31.5	ESMS 1
552	94698075	DC001B-F379	09/09/2003	Trout	23.3	ESMS 3
553	113945658		08/12/2003	Eel	41	ESMS 1
554	94698345	DC001C-6D6D	15/04/2003	Pike	62	ESMS
555	94609082	DC001B-EF48	08/12/2003	Trout	19.4	ESMS 3
556	113945657		08/12/2003	Eel	38	ESMS 3
557	113945656		08/12/2003	Eel	37	ESMS 3
558	113945655		08/12/2003	Eel	38.5	ESMS 3
559	113945654		08/12/2003	Eel	36.8	ESMS 3
560	113945653		08/12/2003	Eel	31.5	ESMS 3
561	94698050		09/09/2003	Trout	19.5	ESMS 4
562		DC0024-EB3F	09/12/2003	Pike	10.9	Rushton 1
563	122451030	DC002B-174A	08/12/2003	Pike	11.5	Rushton 1
564	113945652		08/12/2003	Pike	24	ESMS 2
565		DC0024-7A22	09/12/2003	Pike	10.4	ESMS 2
566	113945651		09/12/2003	Pike	22.5	ESMS 2
567	113945650		09/12/2003	Pike	17.2	ESMS 4
568	113945649		09/12/2003	Pike	14.7	Rushton Extra
569		DC0024-928A	09/12/2003	Pike	122.2	Rushton Extra
570	35471204	DC002A-F470	09/12/2003	Pike	12.1	Rushton Extra
571		DC0024-CB21	09/12/2003	Pike	12.3	Rushton Extra
572		DC0024-8516	09/12/2003	Pike	12.4	Rushton Extra
573	113945648		07/01/2004	Pike	38	ESMS above lilypool
574	113945647		07/01/2004	Pike	43.3	DS Cattle drink
575	113945646		07/01/2004	Pike	40.8	DS Cattle drink
576	113945645		07/01/2004	Dace	23.7	ESMS above weir
577	113945642		07/01/2004	Dace	23.1	ESMS above weir
578	113945643		07/01/2004	Dace	23.8	ESMS eel trap
579	113945644		07/01/2004	Dace	24.2	ESMS eel trap
580	113945641		07/01/2004	Dace	24.1	ESMS eel trap
581	113945639		07/01/2004	Dace	24.2	ESMS eel trap
582	113945632		07/01/2004	Dace	22.6	ESMS eel trap
583	113945633		07/01/2004	Roach	18	ESMS eel trap
584	113945631		07/01/2004	Dace	22.1	ESMS eel trap
585	113945635		07/01/2004	Dace	16.8	ESMS eel trap
586	113945636		07/01/2004	Roach	15.6	ESMS eel trap
587	113945637		07/01/2004	Roach	17.3	ESMS eel trap
588	113945634		07/01/2004	Roach	15.8	ESMS eel trap
589	113945629		07/01/2004	Dace	15.9	ESMS eel trap
590	113945630		07/01/2004	Dace	14.5	ESMS eel trap
591	113945623		07/01/2004	Dace	16.4	ESMS eel trap
592	113945625		07/01/2004	Dace	15.6	ESMS eel trap

593	113945638		07/01/2004	Roach	16.2	ESMS eel trap
594	113945628		07/01/2004	Roach	15	ESMS eel trap
595	124086110	DC002B-O8O8	23/02/2004	Pike	73.4	Main River Frome Weirpool
596	124086111	DC002A-FC2D	23/02/2004	Pike	59.4	Main River Frome Weirpool - T4
597	124086112	DC002A-FCA2	23/02/2004	Pike	54.7	Main River Frome Weirpool - T4
598	94698339	DC001C-AB91	16/04/2003	Pike	54.5	Main River Frome Weirpool
599	113943630	DC002A-FCE0	23/02/2004	Pike	40	Main River Frome Weirpool - T4
600	124086114	DC0024-EE51	23/02/2004	Pike	80	Main River Frome T3
601	124086116	DC002A-FB7D	23/02/2004	Pike	91	Main River Frome T9
602	94698340	DC001C-85C3		Pike	57.2	Main River Frome Weirpool
603	124086117	DC002B-O3B3	23/02/2004	Pike	69.5	Main River Frome T9
604	124086118	DC002B-1BDF	23/02/2004	Pike	57.5	Main River Frome T7 - T9
605	124086119	DC002B-0C0B	23/02/2004	Pike	61.2	Main River Frome T7 - T9
606	124086120	DC002B-12F5	23/02/2004	Pike	59.8	Main River Frome T15
607	124086121	DC002A-F201	23/02/2004	Pike	57.5	Main River Frome T15
608	124086122	DC002B-1CF7	23/02/2004	Pike	70	Main River Frome T15
609	124086123	DC002B-0297		Pike	72.8	Main River Frome T15
610	124086124	DC002B-11D6	23/02/2004	Pike	52.5	Main River Frome T15
611	124086210	DC002B-0CD8	24/02/2004	Pike	58.5	Main River Frome T20
612	124086125	DC002A-FA15	24/02/2004	Pike	69.6	Main River Frome T22 - T25
613	124086126	DC002A-F50B	24/02/2004	Pike	58.9	Main River Frome T22 - T25
614		DC002B-16FC	24/02/2004	Pike	11.6	Main River Frome T22 - T25
615	124086127	DC002B-0D10	24/02/2004	Pike	102	Main River Frome T22 - T25
616	124086115		24/02/2004	Perch	34.2	Main River Frome T25 - T30
617	124086128		24/02/2004	Roach	18.4	Main River Frome T25 - T30
618	124086129			Pike	67.3	Main River Frome MS - Rushton
619	124086131		24/02/2004	Pike	69.2	Main River Frome MS - Rushton
620	124086130		24/02/2004	Pike	90	Main River Frome MS - Rushton
621	124086133		24/02/2004	Pike	64	Main River Frome MS - Rushton
622	94698715		18/03/2003	Pike	48	Rushton 4
623	124086134		24/02/2004	Pike	23.6	Main River Frome MS - Rushton
624	124086135		24/02/2004	Pike	69.5	Main River Frome Oxbow
625	94698716		18/03/2003	Pike	51.5	Rushton 4
626	124086136		24/02/2004	Pike	91.9	Main River Frome Oxbow
627	124086137		24/02/2004	Pike	68.5	Main River Frome Holme Bridge
628	94698719		18/03/2003	Pike	65	ESMS 1
629	94698718	DC001C-793C	18/03/2003	Pike	61.5	ESMS 3
630	98698118	DC0024-DCF4	09/09/2003	Gudgeon	12.7	ESMS 2
631	94698119	DC0024-E533	09/09/2003	Dace	15.2	ESMS 2
632	94698117	DC0024-E0DD	09/09/2003	Dace	16	ESMS 2

633	94698113	DC0024-EC36	09/09/2003	Dace	12.6	ESMS 2
634	94698112	DC0024-DCB9	09/09/2003	Dace	17.9	ESMS 2
635	94698116	DC0024-09BB	09/09/2003	Dace	15.2	ESMS 2
636	94698115	DC0024-F2AF	09/09/2003	Dace	15.7	ESMS 2
637	94698105	DC0024-DC59	09/09/2003	Dace	15.1	ESMS 2
638	94698109	DC0024-C8DA	09/09/2003	Dace	13.5	ESMS 2
639	94698106	DC0024-DE01	09/09/2003	Dace	12.4	ESMS 2
640	94698111	DC0024-CE9A	09/09/2003	Dace	13.4	ESMS 2
641	94698114	DC0024-ED0F	09/09/2003	Dace	14.5	ESMS 2
642	94698110	DC0024-CA18	09/03/2003	Dace	14.8	ESMS 2
643	94698104	DC0024-DEE4	09/09/2003	Dace	14.4	ESMS 2
644	94698108	DC0024-CDEF	09/09/2003	Dace	12.9	ESMS 2
645	94698103	DC001B-E952	09/09/2003	Gudgeon	13.1	ESMS 2
646	94698094	DC001C-0456	09/09/2003	Pike	16.3	ESMS 2
647	94698097	DC001C-0B51	09/09/2003	Dace	14.3	ESMS 2
648	94698095	DC001B-F171	09/09/2003	Dace	14.7	ESMS 2
649	94698099	DC001B-EBCF	09/09/2003	Dace	16.2	ESMS 2
650	94698101	DC001B-F576	09/09/2003	Dace	14.7	ESMS 2
651	94698096	DC001B-F587	09/09/2003	Dace	19.2	ESMS 2
652	94698098	DC001B-E56F	09/09/2003	Dace	12.3	ESMS 2
653	94698102	DC001C-0BA7	09/09/2003	Eel	50	ESMS 2
654	94698093	DC001C-0457	09/09/2003	Gudgeon	13.4	ESMS 2
655	94698091	DC001B-EE53	09/09/2003	Eel	37	ESMS 2
656	94698092	DC001C-0774	09/09/2003	Eel	48	ESMS 2
657	94698089	DC0024-D90D	09/09/2003	Eel	37.5	ESMS 2
658	94698084	DC001C-0406	09/09/2003	Eel	35	ESMS 2
659	94698087	DC0024-DBE8	09/09/2003	Eel	36	ESMS 2
660	94698086	DC001B-E95C	09/09/2003	Eel	35.5	ESMS 2
661	94698085	DC001B-FCB6	09/09/2003	Eel	36.8	ESMS 2
662	94698090	DC001B-E6F3	09/09/2003	Eel	37.6	ESMS 2
663	94698088	DC001C-06BA	09/09/2003	Eel	36	ESMS 2
664	94698073	DC001B-FF59	09/09/2003	Trout	21.9	ESMS 3
665	94698082	DC001B-E7AE	09/09/2003	Trout	19.4	ESMS 3
666	94698068	DC001C-0AF8	09/09/2003	Eel	36	ESMS 3
667	94698080	DC001B-E744	09/09/2003	Dace	13.3	ESMS 3
668	94698069	DC001C-0BC9	09/09/2003	Eel	43	ESMS 3
669	94698074	DC001C-0AEB	09/09/2003	Eel	43.8	ESMS 3
670	94698063	DC001B-EFEA	09/09/2003	Eel	45	ESMS 3
671	94698062	DC001B-FF22	09/09/2003	Eel	51	ESMS 3
672	94698078	DC001C-0BD1	09/09/2003	Eel	43	ESMS 3
673	94698071	DC001B-E4DD	09/09/2003	Eel	42	ESMS 3
674	94698070	DC001B-E3BB	09/09/2003	Eel	44	ESMS 3
675	94698065	DC0024-CD6C	09/09/2003	Eel	54	ESMS 3
676	94698066	DC0024-DC82	09/09/2003	Eel	41	
677	94698064		09/09/2003	Eel	46.5	ESMS 3
678	94698059	DC0024-0992	09/09/2003	Eel	31	ESMS 3
679	94698056	DC0024-DFFC	09/09/2003	Eel	35.5	ESMS 3
680	94698058	DC0024-EDAB	09/09/2003	Eel	58	ESMS 3
681	94698076		09/09/2003	Eel	35	ESMS 3
682	94698072		09/09/2003	Eel	33	ESMS 3
683	94698060		09/09/2003	Eel	37.5	ESMS 3
684	94698081		09/09/2003	Eel	42.5	ESMS 3
685	94698067		09/09/2003	Eel	37	ESMS 3
686	94698079		09/09/2003	Eel	37	ESMS 3

687	94698077		09/09/2003	Eel	33	ESMS 3
688	94698061		09/09/2003	Trout	31.5	ESMS 4
689	94698055		09/09/2003	Eel	34.5	ESMS 4
690	94698054		09/09/2003	Eel	49	ESMS 4
694	124086194	DC002B-145A	04/03/2004	Dace	21.8	ESMS ds eel pool
695	124086205	DC002B-1CC2	04/03/2004	Roach	15.6	ESMS ds eel pool
696	124086208	DC002B-05D1	04/03/2004	Dace	15.5	ESMS ds eel pool
697	124086196	DC002A-F3A8	04/03/2004	Dace	15.6	ESMS ds eel pool
698	124086204	DC002B-12B7	04/03/2004	Roach	13.5	ESMS eel pool
700	124086200	DC002B-0A98	04/03/2004	Roach	13.2	ESMS eel pool
701	124086193	DC002B-0521	04/03/2004	Roach	22.5	ESMS eel pool
702	124086198	DC002B-12B6	04/03/2004	Dace	20.9	ESMS eel pool
703	124086201	DC002B-15B9	04/03/2004	Dace	18.3	ESMS eel pool
704	124086206	DC002A-FC7D	04/03/2004	Roach	18.7	ESMS eel pool
705	124086199	DC002A-FA48	04/03/2004	Dace	16.6	ESMS eel pool
706	124086197	DC002B-OD63	04/03/2004	Dace	14.2	ESMS eel pool
707	124086202	DC002B-15C6	04/03/2004	Pike	41.3	ESMS eel pool
708	124086209	DC002B-1684	04/03/2004	Dace	20.5	ESMS eel pool
709	124086195	DC002B-1478	04/03/2004	Dace	23.9	ESMS eel pool
710	124086186	DC002A-F2AC	04/03/2004	Dace	17	ESMS eel pool
711	124086192	DC002B-1AE7	04/03/2004	Roach	17.2	ESMS eel pool
712	124086190	DC002A-F43A	04/03/2004	Roach	13.7	ESMS eel pool
713	124086189	DC002A-F249	04/03/2004	Roach	16.9	ESMS eel pool
715	124086191	DC002A-F355	04/03/2004	Roach	13.8	ESMS eel pool
716	124086171	DC002B-06CP	04/03/2004	Roach	14.2	ESMS eel pool
717	124086166	DC002A-F6F9	04/03/2004	Dace	16	ESMS eel pool
718	124086178	DC002B-1846	04/03/2004	Dace	16.5	ESMS eel pool
719	124086175	DC002A-F1EA	04/03/2004	Dace	18.1	ESMS eel pool
721	124086177	DC002B-1ADD	04/03/2004	Roach	14.9	ESMS eel pool
722	124086169	DC002B-0C32	04/03/2004	Roach	16.3	ESMS eel pool
724	124086173	DC002A-F4F4	04/03/2004	Dace	13.5	ESMS eel pool
725	124086167	DC002A-FB06	04/03/2004	Dace	13.5	ESMS eel pool
726	124086174	DC002A-F670	04/03/2004	Dace	21.3	ESMS eel pool
728	124086142	DC002B-169B	04/03/2004	Dace	16.1	ESMS eel pool
729	124086138	DC002A-FF0C	04/03/2004	Dace	22.8	ESMS eel pool
730	124086139	DC002B-1B21	04/03/2004	Dace	16.5	ESMS eel pool
731	124086143	DC002B-0358	04/03/2004	Dace	16	ESMS eel pool
732	124086140	DC002B-060C	04/03/2004	Dace	14.6	ESMS eel pool
733	124086147	DC002B-161F	04/03/2004	Dace	15.9	ESMS eel pool
735	124086146	DC002B-1AEC	04/03/2004	Dace	14.6	ESMS eel pool
737	124086144	DC002B-149D	04/03/2004	Dace	13.5	ESMS eel pool
738	124086145	DC002B-0443	04/03/2004	Dace	13.4	ESMS eel pool
739	124086148	DC002B-008F	04/03/2004	Dace	12.9	ESMS eel pool
740	124086141	DC002A-F699	04/03/2004	Roach	13.4	ESMS eel pool
747	124086163	DC0024-E8B3		Roach	15.4	ESMS eel pool
748	124086161	DC002B-0336	04/03/2004	Dace	14.6	ESMS eel pool
749		DC002A-FD22	04/03/2004	Roach	12.7	ESMS eel pool
752	124086162	DC002A-FFFA	04/03/2004	Dace	15.5	ESMS eel pool
753	124086159	DC002A-FA72	04/03/2004	Dace	13	ESMS eel pool
754	124086160	DC002A-F51B	04/03/2004	Dace	14	ESMS eel pool
755	124086150	DC002A-FB3A	04/03/2004	Roach	14.1	ESMS eel pool
757	124086149	DC002B-0917	04/03/2004	Dace	14.4	ESMS eel pool
758	124086158	DC002A-FB55	04/03/2004	Dace	13.1	ESMS eel pool
759	124086184	DC002B-1303	04/03/2004	Dace	21.9	ESMS eel pool

760	124086207	DC002A-FE06	04/03/2004	Dace	22.3	ESMS eel pool
761	124086182	DC002B-1D47	04/03/2004	Dace	15.7	ESMS eel pool
763	124086185	DC002B-0946	04/03/2004	Dace	17.3	ESMS eel pool
764	124086188	DC0020-0D28	04/03/2004	Dace	16.3	ESMS eel pool
765	124086180	DC002B-0201	04/03/2004	Dace	15.8	ESMS eel pool
766	124086187	DC002B-1B8E	04/03/2004	Dace	14.4	ESMS eel pool
768	124086179	DC002B-1268	04/03/2004	Dace	15.7	ESMS eel pool
769	124086181	DC002B-05FB	04/03/2004	Dace	13.2	ESMS eel pool
770	124086183	DC002B-0F5B	04/03/2004	Roach	15.7	ESMS eel pool
771	124086168	DC002B-1560	04/03/2004	Dace	21.5	ESMS eel pool
772	124086176	DC002A-FF15	04/03/2004	Dace	16.5	ESMS eel pool
773	124086170	DC002B-044F	04/03/2004	Dace	13.8	ESMS eel pool
775	124086172	DC002B-1075	04/03/2004	Dace	15.4	ESMS eel pool
776	113943629	DC002B-15EC	16/03/2004	Pike	70.9	Main River Frome Weirpool - T4
777	113945666	DC002A-F712	16/03/2004	Pike	59.8	Main River Frome Weirpool - T4
778	113943657	DC002B-0F4C	16/03/2004	Pike	65.2	Main River Frome Weirpool - T4
779	113945615		16/03/2004	Dace	19.7	Main River Frome 150 m above Oxbow
780	113945616		16/03/2004	Dace	26	Main River Frome 150 m above Oxbow
781	113945614		16/03/2004	Dace	26.1	Flood relief entrance
782	113945613		16/03/2004	Dace	26.5	Flood relief entrance
783	113945612		16/03/2004	Dace	22.9	Flood relief entrance
784	113945611		16/03/2004	Dace	25.5	Flood relief entrance
785	113945610		16/03/2004	Dace	21.8	Flood relief entrance
786	113945609	DC002B-1C1F	16/03/2004	Dace	21.1	Flood relief entrance
787	113945608	DC002A-F7BA	16/03/2004	Dace	21.2	Flood relief entrance
788	113945607	DC002B-0C14	16/03/2004	Dace	19.4	Flood relief entrance
789	113945606	DC0024-E1D7	16/03/2004	Dace	22.6	Flood relief entrance
790	113945605	DC002A-F5FB	16/03/2004	Dace	21.7	Flood relief entrance
791	113945603	DC002B-00B7	16/03/2004	Dace	20.8	Flood relief entrance
792	113945602	DC002A-F467	16/03/2004	Dace	20.5	Flood relief entrance
793	113945600	DC002A-F7AE	16/03/2004	Dace	22.3	ds road bridge
794	113945601	DC0024-7DCE	16/03/2004	Dace	21.5	ds road bridge
795	113945599	DC002B-0E6A	16/03/2004	Dace	22.8	ds road bridge
796	113945598	DC002B-080F	16/03/2004	Dace	21.7	ds road bridge
797	113945597		16/03/2004	Dace	23.2	Main River Frome Weirpool - T4
798	113945596		16/03/2004	Dace	23.8	Main River Frome Weirpool - T4
799	113945595		16/03/2004	Dace	22.9	Main River Frome Weirpool - T4
800	113945594		16/03/2004	Dace	20.3	Main River Frome Weirpool - T4
801	113945593		16/03/2004	Dace	20.8	Main River Frome Weirpool - T4
802	113945592		17/03/2004	Dace	24.9	ESMS 2
803	113945591		17/03/2004	Dace	27.1	ESMS 2
804	113945590		17/03/2004	Dace	22.4	ESMS 2
805	113945589		17/03/2004	Dace	23.2	ESMS 2
806	113945588		17/03/2004	Dace	23.2	ESMS 2
807	113943735		17/03/2004	Dace	24.2	ESMS 2
808	113943741		17/03/2004	Dace	22.5	ESMS 2

809	113943734		17/03/2004	Dace	23.9	ESMS 2
810	113943736		17/03/2004	Dace	20.4	ESMS 2
811	113943742		17/03/2004	Dace	20.6	ESMS 2
812	113943738		17/03/2004	Dace	20.9	ESMS 2
813	113943740		17/03/2004	Dace	25	ESMS 2
814	·113943743		17/03/2004	Dace	19.4	ESMS 2
815	113943737		17/03/2004	Dace	20.2	ESMS 2
816	113943739		17/03/2004	Dace	21.4	ESMS 2
817	113943733		17/03/2004	Dace	18	ESMS 2
818	113943732		17/03/2004	Dace	17.4	ESMS 2
819	113943731		17/03/2004	Dace	18.5	ESMS 2
820	113943730		17/03/2004	Dace	20.5	ESMS 3
821	113943729		17/03/2004	Dace	23.7	ESMS 3
822	113943728		17/03/2004	Dace	18.7	ESMS 3
823	113943727		17/03/2004	Pike	14.8	Rushton 1
824	113943726		17/03/2004	Pike	14.2	Rushton 2
826	0	DC002A-FC1D	17/03/2004	Pike	10.3	Rushton 2
827	113943725		17/03/2004	Pike	42.5	Rushton 4
828	113943724		17/03/2004	Pike	13.5	Rushton 4
829	35471184	DC002A-F234	17/03/2004	Pike	12.8	Rushton 4
830	35471228	DC002B-130A	17/03/2004	Pike	12.6	Rushton 4
831	113943723		18/03/2004	Dace	22.5	Luckford Lake 1
832	113943722		18/03/2004	Perch	25.9	Luckford Lake 3
833	113943714		18/03/2004	Dace	25	Luckford Lake 4
834	113943712		18/03/2004	Dace	25.8	Luckford Lake 4
835	113943716		18/03/2004	Dace	21	Luckford Lake 4
836	113943715		18/03/2004	Roach	18.9	Luckford Lake 4
837	113943713		18/03/2004	Roach	16.7	Luckford Lake 4
838	113943719		18/03/2004	Roach	18.9	Luckford Lake 4
839	113943717		18/03/2004	Roach	17.8	Luckford Lake 4
840	113943720		18/03/2004	Roach	21.8	Luckford Lake 4
841	113943721		18/03/2004	Dace	18.7	Luckford Lake 4
842	113943660		18/03/2004	Roach	17.3	Luckford Lake 4
843	113943663		18/03/2004	Pike	22.4	Luckford Lake 4
844	113943661		18/03/2004	Perch	22.4	Luckford Lake 4
845	113943662		18/03/2004	Roach	20.6	Luckford Lake 4
846	113943658		18/03/2004	Dace	17.6	Luckford Lake 4
847	113943659		18/03/2004	Roach	16.5	Luckford Lake 4
848	113943665		18/03/2004	Dace	15	Luckford Lake 4
849	94698042		17/03/2004	Roach	16.8	ESMS
850	94698039		17/03/2004	Pike	16.5	ESMS
851	94698041		17/03/2004	Dace	13.4	ESMS
852	94698043		17/03/2004	Dace	16.1	ESMS
853	94698047		17/03/2004	Dace	12.5	ESMS
854	94698044		17/03/2004	Dace	14	ESMS
855	94698045		17/03/2004	Roach	20.7	ESMS
856	94698046		17/03/2004	Pike	37.8	ESMS
857	94698040		17/03/2004	Roach	18.5	ESMS
859	113943615		17/03/2004	Roach	18.9	ESMS
860	113943616		17/03/2004	Roach	19.9	ESMS
861	113943614		17/03/2004	Dace	26.5	ESMS
862	113943613		17/03/2004	Roach	18	ESMS
863	113943619		17/03/2004	Dace	23.5	ESMS
864	113943612		17/03/2004	Dace	22.3	ESMS

865	113943623		17/03/2004	Roach	19.7	ESMS
866	113943621		17/03/2004	Roach	18.3	ESMS
867	113943620		17/03/2004	Roach	16.2	ESMS
868	113943622		17/03/2004	Roach	19.2	ESMS
869	113943624		17/03/2004	Roach	17.7	ESMS
870	113943617		17/03/2004	Dace	0	ESMS Eel Pool
872	124086157	DC001B-F16F	17/03/2003	Pike	11.9	Railway 1
873	124086155	DC001B-EBF8	17/03/2003	Pike	11.8	Railway 2
874	94698728	DC001B-EF17	17/03/2003	Pike	24	Railway 3
875	124086154	DC002A-F3AE	12/03/2004	Pike	26.8	Railway 3
876	124086153	DC002B-05B7	12/03/2004	Pike	21.5	Railway 4
877	124086151	DC0024-CA6A	12/03/2004	Perch	22.9	Flood Relief
878	124086152		12/03/2004	Perch	28.4	Flood Relief
880	113943634		15/03/2004	Pike	63.5	Goldsacs 1
881	113943635		15/03/2004	Dace	25.1	Goldsacs 3
882	113943636		15/03/2004	Dace	21.2	Goldsacs 3
883	113943637		15/03/2004	Dace	15.4	Goldsacs 3
884	113943638		15/03/2004	Dace	28.7	Goldsacs 4
885	113943640		15/03/2004	Dace	21.9	Goldsacs 4
886	113943641		15/03/2004	Dace	24.8	Goldsacs 4
887	113943642		15/03/2004	Dace	23.5	Goldsacs 4
888	113943643		15/03/2004	Dace	20.2	Goldsacs 4
889	113943653		15/03/2004	Dace	23.4	Goldsacs 4
890	113943618		15/03/2004	Dace	24.1	Goldsacs 4
891	113943644		15/03/2004	Dace	25.8	Goldsacs 4
892	113943645		15/03/2004	Dace	34.2	Goldsacs 4
893	113943646		15/03/2004	Dace	22.6	Goldsacs 4
894	113943647		15/03/2004	Dace	22.3	Goldsacs 4
895	113943648		15/03/2004	Dace	23.7	Goldsacs 4
896	113943649		15/03/2004	Roach	18.9	Goldsacs 4
897	113943650		15/03/2004	Dace	17.5	Goldsacs 4
898	113943651		15/03/2004	Dace	20.9	Goldsacs 4
899	113943652		15/03/2004	Dace	22.4	Goldsacs 4
900	113943654		15/03/2004	Dace	16.4	Goldsacs 4
901	113943655		15/03/2004	Dace	15.8	Goldsacs 4
902	113943656		15/03/1941	Dace	19.7	Goldsacs 4
903	113943633		15/03/2004	Pike	21.3	Holme Bridge 3
904	113943632		15/03/2004	Pike	50.1	Holme Bridge 3
905	113943668		04/06/2003	Dace	20.3	Wareham Quay
906	122451025		19/07/2004	Pike	22.2	
907	122451109		19/07/2004	Pike	14.1	Rushton 2
910	122451107		19/07/2004	Pike		ESMS
911		DC002A-FA53	20/07/2004	Pike	9.2	Flood Relief 2
912		DC002A-FD80	20/07/2004	Pike	10	Flood Relief 2
913	122451153		20/07/2004	Pike	21	Main River Frome 80m DS of Rushton
914	35471189		21/06/2004	Eel	29	Railway 2
915	35471244		21/06/2004	Eel	43	Railway 2
916	35471239		21/06/2004	Eel	31	Railway 4
917	35471233		22/06/2004	Pike	32.5	Rushton 1
918	35471220		22/06/2004	Pike	20.1	Rushton
919	35471203		22/06/2004	Pike	20.6	Rushton
920		DC002A-F300	22/06/2004	Pike	6.5	Rushton 2
921	35471219		22/06/2004	Eel	43	Rushton

922	113943671		22/06/2004	Pike	28.8	Rushton 2
923	35471187		22/06/2004	Pike	39.5	Holme Bridge 4
924		DC0029-EB76	22/06/2004	Pike	6.3	Holme Bridge 4
925	113943664		22/06/2004	Pike	32	Holme Bridge
926	35471195		23/06/2004	Dace	16.8	ESMS 1
927	35471191		23/06/2004	Dace	12.1	ESMS 1
928	35471202		23/06/2004	Dace	16.9	ESMS 1
929	35471237		23/06/2004	Dace	14.9	ESMS 1
930	35471230		23/06/2004	Eel	39.8	ESMS 1
931	35471175		23/06/2004	Eel	47.5	ESMS 1
932	35471185		23/06/2004	Gudgeon	13.3	ESMS 1
933	35471120		23/06/2004	Dace	16.6	ESMS 1
934	35471121		23/06/2004	Dace	15.6	ESMS 1
935	35471123		23/06/2004	Roach	11.7	ESMS 1
936	35471122		23/06/2004	Eel	37.9	ESMS 1
937	35471174		23/06/2004	Eel	30.5	ESMS 1
938	35471173		23/06/2004	Trout	20.4	ESMS 1
939	35471177		23/06/2004	Eel	52	ESMS 1
940	35471176		23/06/2004	Dace	16.6	ESMS 2
941	35471167		23/06/2004	Trout	19.4	ESMS 2
942	35471172		23/06/2004	Dace	14.2	ESMS 2
943	35471162		23/06/2004	Dace	12.4	ESMS 2
944	35471169		23/06/2004	Roach	12.2	ESMS 2
945	35471163		23/06/2004	Roach	13.8	ESMS 2
946	35471165		23/06/2004	Eel	31	ESMS 2
947	35471156		23/06/2004	Eel	41.5	ESMS 2
948	35471168		23/06/2004	Roach	14.2	ESMS 2
949	35471160		23/06/2004	Eel	34	ESMS 2
950	35471159		23/06/2004	Eel	45	ESMS 2
951	35471158		23/06/2004	Eel	40.5	ESMS 2
952	35471151		23/06/2004	Eel	33	ESMS 2
953	35471150		23/06/2004	Eel	46	ESMS 2
954	35471152		23/06/2004	Eel	34.5	ESMS 2
955	35471155		23/06/2004	Eel	46.8	ESMS 2
956	35471143		23/06/2004	Eel	51	ESMS 3
957	35471139		23/06/2004	Eel	28.5	ESMS 3
958	35471144		23/06/2004	Eel	45.8	ESMS 3
959	35471138		23/06/2004	Eel	35.6	ESMS
960	35471132		23/06/2004	Eel	40.5	ESMS 4
962	35471125		23/06/2004	Eel	30.5	ESMS 4
963	35471128		23/06/2004	Eel	36	ESMS 4
964	35471129		23/06/2004	Eel	33.9	ESMS 4
965	35471124		23/06/2004	Eel	29	ESMS 4
966	35471136		23/06/2004	Eel	33.5	ESMS 4
967	35471166		23/06/2004	Dace	15.5	ESMS 4
968	35471192		23/06/2004	Dace	14.4	ESMS 4
969	94698687		23/06/2004	Dace	34.3	Holme Bridge 2
970	35471164		23/06/2004	Dace	16.2	ESMS 4
971	35471137		23/06/2004	Roach	14.6	ESMS 2
972	35471161		23/06/2004	Roach	15.8	ESMS 2
973	35471145		23/06/2004	Roach	14.1	ESMS 400m US
974	113943677		23/06/2004	Dace	16	ESMS 400m US
975	122451103		23/06/2004	Pike	47.5	ESMS 400m US
976	122451138		23/06/2004	Dace	15.3	ESMS 400m US

977	122451142	23/06/2004	Perch	22.4	ESMS 750m US
978	122451182	23/06/2004	Roach	17.4	ESMS 800m US
979	122451095	23/06/2004	Roach	16.1	ESMS 800m US
980	122451162	23/06/2004	Dace	15.3	ESMS 800m US
981	122451128	23/06/2004	Dace	15.1	ESMS 800m US
982	122451113	23/06/2004	Roach	14.8	ESMS 800m US
983	122451093	23/06/2004	Dace	17	ESMS 800m US
984	122451105	23/06/2004	Dace	16.9	ESMS 800m US
985	122451102	23/06/2004	Roach	15.3	ESMS 800m US
986	35471140	23/06/2004	Dace	15.6	ESMS 800m US
987	122451116	23/06/2004	Dace	16	ESMS
988	122451130	23/06/2004	Roach	15.1	ESMS 800m US
989	122451155	23/06/2004	Roach	15.2	ESMS 800m US
990	122451159	23/06/2004	Roach	16.9	ESMS 800m US
991	122451108	23/06/2004	Roach	14.7	ESMS 800m US
992	122451158	23/06/2004	Dace	16.6	ESMS 800m US
993	122451134	23/06/2004	Dace	14.9	ESMS 800m US
994	122451173	23/06/2004	Dace	18	ESMS 860m US
995	122451156	23/06/2004	Dace	16.4	ESMS 860m US
996	122451167	23/06/2004	Dace	15.3	ESMS 860m US
997	122451148	23/06/2004	Roach	14.6	ESMS 860m US
998	122451115	23/06/2004	Dace	14.7	ESMS 860m US
999	122451178	23/06/2004	Dace	17.2	ESMS 860m US
1000	122451123	23/06/2004	Dace	15.1	ESMS 860m US
1001	35471135	23/06/2004	Dace	17.1	ESMS 860m US
1002	122451160	23/06/2004	Dace	17.2	ESMS 860m US
1003	122450377	23/06/2004	Dace	16.5	ESMS 860m US
1004	122451097	23/06/2004	Dace	15.5	ESMS 860m US
1005	122451057	24/06/2004	Dace	16.9	ESMS 3
1006	122451179	24/06/2004	Roach	14.4	ESMS 3
1007	122451053	24/06/2004	Dace	15.5	ESMS 3
1008	122451145	24/06/2004	Roach	17	ESMS 3
1009	122451037	24/06/2004	Roach	17.5	ESMS 3
1010	35471126	24/06/2004	Dace	22.1	ESMS 3
1011	122451125	24/06/2004	Roach	20.8	ESMS
1012	122451099	24/06/2004	Dace	18.1	ESMS 3
1013	122451084	24/06/2004	Dace	15.5	ESMS 3
1014	122451066	24/06/2004	Dace	18.5	ESMS 3
1015	122451071	24/06/2004	Dace	19.8	ESMS 3
1016	122451072	24/06/2004	Dace	17.5	ESMS 3
1017	122451136	24/06/2004	Dace	14.9	ESMS 3
1018	122451129	24/06/2004	Dace	20.5	ESMS above smolt counter
1019	122451032	24/06/2004	Dace	15.8	ESMS above smolt counter
1020	122451074	24/06/2004	Dace	16.4	ESMS above smolt counter
1021	122451119	24/06/2004		16.2	ESMS above smolt counter
1022	122451069	24/06/2004	Roach	13.9	ESMS above smolt counter
1023	12245069		Dace	15.8	ESMS above smolt counter
1024	122451046	24/06/2004	Dace	15.2	ESMS above smolt counter
1025	35471153	24/06/2004	Roach	17.2	ESMS above smolt

						counter
1026	122451169		24/06/2004	Dace	16	ESMS above smolt counter
1027	122450379		24/06/2004	Dace	17	ESMS above smolt counter
1028		DC0029-FD0A	03/06/2004	Dace	14.6	Redcliff
1029	122451141		24/06/2004	Dace	16.2	ESMS above smolt counter
1030	122450383		24/06/2004	Dace	15.2	ESMS above smolt counter
1031	122451014		24/06/2004	Dace	14.7	ESMS above smolt counter
1032	122451012		24/06/2004	Dace	15.7	ESMS above smolt counter
1033	35471141		24/06/2004	Dace	16	ESMS above smolt counter
1034	122451183		24/06/2004	Dace	15.3	ESMS above smolt counter
1035	122451004		24/06/2004	Dace	15.3	ESMS above smolt counter
1036	122451083		24/06/2004	Dace	16.2	ESMS above smolt counter
1037	122451100		24/06/2004	Dace	16.04	ESMS above smolt counter
1038	122451061		24/06/2004	Roach	25.1	ESMS above smolt counter
1039	122451039		24/06/2004	Dace	15.2	ESMS above smolt counter
1040	122451040		24/06/2004	Dace	17.8	ESMS above smolt counter
1041	35471146		24/06/2004	Dace	17.9	ESMS above smolt counter
1042	122451073		24/06/2004	Dace	23.4	ESMS above smolt counter
1043	122451033		24/06/2004	Dace	18.1	ESMS above smolt counter
1044	122451058		24/06/2004	Dace	16.1	
1045	122451059		24/06/2004	Dace	17.4	ESMS above smolt counter
1047	122451031		24/06/2004	Roach	16.9	ESMS above smolt counter
1048	122451052		24/06/2004	Dace	15.4	ESMS above smolt counter
1049	35471130		24/06/2004	Roach	18.7	ESMS above smolt counter
1050	122451175		24/06/2004	Dace	24	ESMS above smolt counter
1051	122451082		24/06/2004	Dace	14.2	ESMS above smolt counter
1052	122451042		24/06/2004	Dace	13.9	ESMS above smolt counter
1053	122451092		24/06/2004	Dace	14.5	ESMS above smolt counter
1054	122451006		24/06/2004	Perch	23.5	ESMS above smolt counter
1055	122451001		24/06/2004	Dace	17.6	ESMS above smolt counter
1056	122451177		24/06/2004	Roach	19.4	ESMS above smolt counter
1057	122451151		24/06/2004	Dace	22.2	ESMS above smolt

						counter
1058	122451016		24/06/2004	Dace	14.7	ESMS above smolt counter
1059	35471134		24/06/2004	Dace	16.4	ESMS above smolt counter
1060	122451137		24/06/2004	Dace	15.1	ESMS above smolt counter
1061	122451122		24/06/2004	Dace	12.9	ESMS above smolt counter
1062	122451000		24/06/2004	Dace	13.4	ESMS above smolt counter
1063	122451045		24/06/2004	Dace	18.2	ESMS above smolt counter
1069	122450384	DC0024-D72B	17/09/2004	Dace	19	ESMS 2
1070	122451163	DC002B-17A6	17/09/2004	Dace	23	ESMS 2
1071	122451114	DC0024-E5C0	17/09/2004	Dace	18.9	ESMS 2
1072	122451077	DC002B-1376	17/09/2004	Dace	21.8	ESMS 2
1073	122451044	DC002A-FBAA	17/09/2004	Dace	20.4	ESMS 2
1074	122451051	DC0024-7C89	17/09/2004	Dace	19	ESMS 2
1075	122451088	DC0024-91E4	17/09/2004	Dace	20.1	ESMS 2
1076	122451081	DC0024-D924	17/09/2004	Dace	19.3	ESMS 2
1077	122451121	DC0024-DCC2	17/09/2004	Dace	19	ESMS 2
1078	122450731		17/02/2005	Roach	19.1	Wareham Quay
1079		DC002B-10D8	17/02/2005	Roach	21	Wareham Quay
1080		DC0029-F07F	17/02/2005	Roach	26.7	Wareham Quay
1081		DC0029-EAD7	17/02/2005	Dace	24.2	Wareham Quay
1082		DC0024-F2CB	17/02/2005	Roach	22.4	Wareham Quay
1083		DC002B-1A9E	17/02/2005	Dace	24.6	Wareham Quay
1084		DC0024-8F42	17/02/2005	Roach	22.5	Wareham Quay
1085		DC0024-EECD	17/02/2005	Dace	19.8	Wareham Quay
1086		DC0024-D19A	17/02/2005	Roach	20.1	Wareham Quay
1087		DC002B-0992	17/02/2005	Roach	24.4	Wareham Quay
1088		DC0024-757F	17/02/2005	Dace	25.5	Wareham Quay
1089		DC002B-16DF	17/02/2005	Roach	29.9	Wareham Quay
1090		DC0024-CBD0	17/02/2005	Roach	23.1	Wareham Quay
1091		DC002B-1C3D	17/02/2005	Roach	21	Wareham Quay
1092		DC0024-E3A4	17/02/2005	Dace	25.4	Wareham Quay
1093		DC002B-18AF	17/02/2005	Roach	20.1	Wareham Quay
1094		DC002B-13BE	17/02/2005	Roach	24.2	Wareham Quay
1095		DC002A-F7BF	17/02/2005	Dace	25.4	Wareham Quay
1096		DC0024-7419	17/02/2005	Dace	19.6	Wareham Quay
1097		DC002B-07CE	17/02/2005	Roach	36	Wareham Quay
1098		DC0024-DF8C	17/02/2005	Dace	26.4	Wareham Quay
1099		DC002A-FB9A	17/02/2005	Roach	22.2	Wareham Quay
1100		DC001B-E6D1	18/03/2003	Pike	12.7	Rushton
1101	94698717		18/03/2003	Pike	17.9	Rushton
1102	94698714		18/03/2003	Pike	44.6	Rushton
1246	113943700		03/06/2004	Dace	19.1	Redcliff
1247		DC0029-EF4D	03/06/2004	Dace	14.2	Redcliff
1248	35471211		03/06/2004	Dace	19.1	Redcliff
1249	35471223		03/06/2004	Dace	16.2	Redcliff
1250		DC002A-139F	03/06/2004	Dace	21.7	Redcliff
2000		DC002B-1140	17/02/2005	Dace	21.2	Wareham Quay
2001		DC0024-E91D	17/02/2005	Roach	26	Wareham Quay
2002		DC0024-F0EC	17/02/2005	Roach	22.1	Wareham Quay

2003		DC0024-DC07	17/02/2005	Roach	20.1	Wareham Quay
2004		DC002B-103C	17/02/2005	Roach	22.1	Wareham Quay
2005		DC0024-E608	17/02/2005	Dace	22	Wareham Quay
2006		DC0024-9945	17/02/2005	Roach	38.5	Wareham Quay
2007		DC0024-89B3	17/02/2005	Roach	18.3	Wareham Quay
2008		DC002B-0E17	17/02/2005	Dace	25.2	Wareham Quay
2009		DC002A-F9F1	17/02/2005	Roach	21.6	Wareham Quay
2010		DC0024-DA1B	17/02/2005	Roach	21.1	Wareham Quay
2011	35471199		03/06/2004	Dace	21.1	Redcliff
2012		DC0024-D718	17/02/2005	Roach	18.7	Wareham Quay
2013		DC002A-FF8D	17/02/2005	Dace	18	Wareham Quay
2014		DC0024-74AF	17/02/2005	Roach	22.2	Wareham Quay
2015		DC002B-0271	17/02/2005	Dace	22.5	Wareham Quay
2016		DC0024-E0B5	17/02/2005	Roach	18.2	Wareham Quay
2017		DC002A-F4D0	17/02/2005	Roach	20.1	Wareham Quay
2018		DC002B-06BB	17/02/2005	Roach	20.5	Wareham Quay
2019		DC0024-8983	17/02/2005	Hybrid	21.8	Wareham Quay
2020		DC0024-82B2	17/02/2005	Bream	33.1	Wareham Quay
2021		DC0024-98B9	17/02/2005	Dace	20.2	Wareham Quay
2022		DC0024-D6AF	17/02/2005	Roach	18.3	Wareham Quay
2023		DC002B-004B	17/02/2005	Dace	20.5	Wareham Quay
2024		DC0024-DB9A	17/02/2005	Dace	20.2	Wareham Quay
2025		DC0024-E9A8	17/02/2005	Roach	19.1	Wareham Quay
2026		DC0024-82C4	17/02/2005	Dace	18.5	Wareham Quay
2027		DC002B-1BDB	17/02/2005	Dace	22.8	Wareham Quay
2028		DC002A-F65C	17/02/2005	Roach	22.4	Wareham Quay
2029		DC002B-0058	17/02/2005	Roach	25.6	Wareham Quay
2030		DC002B-0ACE	17/02/2005	Roach	18.9	Wareham Quay
2031	122451164		17/09/2004	Dace	19	ESMS 3
2032		DC0024-8225	17/02/2005	Dace	16.3	Wareham Quay
2033		DC0024-7BEE	17/02/2005	Roach	22.9	Wareham Quay
2034		DC002B-15E1	17/02/2005	Dace	18.3	Wareham Quay
2035	35471245		03/06/2004	Dace	0	Redcliff
2036		DC002A-FB16	17/02/2005	Dace	15.2	Wareham Quay
2037		DC0024-DFDF	17/02/2005	Dace	16.7	Wareham Quay
2038		DC002B-1664	17/02/2005	Dace	15.5	Wareham Quay
2039	122450738		17/02/2005	Roach	32	Wareham Quay
2040	127178942		17/02/2005	Roach	22	Wareham Quay
2041	127178979		17/02/2005	Roach	23.5	Wareham Quay
2042	127178941		17/02/2005	Roach	23.4	Wareham Quay
2043	127178940		17/02/2005	Roach	14.1	Wareham Quay
2044	127178939		17/02/2005	Dace	26.7	Wareham Quay
2045	127178938		17/02/2005	Dace	20.1	Wareham Quay
2046	127178937		17/02/2005	Roach	18.8	Wareham Quay
2047	127178936		17/02/2005	Dace	23.5	Wareham Quay
2048	127178935		17/02/2005	Dace	19.5	Wareham Quay
2049	127178934		17/02/2005	Dace	24.1	Wareham Quay
2050	127178933		17/02/2005	Roach	32.6	Wareham Quay
2051	127178932		17/02/2005	Dace	14.6	Wareham Quay
2052	127178981		17/02/2005	Roach	24.7	Wareham Quay
2053	127178980		17/02/2005	Dace	24.1	Wareham Quay
2054	122450702		17/02/2005	Roach	21.4	Wareham Quay
2055	122450703		17/02/2005	Dace	27.1	Wareham Quay
2056	122450704		17/02/2005	Dace	26.8	Wareham Quay

2057	122450705		17/02/2005	Dace	25.9	Wareham Quay
2058	122450706		17/02/2005	Roach	18.2	Wareham Quay
2059	122450707		17/02/2005	Roach	33	Wareham Quay
2060	122450710		17/02/2005	Dace	23.9	Wareham Quay
2061	122450708		17/02/2005	Roach	19.9	Wareham Quay
2062	122450709		17/02/2005	Dace	25.4	Wareham Quay
2063	122450711		17/02/2005	Roach	19.2	Wareham Quay
2064	122450712		17/02/2005	Dace	22.2	Wareham Quay
2065	122450713		17/02/2005	Roach	21.9	Wareham Quay
2066	122450714		17/02/2005	Dace	17.7	Wareham Quay
2067	122450715		17/02/2005	Roach	23.6	Wareham Quay
2068	122450716		17/02/2005	Roach	20	Wareham Quay
2069	122450717		17/02/2005	Bream	32.2	Wareham Quay
2070	122450718		17/02/2005	Roach	20.9	Wareham Quay
2071	122450719		17/02/2005	Dace	24.3	Wareham Quay
2072	122450720		17/02/2005	Roach	32.7	Wareham Quay
2073	122450721		17/02/2005	Dace	15.5	Wareham Quay
2074	122450722		17/02/2005	Roach	34.4	Wareham Quay
2075	122450723		17/02/2005	Dace	18.7	Wareham Quay
2076	122450724		17/02/2005	Roach	34.2	Wareham Quay
2077	122450725		17/02/2005	Roach	18	Wareham Quay
2078	122450726		17/02/2005	Roach	16.5	Wareham Quay
2079	122450727		17/02/2005	Roach	18.1	Wareham Quay
2080	122450728		17/02/2005	Roach	21.1	Wareham Quay
2081	122450729		17/02/2005	Roach	17	Wareham Quay
2082	122450730		17/02/2005	Roach	18	Wareham Quay
2083	122450732		17/02/2005	Roach	23.9	Wareham Quay
2084	122450733		17/02/2005	Roach	22.5	Wareham Quay
2085	122450734		17/02/2005	Roach	22.1	Wareham Quay
2086	122450735		17/02/2005	Dace	17.8	Wareham Quay
2087	122450736		17/02/2005	Dace	18.5	Wareham Quay
2088	122450737		17/02/2005	Dace	18	Wareham Quay
2089		DC0024-7C26	16/02/2005	Dace	14.4	Redcliff
2090		DC0024-90A9	16/02/2005	Dace	14.4	Redcliff
2091		DC002B-16F7	16/02/2005	Dace	20.2	Redcliff
2092		DC002B-106D	16/02/2005	Dace	20.7	Redcliff
2093		DC0024-92F9	16/02/2005	Dace	17.9	Redcliff
2094		DC0024-EB93	16/02/2005	Dace	15.8	Redcliff
2095	113945673	DC001B-FA0C	17/03/2003	Pike	11	Railway 1
2096	122450769	DC001B-FF91	17/03/2003	Pike	12.3	Railway 1
2097	94698734	DC001B-E824	17/03/2003	Pike	38	Railway 1
2098		DC001B-FFF1	17/03/2003	Pike	10.3	Railway 1
2099	94698733	DC001B-E7AF	17/03/2003	Pike	31.1	Railway
2100		DC001C-0907	17/03/2003	Pike	13.2	Railway 2
2101	94698735	DC001B-F464	17/03/2003	Pike	25	Railway 2
2102		DC001B-EFF7	17/03/2003	Pike	11.5	Railway 2
2103	94698732	DC001B-FAC9	17/03/2003	Pike	32	Railway 2
2104	94698731	DC001B-EA63	17/03/2003	Pike	17.9	Railway 2
2105	94698730	DC001B-EDF1	17/03/2003	Pike	19.4	Railway 2
2106	94698729	DC001B-F62E	17/03/2003	Pike	24.4	Railway 2
2107	96498727	DC001C-01F1	17/03/2003	Pike	29.1	Railway 3
2108	94698726	DC001C-018C	17/03/2003	Pike	26.2	Railway 3
2109	94698725	DC001B-F5C4	17/03/2003	Pike	31.2	Railway 4
2110	94698724	DC001C-07E6	17/03/2003	Pike	41.5	Railway 4

2111	94698723	DC001C-025A	17/03/2003	Pike	22	Railway 4
2112	94698722	DC001B-F412	17/03/2003	Pike	45.9	Railway 4
2113	122450754		18/04/2005	Pike	42.7	Rushton 1
2114		DC001C-02C5	17/03/2003	Roach	8.1	Flood Relief 1
2115		DC001B-FDC0	17/03/2003	Pike	14.4	Flood Relief 2
2116		DC001B-E400	17/03/2003	Roach	10.4	Flood Relief
2117	113945627		25/01/2004	Grayling	26	ESMS
2118	113945624		25/01/2004	Grayling	25.8	ESMS
2119	113945626		25/01/2004	Grayling	28.8	ESMS
2120	113945622		25/01/2004	Grayling	24.8	ESMS
2121	113945621		25/01/2004	Grayling	26.5	ESMS
2122	113945620		25/01/2004	Grayling	18	ESMS
2123	113945619		25/01/2004	Grayling	14.8	ESMS
2124		DC0096-D7AB	25/07/2000	Pike	27.4	Rushton
2125		DC001B-F929	20/03/2003	Dace	7.7	Main River Frome Holme Bridge
2126		DC001C-0C8D	20/03/2003	Roach	11.5	Holme Bridge 3
2127	94698686		20/03/2003	Pike	70.2	Holme Bridge 4
2128	122451026		25/06/2004	Eel	35.8	Holme Bridge
2129	113949675		25/06/2004	Pike	27.1	Holme Bridge 200-250m
2130	122451028		25/06/2004	Pike	34	Holme Bridge 400-450m
2131	122451101		25/06/2004	Pike	27.5	Holme Bridge 400-450m
2132	94698338	DC001C-A03A	16/04/2003	Pike	71.5	Main River Frome Weirpool
2133	94698337	DC001C-97CB	16/04/2003	Pike	70.2	Main River Frome Weirpool
2134	94698336	DC001C-68A0	16/04/2003	Pike	22.6	Main River Frome T6-T9
2135	94698335	DC001C-933D	16/04/2003	Pike	21.4	Main River Frome Weirpool
2136	94698333		16/04/2003	Dace	18.4	Main River Frome Weirpool
2137	35471198		23/06/2004	Dace	16.8	ESMS
2139	35474435		23/06/2004	Dace	17.1	ESMS
2140	122491162		23/06/2004	Dace	15.3	ESMS
2141	113949636		23/06/2004	Roach	17.7	ESMS
2143	35471133		23/06/2004	Eel	37	ESMS 4
2144		DC002B-1769	23/06/2004	Salmon	11.5	ESMS 300m US
2145		DC002A-F8AA	21/06/2004	Pike	6.5	Flood relief 1
2151		DC002A-0FDC	03/06/2004	Dace	20.4	Redcliff
2152	35471180		03/06/2004	Dace	14.3	Redcliff
2153		DC0029-FB2F	03/06/2004	Dace	22.9	Redcliff
2154	35471231		03/06/2004	Dace	15	Redcliff
2155		DC002A-052D	03/06/2004	Dace	15.5	Redcliff
2156	35471221		03/06/2004	Dace	24.6	Redcliff
2157		DC0029-FE7F	03/06/2004	Dace	22.3	Redcliff
2158	35471181		03/06/2004	Dace	18	Redcliff
2159		DC002A-00F3	03/06/2004	Dace	23.8	Redcliff
2160	35471193		03/06/2004	Dace	17.4	Redcliff
2161		DC002A-0FE8	03/06/2004	Dace	22.6	Redcliff
2162	35471226		03/06/2004	Dace	15.4	Redcliff
2163		DC002A-0339	03/06/2004	Dace	15.2	Redcliff
2164		DC002A-0DC5	03/06/2004	Dace	21.7	Redcliff
2165		DC0029-FAB6	03/06/2004	Dace	15.6	Redcliff
2166		DC0029-F00F	03/06/2004	Dace	22.2	Redcliff
2167		DC0029-EE11	03/06/2004	Dace	20.8	Redcliff

2168		DC002A-14B4	03/06/2004	Dace	13	Redcliff
2169		DC0024-F2D9	03/06/2004	Dace	19.9	Redcliff
2170		DC002A-0622	03/06/2004	Dace	16.7	Redcliff
2171		DC002A-0246	03/06/2004	Dace	16.5	Redcliff
2172		DC0029-F4A2	03/06/2004	Dace	16	Redcliff
2173		DC0029-F3CF	03/06/2004	Dace	15.1	Redcliff
2174		DC0029-EF10	03/06/2004	Dace	13.1	Redcliff
2175		DC0029-F443	03/06/2004	Dace	21.9	Redcliff
2176		DC0029-FF96	03/06/2004	Dace	0	Redcliff
2177		DC0029-F848	03/06/2004	Dace	23.2	Redcliff
2178		DC0029-FDF1	03/06/2004	Dace	24.2	Redcliff
2179		DC002A-0352	03/06/2004	Dace	21.2	Redcliff
2180		DC0029-FBA5	03/06/2004	Dace	22.2	Redcliff
2181		DC002A-14FF	03/06/2004	Dace	20.8	Redcliff
2182		DC0029-F480	03/06/2004	Dace	16.9	Redcliff
2183		DC002A-0180	03/06/2004	Dace	15.8	Redcliff
2184		DC0029-ECAC	01/03/1964	Dace	14.9	Redcliff
2185		DC0029-F7BA	03/06/2004	Dace	23.4	Redcliff
2186		DC0029-EF66	03/06/2004	Dace	16.1	Redcliff
2187		DC002A-0130	03/06/2004	Dace	18.3	Redcliff
2188		DC002A-1472	03/06/2004	Dace	14.6	Redcliff
2189		DC0029-F17A	03/06/2004	Dace	14.3	Redcliff
2190		DC002A-016D	03/06/2004	Dace	23.3	Redcliff
2191		DC002A-1427	03/06/2004	Dace	14.2	Redcliff
2192		DC002A-0030	03/06/2004	Dace	15	Redcliff
2193		DC0029-EB60	03/06/2004	Dace	13.7	Redcliff
2194		DC002A-1141	03/06/2004	Dace	14.2	Redcliff
2195	35471186		03/06/2004	Dace	18.4	Redcliff
2196	35471235		03/06/2004	Dace	24.9	Redcliff
2197	35471210		03/06/2004	Dace	18.7	Redcliff
2198	35471249		03/06/2004	Dace	21.1	Redcliff
2199	35471196		03/06/2004	Dace	19.6	Redcliff
2200	35471240		03/06/2004	Dace	15.7	Redcliff
2201	35471188		03/06/2004	Dace	20.6	Redcliff
2202	35471217		03/06/2004	Dace	22.7	Redcliff
2203	35471218		03/06/2004	Dace	22.2	Redcliff
2204	35471246		03/06/2004	Dace	22.2	Redcliff
2205	35471238		03/06/2004	Dace	21.9	Redcliff
2206	35471213		03/06/2004	Dace	20.3	Redcliff
2207	35471236		03/06/2004	Dace	21.5	Redcliff
2208	35471197		03/06/2004	Dace	22.8	Redcliff
2209	35471190		03/06/2004	Dace	19.8	Redcliff
2210	35471178		03/06/2004	Dace	18.4	Redcliff
2211	35471242		03/06/2004	Dace	16	Redcliff
2212	35471208		03/06/2004	Dace	21.3	Redcliff
2213	35471212		03/06/2004	Dace	17.8	Redcliff
2214	35471229		03/06/2004	Dace	16	Redcliff
2215	35471247		03/06/2004	Dace	15.2	Redcliff
2216	35471216		03/06/2004	Dace	15.5	Redcliff
2217	35471222		03/06/2004	Dace	20.6	Redcliff
2218	35471248		03/06/2004	Dace	24.6	Redcliff
2219	35471201		03/06/2004	Dace	18.4	Redcliff
2220	35471207		03/06/2004	Dace	15	Redcliff
2221	35471205		03/06/2004	Dace	21.6	Redcliff

2222	35471243		03/06/2004	Dace	25.4	Redcliff
2223	35471234		03/06/2004	Dace	23.9	Redcliff
2224	35471241		03/06/2004	Dace	20.7	Redcliff
2225	35471209		03/06/2004	Dace	15.1	Redcliff
2226	35471179		03/06/2004	Dace	16.8	Redcliff
2227	35471215		03/06/2004	Dace	0	Redcliff
2228	113943696		03/06/2004	Dace	20.9	Redcliff
2229		DC0029-FDBD	03/06/2004	Dace	16.5	Redcliff
2230		DC0029-4602	03/06/2004	Dace	20.2	Redcliff
2231		DC002A-162F	03/06/2004	Dace	19.9	Redcliff
2232		DC0029-EF5D	03/06/2004	Dace	13.3	Redcliff
2233	113943667	DC0029-F25E	03/06/2004	Dace	14.8	Redcliff to Wareham Quay
2234	113943694	DC0029-EC2B	03/06/2004	Dace	21.4	Redcliff to Wareham Quay
2235	113943704	DC0029-FA4E	03/06/2004	Dace	19.2	Redcliff to Wareham Quay
2236	113943695	DC0029-4050	03/06/2004	Dace	18.6	Redcliff to Wareham quay
2237		DC0029-EC7A	03/06/2004	Dace	19	Redcliff to Wareham Quay
2238	113943984		03/06/2004	Dace	15.6	Redcliff to Wareham Quay
2239	113943673		03/06/2004	Dace	17	Redcliff to Wareham Quay
2240		DC002A-00CC	03/06/2004	Dace	21.3	Redcliff to Wareham Quay
2241	113943690		03/06/2004	Dace	25	Redcliff to Wareham Quay
2242		DC0029-F5AC	03/06/2004	Dace	18.4	Redcliff to Wareham Quay
2243	113943693		04/06/2003	Dace	24	Wareham Quay
2244	113943691		03/06/2004	Dace	20.1	Redcliff to Wareham quay
2245	113943703		03/06/2004	Dace	15.2	Redcliff to Wareham quay
2246	113943698		03/06/2004	Dace	21.2	Redcliff to Wareham quay
2247	113943681		03/06/2004	Dace	22.3	Redcliff to Wareham quay
2248	113943682		03/06/2004	Dace	16.5	Redcliff to Wareham quay
2249	113943701		03/06/2004	Dace	15.8	Wareham quay to Redcliff
2250	113943702		03/06/2004	Dace	21.8	Wareham quay to Redcliff
2251	113943676		03/06/2004	Dace	19.7	Wareham quay to Redcliff
2252	113943672		03/06/2004	Dace	23.3	Wareham quay to Redcliff
2253	113943686		03/06/2004	Dace	20.4	Wareham quay to Redcliff
2254	113943675		03/06/2004	Dace	16.2	Wareham quay to Redcliff
2255	113943678		03/06/2004	Dace	21.8	Wareham quay to Redcliff
2256	113943689		03/06/2004	Dace	20.5	Wareham quay to Redcliff
2257	113943674		04/06/2003	Dace	17	Wareham Quay

2258	113943687		03/06/2004	Dace	15.5	Wareham quay to Redcliff
2259	113943685		04/06/2003	Dace	0	Wareham Quay
2260	113943670		03/06/2004	Dace	28	Wareham quay to Redcliff
2261	113943679		03/06/2004	Dace	14.7	Wareham quay to Redcliff
2262	113943705		03/06/2004	Dace	16.2	Wareham quay to Redcliff
2263	113943692		03/06/2004	Dace	19.8	Wareham quay to Redcliff
2264	113943683		03/06/2004	Dace	20.4	Wareham quay to Redcliff
2265	113943680		03/06/2004	Dace	20	Wareham quay to Redcliff
2266	113943666		03/06/2004	Dace	18	Wareham quay to Redcliff
2267	113943697		03/06/2004	Dace	16.2	Wareham quay to Redcliff
2268	113943699		03/06/2004	Dace	18	Wareham quay to Redcliff
2269	113943669		03/06/2004	Dace	17.1	Wareham quay to Redcliff
2270	113943688		03/06/2004	Dace	16.2	Wareham quay to Redcliff
2271		DC0029-FFFE	03/06/2004	Dace	21.4	Wareham quay to Redcliff
2272		DC0029-FC8D	03/06/2004	Dace	15.4	Wareham quay to Redcliff
2273		DC002A-04D8	03/06/2004	Dace	23.1	Wareham quay to Redcliff
2274		DC0029-F83B	03/06/2004	Dace	22.2	Wareham quay to Redcliff
2275		DC0029-F767	03/06/2004	Dace	21.8	Wareham quay to Redcliff
2276		DC0029-EE37	03/06/2004	Dace	17.4	Wareham quay to Redcliff
2277		DC002A-1261	03/06/2004	Dace	21.8	Wareham quay to Redcliff
2278		DC0029-F054	03/06/2004	Dace	17.2	Wareham quay to Redcliff
2279		DC002A-045B	03/06/2004	Dace	20.5	Wareham quay to Redcliff
2280		DC002A-11BC	03/06/2004	Dace	24.4	Wareham quay to Redcliff
2281		DC002A-136D	03/06/2004	Dace	16.2	Wareham quay to Redcliff
2282		DC0029-FFA6	03/06/2004	Dace	15.2	Wareham quay to Redcliff
2283		DC002A-129F	03/06/2004	Dace	15.3	Wareham quay to Redcliff
2284		DC002A-0822	03/06/2004	Dace	16.1	Wareham quay to Redcliff
2285		DC002A-1678	03/06/2004	Dace	14.3	Wareham quay to Redcliff
2286		DC002A-15C9	03/06/2004	Dace	27.3	Wareham quay to Redcliff
2287		DC002A-0653	03/06/2004	Dace	20.8	Wareham quay to Redcliff
2288		DC002A-1304	03/06/2004	Dace	12.8	Wareham quay to

						Redcliff
2289		DC002A-0878	03/06/2004	Dace	17.8	Wareham quay to Redcliff
2290		DC0029-EE2F	03/06/2004	Dace	27.2	Wareham quay to Redcliff
2291		DC0029-F63E	03/06/2004	Dace	19.8	Wareham quay to Redcliff
2292		DC0029-F7E8	03/06/2004	Dace	20.5	Wareham quay to Redcliff
2293		DC002A-04A8	03/06/2004	Dace	24.2	Wareham quay to Redcliff
2294		DC0029-ECF7	03/06/2004	Dace	17.4	Wareham quay to Redcliff
2295		DC002A-0335	03/06/2004	Dace	15.4	Wareham quay to Redcliff
2296		DC002A-11A2	03/06/2004	Dace	15.4	Wareham Quay to Redcliff
2297		DC002A-0272	03/06/2004	Dace	25	Wareham quay to Redcliff
2298		DC0029-EF28	03/06/2004	Dace	20.8	Wareham quay to Redcliff
2299		DC002A-088F	03/06/2004	Dace	15.7	Wareham quay to Redcliff
2300	35471182		04/06/2003	Dace	23.2	Wareham Quay
2301		DC0029-F6F5	04/06/2003	Dace	21.2	Wareham Quay
2302	35471227		04/06/2003	Dace	24.5	Wareham Quay
2303		DC002A-1420	04/06/2003	Dace	26.5	Wareham Quay
2304	35471206		04/06/2003	Dace	24	Wareham Quay
2305		DC002A-109A	04/06/2003	Dace	14.2	Wareham Quay
2306		DC0029-F819	04/06/2003	Dace	20.7	Wareham Quay
2307	35471232		04/06/2003	Dace	23.1	Wareham Quay
2308		DC002A-1315	04/06/2003	Dace	22.8	Wareham Quay
2309	35471194		04/06/2003	Dace	23.8	Wareham Quay
2310		DC002A-1660	04/06/2003	Dace	23.3	Wareham Quay
2311	35471224		04/06/2003	Dace	19.7	Wareham Quay
2312		DC002A-0194	04/06/2003	Dace	15	Wareham Quay
2313	122451131		17/09/2004	Dace	14	ESMS 1
2314	122451011		17/09/2004	Dace	15.5	ESMS 1
2315	122451062		17/09/2004	Dace	13.7	ESMS 1
2316	122451076		17/09/2004	Dace	12.4	ESMS 2
2317	122451070		17/09/2004	Dace	12.4	ESMS 2
2318	122451165		17/09/2004	Dace	12	ESMS 2
2319		DC0024-CB6A	17/09/2004	Dace	43	ESMS 2
2320	122451143		17/09/2004	Dace	20.1	ESMS 2
2321		DC002B-0B72	13/09/2004	Pike	7.9	Railway 1
2322		DC002B-0448	13/09/2004	Pike	9.1	Railway 1
2323	122450618	DC002B-110A	13/09/2004	Pike	10.2	Railway 1
2324		DC002B-16F2	13/09/2004	Pike	9.5	Railway 1
2325		DC002B-10A1	13/09/2004	Pike	10	Railway 1
2326		DC002A-F9F0	13/09/2004	Pike	8.9	Railway 3
2327		DC002B-08B4	13/09/2004	Pike	10	Railway 3
2328	122451091	DC0024-8883	13/09/2004	Pike	24	Railway 4
2329	122451049		14/09/2004	Pike	13.3	Flood Relief 3
2340		DC002B-0065	14/09/2004	Dace	12.3	Goldsacs 1
2341	122451117		15/09/2004	Pike	16.2	Holme Bridge 1
2342	122451161		15/09/2004	Pike	13.9	Holme Bridge 1

2343		DC0024-D368	15/09/2004	Pike	10.5	Holme Bridge 4
2344		DC002B-18C8	15/09/2004	Pike	10	Holme bridge 4
2345		DC0029-FB59	15/09/2004	Pike	9.6	Holme Bridge Extra
2346	122451010		16/09/2004	Pike	19.2	Luckford Lake 4
2347	122451180		17/09/2004	Dace	13.1	ESMS 3
2348	122451027		17/09/2004	Dace	15.4	ESMS 3
2349	35471131		17/09/2004	Dace	17.2	ESMS 3
2350	122451015		17/09/2004	Dace	18.7	ESMS 3
2351	122451140		17/09/2004	Dace	15	ESMS 3
2352	122451096		17/09/2004	Dace	15.6	ESMS 3
2353	122451029		17/09/2004	Dace	14.2	ESMS 3
2354	122451087		17/09/2004	Dace	17.5	ESMS 3
2355	122451157		17/09/2004	Dace	18.1	ESMS 3
2356	122451067		17/09/2004	Dace	14.8	ESMS 3
2357	122451008		17/09/2004	Dace	18.2	ESMS 3
2358	122451080		17/09/2004	Dace	18	ESMS 3
2359	122451002		17/09/2004	Dace	19.8	ESMS 3
2360	122451035		17/09/2004	Dace	18	ESMS 3
2361	122451174		17/09/2004	Dace	17.6	ESMS 3
2362	122451064		17/09/2004	Dace	18.5	ESMS 3
2363	122451126		17/09/2004	Dace	18.3	ESMS 3
2364	122450381		17/09/2004	Dace	18.9	ESMS 3
2365	35471142		17/09/2004	Dace	17.3	ESMS 3
2366	122451047		17/09/2004	Dace	18.3	ESMS 3
2367	122451171		17/09/2004	Dace	18.4	ESMS 3
2368	122451139		17/09/2004	Dace	16.5	ESMS 3
2369	122451060		17/09/2004	Dace	14.5	ESMS 3
2370	122451063		17/09/2004	Dace	40	ESMS 3
2371	122451086		17/09/2004	Eel	47.5	ESMS 3
2372	122451009		17/09/2004	Eel	34.6	ESMS 3
2373		DC0029-FA3C	06/12/2004	Pike	11.2	Railway 1
2374		DC0024-DD32	06/12/2004	Pike	11.3	Railway 1
2375	122450770		06/12/2004	Pike	31	Railway 3
2376	122450780		06/12/2004	Pike	26.4	Railway 3
2377		DC002A-1396	06/12/2004	Pike	12.1	Railway 4
2378		DC002A-0C3C	06/12/2004	Pike	11.8	Railway 4
2379	122451166		06/12/2004	Pike	27.5	Flood Relief 1
2380	122450995		06/12/2004	Pike	24.5	Flood Relief 1
2381	122451135		06/12/2004	Pike	20.2	Flood Relief 1
2382	34571148		06/12/2004	Pike	18.3	Flood Relief 1
2383	122451017		06/12/2004	Pike	13.5	Flood Relief 1
2384	122451144		06/12/2004	Pike	18.5	Flood Relief 2
2385	122450999			Pike	13.5	Flood Relief 2
2386	122451127		07/12/2004	Pike	37.4	Rushton 1
2387	122451149		07/12/2004	Pike	36.4	Rushton 1
2388	122451075		07/12/2004	Pike	20.5	Rushton 1
2389	122451055		07/12/2004	Pike	16.7	Rushton 1
2390	122451152		07/12/2004	Pike	30.5	Rushton 1
2391	122451022		07/12/2004	Perch	18.9	Rushton 2
2392	122450380		07/12/2004	Pike	16.4	Rushton 4
2393		DC002A-15DF	07/12/2004	Pike	10.5	Rushton 4
2394	122450771		08/12/2004	Pike	19.2	Holme Bridge 1
2395	122450774		08/12/2004	Pike	26	Holme Bridge 1
2396	122450773		08/12/2004	Pike	22.3	Holme Bridge 4

2397	122450776		08/12/2004	Pike	26.9	Holme Bridge 4
2398		DC002B-0795	08/12/2004	Pike	10.7	Holme Bridge 4
2399	122450992		08/12/2004	Pike	24	Holme Bridge 4
2400		DC0024-EC61	08/12/2004	Pike	10.8	Holme Bridge 4
2401		DC002B-18D4	08/12/2004	Pike	13.6	Holme Bridge 4
2402	122451106		08/12/2004	Pike	35	Holme Bridge Extra
2403	122450782		08/12/2004	Pike	30.9	Holme Bridge Extra
2404		DC002A-FC06	08/12/2004	Pike	9.5	Holme Bridge Extra
2405		DC002B-0022	08/12/2004	Pike	11	Holme Bridge Extra
2406	122450778		09/12/2004	Eel	39.5	ESMS 1
2407	122450987		09/12/2004	Eel	47.5	ESMS 1
2408	122450781		09/12/2004	Eel	34.6	ESMS 1
2409	122450988		09/12/2004	Eel	39.4	ESMS 1
2410	122451068		09/12/2004	Eel	53	ESMS 1
2411	122451036		09/12/2004	Eel	39.4	ESMS 2
2412	122450984		09/12/2004	Eel	46.2	ESMS 2
2413	122450989		09/12/2004	Eel	49.4	ESMS 2
2414	122450779		09/12/2004	Eel	30	ESMS 2
2415	122450777		09/12/2004	Eel	39.2	ESMS 2
2416	122451054		09/12/2004	Eel	33.2	ESMS 2
2417	122451089		09/12/2004	Eel	40.3	ESMS 2
2418	122450772		09/12/2004	grayling	30	ESMS 3
2419	122450775		09/12/2004	Trout	26.3	ESMS 3
2420	122450985		09/12/2004	Trout	26.3	ESMS 3
2421	122450986		09/12/2004	Trout	20.7	ESMS 3
2422	122451098		09/12/2004	Trout	20.5	ESMS 3
2423	122451147		09/12/2004	Eel	36.6	ESMS 3
2424	122451043		09/12/2004	Eel	36.7	ESMS 3
2425	122451065		09/12/2004	Eel	45.8	ESMS 3
2426	122451133		09/12/2004	Eel	47.3	ESMS 3
2427	122451018		09/12/2004	Trout	26.7	ESMS 3
2428	122451172		09/12/2004	Trout	21.7	ESMS 3
2430	122451079		09/12/2004	Eel	33.8	ESMS 4
2431	122451050		09/12/2004	Eel	36.9	ESMS
2432	122451007		10/12/2004	Pike	49.8	Luckford Lake 1
2433	122451048		10/12/2004	Pike	43.5	Luckford Lake 1
2434	122451094		10/12/2004	Pike	42.5	Luckford Lake 1
2435	122451019		10/12/2004	Pike	44.4	Luckford Lake 1
2436	122451020		10/12/2004	Dace	20.7	Luckford Lake 2
2437	122451176		10/12/2004	Dace	12.2	Luckford Lake 2
2438	122451168		10/12/2004	Dace	19	Luckford Lake 2
2439	122450378		10/12/2004	Dace	13.5	Luckford Lake 2
2440	122451181		10/12/2004	Dace	15.2	Luckford Lake 2
2441	122451104		10/12/2004	Dace	13.1	Luckford Lake 2
2442	122451038		10/12/2004	Pike	21.7	Luckford Lake 3
2443	122450996		10/12/2004	Dace	18.2	Luckford Lake 3
2444	122451078		10/12/2004	Dace	16.2	Luckford Lake 3
2445	122451041		10/12/2004	Dace	12.3	Luckford Lake 3
2446	122451112		10/12/2004	Dace	16	Luckford Lake 3
2447	122451085		10/12/2004	Dace	18	Luckford Lake 3
2448	122451146		10/12/2004	Dace	15.1	Luckford Lake 3
2449	122451111		10/12/2004	Dace	13.8	Luckford Lake 3
2450	122451170		10/12/2004	Dace	14.9	Luckford Lake 3
2451	122451118		10/12/2004	Dace	13.6	Luckford Lake 3

2452	35471147	10/12/2004	Dace	13.9	Luckford Lake 3
2453	122451013	10/12/2004	Dace	14.5	Luckford Lake 3
2454	122450382	10/12/2004	Dace	13.7	Luckford Lake 3
2455	122451124	10/12/2004	Dace	15.8	Luckford Lake 3
2456	122451110	10/12/2004	Dace	16	Luckford Lake 3
2457	122451090	10/12/2004	Dace	19	Luckford Lake 3
2458	122450994	10/12/2004	Dace	14.7	Luckford Lake 3
2459	122450998	10/12/2004	Dace	18.4	Luckford Lake 3
2460	122450991	10/12/2004	Dace	14.8	Luckford Lake 3
2461	35471149	10/12/2004	Dace	15	Luckford Lake 3
2462	122451021	10/12/2004	Dace	13.3	Luckford Lake 3
2463	122450997	10/12/2004	Dace	13.2	Luckford Lake 3
2464	122450990	10/12/2004	Dace	12.7	Luckford Lake 3
2465	113943710	10/12/2004	Dace	13.9	Luckford Lake 3
2466	122450993	10/12/2004	Dace	13.3	Luckford Lake 3
2467	122451023	10/12/2004	Roach	14.5	Luckford Lake 3
2468	122451132	10/12/2004	Roach	14.6	Luckford Lake 3
2469	127178822	10/12/2004	Roach	23.6	Luckford lake 4
2470	127178823	10/12/2004	Roach	20.1	
2471	127178824	10/12/2004	Dace	17.1	Luckford lake 4
2472	127178825	10/12/2004	Roach	16.5	Luckford lake 4
2473	127178826	10/12/2004	Roach	18.3	Luckford lake 4
2474	127178827	10/12/2004	Pike	37.8	Luckford lake 4
2475	127178828	10/12/2004	Roach	19.1	Luckford lake 4
2476	127178829	10/12/2004	Dace	17.5	Luckford lake 4
2477	127178830	10/12/2004	Roach	19.6	Luckford lake 4
2478	127178831	10/12/2004	Roach	18.5	Luckford lake 4
2479	127179182	10/12/2004	Roach	16.6	Luckford lake 4
2480	127179183	10/12/2004	Roach	20.9	Luckford lake 4
2481	127179184	10/12/2004	Roach	23.4	Luckford lake 4
2482	127179185	10/12/2004	Roach	22.4	Luckford lake 4
2483	127179186	10/12/2004	Roach	18.2	Luckford lake 4
2484	127178912	10/12/2004	Roach	20.5	Luckford lake 4
2485	127178911	10/12/2004	Roach	15.5	Luckford lake 4
2486	127178910	10/12/2004	Roach	20.9	Luckford lake 4
2487	127178909	10/12/2004	Roach	16.4	Luckford lake 4
2489	127178908	10/12/2004	Roach	22	Luckford lake 4
2490	127179006	10/12/2004	Roach	17.3	Luckford lake 4
2491	127179005	10/12/2004	Roach	15.6	Luckford lake 4
2492	127179004	10/12/2004	Dace	24.8	Luckford lake 4
2493	127179003	10/12/2004	Dace	17.6	Luckford lake 4
2495	127179001	10/12/2004	Dace	16.9	Luckford lake 4
2496	127179000	10/12/2004	Dace	18.4	Luckford lake 4
2497	127178999	10/12/2004	Dace	18.2	Luckford lake 4
2498	127178998	10/12/2004	Dace	17.7	Luckford lake 4
2499	127178997	10/12/2004	Dace	25.1	Luckford lake 4
2500	127178996	10/12/2004	Roach	20.3	Luckford Lake 4
2501	127178995	10/12/2004	Pike	35.7	Luckford Lake 4
2502	127178994	10/12/2004	Dace	21.6	Luckford Lake 4
2503	127178993	10/12/2004	Roach	17.3	Luckford Lake 4
2504	127178992	10/12/2004	Roach	19	Luckford Lake 4
2505	127178991	10/12/2004	Roach	24.1	Luckford Lake 4
2506	127178990	10/12/2004	Roach	16.6	Luckford Lake 4
2507	127178989	10/12/2004	Roach	20.2	Luckford Lake 4

2508	127178988		10/12/2004	Roach	18.4	Luckford Lake 4
2509	127178987		10/12/2004	Roach	17.6	Luckford Lake 4
2510	127178986		10/12/2004	Dace	18.8	Luckford Lake 4
2511	127178985		10/12/2004	Dace	17.1	Luckford Lake 4
2512	127178984		10/12/2004	Roach	16.6	Luckford Lake 4
2513	127178956		10/12/2004	Dace	26.7	Luckford Lake 4
2514	127178955		10/12/2004	Dace	26.7	Luckford Lake
2515	127178954		10/12/2004	Roach	15.3	Luckford Lake 4
2516	127178953		10/12/2004	Roach	19.8	Luckford Lake 4
2517	127178952		10/12/2004	Roach	18.8	Luckford Lake 4
2518	127178950		10/12/2004	Dace	18.9	Luckford Lake 4
2519	127178951		10/12/2004	Dace	19.4	Luckford Lake 4
2520	127178949		10/12/2004	Roach	16.3	Luckford Lake 4
2521	127178948		10/12/2004	Roach	16.1	Luckford Lake 4
2522	127178947		10/12/2004	Dace	15.7	Luckford Lake 4
2523	127178946		10/12/2004	Roach	17.8	Luckford Lake 4
2524	127178945		10/12/2004	Dace	17.8	Luckford Lake 4
2525	122450609		17/03/2005	Pike	25.8	ESMS
2526	122450611		17/03/2005	Pike	27.7	ESMS
2527	122450610		17/03/2005	Dace	19.5	ESMS
2528	122450608		23/03/2005	Pike	26	Railway
2529	122450766		23/03/2005	Pike	20.4	Railway 1
2530	122450764		23/03/2005	Pike	18	Railway 3
2531		DC0024-D994	23/03/2005	Pike	11.9	Railway
2532		DC0024-EC3E	23/03/2005	Pike	11.7	Railway
2533		DC002B-00AA	23/03/2005	Pike	11.2	Railway
2534		DC002B-13A3	23/03/2005	Pike	10.8	Railway
2535	122450741		08/03/2005	Pike	25.5	River Frome T3
2536	122450743		08/03/2005	Pike	19.5	Main River Frome T7
2537	122450746		08/03/2005	Pike	46.8	Main River Frome T10-12
2538	122450747		08/03/2005	Pike	20.3	Main River Frome T10-12
2539	122450751		08/03/2005	Perch	39.5	Main River Frome Frog T20
2541	122450655	DC002B-0C3F	17/03/2005	Dace	22.3	ESMS 1
2542	122450654		17/03/2005	Dace	20.5	ESMS 1
2543	122450653	DC002A-0768	17/03/2005	Dace	23.9	ESMS 1
2544	122450650		16/03/2005	Dace	18.2	Goldsacs 4
2545	122450647		17/03/2005	Pike	19.1	ESMS 2
2546	122450642	DC002A-061E	17/03/2005	Dace	27.3	ESMS 2
2547	122450646	DC002A-0AA8	17/03/2005	Dace	20.6	ESMS 2
2548	122450643		17/03/2005	Dace	18.5	ESMS 2
2549	122450640		17/03/2005	Dace	18.2	ESMS 2
2550	122450637	DC0029-ECA0	17/03/2005	Dace	22.6	ESMS 3
2551	122450639	DC0029-EFE7	17/03/2005	Dace	22.8	ESMS 3
2552	122450633		17/03/2005	Dace	20.1	ESMS 2
2553	122450628		17/03/2005	Dace	20.4	ESMS 2
2554	122450627		17/03/2005	Pike	24.9	ESMS 2
2555	122450613		17/03/2005	Trout	14	ESMS 2
2556	122450626		17/03/2005	Trout	13.7	ESMS 2
2557	122450630		17/03/2005	Trout	12.9	ESMS 2
2558	122450631		17/03/2005	Trout	14.4	ESMS 2
2559	122450634		17/03/2005	Dace	17.4	ESMS 2
2560	122450615		17/03/2005	Trout	15.8	ESMS 4
2561	122450622		17/03/2005	Trout	14.1	ESMS 4

2562	122450661		16/03/2005	Dace	19.4	Goldsacs 2
2563	122450685		16/03/2005	Dace	18	Goldsacs 2
2564	122450662		16/03/2005	Dace	17.5	Goldsacs 2
2565	122450663		16/03/2005	Dace	23.7	Goldsacs 2
2566	122450660		16/03/2005	Dace	21.9	Goldsacs 2
2567	122450659		16/03/2005	Dace	23.2	Goldsacs 2
2568	122450656		16/03/2005	Dace	18.4	Goldsacs 4
2569	122450657		16/03/2005	Dace	19.7	Goldsacs 4
2570	122450666		16/03/2005	Dace	12.2	Luckford Lake 4
2571	122450665		16/03/2005	Dace	15	Luckford Lake 4
2572	122450664			Dace	12.1	Luckford Lake 4
2573	113945640			Dace	26	Luckford Lake 2
2575		DC0029-F363	15/03/2005	Pike	12	Holme Bridge 4
2576		DC002A-0EE6	15/03/2005	Pike	11.1	Holme Bridge 4
2577	122450679		15/03/2005	Dace	27.3	Luckford lake 4
2578	122450675		15/03/2005	Roach	21.2	
2579	122450678		15/03/2005	Dace	17.7	Luckford lake 4
2580	122450677		15/03/2005	Dace	14.6	Luckford lake 4
2581	122450672		15/03/2005	Dace	13.1	Luckford lake 4
2582	122450673		15/03/2005	Dace	14.4	Luckford lake 4
2583	122450676		15/03/2005	Dace	16.5	Luckford lake 4
2584	122450674		15/03/2005	Dace	14.6	Luckford lake 4
2585	122450671		15/03/2005	Dace	16.1	Luckford lake 4
2586	122450670		15/03/2005	Dace	12.3	Luckford lake 4
2587	122450669		15/03/2005	Roach	23.9	Luckford lake 4
2588	122450668		15/03/2005	Dace	13.7	
2589	122450667		15/03/2005	Dace	15.3	Luckford lake 4
2590	122450691		12/07/2004	Pike	94.5	
2591	122450690	DC002A-161B	15/03/2005	Dace	26.4	Main River Frome us Luckford
2592	122450688		15/03/2005	Pike	73	Main River Frome Oxbow
2593	122450689		15/03/2005	Pike	56.9	Luckford Lake 1
2594	122450686		15/03/2005	Pike	44	Luckford Lake 1
2595	122450684		15/03/2005	Pike	22.2	Holme Bridge 1
2596	122450683		15/03/2005	Pike	22.3	Holme Bridge 1
2597	122450682		15/03/2005	Pike	21.1	Holme Bridge 1
2598	122450681		15/03/2005	Pike	25.7	Holme Bridge 1
2599	122450680		15/03/2005	Pike	15.8	Holme Bridge 3
2600	122450755		15/03/2005	Pike	12.4	Rushton 1
2601	122450753		14/03/2005	Perch	19.5	Rushton 1
2602	122450700		14/03/2005	Pike	23.3	Rushton 2
2603	122450699		14/03/2005	Pike	22.2	Rushton 2
2604	122450697		14/03/2005	Pike	19.6	Rushton 2
2605	122450696		14/03/2005	Pike	16.7	Rushton 2
2606	122450695		14/03/2005	Pike	28	Rushton 4
2607	122450694		14/03/2005	Pike	22.4	Rushton 4
2608	122450768		14/03/2005	Pike	16.3	Railway 1
2609	122450767		14/03/2005	Pike	19.4	Railway 1
2610		DC0024-D99B	14/03/2005	Pike	11.6	Railway 1
2611		DC002A-0C88	14/03/2005	Pike	12.2	Railway 2
2612	122450765		14/03/2005	Pike	22.2	Railway 3
2614	122450763		14/03/2005	Pike	21.5	Flood Relief 1
2616	122450762		14/03/2005	Pike	13.8	Flood Relief 1
2617	122450761		14/03/2005	Pike	16.3	Flood Relief 1

2618	122450760		14/03/2005	Pike	13.8	Flood Relief 1	
2619	122450759		14/03/2005	Pike	16.3	Flood Relief 2	
2620	122450757		14/03/2005	Pike	27.2	Flood Relief 2	
2621		DC002B-0B76	14/03/2005	Pike	13	Flood Relief 2	
2622	122450756		14/03/2005	Pike	15.8	Flood Relief 2	
2944	127179002		10/12/2004	Dace	23.2	Luckford lake 4	
2945	122450632		21/06/2005	Pike	17.8	Rushton 1	
2946	122450629		21/06/2005	Pike	18.1	Luckford Lake 4	
2947	122450621		22/06/2005	Dace	12.9	ESMS 3	
2948	122450617		22/06/2005	Dace	12.6	ESMS 3	
2949	122450619		22/06/2005	Dace	12.8		
2950	122450602		22/06/2005	Gudgeon	14.3	ESMS 3	
2951	122450596		22/06/2005	Gudgeon	12.9	ESMS 3	
2952	122450636		22/06/2005	Eel	35	ESMS 3	
2953	122450595		22/06/2005	Pike	66.6	ESMS 3	
2954	122450599		22/06/2005	Eel	48.5	ESMS 4	
2955	122450638		22/06/2005	Roach	15.4	ESMS 5	
2956	122450612		23/06/2005	Pike	14	Railway 1	
2957		DC002B-0971	23/06/2005	Pike	13.9	Railway 2	
2958		DC002B-11BC	23/06/2005	Pike	8.3	Flood Relief 1	
2959		DC0024-7E72	23/06/2005	Pike	7.5	Flood Relief 1	
2960		DC002B-194D	23/06/2005	Pike	7.2	Flood Relief 3	
2961	122450360		12/07/2005	Roach	20.4	Wareham	
2962		DC0029-F7F6	12/07/2005	Roach	21.5	Wareham	
2963	122450363		12/07/2005	Roach	20.8	Wareham	
2964		DC002A-04A7	12/07/2005	Roach	21.3	Wareham	
2965	122450371		12/07/2005	Roach	24.5	Wareham	
2966		DC002B-0995	12/07/2005	Roach	19.3	Wareham	
2967	122450374		12/07/2005	Roach	18.6	Wareham	
2968		DC0029-EBE9	12/07/2005	Roach	19.3		12/07/2005
2969	122450361		12/07/2005	Roach	21.2		12/07/2005
2970		DC0024-E102	12/07/2005	Roach	22.3	Wareham	
2971	122450359		12/07/2005	Roach	19.2	Wareham	
2972		DC0029-F5ED	12/07/2005	Roach	17.4	Wareham	
2973	122450366		12/07/2005	Roach	20.5	Wareham	
2974		DC002A-0E00	12/07/2005	Roach	16.2	Wareham	
2975	122450369		12/07/2005	Roach	22.8	Wareham	
2976	122450354		12/07/2005	Roach	15.6	Wareham	
2977		DC002B-1A02	12/07/2005	Roach	15	Wareham	
2978		DC002B-1BC3	12/07/2005	Roach	22.8		
2979	122450352		12/07/2005	Roach	17.5	Wareham	
2980		DC0029-FB00	12/07/2005	Roach	13.2	Wareham	
2981	122450358		12/07/2005	Roach	13.2	Wareham	
2982		DC0029-ED19	12/07/2005	Roach	22.2	Wareham	
2983	122450348		12/07/2005	Dace	13.6	Wareham	
2984		DC002B-0BB1	12/07/2005	Rudd	19	Wareham	
2985	122450349		12/07/2005	Roach	19.5	Wareham	
2986		DC002B-1AF7	12/07/2005	Roach	15.8	Wareham	
2987	122450356		12/07/2005	Roach	18.9	Wareham	
2988		DC0029-FA8D	12/07/2005	Roach	17	Wareham	
2989	122450350		12/07/2005	Roach	24.1	Wareham	
2990		DC002A-0AA4	12/07/2005	Roach	15	Wareham	
2991	122450357		12/07/2005	Roach			
2992		DC0029-F34B	12/07/2005	Roach	17.8	Wareham	

2993	122450353		12/07/2005	Roach	22.1	Wareham
2994		DC002A-09D0	12/07/2005	Roach	20.1	Wareham
2995	122450337		12/07/2005	Roach	15.1	Wareham
2996		DC002A-028E	12/07/2005	Dace	26.6	Wareham
2997	122450336		12/07/2005	Roach	22.8	Wareham
2998		DC002A-0B76	12/07/2005	Roach	26.1	Wareham
2999	122450351		12/07/2005	Roach	13.8	Wareham
3000		DC002A-0EB0	12/07/2005	Roach	23.8	Wareham
3001	122450341		12/07/2005	Roach	24.8	Wareham
3002		DC002B-16EE	12/07/2005	Roach	15.7	Wareham
3003	122450347		12/07/2005	Roach	19.8	Wareham
3004		DC0029-F26D	12/07/2005	Roach	26.3	Wareham
3005	122450340		12/07/2005	Roach	25.1	Wareham
3006		DC0029-FAA0	12/07/2005	Roach	19.4	Wareham
3007	122450339		12/07/2005	Roach	21.9	Wareham
3008		DC002A-F293	12/07/2005	Roach	16.5	Wareham
3009	122450346		12/07/2005	Roach	12.9	Wareham
3010		DC002A-0DF5	12/07/2005	Roach	20.5	Wareham
3011	122450355		12/07/2005	Dace	12.8	Wareham
3012		DC002A-F6EE	12/07/2005	Dace	13.1	Wareham
3013		DC002B-1172	12/07/2005	Dace	12.3	Wareham
3014	122450345		12/07/2005	Roach	37.3	Wareham
3015		DC0029-F4D7	12/07/2005	Roach	32.5	Wareham
3016	122450343		12/07/2005	Roach	22.1	Wareham
3017		DC0024-7274	12/07/2005	Dace	12.8	Wareham
3018		DC0029-CF35	12/07/2005	Dace	24.4	Wareham
3019	122450338		12/07/2005	Roach	25	Wareham
3020		DC002A-0B29	12/07/2005	Roach	18.1	Wareham
3021	122450332		12/07/2005	Dace	24.2	Wareham
3022		DC002A-0EB8	12/07/2005	Roach	35.8	Wareham
3023	122450328		12/07/2005	Roach	20.7	Wareham
3024		DC002A-F80E	12/07/2005	Dace	18.8	Wareham
3025	122450331		12/07/2005	Roach	12.9	Wareham
3026		DC002A-12F4	12/07/2005	Roach	18	Wareham
3027	122450334		12/07/2005	Dace	17.6	Wareham
3028		DC002A-086F	13/07/2005	Dace	21.1	Wareham
3029	122450329		13/07/2005	Dace	19.8	Wareham
3030		DC002A-0CE5	13/07/2005	Roach	17.1	Wareham
3031	122450330		13/07/2005	Dace	23.1	Wareham
3032		DC002A-F613	13/07/2005	Dace	13.6	Wareham
3033	122450316		13/07/2005	Roach	35.7	Wareham
3034		DC0029-EF35	13/07/2005	Dace	24.2	Wareham
3035		DC0029-F8CA	13/07/2005	Dace	13.6	Wareham
3036	122450327		13/07/2005	Roach	13	Wareham
3037		DC002A-088C	13/07/2005	Dace	26.6	Wareham
3038	122450322		13/07/2005	Roach	23.1	Wareham
3039		DC002B-000D	13/07/2005	Roach	34.4	Wareham
3040	122450344		13/07/2005	Roach	26.4	Wareham
3041		DC0029-EF3A	13/07/2005	Dace	21.9	Wareham
3042	122450321		13/07/2005	Dace	19.7	Wareham
3043		DC002B-1C07	13/07/2005	Roach	35.3	Wareham
3044	122450333		13/07/2005	Dace	12.4	Wareham
3045		DC0029-F086	13/07/2005	Dace	24.5	Wareham
3046	122450320		13/07/2005	Roach	24.1	Wareham

3047		DC002B-0D6A	13/07/2005	Roach	30.4	Wareham
3048	122450317		13/07/2005	Roach	15.4	Wareham
3049		DC0024-CC3E	13/07/2005	Dace	25.1	Wareham
3050	122450342		13/07/2005	Dace	26.8	Wareham
3051	122450323		13/07/2005	Roach	18.3	Wareham
3052		DC0029-F755	13/07/2005	Roach	27.5	Wareham
3053	122450326		13/07/2005	Dace	24.5	Wareham
3054		DC002A-01F5	13/07/2005	Roach	21.2	Wareham
3055	122450319		13/07/2005	Dace	16.4	Wareham
3056		DC002A-10F2	13/07/2005	Dace	20.5	Wareham
3057	122450310		13/07/2005	Roach	27.3	Wareham
3058		DC0029-F5B2	13/07/2005	Roach	21.2	Wareham
3059	122450315		13/07/2005	Dace	24.5	Wareham
3060		DC0029-EE36	13/07/2005	Dace	23	Wareham
3061	122450313		13/07/2005	Roach	28.2	Wareham
3062		DC002A-F631	13/07/2005	Roach	13.1	Wareham
3063	122450308		13/07/2005	Dace	14	Wareham
3064		DC002A-FFA8	13/07/2005	Dace	21.9	Wareham
3065	122450312		13/07/2005	Dace	12.2	Wareham
3066		DC002A-1423	13/07/2005	Dace	12	Wareham
3067	122450309		13/07/2005	Dace	13.9	Wareham
3068		DC0029-F762	13/07/2005	Roach	32.3	Wareham
3069		DC002B-01C4	13/07/2005	Dace	20.7	Wareham
3070	122450324		13/07/2005	Dace	19.9	Wareham
3071		DC002A-085D	13/07/2005	Dace	23.2	Wareham
3072	122450311		13/07/2005	Dace	17.2	Wareham
3073		DC002A-048E	13/07/2005	Dace	12.5	Wareham
3074	122450302		13/07/2005	Roach	12.5	Wareham
3075		DC002A-0346	13/07/2005	Dace	13.1	Wareham
3076	122450277		13/07/2005	Dace	21.7	Wareham
3077		DC002A-0BDD	13/07/2005	Dace	25.1	Wareham
3078	122450297		13/07/2005	Roach		Wareham
3079		DC002B-17C5	13/07/2005	Roach	24.3	Wareham
3080	122450299		13/07/2005	Roach	19.7	Wareham
3081		DC002A-0B61	13/07/2005	Dace	16.1	Wareham
3082	122450295		13/07/2005	Dace	17.5	Wareham
3083		DC002A-0900	13/07/2005	Roach	12.5	Wareham
3084	122450306		13/07/2005	Dace	12.4	Wareham
3085		DC0029-EEE6	13/07/2005	Roach	12.3	Wareham
3086		DC002B-1CFF	13/07/2005	Roach	12	Wareham
3087	122450298		13/07/2005	Dace	24.7	Wareham
3088		DC0029-F768	13/07/2005	Dace	13.4	Wareham
3089	122450294		13/07/2005	Roach	12.6	Wareham
3090		DC002B-14EF	13/07/2005	Dace	12.7	Wareham
3091	122450304		13/07/2005	Dace	13.1	Wareham
3092		DC0029-EC5F	13/07/2005	Dace	12.4	Wareham
3093	122450314		13/07/2005	Dace	13.7	Wareham
3094		DC002A-FD07	13/07/2005	Dace	12.6	Wareham
3095	122450296		13/07/2005	Dace	14.5	Wareham
3096		DC002A-0DA7	13/07/2005	Roach	12.5	Wareham
3097	122450301		13/07/2005	Dace	12.5	Wareham
3098		DC002A-FF43	13/07/2005	Roach	12.7	Wareham
3099	122450300		13/07/2005	Dace	13.1	Wareham
3100		DC002A-0199	13/07/2005	Dace	12.3	Wareham

3101	122450305		13/07/2005	Dace	12.2	Wareham
3102		DC002A-FBE9	13/07/2005	Dace	12.2	Wareham
3103	122450616		12/07/2005	Dace	12.8	Wareham
3104	122450635		12/07/2005	Dace	17.9	Wareham
3105	122450625		12/07/2005	Dace	13.2	Wareham
3106	122450601		12/07/2005	Dace	20.1	Wareham
3107	122450624		12/07/2005	Roach	13.3	Wareham
3108	122450600		12/07/2005	Dace	21.8	Wareham
3109		DC002A-016E	12/07/2005	Roach	16.1	Wareham
3110		DC002A-148E	12/07/2005	Rudd	17.6	Wareham
3111	122450593		12/07/2005	Roach	15.8	Wareham
3112		DC002B-1475	12/07/2005	Roach	12.7	Wareham
3113	122450597		12/07/2005	Roach	24.7	Wareham
3114		DC002A-0097	12/07/2005	Dace	19.1	Wareham
3115	122450592		12/07/2005	Dace	16.8	Wareham
3116		DC0029-FAA9	12/07/2005	Dace	16.9	Wareham
3117	122450589		13/07/2005	Roach	23.1	
3118		DC0024-8BCD	12/07/2005	Dace	12.5	Wareham
3119	122450591		12/07/2005	Dace	12.5	Wareham
3120		DC002A-060F	12/07/2005	Roach	15.7	Wareham
3121	122450587		12/07/2005	Roach	14.8	Wareham
3122		DC0029-FE3A	12/07/2005	Roach	16	Wareham
3123	122450590		12/07/2005	Roach	35.8	Wareham
3124		DC002A-06A9	12/07/2005	Roach	17.3	Wareham
3125	122450588		12/07/2005	Roach	23.9	Wareham
3126		DC0024-8CBB	12/07/2005	Dace	20.8	Wareham
3127	122450584		12/07/2005	Roach	18.3	Wareham
3128		DC0029-F34D	12/07/2005	Roach	20.3	Wareham
3129	122450585		12/07/2005	Roach	29.2	Wareham
3130		DC0024-E818	12/07/2005	Dace	25.2	Wareham
3131	122450586		12/07/2005	Dace	25.7	Wareham
3132		DC002A-00D0	12/07/2005	Dace	12.6	Wareham
3133	122450376		12/07/2005	Dace	16.7	Wareham
3134		DC002A-0F2C	12/07/2005	Roach	13.5	Wareham
3135	122450375		12/07/2005	Dace	19.2	Wareham
3136		DC002B-1444	12/07/2005	Dace	16.5	Wareham
3137	122450583		12/07/2005	Roach	24.7	Wareham
3138		DC002A-064C	12/07/2005	Dace	18	Wareham
3139		DC002B-130C	12/07/2005	Roach	13	Wareham
3140		DC002B-186A	12/07/2005	Dace	18.2	Wareham
3141		DC002B-0246	12/07/2005	Roach	14	Wareham
3142		DC002B-09A7	12/07/2005	Roach	14	Wareham
3143	122450372		12/07/2005	Roach	13.4	Wareham
3144		DC002A-0919	12/07/2005	Dace	21.1	Wareham
3145	122450373		12/07/2005	Dace	25.3	Wareham
3146		DC0029-FA18	12/07/2005	Dace	26.7	Wareham
3147	122450365		12/07/2005	Roach	20.9	Wareham
3148		DC002A-13C1	12/07/2005	Roach	12	Wareham
3149	122450364		12/07/2005	Roach	12.6	Wareham
3150		DC0024-EDFE	12/07/2005	Roach	12.3	Wareham
3151	122450362		12/07/2005	Dace	12.3	Wareham
3152		DC002A-0F15	12/07/2005	Dace	12.6	Wareham
3153	122450368		12/07/2005	Dace	18.5	Wareham
3154		DC002B-0B46	12/07/2005	Dace	15.5	Wareham

3155	122450370		12/07/2005	Dace	16.5	Wareham
3156		DC002A-0808	12/07/2005	Dace	12.1	Wareham
3157	122450367		12/07/2005	Roach	12.1	Wareham
3158		DC002A-F204	12/07/2005	Dace	13	Wareham
3159	122450303		12/09/2005	Pike	15.3	Luckford Lake 4
3160	133913381		12/09/2005	Dace	16.1	ESMS Extra Shock 1
3161	122450307		12/09/2005	Roach	16.3	ESMS Extra Shock 1
3162	133913380		12/09/2005	Dace	16.7	ESMS Extra Shock 1
3163	133913379		12/09/2005	Dace	13.1	ESMS Extra Shock 1
3164	133913378		12/09/2005	Dace	13.8	ESMS Extra Shock 1
3165	133913373		12/09/2005	Dace	14.6	ESMS Extra Shock 1
3166	133913374		12/09/2005	Dace	14.6	ESMS Extra Shock 1
3167	133913376		12/09/2005	Dace	16.1	ESMS Extra Shock 1
3168	133913375		12/09/2005	Dace	15.4	ESMS Extra Shock 1
3169	133913377		12/09/2005	Roach	15.7	ESMS Extra Shock 1
3170	133913370		12/09/2005	Dace	14.5	ESMS Extra Shock 1
3171	133913372		12/09/2005	Dace	14.7	ESMS Extra Shock 1
3172	133913371		12/09/2005	Dace	13.7	ESMS Extra Shock 1
3173	133912214		12/09/2005	Dace		ESMS Extra Shock 1
3174	133912213		12/09/2005	Dace	14.2	ESMS Extra Shock 1
3175	133912212		12/09/2005	Dace	17.3	ESMS Extra Shock 1
3176	133912211		12/09/2005	Dace	15.2	ESMS Extra Shock 1
3177	133912210		12/09/2005	Dace	15.3	ESMS Extra Shock 1
3178	133912259		12/09/2005	Dace	21.1	
3179	133912258		12/09/2005	Dace	14.5	ESMS Extra Shock 1
3180	133912256		12/09/2005	Roach	15	ESMS Extra Shock 1
3181	133912255		12/09/2005	Dace	16.2	ESMS Extra Shock 1
3182	133912254		12/09/2005	Dace	13.9	ESMS Extra Shock 1
3183	133912253		12/09/2005	Roach	16.5	ESMS Extra Shock 1
3184	133912252		12/09/2005	Dace	15.8	ESMS Extra Shock 1
3185	133912251		12/09/2005	Dace	16.7	ESMS Extra Shock 1
3186	133912250		12/09/2005	Dace	16	
3187	133912249		12/09/2005	Dace	13.8	ESMS Extra Shock 1
3188	133912247		12/09/2005	Roach	15.7	ESMS Extra Shock 1
3189	133912246		12/09/2005	Dace	13.2	ESMS Extra Shock 1
3190	133912248		12/09/2005	Roach	13.3	ESMS Extra Shock 1
3191	133912245		12/09/2005	Roach	14.7	ESMS Extra Shock 1
3192	133912244		12/09/2005	Dace	12.8	ESMS Extra Shock 1
3193	133912243		12/09/2005	Dace	16.2	ESMS Extra Shock 1
3194	133912242		12/09/2005	Dace	15.8	ESMS Extra Shock 1
3195	133912241		12/09/2005	Dace	14.4	ESMS Extra Shock 1
3196	133912240		12/09/2005	Dace	19.2	ESMS Extra Shock 1
3197	133912239		12/09/2005	Dace	14.8	ESMS Extra Shock 1
3198	133912238		12/09/2005	Dace	16.1	ESMS Extra Shock 1
3199	133912237		12/09/2005	Dace	15.7	ESMS Extra Shock 1
3200	133912273		12/09/2005	Eel	44.8	ESMS Extra Shock 1
3201	133912277		12/09/2005	Eel	32.8	ESMS Extra Shock 1
3202	133912274		12/09/2005	Eel	54.3	ESMS Extra Shock 1
3203	133912275		12/09/2005	Eel	41.5	ESMS Extra Shock 1
3204	133912236		12/09/2005	Dace	13.6	ESMS Extra Shock 1
3205	133912235		12/09/2005	Dace	15.3	ESMS Extra Shock 1
3206	133912284		12/09/2005	Dace	15.6	ESMS Extra Shock 1
3207	133912283		12/09/2005	Dace	15.8	ESMS Extra Shock 1
3208	133912282		12/09/2005	Dace	15.9	ESMS Extra Shock 1

3209	133912281	12/09/2005	Dace	14.4	ESMS Extra Shock 1
3210	133912280	12/09/2005	Dace	15.5	ESMS Extra Shock 1
3211	133912279	12/09/2005	Dace	14.9	ESMS Extra Shock 1
3212	133912278	12/09/2005	Roach	12.6	ESMS Extra Shock 1
3213	133912276	12/09/2005	Eel	44.5	ESMS Extra Shock 1
3214	133912272	12/09/2005	Dace	13.3	ESMS Extra Shock 2
3215	133912271	12/09/2005	Dace	15	ESMS Extra Shock 2
3216	133912270	12/09/2005	Roach	13.7	ESMS Extra Shock 2
3217	133912269	12/09/2005	Dace	13.2	ESMS Extra Shock 2
3218	133912268	12/09/2005	Dace	13.5	ESMS Extra Shock 2
3219	133912267	12/09/2005	Dace	12.7	ESMS Extra Shock 2
3220	133912266	12/09/2005	Dace	16.6	ESMS Extra Shock 2
3221	133912265	12/09/2005	Eel	31.6	ESMS Extra Shock 2
3222	133912264	12/09/2005	Eel	35.2	ESMS Extra Shock 2
3223	133912263	12/09/2005	Eel	38.7	ESMS Extra Shock 2
3224	133912262	12/09/2005	Eel	35.5	ESMS Extra Shock 2
3225	133912261	12/09/2005	Dace	12.5	ESMS Extra Shock 3
3226	122450651	12/09/2005	Eel	32.5	ESMS 1
3227	133912260	12/09/2005	Dace	12.9	ESMS 1
3228	133911705	12/09/2005	Dace	15	ESMS 1
3229	133911704	12/09/2005	Dace	19.4	ESMS 1
3230	133911703	12/09/2005	Roach	17.3	ESMS 2
3231	133911702	12/09/2005	Roach	16.2	ESMS 2
3232	133911701	12/09/2005	Roach	16.5	ESMS 2
3233	133911700	12/09/2005	Dace	20.9	ESMS 2
3234	133911699	12/09/2005	Roach	16.9	ESMS 2
3235	133911698	12/09/2005	Dace	14.9	ESMS 2
3236	133911697	12/09/2005	Dace	17.1	ESMS 2
3237	133911696	12/09/2005	Dace	15.7	ESMS 2
3238	133911692	12/09/2005	Roach	15.5	ESMS 2
3239	133911693	12/09/2005	Dace	15.8	ESMS 2
3240	133911695	12/09/2005	Dace	20.1	ESMS 2
3241	133911694	12/09/2005	Roach	16.9	ESMS 2
3242	133911690	12/09/2005	Roach	15.7	ESMS 2
3243	133911689	12/09/2005	Roach	17.1	ESMS 2
3244	133911691	12/09/2005	Dace	14.3	ESMS 2
3245	133911687	12/09/2005	Roach	16.7	ESMS 2
3246	133911686	12/09/2005	Roach	16.2	ESMS 2
3247	133911688	12/09/2005	Dace	17.3	ESMS 2
3248	133911683	12/09/2005	Roach	14.4	ESMS 2
3249	133911684	12/09/2005	Roach	17.4	ESMS 2
3250	133911685	12/09/2005	Dace	20.6	ESMS 2
3251	133911682	12/09/2005	Dace	16	ESMS 2
3252	133911681	12/09/2005	Dace	14	ESMS 2
3253	133911730	12/09/2005	Roach	15.9	ESMS 2
3254	133911731	12/09/2005	Roach	17.3	ESMS 2
3255	133911729	12/09/2005	Dace	17.5	ESMS 2
3256	133911728	12/09/2005	Roach	16.5	ESMS 2
3257	133911727	12/09/2005	Roach	14.6	ESMS 2
3258	133911726	12/09/2005	Roach	17.6	ESMS 2
3259	133911725	12/09/2005	Dace	15.7	ESMS 2
3260	133911723	12/09/2005	Dace	17.5	ESMS 2
3261	133911722	12/09/2005	Dace	15.3	ESMS 2
3262	133911721	12/09/2005	Roach	16.5	ESMS 2

3263	133911720	12/09/2005	Roach	16	ESMS 2
3264	133911719	12/09/2005	Dace	14.3	ESMS 2
3265	133911718	12/09/2005	Roach	15.1	ESMS 2
3266	133911717	12/09/2005	Dace	14.8	ESMS 2
3267	133911716	12/09/2005	Roach	14.5	ESMS 2
3268	133911715	12/09/2005	Roach	19.2	ESMS 2
3269	133911714	12/09/2005	Roach	21.8	ESMS 2
3270	133911713	12/09/2005	Roach	18.4	ESMS 2
3271	133911712	12/09/2005	Roach	16.8	ESMS 2
3272	133911711	12/09/2005	Roach	16.9	ESMS 2
3273	133911710	12/09/2005	Roach	18.4	ESMS 2
3274	133911709	12/09/2005	Dace	13.6	ESMS 2
3275	133911708	12/09/2005	Dace	13.8	ESMS 2
3276	133911707	12/09/2005	Dace	15.9	ESMS 2
3277	133911706	12/09/2005	Dace	15.4	ESMS 2
3278	133911756	12/09/2005	Dace	14.1	ESMS 2
3279	133911755	12/09/2005	Roach	18.2	ESMS 2
3280	133911754	12/09/2005	Roach	15.6	ESMS 2
3281	133911753	12/09/2005	Roach	14.4	ESMS 2
3282	133911752	12/09/2005	Roach	16.2	ESMS 2
3283	133911751	12/09/2005	Roach	16.8	ESMS 2
3284	133911750	12/09/2005	Roach	15.2	ESMS 2
3285	133911749	12/09/2005	Dace	20.6	ESMS 2
3286	133911748	12/09/2005	Dace	15.3	ESMS 2
3287	133911747	12/09/2005	Dace	15.3	ESMS 2
3288	133911746	12/09/2005	Dace	14.9	ESMS 2
3289	133911745	12/09/2005	Dace	14.4	ESMS 2
3290	133911744	12/09/2005	Dace	14.6	ESMS 2
3291	133911743	12/09/2005	Dace	15.3	ESMS 2
3292	133911742	12/09/2005	Dace	17.6	ESMS 2
3293	133911741	12/09/2005	Roach	16.8	ESMS 2
3294	133911733	12/09/2005	Roach	18.3	ESMS 2
3295	133911735	12/09/2005	Roach	16.2	ESMS 2
3296	133911739	12/09/2005	Dace	20.7	ESMS 2
3297	133911740	12/09/2005	Dace	16.6	ESMS 2
3298	133911738	12/09/2005	Roach	14.9	ESMS 2
3299	133911737	12/09/2005	Dace	17.5	ESMS 2
3300	133911736	12/09/2005	Roach	16.4	ESMS 2
3301	133911734	12/09/2005	Dace	14.5	ESMS 2
3302	133911732	12/09/2005	Roach	17	ESMS 2
3303	133911781	12/09/2005	Roach	16.6	ESMS 2
3304	133911780	12/09/2005	Dace	15.7	ESMS 2
3305	133911779	12/09/2005	Dace	17.4	ESMS 2
3306	133911778	12/09/2005	Roach	17.4	ESMS 2
3307	133911777	12/09/2005	Dace	13.4	ESMS 2
3308	133911776	12/09/2005	Dace	16.2	ESMS 2
3309	133911775	12/09/2005	Dace	16.6	ESMS 2
3310	133911774	12/09/2005	Dace	15.4	ESMS 2
3311	133911773	12/09/2005	Dace	15.6	ESMS 2
3312	133911772	12/09/2005	Dace	14.3	ESMS 2
3313	133911771	12/09/2005	Dace	15.4	ESMS 2
3314	133911770	12/09/2005	Dace	15	ESMS 2
3315	133911769	12/09/2005	Dace	15	ESMS 2
3316	133911768	12/09/2005	Dace	15.4	ESMS 2

3317	133911767	12/09/2005	Dace	16.1	ESMS 2
3318	133911766	12/09/2005	Dace	16.3	ESMS 2
3319	133911765	12/09/2005	Dace	14.8	ESMS 2
3320	133911764	12/09/2005	Dace	17.1	ESMS 2
3321	133911763	12/09/2005	Dace	15.9	ESMS 2
3322	133911762	12/09/2005	Dace	16.1	ESMS 2
3323	133911761	12/09/2005	Dace	16.1	ESMS 2
3324	133911760	12/09/2005	Dace	18.5	ESMS 2
3325	133911759	12/09/2005	Dace	15.7	ESMS 2
3326	133911757	12/09/2005	Dace	17.1	ESMS 2
3327	133911758	12/09/2005	Dace	12.9	ESMS 2
3328	133911806	12/09/2005	Dace	16.4	ESMS 2
3329	133911805	12/09/2005	Dace	18.7	ESMS 2
3330	133911804	12/09/2005	Dace	17.1	ESMS 2
3331	133911803	12/09/2005	Dace	18.4	ESMS 2
3332	133911801	12/09/2005	Dace	17.3	ESMS 2
3333	133911800	12/09/2005	Dace	16.2	ESMS 2
3334	133911799	12/09/2005	Dace	17.2	ESMS 2
3335	133911798	12/09/2005	Dace	15.2	ESMS 2
3336	133911797	12/09/2005	Dace	17.5	ESMS 2
3337	133911796	12/09/2005	Dace	14.3	ESMS 2
3338	133911795	12/09/2005	Dace	13.1	ESMS 2
3339	133911794	12/09/2005	Dace	13.5	ESMS 2
3340	133911793	12/09/2005	Dace	16.7	ESMS 2
3341	133911792	12/09/2005	Dace	15	ESMS 2
3342	133911791	12/09/2005	Dace	16.7	ESMS 2
3343	133911790	12/09/2005	Dace	14.9	ESMS 2
3344	133911789	12/09/2005	Dace	15.2	ESMS 2
3345	133911788	12/09/2005	Dace	15.7	ESMS 2
3346	133911787	12/09/2005	Dace	15.3	ESMS 2
3347	133911786	12/09/2005	Dace	18.3	ESMS 2
3348	133911785	12/09/2005	Roach	19.6	ESMS 2
3349	133911784	12/09/2005	Roach	15.5	ESMS 2
3350	133911783	12/09/2005	Roach	19.3	ESMS 2
3351	133911782	12/09/2005	Dace	17.3	ESMS 2
3352	133911831	12/09/2005	Dace	15.2	ESMS 2
3353	133911830	12/09/2005	Dace	16.2	ESMS 2
3354	133911829	12/09/2005	Dace	15	ESMS 2
3355	133911828	12/09/2005	Dace	16.8	ESMS 2
3356	133911827	12/09/2005	Roach	17.7	ESMS 2
3357	133911826	12/09/2005	Dace	15.8	ESMS 2
3358	133911825	12/09/2005	Roach	16.5	ESMS 2
3359	133911824	12/09/2005	Dace	17	ESMS 2
3360	133911823	12/09/2005	Dace	19.8	ESMS 2
3361	133911822	12/09/2005	Dace	14.8	ESMS 2
3362	133911821	12/09/2005	Dace	16.4	ESMS 2
3363	133911820	12/09/2005	Dace	16.5	ESMS 2
3364	133911819	12/09/2005	Dace	17.5	ESMS 2
3365	133911818	12/09/2005	Dace	16.1	ESMS 2
3366	133911817	12/09/2005	Dace	21.1	ESMS 2
3367	133911816	12/09/2005	Dace	15.1	ESMS 2
3368	133911815	12/09/2005	Dace	14.6	ESMS 2
3369	133911814	12/09/2005	Dace	15	ESMS 2
3370	133911813	12/09/2005	Dace	16.3	

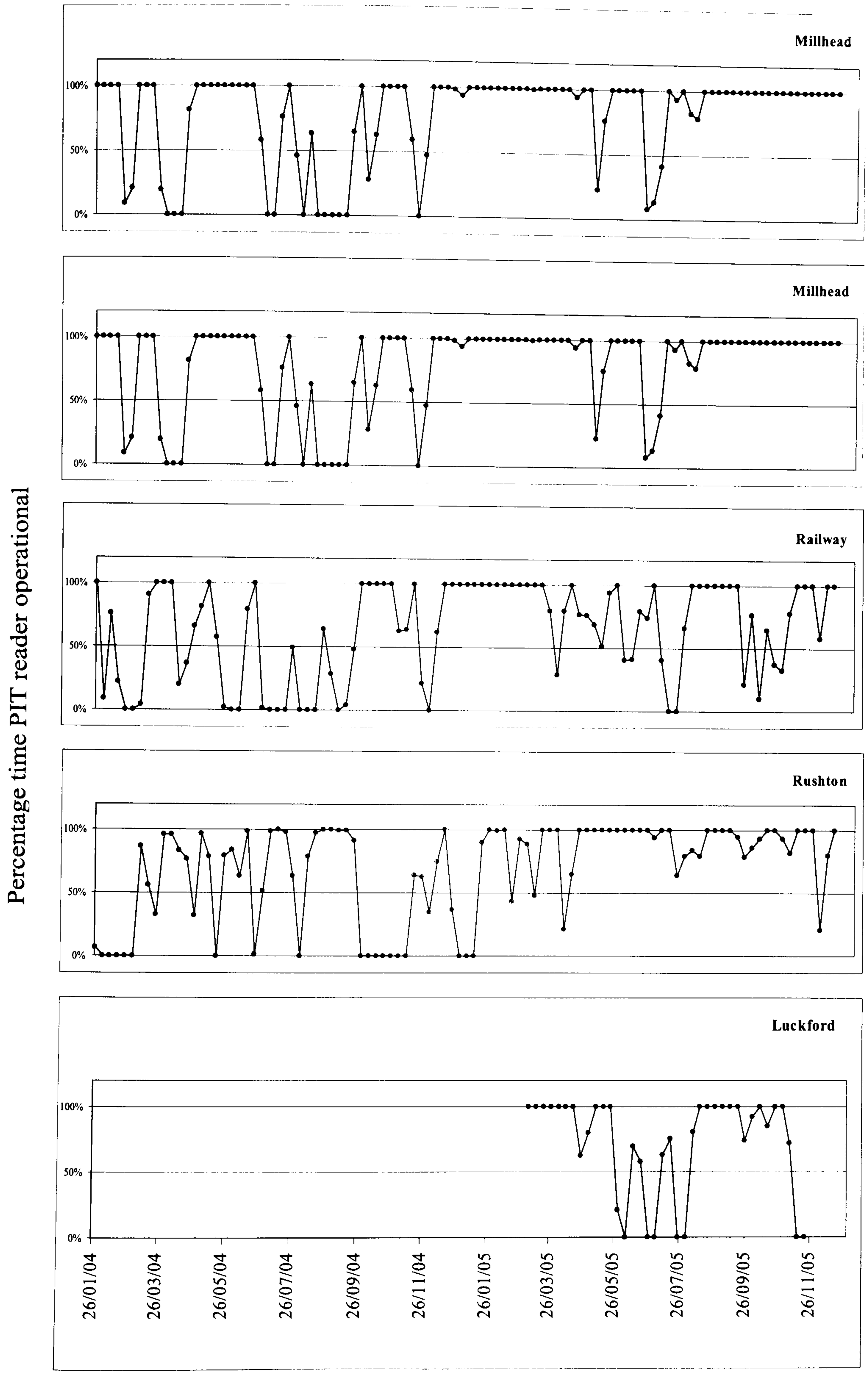
3371	133911812	12/09/2005	Dace	15.1	ESMS 2
3372	133911811	12/09/2005	Dace	15.7	ESMS 2
3373	133911810	12/09/2005	Dace	16.3	ESMS 2
3374	133911809	12/09/2005	Dace	14.7	ESMS 2
3375	133911808	12/09/2005	Dace	12.5	ESMS 2
3376	133911807	12/09/2005	Dace	16.4	ESMS 2
3377	133911855	12/09/2005	Dace	14.8	ESMS 2
3378	133911856	12/09/2005	Dace	18.5	ESMS 2
3379	133911854	12/09/2005	Dace	15.3	ESMS 2
3380	133911852	12/09/2005	Dace	16.8	ESMS 2
3381	133911851	12/09/2005	Dace	16.6	ESMS 2
3382	133911850	12/09/2005	Dace	14.7	ESMS 2
3383	133911849	12/09/2005	Dace	16	ESMS 2
3384	133911848	12/09/2005	Roach	16.4	ESMS 2
3385	133911847	12/09/2005	Dace	15.5	ESMS 2
3386	133911846	12/09/2005	Dace	18.8	ESMS 2
3387	133911845	12/09/2005	Dace	14.3	ESMS 2
3388	133911844	12/09/2005	Dace	14.2	ESMS 2
3389	133911841	12/09/2005	Dace	17.3	ESMS 2
3390	133911840	12/09/2005	Dace	15	ESMS 2
3391	133911865	12/09/2005	Dace	15.9	ESMS 2
3392	133911842	12/09/2005	Dace	15.7	ESMS 2
3393	133911839	12/09/2005	Dace	22.4	ESMS 2
3394	133911838	12/09/2005	Roach	16.9	ESMS 2
3395	133911837	12/09/2005	Dace	14.8	ESMS 2
3396	133911836	12/09/2005	Dace	15.7	ESMS 2
3397	133911835	12/09/2005	Dace	17	ESMS 2
3398	133911834	12/09/2005	Roach	19.1	ESMS 2
3399	133911882	12/09/2005	Dace	15.1	ESMS 2
3400	133911881	12/09/2005	Dace	14.5	ESMS 2
3401	133911833	12/09/2005	Dace	16.4	ESMS 2
3402	133911880	12/09/2005	Dace	16.3	ESMS 2
3403	133911879	12/09/2005	Dace	13.2	ESMS 2
3404	133911878	12/09/2005	Roach	16.6	ESMS 2
3405	133911877	12/09/2005	Roach	16.3	ESMS 2
3406	133911876	12/09/2005	Roach	18.2	ESMS 2
3407	133911874	12/09/2005	Roach	16.5	ESMS 2
3408	133911873	12/09/2005	Dace	16	ESMS 2
3409	133911872	12/09/2005	Dace	15.7	ESMS 2
3410	133911871	12/09/2005	Dace	16	ESMS 2
3411	133911870	12/09/2005	Dace	16.1	ESMS 2
3412	133911869	12/09/2005	Dace	15	ESMS 2
3413	133911867	12/09/2005	Dace	16	ESMS 2
3414	133911866	12/09/2005	Dace	20.7	ESMS 2
3415	133911864	12/09/2005	Dace	18.9	ESMS 2
3416	133911863	12/09/2005	Dace	17.3	ESMS 2
3417	133911862	12/09/2005	Dace	14.2	ESMS 2
3418	133911861	12/09/2005	Dace	17.5	ESMS 2
3419	133911860	12/09/2005	Roach	15.6	ESMS 2
3420	133911857	12/09/2005	Dace	15.7	ESMS 2
3421	133911858	12/09/2005	Dace	17.1	ESMS 2
3422	133911832	12/09/2005	Dace	17.2	ESMS 2
3423	133911859	12/09/2005	Dace	14.9	ESMS 2
3424	133911503	12/09/2005	Eel	15.4	ESMS 2

3425	133911502	12/09/2005	Dace	17	ESMS 2
3426	133911501	12/09/2005	Dace	15.8	ESMS 2
3427	133911500	12/09/2005	Dace	14.6	ESMS 2
3428	133911499	12/09/2005	Dace	17.6	ESMS 2
3429	133911497	12/09/2005	Dace	16	ESMS 2
3430	133911496	12/09/2005	Dace	18.3	ESMS 2
3431	133911493	12/09/2005	Eel	32	ESMS 2
3432	133911494	12/09/2005	Eel	40	ESMS 2
3433	133911495	12/09/2005	Eel	34.8	ESMS 2
3434	133911491	12/09/2005	Roach	23.5	ESMS 2
3435	133911492	12/09/2005	Dace	19.9	ESMS 2
3436	133911490	12/09/2005	Dace	16.5	ESMS 2
3437	133911489	12/09/2005	Roach	15.2	ESMS 2
3438	133911488	12/09/2005	Dace	16	ESMS 2
3439	133911481	12/09/2005	Dace	16	ESMS 2
3440	133911483	12/09/2005	Dace	18	ESMS 2
3441	133911480	12/09/2005	Dace	14.4	ESMS 2
3442	133911482	12/09/2005	Dace	13.7	ESMS 2
3443	133911486	12/09/2005	Dace	15.2	ESMS 2
3444	133911485	12/09/2005	Dace	17.4	ESMS 2
3445	133911484	12/09/2005	Dace	16.4	ESMS 2
3446	133911479	12/09/2005	Dace	17.1	ESMS 2
3447	133911487	12/09/2005	Roach	17.7	ESMS 2
3448	133911528	12/09/2005	Dace	16.2	ESMS 2
3449	133911526	12/09/2005	Dace	15.6	ESMS 2
3450	133911527	12/09/2005	Dace	19.7	ESMS 2
3451	133911525	12/09/2005	Dace	13.7	ESMS 2
3452	133911524	12/09/2005	Roach	15.8	ESMS 2
3453	133911523	12/09/2005	Roach	17.4	ESMS 2
3454	133911521	12/09/2005	Dace	16.5	ESMS 2
3455	133911522	12/09/2005	Roach	15.6	ESMS 2
3456	133911519	12/09/2005	Roach	14.8	ESMS 2
3457	133911520	12/09/2005	Dace	14	ESMS 2
3458	133911518	12/09/2005	Dace	15.7	ESMS 2
3459	133911516	12/09/2005	Dace	14.7	ESMS 2
3460	133911517	12/09/2005	Roach	17.6	ESMS 2
3461	133911514	12/09/2005	Dace	19.7	ESMS 2
3462	133911511	12/09/2005	Roach	15.7	ESMS 2
3463	133911513	12/09/2005	Dace	15.1	ESMS 2
3464	133911512	12/09/2005	Roach	15.8	ESMS 2
3465	133911515	12/09/2005	Dace	15.3	ESMS 2
3466	133911509	12/09/2005	Dace	14.5	ESMS 2
3467	133911510	12/09/2005	Roach	16.1	ESMS 2
3468	133911507	12/09/2005	Roach	17.5	ESMS 2
3469	133911505	12/09/2005	Dace	17.4	ESMS 2
3470	133911508	12/09/2005	Dace	14.6	ESMS 2
3471	133911506	12/09/2005	Roach	17.2	ESMS 2
3472	133911554	12/09/2005	Roach	17.5	ESMS 2
3473	133911504	12/09/2005	Dace	17	ESMS 2
3474	133911553	12/09/2005	Roach	16.1	ESMS 2
3475	133911551	12/09/2005	Dace	15.2	ESMS 2
3476	133911550	12/09/2005	Dace	15.8	ESMS 2
3477	133911549	12/09/2005	Dace	17.7	ESMS 2
3478	133911547	12/09/2005	Dace	17.5	ESMS 2

3479	133911548		12/09/2005	Dace	16.9	ESMS 2
3480	133911552		12/09/2005	Dace	16.8	ESMS 2
3481	133911546		12/09/2005	Dace	14.1	ESMS 2
3482	133911545		12/09/2005	Dace	19.5	ESMS 2
3483	133911538		12/09/2005	Dace	15.8	ESMS 2
3484	133911537		12/09/2005	Dace	16.6	ESMS 2
3485	133911539		12/09/2005	Dace	15	ESMS 2
3486	133911543		12/09/2005	Dace	14.5	ESMS 2
3487	133911544		12/09/2005	Dace	17	ESMS 2
3488	133911542		12/09/2005	Roach	17.6	ESMS 2
3489	133911541		12/09/2005	Roach	17.7	ESMS 2
3490	133911536		12/09/2005	Dace	17.7	ESMS 2
3491	133911535		12/09/2005	Dace	15.5	ESMS 2
3492	133911533		12/09/2005	Dace	13.8	ESMS 2
3493	133912257		12/09/2005	Eel	50.2	ESMS 2
3494	133911593		12/09/2005	Eel	37.5	ESMS 2
3495	133911532		12/09/2005	Eel	35	ESMS 2
3496	133911853		12/09/2005	Pike	21.5	ESMS 3
3497	133911875		14/09/2005	Pike	19.4	Railway 1
3498	133911843		14/09/2005	Pike	16.9	Railway 1
3498	133911843		14/09/2005	Pike	16.9	Railway 1
3498	133911843		14/09/2005	Pike	18.4	Railway 1
3498	133911843		14/09/2005	Pike	18.4	Railway 1
3499	133911802		14/09/2005	Pike	19.4	Railway 1
3500		DC002B-1BC6	14/09/2005	Pike	10.4	Railway 1
3501		DC002A-0819	14/09/2005	Pike	9.7	Railway 1
3502	127178671		14/09/2005	Pike	18	Railway 2
3503	127178668		14/09/2005	Pike	16.5	Railway 2
3504	127178669		14/09/2005	Pike	16.2	Railway 2
3505	127178672		14/09/2005	Pike	13.4	Railway 2
3506	127178673		14/09/2005	Pike	16.8	Railway 2
3507		DC0029-ED9E	14/09/2005	Pike	9.3	Railway 3
3508		DC0029-EBA5	14/09/2005	Pike	9.2	Flood Relief 2
3509		DC002A-F4F5	14/09/2005	Pike	10.2	Flood Relief 2
3510	133911594		14/09/2005	Pike	25.1	Rushton 1
3511		DC002A-0EEC	14/09/2005	Pike	10.4	Rushton 1
3512		DC002A-03AF	14/09/2005	Pike	8.7	Rushton 1
3513		DC002A-FB61	14/09/2005	Pike	9.6	Rushton 1
3514		DC002A-02D0	14/09/2005	Pike	10.2	Rushton 1
3515		DC002B-0298	14/09/2005	Pike	8.8	Rushton 2
3516		DC002A-0E64	14/09/2005	Pike	8.9	Rushton 2
3517		DC0029-F169	14/09/2005	Pike	9.4	Rushton 2
3518		DC0029-EDA7	14/09/2005	Pike	9.7	Rushton 3
3519	127178675		14/09/2005	Pike	34	ESMS 1
3520	127178676		14/09/2005	Pike	36.5	ESMS 1
3521	127178677		14/09/2005	Pike	36.5	ESMS 1
3522	127178678		14/09/2005	Pike	21.2	ESMS 1
3523	127178679		14/09/2005	Pike	21.2	ESMS 1
3524	127178629		14/09/2005	Pike	20.6	ESMS 1
3525	127178713		05/12/2005	Pike	23.3	Railway 1
3526	133911597		05/12/2005	Pike	22	Railway 1
3527	133911596		05/12/2005	Pike	21.2	Railway 2
3528	127178745		05/12/2005	Pike	25.9	Railway 2
3529	127178730		05/12/2005	Pike	24.5	Railway 4

3530	127178968		05/12/2005	Pike	21.4	Railway 4
3531	113945680		05/12/2003	Pike	39.2	Holme Bridge 3
3532	127178746		05/12/2005	Pike	25.9	Railway 1
3533	113945682		05/12/2003	Pike	41.8	Holme Bridge 3
3534	94698295	DC0024-D2EC		Pike		River

Appendix 2 Periods of PIT Detector Operation



Appendix 2 Percentage of each week that each PIT detector was functioning. Note that Luckford was not installed until March 2005.

Appendix 3 Sample of Standardised PIT data

FlinkaFiskar UKAC CF-recorder ver 1.00

			CONSOLIDATED PIT TAG DATA			
Location	**MH**					
Run start/end			**17/12/2003**	**16:32:05**	**06/01/2004**	**10:55:59**
Gate	**PIT no.**	**Species**	**Time in**		**Time out**	
1	94698150	1	25/12/2003	15:28:49	25/12/2003	15:28:49
1	94698212	7	18/12/2003	11:51:34	18/12/2003	11:51:34
2	94698212	7	18/12/2003	11:51:45	18/12/2003	11:51:46
1	94698242	3	25/12/2003	12:36:09	25/12/2003	12:36:10
1	94698253	5	25/12/2003	15:28:50	25/12/2003	15:28:50
1	94698254	2	18/12/2003	11:51:29	18/12/2003	11:51:30
2	94698254	2	18/12/2003	12:11:22	18/12/2003	12:11:22
1	94698254	2	18/12/2003	12:11:31	18/12/2003	12:11:31
1	94698257	3	18/12/2003	16:06:09	18/12/2003	16:06:10
2	94698257	3	18/12/2003	16:06:30	18/12/2003	16:10:16

Appendix 3. Second step in the management of PIT data presenting data having been standardised and compressed.

Appendix 4 Sample of Combined Positions Record

COMBINED POSITIONS RECORD

Location 1 = at gate 1, 0 = beyond gate 1

Location 2 = at gate 2, 3 = beyond gate 2

PIT no.	Species	Reader	Loc.n		From start of run	From arrival	Till departure	Till end of run
94698305	2	MH	0	#	19/03/2004 11:05:10		21/03/2004 18:36:12	
94698305	2	MH	1	#		21/03/2004 18:36:12	21/03/2004 18:36:14	
94698305	2	MH	2	#		21/03/2004 18:36:34	21/03/2004 19:04:49	
94698305	2	MH	1	#		21/03/2004 19:04:52	21/03/2004 19:04:53	
94698305	2	MH	0	#		21/03/2004 19:04:53		24/03/2004 11:30:58
94698305	2	MS	3	#	08/03/2004 10:01:44		24/03/2004 16:11:02	
94698305	2	MS	2	#		24/03/2004 16:11:02	24/03/2004 16:11:04	
94698305	2	MS	1	#		24/03/2004 16:11:18	24/03/2004 16:11:19	
94698305	2	MS	0	#		24/03/2004 16:11:19	24/03/2004 17:58:47	
94698305	2	MS	1	#		24/03/2004 17:58:47	24/03/2004 17:58:54	
94698305	2	MS	2	#		24/03/2004 17:59:08	24/03/2004 18:11:10	
94698305	2	MS	1	#		24/03/2004 18:11:46	24/03/2004 18:11:46	
94698305	2	MS	0	#		24/03/2004 18:11:46		09/06/2004 06:13:40
94698307	1	RW	3	#	15/03/2004 15:58:16		16/03/2004 03:05:27	
94698307	1	RW	2	#		16/03/2004 03:05:27	16/03/2004 03:05:32	
94698307	1	RW	1	#		16/03/2004 03:11:53	16/03/2004 03:15:29	
94698307	1	RW	0	#		16/03/2004 03:15:29	20/03/2004 12:45:12	
94698307	1	RW	1	#		20/03/2004 12:45:12	20/03/2004 12:47:07	
94698307	1	RW	2	#		20/03/2004 12:48:36	20/03/2004 12:48:58	
94698307	1	RW	3	#		20/03/2004 12:48:58	20/03/2004 14:12:10	
94698307	1	RW	2	#		20/03/2004 14:12:10	20/03/2004 14:12:22	
94698307	1	RW	1	#		20/03/2004 14:13:54	20/03/2004 14:13:59	
94698307	1	RW	0	#		20/03/2004 14:13:59		04/04/2004 09:52:57
94698307	1	MH	0	#	04/04/2004 09:48:36		04/04/2004 18:39:09	
94698307	1	MH	1	#		04/04/2004 18:39:09	05/04/2004 05:35:33	

Appendix 4. A sample of the Combined Positions Record, which for each fish brings together all detections from any of the TIRIS PIT readers. It is the main PIT data library, and the starting point for fish centred analysis.

Appendix 5 Sample of PIT Data Overview

LOCATIONS OVERVIEW

For detected fish: U = was here today and departed upstream, u = logically upstream
L = lost D = was here today and departed downstream, . = logically downstream

Fish	Sp	Loc	Mar | Apr | May | Jun (Days 1.....31 1.... 30 1... 31 1... 30)
94698259	2	MH	...................................LDUUUUDD....UUuuUu
94698259	2	MS	....Uuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuu
94698259	2	RU	
94698259	2	RW	
94698301	4	MH	
94698301	4	MS	...........D..UD......................
94698301	4	RU	uuuuuUDU DUuDDU uUUUuUUUuD.UuuuuDDDDU .DDDDDDULDDDDDU
94698301	4	RW	
113943661	4	MH	....Uuuuuuuuuuuuuuuu
113943661	4	MS	....................................UD...................Uuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuu
113943661	4	RU	
113943661	4	RW	
113943713	3	MH	
113943713	3	MS	....UuuuuuuD......................................
113943713	3	RU	..D...........
113943713	3	RW	
113945692	2	MH	...................Uuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuu
113945692	2	MS	.......................D..............Uuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuu
113945692	2	RU	
113945692	2	RW	
124086126	1	MH	
124086126	1	MS	....Uuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuuu
124086126	1	RU	.........D..LLLLDUuD. ..D...........
124086126	1	RW	......DD

Appendix 5. A sample of the summary of all daily movements measured with PIT telemetry for individual fish created by the Overview macro.

Appendix 6 Details of Radio Tracked Pike

Frequency	Name	Start date	End date	No. Fixes	Sex	Size Range* (cm)	Weight Range* (g)
746	Alice	25/05/2000	11/09/2002	689	F	86	5216
788	Anabelle	25/02/2004	28/07/2005	127	F	52-65	2410
561/950	Anakin	01/03/2004	24/06/2005	222	M	72-73	3100-4300
622	Bertie	25/02/2004	28/07/2005	189	M	55	2150
730/930	Boris	25/05/2000	29/07/2005	1222	M	71-78	3300-5330
833	Chica	09/06/2000	05/07/2002	1023	F	61-72	2500-3900
856	Chris	02/02/2003	29/10/2004	66	M	56-65	1600-1730
995	Elizabeth	25/02/2004	28/07/2005	194	F	65	2550
522	Emma	05/07/2000	18/01/2001	52	F	83	4500
893	Fiona	25/07/2000	21/11/2001	103	F	56-63	2000
653	Frances	25/02/2004	28/07/2005	151	F	69.5	2920
682	Fred	03/03/2004	06/01/2005	68	M	55-61	1420-2840
904	Gabby	01/08/2000	07/06/2001	223	F	62-66	2700
778	Gertie	25/02/2004	28/07/2005	150	F	58-73	1790
862	Hannah	25/08/2000	06/10/2003	696	F	58-87	1560-3060
735	Helonn	25/02/2004	28/07/2005	153	F	91	7910
698	Henry	16/01/2004	01/12/2004	50	M	64-67	2330-2640
972	Isaac	16/10/2000	20/04/2003	384	M	81-87	4540-5900
338	Janey	09/03/2005	28/07/2005	92	F	74	3120
959	Julia	01/12/2000	24/07/2002	331	F	87-93	6900-8160
947	Kate	18/01/2001	19/04/2002	120	F	95	8160
376	Kathleen	09/03/2005	28/07/2005	91	F	68	2580
850	Kin	16/01/2004	28/07/2005	146	F	101	9700-10600
541	Lisa	18/01/2001	10/03/2004	1386	F	77-81	3600-4700
323	Luke	09/03/2005	28/07/2005	93	M	50-54	1105
988	Mark	18/01/2001	28/07/2005	737	M	64-72	2800-3800
561	Nicola	26/02/2001	04/07/2001	157	F	65	1900
581	Orla	02/05/2001	28/05/2004	451	F	60-80	1800-5200
530	Pete	23/05/2001	15/07/2004	625	M	58-66	1700-3060
514	Quentin	23/05/2001	14/10/2002	238	M	69	3200
590	Rob	23/05/2001	06/07/2001	13	M	60	2000
505	Willow	30/08/2001	29/10/2001	59	F	63	1800
591	Xena	06/09/2001	22/07/2004	413	F	54-73	1400-3900
921	Yoda	14/11/2001	20/04/2003	205	M	64	2250
756	Yul	25/02/2004	28/07/2005	164	M	73	4370
613	Zac	25/02/2004	28/07/2005	195	M	59	2690
900	Zebedee	28/01/2002	04/06/2005	224	M	55-67	1500-3000
906	Sian	31/07/2001	26/09/2001	74	F	52-55	1200
975	Una	31/07/2001	10/08/2001	20	F	44	1800
602	Victoria	31/07/2001	10/02/2003	323	F	52	1700
065	Mikey	09/03/2005	15/03/2005	7		26	114
164		17/03/2005	28/04/2005	38	M	26	-
188		18/03/2005	20/05/2005	61		26	11-178
404		18/03/2005	24/05/2005	60	M	28	-

015		17/03/2005	24/05/2005	66	M	25	109
026		14/03/2005	21/03/2005	8		25	-
35/002		14/03/2005	28/04/2005	41	F	26	60-135
044		14/03/2005	22/04/2005	30	M	27	162
054		09/03/2005	07/05/2005	54		25	-
072		14/03/2005	06/06/2005	72	M	32	284
084		14/03/2005	25/03/2005	12	M	27	150
093		14/03/2005	30/04/2005	42		25	-
006		14/03/2005	06/04/2005	20	M	26	135
875	MJ	17/03/2004	21/04/2004	75		25	86-116
	Paddy	17/03/2004	21/04/2004	75		25	108-162
307		23/06/2005	15/07/2005	12		25	-
326		23/06/2005	01/08/2005	19		25	-
347		23/06/2005	28/07/2005	17		26	30-142
304	Maddy	20/07/2004	06/08/2004	28		22	97
854	Magnus	20/07/2004	10/08/2004	29		17	11-106
192	Mandy	20/07/2004	22/07/2004	3		14	29
270	Martha	20/07/2004	10/08/2004	21		21	80
728	Maximus	21/07/2004	10/08/2004	29		9.2	8
793	Mildred	20/07/2004	30/07/2004	12		16	53
837	Morris	21/07/2004	10/08/2004	29		10	8-16
764	Maggie	17/03/2004	21/04/2004	60		15	21-235
	Mitch	17/03/2004	09/04/2004	68		14	22
	Morgan	17/03/2004	21/04/2004	76		14	19

Appendix 6 Details of the pike (*Esox lucius*) radio tracked during the study. Start and end date give the tagging date and the date the fish was last located respectively.

* Size and weight range indicates the size/weight of pike at each capture and thus the known size/weight range during the study.

Appendix 7 Details of Radio Tracked Dace

Frequency	Start date	End of tracking	Size (cm)	Weight (g)
173.801	07/01/2004	17/03/2004	24.2	219
173.912	07/01/2004	27/01/2004	24.1	206
173.885	07/01/2004	06/02/2004	25.7	262
173.615	07/01/2004	12/02/2004	24.2	214
173.735	07/01/2004	12/02/2004	23.8	230
173.584	07/01/2004	29/01/2004	23.1	199
173.765	07/01/2004	12/02/2004	23.7	186
173.810	16/03/2004	17/03/2004	19.7	112
173.557	16/03/2004	21/03/2004	26.0	220
173.713	16/03/2004	19/03/2004	26.1	288
173.595	16/03/2004	02/04/2004	26.5	284
173.726	16/03/2004	16/03/2004	22.9	165
173.625	16/03/2004	19/03/2004	25.5	219
173.841	16/03/2004	22/03/2004	21.8	174
173.745	16/03/2004	17/03/2004	23.2	185
173.894	16/03/2004	01/04/2004	23.8	180
173.952	16/03/2004	13/04/2004	20.3	120
173.718	16/03/2004	07/04/2004	20.8	135
173.761	17/03/2004	15/04/2004	24.9	263
173.744	17/03/2004	08/04/2004	27.1	333
173.764	17/03/2004	19/03/2004	22.4	159
173.616	17/03/2004	01/04/2004	23.2	179
173.759	17/03/2004	23/03/2004	23.2	196
173.413	17/09/2004	18/10/2004	20.7	-
173.425	17/09/2004	18/10/2004	20.1	-
173.485	17/09/2004	02/10/2004	21.8	-
173.476	17/09/2004	01/12/2004	20.4	-
173.496	17/09/2004	14/10/2004	22.1	-
173.504	17/09/2004	01/12/2004	19.0	-
173.453	17/09/2004	01/12/2004	23.0	-
173.943	17/09/2004	17/11/2004	19.0	-
173.436	17/09/2004	01/12/2004	19.3	-
173.445	17/09/2004	01/12/2004	18.9	-
173.115	17/03/2005	19/03/2005	22.3	181
173.130	17/03/2005	27/03/2005	20.6	130
173.142	17/03/2005	21/03/2005	22.6	174
173.153	17/03/2005	25/03/2005	22.8	194
173.173	17/03/2005	21/03/2005	26.4	-
173.121	17/03/2005	21/03/2005	22.7	-
173.106	17/03/2005	21/03/2005	21.3	-

Appendix 7 Details of the dace (*Leuciscus leuciscus*) radio tracked during the study. Start and end date give the tagging date and the date the fish was last located respectively. * Size range indicates the size of pike at each capture and thus the known size/weight range during the study.

Appendix 8 Seasonal Habitat Variability

Abiotic data were single measurements with hand-meters made in each side-channel on the day of each quarterly electric fishing sampling. Some variability may arise as measurements were made on different days according to when each channel was sampled. Data presented are the mean over 2003-2005.

TEMPERATURE	March				June				September				December			
(°C)	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	4	0.2	4	4	14	2	16	11	14	2	16	12	4	1	5	4
Millstream	9	0.1	10	9	18	1	20	17	15	1	17	14	7	1	10	5
Rushton	x	x	x	x	14	2	20	12	14	2	16	11	7	1	9	6
Luckford	9	0.1	9	9	14	2	19	12	8	4	13	3	7	2	9	5
Goldsacs	9	0.1	9	9	14	1	15	13	14	1	15	14	7	1	9	6
Holme Bridge	2	0.1	2	1	15	1	18	14	14	1	16	12	7	1	8	5
Flood Relief	7	0.6	7	6	18	4	24	13	15	2	17	7	7	1	9	5

DISSOLVED	March				June				September				December			
OXYGEN (mg/l)	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	2	0	2	2	6	7	31	1	5	2	8	2	6	1	7	5
Millstream	13	4	17	9	11	3	14	8	13	2	16	10	10	1	14	8
Rushton	x	x	x	x	5	2	9	1	8	3	12	5	5	1	6	4
Luckford	2	0.8	18	15	4	2	10	2	6	3	12	4	9	2	12	8
Goldsacs	5	3	9	2	8	2	10	1	10	2	12	7	10	0	10	10
Holme Bridge	4	3	8	1	5	4	11	1	4	2	6	1	5	1	7	5
Flood Relief	1	0.2	2	1	8	4	14	4	7	4	16	3	6	2	8	4

DEPTH (cm)	March				June				September				December			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	36	17	82	7	29	15	70	5	27	12	58	5	33	13	63	9
Millstream	43	22	100	4	50	23	120	18	37	22	99	4	31	17	78	3
Rushton	50	18	83	16	53	25	115	15	47	20	100	2	50	19	100	6
Luckford	59	26	130	10	53	28	120	8	50	26	119	12	50	26	119	12
Goldsacs	30	19	100	8	22	12	55	2	26	17	79	1	37	19	95	7
Holme Bridge	49	29	100	10	52	25	105	15	43	27	100	0	49	24	100	10
Flood Relief	39	22	90	1	45	30	120	2	38	22	100	5	40	21	79	5

WIDTH (m)	March				June				September				December			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	4	2	7	2	3	1	5	1	3	1	4	2	3	1	4	2
Millstream	5	1	8	4	6	1	8	5	5	1	7	3	7	3	14	4
Rushton	3	1	4	2	3	1	4	2	3	1	4	2	3	1	4	1
Luckford	5	1	8	2	6	1	8	2	5	1	9	3	5	1	8	4
Goldsacs	2	1	4	1	2	1	4	1	2	1	4	1	2	1	4	1
Holme Bridge	5	3	13	2	4	2	10	2	4	2	10	0	4	2	9	1
Flood Relief	3	1	6	1	4	1	6	2	3	1	6	1	3	1	6	2

TURBULENT (%)	March				June				September				December			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Millstream	1	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Rushton	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luckford	1	2	5	0	1	2	5	0	0	0	0	0	0	0	0	0
Goldsacs	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	0
Holme Bridge	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flood Relief	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

GLIDE (%)	March				June				September				December			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	10	28	80	0	1	2	5	0	0	0	0	0	8	7	20	0
Millstream	98	5	100	80	93	10	100	60	94	6	100	80	99	4	100	80
Rushton	4	8	20	0	1	4	10	0	0.9	2	5	0	2	3	10	0
Luckford	7	14	50	0	1	2	5	0	14	21	60	0	5	0	5	5
Goldsacs	100	0	100	100	98	4	100	90	68	32	100	10	99	4	100	90
Holme Bridge	6	20	80	0	54	49	100	0	0	0	0	0	3	4	10	0
Flood Relief	0	0	0	0	0	0	0	0	10	24	80	0	5	15	60	0

SLACK (%)	March				June				September				December			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	95	20	100	20	100	1	100	95	100	0	100	100	95	7	100	80
Millstream	2	5	20	0	7	10	40	0	6	6	20	0	3	7	20	0
Rushton	98	5	100	80	100	2	100	90	99	2	100	95	99	3	100	90
Luckford	95	12	100	50	100	1	100	95	91	18	100	40	97	2	100	95
Goldsacs	100	0	100	100	3	5	10	0	32	32	90	0	4	5	10	0
Holme Bridge	94	20	100	20	64	47	100	0	100	0	100	100	98	4	100	90
Flood Relief	100	0	100	100	100	0	100	100	93	20	100	20	96	12	100	40

CLAY (%)	March				June				September				December			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	0	0	0	0	17	24	50	0	19	20	80	0	3	4	10	0
Millstream	1	3	10	0	18	33	80	0	8	9	30	0	5	6	30	0
Rushton	0	0	0	0	28	32	90	0	23	31	80	0	27	22	70	0
Luckford	0	0	0	0	30	45	100	0	20	25	100	0	14	22	80	0
Goldsacs	4	7	20	0	0	0	0	0	6	10	40	0	3	5	15	0
Holme Bridge	0	0	0	0	5	12	40	0	13	12	40	0	7	16	50	0
Flood Relief	0	0	0	0	2	5	20	0	30	37	90	0	8	10	30	0

SILT (%)	March				June				September				December			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	33	45	100	0	83	24	100	50	78	21	100	20	91	18	100	10
Millstream	6	4	10	0	4	5	10	0	99	6	20	0	2	3	10	0
Rushton	12	26	80	0	54	33	100	10	67	39	100	0	61	26	100	10
Luckford	73	29	100	20	58	44	100	0	61	29	100	0	75	30	100	10
Goldsacs	7	5	10	0	15	22	90	0	19	13	40	10	14	13	40	0
Holme Bridge	64	41	100	5	72	37	100	0	77	29	100	10	78	33	100	0
Flood Relief	35	47	100	0	80	29	100	10	40	33	100	0	79	23	100	20

SAND (%)	March				June				September				December			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	33	47	100	0	0	0	0	0	0	0	0	0	0	0	0	0
Millstream	22	21	50	0	14	16	60	0	13	18	80	0	12	10	50	0
Rushton	5	20	100	0	9	15	50	0	0	0	0	0	0	0	0	0
Luckford	31	43	100	0	1	3	15	0	2	4	10	0	2	5	20	0
Goldsacs	57	35	90	10	78	23	100	10	73	23	90	20	76	14	100	50
Holme Bridge	35	43	100	0	17	38	100	0	0	0	0	0	3	7	30	0
Flood Relief	33	48	100	0	3	6	20	0	2	8	40	0	0	1	5	0

GRAVEL (%)	March				June				September				December			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	0	1	5	0	0.2	1	5	0	3	4	10	0	2	5	20	0
Millstream	57	13	80	45	64	35	100	5	62	27	90	0	77	1	90	40
Rushton	33	47	100	0	9	20	90	0	1	21	70	0	13	25	85	0
Luckford	9	18	70	0	12	24	75	0	17	25	80	0	10	22	80	0
Goldsacs	32	42	90	0	6	9	30	0	2	4	10	0	6	9	35	0
Holme Bridge	5	15	70	0	6	11	40	0	10	24	80	0	13	26	80	0
Flood Relief	0	1	5	0	15	25	80	0	20	27	80	0	10	19	60	0

COBBLES (%)	March				June				September				December			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	0	0	0	0	0	0	0	0	0	0	0	0	0	2	10	0
Millstream	16	23	50	0	0	0	0	0	1	2	5	0	4	4	10	0
Rushton	29	46	100	0	0	0	0	0	0	0	0	0	0	1	5	0
Luckford	3	1	40	0	0	1	5	0	0	0	0	0	0	0	0	0
Goldsacs	0	0	0	0	0	1	5	0	0	1	5	0	1	2	5	0
Holme Bridge	0	2	10	0	1	2	5	0	0	0	0	0	0	0	0	0
Flood Relief	0	1	5	0	0	1	5	0	1	3	15	0	3	7	30	0

TREE ROOTS (%)	March				June				September				December			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	1	5	20	0	2	4	10	0	6	9	40	0	7	15	65	0
Millstream	6	12	40	0	1	3	10	0	4	6	25	0	5	8	30	0
Rushton	0	0	0	0	0	1	5	0	3	5	20	0	2	4	10	0
Luckford	21	29	80	0	6	6	20	0	11	14	50	0	9	14	50	0
Goldsacs	9	16	50	0	2	6	30	0	14	23	90	0	3	4	10	0
Holme Bridge	7	17	70	0	2	4	15	0	4	4	10	0	7	11	50	0
Flood Relief	3	10	50	0	1	2	5	0	2	4	20	0	0	1	5	0

BRANCHES/ LOGS (%)	March				June				September				December			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	30	43	100	0	0	2	10	0	4	7	30	0	3	8	40	0
Millstream	3	6	20	0	1	4	20	0	1	3	10	0	0	2	5	0
Rushton	12	21	70	0	2	10	50	0	1	2	10	0	2	5	20	0
Luckford	20	25	80	0	22	23	80	0	37	28	90	0	39	62	300	0
Goldsacs	2	5	20	0	2	4	10	0	0	0	0	0	2	4	15	0
Holme Bridge	17	28	80	0	10	17	60	0	15	19	60	0	30	33	100	0
Flood Relief	6	21	100	0	2	4	20	0	1	2	10	0	3	7	30	0

SUBMERGED SPARSE (%)	March				June				September				December			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	1	5	20	0	0	0	0	0	9	11	25	0	0	0	0	0
Millstream	5	11	40	0	2	5	20	0	2	4	10	0	4	6	25	0
Rushton	0	0	0	0	13	18	70	0	4	11	40	0	7	7	20	0
Luckford	0	0	0	0	0	2	10	0	0	1	5	0	0	0	0	0
Goldsacs	0	0	0	0	0	2	10	0	0	1	5	0	1	2	5	0
Holme Bridge	5	17	70	0	3	6	25	0	1	4	20	0	3	6	20	0
Flood Relief	3	10	50	0	3	7	30	0	12	32	95	0	1	2	5	0

EMERGENT DENSE (%)	March				June				September				December			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	29	44	100	0	86	19	100	20	86	27	100	0	64	32	100	0
Millstream	0	0	0	0	2	5	20	0	5	9	40	0	0	1	5	0
Rushton	12	21	70	0	21	30	80	0	46	36	100	0	33	26	80	0
Luckford	0	2	10	0	1	4	15	0	4	10	30	0	0.6	2	10	0
Goldsacs	0	1	3	0	11	19	50	0	16	23	80	0	1	3	15	0
Holme Bridge	1	2	10	0	6	11	40	0	9	16	60	0	4	10	35	0
Flood Relief	6	21	100	0	1	3	10	0	14	32	100	0	2	4	10	0

SUBMERGED DENSE (%)	March				June				September				December			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	0	0	0	0	0	0	2	0	0	0	0	0	1	3	15	0
Millstream	16	29	80	0	36	37	100	0	2	4	15	0	13	23	70	0
Rushton	8	23	100	0	7	15	60	0	21	23	80	0	14	18	60	0
Luckford	1	4	20	0	0	0	0	0	0	0	0	0	0	0	0	0
Goldsacs	0	0	0	0	0	0	0	0	0.4	1	5	0	0	0	0	0
Holme Bridge	12	25	80	0	3	9	40	0	12	26	90	0	0	0	0	0
Flood Relief	6	22	100	0	35	37	90	0	20	35	100	0	17	33	100	0

OVERHUNG TREES (%)	March				June				September				December			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	0	0	0	0	0	0	2	0	0	0	0	0	1	3	15	0
Millstream	6	12	50	0	6	12	50	0	17	16	40	0	10	11	40	0
Rushton	11	24	100	0	25	30	100	0	28	30	100	0	21	24	90	0
Luckford	32	37	100	0	84	24	100	40	90	22	100	0	37	31	90	0
Goldsacs	13	24	80	0	48	37	100	0	55	40	100	0	39	28	90	5
Holme Bridge	49	40	100	0	77	30	100	0	75	38	100	0	65	37	100	0
Flood Relief	13	24	100	0	44	41	100	0	36	42	100	0	23	24	70	0

EMERGENT	March				June				September				December			
SPARSE (%)	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	4	11	50	0	0	4	15	0	4	13	60	0	9	19	80	0
Millstream	0	0	0	0	4	5	20	0	2	4	10	0	5	11	40	0
Rushton	3	10	50	0	30	30	90	0	7	11	40	0	12	9	40	0
Luckford	7	15	50	0	0	1	5	0	0	0	0	0	0	0	0	0
Goldsacs	3	7	30	0	2	5	20	0	3	7	30	0	1	2	5	0
Holme Bridge	14	29	95	0	5	7	25	0	3	5	20	0	3	5	15	0
Flood Relief	7	14	50	0	5	6	20	0	6	8	30	0	4	8	30	0

Appendix 9 Annual Habitat Variation

Abiotic data were single measurements with hand-meters made in each side-channel on the day of each quarterly electric fishing sampling. Some variability may arise as measurements were made on different days according to when each channel was sampled. Data presented are the mean of all seasons in a given year.

TEMPERATURE	2003				2004				2005			
(°C)	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	9	4	12	4	11	4	15	4	12	6	16	4
Millstream	11	4	15	7	12	3	18	9	13	7	20	5
Rushton	14	0	14	14	11	2	16	8	12	5	20	6
Luckford	7	3	13	3	11	2	16	8	10	5	19	5
Goldsacs	10	4	15	6	11	3	15	8	x	x	x	x
Holme Bridge	11	3	16	8	9	5	16	1	6	0.5	7	5
Flood Relief	11	5	16	5	11	4	17	6	15	6	24	7

DISSOLVED	2003				2004				2005			
OXYGEN (Mg/l)	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	5	0	6	5	5	2	8	1	5	5	31	2
Millstream	10	0	10	10	14	3	17	10	10	2	14	8
Rushton	x	x	x	x	7	3	12	4	4	1	7	1
Luckford	8	0	8	8	10	6	18	2	6	3	12	3
Goldsacs	10	0	10	10	9	4	12	2	8	2	9	1
Holme Bridge	5	0	5	5	5	3	11	1	4	2	8	1
Flood Relief	5	2	8	4	8	5	16	1	6	2	12	3

DEPTH (cm)	2003				2004				2005			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	41	23	100	5	30	20	95	1	48	27	100	10
Millstream	40	22	100	3	34	24	120	1	21	13	74	5
Rushton	53	26	120	10	29	14	63	5	59	23	115	14
Luckford	36	16	82	5	47	21	100	2	42	24	120	4
Goldsacs	45	18	86	6	39	20	99	4	47	24	100	7
Holme Bridge	35	16	100	9	52	26	105	10	61	26	130	12
Flood Relief	46	26	100	0	50	26	120	8	26	11	61	5

WIDTH (m)	2003				2004				2005			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	3	1	4	2	4	2	7	2	3	1	4	2
Millstream	4	1	8	4	6	1	7	4	7	2	14	3
Rushton	3	1	4	2	3	1	4	1	3	1	4	2
Luckford	5	1	8	3	5	2	8	2	6	1	9	4
Goldsacs	2	1	3	1	3	1	4	1	2	1	4	1
Holme Bridge	4	2	13	0	4	3	10	1	4	2	10	2
Flood Relief	3	1	6	1	4	2	6	2	3	1	6	2

TURBULENT (%)	2003				2004				2005			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	0	0	0	0	0	0	0	0	0	0	0	0
Millstream	0.6	2	5	0	0	0	0	0	0	0	0	0
Rushton	0	0	0	0	0	0	0	0	0	0	0	0
Luckford	0	0	0	0	1	2	5	0	0	0	0	0
Goldsacs	1	2	5	0	0	0	0	0	0	0	0	0
Holme Bridge	0	0	0	0	0	0	0	0	0	0	0	0
Flood Relief	0	0	0	0	0	0	0	0	0	0	0	0

GLIDE (%)	2003				2004				2005			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	11	20	80	0	5	0	5	5	0.6	2	5	0
Millstream	98	4	100	80	93	10	100	60	96	6	100	80
Rushton	1	2	5	0	30	6	20	0	1	2	5	0
Luckford	16	20	60	0	6	14	50	0	3	4	20	0
Goldsacs	89	22	100	10	89	26	100	10	92	18	100	20
Holme Bridge	6	20	80	0	12	27	80	0	45	50	100	0
Flood Relief	13	27	80	0	2	3	5	0	3	4	10	0

SLACK (%)	2003				2004				2005			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	95	15	100	20	99	2	100	95	100	1	100	95
Millstream	3	5	20	0	7	10	40	0	5	6	20	0
Rushton	100	2	100	95	98	4	100	80	100	1	100	95
Luckford	92	16	100	40	97	10	100	50	98	4	100	80
Goldsacs	66	41	100	10	15	28	90	0	15	23	80	0
Holme Bridge	97	14	100	20	92	23	100	20	78	42	100	0
Flood Relief	94	20	100	20	100	2	100	95	99	2	100	90

COBBLES (%)	2003				2004				2005			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	0	0	0	0	0	1	5	0	0	2	10	0
Millstream	2	3	10	0	18	30	80	0	0	1	5	0
Rushton	0	1	5	0	0	1	5	0	0	0	0	0
Luckford	0	0	0	0	1	3	15	0	0	0	0	0
Goldsacs	0	1	5	0	3	7	30	0	0	1	5	0
Holme Bridge	0	0	0	0	2	6	25	0	0	2	10	0
Flood Relief	0	0	0	0	2	5	20	0	2	6	30	0

GRAVEL (%)	2003				2004				2005			
	Mean	SD	Max	Min	Mean	SD	Max	Min	Mean	SD	Max	Min
Railway	1	3	10	0	1	4	20	0	1	3	10	0
Millstream	73	18	100	45	56	28	90	0	60	30	90	5
Rushton	32	42	100	0	9	21	70	0	6	12	50	0
Luckford	17	27	80	0	7	18	80	0	11	21	70	0
Goldsacs	2	7	35	0	24	30	80	0	5	7	20	0
Holme Bridge	5	14	70	0	10	21	80	0	10	24	80	0
Flood Relief	15	27	80	0	10	20	80	0	10	16	50	0

SAND (%)	2003 Mean	SD	Max	Min	2004 Mean	SD	Max	Min	2005 Mean	SD	Max	Min
Railway	0	1	5	0	25	44	100	0	0	0	0	0
Millstream	19	19	50	0	14	16	60	0	13	15	80	0
Rushton	4	18	100	0	24	39	100	0	24	39	100	0
Luckford	2	4	10	0	26	42	100	0	0.9	3	15	0
Goldsacs	92	8	100	65	49	24	80	10	74	17	90	10
Holme Bridge	15	33	100	0	23	41	100	0	3	5	20	0
Flood Relief	3	9	40	0	23	41	100	0	0	0	0	0

CLAY (%)	2003 Mean	SD	Max	Min	2004 Mean	SD	Max	Min	2005 Mean	SD	Max	Min
Railway	15	21	50	0	2	6	30	0	12	20	80	0
Millstream	3	4	10	0	2	5	25	0	19	28	80	0
Rushton	32	34	90	0	13	21	80	0	14	19	50	0
Luckford	13	24	100	0	7	20	80	0	28	38	100	0
Goldsacs	0	0	0	0	4	9	40	0	6	7	20	0
Holme Bridge	8	15	50	0	7	12	40	0	4	11	40	0
Flood Relief	5	9	40	0	8	24	80	0	16	29	90	0

SILT (%)	2003 Mean	SD	Max	Min	2004 Mean	SD	Max	Min	2005 Mean	SD	Max	Min
Railway	83	21	100	50	72	43	100	0	59	42	100	0
Millstream	3	4	10	0	4	5	20	0	8	5	20	0
Rushton	32	34	100	0	54	43	100	0	50	36	100	0
Luckford	68	32	100	0	60	43	100	0	60	38	100	0
Goldsacs	6	6	20	0	23	11	40	10	15	17	90	0
Holme Bridge	73	35	100	0	58	43	100	0	83	29	100	10
Flood Relief	83	29	100	10	53	43	100	0	47	39	100	0

BRANCHES/ LOGS (%)	2003 Mean	SD	Max	Min	2004 Mean	SD	Max	Min	2005 Mean	SD	Max	Min
Railway	0.9	3	10	0	24	39	100	0	3	6	30	0
Millstream	0.6	2	10	0	1	4	20	0	2	5	20	0
Rushton	2	9	50	0	10	22	80	0	1	4	20	0
Luckford	24	26	80	0	20	25	80	0	44	54	300	0
Goldsacs	1	3	10	0	0.8	3	15	0	2	5	20	0
Holme Bridge	6	11	50	0	13	19	70	0	35	32	100	0
Flood Relief	0	1	5	0	2	4	10	0	3	7	30	0

TREE ROOT SYSTEMS (%)	2003 Mean	SD	Max	Min	2004 Mean	SD	Max	Min	2005 Mean	SD	Max	Min
Railway	7	13	65	0	2	5	20	0	2	7	40	0
Millstream	6	9	40	0	4	8	30	0	4	8	40	0
Rushton	2	4	20	0	2	3	10	0	0.6	2	10	0
Luckford	6	10	50	0	15	22	80	0	9	10	40	0
Goldsacs	8	19	90	0	2	5	20	0	12	16	50	0
Holme Bridge	6	15	70	0	15	24	80	0	6	9	50	0
Flood Relief	3	10	50	0	0.4	1	5	0	0.5	2	5	0

OVERHUNG TREES (%)	2003 Mean	SD	Max	Min	2004 Mean	SD	Max	Min	2005 Mean	SD	Max	Min
Railway	15	16	50	0	9	13	40	0	11	18	60	0
Millstream	15	18	70	0	21	27	90	0	19	18	75	0
Rushton	22	28	100	0	19	27	100	0	17	24	100	0
Luckford	55	42	100	0	49	41	100	0	77	30	100	0
Goldsacs	19	23	100	0	41	39	100	0	56	35	100	0
Holme Bridge	65	36	100	0	61	46	100	0	66	39	100	0
Flood Relief	36	39	100	0	22	27	70	0	31	38	100	0

EMERGENT SPARSE (%)	2003 Mean	SD	Max	Min	2004 Mean	SD	Max	Min	2005 Mean	SD	Max	Min
Railway	5	10	25	0	1	3	10	0	1	5	20	0
Millstream	4	6	25	0	1	3	10	0	3	6	30	0
Rushton	8	13	50	0	7	15	70	0	3	6	20	0
Luckford	0	0	0	0	2	5	20	0	0	0	0	0
Goldsacs	0.6	2	10	0	1	2	5	0	0	0	0	0
Holme Bridge	2	5	25	0	1	3	15	0	3	6	20	0
Flood Relief	0	1	5	0	10	28	95	0	2	6	30	0

EMERGENT DENSE (%)	2003 Mean	SD	Max	Min	2004 Mean	SD	Max	Min	2005 Mean	SD	Max	Min
Railway	88	22	100	0	57	40	100	0	55	43	100	0
Millstream	1	3	10	0	1	2	10	0	3	9	40	0
Rushton	26	29	90	0	31	30	95	0	28	34	100	0
Luckford	3	8	30	0	2	5	20	0	0	2	10	0
Goldsacs	10	19	80	0	6	13	50	0	8	16	50	0
Holme Bridge	4	9	30	0	5	7	20	0	8	15	60	0
Flood Relief	15	32	100	0	2	4	20	0	2	4	10	0

SUBMERGED SPARSE (%)	2003 Mean	SD	Max	Min	2004 Mean	SD	Max	Min	2005 Mean	SD	Max	Min
Railway	5	10	25	0	1	3	10	0	1	5	20	0
Millstream	4	6	25	0	1	2	10	0	3	6	30	0
Rushton	8	13	50	0	7	15	70	0	3	6	20	0
Luckford	0	0	0	0	2	5	20	0	0	0	0	0
Goldsacs	1	2	10	0	1	12	5	0	0	0	0	0
Holme Bridge	2	5	25	0	1	3	15	0	3	6	20	0
Flood Relief	0	0.9	5	0	10	28	95	0	2	6	30	0

SUBMERGED DENSE (%)	2003 Mean	SD	Max	Min	2004 Mean	SD	Max	Min	2005 Mean	SD	Max	Min
Railway	0	0	0	0	1	3	15	0	0	0	0	0
Millstream	0	1	3	0	21	28	90	0	28	36	100	0
Rushton	16	25	100	0	18	21	70	0	9	17	60	0
Luckford	1	4	20	0	0	2	10	0	0	0	0	0
Goldsacs	0	0	0	0	0	1	5	0	0	0	0	0
Holme Bridge	9	22	80	0	3	13	70	0	7	21	90	0
Flood Relief	16	32	100	0	15	30	100	0	26	39	100	0

Appendix 10 Two-way *ANOVA* results for differences between side-channel sections

Two-way *ANOVA*s were used to elucidate any differences between catch and species diversity in the four 50 m sections of each side channel. As a large number of tests were undertaken to examine this, Bonferroni corrections were applied. Using the Bonferroni correction *P*-values < 0.00029 were significant.

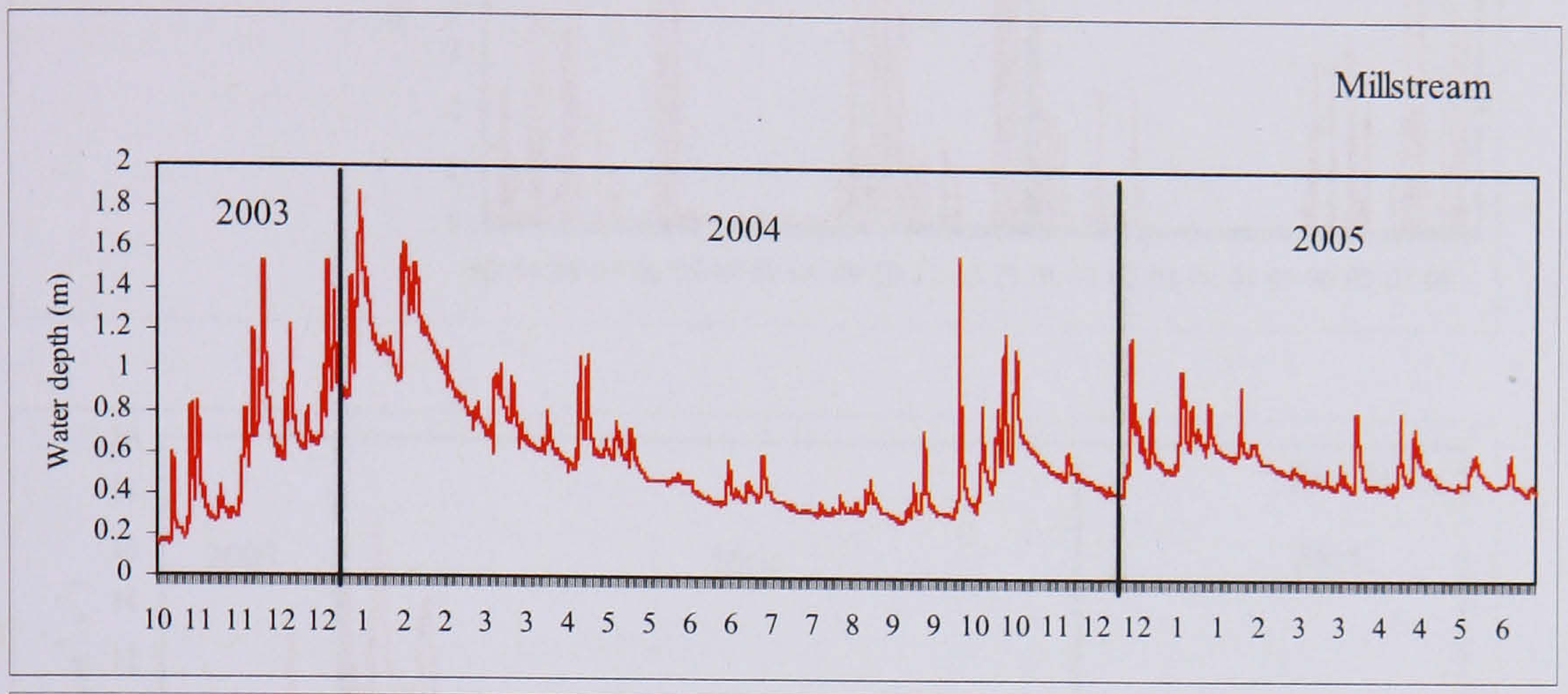
	ESMS		Flood relief		Goldsacs		Holme Bridge		Luckford		Railway		Rushton	
	F	*P*	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*
Bullhead	2.93	0.048	0.83	0.488	0.69	0.565	1.78	0.169	0.66	0.58	1	0.405	5.74	0.003
Dace	2.5	0.077	0.96	0.425	0.3	0.828	1	0.405	1.32	0.28	1	0.405	1	0.405
Eel	3.74	0.02	1.16	0.341	1.85	0.158	1.08	0.37	2.7	0.06	3.77	0.02	0.81	0.497
Flounder	2	0.133	\	\	2.73	0.059	\	\	\	\	\	\	\	\
Grayling	1.1	0.362	\	\	0.65	0.59	\	\	\	\	\	\	\	\
Gudgeon	1.44	0.248	1	0.405	\	\	1	0.405	3.1	0.04	\	\	0.72	0.55
Lamprey	1.17	0.334	2.2	0.107	0.41	0.745	2.2	0.107	1.89	0.15	0.79	0.51	1.34	0.277
Minnow	1.8	0.166	1.19	0.328	0.85	0.476	0.95	0.427	1.11	0.36	1.08	0.372	0.58	0.632
Perch	1	0.405	\	\	\	\	1	0.405	1.66	0.2	\	\	1.37	0.268
Pike	1.04	0.388	3.26	0.034	2.2	0.107	10.3	0	2.79	0.06	2.12	0.117	3.18	0.037
Roach	1.13	0.352	2.63	0.067	0.2	0.898	0.89	0.455	1.62	0.2	\	\	1.34	0.278
almon	3.67	0.022	\	\	0.88	0.459	1	0.405	1.54	0.22	\	\	\	\
Stickleback	1.06	0.378	0.84	0.479	2.55	0.072	0.65	0.59	1	0.41	1.37	0.268	1.25	0.308
Stone loach	1.38	0.267	4.21	0.013	1.6	0.208	2.37	0.089	3.16	0.04	0.53	0.662	1.01	0.401
Trout	1.23	0.315	\	\	5.26	0.004	1	0.405	1.24	0.31	\	\	\	\
Shannon's H'	3.63	0.023	0.91	0.447	1.03	0.393	2.13	0.115	0.72	0.55	1.59	0.211	8.1	0
Shannon's E	2.08	0.122	0.91	0.447	0.64	0.595	6.34	0.002	0.06	0.98	1.03	0.392	3.81	0.019
Richness	5.77	0.003	0.55	0.652	0.42	0.739	4.11	0.014	10.8	0	1.76	0.174	5.18	0.005

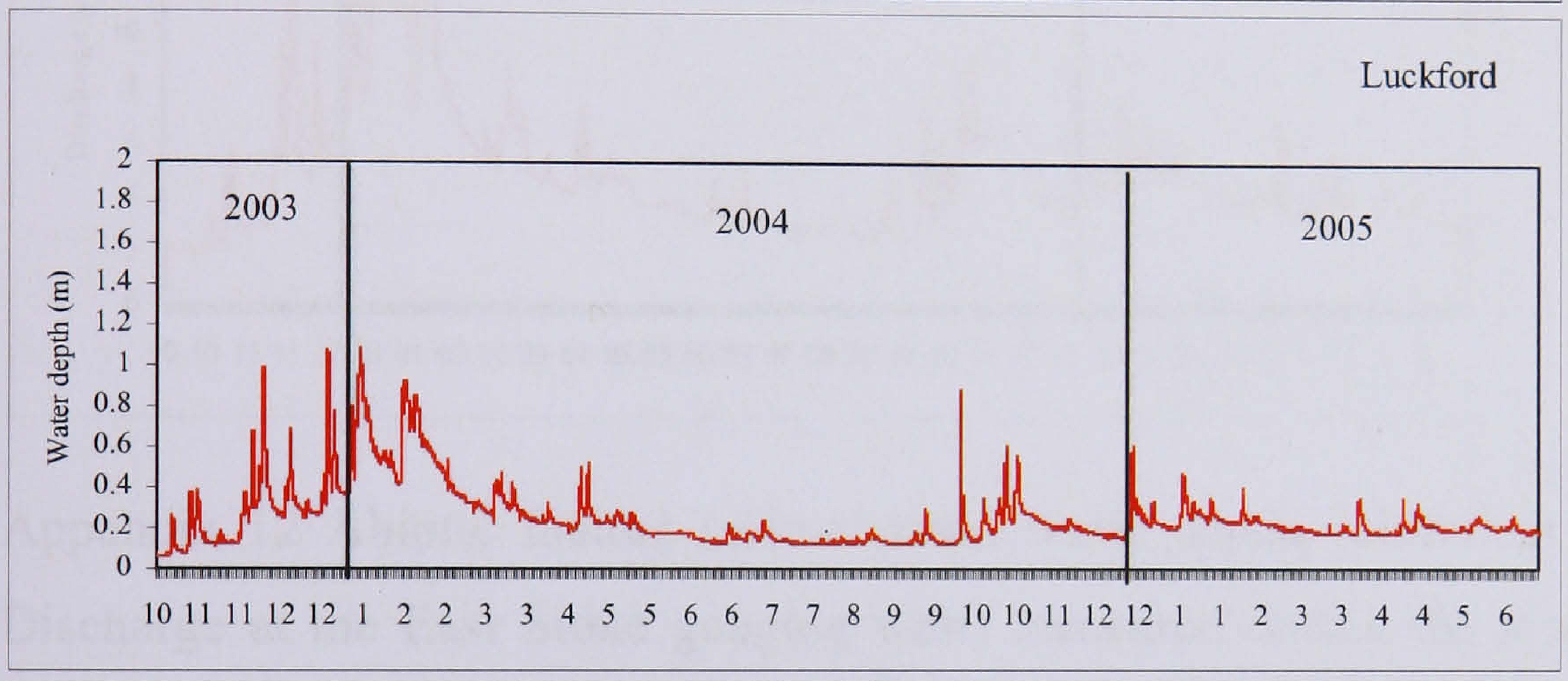
Appendix 11 Habitat Stability Index

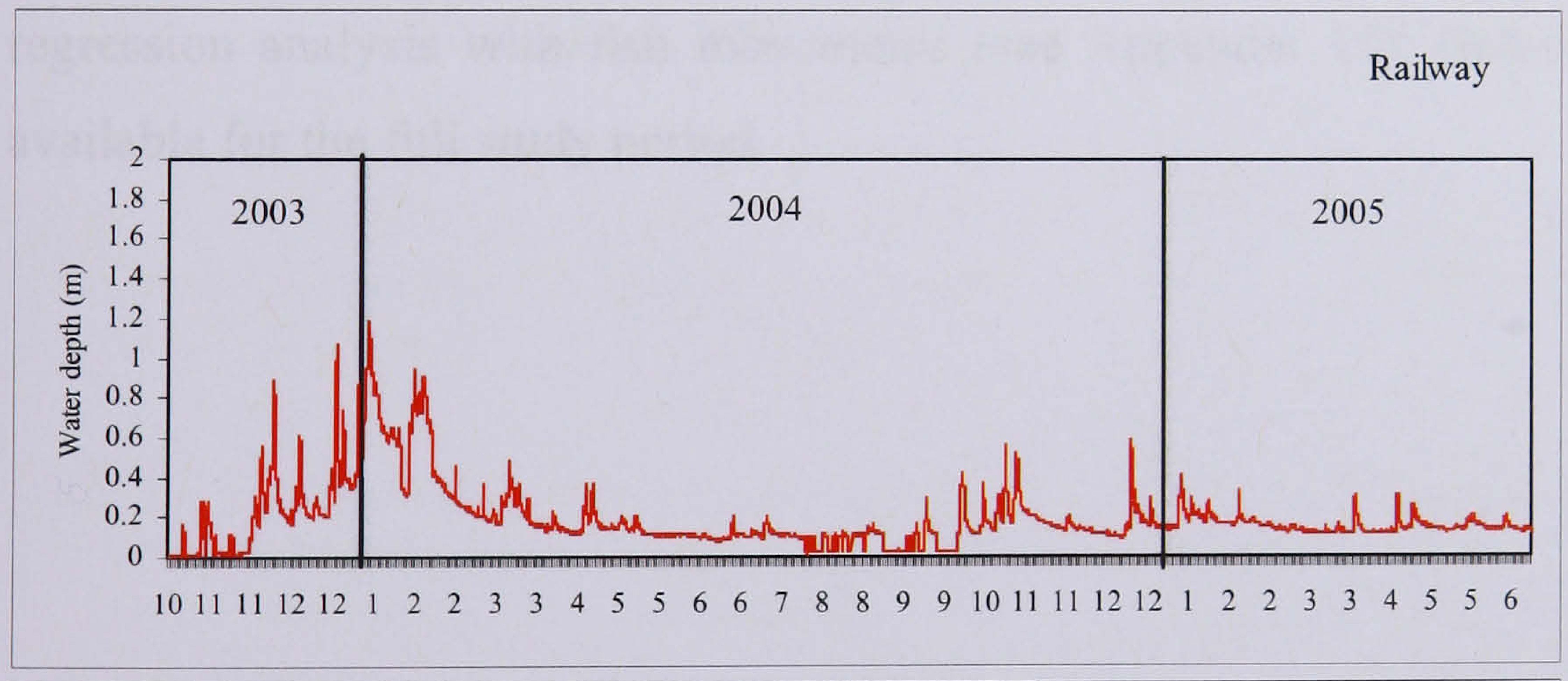
Appendix 11. Habitat stability index for each side-channel studied (2003-2005). Rows give the relative stability of each abiotic factor between streams during different seasons over the three years. The last row gives the average stability (the 'Habitat Stability Index') for each stream. Variability in the stability of side-channels is not due to any one factor strongly weighting the average i.e. different abiotic factors are the strongest influence on the total index for different channels. (FR, Flood Relief; GS, Goldsacs; HB, Holme Bridge; LL, Luckford; MS, Millstream; RU, Rushton; RW, Railway).

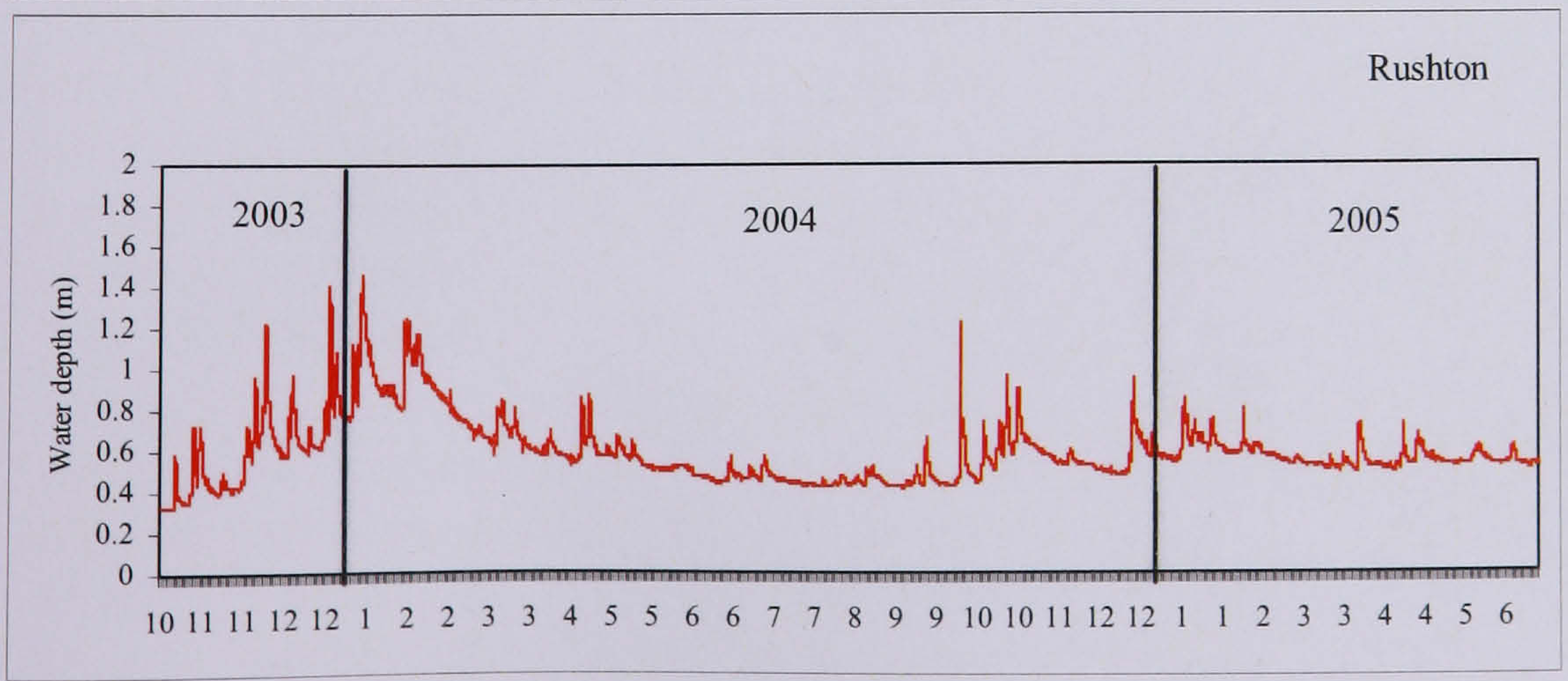
	FR	GS	HB	LL	MS	RU	RW
Depth (cm)	1.11	0.77	1.10	0.87	0.89	0.75	0.59
Width (m)	0.58	0.27	1.07	0.60	0.89	0.31	0.53
DO (mg/l)	0.86	0.79	0.65	1.18	0.73	0.65	0.72
Temperature (°C)	1.18	0.73	1.06	0.76	1.06	0.75	1.10
Glide (%)	0.32	0.74	0.70	0.24	0.14	0.28	0.29
Slack (%)	0.26	0.75	0.64	0.24	0.19	0.03	0.17
Clay (%)	1.00	0.32	0.62	1.33	0.90	1.30	0.85
Gravel (%)	0.80	0.26	0.66	0.78	0.72	1.14	0.16
Sand (%)	0.25	0.63	0.75	0.17	0.54	0.40	0.03
Silt (%)	0.74	0.37	0.76	0.82	0.14	0.88	0.53
Branches/logs (%)	0.28	0.24	1.29	1.54	0.27	0.43	0.27
Emergent dense (%)	0.76	0.53	0.40	0.25	0.19	0.87	1.04
Emergent Sparse (%)	0.59	0.48	0.48	0.17	0.51	1.88	1.09
Overhanging trees (%)	0.99	0.95	0.75	0.95	0.39	0.59	0.42
Submerged Dense (%)	1.56	0.05	1.00	0.14	1.24	0.90	0.11
Submerged sparse (%)	2.02	0.22	0.58	0.17	0.47	1.17	0.70
Tree root systems (%)	0.77	1.63	0.95	0.94	0.95	0.34	0.82
TOTAL	***14***	***9.7***	***13***	***11***	***10***	***13***	***9.4***

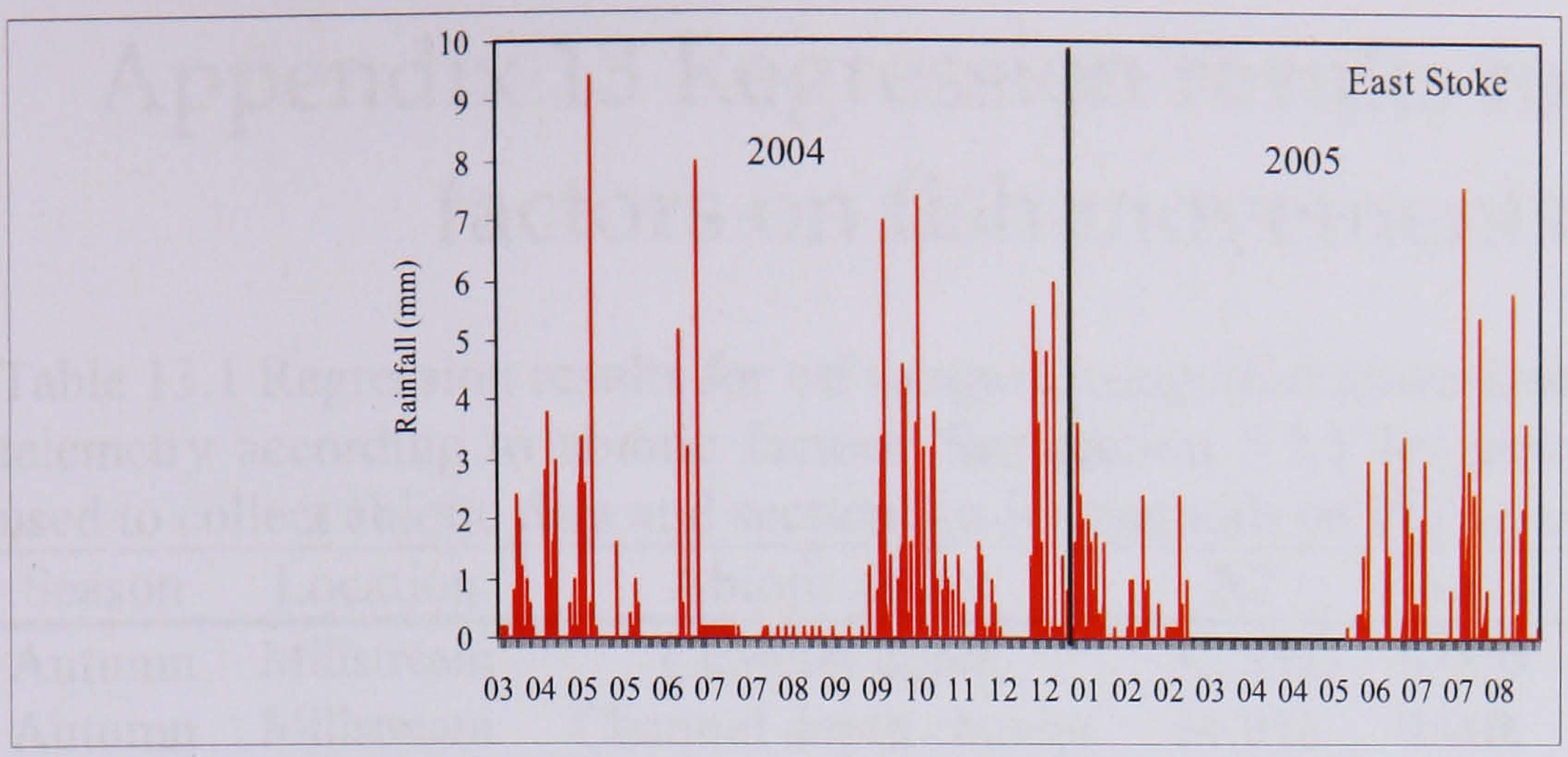
Appendix 12 Abiotic factors measured in side-channels

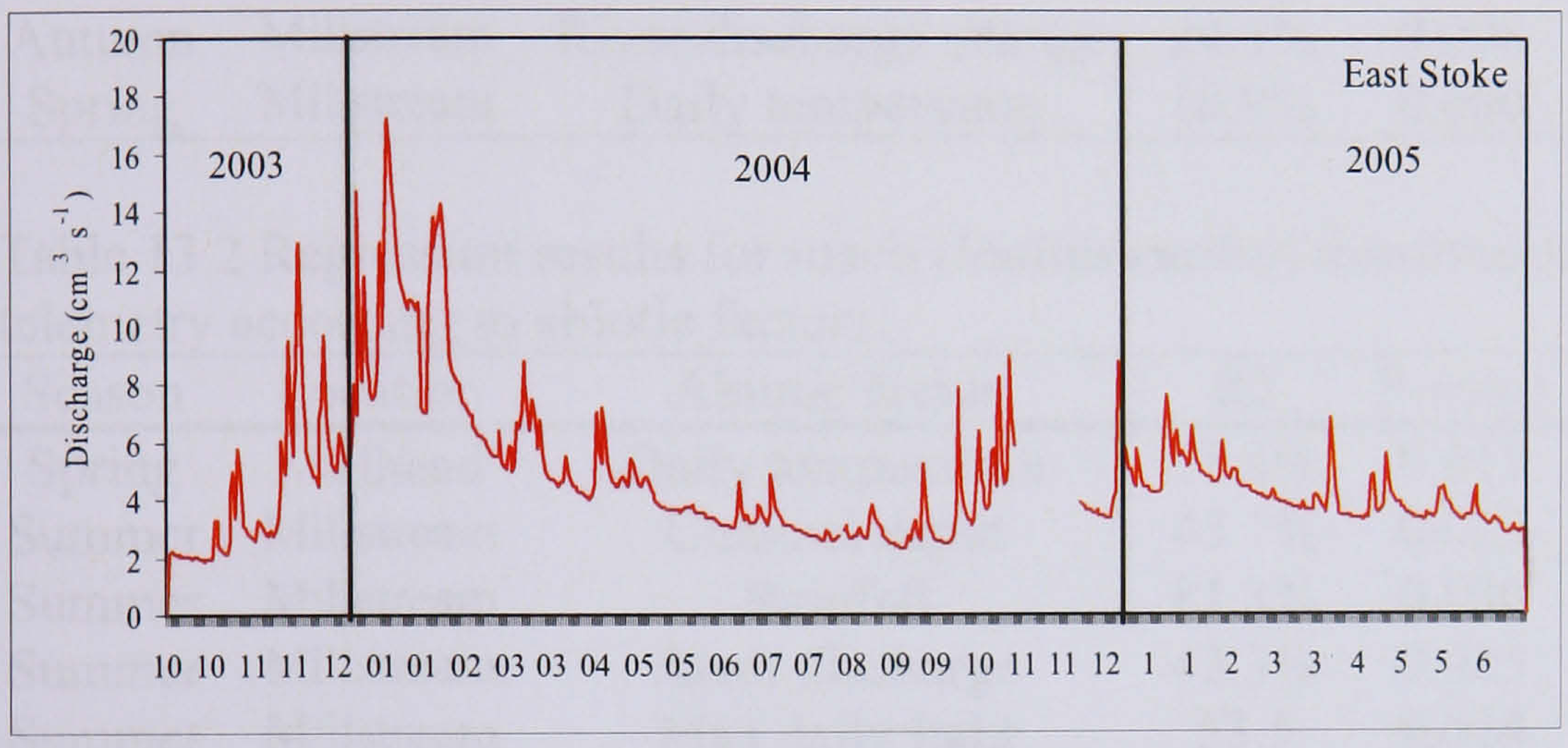












Appendix 12 Abiotic factors (side-channel water depth, rainfall at East Stoke and Discharge at the East Stoke gauging weir) measured during the study and used for regression analysis with fish movements (see Appendix 13). Rainfall data was not available for the full study period.

Appendix 13 Regression results for abiotic factors on fish movements

Table 13.1 Regression results for eel (*Anguilla anguilla*) movements measured by PIT telemetry according to abiotic factors. See section 5.2.1 for description of methods used to collect abiotic data and section 3.6 for methods on PIT telemetry.

Season	Location	Abiotic factor	R2	P-value	n	Coefficient
Autumn	Millstream	Channel depth	52.3%	0.000	24	14.24
Autumn	Millstream	Channel depth change	24.9%	0.008	24	13.89
Autumn	Millstream	River discharge	40.0%	0.001	24	1.47
Autumn	Millstream	River discharge change	24.5%	0.008	24	1.55
Spring	Millstream	Daily temperature	10.9%	0.000	108	1.47

Table 13.2 Regression results for roach (*Rutilus rutilus*) movements measured by PIT telemetry according to abiotic factors.

Season	Location	Abiotic factor	R2	P-value	n	Coefficient
Spring	Millhead	Daily temperature	15.4%	0.015	32	0.44
Summer	Millstream	Channel depth	43.7%	0.022	15	-7.59
Summer	Millstream	Rainfall	81.3%	0.000	11	11.13
Summer	Millstream	River discharge	43.3%	0.023	10	-1.76
Summer	Millstream	Max daily light	53.5	0.024	8	-0.0014

Table 13.3 Regression results for dace (*Leuciscus leuciscus*) movements measured by PIT telemetry according to abiotic factors.

Season	Location	Abiotic factor	R2	P-value	n	Coefficient
Spring	Millhead	Daily temperature	9%	0.006	71	1.46
Winter	Millhead	Daily temperature	6.4%	0.025	63	0.26
Winter	Millhead	Channel depth	12.7%	0.002	63	4.38
Winter	Millhead	River discharge	11.5%	0.006	54	0.44
Autumn	Millstream	Rainfall	69.4	0.002	10	3.19

Table 13.4 Regression results for pike (*Esox lucius*) movements measured by PIT telemetry according to abiotic factors.

Season	Location	Abiotic factor	R2	P-value	n	Coefficient
Winter	Railway	Channel depth	24.4%	0.030	16	9.12
Autumn	Millhead	Daily temperature	12.3%	0.048	25	-0.35
Autumn	Millhead	Rainfall	10.3%	0.065	25	2.89
Spring	Millhead	Daily temperature	37.2%	0.036	25	-0.0081
Autumn	Millstream	Rainfall	65.5%	0.000	25	7.72
Spring	Millstream	Channel depth	27.2%	0.000	51	17.66
Spring	Millstream	River discharge	48.6%	0.000	51	2.18
Summer	Millstream	Rainfall	15.7%	0.007	40	9.13
Winter	Millstream	Channel depth	25.4%	0.078	10	3.14
Winter	Millstream	River discharge	39.8%	0.055	8	0.44
Winter	Millstream	Max daily light	37.2%	0.081	8	0.02
Spring	Rushton	Rainfall	15.3%	0.013	34	33.38
Summer	Luckford	River discharge	38.0%	0.034	10	-28.08

Appendix 14 Large Scale High Flow Experiment

INTRODUCTION

Floods influence the behaviour of most fish species as they respond to the increased discharge or newly available areas (David and Closs 2002). Some species take advantage of the feeding opportunities of invertebrates that have been washed downstream or the protection from visual predators in cloudy, sediment-loaded water, while others must shelter from the high flows (Valdez et al. 2001). Understanding the spatial scale of fishes response to flood events is important in enabling efficient implementation of river management for habitat restoration and maintenance. This investigation used radio-tracking of pike and dace to investigate fish behavioural responses to an artificial flood.

MATERIALS AND METHODS

It was possible to control the flow of the millstream downstream of the fluvarium by adjusting hatches both in the fluvarium and of channels separating just upstream and bypassing the fluvarium. Standard autumn low flow conditions were maintained from 1st October 2003 onwards by leaving hatches low, thus preventing increases in flow during natural high flow periods. This also caused water to back up in the Millhead behind the fluvarium and into the main river, creating a head of water that could be used to generate high flow conditions.

Five pike (Mean FL ± SD: 44.9 ± 8 cm) and seven dace (Mean FL ± SD: 24.1 ± 0.8 cm) captured in the millstream by electric fishing were externally tagged on 7th January 2004 with TW-4 tags as described in section 3.8. Three previously internally tagged pike were present in the millstream at this time (Mean FL ± SD: 74.3 ± 23.2 cm). These fish were tracked at dawn, midday and dusk daily for 3 weeks prior to the experimental flood. This enabled a short-term home range to be estimated.

The experimental flood was carried out on 27th January. By this time three pike and five dace remained in the millstream between the fluvarium and the millstream exit. Fish were tracked every 10 minutes from 09.00 until 14.00. Hatch opening began at 10.00 and one hatch was opened 10% every 15 minutes until 11.30. After this two hatches were opened 10% every 15 minutes to simulate natural increasing flow. Peak flow (all hatches fully open) occurred at 13.30 at the fluvarium and 10 minutes later at the millstream exit. While hatches stayed open for the remainder of the experiment, the water flow reduced after 14.00 once the head of water in the Millhead had passed through.

Fish were tracked hourly from 14.00 until an hour after dark (20.00) to monitor post flood movements. Fish were then once again tracked at dawn, midday and dusk for two weeks following the flood in order to calculate post-flood short-term home ranges.

RESULTS

The response of pike and dace to discharge was investigated at a fine scale during the large scale experimental flood. While the sample size was small, with only three pike and five dace, the results can be used to suggest trends in activity following a flood event. The two species were combined during the analysis because no differences were apparent between species in distance or direction moved upon inspection of the data. Activity was compared before and after the onset of the flood event. It was not possible to make direct comparisons with activity and movements on the day of the flood as fish locations were collected more frequently than during the pre- and post flood periods. Despite this differences in activity were apparent before and after the flood event. The mean distance travelled by fish between subsequent relocations was significantly higher after the flood event (*t*-test, $P < 0.05$) (Figure 14.1). This increase in activity was not due to fish being washed downstream on the first increase in flow and later recovering their original positions as upstream and downstream movement was evenly distributed throughout the experiment (Figure 14.2).

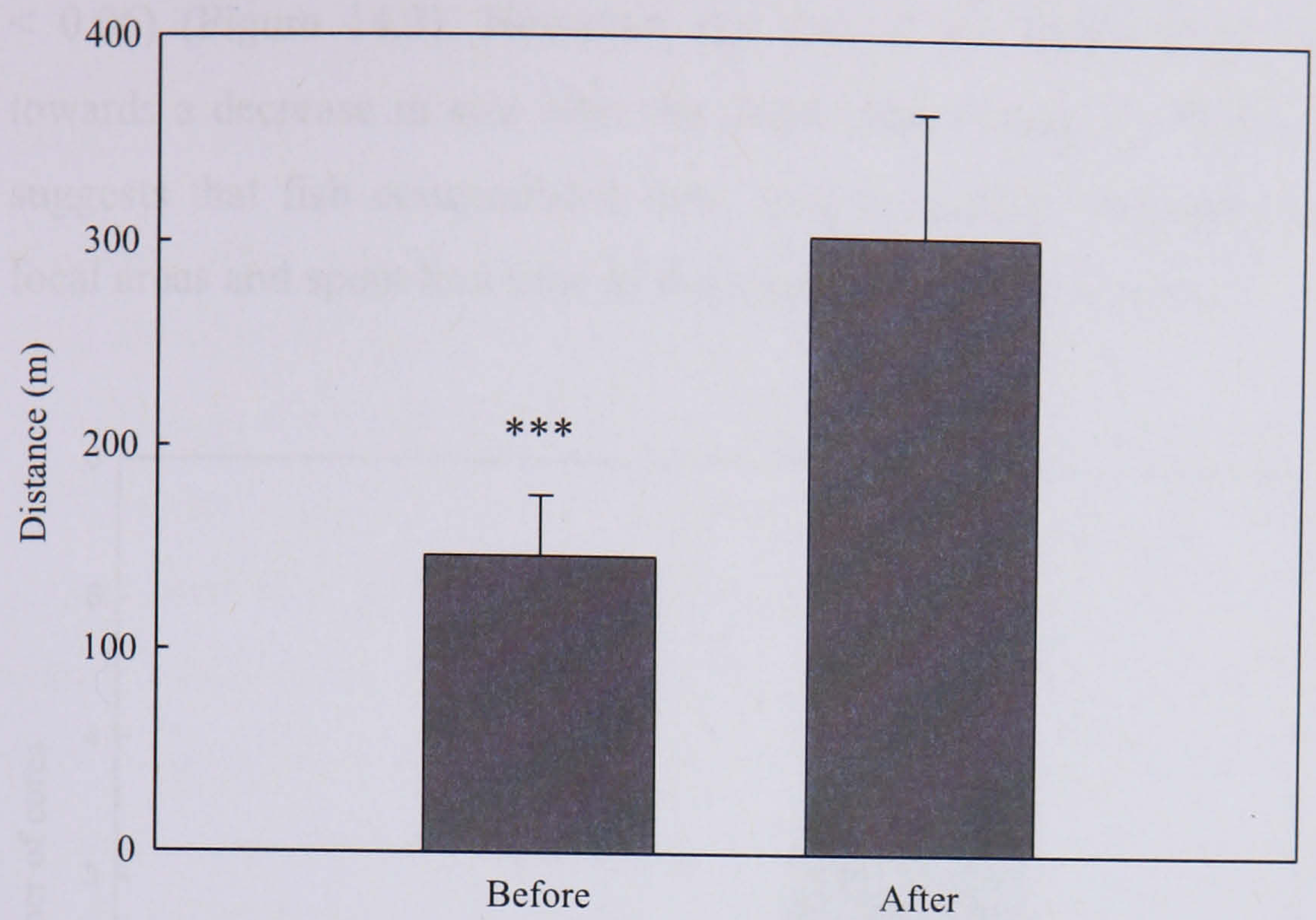


Figure 14.1 Mean distance travelled by pike and dace (combined $n = 8$) two weeks before and two weeks after the flood event.

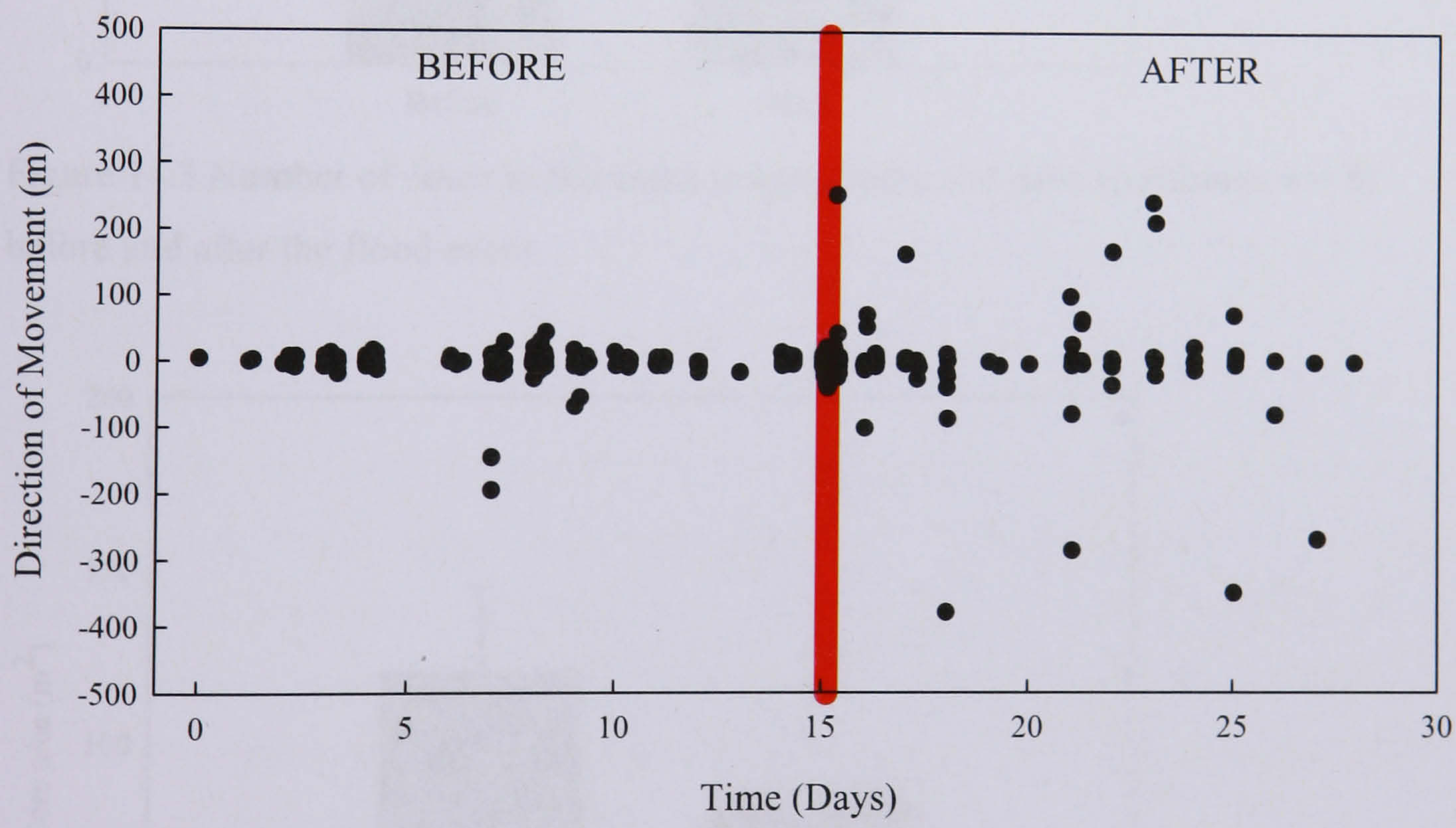


Figure 14.2 Up- and downstream movements (positive and negative values respectively) of pike and dace before, during and after the flood event. Red line denotes the period of the high flow.

In addition to increasing activity, the structure of fish's home ranges also changed during the higher discharges post-flood. The number of home range cores increased significantly during the post-flood period, despite a high level of variability (*t*-test, $P < 0.05$) (Figure 14.3). However, the size of the home range did not and tended towards a decrease in size after the flood event (*t*-test, $P > 0.05$) (Figure 14.4). This suggests that fish concentrated their time in smaller, but more widely interspersed focal areas and spent less time in the river between these areas.

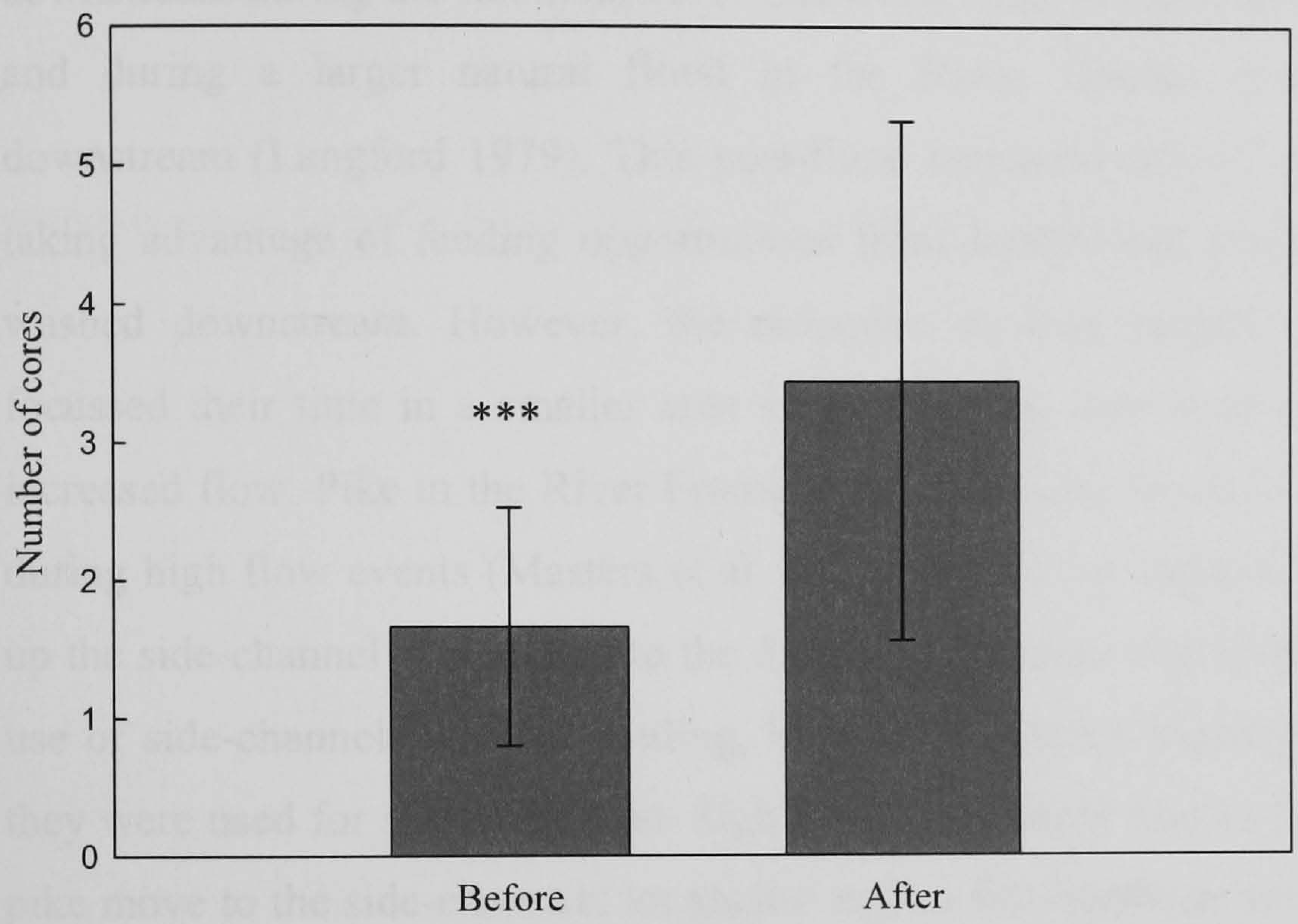


Figure 14.3 Number of cores in the home range of pike and dace (combined $n = 8$) before and after the flood event.

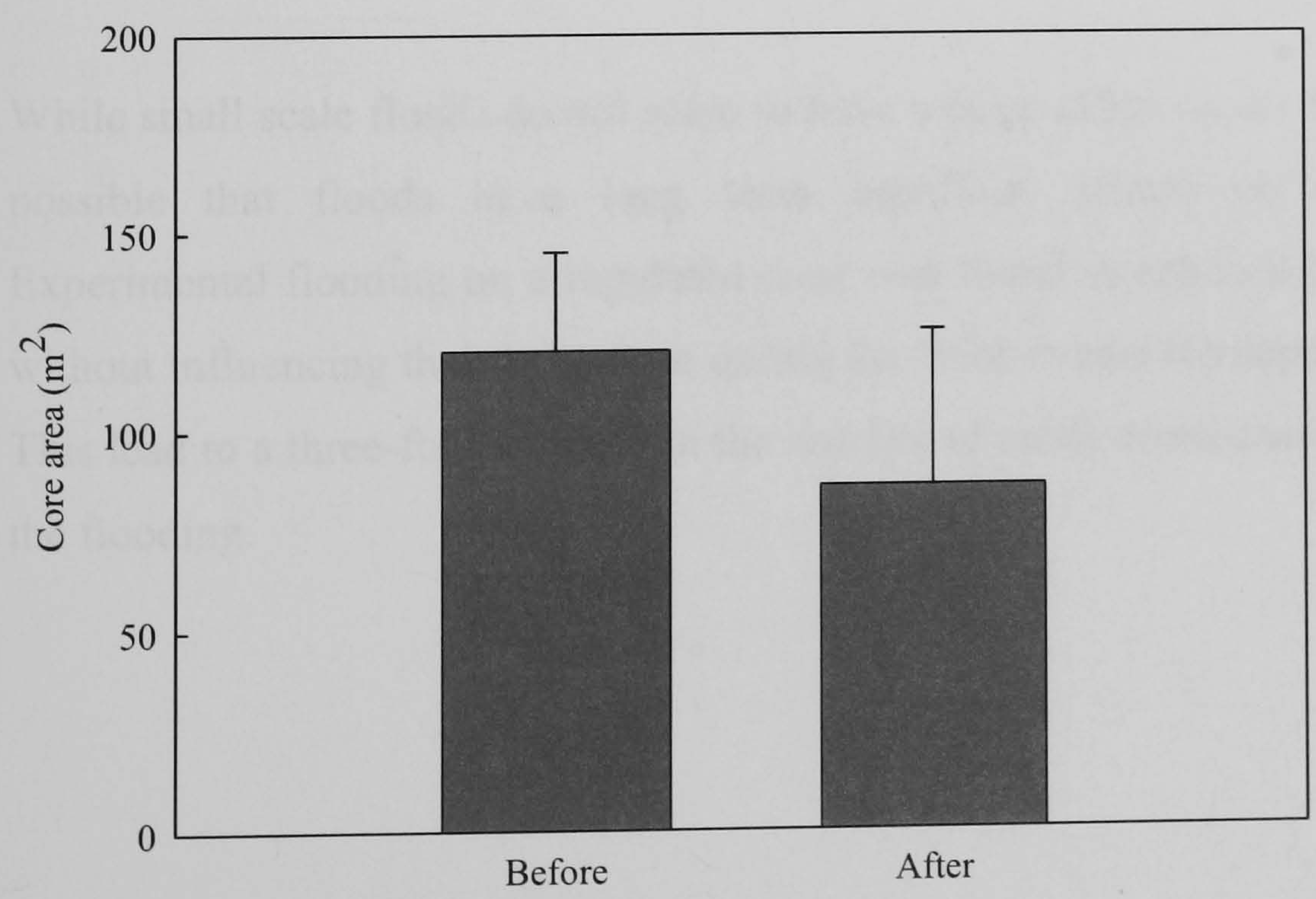


Figure 14.4 Home range area of pike and dace (combined $n = 8$) before and after the flood event.

DISCUSSION

Dace and pike responded to the experimental flood with an increase in activity with time focussed in a larger number of smaller areas (cores). Fish were not displaced downstream during the flood, however this was a small scale flood in terms of the fish and during a larger natural flood in the River Thames pike were displaced downstream (Langford 1979). This post-flood increased activity may be due to fish taking advantage of feeding opportunities from aquatic and terrestrial invertebrates washed downstream. However, the reduction in core ranges indicated that fish focussed their time in a smaller area suggesting that they were sheltering from the increased flow. Pike in the River Frome were previously found to visit side-channels during high flow events (Masters et al. 2002), in fact the distance the fish was found up the side-channel was related to the discharge. Masters et al (2002) argued that this use of side-channels was for feeding, however a simpler explanation would be that they were used for sheltering from high flows. It is likely that as flows increase more pike move to the side-channels for shelter and so fish distribute further from the main river. Pike could probably maintain their position in the main river but it may be energetically more efficient to shelter in a side-channel when possible because of the lower locomotor costs.

While small scale floods do not seem to have a large effect on the fish behaviour it is possible that floods have long term beneficial effects on available habitat. Experimental flooding on a regulated river was found to enhance the habitat of trout without influencing their behaviour during the flood events (Ortlepp and Murle 2003). This lead to a three-fold increase in the number of redds created since the initiation of the flooding.

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