The ecology of otters (Lutra lutra) on the Wansbeck and Blyth river catchments in Northumberland

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The Ecology of Otters (*Lutra lutra*) on the Wansbeck and Blyth River Catchments in Northumberland.

by

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1. SUMMARY.

Signs of otters Lutra lutra were found on 58km out of 78km of the Rivers Wansbeck, Hartburn and Font in Northumberland. Signs of otters were not found on the Rivers Blyth and Pont and it was concluded that otters were no longer present on these two rivers.

Analysis of the contents of otter faeces (spraints) showed that fish formed between 82 and 93 percent of the diet with the largest component of this being bullhead (*Cottis gobio*) followed by eel (*Anguilla anguilla*) and Salmonidae.

The habitat requirements of the otters were determined by surveying fourteen 5km stretches of the rivers for the presence of otter signs. In addition 15 habitat parameters were also recorded. These were then subjected to multivariate analysis. It was found that the use of 5km surveys was not statistically viable when studying the differences between these two catchments. However, when these were divided into 1km stretches some differences between the two catchments were shown. These were that the Blyth system had less dense cover and woody vegetation than the Wansbeck system and that disturbance levels were higher on the Wansbeck. These are given as pssible reasons for the absence of otters on the Blyth.

The relationship between spraint density and habitat utilisation was evaluated and found to be only tentative with little statistical confirmation.

2. INTRODUCTION

2.1. General Description.

The Eurasian otter (*Lutra lutra*) belongs to the family Mustelidae and is one of the largest wild mammals in Britain. An adult male averages approximately 120cm in length and the adult female approximately 105cm (Lenton, Chanin and Jefferies, 1980). Otters are mid-brown in colour with a paler throat, the tail is thick and wide at the base tapering to a point and is used as a rudder. The otter is well adapted for its amphibious habit having a thick waterproof pelage and webbed feet. See Harris (1968) for a full description.

Otters are found in most aquatic habitats providing there is ample provision for dens. This may vary from rockfalls, caves, peat banks, root systems of bankside trees, piles of debris on river banks and field drains. In some areas they use "nests" above ground in "couches" on reeds and grass (Hewson, 1969).

Whilst they are predominantly piscivorous, although otters will also take amphibians, invertebrates and occassionally small mammals depending on the season and habitat (Erlinge, 1968a, 1968b; Jenkins *et al.*, 1979; Jenkins and Harper, 1980; Green and Green, 1980; Wise, 1978; Wise *et al.*, 1981).

The otter is usually nocturnal in Britain and spends the day resting in safe hiding places which are normally adjacent to the waters edge but if conditions are unsuitable or if there is disturbance the animal may shelter some distance from the riverbank or lake shore (Lenton, Chanin and Jefferies, 1980).

2.2. Ranges and Territories.

Individual otters may range some considerable distances along rivers although the actual sizes of ranges will vary depending on the season, habitat and the density of the otter population.

There are two terms in common usage when considering the range and spacing patterns of otters, these are home range and territory. The home range can be considered as an area with which the animal is completely familiar and patrols regularly. This area will contain all the necessary requirements of the individual otter. The home range is not exclusive to the individual and there will be considerable overlap with the home ranges of other otters (Erlinge, 1967a; Mason and Macdonald, 1986). Within the home range there is a core area where the individual will spend the majority of its time. The territory is an area exclusively occupied by an individual and is defended either aggressively or by some form of communication.

All members of the family Mustelidae so far studied typically show three classes of animal. These are resident individuals which stay in an area for long periods of time establishing a home range and territory, temporary residents which stay for only short periods of time and transients which pass through an area without establishing a home range (Powell, 1979).

Since otters in riparian habitats are nocturnal direct observations provide little information about spacing and population densities. The method has however, been of use in studies of diurnal otters in a marine habitat in the Shetlands (Watson, 1978).

Most studies make use of otter faeces or spraints which are highly distinctive and are deposited in prominent places. If these spraints contain items exclusive to an individual then it is possible to gain information about that individuals movements. One of the most effective methods for doing this is the use of radioactive materials which can be detected in the spraint. Otters are trapped and injected with a radio-isotope, usually ^{65}Zn in the form of zinc chloride (Green, Green and Jefferies, 1984; Green and Green, 1985; Jenkins, 1980). The method has been used with captive badgers and it was shown that the ratio of marked to unmarked faeces gave a good estimation of th population (Kruuk, Gorman and Parish, 1980). However this will only occur if the faeces from labelled and unlabelled diets are equally likely to be found. Sprainting activity in otters may not be random and may be influenced by sexual and social functions.

More recently the use of radio-telemetry has been applied to the study of otters. This involves trapping the otter and attaching a small radio-transmitter which makes it possible to locate an individual at any time using a directional aerial and two directional receivers. Also, if different signals are used for different otters it is possible to study several animals at the same time. There are two methods of attaching transmitters, either by using a harness or collar or by implanting the transmitter into the animal. Implanting can be used to study the animal for long periods but it is however illegal to carry out this operation on wild animals in Britain. The method has been used to good effect with Canadian Otters (*Lutra canadensis*) (Melquist and Hornocker, 1983). The harness is a more commonly used method of transmitter attachment but reduces the length of time over which the animal can be studied since the harnesses are designed to fall off after a given period. This reduces the risk of the harness snagging and drowning the otter (Mitchell-Jones *et al.*, 1984).

One of the first informative studies on the ranges of otters was that by Erlinge (1967b) in Sweden. Studying an area of lakes and streams and by searching for tracks and spraints Erlinge determined that female otters with cubs had limited home ranges. The home range of six family groups was determined and it was found that the groups used 2-4km^2 of lakes and 1-3km of stream with a radius of activity of 2-4km when the lake was not frozen and 3-6km of stream with a radius of activity of 2-3km when the lake was frozen. A group which spent the entire time on streams used 10-12km. The males' ranges varied considerably from 10-21km with a mean of 15km.

In a study based in Scotland two adult female otters, one adult male and two young males were radio-tracked and the females were also injected with zinc isotopes. One female was found to have a range of over 16km of waterway which included streams, rivers and small lakes during 22 days of radio-tracking. The labelled spraints gave information for a further $3^{1}/_{2}$ months and added another 2km to the range. The other female ranged over 22.4km of river during 36 days of radio-tracking. Labelled spraints provided a further 4 months of information extending the range by 2-4km. The adult male utilised 39.1km of waterway in 98 days of radio-tracking overlapping with the range of one of the females for a distance of 5km. The two young males had ranges of 20km and 31.6km respectively (Green, Green and Jefferies, 1984; Green and Green, 1985). It was also found that the females utilised core areas where a considerable proportion of the total time was spent. The first female spent 73 percent of the 22 days of radio-tracking in one lake which was 58 percent of the home range. The second female spent 42 percent of the 36 days of radio-tracking in a small marsh. The adult male spent 60 percent of the 98 days of radio-tracking in a 10.7km long stretch of river comprising only 27 percent of the home range. Green *et al.* (1984) also suggested that the females had overlapping ranges and often utilised the same resources. The males showed a hierarchical dominance with dominant males maintaining a territory and sub-dominant males utilising poorer habitat.

2.3. Sprainting activity and its significance.

The importance of scent marking in many vertebrate species has been well established (Macdonald, 1980; Stoddart, 1980). It may provide a number of functions such as indications of sexual status and hierarchical dominance or as identification of individuals. The exact role of otter spraints has not been established despite a number of studies.

If spraint from an unfamiliar otter is placed on spraint piles wild otters will respond by marking these spraint piles, indicating an ability to distinguish between individuals by their spraint (Mason and Macdonald, 1986). It has been suggested that the chemical constituents of an individuals spraint scent is unique to that individual and studies have shown that spraints from different otters do contain different proprtions of chemicals (Trowbridge, 1983).

It has been suggested that if spraints are to be an effective form of communication they must persist for long periods. Studies have shown that spraints will last for between 2 and 8 weeks depending on the environment and habitat (Jenkins and Burrows, 1980; Mason and Macdonald, 1986). It would seem therefore that otters would have to make regular visits to spraint sites in order to replace spraints if they were important for communication.

There is also a possible sexual difference in sprainting activity. In captivity males spraint about seven times per active hour, whereas females spraint only three times per active hour (Hillegart, Ostman and Sandegren, 1981a). In addition there may be a seasonal variation in the use of sprainting sites. Erlinge (1968b) showed that two year old males in Sweden sprainted intensely when attempting to establish territories in October to March with reduced sprainting in June and July. Sprainting activity is also known to vary over the otters home range. Females have been found to deposit more spraints at centres of activity (Green *et al.*, 1984). Male otters mark the boundary of their ranges (Erlinge, 1968b; Erlinge, 1981; Green *et al.*, 1984).

It has suggested that sprainting is for the purpose of communication and that the function of scent marking by spraints is to maintain distance between individuals so that conflict can be avoided (Gosling, 1982; Trowbridge, 1983). Proof of this has yet to be obtained and the actual function of sprainting is still uncertain.

2.4. Decline and Status.

The otter was once abundant in Britain but in the second half of this century there has been a serious decline in numbers. Stephens (1957) in a survey for the Universities Federation for Animal Welfare (UFAW) showed that the populations of otters throughout Britain were stable and numerous at that time. In the early 1960s the otter hunts began to notice a decrease in the number of successes at finding otters during hunts and a voluntary ban was imposed in 1964 which stopped the killing of otters at the end of the hunt. The Mammal Society sent out questionnaires to the otter hunts in 1968 and again in 1973. Analysis of the returns showed that that there had been a marked decrease in the hunting success between 1957 and 1967 (Anon, 1969), and in the period 1968 to 1971 the otter population had remained stable, or increased in some counties but declined in others (Anon, 1974). Chanin and Jefferies (1978) analysed the hunt records for one pack of Otter Hounds hunting in southwest England between 1907 and 1971 and the records of all the packs in Britain between 1950 and 1976 They showed that a decline in the otter populations occurred suddenly in southern England in 1957, and a lesser decline in northern England and southern Scotland. They also showed that the otter had continued to decline up to 1974. The otter received legal protection in 1978 under the Conservation of Wild Creatures and Wild Plants Act 1975 so that it was an offence to kill, injure or take an otter and the otter hunts were disbanded.

The Mammal Society, using volunteers to survey for signs of otters, carried out another national survey from 1973-1979 which showed a probable absence of otters in much of central England although the coverage of this survey was not good.

The lack of knowledge about the distribution of otters in Britain and reasons for their possible decline led to a nationwide otter survey. The Joint Otter Group was set up in 1976 to determine further research areas (Joint Otter Group, 1977, 1979). In 1977 three surveys were initiated in England, Wales and Scotland using full-time surveyors who had training and experience in otter surveying (Lenton, Chanin and Jefferies; 1980; Crawford, Jones and McNulty, 1979; Green and Green, 1980). The surveys were repeated in 1984 (Andrews and Crawford, 1986; Green and Green, 1986; Strachan, unpubl. data). The method chosen was to examine 600m stretches of waterways at each site. The data collected was based on the 10km squares of the national grid. The 1977-1979 survey of England showed that the otter was absent over much of central England but was still present in the coastal areas of East Anglia, the north (Northumbria, Cumbria and Yorkshire), south-west and on the Welsh border. Only 6 percent of sites in England were positive compared to 20 percent in Wales and 73 percent in Scotland. The 1984-1986 survey showed that there had been increases in the number of positive sites in most areas but that there had been a significant decline in the populations within the Wessex and Anglian Water Authority regions. The western regions especially the Welsh border areas showed marked increases in positive sites. Thames region had no positive sites and the central and south-eastern regions were still very low despite some increases. The overall percentage had increased to 9 percent compared to Wales at 32 percent and Scotland at 92 percent.

2.5. Factors affecting the distribution of otters.

The factors affecting the distribution of otters along waterways are complex and inter-related and their relative importance has not yet been fully determined. The main factors are pollution, habitat loss, persecution, disturbance and prey availability.

2.5.1. Pollution.

Pollution may have two effects on otter populations, a direct toxic effect and an indirect effect on fish stocks. In their analysis of hunt records, Chanin and Jefferies (1978) showed a sharp decline in otter populations in the late 1950s. This occurred at the same time as a decline in other predatory species such as the Peregrine (*Falco perigrinus*) and Sparrowhawk (*Accipiter nisus*) which was attributed to the use of organochlorine pesticides such as dieldrin and aldrin (Ratcliffe, 1980). It was suggested that these chemicals were also responsible for the decline in otter populations (Chanin and Jefferies, 1978). These chemicals have been withdrawn from general use but they are persistent in the environment and may still be having an effect on populations (Ratcliffe, 1984). However, the Peregrine and Sparrowhawk have shown a recovery, yet otter populations are still declining indicating that other factors may be responsible for the general decline and that organochlorines have exacerbated the situation.

It has been suggested that polychlorinated biphenyls

(PCBs) were responsible for the decline (Henny *et al.*, 1981; Mason and Macdonald, 1986). However, Chanin and Jefferies (1978) argue that there was no sudden increase in the use of PCBs in the late 1950s when the otter began its decline.

Heavy metal pollutants may also have a direct toxic effect on otters but little evidence is available except that high levels have been reported in otters and mink (Erlinge, 1972a; Mason and Macdonald, 1986; Wobeser, 1976).

Agricultural pollution can be a widespread problem in aquatic systems since it can cause eutrophication through the addition of plant growth nutrients such as nitrates and phosphates. This produces an increase in plant productivity and a resultant increase in fish biomass with salmonids being replaced by cyprinids (Hartmann, 1977). Salmonids are considered to be a more important component of the diet of otters in some studies (Pautard, 1980; Wise, 1978; Wise *et al.*, 1981), therefore eutrophication may have an indirect effect on the otter.

Industrial pollutants containing chlorine, ammonia and phenols also cause substantial fish kills and it has been suggested that both industrial and agricultural pollutants are limiting the distribution of otters in some countries (Green and Green, 1981).

Acid precipitation (Sulphur dioxide (SO_2) and Nitrogen oxides (NO_X) has been implicated in the decline of otters because it causes acidification of water and can produce lakes and rivers devoid of fish and invertebrate life (Chadwick, 1983) thus directly affecting the otters main prey.

2.5.2. Habitat loss.

Habitat loss is probably the single most important factor in the decline of the otter. Dense bankside vegetation and mature trees with extensive root systems providing good holt and resting sites for the otter are essential (Brooker, 1983; Green *et al.*, 1984; Macdonald *et al.*, 1978; Macdonald and Mason, 1983c). Rivers in Britain, particularly in the lowlands have been cleared of vegetation and heavily managed. Tree removal along river corridors has been extensive and river banks are heavily grazed preventing regeneration thus destroying many otter refuges. Otters will, however, use other types of shelter such as rockfalls, bramble scrub, Rhododendron, *Salix* spp. scrub or in reeds and sedges providing these form dense cover (Green *et al.*, 1984; Jenkins, 1982; Mason and Macdonald, 1986).

2.5.3. Persecution and disturbance.

As mentioned earlier, in Britain the otter now receives considerable protection and is no longer hunted. It is also accepted that the otter hunts did not cause the decline in otter populations but may have had an additional effect on an already decreasing population (Chanin and Jefferies, 1978).

A significant number of otters are drowned in nets such as lobster creels and fyke nets set for eels. This may also have contributed to local declines (Jefferies *et al.*, 1984; Twelves, 1983).

Disturbance was once thought to be a factor in the decline of otters. However, signs of otters were found in towns or near houses and roads suggesting that otters are able to tolerate a substantial level of disturbance as long as the habitat provides good shelter (Green and Green, 1980). If hiding places are scarce otters may be greatly affected by human disturbance (Mason and Macdonald, 1986).

2.5.4. Prey availability.

Any factor which has a detrimental effect on the populations of fish in a river will adversely affect otters. Therefore, factors such as pollution, drainage, water abstraction and over-fishing may effect the otter.

2.6. Habitat requirements.

It is clear that the decline in otter populations cannot be attributed to one single factor. The problems of pollution, habitat destruction and disturbance are the result of increased human activity and the impact of these on the otter will have increased steadily. It is therefore necessary to study all the inter-related factors on a river system rather than one factor in isolation. Macdonald and Mason (1983) surveyed fifty 5km stretches of waterway in Wales and the West Midlands for signs of otters. In addition they recorded a number of habitat variables including the number and species of mature trees and the total length of river bordered by woodland. This study showed that the numbers of mature Ash (*Fraxinus excelsior*) and Sycamore (*Acer pseudoplatanus*) were correlated with the number of spraint sites and the number of spraints found. However the correlation coefficients between these variables were low and statistical problems were encountered. This method of determining the habitat requirements of otters has been criticised by other workers who argue that there is no direct relationship between sprainting activity and habitat variables (Kruuk *et al.*, 1986; Kruuk and Conroy, 1987).

2.7. Aims.

The aim of this project was to investigate the distribution of otters in relation to a number of habitat variables including numbers and species of mature trees, disturbance, water quality and prey availability, using similar methods to those used by Macdonald and Mason (1983) to determine whether this method would be viable for more intensive studies of single river systems.

The study was conducted on the rivers Wansbeck, Font and Hartburn and the rivers Blyth and Pont in Northumberland. The Wansbeck, Font and Hartburn have always held good populations of otters and the 1984-1986 survey confirmed this (R. Strachan pers comm). The Blyth and Pont however had a small but stable population up to and during the 1977-1979 survey. Pautard (1980) collected spraint from the River Blyth but since then no positive signs have been recorded (R. Strachan, pers comm.; H. Watson, pers comm.) and it is believed that otters are no longer present on these two rivers.

It was the aim of this project to achieve three main objectives. First, to determine the current status of otters on these river systems. Second, to determine the habitat requirements and factors affecting the distribution of otters on these rivers using the methods of Macdonald and Mason (1983) and to establish the viability of this method. Third, to establish possible reasons for the absence of the otter population on the River Blyth and River Pont.

3.THE STUDY AREA.

Studies were carried out on the Wansbeck and Blyth river systems in Northumberland. Geographically, the two rivers are very close being only about 8km apart at the furthest point.

3.1.The Wansbeck system

The Wansbeck system incorporates the Rivers Wansbeck, Hartburn and Font. The River Wansbeck is about 53km (33 miles) long and varies from 1 metre in width near its source to about 20m at the lower end. The river was surveyed from Kirkwhelpington Bridge (NY:994845) to Stakeford Bridge (NZ:272860) a distance of about 42km (26.25 miles) (See Figure 3.1a.). The river rises near Ridsdale in Northumberland at an altitude of about 300m (NY:914829) and passes through Sweethope Loughs (NY:944825) and on to Kirkwhelpington (NY:994844). The Wansbeck then flows through open pasture to Meldon Park where it is joined by the River Hartburn (NZ:109851). From there it flows through a steep-sided and wooded valley to the confluence with the River Hartburn at Mitford (NZ:173859). The river then passes through the urban areas of Morpeth before flowing through a steep wooded valley past Bothal (NZ:241865) before entering Ashington where it passes through a well-used urban park and eventually into the sea near Newbiggin-by-the-Sea (NZ:307855).

The River Hartburn is about 17km (10.6 miles) long and varies from about 1m to 8m wide at the confluence with the Wansbeck. The river was surveyed from the B6342 road bridge near Hartington (NZ:020881) to Meldon Park Bluebell Wood (NZ:104851) a distance of about 12km (7.5 miles) (See Figure 3.1a.). The river rises in the hills above Kirkwhelpington Common (NY:993893) and passes first through open pasture and then flows through a steep wooded valley past Hartburn (NZ:092866) until the confluence with the Wansbeck at Meldon Park (NZ:109851).

The River Font is about 24km (15 miles) long and varies in width from about 1 metre to 5m at the confluence with the Wansbeck. The river was surveyed from Combhill Bridge (NZ:064933) to the B6343 road bridge at Mitford (NZ:173861) a distance of about 19km (11.9 miles) (See Figure 3.1a.). The river rises in the Simonside Hills (NZ:023953) at an altitude of 265m and flows into and out of Fontburn Reservoir (NZ:040935) before flowing through open pasture and woodland to Stanton Mill (NZ:130889) where it then flows through a steep wooded and rocky valley to Mitford and the confluence with the River Wansbeck.

3.2. The Blyth system

The Blyth system incorporates the rivers Blyth and Pont. The River Blyth is about 46km (28.8 miles) long and varies in width from less than 1 metre in the upper reaches to about 15m in Blyth. The river was surveyed from just upstream of Capheaton

Bridge (NZ:034786) to Furnace Bridge (NZ:277821) a distance of about 41km (25.6 miles) (See Figure 3.1b.). The river rises north of Kirkheaton (NZ:005778) at an altitude of 205m amongst a great many irrigation channels and is no more than a ditch until Capheaton Bridge. It then flows through a mixture of pasture and cropland for much of the way until Twizell (NZ:157788) where it flows through woodland before returning to arable land. At Bellais (NZ:198780) the river enters woodland and flows through a steep sided wooded valley under the A1 at Stannington (NZ:217783) and continues through Plessey Woods and Humford Mill Country Parks before entering the heavy urban and industrial areas of Bedlington and Blyth where it forms an estuary.

The River Pont is about 26km (16.3 miles) long and varies in width from less than 1 metre to 4m at the confluence with the River Blyth (NZ:178777). The river was surveyed from Dissington Bridge (NZ125709) to Kirkley Mill bridge (NZ:167767) a distance of about 11km (6.9 miles) (See Figure 3.1b.). The river rises somewhere near Great Whittington (NZ:010715) at an altitude of 170m and flows through open pasture and cropland to Ponteland then on to the confluence with River Blyth (NZ:178776).

Figure 3.1a. Map of the Wansbeck river system including the Wansbeck, Hartburn and Font.

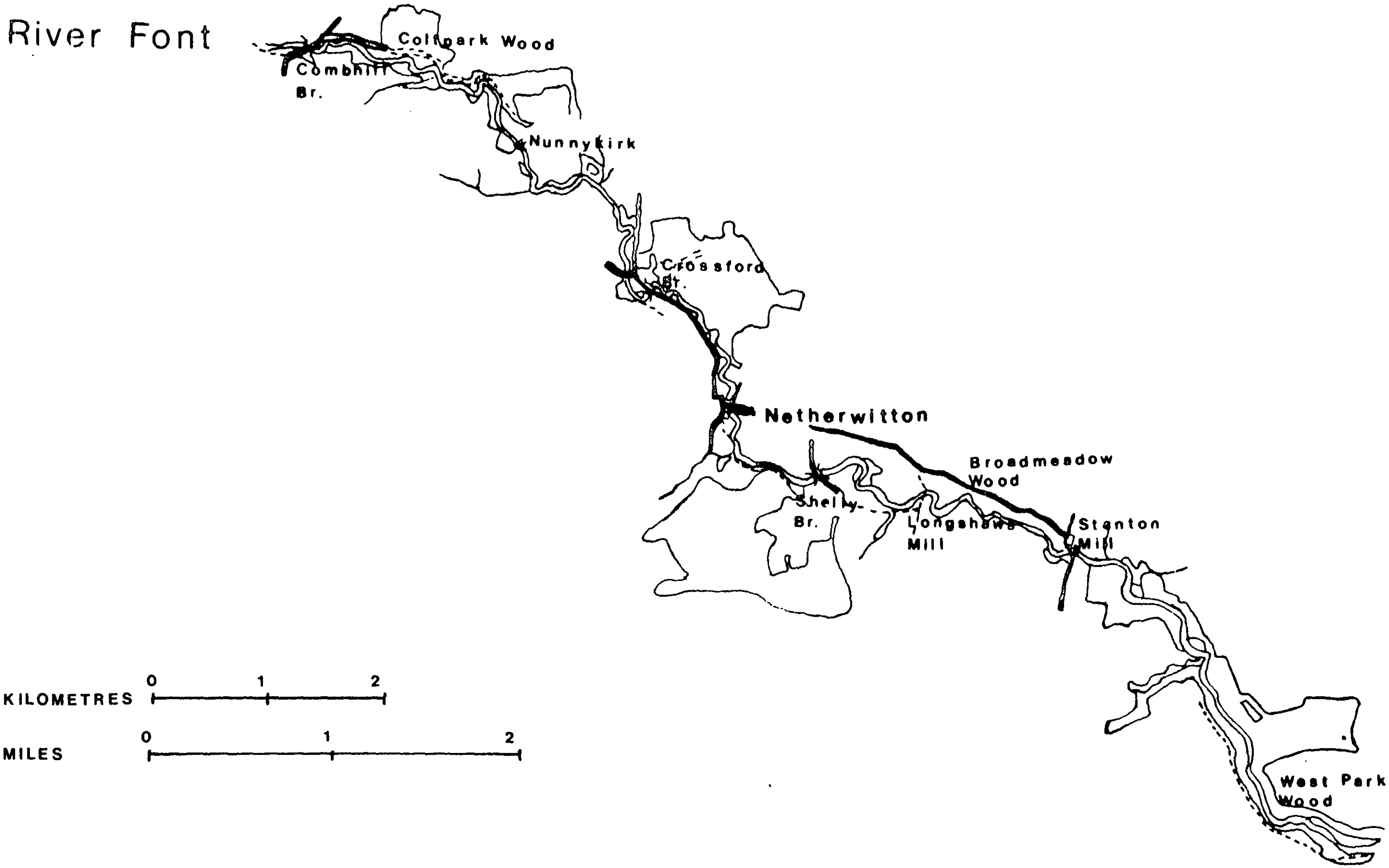


Figure 3.1a. continued.

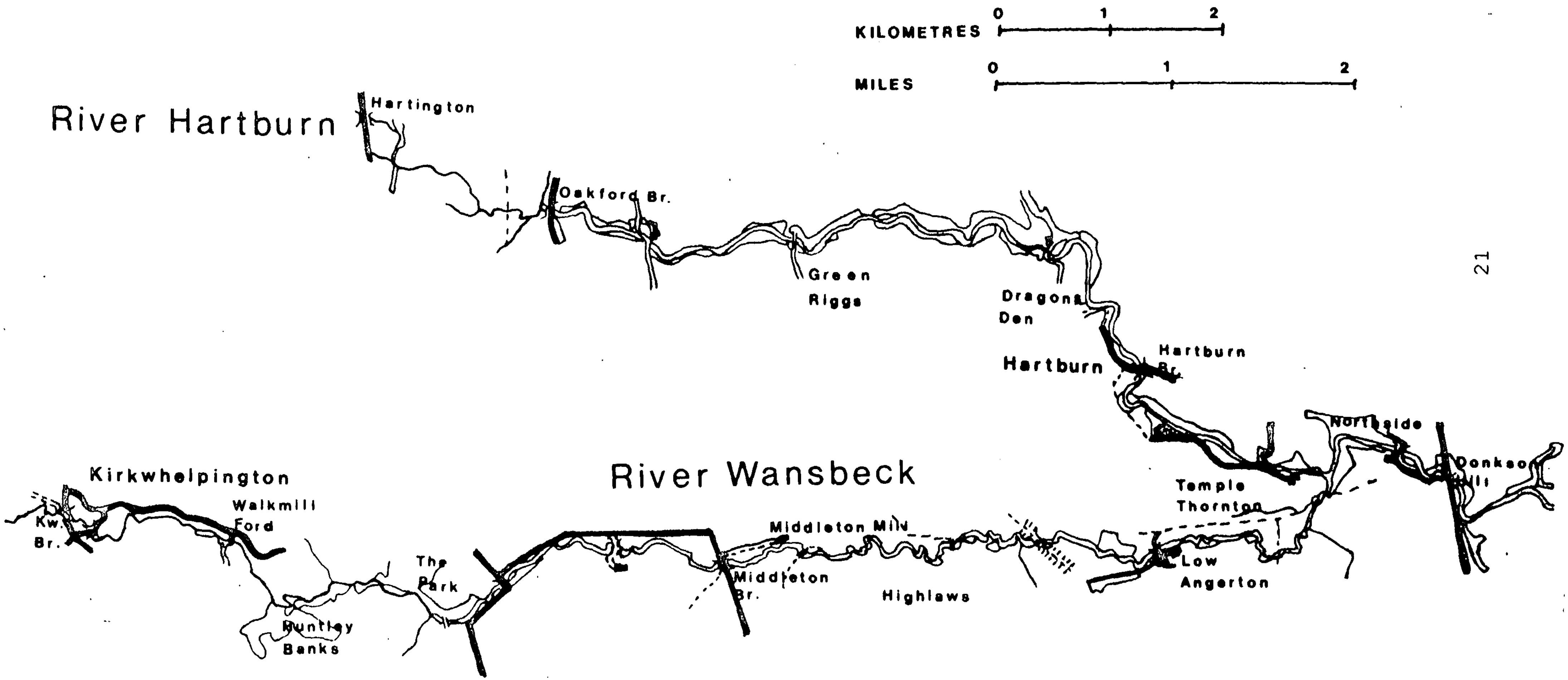


Figure 3.1a. continued

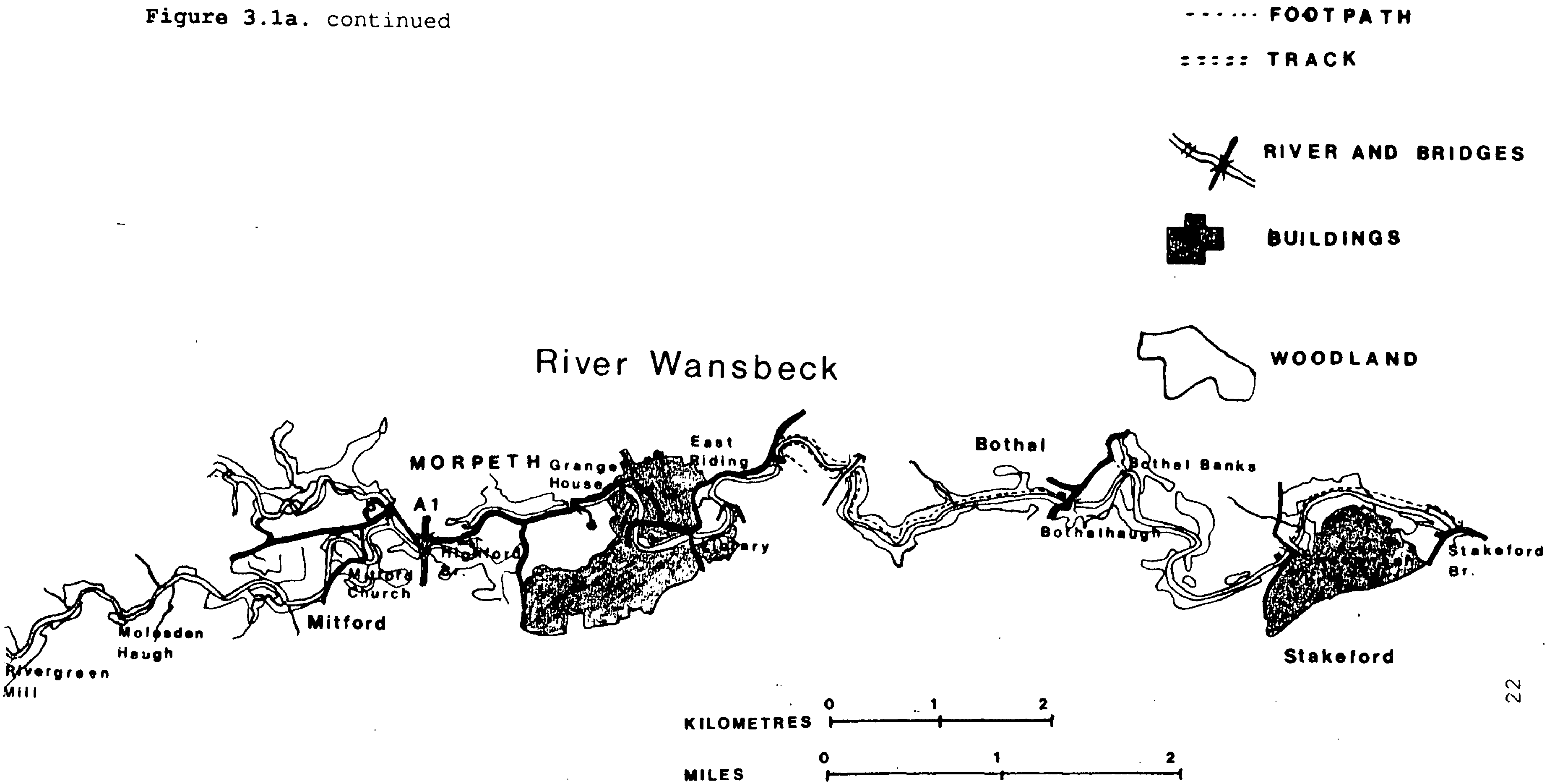


Figure 3.1b. Map of the Blyth river system incorporating the Blyth and Pont.

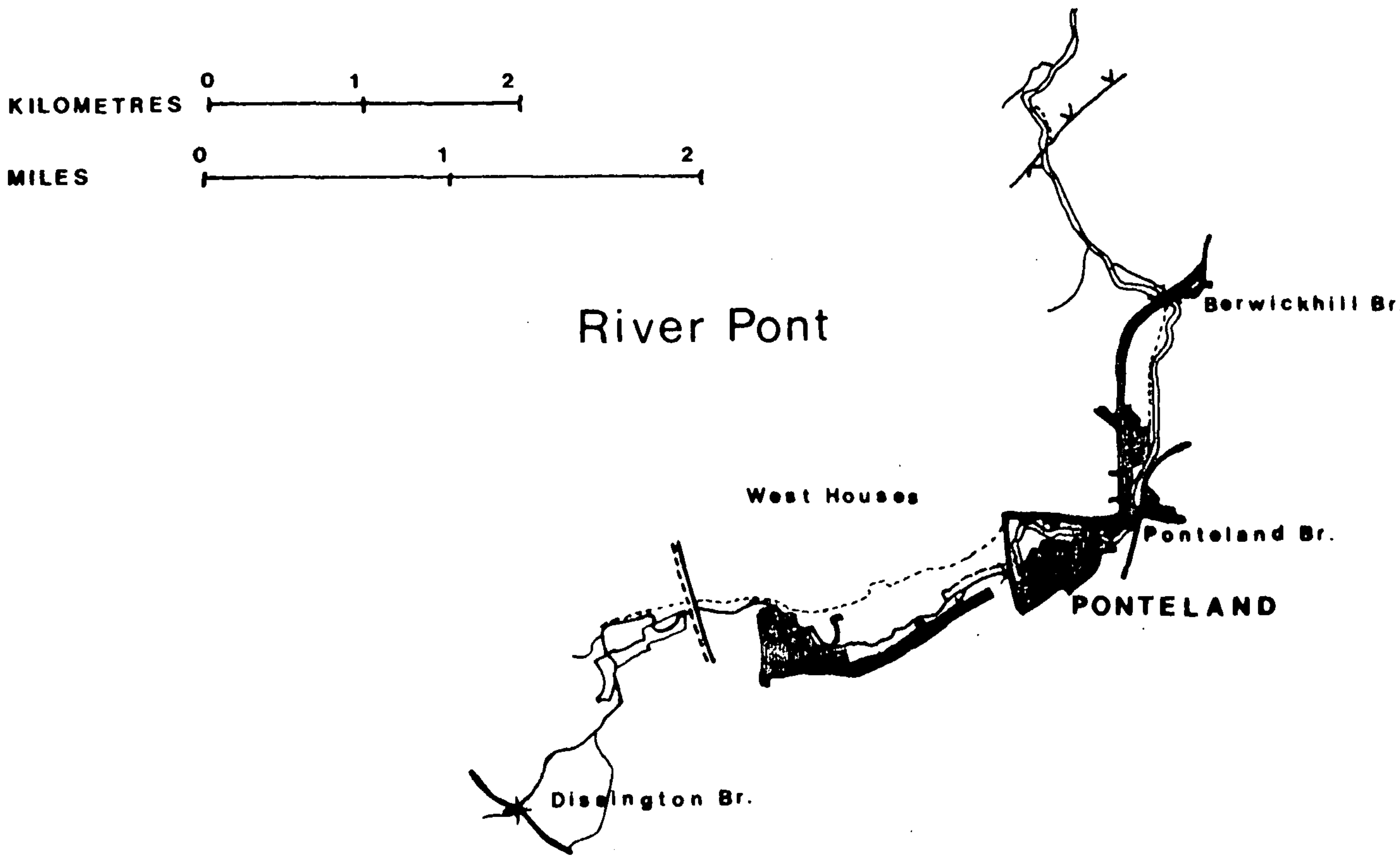


Figure 3.1b. continued.

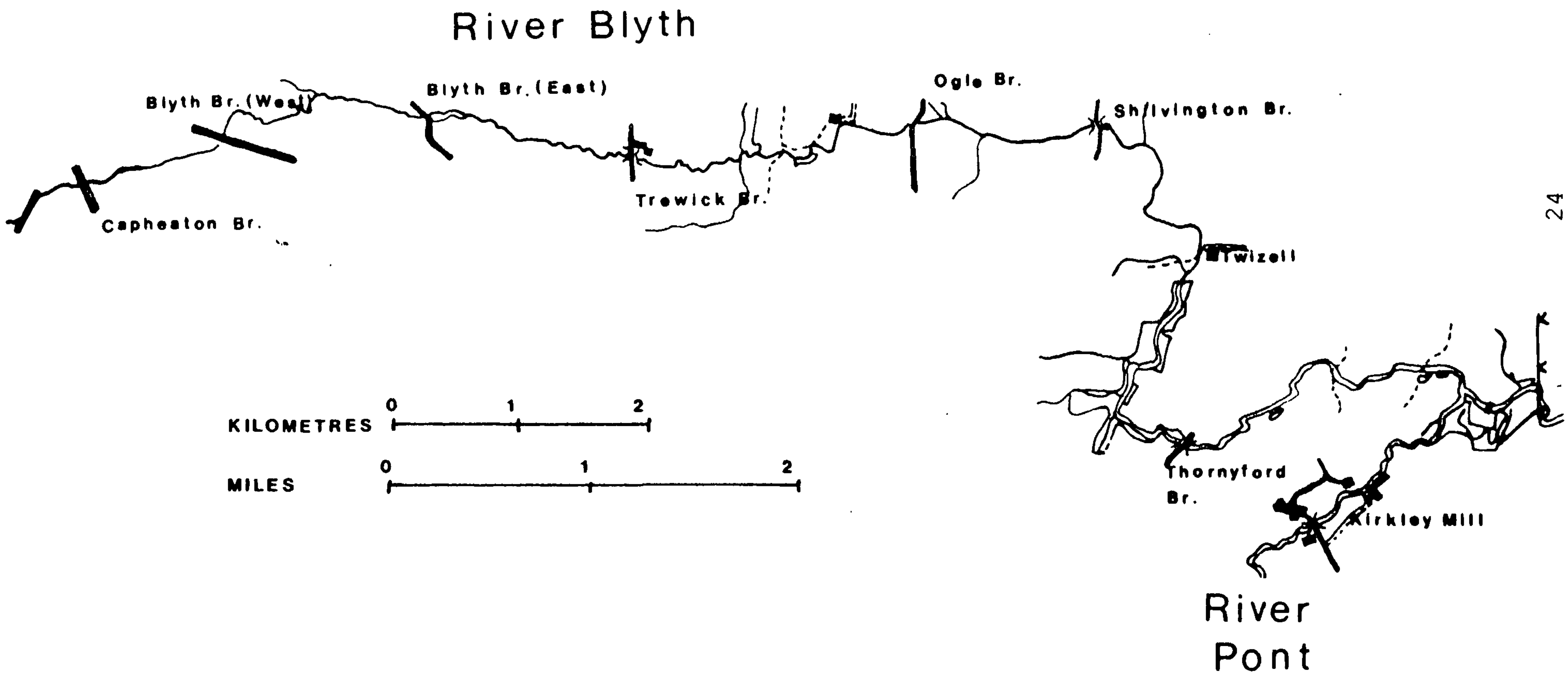
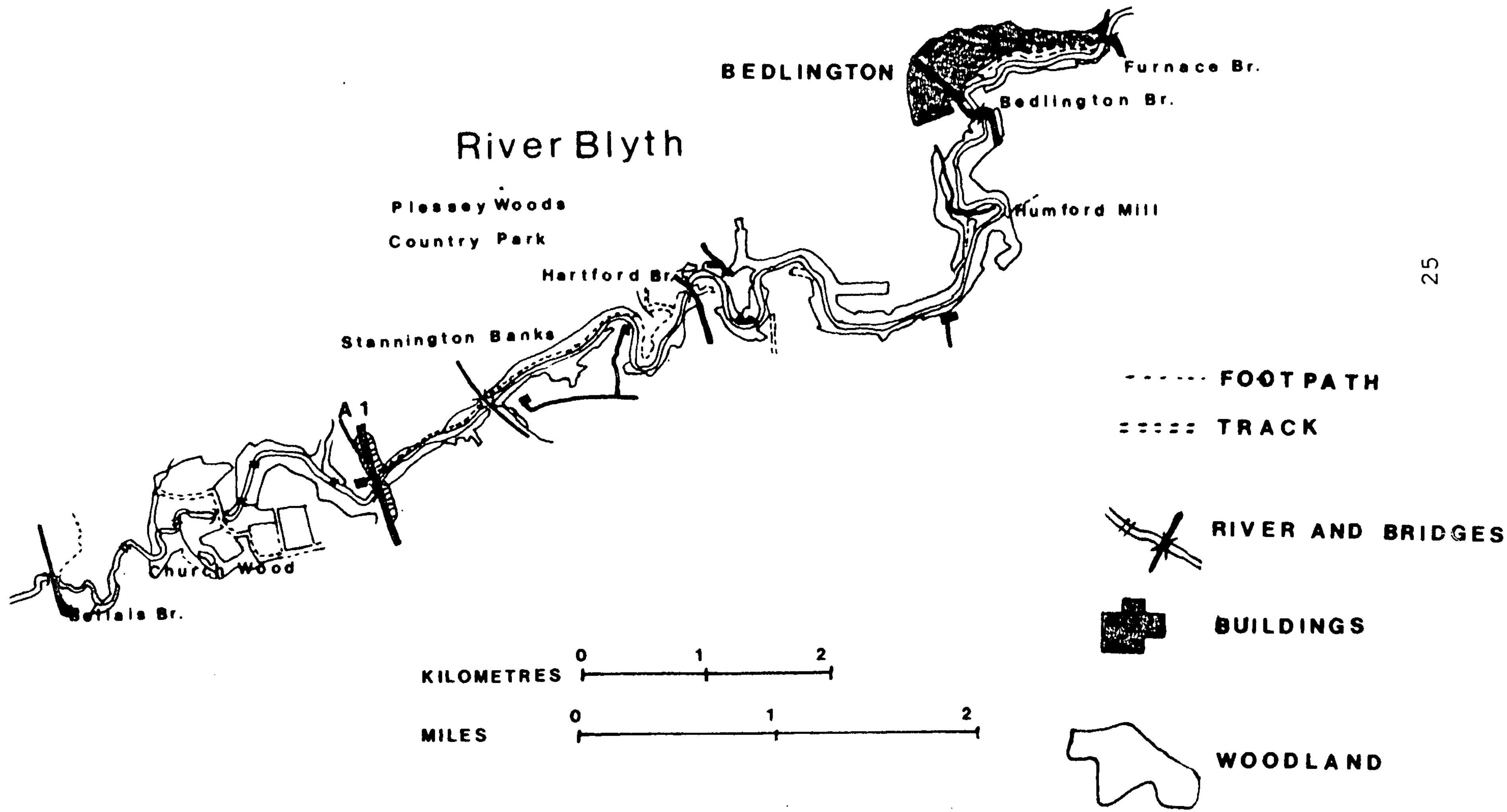


Figure 3.1b. continued



4. DISTRIBUTION SURVEYS.

4.1. Methods.

The distribution of otters along the rivers Wansbeck, Font, Hartburn, Blyth and Pont was determined using an adaptation of the method used during the National Otter Surveys (Crawford, Jones and McNulty, 1979; Green and Green, 1980; Lenton, Chanin and Jefferies, 1980). Sites to be surveyed were selected 2-3km apart at points where the road crossed the river or where access to the river was possible.

Stretches of bank 600m in length were searched on both sides of the river for the presence of otter signs (tracks and spraints). Likely sites to find signs of otters were on ledges under bridges, in the roots of bankside trees, in hollows in the bank and on large rocks or logs in the water. Signs of mink were also noted. The whole 600 metre stretch was searched whether spraint was found or not, unlike the National Surveys where the search was terminated as soon as spraint was found.

The location of spraint was recorded and the spraint was collected in a plastic bag, labelled and returned to the laboratory for further analysis.

The surveys were carried out four times during the period of research, the first was from May the 8th to 11th, the second from May the 23rd to 25th, the third was from June the 18th to 21st for the Wansbeck, Hartburn and Blyth and from July the 2nd to 3rd for the Font and Pont. The fourth survey was from the 30th of July to the 2nd of August. This would give more accurate information than the National Surveys which, because each site was only visited once, may have missed some positive sites.

The past distribution of otters on the two river systems was also determined from the original records of the National Surveys supplied by R.Strachan one of the surveyors for the 1984-1986 survey of England (unpubl. data). This was supplemented by information from R. Wilkin of Northumberland County Council (pers comm.) and H. Watson of the Northumberland Wildlife Trust (pers comm.).

4.2. Results

The results of the four spraint surveys carried out on the Wansbeck and Blyth systems are tabulated with the results of the 1977-79 and 1984-86 National Surveys in Tables 4.1, 4.2, 4.3, 4.4 and 4.5. The data are also plotted on distribution maps (Figures 4.1a. and 4.1b.).

Figure 4.1a. shows that signs of otters were found on the River Wansbeck from Wallington Park bridge (NZ:034839) to Bothal Banks (NZ:241865), a distance of 32km (20 miles). Signs were found on the River Font from Nunnykirk (NZ:080928) to Mitford

Bridge (NZ:173861), a distance of 16km (10 miles). The River Hartburn gave positive sites from Oakford Bridge (NZ:037873) to Hartburn Bridge (NZ:092860), a distance of 10km (6.25 miles). In total, signs of otters were found on 58km (36.25 miles) out of 73km (45.5 miles) of the Wansbeck system surveyed.

Of the sites that showed the presence of otters during the 1977-79 and 1984-86 National Surveys nearly all were positive during the present study. Walkmill Ford (NZ:008843) on the Wansbeck, which was positive in the 1977-79 and 1984-86 surveys, were both negative during the present surveys. Shelly Bridge (NZ:107895) on the Font was positive compared with negative results in the 1977-79 and 1984-86 surveys.

There were no signs of otters recorded on the Rivers Blyth and Pont. The two sites that were positive in the 1977-79 survey, Twizell (NZ:158788) and Stannington Banks (NZ:236797), were negative in the present study. It is probable therefore, that otters are no longer present on the Blyth system.

Figure 4.1. also shows that signs of mink were recorded at most of the sites on the Wansbeck system (Figure 4.1a.) but were only found at a few sites on the Blyth system, centered around the Pont/Blyth confluence (Figure 4.1b.)

SITE			SURVEY					
CODE	PLACE NAME	GRID REF	MAY 1	MAY 2	JUNE	AUG	77-79	84-86
A	Kirkwhelp. Br.	NZ994845	-	-	-	-,M	X	X
B	Walkmill Ford	NZ008843	-	-	-	-	+	-
C	The Park br.	NZ034839	+2,M	+2	+1	+1,M	X	X
D	Middleton Br.	NZ054842	-,M	+1,M	+1	-,M	+	+
E	Highlaws	NZ074844	X	-	-	-	X	X
F	Angerton Br.	NZ093843	+2	+1	+1	+1	X	X
G	Donkson br.	NZ120851	+2,M	+1,M	-	+3,M	X	X
H	Rivergreen	NZ138847	-	+3,M	+1	+3,M	+	+
I	Mitford Ch.br	NZ171857	+1,M	-,M	-	+1,T,M	X	X
J	Highford Br.	NZ180858	+2,M	-,M	+3	+4,M	X	X
K	Grange Hs. Br	NZ190862	+1,M	+1,M	+1,M	+3,M	-	+
L	Morpeth libr.	NZ201858	-	-	-	-	X	X
M	East Riding	NZ205864	+1	-	-	-	X	X
N	Bothalhaugh	NZ236862	-	+1,M	-	+2	-	+
O	Bothal Banks	NZ241865	+2,M	X	+1,M	+4,T,M	X	X
P	Sheepwash Br.	NZ256858	-	-	-	-	X	X
Q	Wellhead Dene	NZ262864	-	-	-	-	X	X
R	Stakeford Br.	NZ272860	-	-	-	-	X	X

+n = presence and number of otter spraints.

\- = absence of otter spraints

T = otter tracks found.

M = mink signs found.

X = not surveyed.

MAY 1 = 9th May.

MAY 2 = 22nd and 24th May.

JUNE = 19th and 20th June.

AUG = 1st and 2nd August.

Table 4.1. The distribution of otters on the River Wansbeck in Northumberland during summer 1990.

SITE			SURVEYS					
CODE	PLACE NAME	GRID REF	MAY 1	MAY 2	JULY	AUG	77-79	84-86
A	Combhill Br.	NZ064933	-,M	-	-	-,M	X	X
B	Coltpark Wood	NZ073932	-	X	-,M	-	X	X
C	Nunnykirk	NZ080928	-	+1,M	-	+1	X	X
D	Crossford Br.	NZ093912	-	-	-	-,M	+	+
E	Netherwitton	NZ100902	-	+1	-	-	X	X
F	Shelly Br.	NZ107895	+2,M	+3	-	+1	-	-
G	Longshaws Mill	NZ117894	-	+1	-	+1	X	X
H	Stanton Mill	NZ130889	+1,M	-,M	-	+1,M	+	+
I	West Park Wood	NZ148867	X	-	-	-	X	X
J	Mitford br.	NZ173861	-	-	-	+1	X	X

+n = presence and number of otter spraints.

\- = absence of otter spraints.

M = Mink signs found.

X = not surveyed.

MAY 1 = 10th May.

MAY 2 = 23rd May.

JULY = 3rd July.

AUG = 1st August.

Table 4.2. The distribution of otters on the River Font, Northumberland during summer 1990.

SITE			SURVEYS					
CODE	PLACE NAME	GRID REF	MAY 1	MAY 2	JUNE	AUG	77-79	84-86
A	Hartington Br.	NZ021876	X	-	-	-	X	X
B	Oakford Br.	NZ037873	-,M	+1	-	+1,M	+	+
C	Green Riggs	NZ060871	+2,M	+1,M	-	-	X	X
D	Dragons Den	NZ083870	+1	-	-	-	X	X
E	Hartburn Br.	NZ092860	+2	+2,M	+1	+1,M	+	+
F	Temple Thorn.	NZ103851	X	-	-	-	X	X

+n = presence and number of otter spraints.

\- = absence of otter spraint.

M = Mink signs found.

X = not surveyed.

MAY 1 = 9th May.

MAY 2 = 24th May.

JUNE = 20th and 21st June.

AUG = 2nd August.

Table 4.3. The distribution of otters on the River Hartburn, Northumberland during summer 1990.

SITE			SURVEYS					
CODE	PLACE NAME	GRID REF	MAY 1	MAY 2	JUNE	JULY	77-79	84-86
A	Nr Capheaton	NZ035787	-	-	-	-	X	X
B	Capheaton Br.	NZ041788	-	-	-	-	-	-
C	Blyth Br.(W)	NZ074799	-	-	-	-	X	X
D	Blyth Br.(E)	NZ095799	-	-	-	-	X	X
E	Trewick Br.	NZ112795	-	-	-	-	-	-
F	Ogle Br.	NZ134799	-	-	-	-	X	X
G	Shilvington Br	NZ149799	-	-	-	-	X	X
H	Twizell	NZ158788	-	-	-	-	+	-
I	Thorneyford Br	NZ156773	-,M	-	-,M	-	X	X
J	Bellais Br.	NZ190776	-	-	-	-	-	-
K	Church Wood	NZ199780	-	-,M	-,M	-,M	X	X
L	Stannington	NZ236797	-	-	-	-	+	-
M	Hartford Br.	NZ243800	-	-	-	-	X	X
N	Humford Mill	NZ268807	-	-	-	-	X	X
O	Bedlington Br.	NZ267817	-	-	-	-	-	-
P	Furnace Br.	NZ277821	-	-N	-	-	X	X

+ = presence of otter spraint.

- = absence of otter spraint.

M = Mink signs found.

X = not surveyed.

MAY 1 = 8th May.

MAY 2 = 22nd May.

JUNE = 18th June.

JULY = 31st July.

Table 4.4. The distribution of otters on the River Blyth, Northumberland during summer 1990.

SITE			SURVEYS					
CODE	PLACE NAME	GRID REF	MAY 1	MAY 2	JULY 1	JULY 2	77-79	84-86
A	Dissington Br.	NZ125709	-	-	-	-	-	-
B	West Houses br	NZ152725	-	-	-	-	X	X
C	Ponteland Br.	NZ167729	-	-	-	-	X	X
D	Berwickhill Br	NZ168743	-,M	-,M	-	-,M	-	-
E	Kirkley Mill	NZ166767	-,M	-,M	-	-,M	X	X

- = absence of otters.

M = Mink signs found.

X = not surveyed.

MAY 1 = 11th May.

MAY 2 = 25th May.

JULY 1 = 2nd July.

JULY 2 = 30th July.

Table 4.5. The distribution of otters on the River Pont, Northumberland during summer 1990.

Figure 4.1a. A map of the Wansbeck sytem showing the positions of the survey sites and the overall results of the four surveys. Positive signs of otters are indicated by filled circles or T for tracks. Positive signs of mink are indicated by M. The other letters are site codes and correspond to the site names given in Tables 4.1., 4.2. and 4.3.

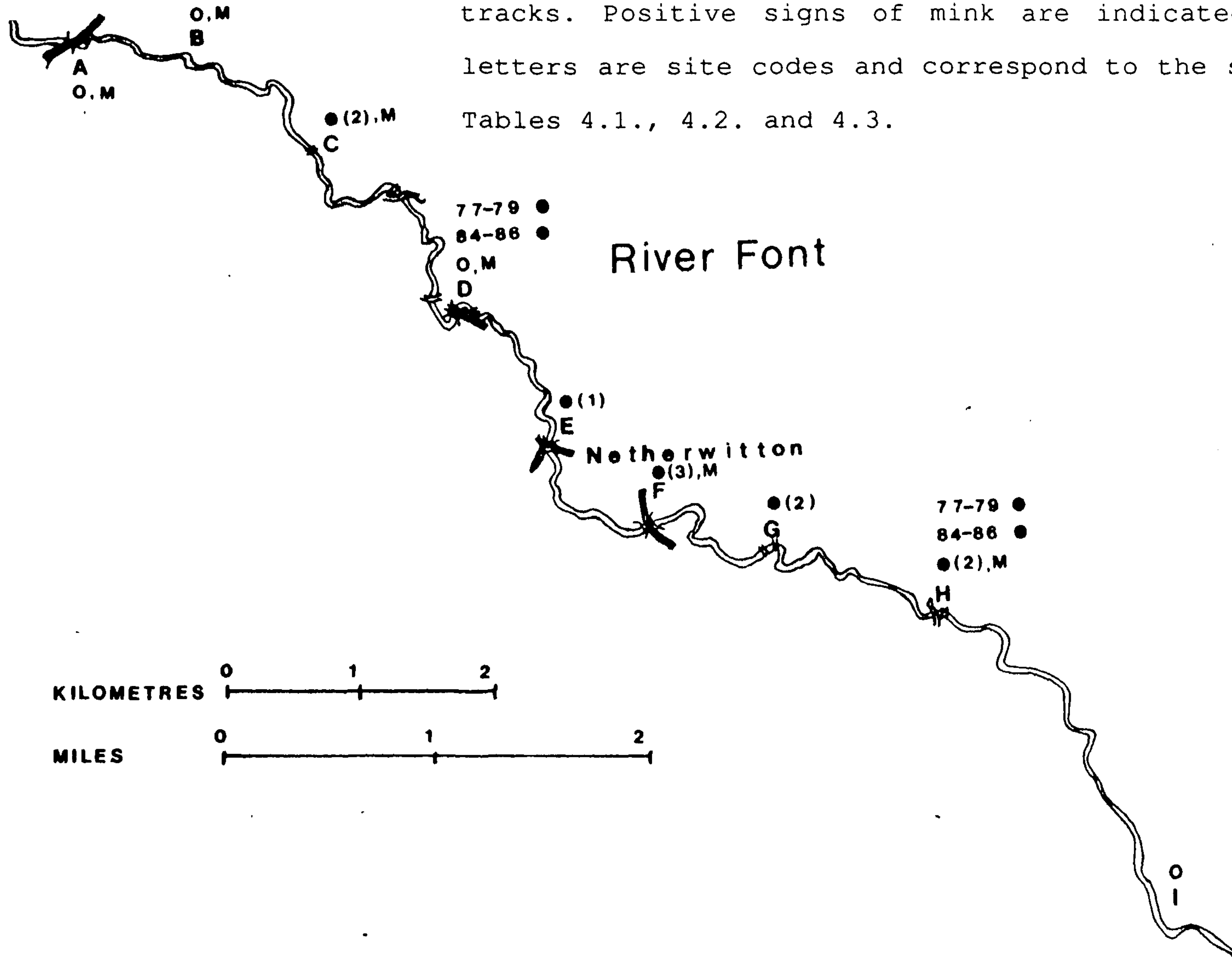


Figure 4.1a. continued.

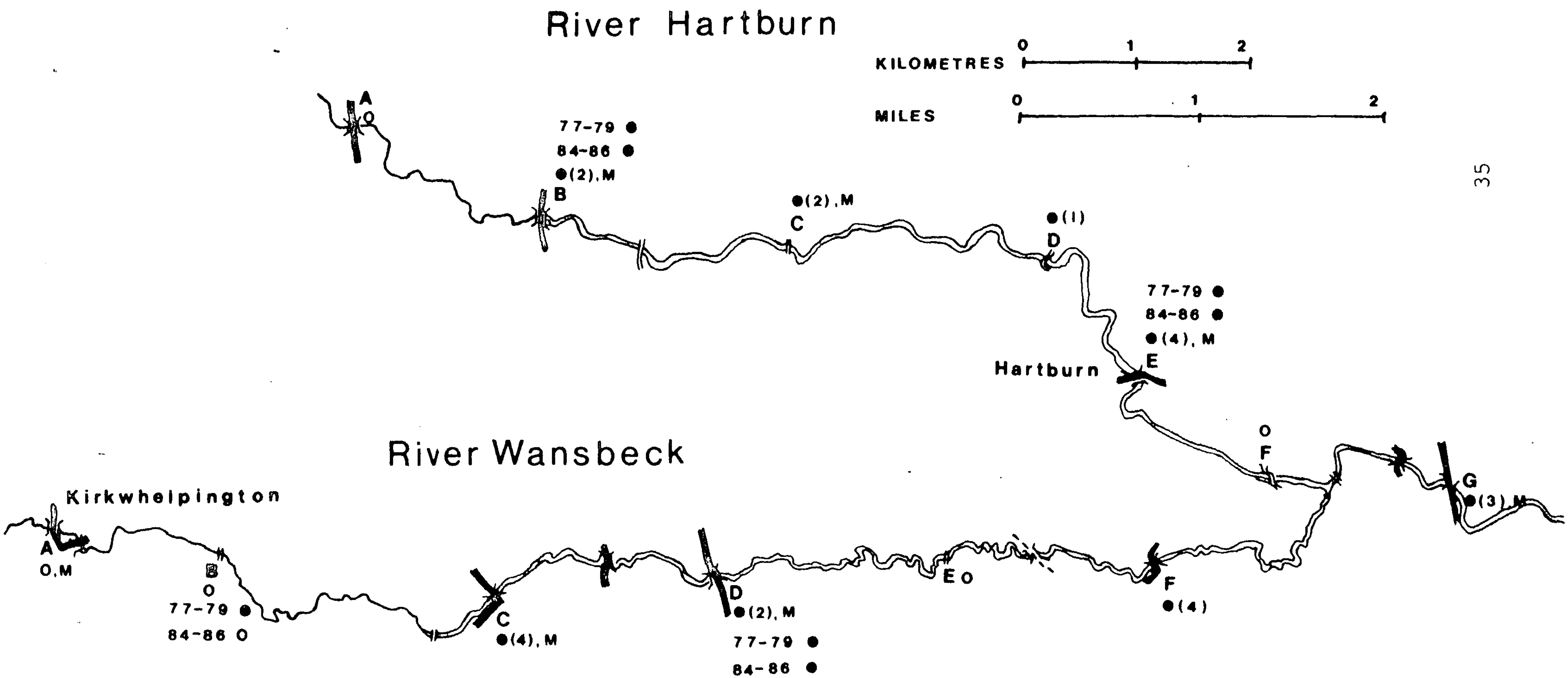
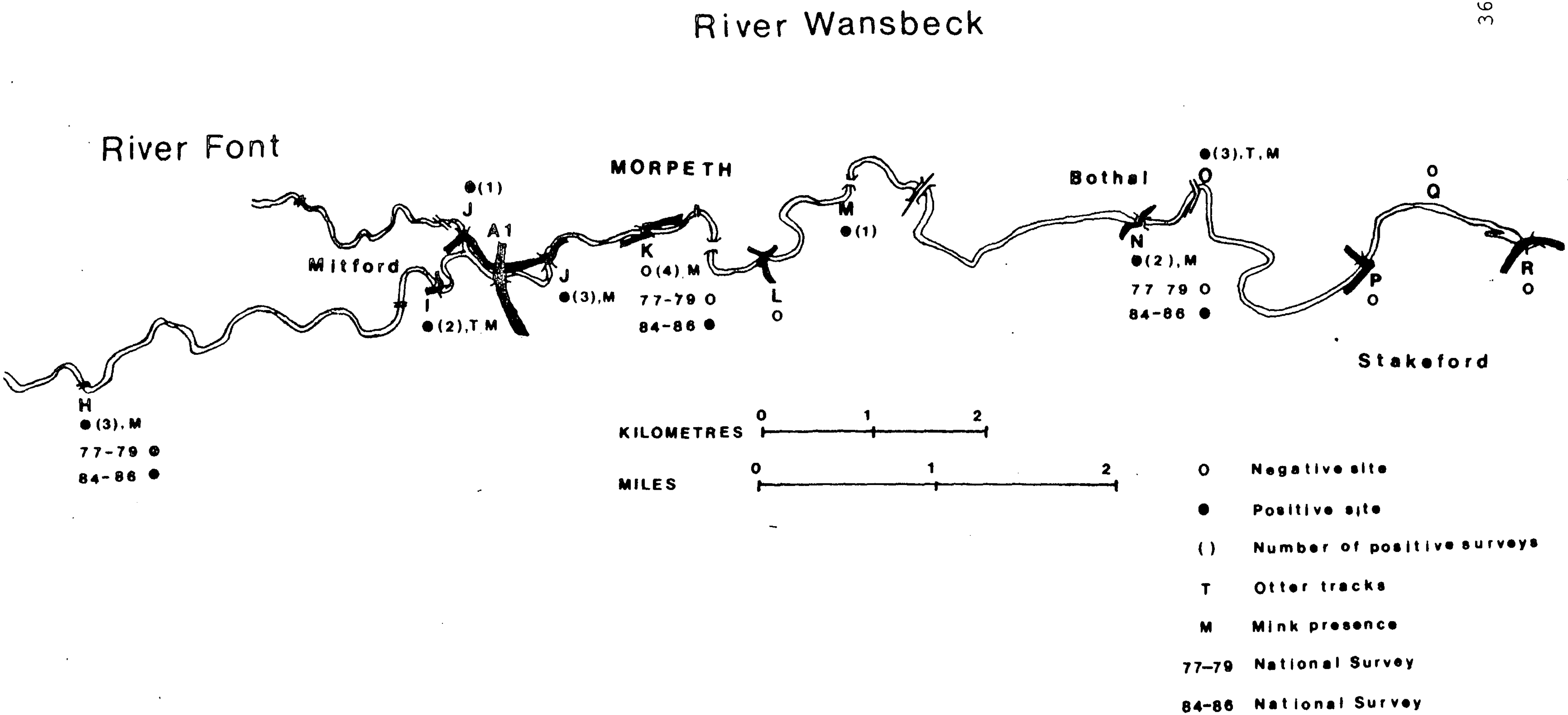


Figure 4.1a. continued.



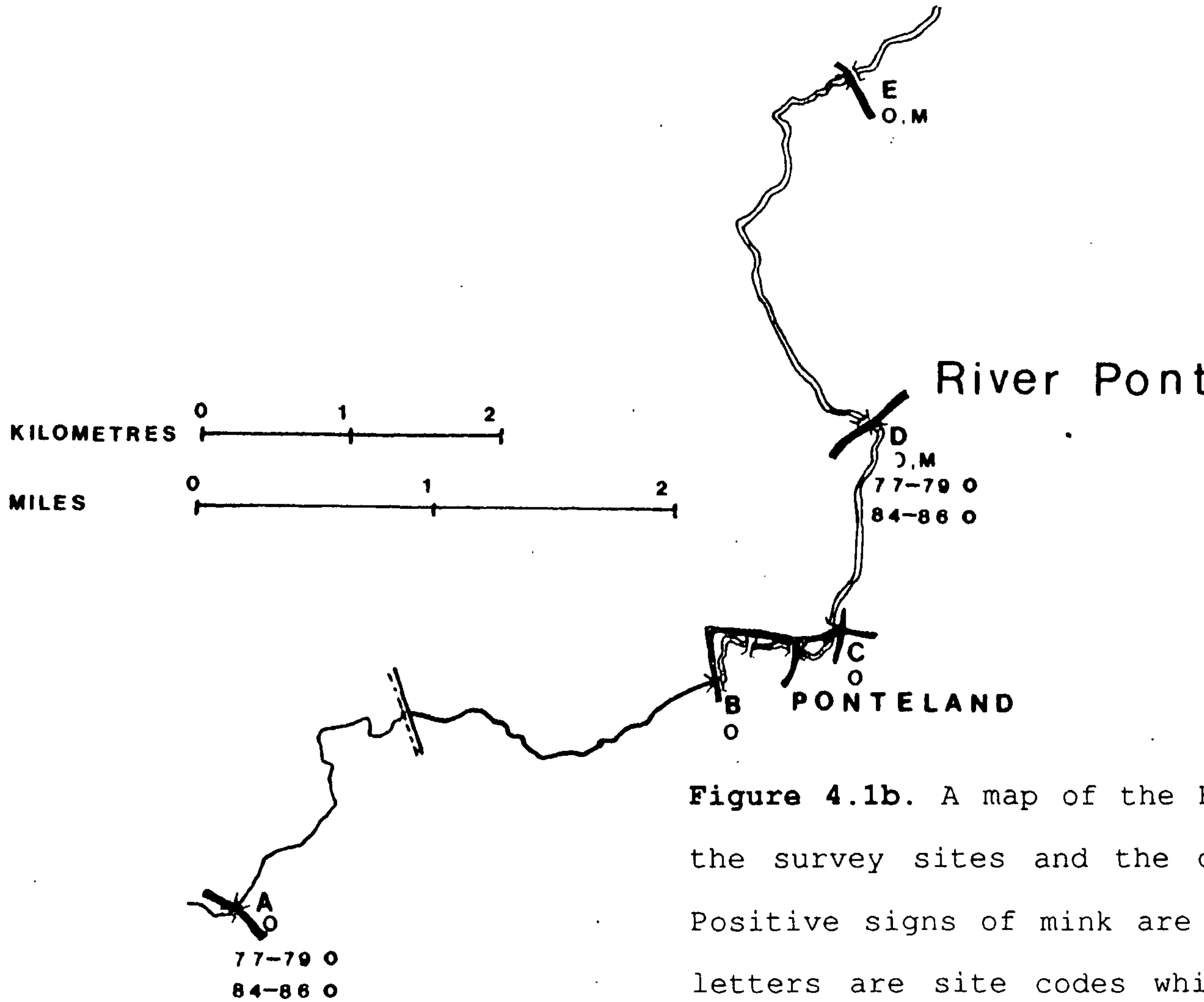


Figure 4.1b. A map of the Blyth system showing the positions of the survey sites and the overall results of the four surveys. Positive signs of mink are indicated by the letter M. The other letters are site codes which correspond to the sites given in Tables 4.4. and 4.5.

Figure 4.1b. continued.

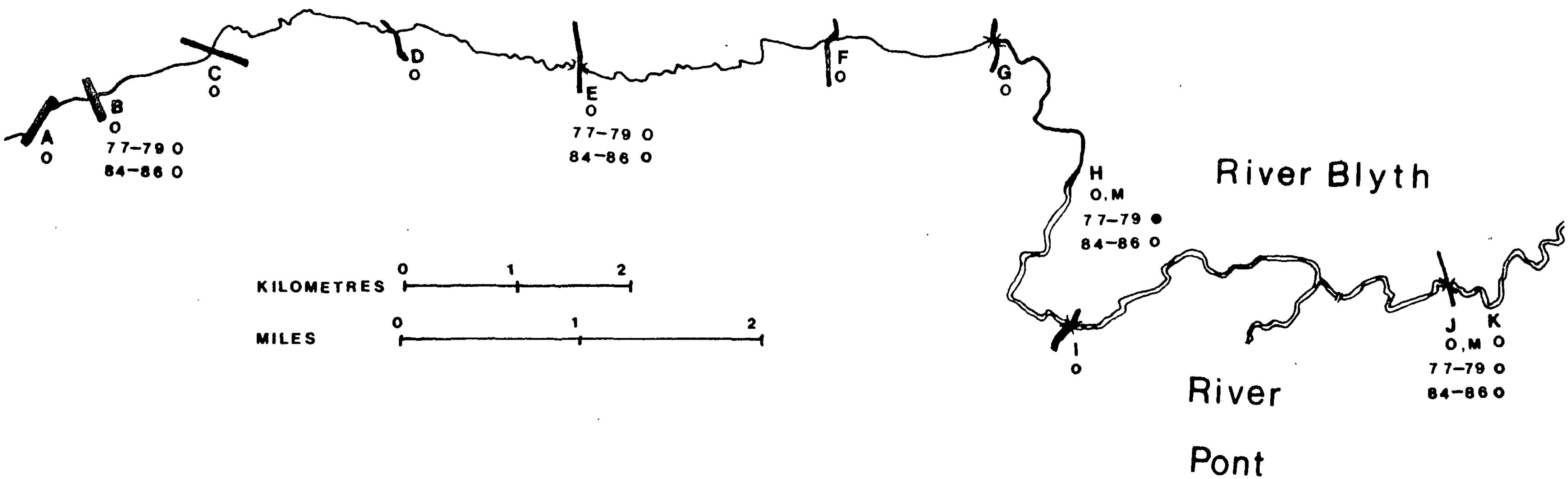
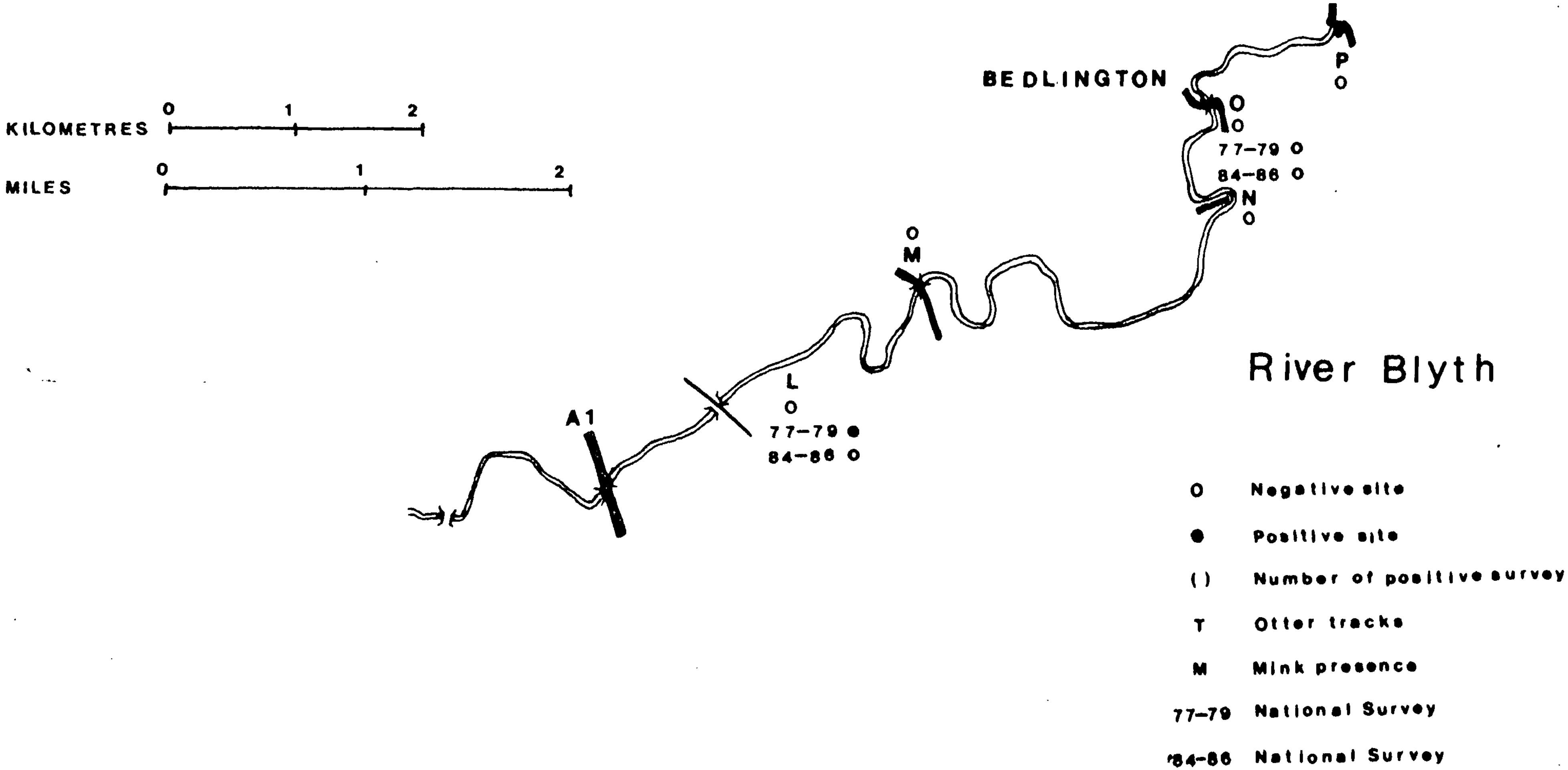


Figure 4.1b. continued



5. DIET ANALYSIS

5.1 Methods

5.1.1. Identification of prey types.

Spraints obtained from the surveys were returned to the laboratory for analysis of their contents.

The spraints were soaked in dilute detergent and then washed over a 0.5 millimetre mesh size sieve, placed in Petri dishes and then dried in air at room temperature for 24 hours. Each dried spraint was weighed and the items identified where possible. The remains of mammals and birds were identifiable using keys (Day, 1966), but since the number of spraints containing mammals and birds was low it was decided to record them as mammals and birds only. Crayfish (*Astacus fluviatilis*) remains were easily identifiable, large beetle remains were not found and earthworm chetae were not looked for although otters do take these when other prey is absent (Pautard, 1980; Wise, 1978; Wise *et al.*, 1981). Other invertebrates were not considered to be part of the normal diet of the otter and were probably from the guts of fish prey taken (Jenkins *et al.*, 1979; Jenkins and Harper, 1980; Wise *et al.*, 1981). Fish remains were identified from their vertebral remains, opercular bones and some other bones such as jawbones and teeth using keys, descriptions and photographs (Webb, 1976; Wise, 1978).

5.1.2 Prey size.

It was only possible to determine the sizes of fish prey taken by otters in this study. However, since other prey types form only a small component of the diet it was not necessary to determine their sizes.

Fish lengths were calculated from the centrum length of the characteristic vertebrae (Wise, 1978; Wise, 1980). Vertebrae were identified to taxonomic group and classified as anterior or caudal. Anterior vertebrae can be distinguished by the separate transverse processes which are joined into one ventral spine in the caudal vertebrae. These were then measured using a calibrated eyepiece on a binocular microscope at x40 magnification giving an accuracy of 0.01mm. Extreme anterior and extreme posterior (caudal) vertebrae were not included in the calculation as these were not representative of the vertebral column as a whole.

Wise (1978) showed that vertebral length is positively correlated with the snout to fork length of the fish. Regression lines and coefficients were calculated for eight species of fish and the equations from these lines were used in this study (See Appendix I). Regression equations were not given for bullhead (*Cottis gobio*) and time and fish were not available to do the necessary calculations for this survey. Therefore, it was not possible to calculate the sizes of bullhead in this study.

However, Pautard (1980) stated that the lengths of vertebrae of this species found in spraints from the Wansbeck, Blyth and North Tyne matched those from an 8cm reference fish.

Vertebrae from chubb (*Leuciscus cephalus*), roach (*Rutilus rutilus*), dace (*Leuciscus leuciscus*) and minnow (*Phoxinus phoxinus*) could not be distinguished from each other and were classified as Cyprinidae. Damaged and unidentifiable vertebrae were recorded as such.

5.1.3. Presentation of results.

There are a number of methods available for the presentation of dietary data. Five methods were chosen and the relative merits of each will be discussed later. The methods were:

(i) Frequency of occurrence expressed as a proportion of the total number of prey items. The occurrence of a prey item in each spraint was recorded then summated for the total number of spraints and expressed as a percentage of the total number of prey occurrences;

$$\text{Frequency of occurrence (\%)} = \frac{\text{Number of occurrences of item A}}{\text{Total occurrences of all prey}} \times \frac{100}{1}$$

(ii) Proportion of spraints containing prey items. The occurrence of a prey item was recorded then summated for the total number of spraints and expressed as a percentage of the total number of spraints;

$$\text{Frequency of occurrence (\%)} = \frac{\text{Number of occurrences of item A}}{\text{Total number of spraints}} \times \frac{100}{1}$$

(iii) Relative estimated bulk. A scoring system of 1-10 was used to assess the relative importance of each prey type in a spraint with 1 being a trace item and 10 for a spraint completely composed of one item. The scores for each prey type were summated and the proportion of the total number of spraints multiplied by 10 (the maximum possible score for each spraint);

$$\text{Relative estimated bulk} = \frac{\text{Sum score of item A}}{\text{Total number of spraints}} \times \frac{100}{1}$$

(iv) Bulk estimate. The bulk proportion factor from (iii) was multiplied by the dry weight. This was then divided by the sum of all prey types multiplied by the total dry weight of spraints and expressed as a percentage;

$$\text{Estimated bulk (\%)} = \frac{\text{Score of item A} \times \text{dry weight of spraint containing item A}}{\text{Sum score all items} \times \text{total dry weight}} \times \frac{100}{1}$$

(v) Conversion Factors. The estimated bulk calculated in (iv) was multiplied by conversion factors (CF) calculated by Wise (1978) to determine the total weights of fish prey ingested (Table 5.1.). The conversion factors were calculated from feeding experiments with captive feral mink. The animals were fed whole prey items daily so that CFs could be calculated for each prey such that;

$$CF = \frac{\text{weight of prey given.} - (\text{weight left + weight loss due to evaporation})}{\text{Dry weight of scats produced}}$$

By applying these to the bulk estimate data the importance of each prey species can be determined and is expressed as the total weight of that species taken over the total period of study as estimated from the total number and weight of spraint.

The length measurements of vertebra were converted to fish lengths using the regression equations in Appendix I. These were then classified into eleven size classes (Table 5.3.).

PREY TYPE	CF
PERCH	16
STICKLEBACK	15
SALMONIDAE	20
CYPRINIDAE	16
EEL	40
BULLHEAD	15

Table 5.1. Conversion factors (CF) for the calculation of the total weight of fish prey ingested (Wise, 1978).

SIZE CLASS	FISH LENGTHS (CM)	
	EEL	OTHER SPECIES
1	0-4.9	0-2.9
2	5-9.9	3-5.9
3	10-14.9	6-8.9
4	15-19.9	9-11.9
5	20-24.9	12-14.9
6	25-29.9	15-17.9
7	30-34.9	18-20.9
8	35-39.9	21-23.9
9	>39.9	>23.9

Table 5.2. Classification of fish lengths.

5.2. Results.

5.2.1. Prey types.

A total of 99 otter spraints were collected during the period of study. Figure 5.1. shows the major prey types found in spraints on the Wansbeck river system. Four of the methods of result presentation are represented. The results used in Figure 5.1. were calculated as the overall means of the four surveys (See Appendix II for actual values).

Fish form the major component of the diet (93% from frequency of occurrence by proportion of prey, 82% from relative estimated bulk and 87% from bulk estimate). Crayfish form the second most important prey item with mammals and amphibians rarely being taken.

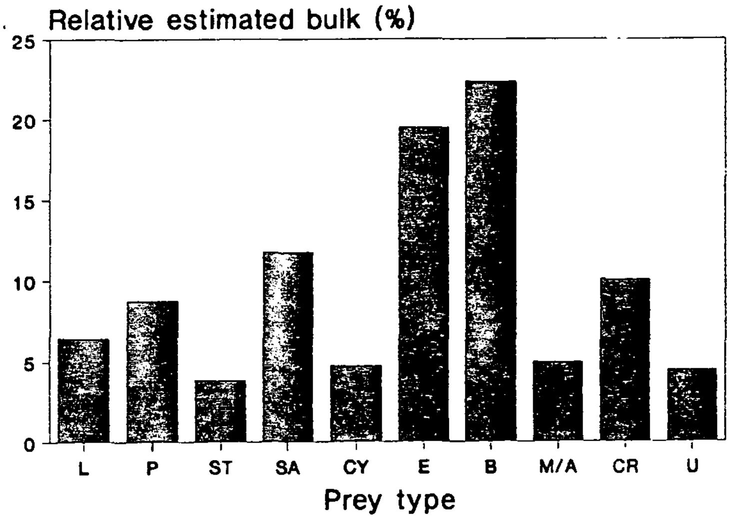
Bullhead formed the largest component of the diet in all the estimation methods. Salmonidae, eel (*Anguilla anguilla*) and perch (*Perca fluviatilis*) attained almost equal importance when relative frequency was the method of presentation used (15.9%, 14.9% and 14.4% respectively) . However, when relative estimated bulk and bulk estimate data were used eel was the second most important component (19.5 and 8 percent respectively), followed by salmonids (11.8 and 11.3 percent respectively). Perch and crayfish also form a significant proportion of the diet. Three-spined stickleback (*Gasterosteus aculeatus*), Cyprinidae, stone loach (*Noemacheilus barbatulus*), mammals and amphibians showed significantly lower than expected values of occurrence in the diet (chisquare goodness-of-fit test) which was mirrored by the significantly higher than expected values of occurrence for bullhead, eel and Salmonidae in the diet.

A comparison was made between spring and summer diets by classifying the two May surveys as a single spring sample and the surveys in June, July and August as summer (See Appendix III for data values). It was found that there were no significant differences between Spring and Summer (chisquare contingency tables using raw data).

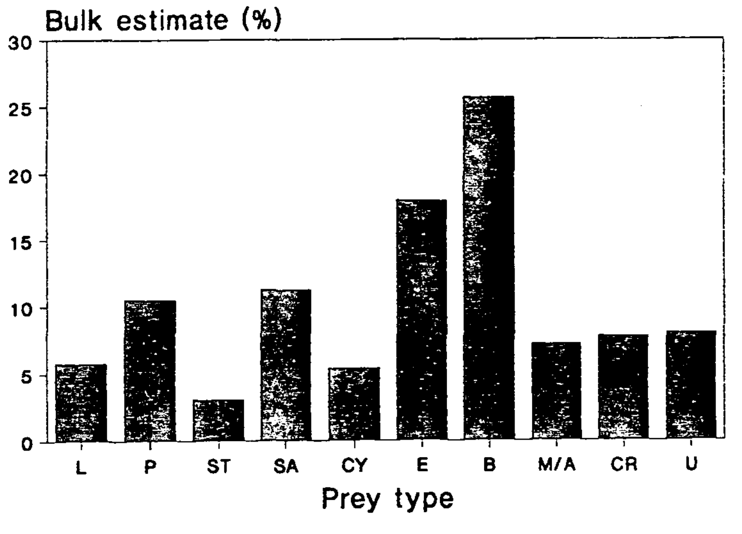
The conversion factors calculated by Wise applied to the bulk estimate data for fish and crayfish to determine the weight of prey ingested in grammes (Table 5.3.). Conversion factors were not applied to the mammal/amphibian component of the diet because the number of occurrences were so small that the result would not have been accurate. Table 5.3. shows that bullhead form the largest component of the total prey ingested during this study at 386 grammes closely followed by eel at 320 grammes. Salmonidae are also an important component of the ingested prey weight (226 grammes) as are perch and crayfish (168 grammes and 133 grammes respectively). Cyprinidae and stickleback form only a small component of the ingested weight.

Figure 5.1. continued.

5.1c Relative estimated bulk.



5.1d Bulk estimate.



PREY TYPE	ESTIMATED BULK (PERCENT)	WEIGHT OF PREY INGESTED (GRAMMES)
BULLHEAD	25.7	386
EEL	8.0	320
SALMONIDAE	11.3	226
PERCH	10.5	168
CYPRINIDAE	5.4	86
STICKLEBACK	3.1	47
CRAYFISH	7.8	133

Table 5.3. Application of conversion factors to determine the weights of prey ingested by otters on the Wansbeck system in Northumberland.

In summary, the results showed that bullhead formed the major component of the diet of the otter on the Wansbeck system followed by eel, salmonids and perch with other species being of only secondary importance with no seasonal differences in the proportions of each prey type being taken.

5.2.2. Prey size.

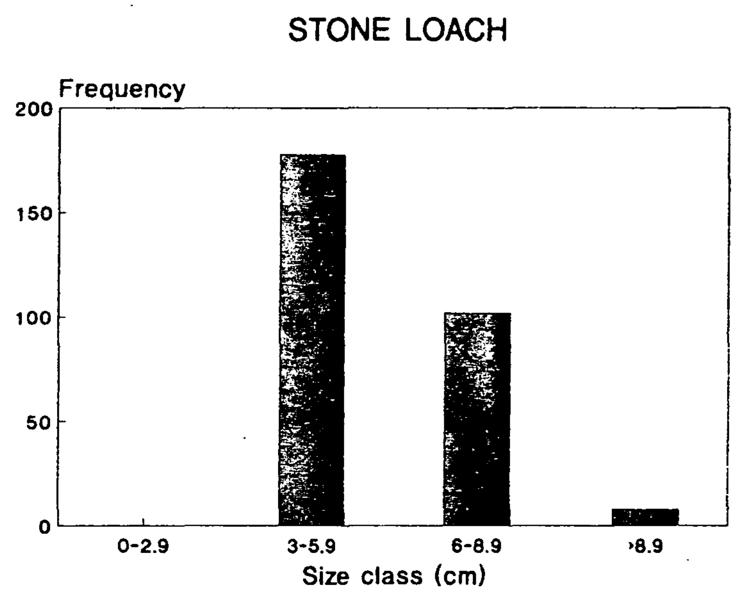
Figure 5.2. gives the length-frequency data for each fish species found in the spraints from all four surveys. The mean sizes of fish taken are shown in Figure 5.3.

The longest fish taken were eels, mean size 14.6±5.8cm. This value was much lower than that found by Pautard (1980) (mean size 31cm). Salmonidae were the longest of the other species, mean size 7.8±2.7cm, again this value was lower than that obtained by Pautard (1980). Perch, stone loach and Cyprinidae were of similar lengths and the smallest prey taken was the stickleback at 3.8±0.6m. All sizes were considerably lower than those of Pautard (For full results see Appendix IV).

A comparison was made between the Spring and Summer length-frequency data and it was found that there were seasonal differences in the size of eels taken. More prey of all size classes were taken in summer (figure 5.4.).

In summary, the longest prey found in the spraints collected was the eel, followed by Salmonidae, and then Perch, Cyprinidae and stone loach with stickleback being the smallest. There were seasonal differences in the sizes of eels taken with more prey of all sizes being taken in the summer.

Figure 5.2. Length frequency data for the prey taken by otters on the Wansbeck river system.



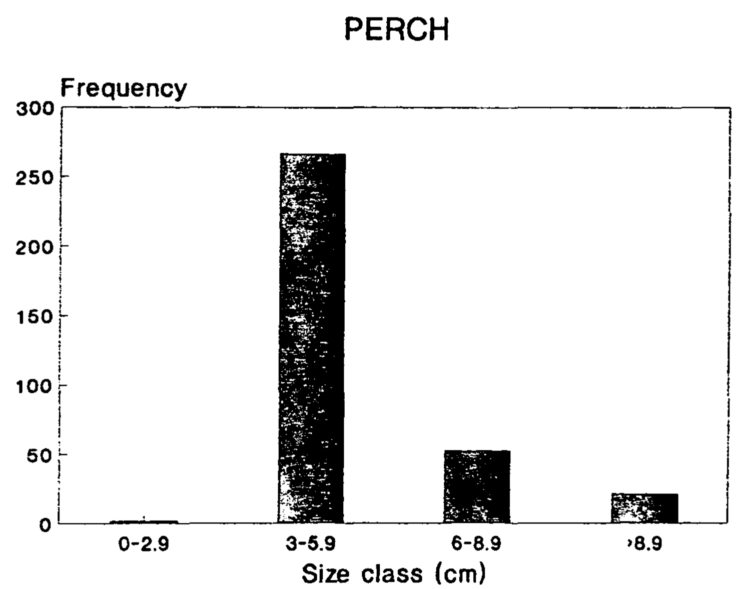
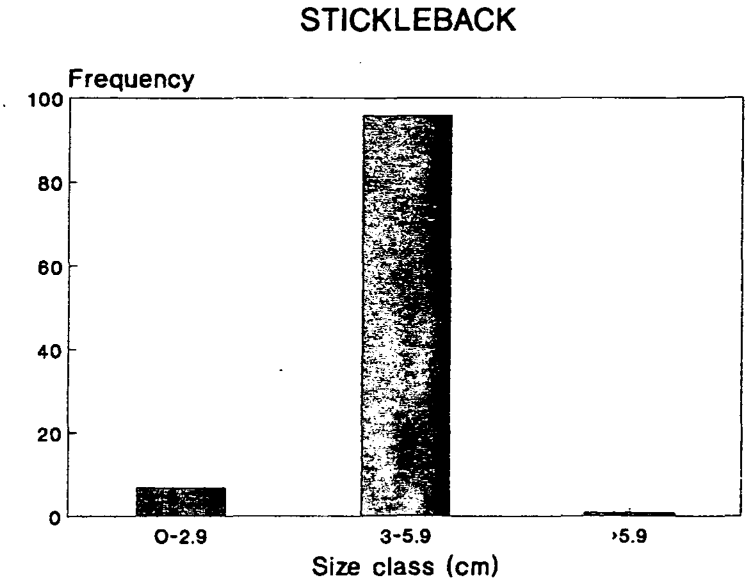


Figure 5.2. continued.



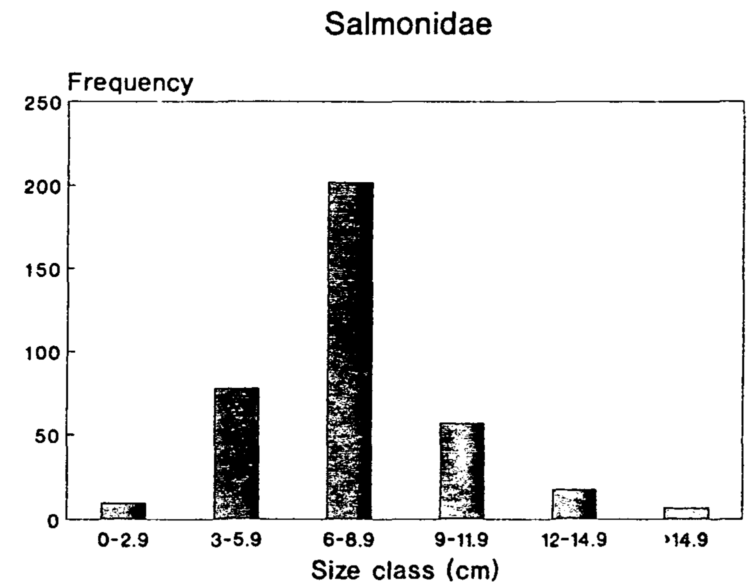
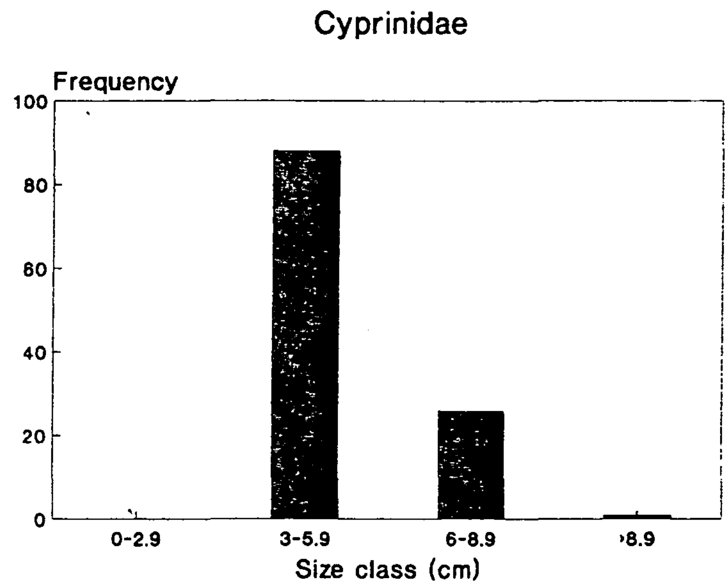


Figure 5.2. continued.



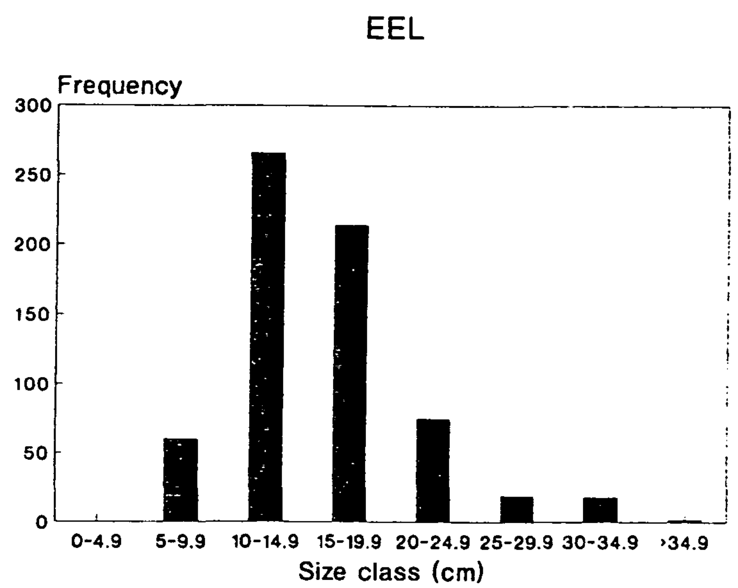


Figure 5.3. Mean prey sizes taken by otters on the Wansbeck river system. L = stone loach, P = Perch, ST = three spined stickleback, SA = Salmonidae, CY = Cyprinidae, E = eel.

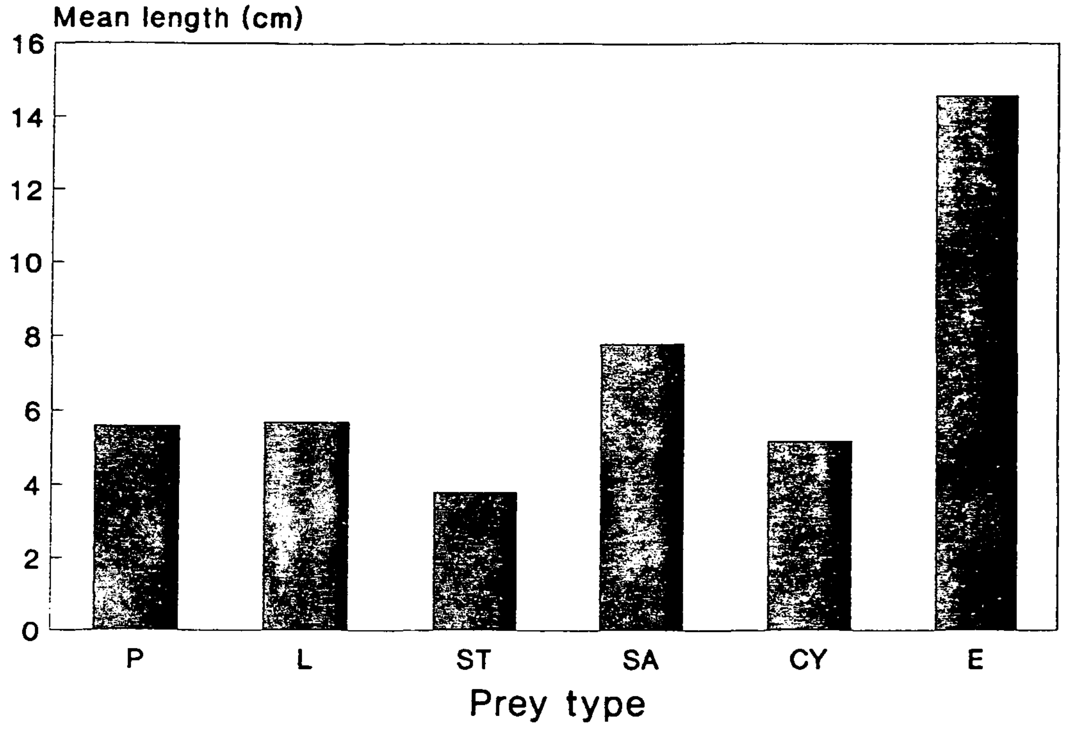
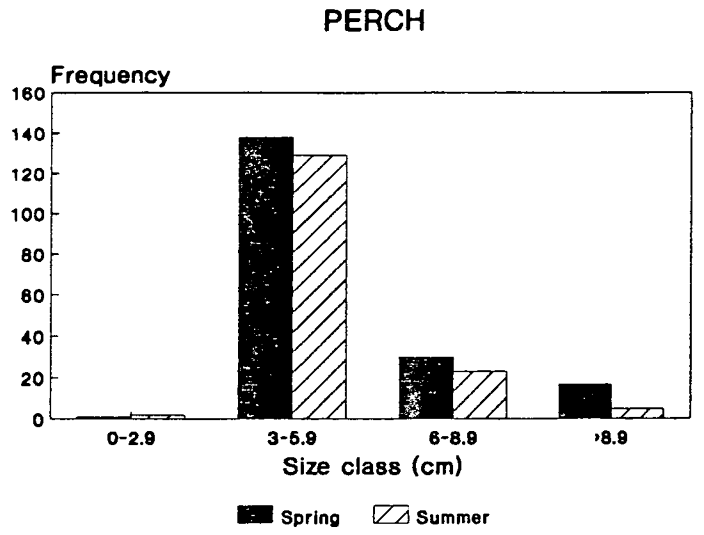


Figure 5.4. Seasonal differeces in the sizes of prey taken on the Wansbeck river system.



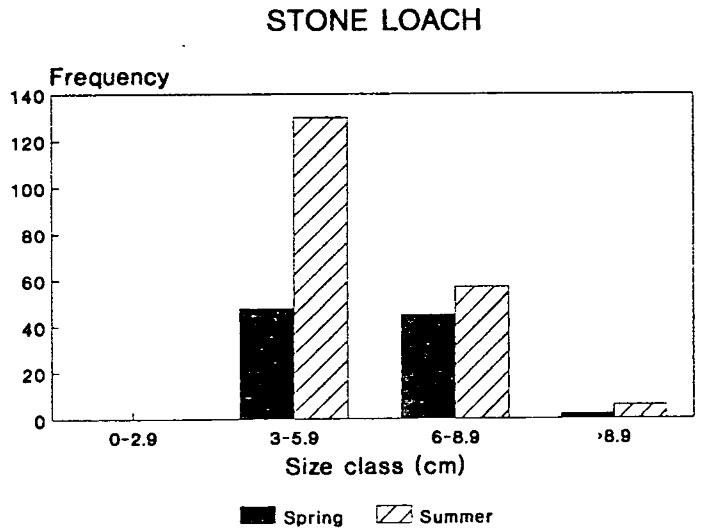
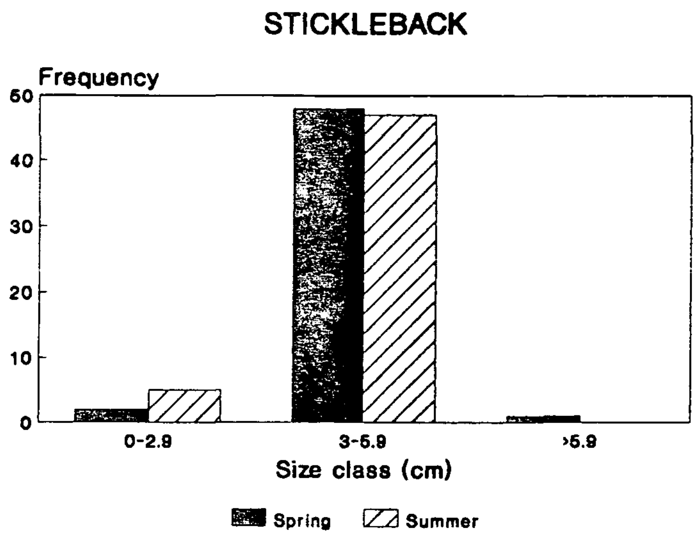


Figure 5.4. continued.



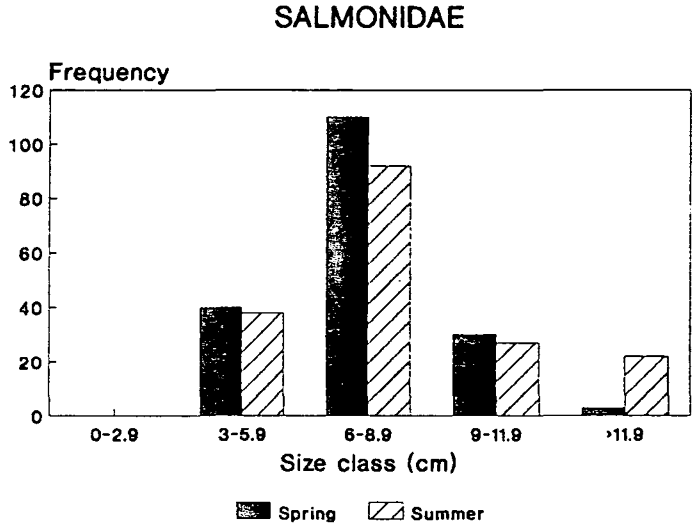
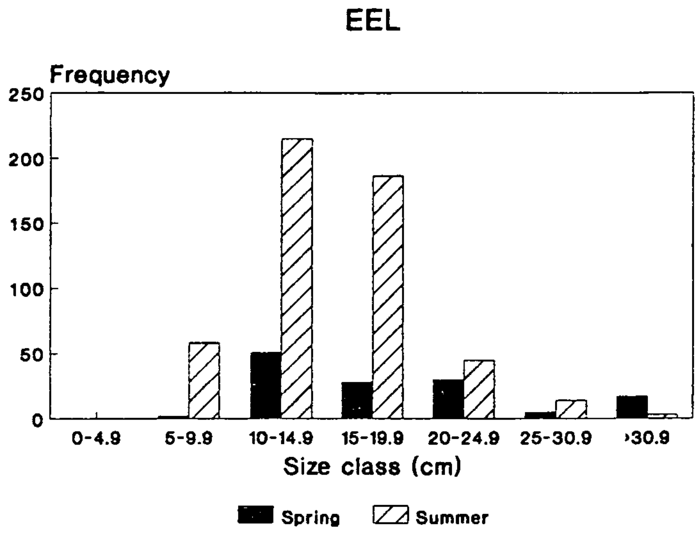
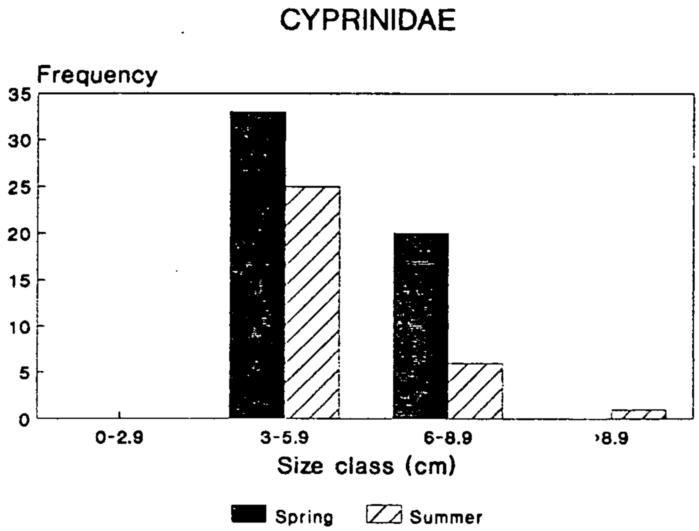


Figure 5.4. continued.





6. HABITAT REQUIREMENTS.

6.1. Methods.

The habitat was surveyed using a method similar to that used in a study of the River Teme in western England and later in Wales and the border counties (Macdonald et al., 1978; Macdonald and Mason, 1983).

5km stretches of one bank of the river were walked and signs of otters were recorded. In addition signs of mink, numbers of trees and shrubs of different species, possible holt sites, type of substrate in the river, amount of cover, possible disturbance levels and width of river were recorded. The total length of woodland (metres) bordering a stretch was determined using the Ordnance Survey Pathfinder Series maps.

Substrate type was determined using the following index;

1: Silt

2: Sand

3: Sand/Stones <10mm

4: Stones >10mm <100mm

5: As 4 with occassional boulders

6: More frequent boulders

7: Large boulders and bedrock

8: Solid bedrock

The amount of cover was assessed using the following index;

0: Bare soil

1: Short cut or grazed grass

2: Vegetation to 10cm-not dense

3: Vegetation to 10cm-dense

4: Vegetation to 50cm-not dense

5: Vegetation to 50cm.-dense

6: Vegetation to 1 metre plus trees and shrubs-not dense

7: Vegetation to 1 metre plus trees and shrubs-dense

The amount of disturbance was assessed using the following index;

0: No disturbance

1: Occassional, from farmers, anglers etc.

2: Footpath running alongside-occassionally used

3: Footpath more heavily used by local anglers, dog walkers etc.

4: Very heavily used footpath and river such as in country parks

5: Roads and houses nearby

6: River passing through urban areas

7: Heavy industry along banks

Water quality was determined by taking two water samples within each 5km stretch. These were sent to the National Rivers Authority Laboratories where a basic sanitary analysis was conducted which provided the following information;

pH

Biological Oxygen Demand (BOD) mg/l Oxygen

Ammoniacal Nitrogen mg/l Nitrogen

Nitrate mg/l Nitrogen

Nitrite mg/l Nitrogen

Particulate Solids mg/l

In order to provide an index of water quality the values for Ammoniacal Nitrogen, Nitrite and Nitrate were summed and an average calculated for each of the 5 km stretches.

The average width of each 5km stretch was determined by noting the width at 100m intervals and determining a mean for the whole stretch.

In summary, the variables recorded for each 5 km stretch were;

Number of Sites with signs of otters.

Number of Signs of otters (spraints etc).

Total number of mature Ash (*Fraxinus excelsior*).

Total number of mature Sycamore (*Acer pseudoplatanus*).

Total number of mature Oak (*Quercus* spp.)

Total number of mature Elm (*Ulmus* spp.)

Total number of mature Alder (*Alnus* spp.).

Total number of mature Willow (*Salix* spp.).

Total number of other mature trees.

Total number of saplings and shrubs.

Total length of woodland (metres) bordering a stretch.

Water quality index and pH.

Amount of disturbance index.

Amount of cover index.

Type of substrate index.

Average width of river (metres).

The data was subjected to mulivariate statistical analysis (multiple regression and principal components analysis on the SPSSX statistical programme Norusis (1988)).

The 5km stretches surveyed were as follows;

Wansbeck

1: Huntley Banks (NZ:025838) to Middleton Mill (NZ:059843)

2: Highlaws (NZ:076845) to Wansbeck/Hartburn confluence (NZ:108848)

3: Northside (NZ:115853) to Molesden Haugh (NZ:149851)

4: Mitford Church bridge (NZ:171857) to Morpeth library Bridge (NZ:201858)

5: East Riding weir (NZ:205864) to Bothal roadbridge (NZ:236862)

Hartburn

1: Near Hartington Hall (NZ:021878) to Green Riggs (NZ:060871)

2: Dragons Den (NZ:083870) to Hartburn/Wansbeck confluence (NZ:109851)

Font

1: Broadmeadow Wood (NZ:121894) to West Park Wood (NZ:148867)

Blyth

1. Capheaton Bridge (NZ:041788) to Blyth Bridge (West) (NZ:074799)
2. Blyth Bridge (West) (NZ:074799) to Trewick Bridge (NZ:112795)
3. Near Shilvington (NZ:147797) to Thornyford Bridge (NZ:156773)
4: Church Wood (NZ:199780) to Plessey Country Park (NZ:238794)
5: Plessey Country Park (NZ:238794) to Humford Mill (NZ:268807)

Pont

1. Ponteland Bridge (NZ:167729) to Kirkley Mill bridge (NZ:166767)

6.2. Results.

6.2.1. Numbers of sites and signs.

The numbers of sites and signs found during the 5km surveys are given in Table 6.1. The number of sites varied between 0 and 7 and the number of signs varied between 0 and 10. Figure 6.1. shows the frequency distribution of sites and signs which agrees with the findings of Macdonald and Mason (1983) who found that most stretches yielded between 0 and 10 sites and between 0 and 10 signs.

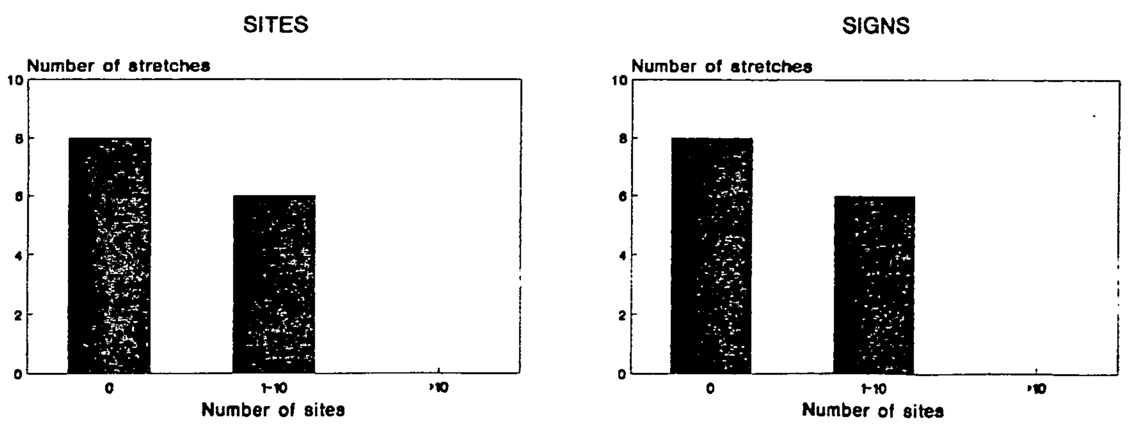
Table 6.2. lists the types of sites where signs of otters were found throughout the period of this study. The majority of signs were found on large rocks in the water and on rockpiles on the bank. A significant number were found under bridges.

No sites or signs were found on the Blyth system. The survey of the River Font also failed to yield signs of otters but this survey was conducted during a period of torrential rain which made finding signs more difficult. This stretch had produced positive signs of otters in previous surveys.

SURVEY	NUMBER OF SITES	NUMBER OF SIGNS
WANSBECK1	5	7
WANSBECK2	4	6
WANSBECK3	2	2
WANSBECK4	4	5
WANSBECK5	7	10
HARTBURN1	0	0
HARTBURN2	3	3
FONT1	0	0
ALL BLYTH	0	0
PONT1	0	0

Table 6.1. The number of sites and signs of otters found during the 5 km surveys of the Wansbeck and Blyth systems.

Figure 6.1. Frequency distributions of sites and signs of otters found during the 5 km surveys of the Wansbeck and Blyth systems.



SPRAINTING SITE	FREQUENCY
Roots of:	
Ash	9
Sycamore	10
Beech	3
Elm	2
Oak	3
Elm and Sycamore	1
Rocks in the water	38
Rockpiles	13
Alder and rocks	3
Bridges	15
Fallen logs	1
Scrapes in the bank	2

Table 6.2. Types of sites where spraints were deposited.

6.2.2. Numbers of potential holts.

Table 6.3. gives the numbers of potential holts and safe refuges for each of the 5km surveys. The mean number of holts (23±15) for the Wansbeck system was significantly higher than the mean number of holts (15±9) on the Blyth system ($t=1.22$, $p<0.05$).

Table 6.4. lists the types of potential holt and safe refuge sites on the two systems and shows that Sycamore form the largest proportion followed by Elm and then Beech, Ash, Oak and rockpiles making up the majority of the remainder.

6.2.3. Trees.

Table 6.5. gives the mean numbers of each tree species for the 5km surveys. A comparison of this data is plotted in Figure 6.2.

There were significantly higher numbers of alder ($t=3.6$, $p<0.001$) and significantly lower numbers of willow ($t=-18.22$, $p<0.01$) on the Wansbeck system than on the Blyth. The total number of mature trees was significantly higher on the Wansbeck system than on the Blyth ($t=1.83$, $p<0.05$). Therefore, it may be the total number of mature trees on a stretch of water which is important in determining the distribution of otters.

SURVEYS	NUMBER OF POTENTIAL HOLTS	
WANSBECK1	7	
WANSBECK2	10	
WANSBECK3	40	
WANSBECK4	18	
WANSBECK5	48	
HARTBURN1	15	
HARTBURN2	24	
FONT1	19	MEAN=23±14
BLYTH1	12	
BLYTH2	6	
BLYTH3	16	
BLYTH4	11	
BLYTH5	44	
PONT1	3	MEAN=15±9

Table 6.3. The number of potential holt sites for each of the 5km surveys.

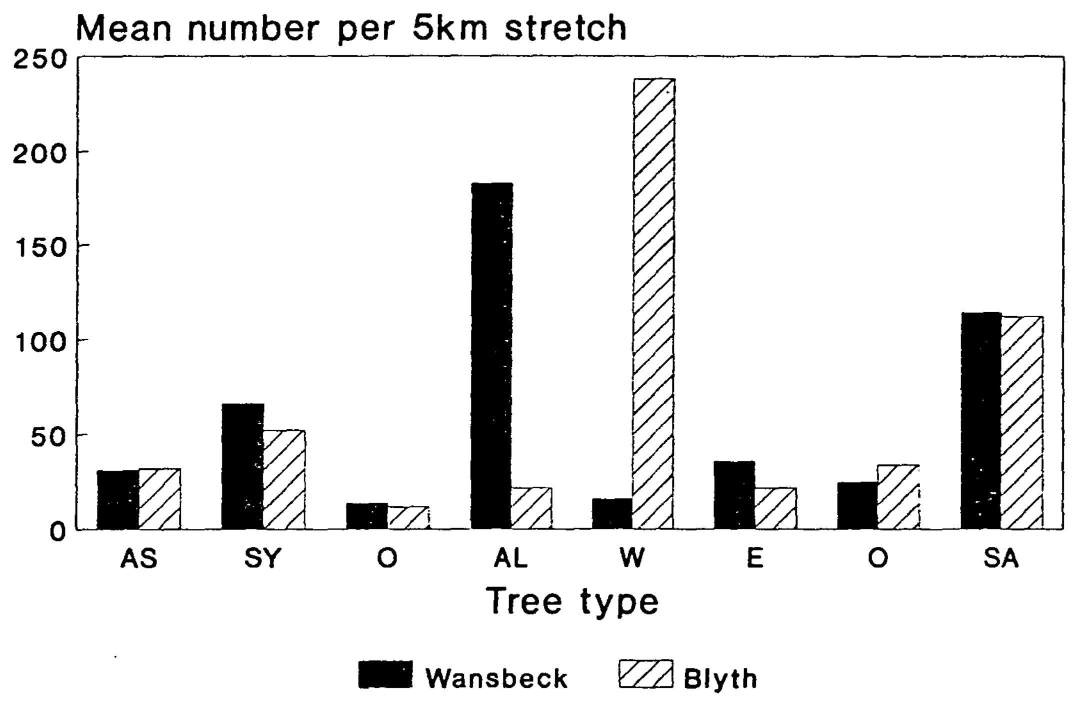
Tree root systems;	
Sycamore	91
Ash	45
Oak	29
Beech	26
Alder	21
Willow	9
Hazel	5
Lime	2
Chestnut	2
Rocks	23
Scrub	9
Stick piles	7
Holes in the Bank	2

Table 6.4. Types of potential holt sites recorded on the 5km stretches.

TREES	MEAN NUMBER PER 5KM STRETCH		
	WANSBECK	BLYTH	t-values
Ash	31±11	32±12	-0.05
Sycamore	66±42	52±56	0.57
Oak	14±11	12±13	0.33
Alder	184±107	22±24	3.60**
Willow	16±24	238±21	-18.22***
Elm	36±41	22±29	0.72
Other	25±23	34±20	-0.74
Saplings	114±76	112±69	0.07
Woodland (m)	2238±1304	2354±2303	-0.12
Total trees	350±161	198±143	1.83*
Total trees +saplings.	469±223	309±207	1.37

Table 6.5. Comparisons of the mean number of trees for 5km. surveys of the Wansbeck and Blyth systems with calculated t-test values and significance levels where $*=p<0.05$, $**=p<0.01$ $***=p<0.001$.

Figure 6.2. Comparison between the Wansbeck and Blyth of the mean number of tree species. AS = Ash, SY = Sycamore, O = Oak, AL = Alder, W = Willow, E = Elm, O = Other tree species, S = Saplings and shrubs.



6.2.4. Disturbance, cover and substrate.

Figure 6.3. shows the average disturbance levels for each 5km survey. The values were based on means of disturbance index values assessed at 100m intervals along the 5km stretch.

More of the stretches on the Wansbeck than the Blyth show no disturbance. However, when the overall mean for the Wansbeck was compared with that for the Blyth there was no significant difference between the two systems ($t=1.09$).

Figure 6.4. shows the average cover index values for the Wansbeck and Blyth systems. These were also calculated as means of the index values assessed at 100m intervals.

The number of stretches of the Wansbeck with higher cover index values was greater than that on the Blyth however the mean cover index for the Wansbeck as a whole was not significantly higher than the Blyth ($t=0.73$).

Figure 6.5. shows the average substrate index values for both systems which were again calculated from 100m interval index values. The index values were higher on most of the Wansbeck surveys than on the Blyth and the mean value for the Wansbeck system (5 ± 1.5) was significantly higher than that on the Blyth (3 ± 1) ($t=3.42$, $p<0.001$). This would indicate a substrate with more rocks and boulders on the Wansbeck than the on Blyth which

may be important when it is considered that a significant proportion of the potential holts were found in rockpiles and under large boulders.

Figure 6.6. shows the average width of each 5km stretch as determined from measurements made every 100m. The average of 9.2±5.0m for the Wansbeck was not significantly higher than that for the Wansbeck at 5.7±4.5m.

6.2.5. Water quality.

Figure 6.7. shows the the average water quality index values for the Wansbeck and Blyth systems. There was no difference between the pH values for the two systems (pH=8.2±0.2 for both systems).

The mean water quality index for the Wansbeck was 0.5±0.3 which was significantly lower than that for the Blyth at 0.9±0.4 ($t=-2.15$), $p<0.05$). This suggests that the Blyth is of lower general water quality.

Biological oxygen demand (BOD) values which are an indirect measure of the organic content of the water showed that the average value for the Wansbeck of 1.45±0.37 mg/ml Oxygen was significantly lower than that for the Blyth at 2.83±1.57 mg/ml Oxygen ($t=-2.43$, $p<0.01$) indicating that the Blyth has a higher organic content. The mean values for total nitrogen showed no difference between the Wansbeck (0.69±0.89 mg/ml Nitrogen) and the Blyth (0.82±1.4 mg/ml Nitrogen) ($t=-0.21$).

Historical data on water quality obtained from the National Rivers Authority (W. Walker, unpubl. data) were also examined for differences between the Wansbeck and Blyth systems from 1978 to 1988. The analysis must be treated with caution since the number of sampling sites on the Wansbeck system was low (2 to 3 sites). The data available included surveys of invertebrate species (Trent Biotic index and Biotic scores) and chemical analyses including pH, suspended solids, Ammoniacal Nitrogen, Nitrite, Nitrate, BOD and dissolved oxygen. The parameters that showed change over the period from 1978 to 1988 were the Biotic Index and Scores, Nitrate levels, BOD and Dissolved Oxygen. These changes are shown in Figure 6.8.

The Mean Biotic scores (Figure 6.8a.) show a significant difference between the Wansbeck system and the Blyth system ($t=20.50$, $p<0.001$). In addition the Blyth system shows a considerable drop in the Biotic score value between 1981 and 1982. The data for the Blyth excluding the 1981 to 1982 mean gave a mean biotic score of 240±17 with a t-test 95 percent confidence interval of 227 to 253. The mean of the 1981 to 1982 data at 201 fell well outside this confidence interval showing that the drop in values between 1981 and 1982 was significant. These results show that there has always been a higher biological score on the Wansbeck than on the Blyth and that there was a significant reduction in the score on the Blyth between 1981 and 1982 which was not reflected by the Wansbeck data.

Similarly, the Trent Biotic Index, which is derived from biotic scores, showed the same relationship with a significant difference between the Wansbeck and Blyth ($t=4.5$, $p<0.01$) and a significant drop in values for the Blyth between 1981 and 1982, the mean (6) for these years falling well below the t-test 95 percent confidence interval of 6.95 to 7.72 (Figure 6.8b.).

Nitrate and BOD values (figure 6.8c. and 6.8d. respectively) showed no differences between the Wansbeck and Blyth ($t=2.12$ and $t=1.75$ respectively) and although there were decreases in Nitrate levels between 1980 and 1981 and increases after that the changes were mirrored by the Wansbeck and could not therefore have been significant factors in the differences in otter populations on the Wansbeck and Blyth systems.

Dissolved Oxygen values (Figure 6.8e.) show a steady decline in values for the Blyth from 1981 to 1984 which was not mirrored by the Wansbeck. The trough in Dissolved Oxygen levels for the Blyth system occurs between 1983-4 but levels recover to concentrations similar to those of the Wansbeck. The difference between the Wansbeck and the Blyth is significant ($t=4.21$, $p<0.01$). The mean value of 79 percent on the Blyth system for the period between 1983 and 1985 falls below the t-test 95 percent confidence limits for the other years (85.8, 91.8). However, this decrease in dissolved oxygen does not coincide with the decrease in biotic scores and was not responsible for that decline in water quality on the Blyth but its effect may have contributed by slowing the improvement in water quality on the Blyth system. It is encouraging to note that there is a general improvement in water quality on the Blyth system, however none of the water quality data given here provides any conclusive evidence for the disappearance of the otter from the Blyth in the early '80s except that this corresponds with a general decline in the biological diversity of the River Blyth.

Figure 6.3. Average disturbance levels for 5km stretches of the Wansbeck and Blyth systems. W = Wansbeck, H = Hartburn, F = Font, B = Blyth, P =Pont.

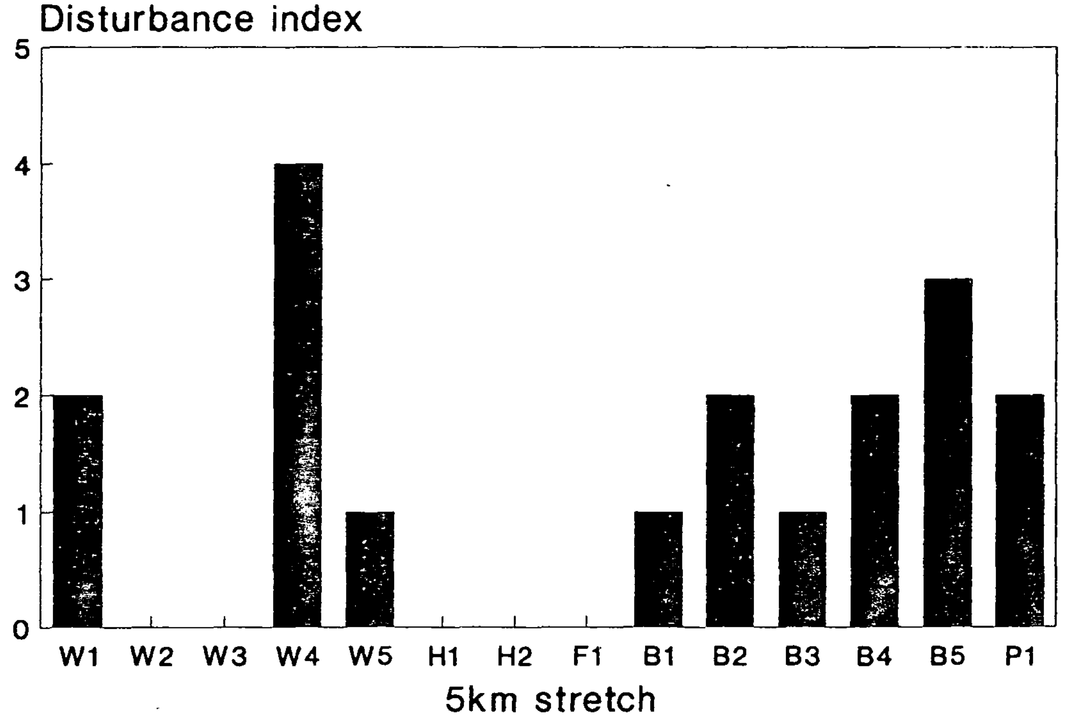


Figure 6.4. Average cover index values for 5km stretches of the Wansbeck and Blyth systems. W = Wansbeck, H = Hartburn, F = Font, B = Blyth, P = Pont.

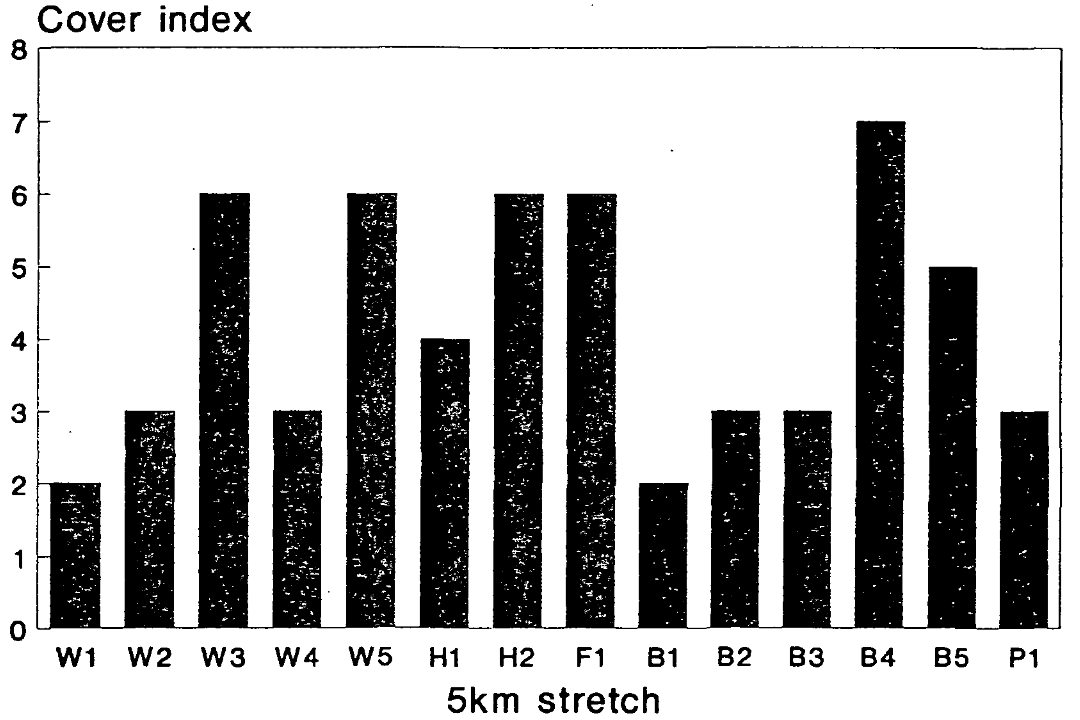


Figure 6.5. Average substrate index values for 5km stretches of the Wansbeck and Blyth systems. W = Wansbeck, H = Hartburn, F = Font, B = Blyth, P = Pont.

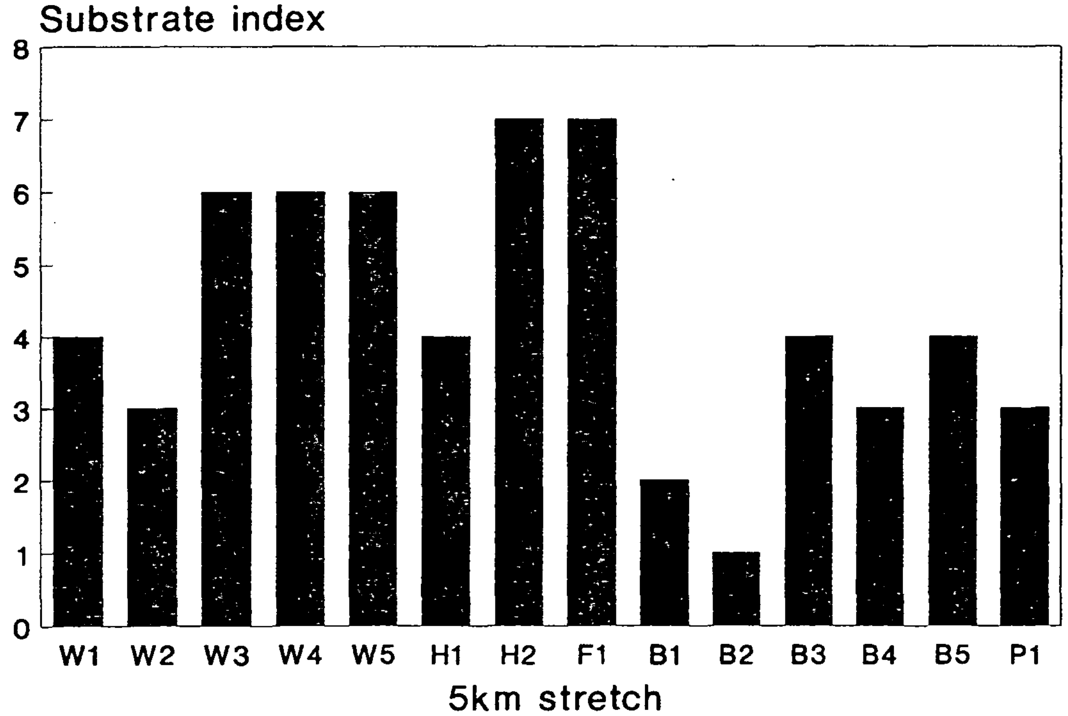


Figure 6.6. Average width (m) for 5km stretches of the Wansbeck and Blyth systems. W = Wansbeck, H = Hartburn, F = Font, B = Blyth, P = Pont.

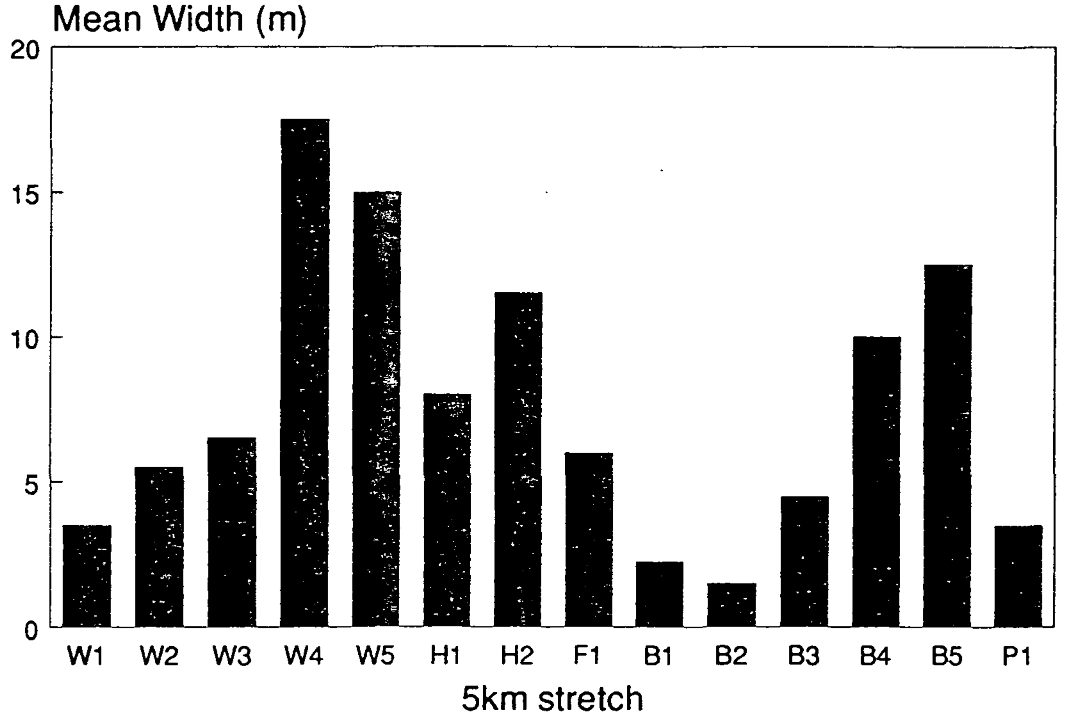


Figure 6.7. Average water quality index values and pH for 5km stretches of the Wansbeck and Blyth systems. W = Wansbeck, H = Hartburn, F = Font, B = Blyth, P = Pont.

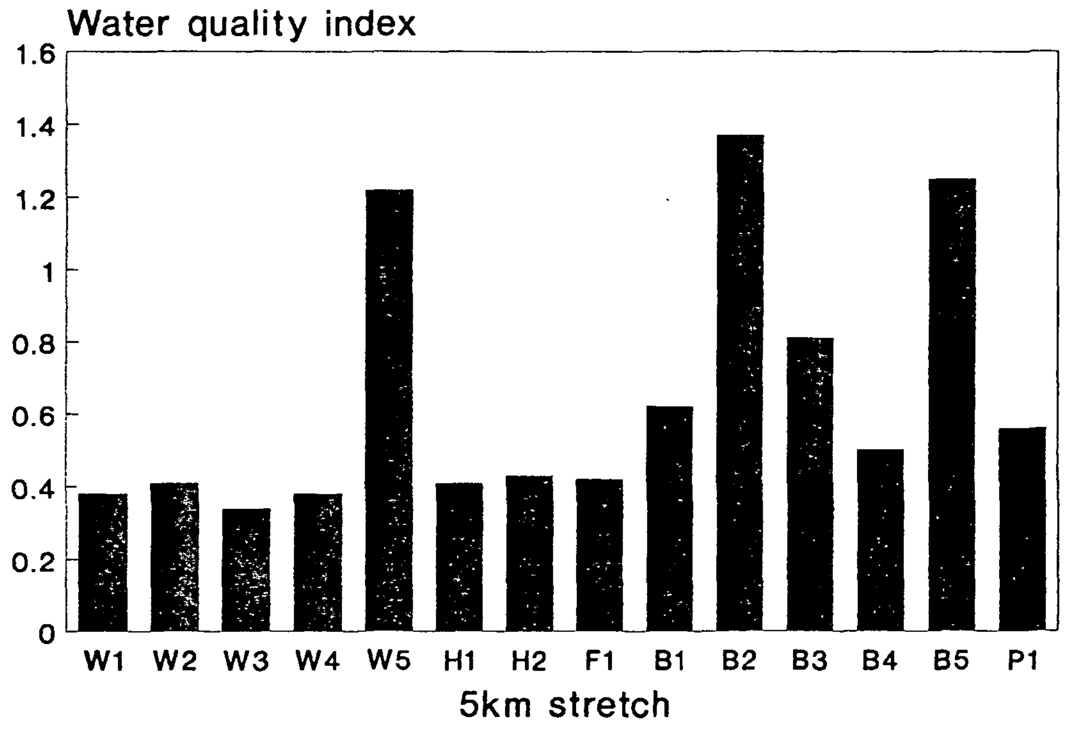


Figure 6.8a. Mean Biotic Index scores for the Wansbeck and Blyth systems for the period from 1977 to 1988.

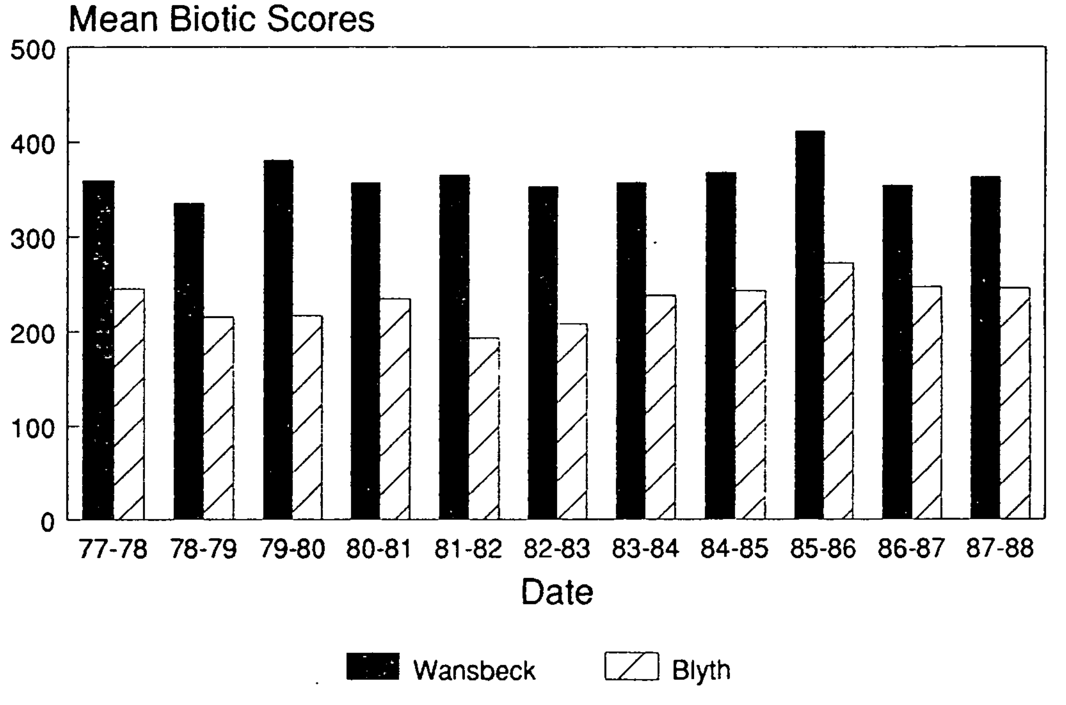


Figure 6.8b. Mean Trent Biotic Index values for the Wansbeck and Blyth systems for the period from 1977 to 1988.

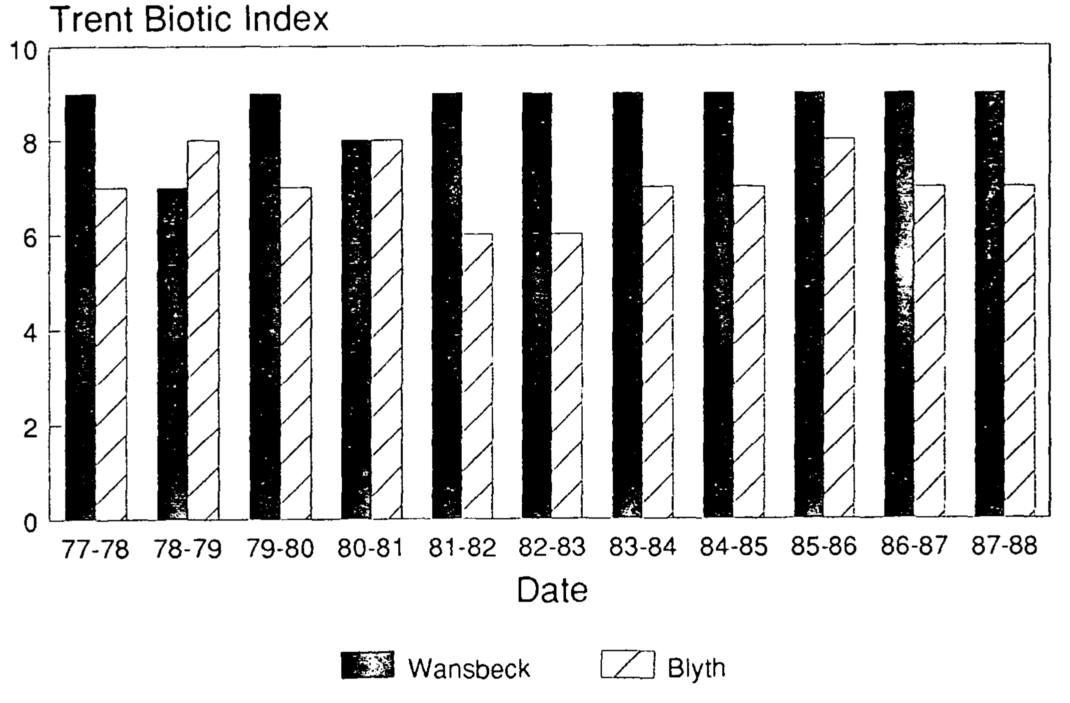


Figure 6.8c. Mean Nitrate levels for the Wansbeck and Blyth systems for the period from 1978 to 1988.

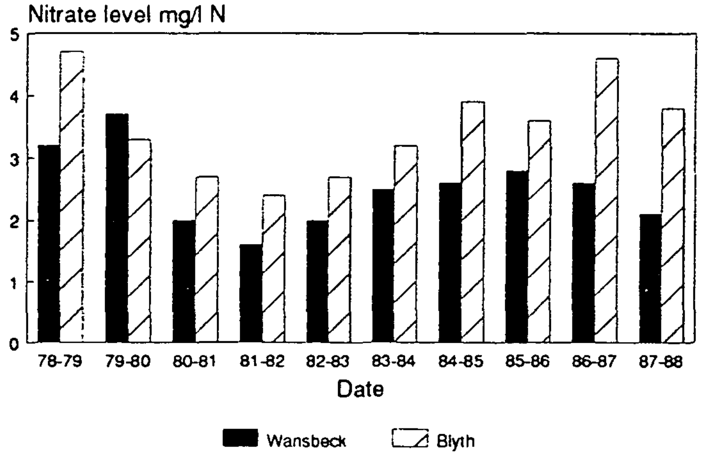


Figure 6.8d. Mean BOD values for the Wansbeck and Blyth systems for the period from 1978 to 1988.

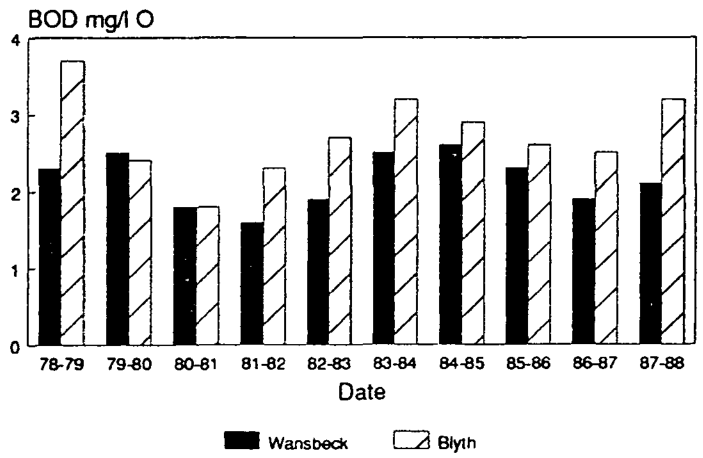
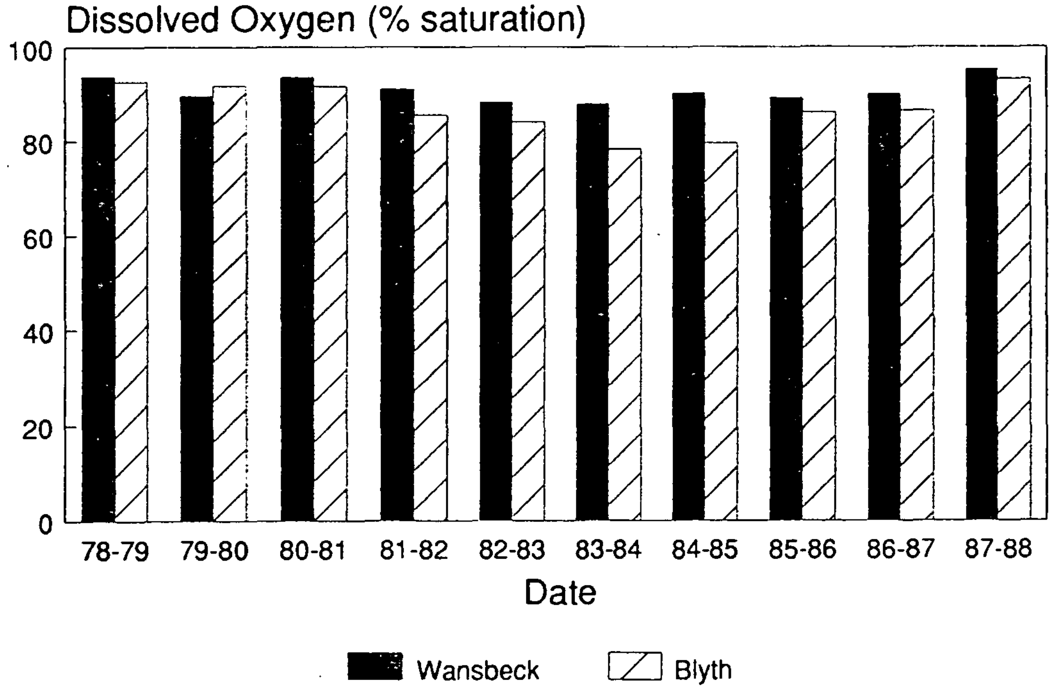


Figure 6.8e. Mean dissolved oxygen values for the Wansbeck and Blyth systems for the period from 1978 to 1988.



6.2.6. Determination of habitat requirements.

Table 6.6. shows that there were no significant correlations between sites of sprainting and habitat variables or between signs and habitat variables. The only significant relationship was between mink and both sites and signs of otter activity. This confirms that competition with mink was not a significant factor in determining the distribution of otters since they are both found in the same areas.

It was possible that since the number of surveys was low at fourteen the variation in data may be such that some correlations were masked. With more stretches surveyed other factors may have shown significant correlations. Holts, elm, substrate and river width gave correlation values close to the critical correlation value, r, at 0.46 and had more sites been included these variables may have shown some significance.

In order to draw comparisons between this study and the methods of Macdonald and Mason (1983) the data were subjected to multiple regression and principal components analysis. Principal components analysis reduces a correlation coefficient matrix to a smaller set of factors which summarise the correlations within the data. Table 6.7. gives the factors for sites and spraints from the 5km surveys. When sites were considered the fifth factor related to otters with the important variables being otter sites, potential holts and the number of oak trees and an inverse relationship with the number of other trees. When signs were considered the fifth factor again related to otters with the important variables being otter signs, holts, oak, mink and an inverse relationship with other trees.

Multiple regression analysis of the correlation matrix showed that when sites were considered as the dependent variable there were no significant regression coefficients. When signs were considered only mink produced a significant regression ($F=6.11, p<0.05$) and accounted for only 28 percent of the variation in the data.

It was considered that, since only fourteen 5km surveys had been carried out, the accuracy of the statistical analyses would have been reduced. In order to compensate for this it was decided to analyse the data on the basis of 1km surveys giving a total of seventy surveys. Table 6.8. gives the mean values for each of the habitat variables. It was found that the amount of disturbance was significantly lower on the Wansbeck system than on the Blyth system ($t=-3.126$, $p<0.001$), the amount of dense cover was greater ($t=2.983$, $p<0.001$), the substrate was significantly more rocky ($t=8.885$, $p<0.001$) and the river was significantly wider ($t=3.001$, $p<0.001$). In addition there were significantly more alder on the Wansbeck ($t=4.952$, $p<0.001$) and the total number of mature trees was significantly higher ($t=3.818$, $p<0.001$). The data were then subjected to correlation analysis, multiple regression and principal components analysis.

The correlation values given in Table 6.9. show that holts, elm, substrate, width and mink were significantly correlated with both sites and signs. Principal components analysis (Table 6.10.) showed that when sites were considered the second factor related to otters with the important variables being sites, ash and elm trees, mink and inverse relationships with the number of mature willow, the number of shrubs and saplings and the disturbance index (ie. a lack of disturbance was important). When signs were considered the second factor related to otters with the important variables being signs, ash and elm trees, cover and mink and inverse relationships with the number of mature willow, the number of saplings and shrubs, and the disturbance index (again meaning that lack of disturbance was important).

Multiple regression analysis with sites as the dependent variable showed other trees to be the only significant variable accounting for 34 percent of the variation. This value was considered to be anomalous but may reflect a higher proportion of other tree species compared to those trees which form potential holts such as oak, elm, ash and sycamore in areas with fewer signs of otters. Other trees was also the only significant variable when signs were considered as the dependent variable accounting for only 27 percent of the variation in data.

Since otters range over considerable distances it was decided to compare as much of the total catchment as possible. Since six 5km surveys were carried out on the Blyth system the sums of the variables for these could be compared with the sums of the variables from six 5km surveys of the Wansbeck system. This would produce a comparison of a total of 30km of waterway from each catchment. This analysis was conducted on the number of potential holts and the tree variables (Table 6.11.). It is not possible to analyse this data statistically with any degree of accuracy but it is possible that there are more potential holts and lying up sites on the Wansbeck than on the Blyth. In general there are greater numbers of most tree species apart from sycamore, willow and the other tree species category. This is confirmed by the total number of mature trees. There is also more woodland bordering the Wansbeck although it is only 550m more which in a 35km stretch is probably not significant.

VARIABLE	SITES	SIGNS
Sites	1.00***	0.99***
Signs	0.99***	1.00***
Holts	0.34	0.31
Ash	-0.03	-0.08
Sycamore	-0.00	-0.01
Oak	-0.13	-0.12
Alder	0.00	-0.03
Willow	0.03	0.03
Elm	0.39	0.40
Other	0.11	0.12
Saplings	-0.11	-0.13
Woodland(m)	0.02	-0.01
Total Trees	0.09	0.06
Total Trees + Saplings	0.03	0.00
Disturbance	-0.03	-0.02
Cover	0.03	-0.02
Substrate	0.35	0.27
Water Index	-0.06	0.07
pH	-0.07	-0.08
Width(m)	0.41	0.40
Mink	0.53*	0.58*

Table 6.6. Correlation coefficients, r, between otter sites, otter signs and habitat variables from 5km habitat surveys. ***=<0.001 *=<0.05 probabilities.

VARIABLE	SITES	SIGNS
Sites	0.55	-
Signs	-	0.54
Holts	0.36	0.33
Ash	0.16	0.12
Sycamore	0.03	0.02
Oak	0.44	0.44
Alder	0.04	0.01
Willow	-0.25	-0.23
Elm	-0.04	-0.03
Other	-0.35	-0.37
Saplings	0.02	0.04
Woodland(m)	0.05	0.02
Total Trees	-1.23	-0.09
Total Trees + Saplings	-0.09	-0.06
Disturbance	0.08	0.09
Cover	-0.08	-0.12
Substrate	0.12	0.16
Water Index	-0.04	-0.04
pH	-0.07	-0.07
Width(m)	0.12	0.16
Mink	-0.10	0.54

Table 6.7. Factor loadings relating to otters from principal components analysis of 5km habitat surveys.

VARIABLE	WANSBECK	BLYTH	t-value
Holts	4.6±4.7	3.2±4.9	1.211
Ash	6.3±4.6	7.1±7.2	-0.012
Sycamore	12.8±12.4	11.2±14.2	0.896
Oak	2.1±3.4	2.5±5.7	-0.366
Alder	36.7±35.0	4.3±8.6	4.952***
Willow	3.1±8.4	5.0±6.3	-1.038
Elm	7.3±9.6	4.5±6.7	1.366
Other	5.0±5.7	7.7±8.9	-1.430
Saplings	24.2±26.1	24.5±27.0	-0.050
Woodland(m)	523±375	392±464	1.306
Total Trees	73.7±45.2	41.9±41.2	3.818***
Total Trees + Saplings	97.8±61.4	66.0±64.6	2.097*
Disturbance	0.8±1.3	1.7±1.2	-3.126***
Cover	4.5±1.9	3.1±2.0	2.983***
Substrate	5.3±1.9	2.9±1.6	8.885***
Width(m)	8.7±4.5	5.5±4.3	3.001**

Table 6.8. Mean values for habitat variables based on 1km habitat surveys. * = $p<0.05$, ** = $p<0.01$, *** = $p<0.001$.

VARIABLE	SITES	SIGNS
Sites	1.00***	0.95***
Signs	0.95***	1.00***
Holts	0.28**	0.24*
Ash	0.04	-0.02
Sycamore	0.08	0.05
Oak	0.01	0.02
Alder	0.11	0.10
Willow	-0.09	-0.08
Elm	0.36***	0.31**
Other	0.02	-0.00
Saplings	-0.10	-0.11
Woodland(m)	0.10	0.05
Total Trees	-0.16	-0.16
Total Trees + Saplings	0.13	0.11
Disturbance	0.25*	0.17
Cover	0.21*	0.20*
Substrate	0.18	0.13
Width(m)	0.09	0.05
Mink	0.29**	0.24*

Table 6.9. Correlation coefficients, r, between otter sites, otter signs and habitat variables for 1km habitat surveys. *=<0.05, **=<0.01, ***=<0.001 probabilities.

VARIABLE	SITES	SIGNS
Sites	0.58	-
Signs	-	0.54
Holts	0.18	0.18
Ash	0.35	0.37
Sycamore	0.07	-0.07
Oak	0.17	-0.15
Alder	-0.17	0.20
Willow	-0.61	-0.62
Elm	0.22	0.21
Other	-0.15	-0.15
Saplings	-0.41	-0.40
Woodland(m)	0.03	0.04
Total Trees	-0.13	0.01
Total Trees + Saplings	-0.18	-0.16
Disturbance	-0.74	-0.76
Cover	0.22	0.24
Substrate	0.18	0.18
Width(m)	-0.20	-0.18
Mink	0.44	0.41

Table 6.10. Factor loadings relating to otters from principal components analysis of 1km habitat surveys.

VARIABLE	WANSBECK	BLYTH
Holts	143	92
Ash	183	190
Sycamore	393	309
Oak	86	70
Alder	939	130
Willow	114	143
Elm	253	132
Other	155	203
Saplings	493	669
Woodland(m)	12300	11750
Total Trees	1940	1185
Total Trees + Saplings	2950	1854

Table 6.11. Comparison of the sums of a number of habitat variables for 30km stretches of the Wansbeck and Blyth catchments.

7. DISCUSSION

7.1. Distribution survey.

The results of this study show that signs of otters were present on 58km out of 73km of the Wansbeck system with 32km of this being on the River Wansbeck itself, 16km on the River Font and 10km on the River Hartburn. Of the sites that were positive during the 1977-1979 and 1984-1986 National Surveys nearly all were positive during the present survey. Crossford Bridge on the River Font was negative during this study but it is likely that this was due to otters not sprainting at this site rather than being absent since signs were found at sites either side of this. Walkmill Ford on the River Wansbeck was also negative for probably the same reasons.

No signs of otters were found on the Blyth system and it was concluded that otters were no longer present on the Blyth system. These results confirmed the observations of other workers in the area who have suggested that there was a good population of otters on the Wansbeck system but that the Blyth no longer held a viable population (H. Watson, pers. comm., R. Strachan, pers. comm.).

The National Survey method of searching for signs of otters was considered to be the most accurate for this survey and evidence from other workers confirms this.

Working in northest Greece (Mason and Macdonald, 1985) and in Spain and Wales (Mason and Macdonald, 1987) it was found that 73 percent of 93 1000m surveys provided sites of otters within the first 600m, with the extra 400m providing a further 6 percent of positive sites. Of these sites, 79 percent were confirmed within the first 200m of survey.

Lenton *et al.* (1980) carried out an evaluation of the National Survey technique to determine how accurate it was at finding positive sites. They surveyed 6km stretches on a number of river systems and then divided them into 600m stretches. It was found that on the River Wansbeck in Northumberland ten 600m stretches would have contained no positive sites and 99 would have contained positive sites using the National Survey methods if otters had been present in a 6km stretch. Therefore, 91 percent of the 600m stretches would have been positive. The furthest distance between spraints was 1100m and this distance would have to be surveyed to find a positive site. However, since the National Surveys surveyed at 5km intervals, in 6km 1200m of river would have been searched, therefore spraint would have been found if it were there. Similar results were obtained for a Shropshire river but it was found that on the River Wensum in Norfolk with a low spraint site frequency the chances of finding signs were lower and could have led to sites being recorded as negative when otters were present. This inaccuracy at low densities could have been applied to the present survey. However, sites were chosen at no more than 3km intervals thus increasing the likelihood of finding spraint sites if they were there. It is considered therefore that the method of survey used in this study gave an accurate reflection of the distribution of otters on the Wansbeck and Blyth systems. The metod used for the National Surveys is accurate enough for providing such general indications of the status of otters on a national basis but more intensive methods such as that used in the present study are needed when assessing more localised distributions.

7.2. Diet of the otter.

Dietary analysis showed that the major prey in the diet of the otter on the Wansbeck system was bullhead followed by eel and Salmonidae. Fish formed between 82 and 93 percent of the diet depending on the method of presentation used. Crayfish formed the second most important important component with mammals and amphibians rarely being taken. It was found that there were no significant differences between the relative proportions of each prey in the diet of the otters.

The longest fish taken were eels, mean size 7.8±2.7cm with the smallest prey being stickleback at 3.8±0.6cm. It was found that all species were of a smaller size than previous studies on the Wansbeck (Pautard, 1980). When Spring and Summer data were compared it was found that more eel of all sizes but particularly the smaller size classes were taken in Summer.

These results confirm the findings of other workers that fish form the most important component of the otters diet with amphibians, invertebrates and mammals being of only secondary importance. The importance of bullhead in the diet of otters on the River Wansbeck was also found by Pautard (1980). This is unusual when compared with other studies in which salmonids and eels usually form the largest component of the diet. Wise found that salmonids formed the most important component of the otters' diet on rivers in Devon (Wise 1978, Wise *et al.*, 1981). Salmonids were twice as important as eels in terms of dietary intake. It was found, however, that bullhead formed a significant component of the diet which was more important in winter than summer. This contrasts with the high importance of bullhead in the present study which was carried out in spring and summer. Wise (1978) also found that amphibia formed a small but significant component of the diet. There is some variation in the importance of the major prey types in a number of studies. Hewson (1973) in a study in Scotland, found that the diet of otters contained a significant amount of mammal and bird prey. However in a study in Norfolk stickleback formed the majority of spraints by bulk (55%), followed by eel (25%) (Weir and Bannister, 1973). Jenkins, Walker and McCowan (1979) working in Deeside, northeast Scotland found that eels were the major prey item followed by perch when relative frequency was used as an estimation of diet but that when bulk analysis was used, pike and salmonids were also important. Jenkins and Harper (1980) working in the same area, found that eel and salmonids were the main prey of otters in rivers but that a wider range of species were taken in eutrophic rivers than in oligotrophic rivers.

The present study showed that there was only a significant seasonal difference in the amount of eel taken when Spring and Summer samples were compared, with eel being taken in higher numbers in Summer. However, the number of spraints was low and the distinction between Spring and Summer was not good since Spring samples were only taken in May. Pautard (1980) in a tentative analysis of seasonal variation showed that there were less crayfish, Cyprinidae, trout and perch in summer. These conclusions were based on a small summer sample and must therefore be treated with caution. Wise (1978) found that there was no seasonal variation in the importance of fish as a component of the otters' diet. However, individual species did show seasonal variation. Weir and Bannister (1973) found a decrease in the importance of cyprinids in summer and early autumn, with crayfish being more important. Jenkins *et al.* (1979) showed that eel predominates in the diet of otters except around mid-winter and after mid-summer. Perch were found to be abundant in February and March whilst the incidence of birds in the diet was highest in winter and in July. Fairley (1972) failed to show any seasonal variation in the diet of otters in Ireland. It is, however accepted that, in all habitats fish form the major component of the otters' diet and they are recognised as being specialist piscivores (Erlinge, 1972a; Jenkins and Harper, 1980; Jenkins *et al.*, 1979; Mason and Macdonald, 1986; Wise, 1978; Wise *et al.*, 1981).

Many authors of studies of the feeding ecology of a number of carnivores have correlated diet with prey availability.

This term encompasses a number of factors including abundance, vulnerability, palatability, the relative availability of alternative sources of prey and specialisations of the predator (Wise, 1978). Ryder (1955) stated that the otter captures fish in proportion to their abundance but it seems likely that the mobility of individual prey species will be of importance. Wise (1978) found that the dietary intake of salmonids and eels was much lower than the relative proportions of salmonids to eels present in the river, as estimated by electrofishing. It was suggested therefore, that eels were being selected for by otters and that this was due to their much slower swimming speed than salmonids. Bainbridge (1958) studied the relative swimming speeds of a number of fish species and found that trout were faster than any of the other species tested and in addition they had a faster acceleration which is important when evading a predator. Erlinge (1968b) in studies of captive otters in artificial clear water conditions found that fast swimming fish were subjected to the same number of catching attempts as slow fish but were caught in relation to their ability to escape. Trout are always caught late in season and eels are a slower and more vulnerable prey than salmonids.

Wise (1978) stated that eels were taken maximally in summer, whereas salmonids were taken more in winter. It was speculated that this pattern of predation was not due to changes in the relative populations but to behavioural availability. The water temperature is higher in summer which will improve reactions and increase swimming speeds benefitting the trout more than the eel. Eels are also more active in summer whereas in winter they stop feeding and remain hidden under stones and in the river mud. It has been found that the hunting behavior of both otter and mink is elicited by movement and therefore active eel were more likely to be preyed upon (Erlinge, 1968b; Poole and Dunstone, 1976). The lower numbers of eel available in winter has been confirmed by electrofishing (Wise, 1978).

Wise (1978) found no evidence that otters selected fish within a particular size range and that apart from the lack of predation on salmonid fry , they took fish of given sizes in relation to their relative abundances. Sizes of prey taken vary for a number of studies. Greer (1955) found that trout of 35cm were taken, Webb (1975) found that eel of between 20cm and 30cm were taken and Jenkins *et al.* found that eel of between 22cm and 42cm were taken. Erlinge (1968b) found that in clear water, captive otters take fish between 15cm and 17cm in length and that fish under 10cm were rarely taken. Wise (1978) found that small fish under 7cm were rarely preyed upon. The mean sizes of fish taken in the present study were considerably lower than those in previous studies of the Wansbeck (Pautard, 1980). It is suggested that for such small prey to be taken they must be very abundant and require very little energy expenditure in catching. No data was available on the abundance of prey in the present study but it was noted that there were a high number of small bullhead and trout in pools along some stretches of the Wansbeck and Hartburn particularly near Meldon Park and Hartburn (pers. obs.). It should also be noted that the total weight of prey items ingested showed good agreement with the results of Pautard indicating that, although small, a considerable number of fish were being consumed.

The methods of presentation used in this study are subject to a number of possible errors. Frequency of occurrence over-emphasises trace items and under-emphasises items which form the majority of some spraints (Wise, 1978; Pautard, 1980). Relative estimated bulk takes into account both the prey species and the volume of the remains in the spraint and is therefore more accurate than frequency of occurrence. Bulk analysis compares the weight of remains to indicate proportions of prey in the diet. Both of the bulk methods require a subjective assessment of the volume of remains and this is a potential source of error. The use of bulk estimate also allows the use of conversion factors which indicate the weight of prey originally ingested and takes into account the variation in prey volume. The use of all the available presentation methods in this study meant that confident conclusions about the diet of the otter on the Wansbeck system could be made which take all the bias of the various methods into account.

7.3. Habitat requirements.

The habitat requirements of otters on the Blyth and Wansbeck were determined using a derivation of the 5km survey methods of Macdonald and Mason (1983). More variables were included in the present study and a more comprehensive estimate of disturbance was used.

It was found that the number of sites with signs of otters on a 5km stretch of waterway varied from 0 to 7 and the number of signs varied from 0 to 10. This was consistent with the findings of Macdonald and Mason. The majority of signs were spraints and during all the distribution surveys it was found that the majority of spraints were deposited on large prominent rocks in the river. Bridges and rockpiles were also important. The relatively low numbers of spraints found in tree roots could have been due to biased sampling methods -spraints on rocks were more obvious. However, the entire stretches of riverbank were searched and potential holt sites, including the roots of mature trees, were searched rigorously and it is unlikely that spraints would have been missed.

The numbers of potential holts and lying-up sites were very high on the Wansbeck system with densities varying from 7-48 holts/lying-up sites per 5km stretch. The range on the Blyth system was similar (3-44 Holts/lying-up sites per 5km stretch). However, when the mean number of Holts/lying-up sites was compared it was found that there were significantly higher numbers of holts/lying-up sites per 5km stretch on the Wansbeck system. The majority of potential holts (the term holt will be used for both holts and lying-up sites) were found in the root systems of sycamore and ash but there were significant numbers found in the roots of oak, beech and alder and in crevices in rocks and in rockpiles. The numbers of potential holts were not in proportion to the mean number of trees per 5km stretch. The numbers of alder on the Wansbeck system were, on average, considerably higher than on the Blyth system yet the number of potential holts in the roots of alder did not form such a large proportion of the total number of potential holts. With so many alder along the the banks of the Wansbeck system it was likely that a few trees would have made potential holts or more probably lying-up sites. It should be emphasised at this point that the present study recorded lying-up sites as well as holts as it was felt that this would give a better reflection of the otters' need for secure resting sites. This may be why there are more potential holts per 5km stretch than in Macdonald and Mason's surveys. It is unclear whether they considered only holts or both holts and lying-up sites.

Alder and willow were the only two species of mature trees which showed significant differences between the Wansbeck and Blyth. The mean total number of trees per 5km stretch was significantly hgher for the Wansbeck than for the Blyth.

On the basis of the 5km surveys there were no differences between the Wansbeck and Blyth systems in the level of disturbance. However the Wansbeck value may have been biased by the high disturbance value for stretch 4 which passed through the urban areas of Morpeth whereas none of the stretches of Blyth surveyed passed through major centres of population. Without this high outlier the mean disturbance level for the Wansbeck was

0.4±0.8 compared to the Blyth at 1.8±0.8, this was a significant difference ($t=-3.012$, $p<0.01$) and it is suggetsted that the average level of disturbance was higher on the Blyth. There was no significant difference between the Wansbeck and Blyth in the amount of cover or in substrate type and river width. However, when all the above habitat variables were compared on the basis of 1km surveys it was found that there were significant differences between the Wansbeck and Blyth in the amounts of disturbance and cover, and in the substrate type and river width. The Wansbeck was on average wider and more rocky than the Blyth with more dense cover and less disturbance. This is very significant since otters may need more cover when disturbance levels are high. Some of the stretches of the Blyth which showed good potential as habitat for otters were subject to heavy disturbance. The Plessey Woods Country Park area used to be a stronghold of the otters on the Blyth with holts being found near Hartford Bridge (Pautard, 1980). However, this stretch is now heavily used for recreational purposes and it is likely that this increased disturbance, in addition to higher pollution levels, have forced otters to abandon this area.

The Wansbeck system is, on average, more rocky and wider than the Blyth system and this will benefit the ecology of the river by creating pools for fish, oxygenating the water where riffles and waterfalls are created and providing good habitat for macro-invertebrates such as crayfish. In addition the rocky banks and cliffs provide potential holt and lying-up sites for the otters.

The water quality of the Blyth was generally lower than that of the Wansbeck and has been since 1977 and probably earlier. It is suggested that a river with lower water quality is more susceptible to pollution incidents than a river of high water quality. It is possible that a past pollution incident may have reduced water quality levels sufficiently enough to make the Blyth unsuitable for otters which, in combination with higher disturbance levels and low cover and numbers of mature trees, led the otters to abandon the Blyth. It is of note that between 1981 and 1983 the invertebrate diversity of the Blyth was degraded. This period is at about the same time that otters were last believed to be resident on the Blyth (R. Strachan, pers. comm.)

It was concluded that the use of 5km surveys was not statistically viable when studying the differences between two small catchments since the sample size was too small. However, when the stretches were divided into 1km stretches meaningful statistical relationships were obtained and some differences between the Blyth and Wansbeck systems were deduced.

7.4. Spraint density as an indicator of habitat use.

There is some doubt expressed as to the validity of using spraint density as an indicator of the distribution, habitat utilisation and population status of otters. Kruuk *et al.* (1986) argued that there was no correlation between the intensity of sprainting and the frequency of use of an area by otters. In a study of diurnal otters in a marine habitat it was found that spraints were associated with otter holts and various habitat features such as freshwater pools but not with the intensity of use of an area. The study was carried out on the Shetland Islands between May and September 1983. The coastline was divided into 21 blocks over a total length of 7km. Each block was observed for a minimum of 5 minutes during the day from hides or vantage points. A measure was made of otter activity and otter visits to each block. In addition three intensive spraint searches were carried out in May, July and September. All the known otter holts were also mapped. It was found that there was no correlation between activity and sprainting. A correlation was found between landing and sprainting but this was to be expected since otters must land to spraint. It was also found that spraints were associated with otter holts. It was argued that since sprainting has a probable function as a means of communication and not simply as a bowel elimination the distribution of spraints did not just depend on activity. However, it was accepted that as otters are elusive, spraint would continue to be used as an indicator of presence. It was suggested that comparisons of otter populations could be made as long as a number of factors were recognised. These were that only large stretches of river with "similar vegetation and physiography" which covered a significant amount of the home range of the otters should be compared. Seasonal variations in sprainting activity should also be considered. It was also stated that some otters do not spraint in prominent places and often only defecate in the water and that this might be more common at lower population densities.

In response to these doubts, Jefferies (1986) and Mason and Macdonald (1987) vigorously defend the use of spraints as a method of survey. In surveys of the Mediterranean basin, Mason and Macdonald produced an index of the number of spraints per 200m surveys. They suggested that if spraint numbers were related to population status then few spraints per 200m would be found in study areas with few positive sites overall, whilst more spraints would be found in study areas with more positive sites. Based on seven extensive and three intensive surveys it was found that there was a positive correlation between the mean number of spraints and percentage of positive sites ($r=0.84$, $p<0.01$) (Mason and Macdonald, 1987). From this analysis it was stated that "spraint densities could be used *with care* to *broadly* define the status of otter populations."

This view was accepted for the present study since the initial stage of the work was to determine the status of the otter on the Wansbeck and Blyth with no further assumptions or conclusions being made. However, spraint density data was also used to determine features of habitat important to otters. This implies a greater use of spraint density data than simply to broadly define the status of otter populations.

There is considerable contraversy as to relating spraint density to habitat type. Kruuk *et al.* (1986) cocluded from their studies in Shetland that spraint numbers could not be used to assess habitat utilisation. Mason and Macdonald (1987) dispute this and cite a number of examples which they suggest provide evidence for a relationship between spraint numbers and habitat utilisation. Macdonald *et al.* (1978) studied a total of 130km of the River Teme in the West Midlands and 213km of its tributaries. It was concluded that more signs of otters were found on stretches of river containing more potential holt sites, more mature ash and sycamore and more woodland abutting the riverbanks. However, as Mason and Macdonald themselves stressed, the habitat was not good with apparently only 1 holt per 1km of river and the numbers of otters were very low. Stating that there were differences between stretches of rivers at such low densities of otters requires some statistical proof which was not given. Their study did show, however, that 18 of the 22 sites which were potentially suitable holts were found in the roots of ash and sycamore trees which was out of proportion to the number of the two species on the river, ash and sycamore accounting for only 12 percent of the tree community on the stretches where otters were resident. The results of work by Coghill on observations throughout Wales showed that 57 out of 66 used holts were in the roots of ash and sycamore. It seems likely therefore, that otters will use the root systems of sycamore and ash as holts on the basis of this data. However, this study of the River Teme did not provide any statistical evidence that the numbers of spraints were ccorrelated with the use of sycamore and ash trees. The study only showed that there were more potential holt sites in the roots of ash and sycamore on stretches of river where otters were present than on stretches where otters were absent.

These are two extremes of the relationship and what is actually needed is data on sites with many signs of otter presence graduating down to sites with no otter signs.

Statistical evidence was provided in a study of 50 5km stretches of rivers in Wales and the West Midlands (Macdonald and Mason, 1983). The stretches of river were searched for the presence of otters and in addition data were collected on fifteen parameters of habitat. These data were then subjected to multivariate analysis. It was found that the distribution of otter sites and signs was correlated with the presence of potential holts and with mature ash and sycamore trees. The measured variables did not however account for all the variation in otter sites and signs and it was suggested that sprainting activity was also affected by age, sex, social status and seasonality. There were no correlations found between the level of disturbance and otter presence although their measure of disturbance was not comprehensive. It was stated that the results, particularly the importance of ash and sycamore could not be applied to all habitat types but that the importance of of holts and secure lying-up sites was significant. Many of their surveys were on rivers with low tree densities and low otter densities. The present study showed that the Wansbeck and Blyth systems had higher numbers of mature trees than on many of the Welsh and West Midlands rivers. It may be that the importance of ash and sycamore trees is diminished when other species of mature trees are present. When 1km stretches were considered in the present study it was found that elm and substrate type produced significant correlation coefficients which may reflect a local importance of these as holt site. Working in northeast Scotland, Jenkins and Burrows (1980) also considered that sprainting activity was more intense when there was more bankside cover, with backing woodland being significant to a lesser extent. The presence of mature trees may also be important for other reasons which benefit the ecology of the river. They stabilise flows and prevent excessive water temperatures and they help to reduce macrophyte growth. They are also important for the prey of otters since they create pools for fish and provide food in the form of invertebrates for fish and macroinvertebrates such as crayfish.

More direct evidence of a relationship between spraint density, otter activity and habitat utilisation comes from radio-tracking studies. In their work with radio-tagged otters in Scotland, Green *et al.* (1984) found that 65Zn labelled spraints were found around centres of activity as shown by radio-tracking. Jefferies *et al.* (1986) radio-tracked the first group of otters released as part of a re-stocking programme in East Anglia and found that they spent 53 percent of their time in woodland areas. Melquist and Hornocker (1983) found that food was the most important factor determining the distribution of the river otter, *L. canadensis* but that radio-tagged otters would avoid areas of good prey availability if cover and the number of resting sites was low.

The present study did not solve the contraversy surrounding the use of spraint density as an indicator of habitat utilisation. Considerable statistical problems were encountered when attempting to determine any relationships between otter presence and habitat variables. When these relationships were analysed on the basis of the 5km surveys few meaningful conclusions could be drawn. Although principal components analysis showed the number of potential holts to be important in the stretches with positive signs of otters, the factor loadings were very low and not considered to be significant. Multiple regression showed that no variables gave significant regression coefficients and accounted for little or no variation in the otter sites and signs. On the basis of 1km stretches giving a larger data set, significant correlations were found between both otter sites and signs and holts, elm, substrate and width confirming earlier conclusions that the number of potential holts and river type were important. Principal components analysis showed that the important variables in a 1km stretch were the presence of mature ash and elm, sites and signs of otters, dense cover and lower numbers of saplings and shrubs, and low disturbance levels. However, multiple regression again gave little meaningful information.

On the basis of this study it is suggested that the relationship between spraint density and habitat utilisation is tentative. Th only strong relationship is probably that between spraint density and the number of potential holts. The study has also shown that there are considerable variations in the habitat of river catchments with one 5km stretch being very different from another. It is suggested that whole catchments rather than short stretches should be compared and that this would still only show generalised differences between catchments.

7.5. Concluding remarks.

The aims of this study were partially realised in that the status of otters on the Wansbeck and Blyth was determined. Also, some possible reasons for the absence of otters on the Blyth were given and it was shown that the Blyth had less cover and woody vegetation than the Wansbeck and that disturbance levels were higher. The study did not however, provide firm and conclusive reasons for the absence of otters on the Blyth. However the possible reasons given were valid and can now be the subject of more intensive research. It is here that the multivariate approach of determining habitat requirements is of value since it does not initially isolate variables from the complex interactions taking place and provides an assessment of the relative importance of each variable. The third aim of this study, to evaluate the relationship between spraint density and habitat utilisation was also achieved in that it was found that the relationship was still circumstantial and based on tentative statistical analyses.

The conservation of any endangered species requires good knowledge of its ecology and habitat requirements. The habitat requirements of the otter are still not fully known yet otter populations are in need of urgent conservation. It is necessary therefore to base otter conservation policy on tentative and subjective evidence. The arguments about using spraint density as indicators of population status and habitat usage are valid since the evidence for a positive relationship is still circumstantial. However, there is enough of this evidence to suggest that some of the conclusions drawn from these studies are correct. To wait for conclusive proof would be folly since it may then be too late to implement the relevant conservation measures. The weight of evidence suggests that the provision of holts, dense cover and stretches of mature woodland abutting the bank, lack of disturbance, good water quality and the abundance of fish are the important factors which determine the survival of otters. Improvements in all of these factors on a river catchment will improve the habitat for resident otters and may lead to the return of otters to rivers where they were once resident. There is potential for the River Blyth to once again hold a resident population of otters since the populations of otters on the rest of Northumberland's rivers are good and with the right conditions these could migrate back onto the River Blyth.

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APPENDIX III: Data for the comparison between spring and summer diets using the four methods of data presentation. SPR = Spring, SUM = Summer.

PREY TYPE	RELATIVE FREQUENCY (%)		PROPORTION OF SPRAINT (%)		RELATIVE ESTIMATED BULK (%)		BULK ESTIMATE (%)	
	SPR	SUM	SPR	SUM	SPR	SUM	SPR	SUM
Loach	8.9	10.4	30.1	47.5	6.8	6.1	5.8	5.8
Perch	13.8	15.1	47.0	67.5	5.9	11.6	7.0	14.0
Stickle-back.	4.0	11.2	13.5	25.0	3.1	4.6	12.2	4.0
Salmonid	16.7	14.9	57.0	67.5	11.9	11.7	14.1	20.1
Cyprinid	5.8	7.8	20.0	35.0	1.2	8.3	2.4	8.4
Eel	6.7	12.8	57.0	75.0	28.0	11.0	25.6	10.3
Bullhead	17.7	15.1	60.1	67.5	22.9	21.9	22.0	29.3
Mamm./Amph.	0.5	3.9	2.0	17.5	1.8	8.2	1.0	13.3
Crayfish	7.9	2.8	26.0	20.0	14.7	5.5	11.0	4.6
Unident.	8.2	11.2	28.0	50.0	3.3	5.7	9.0	6.9

APPENDIX IV: Length-frequency data for fish prey in the diet of otters on the Wansbeck.

SIZE CLASS	FREQUENCY					
	PERCH	LOACH	STICKLE-BACK	SALMONID	CYPRINID	EEL
1	2	0	7	0	0	0
2	267	178	96	78	88	60
3	53	102	1	202	26	266
4	11	7	0	57	1	214
5	1	1	0	18	0	75
6	9	0	0	4	0	19
7	1	0	0	3	0	18
8	0	0	0	0	0	1
9	0	0	0	0	0	1

APPENDIX II: The relative proportions of prey types in the diet of otters on the Wansbeck system as expressed by four methods of estimation

PREY TYPE	RELATIVE FREQUENCY (%)	PROPORTION OF SPRAINT (%)	RELATIVE ESTIMATED BULK (%)	BULK ESTIMATE (%)
Loach	9.9	38.4	6.5	5.8
Perch	14.4	55.6	8.8	10.5
Stickle-back.	4.7	18.2	3.9	3.1
Salmonid	15.9	61.6	11.8	11.3
Cyprinid	6.8	26.3	4.8	5.4
Eel	14.9	57.6	19.5	8.0
Bullhead	16.4	63.6	22.4	25.7
Mamm./Amph.	2.1	8.1	5.0	7.2
Crayfish	5.0	19.2	10.1	7.8
Unident.	9.7	37.4	4.5	8.0

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APPENDICES

APPENDIX I: Regression equations for the conversion of fish vertebral lengths to actual fish lengths. x = vertebral length, y = fish length. Only regression equations for mean fish lengths are given for clarity.

FISH PREY	VERTEBRA TYPE	REGRESSION EQUATION	COEFFICIENT (r)
Cyprinid	Anterior	y=0.506x+2.06	0.984
	Caudal	y=0.514x+1.27	0.988
Perch	Anterior	y=0.531x+1.32	0.992
	Caudal	y=0.985x+0.31	0.985
Salmonid	Anterior	y=0.751x+1.93	0.965
	Caudal	y=0.720x+1.21	0.980
Eel	Anterior	y=1.024x+1.28	0.970
	Caudal	y=1.152x+0.92	0.932
Stickle-back	Anterior	y=0.433x+0.24	-
	Caudal	y=0.471x+0.70	-
Stone loach	Anterior	y=0.489x+0.52	-
	Caudal	y=0.593x+0.51	-