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HABITAT QUALITY, WATER QUALITY AND OTTER DISTRIBUTION

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ABSTRACT – In recent decades the otter (*Lutra lutra*) has declined over much of Europe. Good habitat has been shown to be essential to otters. Specific elements of cover have been identified in some studies but the minimum cover requirements to support otter populations are not known. These are likely to vary in relation to other factors, such as disturbance. Habitat destruction has been severe in many areas of Europe. Water quantity is important to otters, especially where low flows destroy the food base, namely fish. However the minimum food requirements to support populations are not known. The main cause of the decline in otter populations is almost certainly bioaccuinulating pollutants, especially PCBs. These are likely to be inhibiting recolonization in many areas. In Britain, catchment distribution of otters within regions is negatively correlated to mean PCB levels in otter spraints, and these are indicative of tissue levels. PCBs have been found in all samples studied. Current EC statutory monitoring is inadequate to protect otter populations from bioaccumulating contaminants. Standards are presented here for otter protection.
More fundamental research is required to refine our understanding of the requirements of the otter.

Key words: Otter, *Lutra lutra*, Habitat, Water Quality, PCBs.

RIASSUNTO – *Qualità ambientale, qualità dell'acqua e distribuzione della lontra* – Negli ultimi decenni la lontra *(Lutra lutra)* è diminuita su buona parte del suo areale europeo, dove particolarmente pesante è stata la distruzione di ambienti favorevoli. Habitat qualitativamente idonei Sono essenziali per la sopravvivenza della specie. In alcuni studi, specifici parametri di copertura vegetale dei corpi idrici Sono stati ritenuti importanti per la specie, ma quale sia il valore minimo di copertura riparia in grado di supportare una popolazione resta sconosciuto. I parametri di copertura variano probabilmente in relazione ad altri fattori, quali, ad esempio, il disturbo. La quantitii d'acqua è importante per la lontra, specialmente in situazioni di bassa portata dei corsi idrici che ha come conseguenza il depauperamento delle disponibilità trofiche di base c quindi del popolamento ittico. Comunque, il livello minimo di disponibilità di cibo in grado di soddisfare le esigenze di una popolazione di lontra non è noto. La principale causa del declino della lontra è quasi certamente il bioaccumulo di sostanze tossiche, specialmente dei PCB. Questi probabilmente inibiscono la riproduzione e di conseguenza limitano la possibilità di ricolonizzazione di molte zone. In Gran Bretagna, la distribuzione della lontra in bacini idrografici è negativamente correlata ai livelli medi di PCB nelle feci della specie che riflettono indicativamente il tasso di accumulo nei tessuti degli animali. I PCB sono stati trovati in tutti i campioni fecali esaminati. Gli attuali livelli di contaminazione stabiliti dalla Comunità Europea sono inadeguati per proteggere la specie contro I'effetto del bioaccumulo. Nel presente studio sono riportati gli standard cui fare riferimento per la conservazione della specie. Ulteriori ricerche Sono di fondamentale importanza per approfondire le conoscenze sulle esigenze ecologiche della lontra.

Parole chiave: Lontra, *Lutra lutra*, Habitat, Qualità delle acque, PCB

INTRODUCTION

Otter *Lutm lutra* populations have declined severely over much of north-west and central Europe over the last 40 years and the species is now rare or absent from a number of countries (Mason & Macdonald, 1986; Foster-Turley et al., 1990). The decline is related to several aspects of river management.

HABITAT MODIFICATION

Adequate cover is essential to the well-being of otter populations. Before the intervention of man, rivers were bordered by extensive forests or wetlands. The removal of riparian vegetation has been one of the major impacts on the river ecosystem. The density of bankside trees along rivers in Wales and eastern England has been compared (Fig. 1). The majority of Welsh sites receive some management but tree removal has been extensive in eastern England. In Wales the majority of river banks support more than 200 trees (mature and saplings) per km., whereas in eastern England most stretches have less than 50 trees per km.

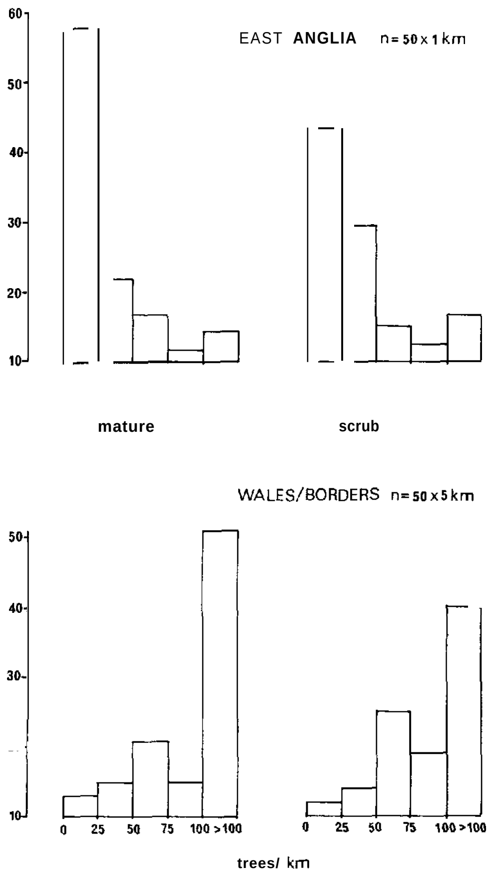

Fig. 1 - Frequency distribution of bankside tree and sapling (scrub) density in East Anglia and western Britain.

Macdonald and Mason (1983) investigated the distribution of otter spraints (faeces), as a measure of otter activity, in relation to a number of habitat and potential disturbance variables on fifty 5 km stretches of rivers in Wales and adjacent counties. The number of signs of otters was significantly correlated with the density of mature *Fraxinus* **excelsior** and *Acer pseudoplatanus* trees and with the number of potential holts, 46% of which were in the root systems of these trees. Mature *Quercus petraea* made up a further **14%** of potential holts. The frequency distribution of these trees on rivers with and without otters is shown in Fig. 2. There were no other significant relationships between otter signs and other measured environmental variables.

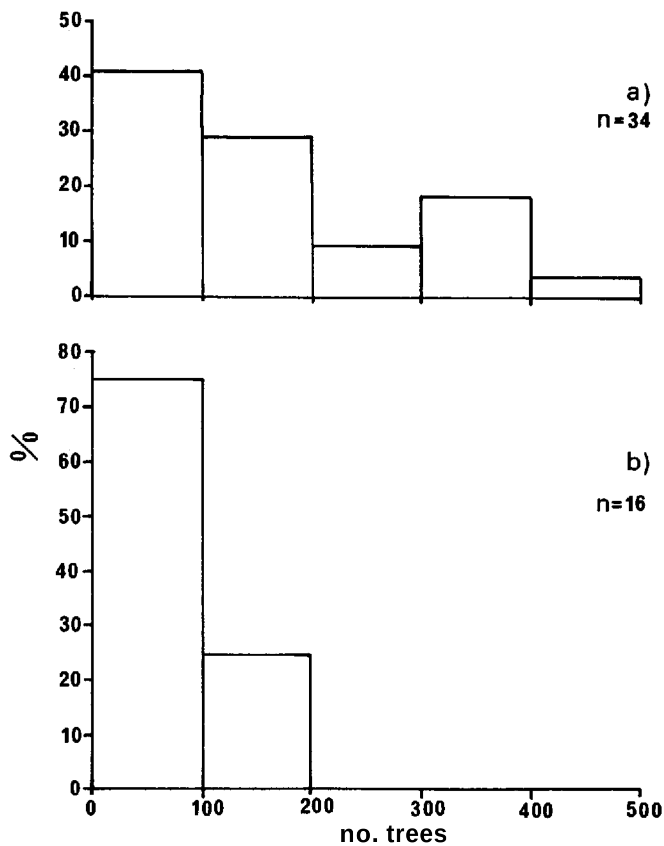

Fig. 2 - Frequency distribution of mature bankside *Quercus* ***petraea, Fraxinus excelsior*** and ***Acer pseudoplatanus*** trees on rivers a) with, and h) without otters.

Other studies have found relationships between the number of otter signs and bankside cover in Scotland (Jenkins & Burrows, 1980; Bas et al., 1984), England (Macdonald & Mason, 1988), Spain (Adrian et al., 1985; Delibes et al., 1991), Germany (Prauser, 1985) and Greece (Macdonald & Mason, 1982a and 1985). In Greece high otter activity was associated with cover of *Phragmites* on irrigation channels, *Salix* on lowland rivers and *Salix* and *Rubus* on rivers in uplands (Macdonald & Mason, 1985).

A radio-tracking study in Scotland (Green et al., 1984) showed many above-ground resting sites of otters associated with scrub, while the most frequent holt sites were the roots of *Fraxinus excelsior* and *Acer pseudoplatanus* trees. Otters radio-tracked as part of a reintroduction programme spent much of their time in riparian woodland (Jefferies et al., 1986) while a radio-tracking study of *Lutra canadensis* in North America (Melquist & Hornocker, 1983) showed that stretches of habitat with ample food were virtually unused by otters in the absence of sufficient cover and resting sites.

The study of Macdonald and Mason (1983) was conducted at a time when the otter population was at a low ebb and animals may have spent much of their time in the best habitat. Since then the population has expanded and some animals are forced into poorer quality habitat so that apparent relationships between otter activity and habitat might be obscured. Indeed a study on the River Severn in 1986-88 (Delibes et al., 1991) found no relationship between otter activity and bankside cover. The study was, however, on a much smaller scale than the earlier investigation, only 20 stretches of 1 km being studied. In 1992 we undertook a survey of two catchments in southwest Scotland which held otters throughout (unpublished data). Of seventy-nine 1 km stretches of river surveyed (77 of which had evidence of otter activity) the cover was considered of poor quality for otters at 33%. Despite the ubiquitous distribution of otters, there was still a significant relationship between otter activity and cover ($r = 0.34$, $p < 0.01$). Although otters will use stretches of river with poor cover, a range of studies has shown that cover is very important to them.

FOOD SUPPLY

Bankside and within-river management will influence the food supply of otters as well as reducing cover. Otters are predominantly piscivorous and manipulation of fisheries could alter the carrying capacity of the habitat for the species. Food shortage was considered to be the ultimate cause of natural mortality in coastal dwelling otters in Shetland, most deaths occurring in the spring when populations of intertidal fish were smallest (Kruuk & Conroy, 1991). Otters are resident in acidified streams in Scotland where fish numbers are low, the animals diversifying their diet and taking a larger number of frogs (Mason & Macdonald, 1989). Nevertheless there was a relationship between otter activity and both pH and conductivity so it appeared that, although otter distribution was not affected, carrying capacity was. There is no information, however, on the minimum prey base required to support otters or on the prey biomass required to support a thriving population.

Fisheries affect otters in another way - many die in fyke nets (see review in Macdonald & Mason, in press). Females and juveniles are most at risk and such losses are likely to be especially significant in depleted populations.

WATER QUANTITY

Low flows in Britain are largely a feature of the lowland agricultural area of eastern and southern England. However the otter is largely absent from this region for other reasons. Low flows may, however, have an impact on those otters being re-introduced to eastern England and could become important should the species begin to recolonize former habitats in lowland England. More is known of the effects of low flows continental Europe.

River flow is altered by the building of dams for hydro-electric schemes and by water abstraction largely for irrigation. The dams themselves seldom provide suitable otter habitat, being too deep and steep-sided for successful foraging and lacking, due to fluctuating water levels, adequate bankside cover. The negative effect of dams on otter distribution has been noted in, for example, Austria, Portugal, Spain and France (Gutleb, 1992; Macdonald & Mason, 1982b; Ruiz-Olmo, 1991; Bouchardy, 1986).

In southern Europe and North Africa, rivers downstream of dams are subject to severely reduced flow or even desiccation especially in summer. The resulting extirpation of the otter population on the Palancia river in Valencia was documented by Jiménez and Lacomba (1991). Water abstraction from downstream reaches for agricultural irrigation exacerbates the problem and is acute in east Spain where the current 51% of total natural water now abstracted is expected to rise to 93% (Jiménez & Lacomba, 1991). Over the last three decades otters have disappeared from Spanish rivers where flow has been reduced to $1 m^3 sec^{-1}$. Under conditions of low flow, relative concentrations of organic and industrial effluents increase.

Water abstraction is increasing in Mediterranean countries due to rising demands for irrigated land and to meet the requirements of growing tourist resorts. Wetlands such as the Coto Doñana marismas are drying as ground water levels fall. Deforestation and overgrazing have also resulted in summer desiccation of rivers and hence the loss of fish populations and of local otters in southern Europe and in, for example, Morocco and Algeria (Macdonald & Mason, 1984; Macdonald et al., 1985). In Tunisia the building of dams on the feeder rivers to Lake Ichkeul has reduced flow to such an extent that the lake is now hypersaline in summer and marshland is being lost. The effects on the food supply and habitat of the resident otters, an important population in North Africa, may be severe.

WATER QUALITY

Some pollutants reduce the food supply of otters. In Britain, of particular concern is the general deterioration of rivers due to farm effluents because it is occurring in otter strongholds in the west and north. However there is no evidence that farm pollution has reduced the carrying capacity of affected rivers for otters. After a major fish kill on an East Anglian river, caused by effluent from a pig farm, otters switched to a diet comprising largely birds for several weeks. It was described above how similar dietary plasticity may allow otters to survive on acidified rivers with limited fish populations, though carrying capacity may be reduced (Mason & Macdonald, 1989). However otters may not be able to live permanently in some acidified headwaters (Mason & Macdonald, 1987).

Otter populations and range are severely depleted over much of northwest and central Europe (Foster-Turley et al., 1990). Populations are thriving on the western seaboards and on the eastern periphery of Europe. Macdonald (1991) noted the plastics production in individual countries as an index of industrial output, and the direction of prevailing winds, and related these to otter distribution. Otters are extinct or threatened in those countries with high industrial output, or downwind of such countries. This indicates that the decline was caused by a contaminant that not only enters watercourses locally but is also widely dispersed by the winds. Because the decline was precipitate over a wide area it suggests a contaminant which reached critical levels during the late 1950s and 60s.

Chanin and Jefferies (1978), examining the decline of otters through hunting records, concluded that dieldrin was the single most important cause. The decline began more or less at the time when this pesticide was introduced into British agriculture. Other contaminants were discussed by them but dismissed. They ignored the fact that widespread industrialisation in Britain and in much of western Europe in the 1950s, following recovery from the 2nd. World War, would have led to increased contamination with compounds such as PCBs and mercury. Studies on lake sediments for example have shown an exponential increase in PCBs during the 1950s and 60s (e.g. Sandars et al., 1992).

Heavy metals, especially mercury are widely dispersed in the rivers of Britain and mercury occurs in eels often above the EC recommended level for human consumption (Mason & Barak, 1990; Barak & Mason, 1990). The majority of otters also contain heavy metals, especially mercury (Mason et al., 1986; Kruuk & Conroy, 1991; Mason & Madsen, 1992; Mason & O'Sullivan in press) but levels are

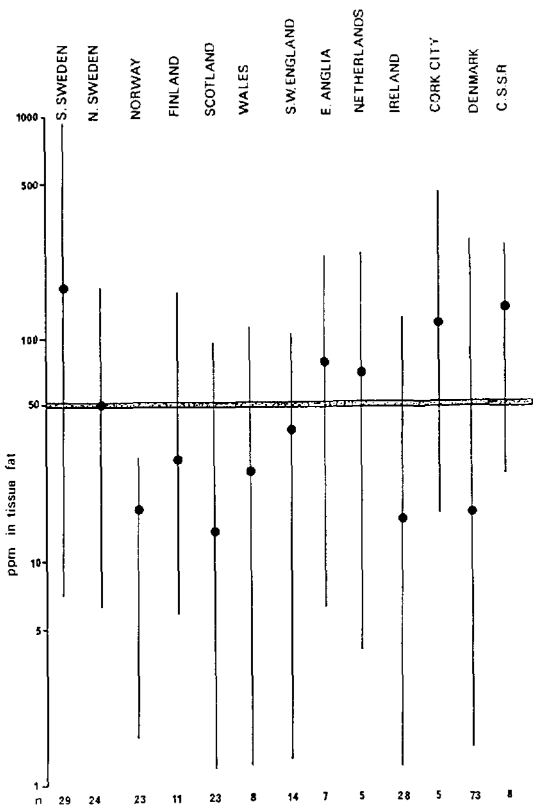

Fig. 3 - Mean and ranges (mg kg^{-1} fat) of PCBs in otter tissues from various regions in Europe. The horizontal line at 50 mg kg^{-1} represents the concentration in tissues known to be associated with reproductive failure in mink. Data from Olsson et al., 1981 (Norway and Sweden), Mason et al., 1986, Mason, 1988, Mason & Macdonald in press c and unpublished (U.K.), Skaren, 1988 (Finland), Broekhuizen, 1989 (The Netherlands), Mason and O'Sullivan, 1992 (Ireland), Mason & Madsen, 1993 (Denmark) and Hlavac, 1991 (Czechoslovakia).

such that it is unlikely that mercury was responsible for the widespread decline. Mercury does, however, act synergistically with PCBs in experiments to reduce the survival of mink pups (Wren et al., 1987). PCBs are known to be more toxic to mammals than organochlorine pesticides and metals and they have marked effects on reproduction, the endocrine system and the immune system of mammals. Because there is little information on the physiological impact of suites of contaminants perhaps they should be considered as a whole.

Fig. *3* shows the concentrations of PCBs in otter tissues from various regions of Britain and Europe. The horizontal line at 50 ppm is the tissue concentration associated with reproductive failure in PCB-dosed laboratory mink (Jensen et al., 1977). Average concentrations of PCBs greater than 50 ppm were found in otters from south Sweden (population endangered), The Netherlands (extinct), East Anglia (wild population probably extinct) and Czechoslovakia (declining in many parts). The two otters with the highest levels from East Anglia showed pathological symptoms which included bleeding feet, deformed toes and claws, uterine tumours

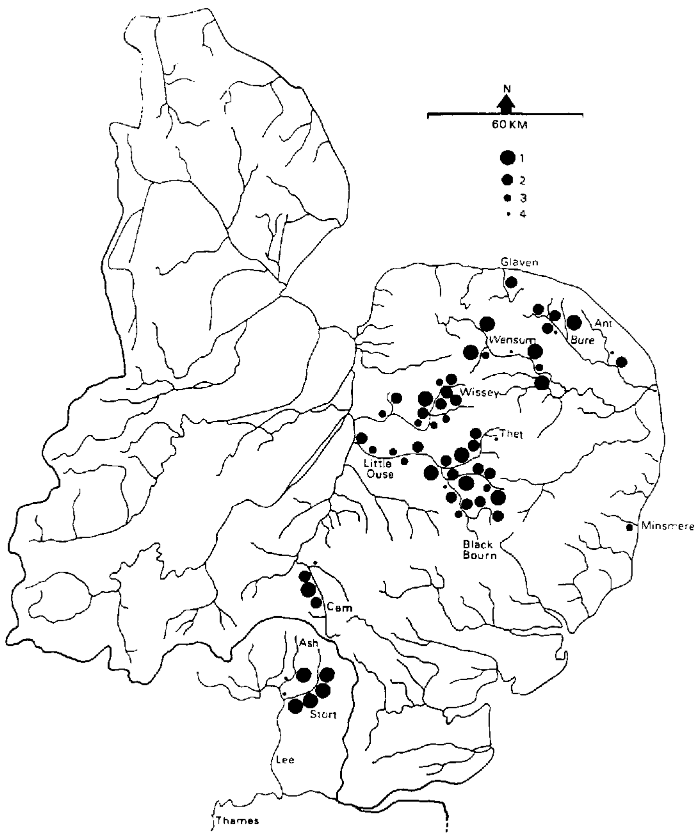

Fig. 4 - Mean total concentration of organochlorine pesticide residues and **PCBs** in otter spraints from sites in East Anglia, grouped in 4 levels. Contaminants in Level 1 are likely to be associated with tissue contaminant levels causing adverse physiological effects on otters, while those in Level 2 may cause effects. Samples in Lcvcl 4 are considered to represent current background levels (Mason & Macdonald in press b provides more details).

and skin lesions (Keymer et al., 1988). Symptoms were similar to those of Baltic seals considered to be suffering from PCB induced adrenocortical hyperplasia, resulting in reproductive failure and dysfunction of the immune system (Bergman & Olsson, 1985; Olsson et al., 1992). Disorientation behaviour was observed in one animal from East Anglia. Such behaviour was also recorded, prior to death, in several otters from Ireland, from where blindness and pedal and integumentary lesions in otters were also recorded; such symptoms are consistent with organochlorine poisoning and all such otters had elevated levels of PCBs (Mason & O'Sullivan, 1992; in press b).

In a congener specific analysis of otter livers from Ireland, Britain and Denmark, fourteen potentially toxic congeners were detected, comprising, on average, 62% of the total PCB concentration (author's unpublished data).

The otter is protected over most of its range and few bodies are received for analysis. The majority come from thriving populations where contaminant levels are likely to be low. To overcome this problem we have recently been analysing for

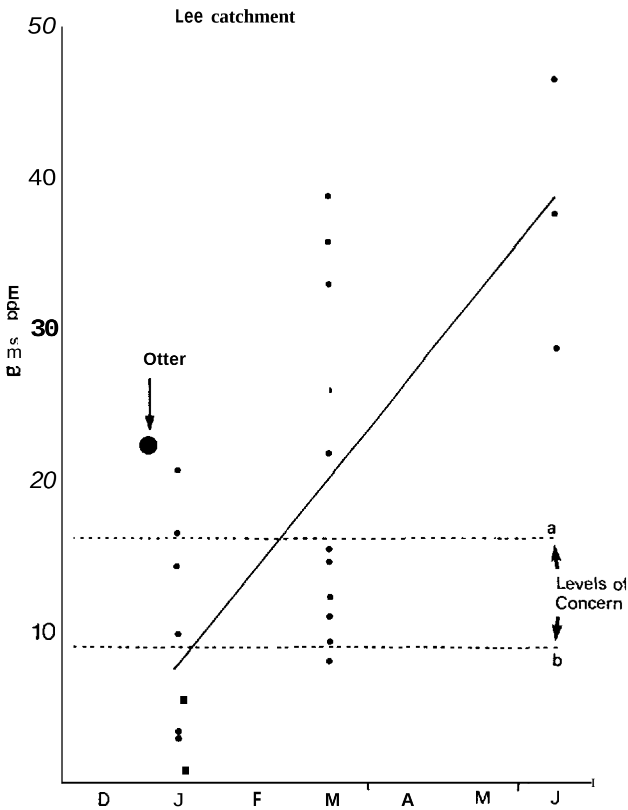

Fig. 5 - Concentrations of PCBs (mg kg^{-1} lipid) in otter spraints collected from the River Lea catchment from January 1992, following a reintroduction of otters in December 1991. Levels of concern a and b are considered likely or probably, respectively, to reflect tissue levels associated with adverse physiological effects on otters. Note the increase in PCB levels as otters expanded their range into the main river and downstream to the industrial town of Harlow. The otter was killed by traffic in the centre of a town, upstream of the release site, less than a month after release; it had already accumulated a substantial amount of PCB in its liver.

organochlorine residues in spraints. The vast majority of the organochlorine residues measured in spraints are derived from the previous meal, i.e. that small proportion (some 10%) which is not assimilated. This can then be related back to intake and to likely accumulation in tissues (Mason et al., 1992). An example of the results obtained is given in Fig. 4. Otters in East Anglia now belong largely, if not entirely, to a population which was introduced from captive-bred stock. This region had the highest average level of organochlorine pesticide residues and PCBs in spraints. PCB levels in spraints (and presumably otters) increase rapidly following release (Fig. 5).

Although East Anglia showed the most consistently high level of contamination, our studies have demonstrated the widespread presence of organochlorine pesticides and PCBs in aquatic ecosystems. There is a general increase **in** PCB levels from west to east in England and Wales (Mason &

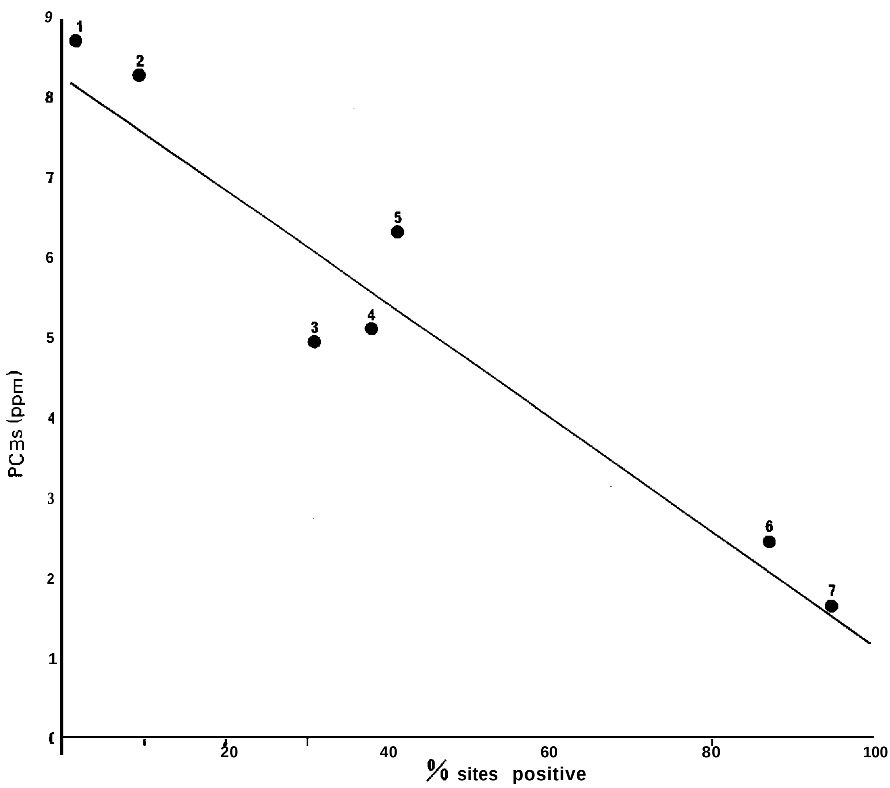

Fig. 6 - The mean concentration of PCBs (mg kg^{-1}) in otter spraints from seven regions and the percentage of sites in the region positive for otters during the most reeent national otter surveys carried out in the mid-1980s ($r = -0.96$, $p < 0.001$). There were no significant correlations with individual pesticides. 1, southwest Ireland; 2, southwest Scotland; 3, Wales; 4, southwest England; 5, east-central Scotland; 6, northern Egland; 7, East Anglia.

Macdonald in press a and b), northern Britain (Mason, 1993) and Ireland (O'Sullivan et al., 1993). Lowland stretches of rivers are more contaminated than stretches in uplands (Mason & Macdonald in press a). There are "hot-spots" of PCBs within this general distribution pattern (Mason & Macdonald, 1993; in press c). Fig. 6 relates the mean concentration of PCBs in spraints in regions to the percentage of positive sites for otters recorded in the most recent national survey. Clearly regions with poor otter distribution are more contaminated with PCBs. Our study has indicated that, in some localities, PCB levels may be sufficiently high to pose a threat to otters.

CONCLUSIONS

To effectively conserve otter populations (and indeed any other animal group) in managed river corridors it is essential to have detailed knowledge of their precise habitat and ecological requirements. A number of studies have emphasized the importance of bankside cover to otters and several have identified specific features (e.g. tree species used as holts) in some areas. However specific habitat features may differ in other regions, depending on availability, and we do not know the minimum amount of cover required to support a thriving otter population, or indeed how this may vary with other factors such as disturbance. For example a river in northern Scotland, with poor cover but rarely visited by man, may have sufficient refuges for otters. A river in lowland England with equally poor cover but lined at weekends with anglers and with heavy pressure from walkers and their dogs, may prove totally unsuitable.

There have been a number of conservation initiatives for otters over the past decade. Project officers, sometimes after only cursory surveys, invariably recommend tree planting schemes. Such planting may often be quite unnecessary and indeed blanket planting of banks could be detrimental, for some stretches of bare bank clearly have major social significance to otters; they are heavily marked with spraints and other signs of activity, such as rolling places (Macdonald & Mason, 1987).

Inadequate water quantity is likely to have a negative impact on otters where it affects food resources, especially fish numbers. Where rivers dry up completely and fish are absent, otters are likely to disappear. Nevertheless, where partial drying occurs, reducing the river to a series of pools where fish and amphibians may be concentrated, otter activity can be very high (e.g. in Portugal, Macdonald & Mason, 1982b). Otters certainly do live on rivers with a very poor food base but we do not know the minimum requirements necessary to support a viable population.

Bioaccumulating pollutants, and especially PCBs, were not only a major cause of the widespread and precipitate decline in otters over much of Europe but they are likely to be a major limiting factor preventing recovery in many areas (Mason, 1989). PCBs have been present in every otter, otter spraint and fish analyzed in our laboratory and those PCB congeners known to exert physiological effects make up a substantial proportion of the total. Yet the statutory monitoring programme of river water carried out under EC law rarely detects the presence of PCBs or other bioaccumulating contaminants. The statutory monitoring programme is therefore totally inadequate for protecting the wildlife resources of our ,rivers against the possible effects of these bioaccumulating contaminants.

From our recent detailed studies of organochlorines in otters and otter spraints we have derived some standards for PCBs (Tab. 1) which we believe would protect otter populations (Macdonald & Mason in press). The derivation of the standards can be criticized, for example because the mink has been used as the experimental model to determine the adverse effects of **PCBs.** However we believe they are every bit as good as those used to protect human populations. Similar standards will also protect populations against organochlorine pesticides, which now occur at much lower concentrations in most rivers than do PCBs. However because of previous concern over dieldrin, standards for this and PCBs should perhaps be considered in combination.

Tab. 1 - PCB quality standards for protecting otter populations.

In Fish (whole body mince or flesh):		
	PCBs	<0.026 mg kg^{-1} fresh weight is safe
	PCBs	>0.05 mg kg^{-1} fresh weight require action
In Otters (liver or muscle):		
	PCBs	<10 mg kg^{-1} lipid weight is safe
	PCBs	>30 mg kg^{-1} lipid weight require action
In Otter Spraints:		
	PCBs	<4 mg kg^{-1} lipid weight is safe
	PCBs	>9 mg kg^{-1} lipid weight require action

REFERENCES

ADRIÁN, M.I., WILDEN, W. & M. DELIBES. 1985. Otter distribution and agriculture in southwestern Spain. 17th. Congr. Int. Union Game Biologists, Brussels, 1985, 17-21.

BARAK, N.A.-E. & C.F. MASON. 1990. A survey of heavy metal levels in eels (*Anguilla anguilla*) in some rivers in East Anglia, England; the use of eels as pollution indicators. Int. Rev. ges. Hydrobiol., 75: 827-833.

BAS, N., JENKINS, D. & P. ROTHERY. 1984. Ecology of otters in northern Scotland, V. The distribution of otter *Lutra lutra* faeces in relation to bankside vegetation on the River Dee in summer 1981. J. Appl. Ecol., 21: 507-513.

BERGMAN, A. & M. OLSSON. 1985. Pathology of Baltic grey seal and ringed seal females with special reference to adrenocortical hyperplasia: is environmental pollution the cause of a widely distributed disease syndrome? Finn. Game Res., 44:47-62.

BOUCHARDY, C. 1986. La loutre. Sang de la terre, Paris, 174 pp.

BROEKHUIZEN, S. 1989. Belasting van otters met zware metalen en PCBs. De Levende Natuur, 90: 43-47.

CHANIN, P.R.F. & D.J. JEFFERIES. 1978. The decline of the otter *Lutra lutra* L. in Britain: an analysis of hunting records and discussion of causes. Biol. J. Linn. Soc., 10: 305-328.

DELIBES, M., MACDONALD, S.M. & C.F. MASON. 1991. Seasonal marking, habitat and organochlorine contamination in otters (*Lutra lutra*); a comparison between catchments in Andalucia and Wales. Mammalia, 55: 567-578.

FOSTER-TURLEY, P., MACDONALD, S.M. & C.F. MASON (eds.). 1990. Otters: an action plan for their conservation. I.U.C.N., Gland, 126 pp.

GREEN, J., GREEN, R. & D.J. JEFFERIES. 1984. A radio-tracking survey of otters *Lutra lutra* on a Perthshire river system. Lutra, 27: 85-145.

GUTLEB, A.C. 1992. The otter in Austria: a review of the current state of rcscarch. I.U.C.N. Otter Specialist Group Bull., 7: 4-9.

HLAVÁC, V. 1991. Finding of dead otters (*Lutra lutra*) and preliminary results of analyses of dead animals. Vydra, 2: 7-13.

JEFFERIES, D.J., WAYRE, P., JESSOP, R.M. & A.J. MITCHELL-JONES. 1986. Reinforcing the native otter *Lutra lutra* population in East Anglia: an analysis of the behaviour and range development of the first group. Mammal Rev., 16:65-79.

JENKINS, D. & G.O. BURROWS. 1980. Ecology of otters in northern Scotland. III. The use of faeces as indicators of otter (*Lutra lutra*) density and distribution. J. Anim. Ecol., 49: 755-774.

JENSEN, S., KIHLSTROM, J.E., OLSSON, M., LUNBERG, C. & J. ORBERG. 1977. Effects of PCB and DDT on mink (*Mustela vison*) during the reproductive season. Ambio, 6: 239.

JIMÉNEZ, J. & J. LACOMBA. 1991. The influence of water demands on otter (*Lutra lutra*) distribution in Mediterranean Spain. In Reuther, C. & Rochert, R. (eds.): Proc. Vth Int. Otter Colloqu., Habitat, 6: 249-259.

KEYMER, I.F., WELLS, G.A.H., MASON, C.F. & S.M. MACDONALD. 1988. Pathological changes and organochlorine residues of wild otters (*Lutra lutra*). Vet. Record, 122: 153-155.

KRUUK, H. & J.W.H. CONKOY. 1991. Mortality of otters (*Lutra lutra*) in Shetland. J. Appl. Ecol., 28: 83-94.

MACDONALD, S.M. 1991. The status of the otter in Europe. In Reuther, C. & Rochert, R. (cds.): Vth. int. Otter Colloquium., Habitat, 6: 1-3.

MACDONALD, S.M. & C.F. MASON. 1982a. Otters in Greece. Oryx, 16: 240-244.

MACDONALD, S.M. & C.F. MASON. 1982b. The otter in central Portugal. Biol. Conserv., 22: 207-215.

MACDONALD, S.M. & C.F. MASON. 1983. Some factors influencing the distribution of orters (*Lutra lutra*). Mammal Rev., 13: 1-10.

MACDONALD. S.M. & C.F. MASON. 1984. Otters in Morocco. Oryx, 18: 157-159.

MACDONALD, S.M. & C.F. MASON. 1985. Otters, their habitat and conservation in north-east Greece. Biol. Conserv., 31: 191-210.

MACDONALD, S.M. & C.F. MASON. 1987. Seasonal marking in an otter population. Acta Theriol., 32: 449-462.

MACDONALD, S.M. & C.F. MASON. 1988. Ohservations on an otter population in decline. Acta Theriol., 33: 415-434.

MACDONALD, S.M. & C.F. MASON. Status and conservation needs of the otter (*Lutra lutra*) in the western Palearctic. Council of Europe, Nature and Environment Series, Strasbourg (in press).

MACDONALD, S.M., MASON, C.F. & K. DE SMET. 1985. The otter in north-central Algeria. Mammalia, 49: 215-219.

MASON, C.F. 1989. Concentrations of organochlorine residues and metals in tissues of otters *Lutra lutra* from the British Isles. Lutra, 31: 62-67.

MASON, C.F. 1989. Water pollution and otter distribution: a review. Lutra, 32: 97-131.

MASON, C.F. 1993. Regional trends in PCB and pesticide contamination in northern Britain as determined in otter (*Lutra lutra*) scats. Chemosphere, 26: 941-944.

MASON, C.F. & N.A.E. BARAK. 1990. A catchment survey for heavy metals using the eel (*Anguilla anguilla*). Chemosphere, 21: 695-699.

MASON, C.F., FORD, T.C. & N.I. LAST. 1986. Organochlorine residues in British otters. Bull. Environ. Contam. Toxicol., 36: 656-661.

MASON, C.F., LAST, N.I. & S.M. MACDONALD. 1986. Mercury, cadmium and lead in British otters. Bull. Environ. Contam. Toxicol.. 37: 844-849.

MASON, C.F. & S.M. MACDONALD. 1986. Otters: ecology and conservation. Cambridge University Press, Cambridge, 236 pp.

MASON, C.F. & S.M. MACDONALD. 1987. Acidification and otter (*Lutra lutra*) distribution on a British river. Mammalia, 51: 81-87.

MASON, C.F. & S.M. MACDONALD. 1989. Acidification and otter (*Lutra lutra*) distribution in Scotland. Water, Air and Soil Poll., 43: 365-374.

MASON, C.F. & S.M. MACDONALD. 1993. PCBs and organochlorine pesticide residues in otter (*Lutra lutra*) spraints from Welsh catchments and their significance to otter conservation strategies. Aquatic Conserv., 3: 43-51.

MASON, C.F. & S.M. MACDONALD. Impact of organochlorine pesticide residues and PCBs on otters (*Lutru lutra*): a study from western Britain. Sci. Total Environ. (in press a).

MASON, C.F. & S.M. MACDONALD. Impact of organochlorine pesticide residues and PCBs on otters (*Lutru lutra*) in eastern England. Sci. Total Environ. (in press b).

MASON, C.F. & S.M. MACDONALD. PCB and organochlorine pesticide residues in otters (*Lutra lutra*) and in otter spraints from southwest England and their likely impact on populations. Sci. Total Environ. (in press c).

MASON, C.F., MACDONALD, S.M., BLAND, H.C. & J. RATFORD. 1992. Organochlorine pesticide and PCB contents in otter (*Lutra lutra*) scats from western Scotland. Water, Air and Soil Pollut., 64: 617-626.

MASON, C.F. & A.B. MADSEN. 1992. Mercury in Danish otters (*Lutra lutra*). Chemosphere, 25: 865-867.

MASON, C.F. & A.B. MADSEN. 1993. Organochlorine pesticide residues and PCBs in Danish otters (*Lutra lutra*). Sci. Total Environ., 133: 73-81.

MASON, C.F. & W.M. O'SULLIVAN. 1992. Organochlorine pesticide residues and PCBs in otters (*Lutru lutra*) from Ireland. Bull. Environ. Contam. Toxicol., 48:387-393.

MASON, C.F. & W.M. O'SULLIVAN. Heavy metals in the livers of otters, *Lutra lutra*, from Ireland. J. Zool., (in press a).

MASON, C.F. & W.M. O'SULLIVAN. Further observations on PCB and organochlorine pesticide residues in Irish otters (*Lutra lutra*). Biology and Environment (in press b).

MELQUIST, W.E. & M.G. HORNOCKER. 1983. Ecology of river otters in west central Idaho. Wildlife Monogr., 83: 1-60.

OLSSON, M., ANDERSON, O., BERGMAN, A., BLOMKVIST, G., FRANK, A. & C. RAPPE. 1992. Contaminants and diseases in seals from Swedish waters. Ambio, 21: 561-562.

OLSSON, M., REUTERGARDH, L. & F. SANDEGREN. 1981. Var ar Uttern? Sverigcs Natur, 6: 234-240.

O'SULLIVAN, W.M., MACDONALD, S.M. & C.F. MASON. 1993. Organochlorine pesticide residues and PCBs in otter spraints from southern Ireland. Biology and Environment, 93B: 55-57.

PRAUSER, N. 1985. Vorkommen von Fischottern (*Lutra lutra* L. 1758) und ihre Abhangigkeit von der Struktur verschiedener Habitat-Zonen der Wumme-Niederung. Z. Ang. Zool., 72: 83-91.

RUIZ-OLMO, J. 1991. Conservation and management plan for the otter in Catalonia (NE Spain). In Reuther, C. & Rochert, R. (eds.): Proc. Vth. Int. Otter Colloquium, Habitat, 6: 259-262.

SANDARS, G., JONES, K.C., HAMILTON-TAYLOR, J. & H. DORR. 1992. Historical inputs of polychlorinated biphenyls and other organochlorines to a dated lacustrine sediment core in rural England. Environ. Sci. Technol., 26: 1815-1821.

SKARÉN, U. 1988. Chlorinated hydrocarbons, PCBs and cesium isotopes in otters (*Lutra lutra*) from central Finland. Ann. Zool. Fenn., 25: 271-276.

WREN, C., HUNTER, D.B., LEATHERLAND, J.F. & P.M. STOKES. 1987. The effects of polychlorinated biphenyls and methyl-mercury, singly and in combination, on mink. II. Reproduction and kit development. Arch. Environ. Contam. Toxicol., 16: 449-454.