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Impact of pollution on the European Otter

par
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SUMMARY

Pollution of watercourses, especially by bioaccumulating contaminants, is undoubtedly the main cause of the widespread decline of the otter in Europe, though other impacts, such as habitat loss, accidental and deliberate killing by man, have played a part. Initial concern was with the insecticide dieldrin because dieldrin was introduced into the environment when otters began to decline, but there is otherwise little data to support the hypothesis.

Evidence is much stronger for the role of PCBs in the otter decline. PCBs increased rapidly as environmental contaminants through the 1950s and 1960s. Mean PCB levels in declining and endangered populations are high, above a concentration known to produce reproductive impairment in mink. In thriving otter populations mean PCB levels are low. In Britain there is an inverse relationship between mean PCB level in spraints and regional otter distribution, but not with any other organochlorine. PCBs are likely to be inhibiting the spread of otters into lowland Britain. Synergistic effects of PCBs with other contaminants, especially mercury, are possible.

Standards of PCBs in aquatic systems to protect otter populations are presented.

RESUME : incidences de la pollution sur la loutre d'Europe.

En Europe, la pollution aquatique et atmosphérique sont deux causes de raréfaction de la loutre, principalement depuis les années '50 et '60. Les polluants affectent l'espèce selon deux modes d'action. D'une part, en détériorant la qualité des eaux, ils éliminent les populations de poissons et la privent ainsi de ses ressources alimentaires. D'autre part, par bioaccumulation, ils ont un effet direct sur son métabolisme. En Grande-Bretagne, on a d'abord mis en cause le dieldrin parce que le début du déclin des loutres a coïncidé avec l'introduction de ce produit en agriculture. Les données qui plaident en faveur de cette hypothèse sont cependant rares, contrairement à ce que l'on peut constater avec les PCBs. Dans plusieurs pays où l'espèce est rare ou éteinte, des analyses écotoxicologiques ont révélé des concentrations en PCBs dans les graisses supérieures à celles qui perturbent la reproduction chez le vison. Dans les populations qui prospèrent, les niveaux de PCB sont faibles mais on note cependant que, dans

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des régions peu contaminées, les individus contraints, sous la pression démographique, de fréquenter des habitats marginaux contaminés présentent des concentrations très élevées, nettement supérieures à la moyenne. En Grande Bretagne, on observe une relation inverse entre les concentrations moyennes en PCBs des épreintes et la répartition régionale de la loutre. Semblable relation n'est trouvée avec aucun autre organochloré.

En ce qui concerne une stratégie de protection, nous devons être conscients des risques que courent les loutres qui recolonisent certaines zones contaminées. Dans certaines régions de Grande-Bretagne, les niveaux de PCBs, à eux seuls, pourraient engendrer des problèmes au niveau de la reproduction, sans compter l'incidence des métaux lourds et d'autres pesticides qui exacerbent l'effet des PCBs. Toute stratégie de protection, en particulier tout programme de réintroduction, devrait tenir compte des problèmes de contamination de la chaîne alimentaire par l'ensemble des polluants et de leurs conséquences possibles sur l'espèce.

Introduction

Otter populations and range are seriously reduced over much of northwest and central Europe (FOSTER-TURLEY *et al.*, 1990). Populations are thriving mainly on the western seaboards and on the eastern periphery of Europe (MACDONALD and MASON, 1994). The species is extinct or threatened in those countries with high industrial output, or downwind of such countries (MACDONALD, 1991). This indicates that the decline has been 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. Nevertheless, for any one population, reasons for the decline may be multifactorial and these other pressures, e.g. habitat destruction, road deaths and mortality in fish traps, should not be ignored.

Pollutants affecting food supplies

Some pollutants reduce the food supply of otters. Severe organic pollution, such as that from untreated sewage outfalls, can eliminate fish populations and it may be one reason for the absence of otters on some major European rivers. In Britain, the concern is mainly with accidents causing fish kills, or with the general deterioration of rivers due to farm effluents, this latter being of particular concern because it is taking place in otter strongholds in the west and north (MASON, 1996). There is, however, no evidence that deteriorating water quality caused by organic farm effluents has led to a reduction in the range of otters. After a fish kill in eastern England, otters switched largely to a diet of birds for some weeks (MASON, 1989).

In arable lowlands, eutrophication of watercourses is a more general problem. It might be argued that eutrophication could benefit otters because a higher fish biomass is supported. However *Abramis brama* may be favoured under such conditions but is apparently little eaten by otters (DE JONGH, 1989).

Another general problem, mainly affecting uplands, is that of acidification. Our evidence from studies in Wales and south-west Scotland suggests that there may be a reduced carrying capacity for otters in acid-impacted rivers but otters may still occur because of their dietary flexibility (MASON and MACDONALD, 1987 ; 1989). They may not be able to live permanently in some headwaters.

Bioaccumulating contaminants

An examination of the decline of otters in Britain through hunting records concluded that dieldrin, an organochlorine pesticide, was the single most important cause (CHANIN and JEFFERIES, 1978). The decline began at about the time when this pesticide was introduced into British agriculture and it was associated with mortalities of raptors. Other contaminants were considered but dismissed. The authors ignored the fact that widespread industrialization in Britain and in much of western Europe following the 2nd. World War, would have led to increased contamination with compounds such as PCBs and mercury. Studies on lake sediments and fish in museums have shown an exponential increase in PCBs during the 1950s and 60s (see review in MACDONALD and MASON, 1994).

PCBs are known to be more toxic to mammals than either dieldrin or DDT and they have marked effects on reproduction, the endocrine system and the immune system. Other contaminants should not, however, be ignored because we have little knowledge of synergistic effects which may occur between the suites of contaminants which may be present in tissues.

Of heavy metals, mercury is the most widespread (MASON, 1989) but it is unlikely to have been the cause of the decline in otters, though it occurred in all of those otters we have analyzed, in a few at levels of concern. Mercury acts synergistically with PCBs to reduce the survival of pups in experiments with mink (WREN *et al.*, 1987). Mercury concentrations tend to be correlated with those of PCBs and dieldrin in British otters (MASON, 1989).

We have analyzed mercury from a large number of *Anguilla anguilla* in Essex, U.K. (BARAK and MASON, 1990 ; MASON and BARAK, 1990). At over 25 % of sites the level in flesh was above the EC recommended level for human consumption of 300 $\mu g\ kg^{-1}$. Levels in liver were higher still. Elevated levels were especially associated with small sewage works. A more widespread survey in lowland Britain has shown similar levels of contamination (MASON, 1987).

Sewage works are also one of the sources of organochlorines, especially PCBs. Of the total world PCB production, at least 57 % is still in use and their future dispersal cannot easily be controlled (KLAMER *et al.*, 1991). These authors suggest that PCBs may ultimately result in the extinction of fish-eating marine mammals. Much of these PCBs reach the ocean via rivers, so the impact on the fish-eating otter could be similar.

A number of studies have now been conducted on the concentrations of PCBs in otter tissues. In laboratory mink given PCBs in their diet, reproduction is impaired when muscle concentrations of PCBs exceed 50 mg kg-1 (lipid weight). This value can be used, in the absence of any experimental data on otters, to assess likely effects on otters from the wild (OLSSON *et al.*, 1981). Average concentrations (**fig. 1**) of total PCBs (determined against an Aroclor 1260 standard) greater than 50 mg kg-1 have been measured in otters from south Sweden (population endangered), East Anglia (wild population probably extinct), the Netherlands (extinct) and Czechoslovakia (population fragmented). Otters are thriving and mean PCB levels are below 50 mg kg-1 in Norway, southwest England, Ireland, Scotland and Denmark (see review in MACDONALD and MASON, 1994).

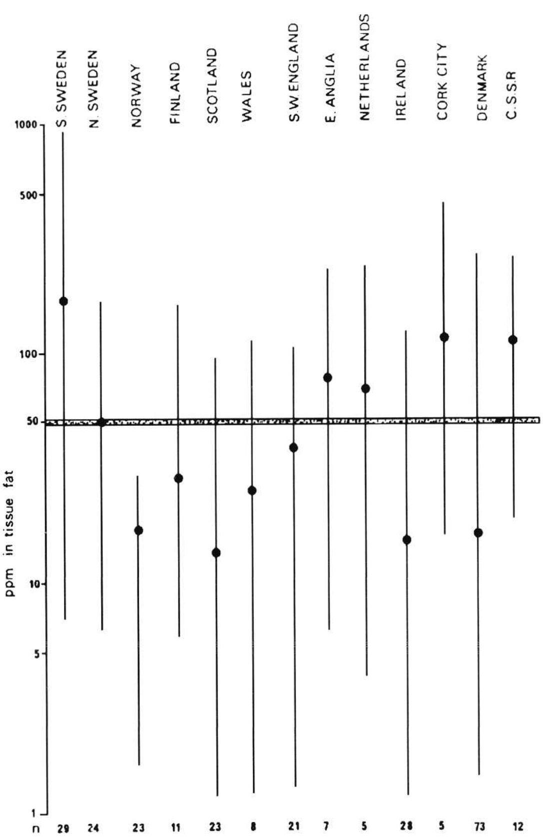

Fig. 1. Mean and ranges (mg kg-1 fat) of PCBs in otter tissues from various regions of Europe. The horizontal line at 50 mg kg-1 represents the concentration in tissues known to be associated with reproductive impairment in mink (see MACDONALD and MASON, 1994 for sources of data).
Moyennes et valeurs extrêmes (mg/kg de lipides) des concentrations en PCB dans des tissus de loutres provenant de différentes régions d'Europe. La ligne horizontale figurant à 50 mg/kg représente la concentration tissulaire à partir de laquelle l'échec de la reproduction a été constaté chez le vison américain (cf. MACDONALD & MASON, 1994 pour l'origine des données).

It should be stressed (see **fig. 1**) that, even in areas where contaminant levels are generally low, some individuals are highly contaminated. This is likely to be especially so where thriving populations exist in uncontaminated upland/ western areas (e.g. Ireland, Scotland) and some individuals are forced, through population pressure, to inhabit marginal, contaminated habitats. Such habitat is usually also subject to increased human pressure (e.g. traffic) so animals living there are more likely to be killed and found, thus inflating the mean level of PCBs for the region as a whole. Such individuals are also quickly replaced by animals from the uncontaminated strongholds of the population.

In Denmark otters are restricted to the north of Jutland in a region of extensive wetlands and coastal embayments. PCB concentrations in the population centre were generally low but some animals from isolated populations on the periphery had rather high concentrations (MASON and MADSEN, 1993). A recent survey has shown that, while range has consolidated in the population centre, some of these peripheral populations have disappeared (MADSEN *et al.*, 1992).

The two otters with the highest levels from East Anglia presented pathological symptoms similar to those of Baltic seals. These included bleeding feet, deformed claws and toes, uterine tumours and skin lesions (KEYMER *et al.*, 1988). The seals were considered to be suffering from PCB induced adrenocortical hyperplasia, resulting in reproductive failure and a breakdown in the immune system (BERGMAN and OLSSON, 1985). One of these otters was showing disorientation behaviour prior to death, walking round in circles. It was seen regularly by day when, in this region, otters are nocturnal. Similarly several of the Irish otters showed disorientation behaviour, some entering riverside shops. Several of these otters were blind, something recorded quite regularly in British and Irish otters (MASON and O'SULLIVAN, 1992). Such behaviour is consistent with organochlorine poisoning.

An analysis of 24 PCB congeners in a sample of otter tissues has shown that 58-78 % of the total PCB consists of the most environmentally threatening congeners (MASON and RATFORD, 1994).

Measuring contaminants in scats (spraints)

The otter is legally protected throughout much of its range and we receive relatively few bodies for analysis. To overcome this problem we have been analysing for contaminants in otter scats (spraints). The vast majority of the OC we measure in spraints is derived from the previous meal, i.e. that small proportion that is not assimilated. This can then be related back to intake and to build-up in tissues (MASON *et al.*, 1992).

On the River Lugg in western Britain we have data for PCBs in fish tissues and in spraints (MASON and MACDONALD, 1993a). There is a direct relationship between the mean PCB concentration in whole body mince of eels and trout and the mean PCB concentration in otter sprainsts at various sites down the river (**fig. 2**).

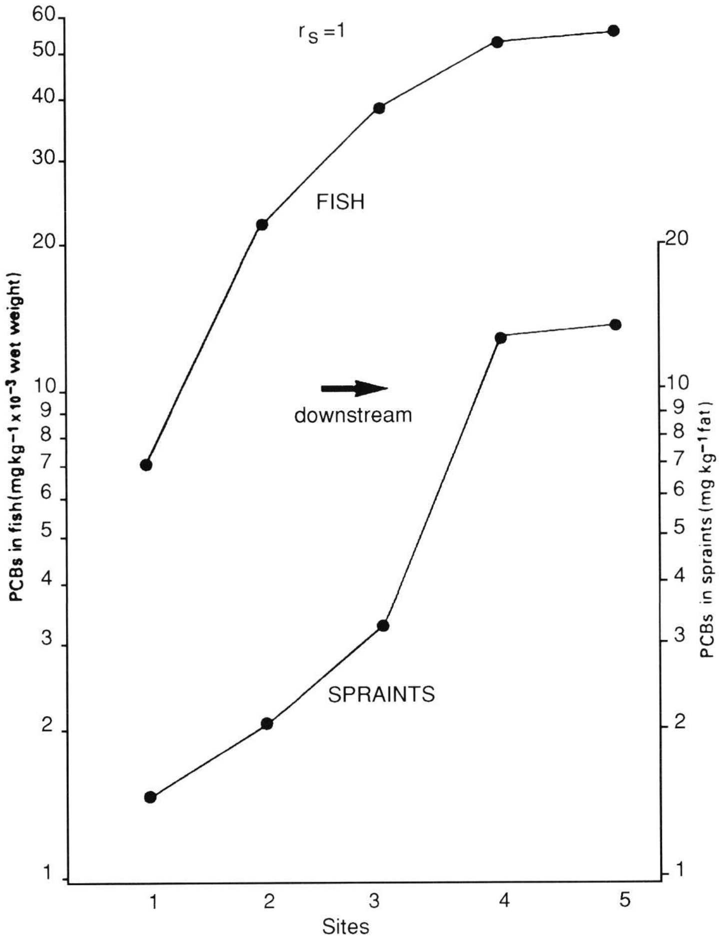

Fig. 2. Mean concentration of total PCBs in whole body mince of fish and in otter spraints at five stations on a Welsh river (from MASON and MACDONALD, 1993).
Concentrations moyennes en PCB totaux dans des homogénats de poissons et dans des épreintes de loutres récoltés en cinq sites d'une rivière du Pays de Galles (d'après MASON et MACDONALD, 1993).

Captive-bred otters were released onto the River Lea catchment just north of London in December 1991. A male animal was killed by traffic in January 1992 and had already accumulated 25 ppm PCB (lipid weight) in its tissues. There was a rapid increase in PCB contamination in spraints from the catchment in the six months following release (**fig. 3** ; MASON, 1992). We believe this reflected the increase in range of the animals after release as they moved downstream into an industrialized area. By March mean PCB levels exceeded 16 mg kg^{-1}, which we believe is equivalent to tissue levels associated with reproductive problems in experimental mink.

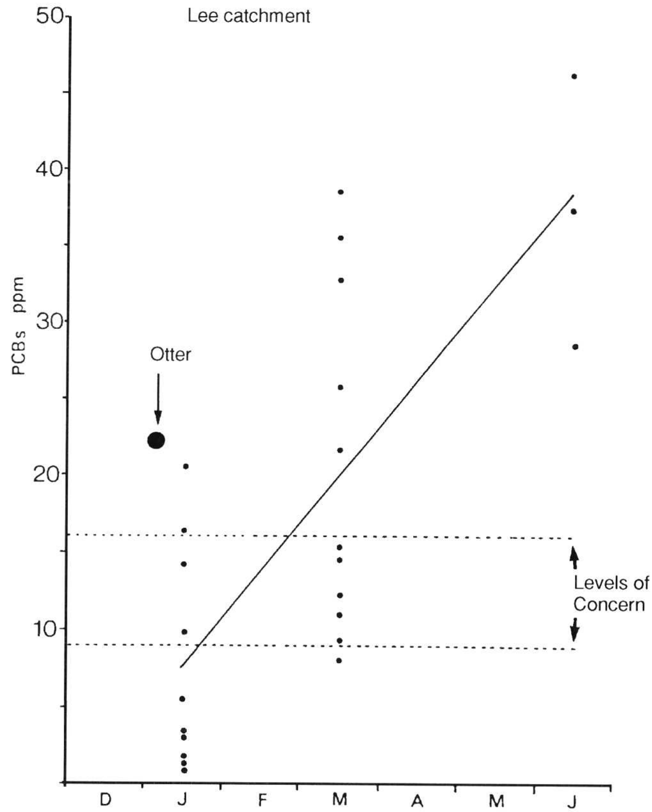

Fig. 3. Total PCB concentrations (mg kg^{-1}) in otter spraints collected from a tributary of the Thames, north of London, following a release of captive-bred otters there in December 1991. The otter was killed by traffic in a town in January 1992.
Concentration totale en PCB (mg/kg) dans des épreintes de loutre récoltées sur un affluent de la Tamise, au nord de Londres, à la suite d'un lâcher (décembre 1991) de loutres élevées en captivité. La loutre a été victime du trafic routier en janvier 1992.

We can measure PCBs and other OCs in spraints but we need to know how these may be impacting otter populations and, of course, counting numbers of otters on rivers is almost impossible. We have developed an index, combining the percentage of sites positive for otters with the intensity of marking (**table I**), i.e. the number of spraints per sprainting site (MASON and MACDONALD, 1993b). It takes account of seasonal changes in marking levels. We believe that this gives an assessment of performance. One of our study areas, the River Severn in upland Wales, has supported a thriving population over at least the past twelve years. The index is high and stable. Otters began to recolonize the downstream reaches of the river in the early 1980s but there is little evidence that the population is consolidating (**fig. 4**). Marking intensity is low and sporadic over much of the length (MASON and MACDONALD, 1993b). Most of a large sample of spraints from the upper Severn had organochlorine levels below our level of concern (9 mg kg^{-1}). Some 47 % of samples from the lower Severn exceeded our level of concern, i.e. could be associated with tissue concentrations causing reproductive problems (**fig. 5**). Several other rivers in this region have shown similar patterns, with thriving otter populations and low PCB levels in spraints from upland stretches but sporadic or low populations and high PCB levels in lowland stretches (MASON and MACDONALD, 1993b).

Table I. Annual index of otter population activity in a catchment.

1 = p/10 + 10 (log [x+1])
p = percentage of positive stations over all surveys in a year
x = mean number of spraints/sprainting site, calculated from all sprainting sites at all stations during that year

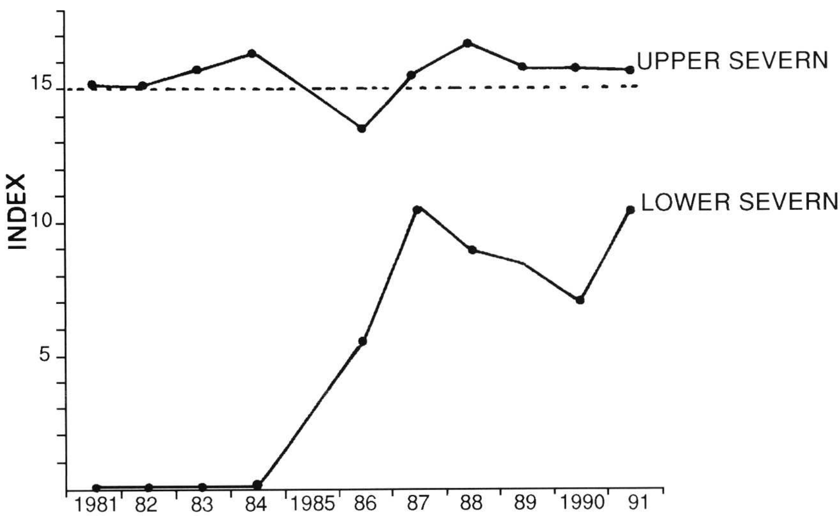

Fig. 4. Annual population index of otters in the Severn catchment, western Britain : a) upper Severn in Wales where otters were present throughout the study period and breeding regularly ; the value of 15 is the mean index and is considered as a target value for otters on oligotrophic rivers : 2) the lower Severn in England which otters recolonized in 1984 but where marking has remained low and sporadic.
Index annuel d'abondance de population de loutres dans le bassin de la Severn (ouest de la Grande Bretagne). Sur la Severn supérieure, aux Pays de Galles, la loutre est présente toute l'année et se reproduit régulièrement. L'index moyen (15) est considéré comme un objectif pour les loutres en systèmes oligotrophes. Sur la Severn inférieure, en Angleterre, le marquage est demeuré faible et sporadique après la recolonisation observée en 1984.

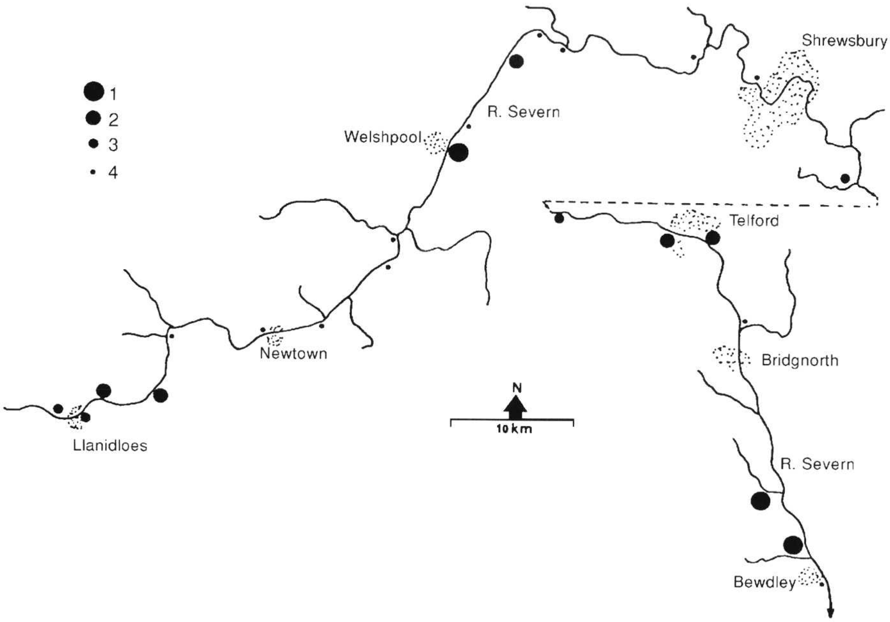

Fig. 5. Mean total concentration of contaminants in spraints (PCBs, Dieldrin and DDT at study sites) in the Severn catchment. The « lower Severn » is below Welshpool. Categories 1 and 2 are considered to be likely and probably associated with adverse effects on otters, while 4 represents background levels (see MASON and MACDONALD, 1993b for details).
Concentration totale moyenne des épreintes en contaminants organochlorés (PCBs, Dieldrin, DDT) dans le bassin de la Severn. La Severn inférieure commence à l'aval de Welshpool. Les catégories 1 et 2 sont probablement associées à des effets adverses pour la loutre alors que la catégorie 4 représente un bruit de fond (cf. MASON & MACDONALD, 1993b, pour les détails).

These studies involved detailed sampling and survey but we have also used the technique to provide regional fingerprinting of OC burdens in otters and to try to identify populations which may be at risk. For example, we surveyed the Clyde River and estuary in Scotland (MASON *et al.*, 1992). The upland reaches of the river had very low levels of PCBs in spraints (pesticides were not significant in this survey). As the river flowed into urban areas PCBs in spraints increased sharply. In the estuary, PCBs were high in samples from around naval bases and other centres of shipping activity and in the current system circulating from a major sewage sludge-dumping site.

Not only have these regional studies shown an increase in PCBs in spraints from downstream sites but also an increase in PCBs from west to east. This occurs, for example, in southern Ireland, even though levels throughout are generally low (O'SULLIVAN *et al.*, 1993), in south Scotland and northern England (MASON, 1993), in Wales (MASON and MACDONALD, 1993a), and south-west England (MASON and MACDONALD, 1994) while in eastern England, a majority of spraints have PCB levels of concern (**fig. 6** and MASON and MACDONALD, 1993c). This trend is also present in western France (MASON and

LODÉ, 1992). By contrast, across Germany there is an increase in PCBs in spraints from east to west (REUTHER and MASON, 1992). These data fit in with the pattern of industrialization and prevailing winds (MACDONALD, 1991).

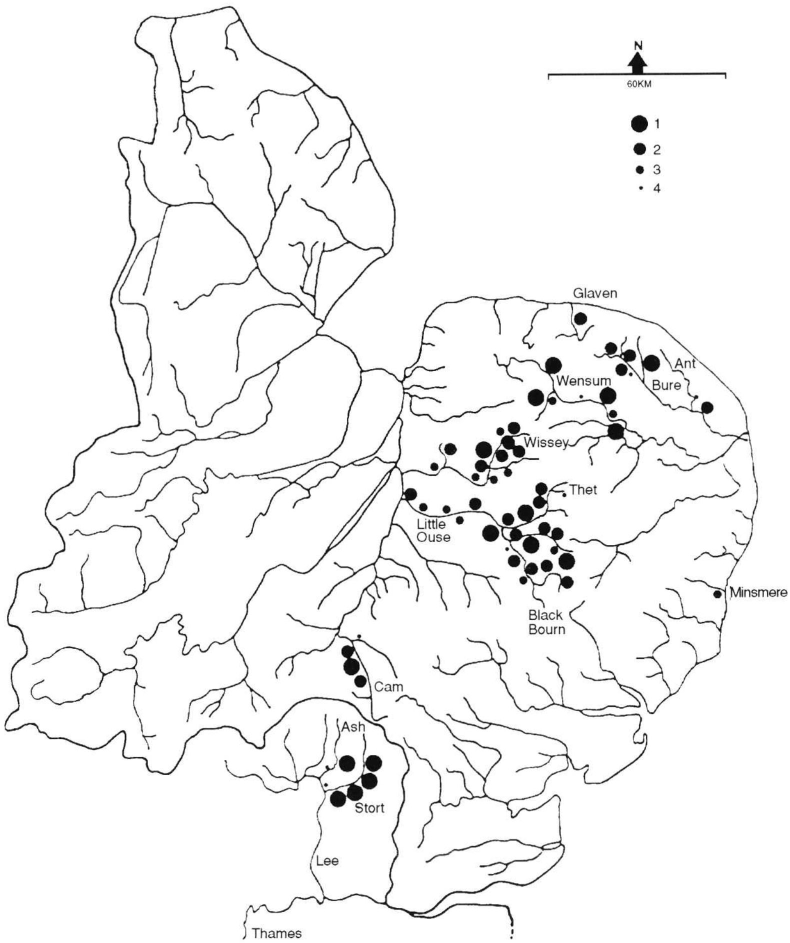

Fig. 6. Mean concentrations of contaminants in spraints from eastern England, where the otter population is largely, if not entirely, reintroduced. Symbols as in **fig. 5**.
Concentrations moyennes de contaminants dans des épreintes récoltées dans l'est de l'Angleterre où la population de loutres est largement dominée par des individus réintroduits. Symboles comme à la ***fig. 5***.

There is a strong negative correlation between mean PCB concentration in spraints from individual catchments in Wales and both the proportion of sites where otter signs are found and the sprainting intensity (MASON and MACDONALD, 1993a). The higher the concentration of PCBs in spraints, the less evidence of otters is found in the catchment. These correlations were strong in spite of other factors which might influence marking intensity, such as habitat or season (MACDONALD and MASON, 1983 ; 1987). There was no such correlation with organochlorine pesticides. The mean concentration of PCB in spraints also correlated strongly with levels in eggs of *Cinclus cinclus* reported by ORMEROD and TYLER (1990). The negative relationship between catchment distribution and the mean PCB level in spraints holds for the seven regions in Britain for which we have data (see **fig. 7** and MASON, 1995).

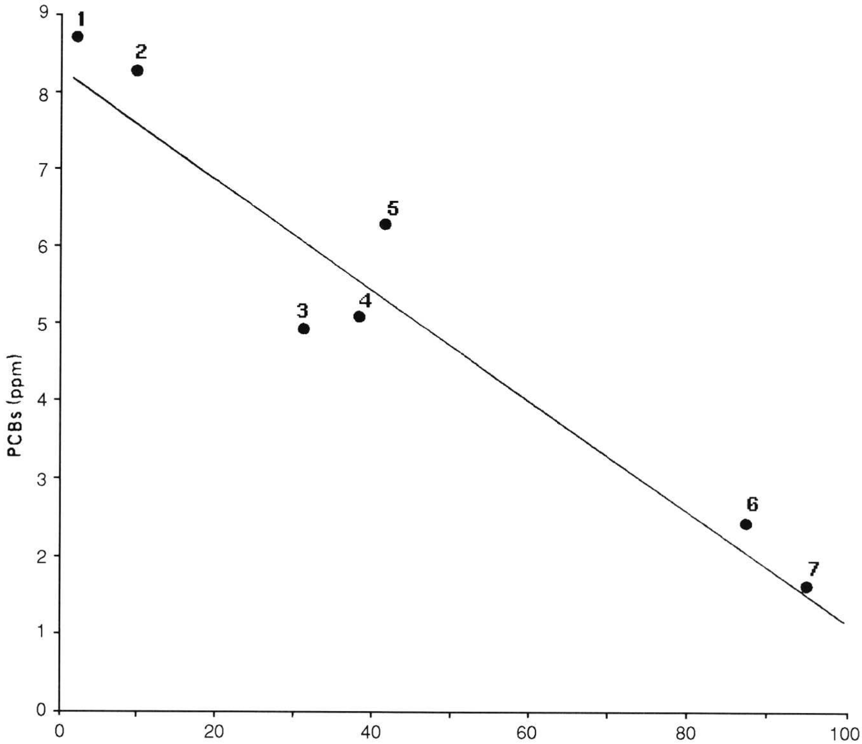

Fig. 7. The mean concentration of PCBs (mg kg^{-1}) in otter spraints from seven regions and the percentage of sites in the region positive for otters during the most recent national otter surveys carried out in the mid-1980s ($r = -0.96$, $p < 0.001$). There were no significant correlations with individual pesticides. 1, southwest Ireland ; 2, southwest Scotland ; 3, Wales ; 4, southwest England ; 5, east-central Scotland ; 6, northern England ; 7, east Anglia.
Relation entre la concentration en PCB (mg/kg) dans des épreintes de loutre et la proportion de sites « positifs » pour la loutre dans sept régions inventoriées lors du dernier recensement national (au milieu des années '80) (r = -0,96, p < 0,001). Aucune corrélation n'a été observée pour chacun des pesticides pris isolément. 1 : sud-ouest de l'Irlande ; 2. sud-ouest de l'Ecosse ; 3 : Pays de Galles ; 4 : sud-ouest de l'Angleterre ; 5 : centre-est de l'Ecosse ; 6 : nord de l'Angleterre ; 7 : Anglia est.

Table II. 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	< 10mg 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

Conclusions

Otter populations are still widely contaminated with OCs, especially PCBs and some populations may still be adversely impacted by them. Is there anything that we can do ? A first conservation step is to know when to demand action and that requires standards for the protection of otter populations. We suggest the following tentative standards for PCBs for protecting otters (**table II**). In otter spraints, < 4 mg kg^{-1} lipid weight is safe but > 9 requires action. A detailed derivation is given in MACDONALD and MASON (1994). The suggested standards for PCBs in fish are very similar to values developed by the Dutch after long-term feeding experiments on mink, so differing approaches have come to similar conclusions.

The statutory monitoring programme for river water quality carried out under EC law rarely detects the presence of PCBs or other bioaccumulating contaminants because they occur at exceedingly low levels in water but accumulate in the food chain, concentrations in top carnivores such as otters being up to ten million times those in water. The statutory monitoring programme is therefore totally inadequate for protecting otters against these contaminants.

The otter may have a good future in its current strongholds. However, as populations begin to expand into areas, especially lowlands, from which they were extirpated, they may run into contamination problems. In Britain, which may be typical of other western European countries, PCB levels alone may be sufficient to cause reproductive problems. The presence of additional compounds, such as metals and pesticides, exacerbate the effects of PCBs. It is therefore essential that any conservation strategy for otters takes food-chain contamination fully into account.

Such a requirement is particularly true of reintroduction and restocking projects. Contaminants were not adequately considered in the restocking projects in either East Anglia (MASON, 1992) or in the River Derwent (GREEN and GREEN, 1992 and 1995). GREEN and GREEN (1995) argue that they did not research contaminant levels because of the controversy over the precise role of contaminants in the otter decline, various authorities placing emphasis on PCBs (this paper), Dieldrin (CHANIN and JEFFERIES, 1978) and mercury (KRUUK and CONROY, 1991). It would thus be difficult to interpret analysis of fish tissues. This argument is seriously flawed on several counts. Firstly, although the controversy exists, there is a consensus that contaminants were responsible for the sudden and widespread decline of the otter so that, not to consider contaminants prior to the releases, was grossly in breach of IUCN and national policy on restocking projects. Secondly, there are standards from the various authorities against which to assess the significance of concentrations of different contaminants in fish so that, in a prudent project, each contaminant should have been separately assessed in an objective way. In contrast, GREEN and GREEN did assess both habitat quality and fish stocks, even though the minimum requirements of otters for these are not known (MASON, 1995) such that any assessment must have been entirely subjective. Thirdly, had the measurements been made and the restocked population expanded, as is claimed by GREEN and GREEN, we would have had an objective assessment of contaminants in fish which allow for reproduction in otters.

Otters may be unable to survive in some rivers which form the basis of our own domestic water supplies. In the U.S.A. it has been shown that retarded physical and behavioural development occurs in the children of mothers who have had only a moderate intake of fish, contaminated with PCBs, from the Great Lakes (JACOBSON and JACOBSON, 1993). Such links have not been searched for in Europe. The decline of the otter should be seen as a warning for what could occur in man.

BIBLIOGRAPHY

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

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

CHANIN P.R.F. & JEFFERIES D.J. (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.

FOSTER-TURLEY P. *et al.* (1990). — *Otters : an action plan for their conservation.* I.U.C.N., Gland, Switzerland.

GREEN R. & GREEN J. (1992). — The rehabilitation programme for orphans and injured otters of the Vincent Wildlife Trust, Great Britain. *In* : Reuther C. (ed.) : *Otterschutz in Deutschland. Habitat,* ***7*** : 147-151.

GREEN R. & GREEN J. (1995). — Ecological and Ethological requirements of the European otter. Experience of the reintroduction of the species in Britain. *Cah. Ethol.*, ***15*** (2-3-4) : 369-378.

JACOBSON J.L. & JACOBSON S.W. (1993). — A 4-year followup study of children born to consumers of Lake Michigan fish. *J. Great Lakes Res.*, ***19*** : 776-783.

JONGH A.W.J.J. de (1989). — Ecologisch onderzoek aan de otter in Nederland. *De Levende Natuur,* ***90*** : 40-43.

KEYMER I.F. *et al.* (1988). — Pathological changes and organochlorine residues in tissues of wild otters (*Lutra lutra*). *Vet. Record,* ***122*** : 153-155.

KLAMER J. *et al.* (1991). — Sources and fate of PCBs in the North Sea : a review of available data. *Wat. Sci. Technol.*, ***24*** : 77-85.

KRUUK H. & CONROY J.W.H. (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. and Röchert R. (eds.) : *Proc. V. Int. otter Colloqu., Habitat, **6*** : 1-3.
MACDONALD S.M. & MASON C.F. (1983). — Some factors influencing the distribution of otters. *Mammal Rev., **13*** : 1-10.
MACDONALD S.M. & MASON C.F. (1987). — Seasonal marking in an otter population. *Acta Theriol., **32*** : 449-461.
MACDONALD S.M. & MASON C.F. (1994). — *Status and conservation needs of the otter (Lutra lutra) in the Western Palearctic*. Council of Europe, Nature and Environment Series, Strasbourg.
MADSEN A.B. *et al.* (1992). — Odderens (*Lutra lutra* L.) forekomst i Danmark 1991 og adviklingen i bestnaden 1986-1991. *Flora og Fauna, **98*** : 47-52.
MASON C.F. (1987). — A survey of mercury, cadmium and lead in muscle of British freshwater fish. *Chemosphere, **16*** : 901-906.
MASON C.F. (1989). — Water pollution and otter distribution : a review. *Lutra, **32*** : 97-131.
MASON C.F. (1996).— *Biology of freshwater pollution*. 3nd. edition, Longman, London.
MASON C.F. (1992). — Machen Otter-Aussetzungen Sinn? Die Erfahrungen in Grossbritannien. *In* : Reuther C. (ed.) : *Otterschutz in Deutschland, Habitat, 7* : 57-62.
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. (1995). — River management and mammal populations. *In* : Harper D. and Ferguson A. (eds.) : *Ecological basis for river management*, pp. 289-305. Wiley, Chichester.
MASON C.F. & BARAK N.A.-E. (1990). — A catchment survey for heavy metals using the eel (*Anguilla anguilla*). *Chemosphere, **21*** : 695-699.
MASON C.F. & LODÉ Th. (1992). — Analyse de la concentration des résidus de pesticides organochlorés et PCBs dans les fèces de la loutre *Lutra lutra* dans la région des Pays de Loire. *Bull. Soc. Sc. Nat. Ouest de la France, **14*** : 109-113.
MASON C.F. & MACDONALD S.M. (1987). — Acidification and otter (*Lutra lutra*) distribution on a British river. *Mammalia, **51*** : 81-87.
MASON C.F. & MACDONALD S.M. (1989). — Acidification and otter (*Lutra lutra*) distribution in Scotland. *Water, Air, Soil Pollut., **43*** : 365-374.
MASON C.F. & MACDONALD S.M. (1993a). — PCBs and organochlorine pesticide residues in otter (*Lutra lutra*) spraints from Welsh catchments and their significance to otter conservation strategies. *Aquat. Conserv., **3*** : 43-51.
MASON C.F. & MACDONALD S.M. (1993b). — Impact of organochlorine pesticide residues and PCBs on otters (*Lutra lutra*) : a study from western Britain. *Sci. Total Environ., **138*** : 127-145.
MASON C.F. & MACDONALD S.M. (1993c). — Impact of organochlorine pesticide residues and PCBs on otters (*Lutra lutra*) in eastern England. *Sci. Total Environ., **138*** : 147-160.
MASON C.F. & MACDONALD S.M. (1994). — 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., **144*** : 305-312.
MASON C.F. *et al.* (1992). — Organochlorine pesticide and PCB contents in otter (*Lutra lutra*) scats from western Scotland. *Water, Air, Soil Pollut., **64*** : 617-626.
MASON C.F. & MADSEN A.B. (1993). — Organochlorine pesticide residues and PCBs in Danish otters (*Lutra lutra*). *Sci. Total Environ., **113*** : 73-81.
MASON C.F. & RATFORD J.R. (1994). — PCB congeners in tissues of European otter (*Lutra lutra*). *Bull. Environ. Toxicol. Chem., **53*** : 548-554.
MASON C.F. & O'SULLIVAN W.M. (1992). — Organochlorine pesticide residues and PCBs in otters (*Lutra lutra*) from Ireland. *Bull. Environ. Contam. Toxicol., **48*** : 387-393.
OLSSON M. *et al.* (1981). — Var ar uttern ? *Sveriges Natur, **6*** : 234-240.
ORMEROD S.J. & TYLER S.J. (1990). — Environmental pollutants in the eggs of Welsh dippers (*Cinclus cinclus*) : a potential monitor of organochlorines and mercury contamination in upland rivers. *Bird Study, **37*** : 171-176.
O'SULLIVAN W.M. *et al.* (1993). — Organochlorine pesticide residues and PCBs in otter spraints from southern Ireland. *Biology and Environment, **93B*** : 55-57.
REUTHER C. & MASON C.F. (1992). — Erste Ergebnisse von Kotanalysen zur Schadstoff-Belastung deutscher Otter. *In* : Reuther C. (ed.) : *Otterschutz in Deutschland, Habitat, **7*** : 7-21.
WREN C.D. *et. al.* (1987). — The effects of polychlorinated biphenyls and methylmercury, singly and combined on mink. II. Reproduction and kit development. *Arch. Environ. Contam. Toxicol., **16*** : 449-454.