Proceedings of the First Otter Toxicology Conference

Edited by J. W.H. Conroy, P. Yoxon and A. C. Gutleb

Isle of Skye
September 2000

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SCOTLAND

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Skye 2000

It is over ten years since a group of us thought there was a need to bring together those people throughout Europe who have been involved in otter toxicology. We felt it would be a good idea to get together and look at what we, as a group, were doing, and to decide some common approaches to techniques used, tissues sampled and how best to present data.

The gestation period for the meeting was long, but perhaps this was fortunate. In the intervening period, many new and innovate research projects have evolved and the role of pollutants has become integrated with other studies. For example recent work on diseases, the role of vitamin A, reintroductions etc.

The format of the conference allowed for several papers to 'set the scene' – an examination of the current status of the species in Europe; review the role of pollutants in the decline of the otter. Other papers presented new information including data from the 1970s in the UK (a critical period in the history of otter populations). Speakers examined the role of pollutants and diseases, as well as the potential of using DNA finger printing.

The aims of the meeting were to:

- Identify what future research might be required to determine pollutant impacts on otters;
- Determine common protocols for the collection, storage and analysis of otter tissues;
- Identify protocols for the post-mortem of otter carcasses;
- Try and develop a pan-European approach to the integration of pollutant research in otters.

These Proceedings are a result of the meeting. The papers show how far we have come in recent years regarding the role of otters and pollutants. It is clear that there are still many questions unanswered, however, we feel that this meeting made a start at addressing some of these.

It was agreed by all attending that the meeting was worthwhile and that we should consider a further meeting, also on Skye, in the not too distant future.

We are grateful to a number of people who helped make the conference possible. The financial support from Worldwide Fund For Nature, Skye and Lochalsh Enterprise and the Environment Agency ensured that we were able to invite a number of colleagues from eastern Europe and to ensure that the Proceedings are produced.

Can we also thank all who came to Skye; it was their conference and their input which made it a memorable event. We must also thank the staff at Sabhal Mor Ostaig who made us feel most welcome and looked after the inner needs of everyone! The young people from Skye and Lochalsh Feis who entertained everyone with their music and dance on the Saturday evening also deserve our thanks. And of course, Janet Wildgoose, of IOSF, who painstakingly compiled these Proceedings from their different formats.

Finally to the 'gods of Skye', a big thank you for giving us beautiful weather and the opportunity to see wild otters swimming along the coasts most mornings. For some, this was the first time they had seen otters in the wild!

Jim Conroy, Paul & Grace Yoxon and Arno Gutleb
IOSF
Broadford
January 2002

THE STATUS OF THE EURASIAN OTTER (*LUTRA LUTRA*) IN EUROPE – A REVIEW

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1 INTRODUCTION

The Eurasian otter (*Lutra lutra*) has been described as having *one of the widest distributions of all Palearctic mammals* (CORBET, 1966). Its range originally extended from Portugal in the west to Japan in the east, and from Northern Europe and Asia, to the southern shores of the Mediterranean. In Asia, it is found as far south as Indonesia (FOSTER-TURLEY and SANTIAPILLAI, 1990).

Over the past 40 years there have been marked declines in the number of animals throughout much of the otter's range, particularly in Western Europe, and concern expressed for the survival of the species in several countries.

This paper reviews the current status in Europe, other reviews on the status of the species in other parts of its range can be found in CONROY, MELISCH and CHANIN (1998) and CONROY and CHANIN (in press).

2 THE BRITISH ISLES

The otter was once widespread throughout the British Isles, and this is reflected by its inclusion in many early natural history books, the fact that bounties were paid on them and that hunts were organised as a sport and as a means of control, with in some areas dramatic effects.

Populations appear to have been still relatively healthy in the early 1950s (STEPHENS, 1957), but shortly afterwards the situation changed. There was a serious decline in numbers, which started suddenly about 1957/58, and occurred simultaneously throughout much of England, Wales and the Scottish Borders. CHANIN and JEFFERIES (1979) reviewed the situation and concluded that the factor most likely to have been responsible for these events was the introduction in 1956 of the organochlorine groups of insecticides, in particular the dieldrin (see also JEFFERIES and HANSON, 2001).

Detailed monitoring programmes have shown that following the decline in otter numbers over large areas of the UK, there has been, since in the late 1970s, a slow expansion of the animals' ranges over the last 15 years (Table 1). These have centred on those otter strongholds, which survived the population crashes of the late 1950s. There are, however, still large areas, particularly of Central and Southern England, where the species remains absent, or is very rare; but even in some of these there are occasional reports of individual animals being seen, suggesting a continuing expansion of the species range.

Table 1 Results of the three national surveys of England, Wales and Scotland

Country	Year	No. of sites	No. positive	% positive	Reference
England	1977-79	2,940	170	5.8	Lenton *et al.* (1980)
	1984-86	3,188	286	9.0	Strachan *et al.* (1990)
	1991-93	3,188	706	22.2	Strachan & Jefferies (1996)
Wales	1977-78	1,030	210	20.4	Crawford *et al.* (1979)
	1984-85	1,097	421	38.4	Andrews *et al.* (1993)
	1991	1,102	579	52.5	Andrews & Crawford (1986)
Scotland	1977-79	4,636	3,385	73.0	Green & Green (1980)
	1984-85[1]	2,650	1,717	64.7	Green & Green (1987)
	1977-79	2,650	1,511	57.0	Green & Green (1987)[2]
	1991-94	3,706	3,245	88.0	Green & Green (1997)
	1977-79	2,538	1,726	68.0	Green & Green (1997)[2]

1 Only areas which showed sub-optimal distribution in 1977-79 were surveyed
2 Data for the sites that were surveyed in 1984-85

STRACHAN and JEFFERIES (1996) and JEFFERIES (1997) reviewed the findings of the three national otter surveys, and concluded that should the current rate of recovery be maintained, a level of 75% occupation over all of Britain may be achieved by 2010, just over half a century following the population crash.

Shortly after the decline of the otter was reported in Britain, similar declines were recorded throughout much of Western Europe. (MACDONALD and MASON, 1990)

3 WESTERN EUROPE

Portugal, Spain, Andorra, France, Belgium, Netherlands, Luxembourg, Switzerland, Germany, Austria, Liechenstain

The otter is widespread and thriving throughout much of **Portugal,** with animals being found both on the coast and in freshwater habitats (TRINDADE, 1994; SANTOS-REIS, TRINDADE and BEJA, 1996). Since 1990, otters have been recorded as present in 171 10kmx10km UTM squares and at around 70% of the sites visited (RUIZ-OLMO *et al.,* 2001). The animals are most common in the north-east and south-west parts of the country and least common in the central area. Portugal could, therefore, hold one of the most important otter populations in Western Europe (TRINDADE, FARINHA and FLORENCIO, 1998). There is no evidence to suggest that the population is currently under threat, although SANTOS-REIS (1994) identified a new potential danger, periods without rain, resulting in many watercourses becoming dry in the summer. Also the damming of rivers has resulted in reduced water flow down stream (P.J. BEJA, *pers. comm.)* The species has been fully protected since 1974, but still subject to illegal hunting.

It was thought that there had been a marked decline in otter numbers in **Spain** since the mid 1960s (BLAS-ARITIO, 1978). In the early 1980s, however, it was still widely distributed in the west, but by the end of that decade was considered threatened in the east, and restricted in the Central Region (DELIBES, 1990).

A spraint survey of 3,966 sites throughout the country in 1984-85 found evidence of otters at just 1,327 (33.5%) (DELIBES, 1990). Signs of otters were most frequent in the north and north-west of the country: Galicia, Asturias, and in West Central Spain on the borders of Portugal, where there is also a healthy population (SANTOS-REIS, TRINDADE and BEJA, 1996). Fewest signs were found in the east, south-east and central part of the country, with Cataluña (3.1%) and Comunidad Valenciana (6.3%) being the lowest.

Recent surveys (1994 and 1996) have shown a recovery throughout much of the country. Of 4,198 sites visited, 2,082 had evidence of otters (49.6%) compared with 33.5% in 1984-85. Marked increases were found in five regions - Cataluña, Aragón, Asturias, Galicia and Western Andalucía, but declines were reported in others, including Navarra, the Basque country, Rioja and to the north of Castilla-León (RUIZ-OLMO and DELIBES, 1998). increases have also been reported from both the coastal and subalpine areas of the Pyrennes (RUIZ-OLMO, 1994).

There is, however, concern that damming of streams, particularly in the Mediterranean part of the country, will have an adverse effect on otter numbers (PEREZ and LACOMBA, 1991).

The otter was once found in **Andorra** (RUIZ-OLMO and GOSÁLBEZ, 1988), but is now thought to be extinct (RUIZ-OLMO *et al.,* 2001)

At the beginning of the 20th century, the otter was found in every region of **France** except Corsica, and remained common throughout the country until about1930 (ROSOUX *et al.,* 1996). Over the next two decades a decline occurred and since the 1950s the species has disappeared from 47 of the 95 French Departments. Otters are widespread in the area west of Brittany, south to the Pyrennes and in the Massif Central, but are absent from much of the north and east of the country (ROSOUX et *al.,* 1996).

There has been a recolonisation, in the area around the Massif Central, which started around 1984. In a survey carried out between 1989 and 1993, the otter was recorded as common in 11 Departments, all being around the Massif Central or in the western part of the country and it was sporadically seen in a further 16 Departments (ROSOUX *et al.,* 1996). The number of Departments without otters, however, continued to increase over the past 40 years, from 21 in the period 1930-1950 to 47 in the most recent survey (1989-1993). Recent surveys also confirm an expansion in Brittany which is now thought to contain about 25% of the country's otters (LAFONTAINE, 1993). More detailed information about the status of the species in certain parts of France can be found in GAUTIER, LIBOIS & ROSOUX (1996). The 1989-1993 survey recorded otters as occurring regularly in 192 10km x 10km UTM squares, and sporadically in a further 59 (from ROSOUX *et al.,* 1966). The species has been protected in France since 1972.

The otter was once common in **Belgium**. Such was the density of animals in Flanders that a campaign to eradicate the species was introduced in 1889, and over the next seven years more than 2,000 otters were destroyed (ANONYME, 1896). At the turn of the century around 300 individuals a year were being killed. During the 1960s numbers declined dramatically at most locations, and by the 1980s, only a few small relic populations were left (LIBOIS *et al.,* 1982; CRIEL, 1984, 1989). In the northern part of the country (Flanders), the species became extinct, although recently there have been occasional signs of animals. In the southern part of the country (Wallonie), a few animals continued to survive (LIBOIS *et al.,* 1982; METSU and VAN DEN BERGE, 1991; VAN DEN BERGE, 1998). OVERAL (1995) recorded that a small, but viable, population has existed, possibly for a number of years, on the Haute-Sûre, on the border between Luxembourg and Belgium. Between 1965 and 1969 game records showed otters to be present in 84 10km x 10km UTM squares.

Over the next 14 years evidence of otter presence dropped, and by 1984, the animal was recorded in only 50 squares (LIBOIS and HALLET, 1996).

The current state of the majority of Belgian rivers, heavily polluted and with few fish, means that they are considered unsuitable for otters (LIBOIS and HALLET, 1996). The species is fully protected in Belgium, and is listed in the Red Data Book (K. VAN DEN BERGE, *pers. comm.*).

The species is currently thought extinct in **Luxembourg.** Otters were, however, found throughout the country in the 19th century. Pressures from hunters and fishing interests convinced the legislators that the otter was *un pilland de poissons terrible*, and allowed otter hunting to take place. This lasted until 1955 and as a result the population was dramatically reduced. Although hunting ceased in the mid 1950s, and the species was protected in 1972, the population continued to decline (SCHMIDT and ADAM, 1992). The last otters were seen in 1995 in La Haute-Sûre Region (GROUPE LOUTRE LUXEMBOURG, 1997).

As early as 1940, the otter population in **the Netherlands** was thought to have reached an all time low of between 30 and 50 animals (BROUWER, 1940, 1942), and legislation was enacted to protect the species. By 1962, however, there had been a significant increase with an estimated 300 individuals distributed in five areas (VAN WIJNGAARDEN and VAN DE PEPPEL, 1970). As late as 1983, the species was considered to be widely distributed (VEEN, 1984). However, by 1988 otters were restricted to a few isolated areas (NOLET and MARTENS, 1989), and are thought to have become extinct shortly after this (WINTER, 1993). In recent years, signs of animals have been reported from some parts of the country (DULFER *et al.,* 1993).

In the early 1950s it was thought that there were 40-60 individuals in central and northern parts of **Switzerland** (KREBSER, 1959). The distribution of otters dropped from at least 50 localities in1960 to only one in 1989 (WEBER, 1990), this despite the reintroduction of eight animals in 1975 (WEBER, WEBER and MÜLLER, 1991). WEBER and WEBER (1991), however, suggested that as late as 1989, a small population, thought to be less than five animals, was living on the north-east shore of the Lake of Neuchâtel, but the species is now considered extinct.

In **Germany**, where the otter is fully protected by hunting law, the species is highly endangered in the old Federal Republic, with otters being rare or extinct in many of the federal states. Over 20 years ago, HODL-ROHN (1977) suggested that only one percent of the former otter population survived in both German Republics, however, she presented no information to support her statement, and only three years previously, RÖBEN (1974) had stated the population in the Federal German Republic (FDR) was nearly 500 animals. It is locally common in the former German

Democratic Republic, but even here, the distribution is becoming more restricted, possibly because of changes in land-use practices and the rapid increase in the volume of traffic in the former GDR following reunification in the late 1980s. The species is absent, for example, in the more lowland regions and along the Baltic coast (STUBBE, 1989; MACDONALD and MASON, 1990,1994; REUTHER, 1992; STUBBE *et al*., 1993). STUBBE and STUBBE (1994), however, reported that the species was now endangered and rare in the former GDR, with both populations and distribution area declining.

REUTHER (1980) examined the changing populations of otters in Lower Saxony over the past 100 years. Until about 1900, the species appeared to occur in relatively large numbers and was distributed fairly uniformly throughout the Province. Persecution, however, was taking its toll, e.g. between 1882 and 1913, bounties were paid for the bodies of over 8,000 otters in Hanover alone. By 1920, the species had become rare in the southern part of the province. This decline continued over the next 25 years. A second serious decline began in the 1950s and continued at least into the 1980s. Recent surveys in Lower-Saxony suggest that a recovery has taken place there in the past decade. Two hundred and twenty six sites were surveyed in 1991 and 1999. The number of positive sites increased from 2.2% in 1991 to 14.2% in 1999. In addition, there was a marked increase in the number of 10x10km UTM squares with evidence of otters, from 12.5% in 1991 to 43.8% in 1999 (REUTHER and ROY, 2001). REUTHER (1995) reported an east-west split in distribution, the species becoming rarer as one moved westwards.

The **Austrian** population is also expanding. In their account of the status of the otter in Austria, MACDONALD and MASON (1990) reported that the species was threatened. By 1997, A. KRANZ (*pers. comm.*) suggested otters were found in about 30% of the country. There are two main populations. The larger is found in the northern parts of Upper and Lower Austria and recent surveys have shown that this population is expanding southwards and has crossed the Danube (KRANZ, 1994). The smaller population, in the south-east of the country, expanded between 1986 and 1993-94; from 11.1% to 25.2% of the sites visited (SACKL, ILZER and KOLMANITSCH, 1996).

Both populations continue to expand (BODNER, 1994; GUTLEB, 1994) and there is some evidence that the two populations have made contact in the Northern Limestone Alps (A. KRANZ, *pers. comm.).*

A distribution map in GUTLEB (1994) shows definite evidence of otters in 39 10x10km UTM squares, with the possibility of otters in a further seven.

The otter in Austria is treated as a game species, but since 1947 has had all year round protection. It is listed as an endangered species in the Austrian Red Data Book (BAUER and SPITZENBERGER, 1994).

The otter is extinct in **Liechtenstein.**

4 SCANDANAVIA

Denmark, Norway, Sweden, Finland

The countries of Scandinavia have shown a slight increase in the range of the otter over the past few years. In **Denmark**, game bag statistics showed that otters had been killed all over the country with no apparent effect on the population (JENSEN, 1964). By 1967, however, concern was being expressed about the status of the species and it was granted full protection (SØGAARD and MADSEN, 1996). The otter population at the end of the 1970s was thought to be between 200 and 500 individuals (JENSEN, 1980). [This compares with a regular cull of around 200 animals per annum between 1941 and 1962 (JENSEN, 1964)] The critical state of the population was evident from surveys in the early 1980s when only 106 (9.2%) of 1,154 sites visited showed any presence of otters (MADSEN and NEILSEN, 1986), with the majority in Central and North-west Jutland. Six hundred and thirty three sites were visited in three surveys 1984-86; 1991 and 1995; the number of positive sites in each survey was 15.2%, 24.1% and 35.5% respectively (MADSEN and NEILSEN, 1986; HAMMERSHØJ *et al.,* 1996). Today the otter is still regarded as endangered, but MADSEN (1996) concludes that *after 10 years work, there are positive indications of a successful enhancement of the living conditions for otters in Denmark.*

The **Norwegian** populations are fragmented in the south, but large and widespread in the north, where it is widely distributed along the coast and inland in lower densities (HEGGBERGET, 1994). MYBERGET and FRØILAND (1972) showed that the species was already uncommon in the south, the decline continuing in many areas in the 1970s) (HEGGBERGET and MYBERGET, 1980). During the 1980s and 1990s the population in the north recovered to an estimated 10-15k individuals, while populations in the south of the country are considered fragmented, vulnerable and probably threatened (HEGGBERGET, 1996).

A survey of otters in 1989-1990 (CHRISTENSEN, 1995) indicated that the present distribution of otters in Norway is characterised by a metapopulation in the north (62^0N - 67 ^{0}30'N), where 85% of coastal sites surveyed had evidence of otters. The species had all but disappeared from along the south-eastern coasts 58 ^{0}N - $59^0$50'N where only 3% of 80 sites visited proved positive for otters. In the western provinces, between the northern and south-eastern areas, otters signs were found at 22.1% the sites visited, there was an increase in the number of sites with evidence of otters from south to north. The northern region is considered to hold a viable otter population.

Based on two survey in the mid1960s and 1970s as well as information from game bags, it was concluded that that the otter population in **Sweden** was declining, a decline which probably began around 1950 (ERLINGE, 1971; ERLINGE and NILSSON, 1978; ERLINGE, 1980). The decline, at least in part of the country continued, and by 1997 it was estimated that there were only 500-1500 otters in the country, which was less than the annual otter harvest for around 1950 (ERLINGE and NILSSON, 1978).

Surveys in the 1980s showed only 5% of 2,000 sites visited in southern part of the country with evidence of otters (OLSSON and SANDEGREN, 1986), while in Northern Sweden otters were evident in slightly more, 10% of the sites visited (OLSSON in MACDONALD and MASON, 1994).

More recent research, based on the otter reintroduction programme in Central Sweden has shown an expansion of the otter population, (SJÖÅSEN and SANDEGREN, 1992; SJÖÅSEN, 1996). There is evidence that the reintroduced otters are now in contact with the northern population and signs of otters are being found in areas where there have been none reported for nearly 20 years (T. SJÖÅSEN, *pers. comm*.). The species is classified as vulnerable in the central and northern parts of Sweden and endangered in the south (T. SJÖÅSEN, *pers. comm.*).

Historically, otters in **Finland** were found throughout the country, including the coasts and on small offshore skerries. In the late 19th century hunting bags of 1,000 animals a year were reported, but by 1910, bags had fallen to around 100 otters per annum, and this decline in the numbers killed continued over the next 20 years (WIKMAN, 1996). The otter was first protected in 1938, but the subsequent increase in numbers resulted in trapping being legalised again 12 years later, after which bags of 100-200 animals were reported annually. The population declined and, despite protection being reintroduced in 1975, and MACDONALD and MASON (1990) reported that populations were becoming more fragmented in some areas and absent in others. KAUHALA (1996) confirmed otter numbers declined in the 1970s, but increased again in the 1980s, with a marked increase in distribution between 1981 and 1991.

In Finland, otters are currently thought to be widespread, but with a patchy distribution (SKARÉN and KUMPULAINEN, 1986; HAGNER-WAHLSTEN and STJERNBERG, 1991), and while they are rare in the southern part of the country and in coastal areas, good populations are found inland in eastern and central parts of the country (SKARÉN, 1990). WIKMAN (1996) suggested that there are currently in excess of 1,000 otters in the country.

The most recent surveys, using snow tracking suggest decreases in otter numbers throughout much of the country over the period 1989-1997 (HELLE *et al*., 1997). There were, however, some noticeable increases in parts of the country during the early part of the 1990s. For example, in Central Finland, from snow tracks, SULKAVA and STORRANK (1993) and SULKAVA (1994) estimated that the population had increased from 25 animals in 1985 to 35-40 in 1993.

The overall picture, therefore, appears confused, with increases in some areas, decreases in others and some marked fluctuations over the past ten years. The species is classified as “declining, in need of monitoring” (U. SKARÉN, *pers. comm*.)

5 EASTERN MEDITERRANEAN AND BALKANS

Italy, Greece, Cyprus, Albania, Slovenia, Croatia, Bosnia and Herzegovina, Federal Republic of Yugoslavia (Serbia and Montenegro), Former Yugoslav Republic of Macedonia

The **Italian** otter population is endangered and its survival depends upon the conservation of the populations living in the southern part of the country (PRIGIONI and FUMAGALLI, 1992). In the early 1970s the species range already appeared to be highly restricted (CAGNOLARO *et al*., 1975), and in the first national field survey conducted in 1984 found only 6.2% of nearly 1,300 sites visited with evidence of otters. Less than 100 individuals were thought to survive (CASSOLA, 1986). Some areas have been surveyed more recently with differing results. In the Sele-Calore river catchments, for example, the population appears to be stable, while some populations in Southern Tuscany and Northern Latium showed apparently dramatic decreases by late 1990, and may even be extinct (CASSOLA, 1994). The persistence of otters in several water bodies in Campania, Basilicata and Calabria was confirmed in 1994, when 45% of 35 sites visited had evidence of otters; the local density and demographic trends of the species in these regions remain unknown (REGGIANI *et al*., 1997).

Otters were found on 50 water bodies, mainly in Southern Italy, during the period 1984 to 1994, with the population fragmented into five main groups (PRIGIONI, 1997). Based on an estimate of 1.4 otter/10km of river, and the assumption that the species is distributed along 950km of watercourses, he calculated about 130 individuals in the country. In Italy, the species had been legally protected since 1977 and is included in the national red data book as critically endangered (AMORI *et al*., 1996).

The otter is thought to be widespread throughout much of **Greece**, but particularly in the north-east. The distribution is, however, fragmented in some parts of the country, in particular the central area. A recent survey (1997) of the north-west part of the country found signs of otters at 63% of the 46 sites visited, suggesting the species is still relatively widespread (URBAN, 1998). In 1997, however, DELAKI *et al*. (1989) considered that otters had declined during the previous ten years. The species is still found along the north and east coasts of Corfu, but is absent from the west (URBAN, 1998). All year protection throughout the country was granted under the hunting laws in 1968.

Animals are still found along the north and east coasts of Corfu, but are absent from the west, where URBAN (1998) reported evidence of otters at 8 of 14 sites visited. On this island, the species is, however, considered endangered by tourist expansion and the traditional olive oil production (GRÉMILLET, 1993; URBAN, 1998).

The otter is not found on the island of **Cyprus** (SMIT and VAN WIJNGAARDEN, 1976).

Little is known about the distribution of otters in **Albania.** During the 1960s, the species was considered to be widespread in the country. In 1985, PRIGIONI, BOGLIANI and BARBIERI (1986) visited a small part of the country and found evidence of otters at nearly 55% of the sites examined. From this they concluded that the species was likely to be distributed throughout the country, but with some restriction of its range in the central area and coastal plain. URBAN (1998) reported that local fishermen persecute the species.

The situation in parts old **Yugoslavia** is difficult to determine because of the recent conflicts. MACDONALD and MASON (1990) reported that the species was found throughout much of the country, with the exception of the mountainous north-west area of the Adriatic coast. Inland, along the main rivers, the species was thought to be at a low density of extinct.

In Slovenia, the otter is considered rare. Enquiries in the 1980s (HÖNIGSFELD, 1985 *a* & *b*) indicated a decline throughout the country as well as a change in distribution over the previous decades. The main stronghold is in the north-east part of the country (Prekmurje), where the population is recorded as viable (HÖNIGSFELD, 1998). Of 74 sites surveyed in this area, between 1996 and 1998, 65 (88%) showed evidence of otters, while the sites with no evidence were considered as unsuitable for sprainting.

The species is listed as endangered in the Red List of Endangered Mammalia in Slovenia (KRYTSTUFEK, 1992). It has been fully protected since 1976, and is currently protected by the Order of the Government of the Republic of Slovenia under the Protection of Threatened Animal Species (1993).

Croatia - Rare along coastal strip, but relatively numerous in the northern part of the country (MACDONALD and MASON, 1994);

Bosnia and Herzegovina - Widespread and relatively numerous (MACDONALD and MASON, 1994).

Federal Republic of Yugoslavia (Serbia and Montenegro) - PAUNOVIĆ and MILKENOVIĆ (1994) concluded that the species was more widespread in these two republics than had previously been reported. Animals were found in most areas except for the central part of Serbia and West Central Montenegro. It is found along the coast, probably in small numbers up to 1,400m asl (PAUNOVIĆ and MILKENOVIĆ, 1996). The otter is currently protected (in Serbia since 1976 and Montenegro since 1982) as a 'natural rarity' under the hunting laws. This category has, however, become outdated, and hopefully the legislation will be revised, although it is expected that the otter will remain protected.

Former Yugoslav Republic of Macedonia - Widespread and relatively numerous in areas alongside Albanian border: rare elsewhere. M. PAUNOVIĆ (*pers. comm.*) confirms that the overall situation in the former Yugoslavia is of a general decline in numbers from east to west.

6 BALTIC REPUBLICS

Latvia, Lithuania, Estonia

In the Baltic Republics otters are widely distributed. Despite intensive hunting pressures, otters are widespread throughout **Latvia**, being found on most water courses (OZOLINŠ and RANTINŠ, 1992*a*), but with an uneven distribution. More dense populations are in the western and eastern parts of the country, with less dense populations in the north, north-east and on the coastal plain. ORNICANS (1994) detailed the changing otter population in Latvia this century, from around 500 individuals in 1914, numbers dropped to an all time low of 255 in 1947. This decline was associated with the rapid development of agriculture and land reclamation and persecution by fish and crayfish breeders (OZOLINŠ and PILÃTS, 1995). They increased to 2,370 in 1968, before declining again to 1,050 in 1982. Since then there has been a steady recovery, with the 1993 population being estimated at 4,000 animals. Between 1980 and 1987, the otter was included in the *Red Data Book of Latvia*, but was subsequently removed when it became clear from hunting returns that the species was numerous, It is thought that the successful re-establishment of the beaver in Latvia has benefited the otter (OZOLINŠ and RANTINŠ, 1995), the latter making use of the beaver lodges and fish ponds. OZOLINŠ and RANTINŠ (1992*b*) state that otters inhabit, at least for a short period, at least 50% of the Latvian lakes and over 80% of the rivers.

In **Lithuania**, the population is described as widespread, the species being found in all 44 regions of the country (MICKEVIČIUS, 1993). There was, however, evidence of a decline between 1969 and 1984, but since then the population has stabilised or increased. Based on a questionnaire survey it was estimated that there were 420 otters in the country in 1990 and 340 in 1991. According to K. BARANAUSKAS and E. MICKEVIČIUS (*pers. comm.*), the Annual State Wildlife Census suggested that there were 1,430 otters throughout the country in 1997, an increase of 130 from the previous year. These authors, however, feel that this number is rather low, and suggest a more realistic figure of between 3,000 and 12,000. A recent survey of 446 sections on 269 rivers found evidence of otters at 94% of the sites (BARANAUSKAS and MICKEVIČIUS, 1995). Beaver trapping is seen as a serious threat to the otter in this Baltic State, although even this danger has declined as the demand for beaver fur has diminished (BARANAUSKAS *et al.,* 1994). The species is classified in the *Red Data Book of Lithuania* (2nd edition, 1992) under Category 4, i.e. undetermined, insufficiently investigated.

At the beginning of the 20th century, the otter was considered widespread in **Estonia**, but according to LAANETU (1989), by the mid 1980s, the species was sparsely distributed throughout the country with an estimated population of only 600 individuals. Between 1920 and 1935, numbers dropped considerably, probably as a result of poaching (N. LAANETU, *pers. comm.*). Numbers slowly grew and, by the mid 1950s, the population was estimated to be 800-900 individuals, and had increased to over 2,000 by the 1960s, but numbers dropped by nearly 50% over the following eight years. This decline continued until about 1975, when it was thought that there were only 300-350 animals; since then numbers remained relatively stable for seven years after which there has been a slight increase with a count of around 550 in 1988. The species is now concentrated in eight districts which are not isolated (KILLI, 1991). The most recent estimates gave 1,400 -1,500 animals in 1993, but since then there have been a decline (N. LAANETU, *pers. comm.*). The species is currently protected, and is listed in the Red Book of Endangered Species.

7 EASTERN EUROPE

Czech and Slovak Republics, Poland, Hungary, Romania, Bulgaria, Belarus

There have been extensive surveys of the otter in the former Czechoslovakia, and these have continued in the newly formed **Czech** and **Slovak Republics**

In 1977/78, BARUŠ and ZEDJA (1981) identified 342 localities where otters were present in **Czechoslovakia**, and estimated that the minimum number to be 174 individuals. TOMAN (1992) reported the results of the most recent surveys using both snow tracking and spraints. He estimated 300-350 animals in the **Czech Republic** in three isolated populations - a small one in the north extending to the

German border, another, in the east, joining with Slovakia and a third, the main centre of otter activity, in the South Bohemian fish pond area, a population that extends into the Austrian Waldviertel. He suggested that about 25% of the country is occupied by otters, and that numbers have increased slightly over the past five years. In *The Atlas of Mammals of the Czech Republic*, three or four populations are identified, numbering 350-400 individuals (ANDĚRA and HANZAL, 1996).

In **Slovakia**, the status seems unclear, (KADLEČÍK, 1994) regarded the species to be seriously endangered, but the same author (KADLEČÍK, 1992) had earlier stated the species was still widely distributed, with the main population in the central and eastern parts of the country. URBAN (1992) reports a marked drop (70%) in otter numbers in part of Pol'ana, Slovakia over the previous quarter of a century, but showed that the population then remained stable in the area up to 1995 (URBAN, 1995). Following the most recent survey in 1994-1995, KADLEČÍK and URBAN (1997) concluded that there had been no major changes in otter distribution over the past 20 years, the species had, however, occupied new parts of the country.

In the Czech Republic the species has been protected since 1949, but in 1996 was listed in the new hunting laws, with a year-long open season. Thus the otter is currently subject to two conflicting laws, although the former still ensures the animals' protection (A. TOMAN, *pers comm*.). The species is listed as "endangered" in the *Red Data Book* (BARUŠ, 1989). In Slovakia, the otter is strictly protected under the Act on Native and Landscape Conservation, and is listed as "vulnerable" in the Red Data Book (ŠTOLLMANN, *et al*., 1997).

In **Poland**, BUCHALCZYK (1983) reported that the otter was still numerous, but several other reports published in the early 1980s indicated a decline of otters throughout the country (ROMANOWSKI, 1984; BIENIEK, 1988). The species was described as rare and endangered in the Polish Red Data Book (BIENIEK, 1992). Between 1991-1994, evidence of otters was found throughout Poland, with nearly 80% of over 2000 sites visited showing presence of the animal (BRZEZIÑSKI and ROMANOWSKI, 1997), this represents one of the highest percentages of positive sites of otters in continental Europe. Only two areas, Silesia and Central Poland had few signs of the species (BRZEZIÑSKI and ROMANOWSKI, 1994; BRZEZIÑSKI *et al*., 1996). The last named authors reported increases throughout much of the country, including the capital Warsaw. They attributed the increase to a reduction in the effluent entering the water, and possibly the increase in beaver numbers. Summarising the national otter survey, BRZEZIÑSKI and ROMANOWSKI (1997) concluded that the species is widely distributed throughout Poland and should no longer be considered endangered in the country. More recent surveys in 1996 showed that the otter continues to expand its range, with positive signs of otters (54%) in an area of Central Poland and the city of Warsaw that had no evidence of otters in survey of the early 1990s (ROMANOWSKI, GRUBER and BRZEZIÑSKI, 1997).

The **Hungarian** otter population is thought to be stable, but there has been a decline in the area east of the Danube (NECHAY, 1980). A large-scale questionnaire survey in 1995/96 showed that out of 464 10x10 km UTM squares, otters were living permanently in 333 (72%) (EGYETEMES LÉTEZÉS TERMÉSZETVÉDELMI EGYESÜLET KLUBJA, 1997), a slight drop from the 1987-88 survey, where the species was recorded in 86% of the sites visited (KEMENES, 1991). The population was reported as being stable, but growing. There was, however, concern about illegal killing (EGYETEMES LÉTEZÉS TERMÉSZETVÉDELMI EGYESÜLET KLUBJA, 1997). The species was given "strict" protection in 1978, but legal killing of individuals can be sanctioned after it has been established that they have been responsible for damage (RAKONCZAY, 1990; LANSKI and KÖROMENDI, 1996).

There are few data from **Romania.** Numbers declined from 2,050 in 1950 to 1,550 in 1991 (WEBER in MACDONALD and MASON, 1994). GEORGESCU (1994) reported that the species was found throughout the country, from sea level to the subalpine zone (1,700m asl) but that the population had declined from 2,180 in 1980 to 920 in 1993. IONESCU and IONESCU (1994) also reported a decline in population, in this case, between the delta of the Danube to the Carpathian Mountains, from *ca.* 3,200 animals in 1955 to *ca.* 1,700 in 1994. There are obvious discrepancies in the estimated number of otters, but the important feature is that they have all shown declines over the past 25-30 years, and the species is considered endangered.

According to SPIRIDONOV and MILEVA (1994), the **Bulgarian** population is considered to have been stable for the previous 15 years, and numbers 1,000 to 1,400 animals. They are widely distributed throughout the country from sea level to about 1,400m asl. MACODNALD and MASON (1994), however, report that numbers have declined since the 1950s, with increases in some areas. The species is currently considered "endangered" and has been protected since 1962 (ROMANOWSKI, 1991).

The otter in **Belarus is** widespread, and, since 1995 can only be hunted under license. Numbers were thought to have stabilised over the period 1984-1989, except for a slight decrease in numbers in the south-west of the country, and in areas of high human population (SIDOROVICH, 1991). The population was estimated as being nearly 12,000 individuals between 1984 and 1988; this had dropped to 7,000 by 1989-1991, the decline caused principally by large scale poaching (SIDOROVICH, 1991; SIDOROVICH and LAUZHEL, 1992). It is currently estimated that the average density of otters on the country's rivers varies between 1.7 and 4 individuals per 10 km of river in protected areas to between 1.2 and 2.0 in exploited areas.

8 CIS RUSSIAN FEDERATION

The **CIS Russian Federation** extends from Eastern Europe through Asia to the Pacific Ocean. Within this area are many republics and provinces. Information from such a vast country is, as would be expected, patchy. For the sake of this review, we review the status of the species throughout the country and in its associated republics. The otter is distributed throughout the country with the exception of the tundra. It became extinct on the Kuril Islands at the beginning of the 20th century and more recently has disappeared from many waterways in the regions of Krasnodar and Kursk (BYTCHKOV and CHACHIN, 1994). In the European sector, the otter population is thought to have been stable over the past decade, but overall numbers have declined by 30-40% since the 1930s and 1940s when the population was thought to number 80,000-100,000. The species has been confirmed in the Zabaikalsky National Park, Lake Baikal, Siberia (KRANZ *et al*., 1995), from Sakhalin Island, Kargasoksky District (Tomskaya Region), Todzhinsky District (Tuvinskaya Autonomous Region) and the mid-reaches of the Pur River (Tyumenskaya Region), while the status in Northern Magadan district, Chukotka and Koryak is unknown (ZHOLNEROVSKAYA *et al*., 1994). Otters are rare in **Tajikistan** and **Uzbekistan** (ANON, 1983; ZHOLNEROVSKAYA *et al*., 1994; PERELADOVA, KREVER and WILLIMAS, 1997). They are also reported in **Turkmenistan (**MAROCHKINA, 1995), **Kazakhstan (**ANON, 1977) and the Far Eastern **Primorye Province** (R. MELISCH, *pers. comm.*).

On the basis of census returns, ROZHNOV and TUMANOC (1994) estimated the Russian population to be in the region 60,000 individuals in 1987 - 27,000 in the European sector; 3,500 in the region of the Urals and 30,000 in the Asian sector. There is a decrease in density from west to east. Between 1991 and 1995 numbers dropped from 60,400 to 52,600 animals, a decline of 13% over the five-year period. Declines were recorded in all but one of the 12 regions listed, with the greatest decline 17.5% in the Far East (BORISOV, 1996).

At present the species is protected in some, but not all of the republics, including Kazakhstan, Turkmenistan, Tajikistan, Uzbekistan, Kirghiztan. It is considered rare in both Tajikistan and Uzbekistan (PERELADOVA, KREVER and WILLIMAS, 1997).

Two sub-species *L. l. seistanica* and *l. l. meridionalis* were listed in the *Red Data Book of the USSR* (Vol. 1) published in 1984.

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THE ROLE OF POLLUTANTS IN THE DECLINE OF THE OTTER

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1 Introduction

Populations of Eurasian otters (*Lutra lutra*) suffered serious declines during the past decades in many parts of Western Europe and in some areas the species has become extinct (for recent review see CONROY and CHANIN, 2001). Apart from factors such as habitat destruction, isolation of populations, mortality due to hunting, traffic accidents or drowning in fish fyke nets, the contamination of the diet and the otters themselves are considered as important causal factors with mercury, dieldrin and polychlorinated biphenyls (PCBs) named most frequently (MASON, 1989; KRUUK and CONROY, 1991; JEFFERIES, 1996; SMIT *et al*., 1998).

In this paper, a review on chemical properties, technical use, general toxic effects of mercury and PCBs and specific information on what is known in respect to otters will be given. For dieldrin such a review is given by JEFFERIES AND HANSON (2001).

2 COMPOUNDS AND THEIR EFFECTS ON OTTERS

2.1 Mercury

Mercury, a heavy metal, is naturally present in the environment at concentrations of up to 0.08mg/kg in most soils, with higher concentrations found near areas of volcanic activity. Some 800 metric tons are released every year due to natural erosion. Most is transported bound to particles into the oceans (GAVIS and FERGUSON, 1972). Human activities, both historical as well as the present industrial, agricultural and consumer uses, have produced and emitted mercury into the global environment for several centuries (KAISER and TÖDL, 1980). In addition, human influences, such as mining and acidic depositions due to sulphate emissions, increased the mobility for mercury, resulting in a potential increase in exposure of wildlife.

Mercury has been used for many applications including dyes and pesticides, production of chlorine, for laboratory purposes, as a catalytic agent in many chemical processes, as well as a drug and in dentistry. At a local level the use of elementary mercury for gold mining forms a specific threat to humans and wildlife (GREER, 1993). The use of elementary mercury for the process of amalgamation during gold mining forms the major input of mercury in South American countries (GUTLEB, SCHENCK, and STAIB, 1997).

Mercury is unique among the heavy metals in that it can exist in several physical and chemical forms. It is liquid at room temperature, and in the environment two ionic states - mercury (I) and mercury (II) can be found. Both are water-soluble. They are therefore bioavailable, and can be converted into organomercury compounds, which are more toxic than inorganic forms. Elementary mercury is vaporised very easily and is thereby transported via the atmosphere. It returns to earth as a water-soluble form in precipitation, finding its way into lakes and oceans. Whereas this cycle mainly contributes to the long-range transport of mercury there is a second, more local, cycle that depends on the methylation of mercury into organic forms due to the biological activity of bacteria and algae. This is especially the case under tropical conditions such as low pH and low salinity, which favour the formation of dimethylmercury. This can be concentrated in fish and other aquatic organisms as a result of biomagnification and bioaccumulation (BOENING, 2000). In addition, average mercury concentrations in fish were found to increase steadily following the elimination of selenium-rich discharges of fly ash into a water-system (SOUTHWORTH, PETERSON and RYON, 2000). MASON, LAPORTE and ANDRES (2000) were able to show the importance of water chemistry in determining the bioaccumulation of mercury into insects and thereby into higher trophic levels. The passive uptake of methylmercury does not control bioaccumulation at the base of aquatic food webs and methylmercury concentrations at higher trophic levels reflect uptake at low trophic levels and other factors, such as diet and growth (WATRAS *et al*., 1998).

In adult mammals 1% to 3% of ingested inorganic mercury is resorbed in the gut. Juveniles, however, are especially threatened because 30% to 40% can be resorbed. Methylmercury is resorbed more or less completely from the diet (KOSTIAL *et al*., 1978). It is also the position in the food chain, which determines the risk of mercury exposure in wildlife. Carnivores tend to accumulate higher concentrations of mercury than herbivores, and fish-eating animals more than meat-eating animals (WREN, 1986).

The global cycling of released mercury has increased concentration even in remote areas. In mammals from the Canadian Arctic marine ecosystem increased levels of mercury in samples from the 1990s were found when compared with samples from the early 1980s, thus giving evidence that mercury levels continue to increase (MUIR *et al*., 1999). Although mercury is not used in the Arctic region, levels found in the traditional diet of Inuit are so high that dietary advice for Arctic people has been recommended (HANSEN, 2000). In addition, over the last 20 years there is evidence of increasing levels of mercury in animals living in Greenland (RIGET and DIETZ, 2000).

Methylmercury is more or less found exclusively in seafood and freshwater fish and is known to be a highly neurotoxic agent. In this form, mercury is readily transported across the placenta, in contrast to the inorganic form, which has a low transport into the foetus (KAJIWARA *et al*., 1996). The behavioural and cognitive changes associated with effects on the central nervous system and preclinic kidney changes are the symptoms which are of most concern today. The classical triad of symptoms, erethism, tremor and gingivitis are now rarely found outside humans living near gold-mining areas (DOLBEC *et al*., 2000).

Because of the high affinity between mercury and sulfhydril molecules, interaction between mercuric ions and the thiol groups of proteins, peptides and amino acids such as albumin, metallothionein, glutathione and cysteine occur. These mechanisms have all been shown to be involved in the proximal tubular uptake and accumulation, transport, and toxicity of mercuric ions in the kidney (ZALUPS, 2000). Mercury compounds often exerted clastogenic effects in eukaryotic cells, acting as a spindle inhibitor, thereby causing c-mitosis and consequently aneuploidy and/or polyploidy (DE FLORA, BENNICELLI and BAGNASCO, 1994). Selenium has a protective effect against mercury intoxication. KOEMAN *et al*. (1973) reported on a 1:1 correlation between selenium and mercury in marine mammals, whereas metallothioneins appear to play a minor role in the binding and detoxification of mercury by marine mammals (DAS, DEBAKER and BOUQUEGNEAU, 2000). Among other effects mercury is also able to inhibit the coupling process of iodide in the thyroid gland resulting in changes of the thyroid homeostasis (NISHIDA *et al*., 1986), which is also influenced by several other xenobiotic such as PCBs (BROUWER *et al*., 1998).

2.2 Mercury and otters

Liver concentrations in otters have been reported from many countries such as Sweden (4.1 - 30.7µg g^{-1}, OLSSON, REUTERGÅRDH and SANDEGREN, 1981), Finland (0.05 - 31.0µg g^{-1}, SKARÉN, 1992), Orkney Islands (1.0 - 20.3µg g^{-1}, MASON and REYNOLDS, 1988), Spain (3.92 - 17.48µg g^{-1}, HERNANDEZ *et al*., 1985), and Ireland (0.15 - 17.03µg g^{-1}, MASON and O´SULLIVAN, 1993) and in general these levels are considered to represent the range of background levels.

Experimentally dosed Canadian river otters (*Lutra canadensis*) died with symptoms of mercurialism and mean total mercury levels of 33.4µg g^{-1} were found in their livers (O´CONNOR and NIELSEN, 1981). WREN (1985) reported on an otter (*Lutra canadensis*), which was found dead near to a river known to be severely mercury polluted. A concentration of 96µg g^{-1} mercury was found in the liver. The tracks indicated that the otter showed erratic behaviour such as travelling in circles, falling over and burrowing into the snow before dying. Two otters from the Shetland Islands were observed dying with similar symptoms and later liver concentrations higher than 30µg g^{-1} were analysed (KRUUK and CONROY, 1991). WOBESER and SWIFT (1976) reported on a mink (*Mustela vison*), which died due to mercury intoxication with a similar liver concentration. GUTLEB *et al*. (1998) reported a concentration of 55.6µg g^{-1} in the liver of an otter from the Czech Republic. Most animals of which data have been published are road victims and no observations on their behaviour prior to death are made. Therefore it cannot be excluded that negative effects of mercury occur at least on single individuals within otter populations as tissue concentrations were exceeding critical tissue concentrations.

2.3 Polyhalogenated aromatic hydrocarbons (PHAHs)

Over the past three decades intensive research on the toxic effects of polychlorinated dibenzo-p-dioxins (PCDDs), dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs) has taken place. The ubiquituos presence of members of these groups of persistent compounds has been widely documented (TATTON and RUZICKA, 1967; TANABE *et al*., 1983, 1987; TANABE and TATSUKAWA, 1986; VOOGT and BRINKMAN, 1989; KLEIVANE, SEVERINSEN and SKAARE, 2000). They belong to the large group of polyhalogenated aromatic hydrocarbons (PHAHs) and cause a broad range of toxic effects in different vertebrates, e.g. dermal-, hepato- and immunotoxicity, carcinogenic, teratogenic, neurobehavioural and endocrine effects as well as diverse biochemical responses especially the induction of several drug metabolising enzymes (SAFE, 1994; KIMBROUGH, 1995). A detailed description of the mechanisms involved in toxic effects of PHAHs, especially those related to retinoid homeostasis is given by GUTLEB and MURK (2001).

2.4 PCBs and otters

The first suggestion that polychlorinated biphenyls (PCBs) played a major role in the decline of otters in Europe was made by SANDEGREN, OLSSON and REUTERGÅRDH (1980), OLSSON *et al.* (1981) and OLSEN and SANDEGREN (1991). This assumption was based on an observed correlation between the status of the population and the total concentration of PCBs in otter tissues. Low concentrations of PCBs were found in a thriving population in Norway and high concentrations in a threatened and declining population in Southern Sweden. This hypothesis was further supported by an extrapolation of toxicological data of PCBs for mink (JENSEN *et al.*, 1977). Later, other authors (MASON, 1989; BROEKHUIZEN, 1989) have suggested similar relationships. Also, in the North American Great Lakes region, populations of Canadian river otters and American mink declined in areas (along the Great Lakes) where the diet of the mustelids (fish) is highly contaminated with PCBs (WREN, STOKES and FISCHER, 1986; WREN, 1991; GIESY *et al.*, 1994). However, high levels of total PCBs have been reported in a thriving otter population in Shetland (KRUUK and CONROY, 1991; KRUUK, CONROY and CARSS, 1993).

LEONARDS *et al.* (1996) conducted a study to investigate the concentrations and patterns of di-, mono- and non-*ortho* substituted CBs in autopsy material from different otter populations of Europe in relation to biological factors such as age, sex and reproductive status. The second aim of their study was to investigate if the health status of the otter was affected by contamination of CBs based on an extensive database for the Danish population. Experimental studies with several species have shown that CBs can affect the immune responses, and that immunosuppression is caused by non- and mono-*ortho* CBs, which are mediated by the *Ah*-receptor (DAVIS and SAFE, 1990).

The following questions will be answered:

- Are there regional differences in the PCB patterns in otters?
- Are there differences in the pattern of PCBs within a population?
- Are PCB concentrations declining in otters?
- Is there a relation of the health status of Danish otters in relation to the concentration of PCBs?
- Are PCBs now to be blamed for the decline of otters?

2.4.1 Are there regional differences in the PCB patterns in otters?

Principal component analysis was used to compare the CB patterns in otters from the Czech Republic, Denmark, Ireland, The Netherlands and the United Kingdom (LEONARDS *et al.*, 1996). It was shown that the samples from the different countries could not be separated from each other. This indicates that the variation in CB pattern between otters is larger than the variation between countries.

In the same study it was shown that there are two clusters of CBs (LEONARDS *et al.*, 1996). One contains the CBs (CB 28, CB 31, CB 44, CB 52, CB 77, CB 101 and CB 149), and the other cluster contains the persistent congeners. This indicates that the main separation factor in CB patterns between the otters is due to the differences in the relative concentration of metabolisable and persistent CBs, and that no large differences can be observed in CB patterns between the countries. This implies that other factors such as age, sex, condition of the animal, reproduction status, the biological differences between animals and a concentration dependent metabolism (TANABE *et al*., 1987; WELLS *et al*., 1994; WELLS, MCKENZIE and ROSS, 1996; BOON *et al.*, 1997) are important to explain the differences in CB patterns between otters.

2.4.2 Are there differences in the pattern of PCBs within a population?

CB patterns of the metabolisable congeners (CB 28, CB 31, CB 44, CB 77, CB 101 and CB 149) between otters were not constant. This in contrast with the CB patterns of the persistent congeners, which are more or less constant between the otters. The ratios of the metabolisable CBs decrease with increasing concentration of the persistent congeners. A decreased ratio for the metabolisable congeners is observed with increasing concentration of CB 153. However, for the relative concentration of CB 180, which is a persistent congener, there is no relationship with the concentration of CB 153.

An increased induction of isozymes of cytochrome P450 due to an increased absolute concentration of CBs has been proposed as explanation for the concentration dependent metabolic process (LEONARDS *et al*., 1996). A consequence of this process is that otters exposed to high concentrations of CBs are not only exposed to "high" concentrations of the parent compound but also to relatively high concentrations of CB-metabolites. Hydroxylated CB-metabolites interfere with, for example, retinol and thyroid hormone homeostasis (BROUWER *et al*., 1994).

2.4.3 Is there a relation of the health status of Danish otters in relation to the concentration of PCBs?

From 145 Danish otters (MADSEN *et al.*, 1999), 43 were analysed for non-, mono- and di-*ortho* substituted CBs. Toxic equivalent concentrations (TEQ) were calculated by multiplying the toxic equivalent factor of SAFE (1994) for each non- or mono-*ortho* CB with the corresponding concentration. Furthermore, the sum of the individual TEQ concentrations was calculated (ΣTEQ).

For each exposure TEQ-group the percentage of diseases, which consists of bacterial diseases, viral infections, endoparasites and pathological changes was calculated (Table 1). In the first TEQ-group 17% of the otters had a disease. In the second group a higher percentage of disease (29%) was found. A further increase of the percentage of diseases to 33%, was found in the third group. In this group some otters had multiple diseases, which were less observed in both other groups. The number of diseases per sick-otter increased from one in group 1 to 2.25 in the highest TEQ-group. The diseases in the third group were a tumour in the intestine, hepatitis, gal stone, enlarged liver (10% of body weight), umbilical hernia and deformed uterus. The tendency of increased incidence of diseases with TEQ concentration however, is not significant ($p>0.05$), which is probably due to the low number of otters ($n = 43$).

These data suggest that an increased percentage of diseases are associated with increasing concentrations of PCBs, which may be caused by immunosuppression in the otter. This is further supported by a recently reported dose-effect relationship between vitamin A (retinol or retinylpalmitate) in the liver and the concentration of CBs on TEQ basis for otters (MURK *et al.,* 1996). Vitamin A plays an important role in resistance to microbial infections (HOF and WIRSING, 1979; NAUSS, MARK and

SUSKIND, 1979; SHENAI, CHYTIL and STAHLMAN, 1985). Retinol or retinylpalmitate levels in otter liver decreased sharply at TEQ concentrations higher than 4 to 5ng/g: lipid weight (MURK *et al.*, 1998). This concentration corresponds very well with the TEQ range of enhanced percentage of diseases as reported in our study. The combination of a decreased level of retinol or retinylpalmitate in the liver and an increased percentage of diseases in otters supports the hypothesis that this is probably caused by PCBs. The presently found concentrations of CBs in wild otter population are high enough to cause severe adverse health effects for this animal.

The mean condition index of the otters from group 3 was significantly lower (p <0.05) than of the otters from group 1 or 2. This indicates that lower relative body weights were found in this group; 13% relative lower body weight than for otters without diseases. Experimental studies with mink have shown that at high levels of CB exposure the animals were eating less than the control groups. If this would also be the case for the otters of group 3 is not known. A higher mean relative liver weight (44% higher than in otters without diseases) was observed in group 3 compared with groups 1 and 2, however, this difference was not significant.

Table 1. For each TEQ-group (ng/g lipid weight) the number of otters with a disease (viral infection, bacterial disease, pathological deviations and/or endoparasites), number of diseases per sick-otter, percentage of otters with a disease, condition index (CI), liver somatic index and mean differences (%) of condition index and liver index compared to healthy otters are shown.

	TEQ Group 1	*TEQ* **GROUP 2**	*TEQ* **Group 3**
TEQ concentration (ng/g: lipid weight)	0-4	4-8	8-26
Number of otters in each group	24	7	12
Number of otters with diseases	4	2	4
Number of diseases Per sick otter	1	1.5	2.25
% diseases	17	29	33
CI (mean ± SD)	1.17 ± 0.14	1.22 ± 0.15	1.01* ± 0.19
Difference of CI compared to healthy otters	+ 1%	+ 5%	- 13%
LSI (mean ± SD)	0.037 ± 0.011	0.034 ± 0.011	0.052 ± 0.029
Difference of LSI compared To healthy otters	+ 3%	- 6%	+ 44%

LSI = Liver somatic index (relative liver weight to body weight);
***=mean CI of group 3 is significant lower than group 1 or 2.**

The mean condition index of the otters from group 3 was significantly lower (p <0.05) than of the otters from group 1 or 2. This indicates that lower relative body weights were found in this group; 13% relative lower body weight than for otters without diseases. Experimental studies with mink have shown that at high levels of CB exposure the animals were eating less than the control groups. If this would also be

the case for the otters of group 3 is not known. A higher mean relative liver weight (44% higher than in otters without diseases) was observed in group 3 compared with groups 1 and 2, however, this difference was not significant.

The main question is, whether an increased percentage of diseases has an adverse effect on the population. This will be the case if diseases influence the reproduction, growth or mortality rate in a population. At this moment the Danish population is stable and in some areas even expanding. During a survey in 1991 otter tracks were found in greater numbers than during a survey made in 1984-1986 (MADSEN and NIELSEN, 1986; MADSEN, 1991). In this period an annual decrease of 7% in the concentration of CBs in Danish otters was found (MASON and MADSEN, 1993). This suggests that the PCB exposure could have played a role in the population dynamics in the 1980s. But at this moment the increased frequency of diseases in the higher CB exposed otters does not seem to be a major factor in the Danish population dynamics.

Too limited information is currently available about the health status, population dynamics and CB levels of the different populations in Europe. More research in the field of detailed necropsies and the measurement of CBs on a congener specific basis (non- and mono-*ortho* substituted CBs) in otters is needed, to further clarify the relationship between diseases, CB contamination and population dynamics.

2.4.4 Are PCB concentrations declining in otters?

MASON (1998) found an annual decrease in PCB concentrations of about 8% in otters collected over the period 1983 to 1992 in England and Wales, which was later confirmed by the data of SIMPSON *et al.* (2000) for otters from South-West England. This rate is similar to the earlier observed annual decrease of 7% in otters from Denmark (MASON and MADSEN, 1993). ROOS *et al.* (2001) investigated time trends of PCBs in otters from Sweden collected in the years 1968 until 1999. For Northern Sweden they found an annual decrease of about 14% or an overall decrease during the study period of 70%. A similar, although smaller decrease of 50% (6% per annum), was observed in otters from Southern Sweden.

2.4.5 Are PCBs now to be blamed for the decline of otter populations observed in nearly all European countries?

This issue has raised a lot of discussion during recent years (KRUUK, 1997; MASON, 1997). The mechanisms of PCB toxicity have been well investigated during the last years (for detailed information see: BROUWER *et al.,* 1998; GUTLEB and MURK, 2001). For the Danish population a correlation was found between increasing PCB concentrations expressed as TCDD-equivalents, TEQs) and decreasing concentrations of Vitamin A (MURK *et al*., 1996). In the same sample a tendency of increasing frequency of diseases with increasing TEQ concentrations in the liver was found (LEONARDS *et al*., 1996).

In most areas where otters are scarce, or have decreased in numbers, high concentrations of PCBs have been found in otter tissues (MASON, 1989; SMIT *et al*., 1998). In thriving otter populations such as in Latvia (SJÖÅSEN *et al*., 1997) or Northern Norway (CHRISTENSEN and HEGGBERGET, 1995) PCB concentrations are low. The remarkable exception is the healthy otter population on Shetland with high mean PCB levels (KRUUK and CONROY, 1991; KRUUK, 1997). All data published for the Shetland otter population indicate a serious pollution of the islands, but the exact sample locations in respect to harbours etc. have never been published, so that it remains unclear in how far the samples are representative for the overall situation on the Shetland Isles.

3 CONCLUSIONS

In otters from several countries, single individuals were found with mercury concentrations exceeding critical tissue concentrations so that it cannot be excluded that negative effects of mercury occur at least on an individual level.

Small differences in CB patterns between otters from the United Kingdom, Ireland, Czech Republic, The Netherlands, Sweden and Denmark were found. CB patterns of the metabolisable CBs differ between the otters; decreased ratios of metabolisable CBs with increasing concentrations of the persistent CBs were observed. Induction of cytochrome P450 enzymes offers the best explanation for this process.

Several studies on PCB concentrations in otter tissues showed annual decreases of about 6% to 14% during the last years, which is coincided by the observation that otter populations are expanding in range in these countries.

A tendency of an increased percentage of diseases in Danish otters was observed at liver concentrations higher than 4ng TEQ/g lipid weight. This increase correlates well with a reported dose-effect relationship between vitamin A and the TEQ concentration. The consequence of the increased percentage of disease for the population is not known, as too limited information about the population dynamics, and diseases in otter populations is available.

Further aspects of the role of PHAHs on vitamin A homeostasis and possible negative effects on otters are discussed by GUTLEB and MURK (2001; this volume).

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DISEASES OF OTTERS IN BRITAIN

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ABSTRACT
Between 1988 and 2000 the author performed post mortem examinations on more than 230 otters from South West England. This paper reviews many of the pathological conditions seen, together with those reported elsewhere in Britain. Road traffic deaths were responsible for more than 80% of submissions. Approximately one sixth of all otters were suffering from bite wounds, apparently due to intraspecific aggression, and this was the second most common cause of death. The commonest infectious disease was adiaspiromycosis but in most cases the lesions were of little clinical significance. Tuberculosis has been recorded in British otters and, although suspected pulmonary lesions were seen in this study, all tests proved negative. Hepatic levels of polyhalogenated hydrocarbons decreased annually and this coincided with increased vitamin A levels. Biliary and adrenal hyperplasia were seen and the possible involvement of PCBs is discussed. Stress factors were considered responsible for adrenocortical nodular hyperplasia and for haemorrhagic gastritis, often with stomach ulcers. Convoluted, nodular uteri were seen in several otters but their significance was not established.

There is a tendency when referring to 'disease' in animals, for people to think only of those diseases caused by infectious agents, such as bacteria, viruses, fungi, parasites, etc. There are, of course, many other types of disease, for example toxic, metabolic, genetic and nutritional diseases. However, in Britain, as in most other countries, the diseases of otters (*Lutra lutra*) are poorly understood and this is principally because so few otters have been examined by veterinary pathologists (KEYMER, 1991). An important part of a veterinarian's training is to learn to recognise disease, and to distinguish one disease from another, - different diseases may produce clinical signs or pathological lesions that are similar. The work of the wildlife pathologist is made more difficult by the fact that we often do not have adequate knowledge of what is 'normal' for wild species. This is particularly important when trying to interpret the histopathological appearance of an organ.

In order to address these problems the author, with the support of the Environment Agency, has carried out post mortem examinations on more than 230 otters from South West England since 1988 (SIMPSON, 1997). This paper describes many of the pathological conditions seen and summarises those reported by earlier workers.

Over 80% of otters submitted for examination had died in road traffic accidents. This is slightly higher than the proportion (70%) killed by traffic in Southern Ireland (MASON and O'SULLIVAN, 1992) but markedly higher than the 42% recorded in Shetland (KRUUK and CONROY, 1991). The high proportion of road traffic deaths in South West England was possibly a consequence of the higher traffic density in this area. However, there was only one death in a fish trap, whereas in Shetland, as in some other countries, fish traps are a common cause of mortality. Approximately a

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sixth of all otters (16.6%) had suffered bite wounds, mainly to the head, feet and perineal area, and it is believed that most of these were due to intraspecific aggression. Some wounds became septic, mostly with a streptococcal infection, and bite wounds were the second most common cause of death (SIMPSON, 1997; SIMPSON and COXON, 2000). Fighting between adult males has been recorded previously, with anecdotal reports of males suffering fractures of the baculum and even castration as a result (STEPHENS, 1957). In the present study 22.6% of males had bite wounds and these frequently involved the anus and genitals. However, 12.6% of females had also been bitten and many had wounds to the vulva and anus. Bite wounds were seen in cubs and juveniles as well as adults. Dental disease, principally fractures, has become more common recently and often appears to be related to fighting.

The commonest infectious disease was adiaspiromycosis, caused by inhalation of spores of the fungus *Emmonsia* sp. Although the granulomatous lesions in the lungs can resemble those of tuberculosis they normally appear to be of little clinical significance. However, one juvenile which died naturally had very extensive lung pathology and was considered to have died from atypical adiaspiromycosis (SIMPSON and GAVIER-WIDEN, 2000). There is an historical record of tuberculosis (mycobacterial species not specified) in an otter in Cornwall (STEPHENS, 1957) and a recent report of a case in Scotland caused by *Mycobacterium avium* ssp. *avium* (PATTERSON, A., *pers. comm.*) However, although a small number of otters from South West England had pulmonary lesions suggestive of tuberculosis, all were negative on culture and no acid-fast organisms were seen in Ziehl-Neelsen stained sections. The lungs of the majority of the otters were examined histologically but none showed evidence of parasitic disease. *Angiostrongylus vasorum* infection has been reported in an otter in Denmark (MADSEN *et al*., 1999) and, as the parasite is commonly found in foxes (*Vulpes vulpes*) in Cornwall (SIMPSON, 1996), it is perhaps surprising that some cases were not seen in the present study.

Arteriosclerosis and arteritis were described in an aged otter from Norfolk which had lesions suggestive of Aleutian disease (WELLS, KEYMER and BARNETT, 1989). The animal also had a rounded apex to the heart and right ventricular dilation. Left ventricular hypertrophy was reported in an oiled otter in Shetland (BAKER *et al*., 1981). No specific cardiac or vascular lesions were seen in the otters from South West England. However, it was observed that otters have an unusually globular-shaped heart, associated with a thick walled left ventricle and a relatively thin walled right ventricle (SIMPSON, 1997). Some of the otters suffering from septic bite wounds had vegetative heart valve lesions and vascular thromboses, particularly in lungs.

No gross liver lesions were seen in the present study. Bacterial cultures were performed only where animals had died from non-traumatic causes. The predominant isolates were *Streptococcus* spp. and *Escherichia coli,* usually associated with septicaemia in animals suffering from bite wounds. *Staphylococcus lutrae* was also isolated on two occasions. This organism was first described from otters in Scotland (FOSTER *et al*., 1997) but its pathogenic significance is uncertain. KEYMER (1991) reported the isolation of *Yersinia pseudotuberculosis* from the liver of an otter found dead in Norfolk. However, the animal had no lesions typical of pseudotuberculosis and the cause of death was uncertain. In the otter with suspected Aleutian disease (WELLS, *et al.,* 1989), the liver was enlarged and there was a single cholelith (gall-stone) in the gall bladder. Neither choleliths nor Aleutian disease were seen in any of the otters from South West England. WELLS *et al*. (1989) also described hepatic adenocarcinoma in their case and considered that it might be an extreme consequence of biliary hyperplasia. Polychlorinated biphenyls (PCBs) are known to cause biliary hyperplasia in various species and many otters in the present study appeared to show this to some degree. At the present time, however, it has not been possible to relate the degree of hyperplasia with the tissue concentrations of PCBs and other factors may be involved. Hepatic PCB and organochlorine pesticide (OC) concentrations in otters in South West England fell markedly during the ten year study period (SIMPSON *et al*., 2000) and similar declines in PCBs, though not OCs, have been reported for otters elsewhere in Britain (MASON, 1997). If biliary hyperplasia in otters is related to PCB levels, we might therefore expect the lesions to become progressively less marked in the future. In South West England it was also observed that, as the concentrations of PCBs and OC pesticides declined, the hepatic concentrations of vitamin A increased (SIMPSON *et al*., 2000). This is consistent with recent Dutch studies on Danish otters that have shown a strong negative relationship between the concentrations of certain PCB congeners and vitamin A (MURK *et al*., 1998).

Adrenocortical nodular hyperplasia has been described twice in British otters (KEYMER *et al.,* 1988; WELLS, *et al*., 1989) and the authors suggested that this could be a consequence of age, stress or exposure to PCBs. The condition was commonly seen in the otters in the present study and the extreme cases were attributed to stress. Typically these were males that had died from severe bite wounds, but it was also present to a lesser degree in females that were in late pregnancy or lactating (SIMPSON, 1997). However, when these animals were excluded from the data set, there remained a strong positive correlation between adrenal weight and hepatic concentration of PCB congeners 138, 153 and 180 (SIMPSON, 1998). These results suggest that some PCB congeners may be influencing adrenal development and possibly function.

Renal calculi are common in captive otters and have been described occasionally in wild ones (STEPHENS, 1957; KEYMER, LEWIS and DON, 1981; WEBER, H., *pers. comm*.). However, only five out of 230 otters from South West England were affected. KEYMER *et al.* (1981) suggested that hypovitaminosis A might be one cause of renal calculi but the present author found no evidence of a relationship between vitamin A deficiency and renal calculi, in either wild or captive otters (SIMPSON, 1998, SIMPSON *et al*., 2000).

Evidence of reproductive failure can be difficult to obtain in a free-living carnivore but abortion due to foetal infection with *Plesiomonas shigelloides* has been reported in an otter from Scotland (WEBER and ROBERTS, 1989) and a novel *Brucella* sp. has also been isolated from an otter in Scotland (FOSTER *et al*., 1996). This latter organism was initially isolated from cetaceans and pinnipeds (ROSS *et al*., 1994) but the pathological significance of the organism in either marine mammals or otters is uncertain. KEYMER *et al*. (1988) reported a leiomyoma (smooth muscle tumour) of the uterus in an otter from Norfolk and there was a single case of pyometra in the South West otters (RIVERS and SIMPSON, unpublished data). Foetal resorption was suspected on several occasions where there was a pale orange placental scar in addition to normal blackish ones. Similar findings have been reported in Danish otters (ELMEROS and MADSEN, 1999). Apart from this there was little evidence of reproductive disease but in five females the uteri were nodular and highly convoluted. Single cases of what may be the same condition have been reported in Norway (HEGGBERGET, 1988) and in Denmark (ELMEROS and MADSEN, 1999).

Somewhat similar uterine changes have also been observed in seals and attributed to the effects of pollutants, such as PCBs (BERGMAN and OLSSON, 1985). However, although these changes in the otter uteri appear pathological, in each case a corpus luteum was present, and they may possibly represent a normal stage of uterine development in early pregnancy (SIMPSON, 1997). No convoluted uteri have been seen in otters in the last two years, but the number of pregnant females also appears to have decreased in this period. This merits further investigation.

There is little evidence of enteric infections in otters in Britain but KEYMER (1992) reported *Salmonella binza* infection in the gut of a free-living otter in Norfolk. Haemorrhagic gastro-enteropathy associated with ingestion of oil was considered to be the main cause of death in five otters following an oil spill in Shetland (BAKER *et al*., 1981). Several authors (KEYMER *et al*., 1988; KRUUK and CONROY, 1991) have observed blackish fluid in the stomach and intestines of otters in poor condition. Similar cases were seen in the present study, mostly in animals that had severe fight wounds, but also in orphaned cubs a few days after the start of attempted hand-rearing. In the case of two such cubs there was also a large ulcer in the mucosa of the stomach near the pylorus (SIMPSON, unpublished data). BAKER *et al*., (1981) observed very similar ulcers, plus blackish fluid in the lower intestine, of an oiled otter a few days after hospitalisation. The present author strongly suspects that these lesions are due to stress. An unusual post mortem finding in early 2000 was the presence of the remains of a cub, aged about three to four weeks, in the stomach of a male otter. This appears to be the first evidence of cannibalism in otters and was possibly a case of infanticide. The male had died in a road accident whilst fighting with another male and DNA analysis showed it was not the father of the cub (SIMPSON and COXON, 2000).

There have been a number of reports of otters showing neurological signs but, although tissues have been analysed for pollutants, rarely has a brain been made available for pathological examination. A notable exception was a cub from the Vincent Wildlife Trust rehabilitation centre in Scotland that was shown to have hydrocephalus (GREEN, R. *pers. comm*.). Two similar subsequent cases, one from Devon and the other from Scotland, had additional lesions suggestive of an in-utero viral infection. Further investigations are proceeding to try and establish the aetiology. Eyes were examined from many otters in South West England and the results will be reported elsewhere.

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