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RECOVERY OF THE OTTER *LUTRA LUTRA* IN DENMARK MONITORED BY FIELD SURVEYS AND COLLECTION OF CARCASSES

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ABSTRACT - The otter *Lutra lutra* suffered serious declines in Denmark during the 1960s and 1970s. A series of conservation and management projects were initiated to protect the remnant population, including national surveys and collection of otter carcasses. The recovery of the otter in Denmark since the 1980s was described by four national field surveys in 1984-86, 1991, 1996 and 2004 following the standard otter survey method, and by the geographical distribution of otter carcasses collected in 5-year periods prior to the field surveys. The surveys document a substantial increase in distribution range during the past 20 years. The number of collected carcasses increased annually by 9.1 ± 0.7% (mean ± S.E.) between 1980-2003. The spatial distribution of carcasses collected in the 5-year period prior to field surveys was correlated with regional site occupancy in field surveys. The implemented management practices are presented and discussed. We conclude that the standard otter survey method is a reliable method to monitor otter distribution range in Danish habitats, and that compiling records of otter casualties is a suitable methods to monitor long-term population trends.

Key words: distribution range, *Lutra lutra*, monitoring, otter, population trend, standard survey

RIASSUNTO – ***L'espansione della Lontra* Lutra lutra *in Danimarca monitorata tramite rilevamenti di campo e la raccolta delle carcasse.*** In seguito al netto declino subito in Danimarca dalla Lontra *Lutra lutra* durante gli anni '60 e '70, è stata avviata una serie di progetti di conservazione e di gestione, incluse indagini di campo e raccolta di carcasse, finalizzati alla protezione della popolazione residua. A partire dagli anni '80, il trend della popolazione è stato valutato tramite quattro censimenti estesi all'intero territorio nazionale (1984-86, 1991, 1996 e 2004), effettuati tramite metodiche standard, e tramite la distribuzione geografica delle carcasse rinvenute nei 5 anni precedenti ciascun censimento. Le indagini di campo hanno accertato il progressivo incremento dell'areale della specie, mentre, tra il 1980 e il 2003, il numero di carcasse ritrovate è aumentato annualmente del 9,1 ± 0,7% (media ± E.S.). A livello regionale, i dati ottenuti dai due metodi di rilevamento sono risultati correlati, permettendo di stabilire che le metodiche standard di accertamento della presenza della lontra rappresentano uno strumento affidabile di censimento negli habitat danesi e che la raccolta di dati di mortalità permette di monitorare il trend a lungo termine della popolazione.

Parole chiave: Areale, Lontra, *Lutra lutra*, monitoraggio, trend distributivo, metodiche standard di rilevament

INTRODUCTION

The otter *Lutra lutra* suffered serious declines in most countries in western Europe during the 1960s and 1970s (Mason, 1989; Conroy and Chanin, 2001). The otter was widespread throughout Denmark in 1960s, but the future status and survival of the population was uncertain due to hunting, increased degradation and loss of river and wetland habitats (Jensen, 1964). A questionnaire survey in 1980 suggested that otters were still found in most parts of the country but at very low densities (Schimmer, 1982). A series of conservation and management projects and regulations were started to protect the remnant population, including regular national surveys, collection of otter carcasses for post mortem examinations (Søgaard and Madsen, 1996). Systematic and comparable surveys are important for conservation and management of wildlife species. Because of their nocturnal and secretive behaviour otters are difficult to monitor directly. A standardised field method based on registration of signs of otters (spraints and footprints) was developed for surveys in the British Isles (Green and Green, 1980; Lenton *et al*., 1980; Chapman and Chapman, 1982). Although the value of spraints for monitoring otters and the ecological significance of sprainting distribution and densities at survey sites has been questioned (Kruuk *et al*., 1986) the standard method is widely used for monitoring otter distribution in freshwater habitats (Mason and Macdonald, 1987; Reuther *et al*., 2000; Harris and Yalden, 2004). Density of spraints at survey sites correlates with overall site occupancy in the area (e.g. Strachan and Jefferies, 1996) and Ruiz-Olmo *et al.* (2001) found a general relationship between the numbers of sprainting sites and numbers of otters in a small, reintroduced population. Positive correlations have been reported between the regional site occupancy, spraint density and the number of otter carcasses (Green, 1991; Madsen and Gaardmand, 2000). Madsen and Gaardmand (2000) sampled carcasses over 15 years, but it did not analyse temporal development of the distribution range and spatial distribution of carcasses.

The present paper presents the progress of the recovery of the Danish otter population as described through four national field surveys and compiling records of otter carcasses.

METHODS

1. Field surveys

National otter surveys were made in 1984-86, 1991, 1996 and 2004 according to the standardised method (Lenton *et al*., 1980; Reuther *et al*., 2000). Survey sites were distributed at 5-8 km intervals along rivers, lakes and on the coast. Otters frequently deposit spraints near bridges and other conspicuous places along waterways. A maxi-

mum of 600m of bank were surveyed at each site. The search was halted at the first finding of signs of otters (spraint or footprint) and the site designated as positive. The site was regarded as negative for otters if no signs were found within 600m.

The same series of survey sites formed the basis for all surveys, but the number of surveyed sites and 10km-squares were increased for better coverage in the most recent survey (Tab. 1). The 1984-86-survey was carried out in the months November-December and March-April. The 1991-survey was made during March-May. In 1996 a rare spell of winter, which covered most inland waters with ice, delayed the start of the survey until mid March. The 2004-survey was made during March-May. The most optimal period for spraints surveys in Danish habitats is during spring when sprainting activity and detectability peak (Reuther *et al.,* 2000). Financial constrains reduced the extent of the 1991-survey, which was concentrated on the northern counties in Jutland. Survey sites in other counties were only surveyed when anecdotic information suggested occurrence of otters in the area. Results of the individual surveys in 1984-86, 1991, and 1996 have previously been published in Madsen and Nielsen (1986), Madsen *et al*. (1992) and Hammershøj *et al*. (1996).

For statistical analysis the distribution range was described as presence or absence of otters in 10km-squares, i.e. positive and negative 10-km squares. Relative occurrence of otters was estimated as percentage of positive survey sites in arbitrary regional units based on administrative counties (Fig. 1). Three small counties in the northeastern part of Zealand (FR, KØ, and RO) were combined for the statistical analysis. Changes of distribution range between surveys expressed as presence or absence of

Table 1 - Numbers of sites surveyed and percentage of positive sites (% +ve) per county and 10km-squares in the four national field surveys in Denmark. The total percentages of positive sites and 10km-square in the 1991-survey are not directly comparable with the other totals, as presumed negative catchments were not surveyed.

	1984-86		1991		1996		2004	
County	Surveyed	% +ve	Surveyed	% +ve	Surveyed	% +ve	Surveyed	% +ve
Nordjylland (NJ)	136	13.2	151	27.8	152	37.5	161	90.7
Viborg (VI)	87	47.1	119	79.0	119	78.2	120	92.5
Ringkøbing (RK)	141	25.5	151	26.5	151	59.6	153	88.9
Århus (ÅR)	121	7.4	135	17.8	135	17.0	136	77.2
Ribe (RI)	91	0	30	0	93	1.1	93	51.6
Vejle (VE)	84	2.4	40	0	86	1.2	86	44.2
Sønderjylland (SJ)	121	0	28	0	120	0	120	17.2
Fyn (FY)	114	0	26	0	116	0	116	0
Vestsjælland (VS)	98	0	37	0	99	0	99	0
Frederiksborg (FR)					42	0	42	0
Roskilde (RO)	71	0	28	0	3	0	3	0
København (KO)					26	0	26	0
Storstrøm (ST)	90	0	22	0	93	0	93	0
Total survey sites	1154	9.2	767	26.1	1235	21.5	1248	48.2
Total 10km-squares	476	14.1	313	30.4	475	27.8	484	53.7

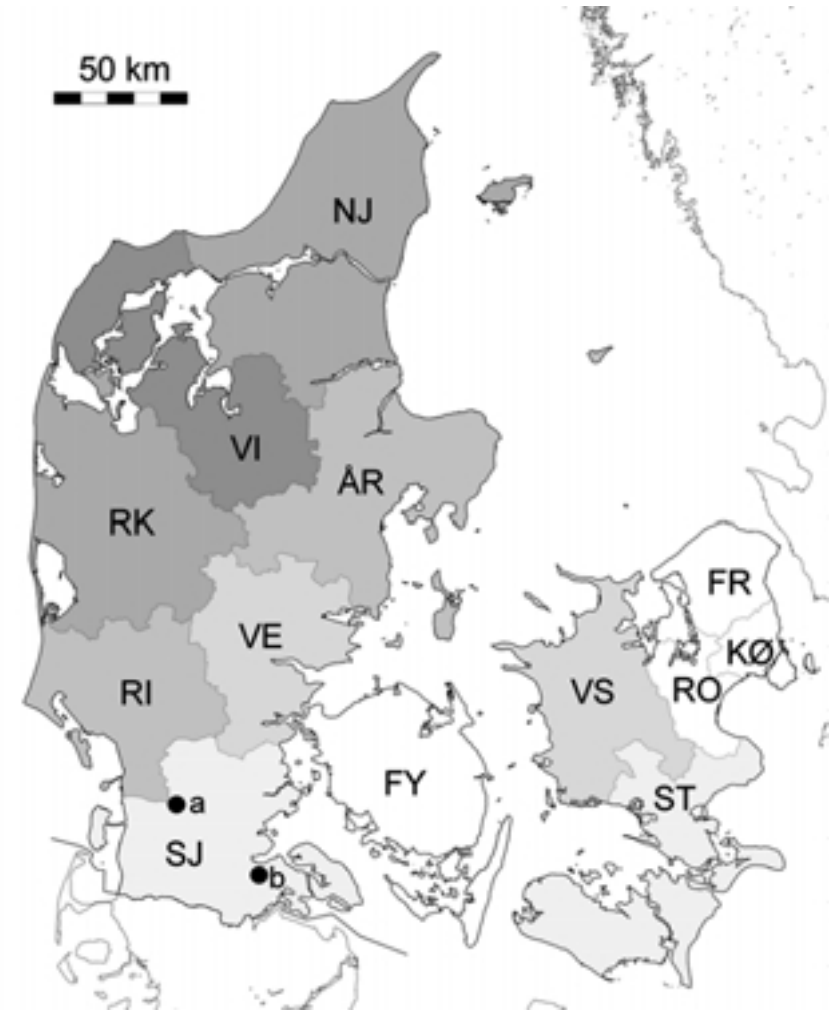

Figure 1 - Counties in Denmark. See Tab. 1 for county abbreviations. Closed circles indicate re-introduction sites for four otters in 2000 (a) and three otters in 2003 (b).

otters in 10km-squares were analysed by McNemar's test (Zar, 1984).

2. Collection of carcasses

Private taxidermists, zoological museums, and the National Forest and Nature Agency collected the otter carcases. Since 1984 private taxidermists have been prohibited from preserving otters, and subsequently all carcasses have been collected by the National Forest and Nature Agency and zoological museums. A total of 568 otters were collected between 1979 and 2003. Information on location and date, and circumstantial evidence of cause of death was recorded. Mortalities were categorised as traffic, drowning, and other. Cause of death was established by necropsy of most carcasses collected between 1980-1996 (Madsen *et al*., 1999). There was no significant difference between circumstantial

information on cause of death and causes established by necropsy of 271 animals (G = 2.04, d.f. = 2, N.S.). Three carcasses could not be located to county and 19 animals could not be located to 10km-square. No information on year of death was available for three animals, but it was assumed to be equivalent to year when the specimens were listed by the museums. When no circumstantial information on cause of death was given it was categorized as "others". Numbers of traffic-killed otters were corrected for development of traffic volume between 1984-2003 obtained from the Danish Road Directorate (Vejdirektoratet, 2004). Numbers of carcasses per km^2 in each county were used as a simple measure of regional population density. The regional site occupancy was compared to regional numbers of carcasses as Ln(1 + no. carcasses/km^2). We assumed an analogous development in traffic intensity throughout the country and we did not correct for a 5% increase of total road length during 1980-2003, as fauna passages have been constructed at watercourse crossings of all new roads since the 1990s (Vejdirektoratet, 2000).

RESULTS

1. Field surveys

The number of positive survey sites and 10km-squares increased in successive surveys from 1984-86 to 2004 (Tab. 1). Otters were found in 67 10km-squares in the 1984-86-survey. In the subsequent surveys in 1991, 1996 and 2004 the numbers of positive 10km-squares were 95, 132, and 260, respectively (Fig. 2). Considering only the 10km-squares that were monitored in all surveys the figures were 67, 88, 123, and 219 positive 10km-squares, respectively. In 1984-86-survey showed that a significant otter population was only found in central and northwestern parts of Jutland with scattered occurrences in neighbouring regions. The overall dispersion of positive sites had receded by 1991, but the number of positive 10km-squares was significantly larger than the overall number of positive 10km-squares from 1984-86 (McNemar χ^2 = 9.3, N = 302, P < 0.01). The 1996-survey showed an increase in distribution range (McNemar χ^2 = 21.8, N = 313, P < 0.001). The survey in 2004 showed a continued recovery of range (McNemar χ^2 = 113.2, N = 475, P < 0.001).

The natural expansion of otter range was reinforced by reintroduction of four otters in 2000 and three otters in 2003 at the southern fringes of the distribution range (Fig. 1). A natural recolonisation of both catchments had occurred prior to both releases (Elmeros, 2000; Hansen H.H., unpublished data). The 11 southernmost positive 10km-squares in the 2004-survey might have become positive as a result of the reintroductions. Regarding these 10km-squares as negative had minimal effect on the significance of the distribution expansion during 1996-2004 based on 10km-squares (McNemar χ^2 = 102.2, N = 475, P < 0.001).

2. Collection of carcasses

The numbers of recovered carcasses increased annually by 9.1 ± 0.7% (mean ± S.E.) between 1980-2003 (r = 0.95, d.f. = 22, t = 13.98, P < 0.001) (Fig. 3). Drowning in fyke nets was the most important directly anthropogenic related mortality in the 1980s. Number

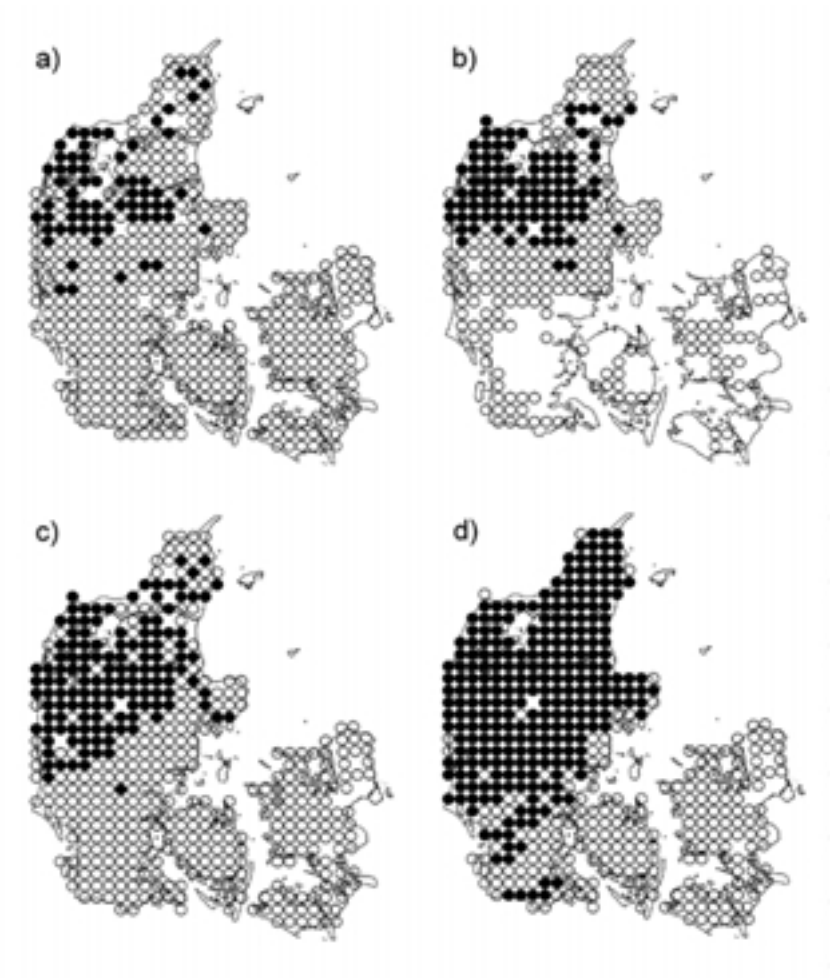

Figure 2 - Otter distribution range by 10km-squares in Denmark as shown by field surveys: a) 1984-86, n = 476; b) 1991, n = 313; c) 1996, n = 475; and d) 2004, n = 484. Closed circles show 10km-squares with otter presence and black circles are negative 10km-squares. Grey circles (c) indicate positive 10km-squares in a complementary detailed survey in 1996.

of traffic-killed otters increased 14.4 ± 1.1% annual ($r = 0.88$, d.f. = 22, $t = 12.69$, $P < 0.001$). After correction for a 2.8% annual increase of traffic intensity during 1984-2003 the annual increase in number of traffic-killed otters was 9.1 ± 1.2% ($r = 0.88$, d.f. = 18, $t = 7.61$, $P < 0.001$). An 11.2 ± 2.1% annually increase ($r = 0.79$, $t = 7.61$, d.f. = 18, $P < 0.001$) was seen in mortalities categorized as “others”. This increase did not differ from growth in traffic-killed corrected for traffic intensity ($t = 0.90$, d.f. = 36, N.S.). Numbers of carcasses increased in all counties during the sampling period but the annual numbers fluctuate widely.

Geographical distribution of carcasses in the four sampling periods is shown in Fig. 4. There was a significant relation-

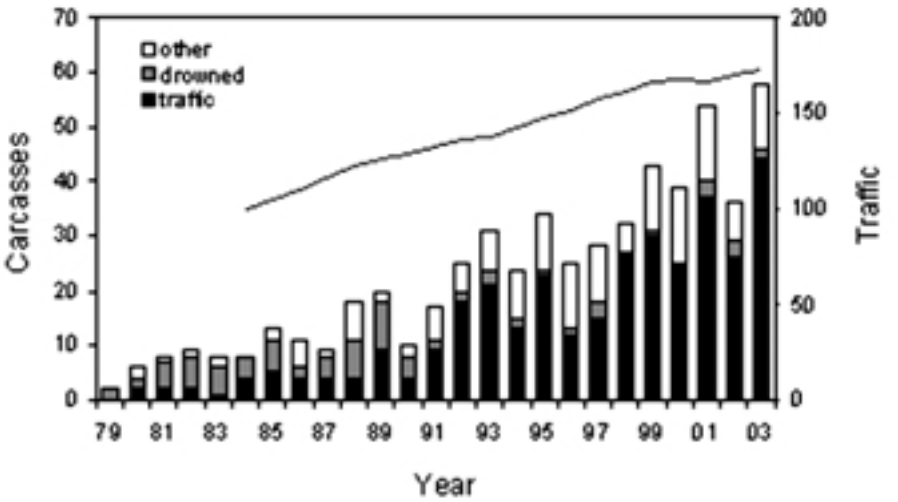

Figure 3 - Traffic volume and the annual number of recovered otters carcasses according to cause of death. The line indicates traffic volumes indexed with 1984 as 100.

ship between regional numbers of carcasses and the percentage of positive survey sites in each county: 1981-85 *vs* 1984-86-survey: $r = 0.98$, $t = 13.33$, d.f. = 9, $P < 0.001$; 1986-90 *vs* 1991-survey: $r = 0.97$, $t = 11.63$, d.f. = 9, $P < 0.001$; 1991-95 *vs* 1996-survey: $r = 0.99$, $t = 17.43$, d.f. = 9, $P < 0.001$; 1999-2003 *vs* 2004-survey: $r = 0.98$, $t = 10.02$, d.f. = 9, $P < 0.001$.

DISCUSSION

The four national field surveys have shown a significant recovery of the otter distribution range in Denmark during the past 20 years. Otters now occupy most suitable habitats on the Jutland peninsula. The temporal development of the geographic distribution of otter carcasses collected during the past 25 years correlated with the range expansion as determined by national field surveys. Otters are absent or very sparsely distributed in most of Schleswig-Holstein in northern Germany. Widespread occurrence of otters is found more than 100 km south of the Danish-German border (Blew and Fehlberg, 2002). The distribution patterns in Denmark and Schleswig-Holstein suggest that immigration to Denmark from the neighbouring population is negligible.

Although all national surveys following the standard survey method failed to detect otters on the island of Zealand detailed surveys in Vestsjælland (VS) in 1995 and 1996 detected presence of otters in two catchments (Leth and Byrnak, 1996; Elmeros, 1996). Including the positive 10km-squares from the detailed surveys did not affect the significance of the comparisons of overall range expansion. Molecular analysis of the samples collected in VS in 1995 has successfully identified the samples as otter spraints (Gravlund P., unpublished data) demonstrating the methodological limitations of the stan-

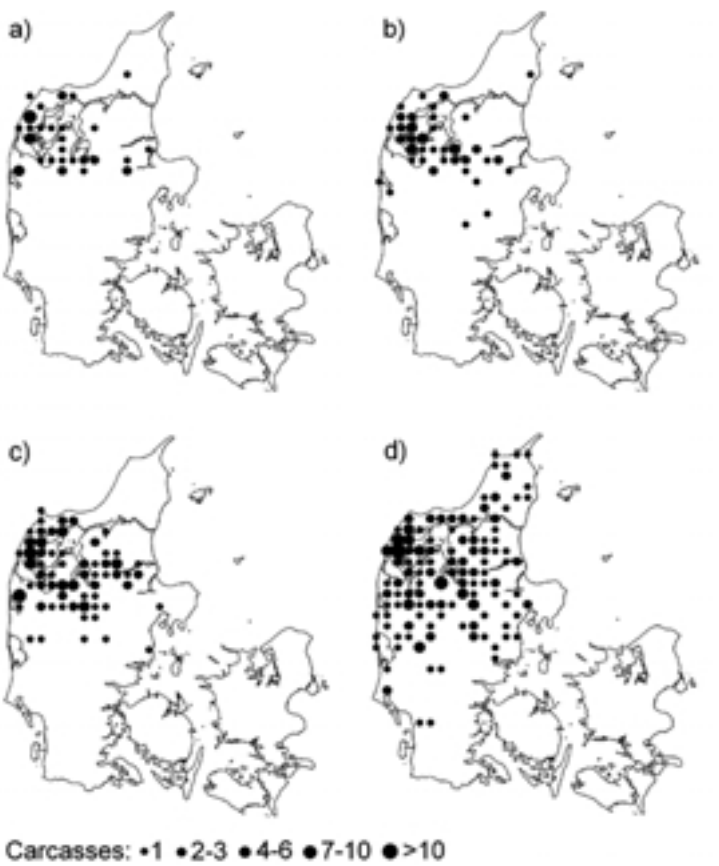

Figure 4 - Geographic distribution and numbers of carcasses by 10km-squares in Denmark of otters dead in 5-year periods prior to field surveys: a) 1981-1985, n = 46; b) 1986-1990, n = 67; c) 1991-1995, n= 131; and d) 1999-2003, n = 214.

dard method in areas with a very small population of otters as discussed by several studies (Madsen and Gaardmand, 2000; Ruiz-Olmo *et al*., 2001; Elmeros and Bussenius, 2002).

Traffic is widely recognised as an important anthropogenic mortality factor and potential threat to otter populations (e.g. Green, 1991; Crawford, 2003). Fauna passages have been constructed at many road crossings of watercourses in the core area of the otter range in Denmark to reduce the probability of traffic mortalities of otters and other mammals (Vejdirektoratet, 2000; Madsen and Søgaard, 2001). Despite these attempts to mitigate traffic mortalities their numbers have increased although fewer otters are killed at sites where fauna passages have been constructed (Madsen and Søgaard, 2001). However, if traffic mortalities had a major impact on the Danish otter population size over the past two decades the rate of otter carcasses should be declining. Conversely,

the numbers of traffic killed has increased at a greater rate than traffic volumes. Gehrt *et al*. (2002) found that traffic kill census data accurately detected long-term population trends of medium sized mammals over large spatial scales, but the techniques should be used with caution when comparing annual variations, local populations with different habitat characteristics or populations at low densities (Heggberget, 1998; Gehrt, 2002; Baker *et al*., 2004). We assume that the numbers of otter carcasses reflect population trends in Denmark, but the impact of traffic casualties and the efficiency of fauna passages cannot be appropriately assessed without an alternative estimate of the population size.

Several other factors have contributed to the recovery of the otter population in Denmark. The reduction in drowned otters coincided with the implementation of a mandatory use of stop grids in fyke nets in freshwaters and selected salt-water areas (Søgaard and Madsen, 1996). Furthermore, otters have benefited by receiving a larger consideration in the spatial planning of land use, enlightened maintenances schemes for waterways and riparian habitats, reduced organic pollution from agricultural industries and sewage treatment plants from all urban areas, which has led to higher structural habitat variability, improved water quality and increase in fish stocks in freshwaters.

The recovery of otters in Denmark parallels recoveries across most of Western Europe (Conroy and Chanin, 2001; Roos *et al*., 2001; Crawford, 2003). Contamination with polychlorinated biphenyls and persistent organochlorinated pesticides was probably a significant contributing factor in the widespread simultaneous declines throughout Western Europe during the 1960s and 1970s (Mason, 1989; Strachan and Jefferies, 1996; Roos *et al*., 2001). High levels of organochlorine contaminants have been associated with low vitamin A levels and impaired health conditions in wild otters from Denmark and England and tested experimentally in American mink *Mustela vison* (Brunström *et al*., 1991; Smit *et al*., 1996; Simpson *et a*l., 2000). Following restrictions in the use of polychlorinated biphenyl and persistent organochlorinated pesticide the contaminant burdens in otters have declined with resultant improved health conditions and recovering populations during the latest decades (Mason and Madsen, 1993; Strachan and Jefferies, 1996; Simpson *et al*., 2000; Roos *et al*., 2001).

The otter has a high level of protection under Danish legislation and international directives and conventions (Søgaard and Madsen, 1996). The 2004-survey was performed to comply with the regional and national monitoring requirements of the EU Habitats Directive 1992 (Council Directive 92/43/EEC). National surveys are to be repeated with a 6-year interval and form the basis for assessment of the conservation status of otters in Denmark (Søgaard *et al*., 2003). Despite the limitations of the standard otter survey method as well as collection of carcasses at low population densities the relationship between regional numbers of carcasses and regional site occupancy suggests that the standard method is a reliable method to monitor

distribution range on large spatial and temporal scales. The annual number of collected otter carcasses is relatively low and regional differences should be interpreted with caution as habitat characteristics of the regions differ. Nevertheless, as alternative cost-effective methods to monitor population size are not available, compiling records of otter casualties is a useful method to monitor population development in the years between national field surveys and provides a valid indication of the long-term population and distribution trends.

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