Cahiers d'Ethologie, 1995, **15** (2-3-4) : 325-336

Otters and oil spills - the impacts and the effects

by
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SUMMARY

On 5 January '93, the tanker Braer ran aground and lost 85 000 tons of crude oil. This paper evaluates the potential impact on Shetlands otter population, and the actual effects both short-term and long-term. It also examines the whole issue of oil pollution of otters.

RESUME : la loutre et les pollutions par les hydrocarbures : impacts et conséquences.

En 1993, la population de loutres des îles Shetland (entre 700 et 900 individus) était touchée par la marée noire causée par le naufrage du Braer, au sud de l'archipel. Dans ces îles, en effet, les loutres vivent principalement sur le littoral et se nourrissent en mer. En cas de marée noire, deux causes de mortalité entrent en jeu : l'hypothermie, causée par la perte du pouvoir isolant de la fourrure des animaux et l'intoxication, causée par l'ingestion de pétrole ou l'inhalation de vapeurs toxiques. Avant 1993, deux événements majeurs se sont produits au cours desquels des loutres ont été contaminées : le naufrage de l'Esso Bernicia, en 1978, et celui de l'Exxon Valdez, en 1989. Dans le premier cas, l'accident a causé la mort d'au moins 13 individus. Cependant, la population a récupéré rapidement dans l'année qui a suivi. Dans le second cas, le pétrole a affecté entre 10 et 11 000 loutres de mer (*Enhydra lutris*) et tué 2 à 3 000 d'entre elles au cours de l'année suivante. Parmi les loutres soignées, beaucoup sont mortes dans les jours qui ont suivi leur capture. Cette catastrophe a également eu comme effet une modification de la structure d'âge, avec une diminution du nombre de juvéniles et de vieux individus. Elle a, en outre, affecté la population de loutres de rivière (*Lutra canadensis*) vivant et se nourrissant sur la côte. Toutefois, seulement quelques décès ont été constatés chez cette espèce. En revanche, quelques modifications physiologiques ou comportementales ont été signalées : augmentation des taux d'haptoglobine dans le sang, diminution de la masse corporelle, diminution du nombre de proies dans les épreintes, élargissement du domaine vital. L'accident du Braer a ceci de particulier qu'au moment de l'accident, plusieurs conditions étaient rassemblées pour empêcher la formation d'une nappe trop épaisse : vents violents, mer agitée, pétrole très léger.

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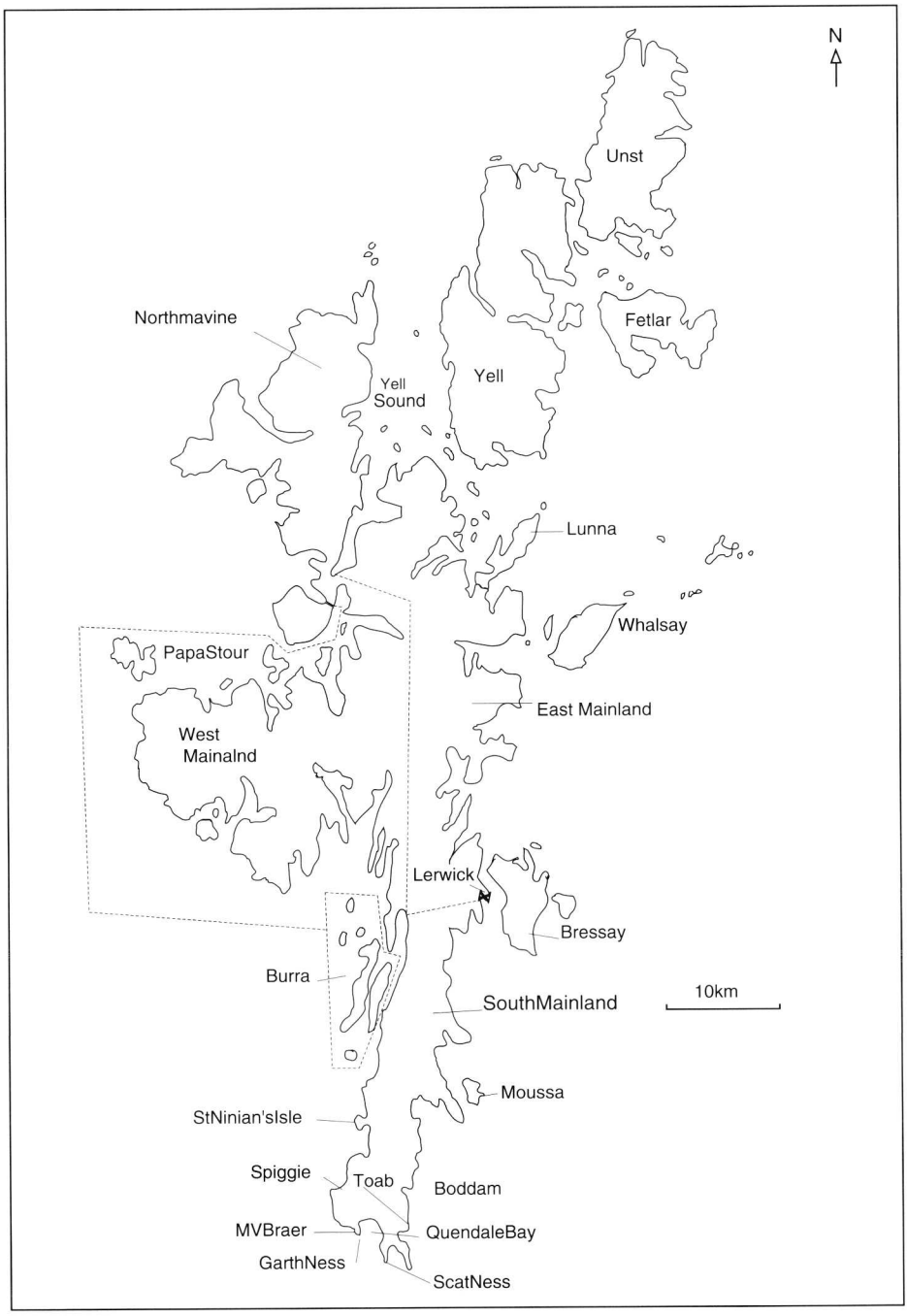

Fig. 1. Shetland, showing the geographic areas and places mentioned in text.
Carte générale des Shetlands montrant les lieux évoqués dans le texte.

Immédiatement après l'accident, un programme de surveillance a été mis en place. D'après le nombre d'observations directes réalisées, il semblerait que la marée noire n'ait eu que peu d'effets immédiats sur la population de loutres. En revanche, différents effets à long terme ont été mis en évidence. Ainsi, dans les environs du lieu du naufrage, on a constaté une diminution, voire une disparition de la population des poissons benthiques (espèces-proies), des niveaux élevés de contamination par les hydrocarbures chez les espèces-proies et une diminution de la population de loutres. Des études sont en cours pour déterminer les taux d'hydrocarbures présents dans les cadavres trouvés dans la zone polluée et l'influence éventuelle de la contamination sur le recrutement. Cet accident a révélé la nécessité de disposer d'une base de données sur la loutre lorsqu'il s'agit d'évaluer avec précision les conséquences des marées noires sur l'espèce. Il a également montré l'efficacité du plan de contingence. Il est regrettable que ce type de plan n'existe que dans les Shetland alors qu'ailleurs en Europe, les populations de loutres sont également menacées par les hydrocarbures. Il est de la responsabilité des industries pétrolières et des gouvernements nationaux d'élaborer de tels plans.

Introduction

In the early morning of 5 January 1993, the tanker *Braer* lost power off Sumburgh Head, South Shetland (**fig. 1**). The crew were air lifted off the stricken vessel, and in very heavy gales and high seas, the ship ran aground on the rocks of Garth Ness (WILLS & WARNER, 1993). Shortly after grounding, oil was seen spilling from the ruptured tanks. With 85 000 tonnes of Gullfaks crude and a large volume of bunker fuel oil, this was one of the world's largest oil spills, and for an area of such high wildlife interest as Shetland, potentially a major ecological disaster. Among the many species to be affected was the Islands' otter (*Lutra lutra*) population.

In this paper I will :
— explain the unique features of the *Braer* oil spill ;
— discuss the implications of major oil spill on otters ;
— explain the concern about the otter population on Shetland ;
— give a summary of the effects the spill has had on the local otter population.

The Eurasian Otter

Status

Since the mid 1950s there has been a serious decline in the Eurasian otter population throughout much of western Europe, resulting in its extinction in several countries, including Holland, Belgium and Switzerland. In others, numbers may be so low, and populations so fragmented, to make recovery difficult (MACDONALD & MASON, 1990 ; MACDONALD, 1995).

Concern about the otter's survival has resulted in it being listed in Appendix 1 of CITES (Convention for the Trade in Endangered Species) ; because of its endangered and declining status, considered vulnerable by the

International Union for the Conservation of Nature and Natural Resources (IUCN). It is also protected under the Bern Convention which aims to conserve both species and habitats, including breeding and resting sites. Recent legislation, enacted by the European Community (EC) (*the Habitats Directive*) protects the flora, fauna and habitats. To achieve this, member states must, where necessary, designate Special Protection Areas. In many countries otters are also protected by national laws.

The otter in Shetland

The species is common in Shetland (BERRY & JOHNSTON, 1980), with the Islands accounting for a high proportion of the UK population (ANON, 1987). Shetland is therefore of national and international importance (KRUUK *et al.*, 1989).

On Shetland the species is diurnal, lives mainly on the coast and feeds largely in the sea. With the oil terminal at Sullom Voe, and laden tankers, from Norway to America, sailing between Orkney and Shetland, the otters are at risk from oil pollution.

Until recently there had been no census of the Islands' population. While individuals can be identified by unique throat patches, an actual count of otters would be time consuming and impractical — an unknown proportion of animals being missed in a *one-off* survey.

While studying otters at Lunna on the East Coast of Shetland, MOORHOUSE (1988) found a significant relationship between the number of occupied otter holts (dens) adjacent to the coast and the number of females in the area. He also knew the relationship between females and males. From this study it is possible to use holts as an index of otter numbers (KRUUK *et al.*, 1989).

In 1988, it was felt that the otters in Shetland which came in regular contact with common seals (*Phoca vitulina*) were possibly at risk from what was then thought to be a canine distemper virus (OSTERHAUS & VEDDER, 1988), which at the time was killing thousands of seals in the North Sea. Otters are known to be susceptible to canine distemper (DUPLAIX-HALL, 1975).

Baseline data were therefore needed so that the effects this viral, or other potential, threat could be accurately assessed. A population estimate of between 700 and 900 adults was calculated, with animals showing a distinct preference for the northern part of the archipelago and for areas with good coverage of peat and freshwater and a general absence from coasts which were predominately cliff (KRUUK *et al.*, 1989).

Otters and Oil

Introduction

Otters do not have any blubber, rather they are dependent on air being trapped between the hairs of their fur for insulation (CHANIN, 1985). Any agent which causes this insulating layer to become ineffective results in the animals

becoming lethargic and hypothermic, and, if not treated quickly, dying. Oil is such an agent. For example, experiments on the pelts of sea otters (*Enhydra lutris*) showed that conductivity increased four-fold once coated with oil (WILLIAMS *et al.*, 1988). Otters also groom and are therefore likely to ingest oil and, in contaminated areas, eat prey which too may be oiled. During the period immediately after a spill, animals in the vicinity of oil slicks are also at risk from exposure to toxic vapours as they evaporate from the crude.

Major oil incidents involving otters

Prior to 1993 there had been two major incidents in which otters were contaminated by oil — the *Esso Bernicia* and the *Exxon Valdez*.

Esso Bernicia

On 30 December 1978, the tanker *Esso Bernicia,* while berthing at Sullom Voe in Shetland, Europe's largest oil terminal, lost nearly 1 200 tonnes of bunker C fuel when her tanks ruptured on the jetty. In the resulting spill, at least 13 otters were known to have died as a result of coming into contact with the oil (RICHARDSON, 1979). Several others were seen oiled, and it is likely that the number which died was much higher, but unlikely to have been half the Islands' total otter population as had been stated.

Post mortems on several of the carcasses showed the major cause of death to have been hypothermia and haemorrhagic gastroenteritis conducive with the ingestion of oil (BAKER *et al.*, 1981).

Recovery appears to have been rapid, with otters being seen on all the affected coasts within 12 months of the spill, and a female breeding in the boulders under one of the terminal loading jetties the following year.

Exxon Valdez

This incident received international publicity when the *Exxon Valdez* ran aground in Prince William Sound, Alaska in March 1989 loosing around 30 000 tonnes of crude oil. The resultant spill caused the deaths of several thousand animals including sea otters and river otters (*L. canadensis*), which like the otter in Shetland, live on the coasts, and feed along the shore.

a. Sea otters

It has been estimated that their population in the area affected by the oil was in the region of 10 000-11 000 (WALDICHUK, 1990). To May 1989, 458 carcasses had been found, a fraction of the total which died ; an unknown number sinking or being scavenged. Estimates of the actual numbers which died vary from between two and three thousand (see WALDICHUK, 1990). Experimentally, DOROFF *et al.* (1993) calculated a figure as high as 4026. There was little accurate base line data on otter numbers in the area prior to the spill. BURN (1993) compared counts from boat surveys in the summers of 1989, 1990 and 1991 with data collected from shore line census from 1984 and 1985 (IRONS *et al.*, 1988). In the unoiled areas, the population increased by 13.5 % between the pre-spill counts and those of 1989 ; by comparison the populations in the oiled coasts declined by approximately 34.6 %. Using these data and information

from various other sources, GARROT *et al.* (*in* BURN, 1993) estimated that approximately 2800 sea otters died in the first year post spill. Additional losses may have occurred beyond the first years, but these have not been quantified (BURN, 1993).

The immediate cause of death for many animals was hypothermia induced by the pelt becoming oiled and subsequent loss of insulation (DAVIS *et al.*, 1988). Otters also died from liver damage induced by digesting oil, either through grooming or eating contaminated prey (HUFF in WALDICHUK, 1990). DAVIS & WILLIAMS (1993) pointed out the vulnerability of otters to petroleum hydrocarbon toxicosis, heavy fractions are absorbed through the skin while more volatile components are inhaled.

Of 214 carcasses upon which post mortems were carried out, 66 % showed evidence of interstitial pulmonary emphysema and 55 % gastric erosion and haemorrhage (LIPSCOMB *et al.*, 1993).

Even when taken into care, a large number of otters (123) died, 81 % within ten days of arrival — the main clinical syndrome associated with their death, regardless of the degree of oiling was hypothermia, lethargy and haemorrhagic diarrhoea. Shock, induced by captivity developed within 48 hours in severely oiled individuals, and within two weeks in less heavily oiled animals.

At the recent symposium on the effects of *Exxon Valdez* oil spill (*Exxon Valdez* Oil Spill Trustee Council 1993), evidence of the longer term effects on sea otters were presented. There appears to have been a significant change in mortality from the affected areas. Prior to the spill, the proportions of juvenile, prime age and aged animals in the population was 45 %, 15 % and 40 % respectively (JOHNSON, 1987) post spill the corresponding values for 1989 were 32 % 44 % and 24 % and for 1990/1991 (combined) 33 % 43 % 24 % (MONSON & BALLACHEY, 1993). Monitoring of these mortalities should continue for several years in an attempt to understand fully the implications of these changes in population structure.

More detail on the effects of the spill on the sea otters, including histopathological studies, can be found in BAYHA & KORMENDY (1989) & *Exxon Valdez* Oil Spill Trustee Council (1993).

b. River otters

Although they feed along the coasts of Alaska including the area of Prince William sound affected by the oil, few carcasses were found, and the immediate effects of the spill were not catastrophic (BOWYER *et al.*, 1993)

Subsequent research, however, has identified several possible changes in the behaviour of the river otters from affected and unaffected coasts, implicating the oil as the potential cause (BOWYER *et al.*, 1993 ; DUFFY *et al.*, 1993). These include the otters in the affected areas having :

— significantly higher levels of haptoglobin in the blood, indicative of physiological damage — levels still high two years after spill ;
— significantly lower body mass ;
— by 1990, a reduction in the number of prey items in their faeces (diet), indicative of changes either in the availability of the prey species, or the

otters' ability to catch them ;
— home ranges twice those on unaffected coasts.

Any major changes in the river otter population may, therefore, have been delayed (BOWYER *et al.*, 1993).

The *Braer* Oil Spill

Summary of the actual spill

The combination of several events during the actual *Braer* oil spill were unique (RITCHIE & O'SULLIVAN, 1994). The weather, even by Shetland standards, was severe, with winds rarely dropping below gale force, pounding the vessel from the south west. The power of the sea was awesome. After about a week, the vessel broke, by which time all the oil had been lost into the sea. The nature of the oil, Gulfaxs crude being very light, the strong wind, and heavy swell ensured that no serious slicks developed. Rather the oil dispersed quickly into the water column, and the seas, except in the immediate vicinity of the tanker, tended only to have either light oiling or sheens. A more detailed account of the spill can be found in the report of the Scottish Office (1993).

The immediate post spill situation

Within three days of the spill, a monitoring programme for otters began in the immediate vicinity of the stricken vessel. Field parties out searching the Shetland shores were asked to record all the otters they saw, their condition, what they were doing, and whether or not they were in oil or sheens.

During the next two weeks, there were 20 sightings of otters along the coast between Boddam and St Ninian's Isle (**fig. 1**) ; several of these were reported as being in oil or sheen.

Nine holts were found to be in use in that area — two in the 5 km section around Quendale Bay sampled in the 1988 otter census ; one in a hole immediately above the wreck at Garths Ness. Continual heavy rain and high winds during this period made spraint surveys very difficult, many sites having been washed out at the time they were visited. The figure of nine holts must therefore be taken as a minimum estimate.

Six otters were found dead or dying, but none of the deaths could be directly linked with the *Braer*. Three were killed by cars. One, a cub, which had oil on its pelt was found dead near Scalloway on the day following the grounding. This animal was dead before any of the oil from the *Braer* reached these more northerly shores — the source of this oil was never established. Another slightly oiled animal, a female, was recovered from Quendale alive, but in very poor condition, and died shortly after being taken into care. Because of her condition at the time of collection, it is highly likely that she would have died within the next 24 hours oiled or not. The sixth animal was found dead beside a house. She had previously been seen feeding in the Voe below Boddam, apparently having no difficulty catching food. The cause of death was never established.

Winter is the worst time of year for otters with the biomass of fish available to the animals at its lowest. It can also be difficult to obtain food because of bad weather. This time of the year, is also the period of highest natural mortality in otters, and is the time when animals are usually in poorest condition (KRUUK *et al.*, 1987).

Bearing in mind the severe weather, and the number of people searching the shores, it is surprising that so few animals were found.

Three cubs were taken into care, two were apparently abandoned, but there is no evidence to support the statement that their mothers had been oiled (Scottish Office, 1993). In the third instance, a mother was disturbed and left her cub, the young animal should not have been taken into care ; rather it should have been left for the mother to return. Of these three, two survived and have subsequently been released back into Shetland waters.

In summary, like the River otter in Alaska, from direct casual observations, the oil spill appears to have had little apparent immediate effect on the local otters.

Longer term effects

The long term effects of the spill could manifest themselves in several ways, including :

— a reduction in the prey population ;
— an increase in the hydrocarbon levels in the flesh of the prey species ;
— a reduction in the otter population ;
— migration of the otter population away from the affected coasts ;
— increase in the levels of hydrocarbons in the tissues of the otters ;
— reduction in the breeding performance of the otters living in the affected areas.

Prey populations

During the Institute's long term otter studies on Shetland, regular monthly sampling gave accurate data on the seasonal distribution and abundance of the bottom living fish upon which the otter primarily feeds (KRUUK *et al.*, 1988). To determine the fish populations in the vicinity of the tanker and to examine the prey for hydrocarbons levels, a series of fish traps were set at a number of sites. Some, including Quendale Bay, were affected by oil, others, including Lunna, were not. The results of this work are published elsewhere (CONROY *et al.*, 1994). They show :

— no bottom living fish were caught in Quendale Bay, adjacent to Garth's Ness, during 40 trap nights in June and August 1993. Fish were caught at all other sites.

— measuring the inductive response of the hepatic mixed function oxygenase, CYP4501A, to polyaromatic hydrocarbons provides a sensitive sublethal method of measuring the bioavailability of the impact of oil pollutants in animals. The levels measures were high in fish samples collected from the contaminated sites during the sampling periods April and June, these had declined by the August sample. There were no significant levels in the fish from the uncontaminated sites (CONROY & GEORGE, 1993).

Otter census

In September 1993, a census of otters was carried out using the same 5 km sections of coast as those surveyed in 1988 (CONROY & KRUUK, 1994 ; 1995) The preliminary analysis showed that in the area of Quendale Bay, the two holts occupied in 1988, and three in January 1993, were not being used in September 1993. In fact in the area between Toab and Spiggie Loch (5 km of coast), not only were no holts found, there was no evidence of sprainting.

Current implications of the Braer oil spill on the Shetland otter population

Analysis of the recent work are being completed and will be published in detail elsewhere. What appears to have happened is :

— there has been a marked reduction/disappearance of bottom living fish in the immediate vicinity of the wreck ;

— prey species collected from within the area of oil contamination in April and June had significantly higher levels of oil contamination in their livers than in prey collected from outwith the area. These had begun to decline and by August had returned to background ;

— a number of holts in Quendale Bay, which were occupied in September 1988 and January 1993 are no longer occupied, also no spraints were found in the vicinity (CONROY & KRUUK, 1993). This suggests that there are fewer otters around there than in 1988, while elsewhere on the Islands, there is evidence of an increase in otter numbers. By January 1994, otters had returned to the area.

Work in progress

— In addition to the work described above, a number of otter carcasses from the vicinity of the wreck will be analysed for hydrocarbons. These will be compared with a sample of otters from elsewhere in Shetland and the Scottish Mainland as well as with tissues from carcasses collected from Shetland before the spill.

— to determine whether the contamination has affected recruitment, it is planned to visit Shetland in the early winter to check on the breeding performance of otters in different parts of the Island, in areas contaminated with oil and those which were unaffected with oil, in particular Lunna, where there are already data on recruitment (KRUUK *et al.*, 1987).

Discussion

What has been learned from the recent oil spills ? One question regularly asked following any ecological disaster is *what has been the effect on a certain species ?* In most instances no base line data prior to the event are available, and any estimates are often based on few data. Such was the situation with the otters in Shetland following the *Esso Bernicia* and in Alaska following *Exxon Valdez.*

Fortunately the oil industry in Shetland commissioned research after the *Bernicia* incident to try and develop a programme to monitor otter populations in the event of another spill (CONROY & FRENCH, 1985, 1987). This led to the Institute of Terrestrial Ecology work on the Islands' otter population which gave base line data on otter numbers, distribution, reproduction and diet. Without these data it would not have been possible to undertake such a detailed study of the effects of the *Braer* oil on the otters.

Throughout many European countries there are otters living on the coasts. In addition to Scotland, these include Portugal, France, Ireland and Norway (MACDONALD, 1995). Many of these countries are adjacent to major tanker routes. All these populations are therefore at risk from oil pollution, either directly, by coating the pelt, or by ingestion of toxic compounds while grooming or by eating contaminated prey. The result is either death or in some instances, the individuals being taken into care, and cleaned.

It is during the initial days following the spill that many of the most badly oiled animals are found, it is therefore important that wildlife contingency plans be produced to ensure that rehabilitation can begin as soon as possible after the release of oil. The value of the Shetland plan was demonstrated by the speed with which the rehabilitation and operations' centre were established (within a few hours of the actual grounding), and cleaning of oiled animals begun. Although in the current incident, few affected otters were taken into care, the facilities were in place to deal with it.

Other than Shetland, and a plan to deal with an offshore spill (CONROY, 1992), no wildlife contingency plan is known to exist for anywhere else in the UK or Europe.

Concern must be expressed about this lack of forward planning. The next time a tanker looses oil, we may not be as fortunate as in January 1993 on Shetland — light crude, very severe weather and the existence of a contingency plan. The more likely scenario is heavy crude, bad, but not severe weather which will hamper cleaning operations, a remote or heavily populated coastline and no one immediately available to coordinate a response — this is the recipe for disaster. The responsibility for ensuring such a plan is drawn up must rest with the oil industry and national governments.

ACKNOWLEDGEMENTS

I would like to thank Professor Brian Stanies, Drs. Hans Kruuk and Paul Chanin for comments on the manuscript. Also my thanks to the Société Française pour l'Etude et la Protection des Mammifères for inviting me to attend the Conference in Niort.

BIBLIOGRAPHY

ANON (1987). — *Shetland in Statistics.* Shetland Islands Council, Shetland.

BAKER J.R., JONES A.M., JONES T.P. & WATSON H.C. (1981). — Otter *Lutra lutra* L. mortality and marine oil pollution. *Biol. Conserv.*, ***20*** : 311-321.

BAYHA K. & KORMENDY J. (Eds.) (1990). — Sea otter symposium : Proceedings of a symposium to evaluate the response effort on behalf of sea otters after the T/V « Exxon Valdez » oil spill into Prince William Sound, Anchorage. Alaska, 17-19 April 1990. *U.S Fish & Wildl. Serv. Biol. Rep.*, ***90*** (12).

BERRY R.J. & JOHNSTON L.J. (1980). — *The Natural History of Shetland.* Collins, London.

BOWYER R.T., TESTA J.W., FARO J.B. & DUFFY L.K. (1993). — Effects of the *Exxon Valdez* oil spill on river otters in Prince William Sound. 316-318 *in* : ***Exxon Valdez*** *Oil Spill Symposium.* Ed. *Exxon Valdez* Oil Spill Trustee Council. *Exxon Valdez* Oil Spill Trustee Council, Alaska.

BURN D.M. (1993). — Boat-based surveys of sea otters (*Enhydra lutris*) in Prince William Sound, Alaska. 316-318 *in* : ***Exxon Valdez*** *Oil Spill Symposium.* Ed. *Exxon Valdez* Oil Spill Trustee Council. *Exxon Valdez* Oil Spill Trustee Council, Alaska.

CHANIN P. (1985). — *The Natural History of Otters.* Croom Helm, London.

CONROY J.W.H. (1992). — *Oil Spill contingency Plan Section K Rehabilitation of oiled animals.* Contract Report to Mobil North Sea Ltd. Institute of Terrestrial Ecology, Banchory.

CONROY J.W.H. & FRENCH D.D. (1985). — *Monitoring Otters in Shetland.* Contract Report to the Shetland Oil Terminal Environmental Group. Institute of Terrestrial Ecology, Banchory.

CONROY J.W.H. & FRENCH D.D. (1987). — The use of spraints to monitor populations of otters (*Lutra lutra*). *Symp. Zool. Soc. Lond.*, ***58*** : 247-262.

CONROY J.W.H. & GEORGE S. (1993). — *Otters in Shetland : monitoring the effects of the « Braer » oil spill. 1. Petroleum hydrocarbons in inshore fish.* Contract Report to Greenpeace Environmental Trust and ESGOSS. Institute of Terrestrial Ecology, Banchory.

CONROY J.W.H. & KRUUK H. (1993). — *Otters in Shetland : monitoring the effects of the « Braer » oil spill. 2. A census of otter numbers and distribution.* Contract Report to Worldwide Fund for Nature and ESGOSS. Institute of Terrestrial Ecology, Banchory.

CONROY J.W.H. & KRUUK H. (1995). — Changes in otter numbers on Shetland between 1988 and 1993. *Oryx,* ***29*** : 197-204.

CONROY J.W.H., KRUUK H. & GEORGE S.E. (1994). — *Otters in Shetland : Monitoring the impact of the Braer oil spill. Final Report.* Institute of Terrestrial Ecology, Banchory.

DAVIS R.W. & WILLIAMS T.M. (1993). — Rehabilitating oiled sea otters and other fur-bearing marine mammals. 269-272 *in* : ***Exxon Valdez*** *Oil Spill Symposium.* Ed. *Exxon Valdez* Oil Spill Trustee Council. *Exxon Valdez* Oil Spill Trustee Council, Alaska.

DAVIS R.W., WILLIAMS T.M., THOMAS J.A., KASTELEIN R.A. & CORNELL L.H. (1988). — The effects of oil contamination and cleaning on sea otter (*Enhydra lutris*). II. Metabolism, thermoregulation, and behaviour. *Can. J. Zool.*, ***66*** : 2782-2790.

DOROFF A., DEGANGE A.R., LENSINK C., BALLACHEY B.E., BODKIN J.L. & BRUDEN D. (1993). Recovery of sea otter carcasses following the *Exxon Valdez* oil spill. 285-288 *in* : ***Exxon Valdez*** *Oil Spill Symposium.* Ed. *Exxon Valdez* Oil Spill Trustee Council. *Exxon Valdez* Oil Spill Trustee Council, Alaska.

DUFFY L.K., BOWYER R.T., TESTA J.W. & FARO J.B. (1993). — Differences in blood haptoglobin and length-mass relationships in river otters (*Lutra canadensis*) from oiled and non oiled areas of Prince William Sound, Alaska. *J. Wildl. Dis.*, ***29*** : 353-359.

DUPLAIX-HALL N. (1975). — River otters in captivity. 315-327 *in* Ed. R.D. Martin : *Breeding Endangered Species in Captivity.* Academic Press, London.

Exxon Valdez Oil Spill Trustee Council (Ed.) (1993). — ***Exxon Valdez** Oil Spill Symposium, Exxon Valdez,* Oil Spill Trustee Council, Alaska.

Garrot R.A., Eberhardt L.L. & Burn D.M. (1992). — Some impacts of the T/V *Exxon Valdez* oil spill on Prince William Sound sea otter population. (Mss in preparation - quoted in Burn 1993).

Irons. D.B., Nysewander D.R. & Trapp J.L. (1988). — *Prince William Sound sea otter distribution in relation to population growth and habitat type.* U.S Fish Wildl. Serv. Report. 31 pp. Unpublished.

Johnson A.M. (1987). — *Sea otters of Prince William Sound, Alaska.* U.S Fish Wildl. Serv. Report. 87 pp. Alaska Fish and Wildlife Research Center, Anchorage, AK. Unpublished.

Kruuk H., Conroy J.W.H. & Moorhouse A. (1987). — Seasonal reproduction, mortality and food of otters (*Lutra lutra*) in Shetland. *Symp. Zool. Soc. Lond.,* ***58*** : 263-278.

Kruuk H., Moorhouse A., Conroy J.W.H., Durbin L. & Frears S. (1989). — An estimate of numbers and habitat preferences of otters *Lutra lutra* in Shetland, UK. *Biol. Conserv.,* ***49*** : 241-254.

Kruuk H., Nolet B. & French D.D. (1988). — Fluctuations in numbers and activity of inshore demersal fishes in Shetland. *J. Mar. Biol. Ass UK.,* ***68*** **:** 601-617.

Lipscomb T.P., Harris R.K., Moeller R.B., Pletcher J.M., Haebler R.J. & Ballachey B.E. (1993). — Histopathologic lesions in sea otters exposed to crude oil. 276-279 *in* : ***Exxon Valdez** Oil Spill Symposium.* Ed. *Exxon Valdez* Oil Spill Trustee Council. *Exxon Valdez* Oil Spill Trustee Council, Alaska.

Macdonald S. (1995). — Otter distribution in Europe. *Cah. Ethol.,* ***15*** (2-3-4) : 143-148.

Macdonald S.M. & Mason C.F. (1990). — Action plan for European otters. 29-40 *in* : Foster-Turley P., Macdonald S. M. & C. F. Mason (eds) : *Otters an action plan for their conservation.* IUCN, Gland, Switzerland.

Monson D.H. & Ballachey B.E. (1993). — Age distribution of sea otters dying in Prince William Sound, Alaska after the *Exxon Valdez* oil spill. 282-284 *in* : ***Exxon Valdez** Oil Spill Symposium.* Ed. *Exxon Valdez* Oil Spill Trustee Council. *Exxon Valdez* Oil Spill Trustee Council, Alaska.

Moorhouse A. (1988). — *Distribution of holts and their utilisation by the European otter (Lutra lutra) in a marine environment.* M.Sc. thesis. University of Aberdeen, Aberdeen.

Osterhaus A.D.M.E. & Vedder E.J. (1988). — Identification of virus causing recent seal deaths. *Nature, Lond.,* ***335*** : 20.

Richardson M.G. (1979). — *The Environmental Effects of the « Esso Bernicia » Fuel Oil Spill, Sullom Voe, Shetland, Jan. 1979.* Nature Conservancy Council, Lerwick.

Ritchie W. & O'Sullivan M. (1994). — *The Environmental Impact of the Braer Oil Spill.* Scottish Office, Edinburgh.

Scottish Office (1993). — *The Ecological Steering Group on the Oil Spill in Shetland — an interim report on survey and monitoring, May 1993.* Scottish Office Environment Department, Edinburgh.

Waldichuck M. (1990). — Sea otters and oil pollution. *Mar. Poll. Bull.,* ***21*** : 10-15.

Williams T.M., Kastelein R.A., Davis R.W. & Thomas J.A. (1988). — The effects of oil contamination and cleaning on sea otters (*Enhydra lutris*). I. Thermoregulatory implications based on pelt studies. *Can. J. Zool.,* ***66*** : 2776-2781.

Wills, J. & Warner, K. (1993). — *Innocent Passage : The wreck of the tanker Braer'.* Mainstream Publishing, Edinburgh & London.