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The Shetland Beached Bird Survey, 1979–1986

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The results of 7 years of monthly Beached Bird Surveys in Shetland (March 1979 to February 1986) are described and discussed. The occurrence of corpses of the more frequently found species showed highly seasonal patterns which changed little over the period. Densities of Guillemot corpses increased greatly, mainly due to wrecks of unoiled birds during winter. The occurrence of oiled corpses showed a marked seasonal pattern, being highest during winter and lowest in late summer. The incidence of oiling was highest in 1979/80 and remained at a lower, fluctuating level in subsequent years. Few oiled corpses were found in the vicinity of the Sullom Voe Terminal since early 1979. Most oil pollution was considered to have originated from offshore sources, particularly to the east of Shetland.

INTRODUCTION

In 1978, the Shetland Oil Terminal Environmental Advisory Group began ornithological monitoring in response to the siting of a major oil terminal at Sullom Voe in the north Mainland of Shetland. Because there was a potential threat to seabirds from oil pollution from the terminal and its associated tanker traffic a Beached Bird Survey (BBS) was established as a part of that programme. The aims of the survey were to obtain an index of the mortality of seabirds around Shetland, as shown by the occurrence of corpses on beaches, and to determine the proportions of those corpses that were contaminated by oil. Prior to 1978, no regular BBS had been carried out in Shetland and so, while some pollution incidents occurred (Bourne & Johnston 1971), no information is available on the extent of chronic oil pollution in the area.

METHODS

The coast of Shetland, estimated to be 1450 km in length (Flinn 1974), is very convoluted and contains a large number of small beaches, often separated by long stretches of rocky coastline with cliffs of varying height. Beaches suitable for the survey were selected using the following criteria:

(1) To be easily accessible.
(2) To provide a large sample of corpses.
(3) To face a variety of directions.
(4) To give good geographical coverage of the islands.

In addition, several long stretches of shoreline adjacent to the oil terminal in Sullom Voe were selected. These relatively sheltered shores, typical of Shetland's 'inner' coastline (Flinn 1974), would normally be expected to hold few seabird corpses but they were included in the survey to detect the effects of any oil pollution from the Sullom Voe Terminal.

Most of the beaches selected on Mainland were surveyed by myself but a network of volunteers was established throughout the islands during 1979 to provide greater coverage. Surveys were carried out on the last Sunday in each month, or as soon as possible during the following week. All corpses were identified, aged where possible, inspected for oil contamination and rings and then removed from the beach. Single wings and pairs of wings joined by the sternum were recorded separately but were included in the totals (separated right and left wings of the same species and age were counted as just one corpse). Corpses of waders, freshwater ducks and landbirds have been included in the totals but the numbers found were so low as to have had little influence on the overall figures and analyses.

'Emergency' surveys during which corpses were removed from beaches were carried out on three occasions: in mid-December 1979 and mid-September 1985 in response to reports of oil and oiled birds coming ashore and in mid-February 1982 in response to large numbers of unoiled auks being found. The birds removed were added to the routine monthly totals, which were therefore slightly elevated since some of the corpses would be expected to have disappeared from the beach in the interval had the emergency survey not taken place.

Overall, 782 out of 7245 possible surveys of individual beaches were missed (10.8%). This was likely to cause the number of corpses found the following month on those beaches to be higher by an unknown factor, but no allowance has been made for this in the analyses. While there was a tendency for more surveys to be missed at the end of September and December (largely because of observers being on holiday and snow-covered tidelines, respectively), there was no clear seasonal pattern that was consistent between years.

At the end of 1985, 33 people were involved in surveying 91 beaches totalling 58.85 km in length. Of these beaches, 82 (56.5 km) had been surveyed since March 1980 and 49 (41.4 km) since March 1979. Twenty beaches had been dropped from the scheme, largely because volunteers became uninterested or moved from the area. To test whether this introduced bias into the results, the difference was calculated between the mean density of corpses found on each beach that had not been surveyed continuously since March 1980 and the mean for all other beaches over the period during which that particular beach had been surveyed. For beaches that had been dropped from the scheme, the mean difference (−0.06 corpses/km; s.d. = 2.93) did not differ significantly from zero (one sample *t*-test). However, the density of corpses on the 9 beaches added since March 1980 was greater than on all other beaches (+5.68 corpses/km; s.d. = 5.32; $P < 0.01$). Nevertheless, the small number of beaches added meant that the effect on the overall results was small, raising the annual density of corpses by a maximum of 4.1% in 1984/85. The distribution of surveyed beaches is shown in Fig. 1.

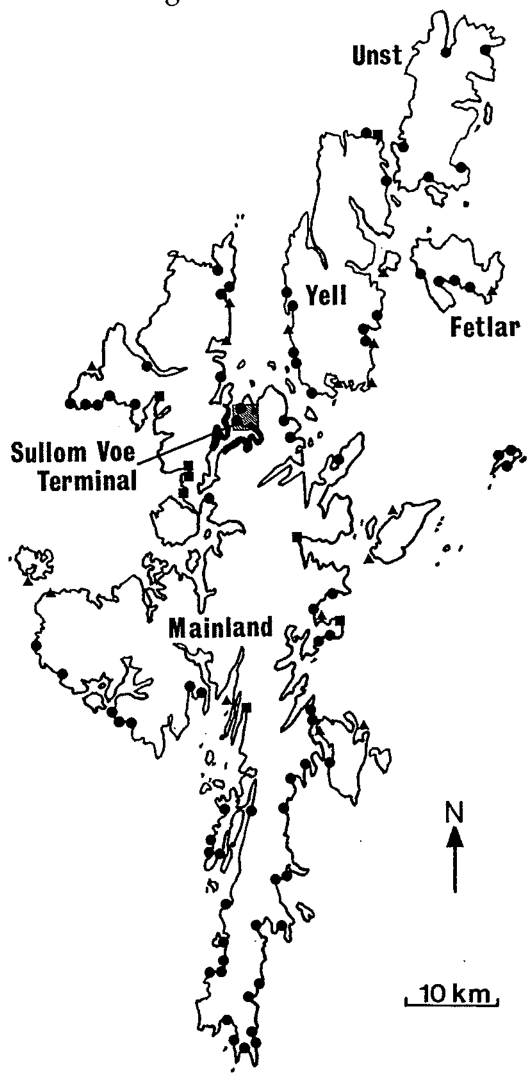

Figure 1. Distribution of beaches included in the Shetland Beached Bird Survey. ● = beaches surveyed since March 1980 or before; ■ = beaches added to the scheme since March 1980; ▲ = beaches dropped from the scheme. The thick lines represent long sections surveyed near the Sullom Voe Terminal.

The survey was not properly established until March 1979 and this paper summarizes the results obtained from then until February 1986. Where 'annual' results are presented, the period referred to is therefore from March until the following February.

RESULTS

A summary of the results from March 1979 to February 1986 is given in Table 1, while the 20 species of seabird and seaduck recorded most frequently on the BBS in Shetland are listed in Table 2. Many factors must affect the numbers found dead—e.g., distribution

Table 1. Summary of the Shetland Beached Bird Survey results for the 7 12-month periods, March 1979–February 1986

	1979/80	*1980/81*	*1981/82*	*1982/83*	*1983/84*	*1984/85*	*1985/86*
Km surveyed	617.30	620.05	516.50	594.85	645.00	622.25	657.20
Corpses/km	3.77	4.23	4.02	4.40	5.95	4.82	4.33
Oiled corpses/km	0.87	0.28	0.28	0.20	0.43	0.24	0.44
Percentage oiled	23.00	6.72	8.63	4.58	7.30	4.96	10.06

Table 2. The 20 most frequently recorded species of seabird and seaduck on the Shetland Beached Bird Survey, March 1979–February 1986

Species	*Number of corpses*	*Percentage of total*	*Percentage oiled*
Guillemot *Uria aalge*	4979	25.7	15.6
Fulmar *Fulmarus glacialis*	3791	19.6	6.9
Kittiwake *Rissa tridactyla*	2942	15.2	3.1
Herring Gull *Larus argentatus*	1488	7.7	3.9
Shag *Phalacrocorax aristotelis*	1101	5.7	6.6
Great Black-backed Gull *Larus marinus*	1064	5.5	3.2
Puffin *Fratercula arctica*	575	3.0	12.3
Razorbill *Alca torda*	419	2.2	15.3
Gannet *Sula bassana*	378	2.0	8.2
Common Gull *Larus canus*	321	1.7	2.2
Eider *Somateria mollissima*	259	1.3	18.5
Great Skua *Catharacta skua*	197	1.0	3.0
Black Guillemot *Cepphus grylle*	189	1.0	24.9
Little Auk *A. alle*	142	0.7	49.3
Common/Arctic Tern *Sterna hirundo/paradisaea**	138	0.7	0.0
Cormorant *Phalacrocorax carbo*	139	0.7	5.0
Lesser Black-backed Gull *Larus fuscus*	119	0.6	0.0
Black-headed Gull *Larus ridibundus*	36	0.2	0.0
Long-tailed Duck *Clangula hyemalis*	27	0.1	51.9
Glaucous Gull *Larus hyperboreus*	20	0.1	10.0

*Many Common and Arctic Tern wings were not specifically identified, so the two species are combined here.
Other species and numbers recorded: Red-throated Diver *Gavia stellata* 18, Red-breasted Merganser *Mergus serrator* 12, Sooty Shearwater *Puffinus griseus* 8, Manx Shearwater *P. puffinus* 8, Great Northern Diver *Gavia immer* 6, Iceland Gull *Larus glaucoides* 6, Storm Petrel *Hydrobates pelagicus* 4, Common Scoter *Melanitta nigra* 3, Velvet Scoter *Melanitta fusca* 3, Goldeneye *Bucephala clangula* 3, Pomarine Skua *Stercorarius pomarinus* 2, Brunnich's Guillemot *Uria lomvia* 2, White-billed Diver *Gavia adamsii* 1.

(offshore or inshore), movements (resident or seasonal visitor), mortality rates, and conspicuousness and durability of corpses. Furthermore, incidents involving abnormal numbers of corpses have affected several species during the period, so comparisons of relative frequency of occurrence with other areas or other periods of time should only be made with caution. Table 2 shows that just 3 species (Fulmar, Kittiwake and Guillemot) comprised almost 60% of the total number of corpses and that over the period as a whole Guillemot was the most frequently recorded species. The small numbers found of some species—e.g., divers, Arctic Skua and Black-headed Gull—is perhaps surprising, but these all have relatively small populations in Shetland and are present in the area for only a part of the year.

Seasonal trends

The monthly densities of corpses were examined for 8 species, which between them comprised 85% of the total number of corpses. Fulmars, Herring and Great Black-backed Gulls and Kittiwakes showed a distinct seasonal pattern of occurrence, with low densities of corpses in winter followed by a peak in July or August (Figs 2 & 3). Post-fledging mortality of juveniles contributed greatly to this peak, although numbers of corpses of adult birds were also greater in summer than in winter. Puffin corpses, both of adults and juveniles, also peaked in mid-summer and, while small numbers of Puffins were found each winter, the high density of corpses shown for January (Fig. 2) was largely due to a wreck of birds in 1984. One of the few mainly resident seabirds in Shetland, Shags are likely to be vulnerable to the effects of prolonged gales and rough seas and more corpses were recorded during winter than in summer, with particularly high numbers found following storms in February 1984. No marked change was noticed in these seasonal patterns, which for Fulmar, Shag and Kittiwake were similar to those previously reported for Orkney (Jones 1980). Guillemots showed a dramatic seasonal pattern of high mid-winter densities of corpses falling through the year to low levels in late summer and autumn (Fig. 3). However, the scale of occurrence changed considerably over the period: this is discussed further below. Similarly, the occurrence of Razorbill corpses varied considerably over the period. Between February 1982 and autumn 1984, the densities showed a pattern similar to that of Guillemot. Prior to February 1982 and since autumn 1984, however, too few Razorbills were found for any clear pattern to emerge, although numbers appeared greater in mid-summer.

Changes between years

The overall annual densities of corpses of the same 8 species are plotted in Fig. 4. There is no obvious trend in the occurrence of Herring and Great Black-backed Gulls and the same is

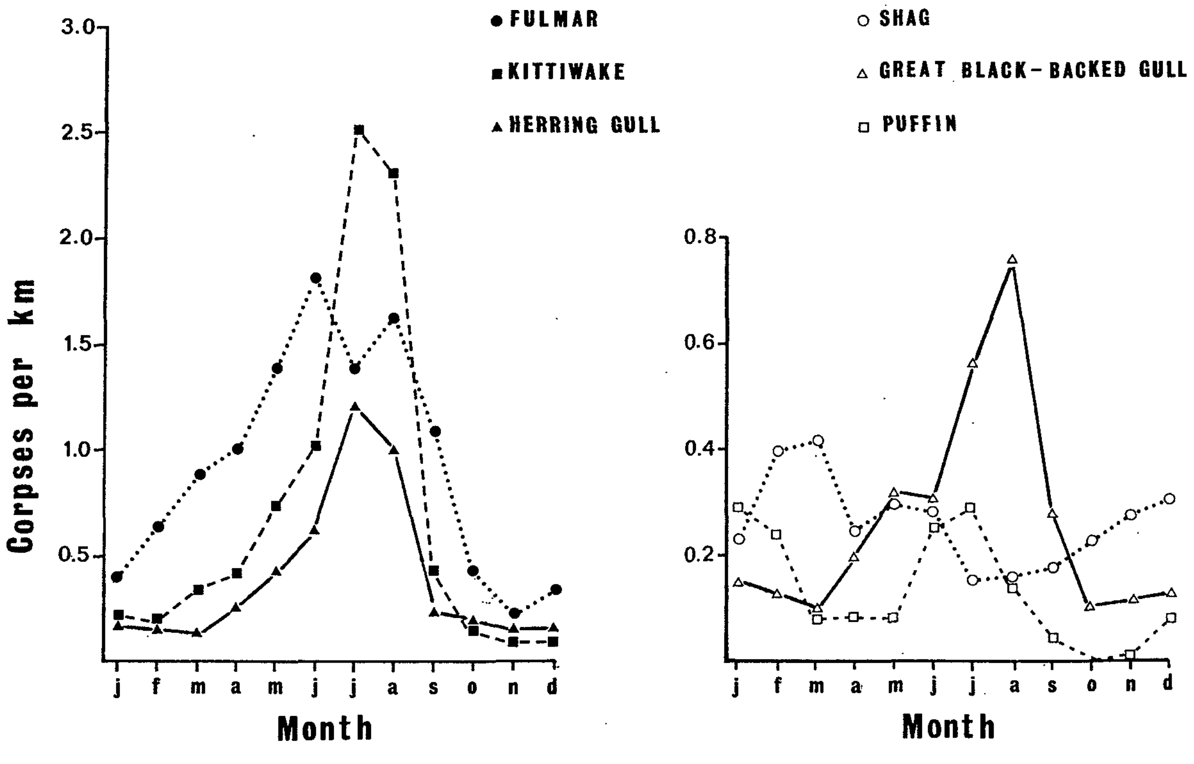

Figure 2. Seasonal pattern of occurrence of corpses of Fulmar, Shag, Great Black-backed Gull, Herring Gull, Kittiwake and Puffin. Values are combined monthly totals for March 1979–February 1986.

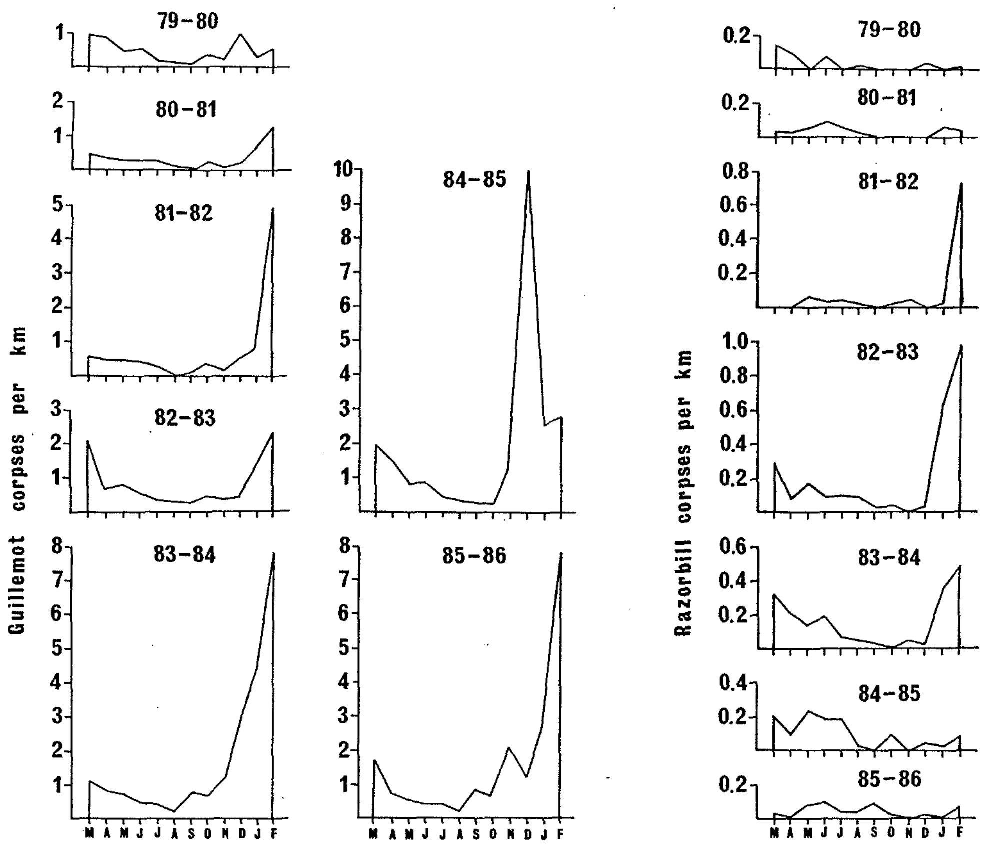

Figure 3. Monthly densities of Guillemot (left) and Razorbill (right) corpses in each annual period, March 1979–February 1986.

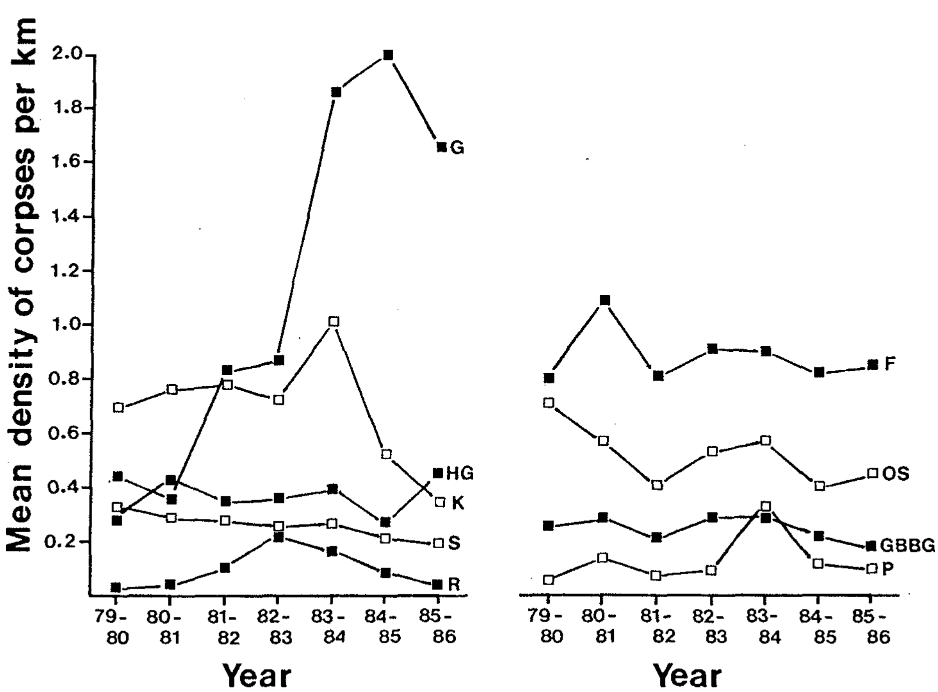

Figure 4. Annual densities of corpses of Fulmar (F), Shag (S), Great Black-backed Gull (GBBG), Herring Gull (HG), Kittiwake (K), Guillemot (G), Razorbill (R), Puffin (P) and all other seabird species combined (OS).

Table 3. Incidence of oiling during March 1979 to February 1980 and March 1980 to February 1986 for the 10 species recorded most frequently as oiled, as numbers and as percentages of the totals for each species

	1979/80		*1980/86*	
Species	*Number oiled*	*Percentage of total*	*Number oiled*	*Percentage of total*
Fulmar	80	14.0	182	5.5
Shag	48	24.3	25	2.8
Eider	37	43.0	11	6.4
Herring Gull	7	3.9	51	3.9
Kittiwake	17	4.0	73	2.9
Guillemot	179	65.3	596	12.7
Razorbill	11	61.1	53	13.2
Black Guillemot	27	54.0	20	14.4
Little Auk	49	96.1	21	23.1
Puffin	11	30.6	60	11.1

true for the Puffin, other than a peak in 1983/84 created by the winter wreck already referred to. Similarly, relatively high numbers of Fulmar corpses were recorded in 1980/81 but the annual density has otherwise remained stable. There appears to have been a slight decline in the density of Shag corpses, although greater numbers of oiled birds were found in 1979/80 (Table 3). The annual density of Kittiwake corpses can be influenced considerably by the number of dead juveniles found on the July and August surveys (Jones 1980), the density of which was at least 6 times greater in 1983 than in 1985, a year in which Kittiwakes had an abnormally poor breeding season (Heubeck & Ellis 1986).

Before February 1982, only 53 Razorbills had been found on surveys, of which 25% were oiled. The density of corpses increased markedly during 1982–84 showing a seasonality similar to that of Guillemot and peaking at 0.98/km in February 1983 (Fig. 3). Although the ratio of Razorbills to Guillemots on that survey (0.43 to 1) was the highest recorded in Shetland, it was considerably lower than the 0.72–2.35 to 1 reported from parts of the east coast of Britain during the wreck of that month (Underwood & Stowe 1984). Since autumn 1984, densities reverted to their previous low levels.

Relatively low densities of Guillemots were recorded between March 1979 and January 1982, with a peak of only 1.28/km in February 1981 (Fig. 3). Thereafter, pronounced peaks have occurred in February each year, apart from the winter of 1984/85 when 9.95 corpses/km were found on the December survey. Unoiled Guillemots involved in these wrecks were generally found to be underweight with little or no fat reserves and had apparently starved to death. It is possible that the BBS has underestimated the scale of this mortality. In the weeks prior to the 1984, 1985 and 1986 wrecks, unusual numbers of Guillemots were seen close inshore, many of which appeared to be in poor condition with hunched necks and wings drooping low in the water (pers. obs.). These birds tended to congregate in the sheltered waters of Shetland's 'inner' coastline, whereas most surveyed beaches were on the more exposed 'outer' coast. Certainly, many hundreds of Guillemot corpses went undetected by the BBS at the time of the wrecks, since spot checks of stretches of 'inner' coast likely to collect corpses (based on prevailing wind direction) revealed densities either equal to or greater than those recorded on the BBS. Prior to the wreck in February 1982 the average summer density of Guillemot corpses during May to September inclusive was 0.21/km (s.e. = 0.017). In the 4 summers since, the mean density has been 0.41/km (s.e. = 0.036), a significant increase ($P < 0.01$).

OIL POLLUTION

Although it is conventional to describe the incidence of oiling in terms of the percentage of corpses oiled, this can exaggerate the importance of a small number of oiled corpses found when the total number of corpses is also low and it can diminish the significance of large numbers of oiled corpses if the total number of corpses is abnormally high. Thus it is also useful to consider the absolute densities of oiled birds and Table 1 shows annual summaries for both measures of pollution.

Seasonality of oiling

There has been a clear seasonality in the incidence of oiling, with high levels during mid-winter falling to low levels during late summer (Fig. 5). This seasonal pattern has long been recognized but its cause is unknown: more oil may be spilled in winter (Stowe & Underwood 1984), oil may remain liquid for longer in winter because of lower temperatures (Bourne & Bibby 1975), or birds stressed by winter conditions may be less able to survive contamination by oil. With the exceptions of March and April 1979, when many of the 233 oiled birds found were undoubtedly long-dead casualties of that winter's pollution incidents (Heubeck & Richardson 1980), the only month outwith December—February when more than 50 oiled corpses were found was September 1985 and the 81 oiled birds found heavily influenced the September values in Fig. 5.

Trends and origins of oil pollution

Other than a reduction from the high levels of 1979/80, no subsequent trend is apparent in the incidence of oiling, with some years being relatively free of pollution while specific incidents in others resulted in higher annual densities and proportions of oiled corpses (Table 1, Fig. 6). Limited comparison can be made with data from initial surveys in 1978, prior to the opening of the Sullom Voe Oil Terminal to tanker traffic. Of the 1156 corpses found between July and November 1978 (inclusive), only 0.6% were oiled compared to values ranging from 1.6–11.2% for the same period in the years since.

Despite small-scale oilspills at the Sullom Voe Terminal, consistently low values of both percentages oiled and densities of oiled corpses have been recorded on beaches in the Yell Sound area since 1979/80. The higher percentages of oiled corpses in Yell Sound compared to the west coast of Shetland are a consequence of both the relatively low numbers of corpses found on Yell Sound and Sullom Voe beaches and the high densities of corpses that can be recorded on west coast beaches in late summer when the incidence of oiling is normally low. The incidence of oiling has generally been greatest on the east coast of Shetland. Prolonged east or southeast winds preceded high densities of oiled corpses on several surveys, notably in December 1979, May 1981 and 1983, and January 1984.

Few samples of oil from plumage have been collected for analysis since 1980, but of 43

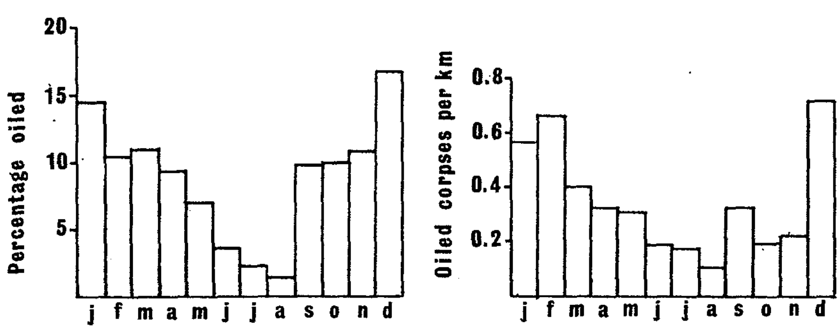

Figure 5. Seasonal occurrence of oiled corpses, expressed as the percentage of the total number of corpses (left) and the density of oiled corpses per km (right). Values are the combined monthly totals for the period March 1979–February 1986.

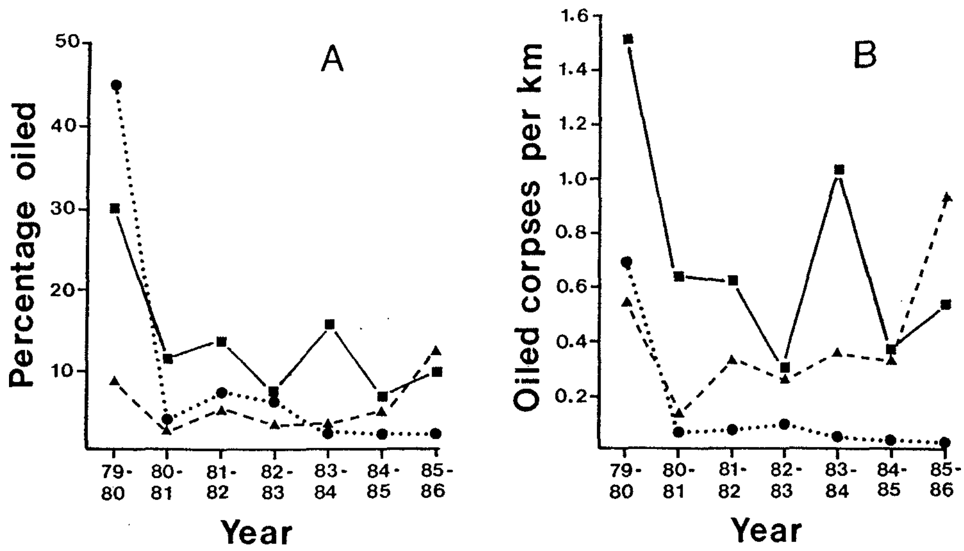

Figure 6. Occurrence of oiled corpses on the east (■) and west (▲) coasts of Shetland and in Yell Sound and Sullom Voe (●), expressed as (A) the percentages of the total number of corpses and (B) the density of oiled corpses per km.

samples from the winters of 1981/82, 1984/85 and 1985/86, 30 (70%) were found to be heavy fuel oil, 1 (3%) a medium fuel oil and 12 (27%) weathered crudes. This preponderance of heavy fuel oils contrasted with the 45 samples taken during the winter of 1979/80, of which 44% were heavy fuel oils and 53% either crudes or crude oil sludges (Richardson, Heubeck, Lea & Reynolds 1982).

Species oiled

Three main factors influence the species composition of the oiled corpses found—seasonal distribution (oiling being most frequent during winter), behaviour (the more aerial species being less likely to encounter floating oil), and population size. In addition, if the source of most oil pollution is offshore rather than inshore (as seems to have been the case in recent years) then foraging distribution is also important. It is therefore not surprising that the overall percentage oiled of each of the auk species was in excess of 10% (Table 2). The overall percentages of oiling for the more inshore species—Shag, Eider and Black Guillemot—were clearly influenced greatly by the numbers found in 1979/80 and the incidence of oiling for these 3 species has been low in the years since (Table 3). Similarly, of the 13 oiled Long-tailed Ducks recorded, 11 were found in 1979/80.

DISCUSSION

The geographic and seasonal coverage of the Shetland BBS is extensive enough to provide a fairly sensitive index of both the occurrence of different species as corpses on beaches and the incidence of chronic oil pollution around the islands. Small-scale but unusual occurrences can be identified and the occurrence of large numbers of corpses that would probably be noticed without the aid of a BBS can be quantified and put into perspective.

The densities of corpses found on the Shetland BBS were considerably higher than those reported from analyses of the national BBS (Stowe 1982), which excluded Shetland and Orkney, although they were comparable to those recorded in Orkney (Jones 1980). One factor contributing to such high densities was the inclusion in the survey of many small beaches, onto which large accumulations of flotsam (and corpses) are concentrated. This concentrating factor was shown in the strong inverse relationship found between mean density of corpses and beach length ($r = -0.66$; $n = 110$; $P < 0.001$). Another factor was the inclusion of counts of detached wings in the Shetland data: these were excluded from the national analyses.

The BBS in Shetland and Orkney differ from the national scheme in that surveys are carried out throughout the year instead of just during winter months when the incidence of chronic oil pollution is highest. However, the two island groups are host both to large, internationally important concentrations of breeding seabirds and to major oil terminals from which millions of tonnes of crude oil are exported annually. Oil throughput continues throughout the year, as does production of oil from offshore installations to the east and exploration to the west of the islands. Oilspills at the Sullom Voe and Flotta Terminals can occur at any time of year so a monthly BBS is essential to monitor the consequences of the oil industry activity and of general shipping in the area.

The evidence from numbers and densities of oiled corpses indicates that the amount of chronic oil pollution in Shetland waters was high during 1979/80 and that it has since declined and remained at a lower, albeit fluctuating,level since then. The occurrence of crude oil and its residues was relatively high around Shetland and Orkney during 1979 and early 1980 (Richardson *et al.* 1982) and this has been linked to illegal discharges of oil from tanker traffic associated with the Sullom Voe Terminal, which opened in November 1978. Stricter operational controls were introduced during 1979, including aerial surveillance of tankers bound for and leaving Shetland, and these appear to have been effective in reducing the extent of chronic oil pollution (Richardson *et al.* 1982), although a background level remains, largely composed of heavy fuel oil.

In only one month since February 1980 did the proportion of corpses oiled exceed 25% (33% in September 1985), which compares favourably with other areas of Britain (Stowe 1982; Underwood & Stowe 1984). Similarly, the proportions of auks found oiled since 1982 have been considerably lower than was found during the 1970s around the British mainland, but it must be remembered that the winter wrecks of unoiled Guillemots are a recent phenomenon and greatly influence the overall figures. It is reassuring that the incidence of oiled corpses in the vicinity of the Sullom Voe Terminal has been consistently low since 1979/80, for it is the populations of inshore-feeding species such as Eider and Black Guillemot that are most at risk from oil pollution, with large proportions of their Shetland populations forming moulting and feeding concentrations within a 30-km radius of the oil terminal (Ewins & Kirk 1985; Jones & Kinnear 1979).

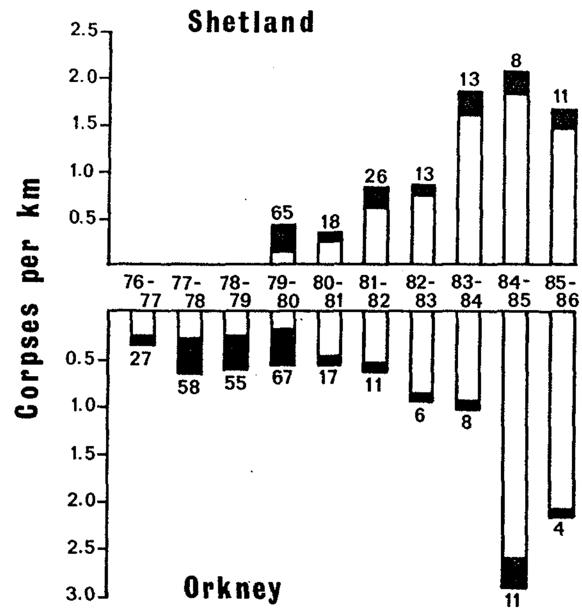

Figure 7. Annual density of Guillemot corpses recorded on the Shetland and Orkney Beached Bird Surveys. Shaded areas indicate oiled corpses and the percentage of the total number of corpses oiled is given (Orkney data from unpublished surveys by the Royal Society for the Protection of Birds).

The rise in numbers of unoiled Guillemot corpses during winter has been the most dramatic feature of the Shetland BBS. A similar increase has occurred in Orkney (Fig. 7). While breeding populations of Guillemots have increased in northern Scotland and on the North Sea coast of Britain in recent years (Stowe & Harris 1984), the increase in winter densities of corpses has been too great and too sudden to be explained simply in terms of population increase. It may be that a geographic shift in the autumn and winter distribution of Guillemots has taken place so that mortality which previously occurred elsewhere is now being recorded by the BBS schemes in the northern isles of Scotland. Certainly, there seems to have been a recent increase in the numbers of Guillemots remaining to moult in Shetland waters after the breeding season (Robertson 1985; pers. obs.). If such a change in distribution has occurred, it might be revealed by examination of the geographic spread of ringing recoveries. Food availability is a major factor in determining Guillemot distribution during winter (Blake, Dixon, Jones & Tasker

1985) and Blake (1984) cited the decline in Spratt *S. sprattus* biomass in the northwestern North Sea as a factor contributing to the large wreck of auks in February 1983. Examination of unoiled Guillemots found in winter wrecks in Shetland indicated that starvation was the immediate cause of death and it seems that those Guillemots which remain in Shetland waters during winter have been experiencing difficulty in finding sufficient food to sustain them.

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