The utility of national ring recoveries for identifying the effects of an exceptional mortality event amongst seabirds

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Ring recovery data were used to describe a seabird mortality event (or ‘wreck’) affecting mainly Shags *Phalacrocorax aristotelis* and Guillemots *Uria aalge* in the North Sea during February and March 1994. Stormy weather and onshore winds are thought to have caused this mortality. Most Shags and Guillemots were recovered along the North Sea coast of the British Isles, particularly around northeast Britain. In non-wreck years, recoveries of Shags and Guillemots were more widespread around the British Isles. Most Shags recovered during the wreck originated from North Sea breeding colonies in northeast England, eastern Scotland and the Northern Isles, while most Guillemots originated from colonies in eastern Scotland and the Northern Isles. In contrast to previous wrecks, the 1994 wreck affected mainly adult Shags and first- and second-year Guillemots. The national ring recoveries confirmed the extensive scale differences in mortality between species and age classes that were previously evident from an intensive study on the Isle of May.

The recovery of dead ringed birds can provide a range of information about the birds affected by sudden mortality events. These include seabird wrecks (Underwood & Stowe 1984), oil pollution incidents (Baillie & Mead 1984), algal blooms (Armstrong et al 1978) or severe meteorological events (Clark 2004). Additionally, at a wider geographical scale, information from ring recoveries can be used to validate the results of intensive local studies.

Wrecks of seabirds, in which unusually large numbers of individuals die and are washed ashore, occur at irregular intervals throughout Britain & Ireland (Underwood & Stowe 1984, Bourne 1990, Mudge et al 1992). Around the British Isles, wrecks usually occur between January and March (Hudson & Mead 1984, Underwood & Stowe 1984) with auks, particularly Guillemots *Uria aalge*, being the species most commonly affected (Harris & Wanless 1984, Hudson & Mead 1984, Underwood & Stowe 1984, Bourne 1990, Mudge et al 1992). Although the proximal causes of such wrecks are often unclear, weather conditions and food shortages are usually implicated (Underwood & Stowe 1984, Mudge et al 1992, Harris & Wanless 1996).

Seabirds around Britain & Ireland have been involved in a number of wrecks over the last two decades. A number of small wrecks occurred during the 1980s in northeast Scotland (Bourne 1990, Mudge et al 1992) and a major wreck occurred along the east coast of Britain during February 1983, when large numbers of Guillemots, Razorbills *Alca torda*, Puffins *Fratercula arctica* and Little Auk *Alle alle* were affected (Harris & Wanless 1984, Hudson & Mead 1984, Underwood & Stowe 1984).

During February and March 1994, following a prolonged period of onshore winds, large numbers of dead seabirds came ashore along the North Sea coast of Britain (Bourne 1994, Brindley 1994, Swann 1994, Harris & Wanless 1996). Most dead birds were found in northern areas (Shetland to Humberside), although smaller numbers of corpses were found as far south as Kent. The main species found dead were Shag *Phalacrocorax aristotelis* and Guillemot. During the Royal Society for the Protection of Birds’ National Beached Bird Survey at the end of February 1994, nearly 1,000 dead Shags (0.9/km) and 6,000 dead Guillemots (5.5/km) were counted on 1,040 km of beach in eastern Britain (Brindley 1994). The total mortality was estimated as 3,000 – 5,000 Shags and 20,000 – 50,000 Guillemots.

The effects of the 1994 wreck on the breeding populations of one large colony (Isle of May, Firth of Forth) have been examined by Harris & Wanless (1996). The local Shag population was much more seriously affected by the wreck than the Guillemot population, but whether this pattern applies more widely to other North Sea colonies remains unclear (Harris & Wanless 1996).
This paper combines reports of dead ringed birds with estimates of numbers of live ringed birds to describe the pattern and extent of the 1994 seabird wreck. These data provide a wider geographic perspective to the local, intensive study of Harris & Wanless (1996).

METHODS

Two species are considered in this study, Shag and Guillemot. These are the two species for which the most data were available, and they were also the focus of the Isle of May study (Harris & Wanless 1996) and hence allow comparison of local and wider patterns. The term “recovery” refers to a ringed bird that has been found and whose finding details have been reported to the British Trust for Ornithology. Only recoveries reported as “dead” or “freshly dead” were analysed. Birds known to have died due to non-wreck causes (e.g. oiled or caught in fishing nets) and those which had inaccurate finding dates (not known to within ±15 days) were excluded from the analysis. The wreck sample may still have included some birds whose deaths were not associated directly with the wreck, but the proportion of these is thought to be small. A major of the additional recoveries in 1994 occurred during February and March (see results) this was defined as the wreck period. The same criteria were applied to the recovery data for 1984-93 to provide a comparable non-wreck sample of dead seabirds. The recovery data were analysed to provide information on the timing of the wreck, the relative impact on the Shag and Guillemot populations and the breeding origins and ages of birds involved.

Various parts of the analysis employed “ringed birds at risk” calculations (as used by Baillie & Mead 1984) to take account of annual variations in the number of birds ringed. These calculations use average survival rates to predict the numbers of ringed birds still alive (and at risk of recovery) in any particular year. The survival estimates used in these calculations were 50%, 74.5% (Aebischer 1986) and 87.8% (Harris et al 1994) for first-year, immature and adult Shags respectively, and 50% (Harris & Wanless 1995) 84% and 94.9% (Mead 1974) for first-year, immature and adult Guillemots respectively. Survival rates were assumed to remain constant across years.

We identified when the wreck occurred by comparing the distribution of recoveries in each half-month period in 1994 with the average distribution during the same half-month periods during 1984-93. To establish if abnormally high numbers of dead Shags and Guillemots were recovered in 1994, the number of recoveries in that year was compared to those in each of the previous ten years. We also investigated whether the proportion of live, ringed birds that was recovered dead was higher during the wreck period in 1994 compared to the previous ten years. A “corrected recovery rate”, calculated as the number of recoveries per 1,000 birds “at risk”, was used for this purpose. We plotted the ringing and recovery locations of birds affected by the wreck using the mapping software DMAP (www.dmap.co.uk). We also compared the latitude and longitude of recovery locations during 1994 with those of the previous ten years.

The numbers of nesting and adult Shags and Guillemots ringed each year between 1980 and 1994 were collated for the main breeding colonies in each of five regions. These regions were defined as 1) Irish Sea; 2) northwest Scotland; 3) Northern Isles; 4) eastern Scotland and 5) northeast England (Fig 1). The numbers of ringed birds “at risk” and the number recovered both during the wreck and the comparison period were calculated using ringing data obtained from the bird ringers operating at the principal colonies in each of the regions. Region-specific ringing totals were not available

Figure 1. Regions containing the main breeding colonies used in the analyses.
prior to 1979, so the “at risk” estimates for 1991-93 were based on birds ringed during the previous 10 years. Most seabirds are ringed either as nestlings or as breeding adults, and it was assumed that the ringing location of a bird indicated the breeding population to which it belonged. We checked for regional differences in mortality by comparing region-specific corrected recovery rates during the wreck and a non-wreck period (February – March 1991-93).

The ages of birds recovered during the wreck and the previous ten years were also compared. Only recoveries of birds of known age (ie ringed as nestlings) were included in this analysis. Birds were categorised as first-year, immature or adult at the time of recovery. Shags were assumed to commence breeding at three years of age (Aebischer 1986) and Guillemots at six years of age (Harris & Wanless 1995).

RESULTS

Timing of the wreck
The majority of Shag and Guillemot recoveries in 1994 were reported during February and March, particularly in the second half of February (Fig 2). The wreck was therefore considered to have occurred during February and March 1994.

The numbers of ringed Shags and Guillemots found dead each year between 1984 and 1994 are presented in Table 1. A total of 267 ringed Shags and 86 ringed Guillemots were recovered during the 1994 wreck. However, the number of Shags recovered during the whole of 1994 was significantly higher than the average number of recoveries during 1984–93 ($t_{9} = 6.90, P < 0.001$) by, on average, 55%. The number of Guillemots recovered in 1994 was not significantly higher than during 1984–93 ($t_{9} = 0.42, P > 0.05$). For both Shag and Guillemot, the proportion of the year’s recoveries reported during February and March was significantly higher in 1994 than during the same period over the preceding ten years (Shag $\chi^2 = 257, P < 0.01$; Guillemot $\chi^2 = 80, P < 0.01$). The proportion of the 1994 mortality occurring during February and March, was 68% for Shags and 77% for Guillemot.

The unusually large number of recoveries during February and March 1994 was not due to increased ringing effort in previous years. The number of Shags ringed since 1984 decreased from 8,000 per annum in 1984, to 4,000 per annum during 1990–94. The number of Guillemots ringed each year remained constant at 10,000–12,000 during 1984–94 (Fig 3).

The corrected recovery rate of Shags was significantly higher in 1994 than in the previous ten years ($t_{9} = 6.91,
Finding locations and origins of ringed birds
Over the ten-year period immediately preceding the 1994 wreck, ringed Shags and Guillemots were recovered all around the coastlines of Britain and Ireland during February and March (Figs 4 & 5). During the 1994 wreck the majority of dead ringed Shags was found along the North Sea coast of Britain (Fig 4a), predominantly in northeast England, eastern Scotland and around the Orkney Islands. The median latitude of finding place in 1994 differed significantly compared to the previous ten years, shifting 3° northwards (U = 36,333, P < 0.001). However, the median longitude of finding place did not differ significantly (U = 72,088, NS). A small number of dead ringed Shags were reported from the west coast of Britain and none were reported from around Ireland.

A similar pattern was evident for Guillemots with the majority of ringed birds being recovered along the northeast coast of Britain during the 1994 wreck (Fig 4b). There was a significant northerly shift (by 1.4°) in median finding latitude (U = 10,800, P < 0.001) but no significant difference in the median finding longitude (U = 13,306, NS) in 1994.

The origins of ringed Shags and Guillemots recovered during February and March in the ten years prior to the 1994 wreck and in 1994 are shown in Fig 5. Shags found dead during the 1994 wreck originated from more northerly and easterly colonies, with there being a significant shift of 0.1° in median latitude (U = 53,193, P < 0.001) and longitude (U = 55,330, P < 0.001). For Guillemot the origin of ringed birds was not significantly different with respect to latitude (U = 12,703, NS), but there was a significant 1.0° easterly shift in median longitude (U = 10,916 P < 0.001). The majority of ringed Shags and Guillemots found dead during February and March in the non-wreck years originated from colonies in northeast England, the Firth of Forth, northern Scotland, along the west coast of Britain and from various colonies around Ireland (Fig 5). Whereas during the 1994 wreck, the majority of ringed Shags found dead originated from colonies in eastern Scotland (75%) (Fig 5a), whilst Guillemots originated from colonies in the Northern Isles (39%), northwest Scotland (36%) and eastern Scotland (24%) (Fig 5b). No Shags or Guillemots ringed abroad were found in Britain or Ireland during February and March 1994. Overall 92% of Shags and 64% of Guillemots recovered during the 1994 wreck originated from North Sea colonies.

The age of birds involved in the wreck
Shags recovered during the 1994 wreck were significantly older than those recovered during February and March in previous years (8 years vs 1 year; U = 15,3, P < 0.001). A higher proportion of Shags that died during the 1994 wreck

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**Table 1.** Annual national recovery rate of Shags and Guillemots for the whole year and for the period of the 1994 wreck (February & March).

| YEAR | SHAG | Estimated
d| Number Recovered (Whole | Annual Recovery Rate | Number Recovered (Feb-Mar) | % | GUILLEMOT | Estimated
d| Number Recovered (Whole | Annual Recovery Rate | Number Recovered (Feb-Mar) | % |
<table>
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<tr>
<td>1984</td>
<td>315</td>
<td>16.9</td>
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<tr>
<td>1985</td>
<td>162</td>
<td>8.0</td>
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<td>1986</td>
<td>151</td>
<td>6.9</td>
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<tr>
<td>1987</td>
<td>131</td>
<td>6.1</td>
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<td>8.6</td>
</tr>
<tr>
<td>1992</td>
<td>198</td>
<td>9.3</td>
</tr>
<tr>
<td>1993</td>
<td>390</td>
<td>18.9</td>
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<td>1994</td>
<td>394</td>
<td>19.7</td>
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1 The estimated recovery rate denotes the number of recoveries per 1,000 birds at risk (ie ringed and estimated to be alive)
The use of ring recoveries

Table 2. Regional variation in the recovery rates of Shags and Guillemots recovered during February and March between 1991-93 and 1994. The contingency table compares the total number of birds at risk and the total number of birds recovered in 1991-93 with the same information from 1994.

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<td>10.0</td>
<td>1,045</td>
<td>3</td>
<td>2.1</td>
<td>253</td>
<td>&lt;1.0</td>
<td>260</td>
<td>0</td>
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<td>3,777</td>
<td>16</td>
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<td>9.3</td>
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<td>7.7</td>
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<tr>
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<td>5,011</td>
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<td>3,676</td>
<td>188</td>
<td>49.6</td>
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The differences in the age structure of Shags recovered during the 1994 wreck and in non-wreck years cannot be accounted for by variations in ringing effort (all tests NS). Analyses allowing for the number of ringed Shags at risk within each age cohort showed a similar pattern to that in Fig 6.

**DISCUSSION**

The increased number of recoveries reported in February and March 1994 would have independently indicated that Shags and Guillemots had suffered unusually high mortality during this period. The timing of the increases in ring recoveries (February and March) coincided with the period when most dead birds were washed ashore (Brindley 1994, Bourne 1994). The increased number of recoveries in 1994 was not a result of changes in ringing effort, which during the period immediately prior to the 1994 wreck had decreased for Shags and had remained stable for Guillemots (Fig 3). Mortality of ringed Shags was high in 1994 compared to previous years, and was concentrated during the wreck period. Mortality of ringed Guillemots was not unusually high during 1994, but 77% of ring recoveries were reported during February and March.

The majority of the finding locations of Shags and Guillemots recovered during the 1994 wreck were concentrated along the North Sea coast, predominantly from northeast England to Shetland, showing that this was the area most affected by the wreck. There was a much wider distribution of recoveries during non-wreck years, when ringed Shags and Guillemots were found around most of the British coastline, including the west coast, and around Ireland (Harris & Wanless 1995, Harris & Swann 2002a,b). A number of plausible explanations might account for this difference. It is possible that finding effort along the Irish Sea coast was lower, or that prevailing easterly winds may have resulted in more birds being washed up along the North Sea coast, or the actual number of ringed birds at risk in the Irish Sea was much lower than elsewhere. However, the most likely explanation is that only birds in the North Sea suffered mortality during the wreck period. Shag and Guillemot recoveries indicate that only birds found along the North Sea coast in winter originate from North Sea colonies. Additionally, birds found along the west coast and around the Irish Sea tend to originate from relatively local colonies and there appears to be little winter mixing of eastern and western populations of Shags and Guillemots (Tasker et al 1987, Webb et al 1990, Harris & Wanless 1995, Harris & Swann 2002a,b). Our
conclusion, that the majority of Shags and Guillemots recovered during the 1994 wreck originated from North Sea colonies, supports these previous studies. The most severely affected Shag colonies, in terms of number of birds recovered, were the Isle of May (Fife) and the Farne Islands (Northumberland). Guillemot colonies along the east coast of Scotland and around the Shetland Isles were the most seriously affected.

Shags recovered during the 1994 wreck tended to be much older than Shags usually recovered during February and March (Fig 6a). Ring-recovery samples are usually dominated by first-year Shags, but the majority of Shags recovered during the 1994 wreck were adults. At the local level, Harris & Wanless (1996) observed that mortality during the 1994 wreck was higher amongst adult Shags than first-years on the Isle of May whereas Swann (1994) suggested that adult, first-year and immature Shags in the Moray Firth suffered a similar overall mortality. Normally during wrecks immature birds dominate and local breeding populations are normally unaffected. However, during the 1994 wreck adult mortality resulted in immediate, serious consequences for the size of breeding population (Harris & Wanless 1996). High adult losses are therefore of more importance than high losses of immatures. The relative scarcity of first-year Shags in the 1994 wreck could have been a consequence of young birds dispersing further than adults (Galbraith et al 1981, Harris & Swann 2002a) and possibly out of the main area affected by the wreck. The age composition of Guillemots recovered during the 1994 wreck was similar to non-wreck years, suggesting that the different ages in the population had been affected proportionately.

Whilst the exact causes of seabird wrecks are unknown, the majority of previous wrecks occurred after a period of stormy weather with strong easterly winds as did the 1994 wreck. It is likely that stormy weather can make fishing difficult for seabirds, particularly Guillemots, leading to exhaustion and starvation. Although reduced food availability in the early 1990s was shown to result in mass mortality of nestling seabirds (eg Hamer et al 1993), food availability was not limited during the 1994

Figure 4. Distribution of a) Shag and b) Guillemot recoveries during February and March of 1984-93 and 1994. The size of dot reflects the number of recoveries.

Figure 5. Origins of a) Shags and b) Guillemots recovered during February and March of 1984-93 and 1994. The size of dot reflects the number of recoveries.
The use of ring recoveries

This study clearly shows the importance of a national ringing scheme in providing information on birds affected by sudden mortality incidents including the timing of mortality, the numbers and breeding populations involved, their origin and age structure. The results of this study demonstrate the importance of bird ringing in providing information which field observations alone cannot provide. The recovery of ringed birds gives unique additional information on age and breeding origin, which is rarely available from other field observations. Our study also confirms and extends the main findings of Harris & Wanless (1996).

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REFERENCES


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