



## Ringling recoveries confirm higher wader mortality in severe winters

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Periods of severe weather can result in significant mortality in bird populations. In Britain there is a system of voluntary, followed by official, bans on wildfowl hunting in coastal areas during periods of severely cold weather, in order to minimise disturbance to bird populations during these periods of energetic stress. The effectiveness of such hunting bans will be influenced by the spatial variation in severe weather and consequent mortality. Reports of dead ringed birds (recoveries) clearly show that the number of recoveries of waders increases in severe weather periods. The distribution of this mortality in severe weather varies between species and both temporally and spatially. It is suggested that the numbers of recoveries received in severely cold weather could be monitored and used to confirm that increased mortality is occurring.

Waterfowl in Britain & Ireland are known to experience increased mortality during winter (Goss-Custard *et al* 1977) and particularly during severely cold winter weather (Dobinson & Richards 1964, Davidson & Evans 1982). There is concern that disturbance to birds, including that caused by shooting, may become a critical factor influencing mortality rates in severe weather (Stroud 1992). During the severe winter of 1978/79, a ban on wildfowling in Britain was introduced in January 1979. There was considerable disagreement over the ban and, as a result, a working group was set up to devise criteria for the implementation of future bans. The use of biological criteria to trigger bans was considered, but was rejected due to the problems of collecting such data at short notice. It was agreed that meteorological data should be used instead (Batten & Swift 1982). The Joint Nature Conservation Committee (JNCC), the government agency responsible for coordinating the work of the Country Conservation Agencies, therefore developed an index which used freezing ground conditions (a measure of cold) to assess the severity of the weather. A call for voluntary restraint from shooting is made if half, or more, of a set of meteorological stations distributed around Britain report either freezing or snow-covered ground at 0900 hrs. If severe conditions persist for 14 days, an official shooting ban may then be implemented by the relevant Secretaries of State in England, Scotland and Wales. The use of this criterion triggered hunting bans in Britain in the winters of 1981/82, 1984/85 and 1986/87. Since 1993/94 the number of stations used has been expanded and data have been

considered separately for the three countries. Freezing or snow-covered ground is, however, now becoming a difficult criterion to use, as meteorological stations are being automated so freezing conditions are now recorded at fewer stations. A new system using a combination of air and grass temperature was tested in parallel with the current system in winter 2001/02 but use of the new method has yet to be assessed (D Stroud pers comm). In the Netherlands, a winter severity index based on mean daily air temperature has been used to assess winter weather severity for waders. Peaks of mortality amongst Oystercatchers *Haematopus ostralegus* were found to occur in winters with a high number of cold days, although the availability of prey was clearly also a factor in Oystercatcher mortality (Camphuysen *et al* 1996).

Several spells of severe weather in Britain in the 20th century caused unusually high mortality in wading birds. The severe spells occurring in the last twenty years of the twentieth century, since criteria for wildfowling bans have been established, are considered here. These include winters where the weather was reported to be severe in the literature (Table 1); some of these severe periods triggered a wildfowling ban. This analysis investigates the use of reports of ringed birds to determine whether increased mortality is apparent during severe weather periods.

### METHODS

Recoveries (reports of ringed birds) from the British Trust for Ornithology (BTO) Ringling Scheme were used to

**Table 1.** Winters reported as severe and which have had an effect on bird mortality in different regions of Britain. Start, finish and duration refer to the period of severe weather. Location and level of mortality are shown, as is whether or not a shooting ban came into effect during the severe weather period.

Winter	Start	Finish	Duration	Ban?	Distribution of mortality	Level of mortality	Reference
1981/82	6 December	26 December	21 days	Yes	Localised - worst in east	High in east	Clark 1982
"	5 January	16 January	12 days		(particularly northeast) Britain Low, or no, mortality in west		Evans 1982
1984/85	2 January	24 January	23 days	Yes	Mainly in southeast Britain,	Medium	Davidson &
"	9 February	20 February	12 days	No	but some mortality in western and northern Britain		Clark 1985
1985/86	Mid January	Early March	c. 6 weeks	No	Mainly in southeast England, particularly on the Wash and the Stour	Medium	Clark & Davidson 1986, Beecroft & Clark 1986
1986/87	7 January	18 January	13 days	Yes		Low	Stroud 1992
"	End January		4 days				Stroud 1992
1990/91	2 February	14 February	13 days	No	Southeast England	High	Clark <i>et al</i> 1993

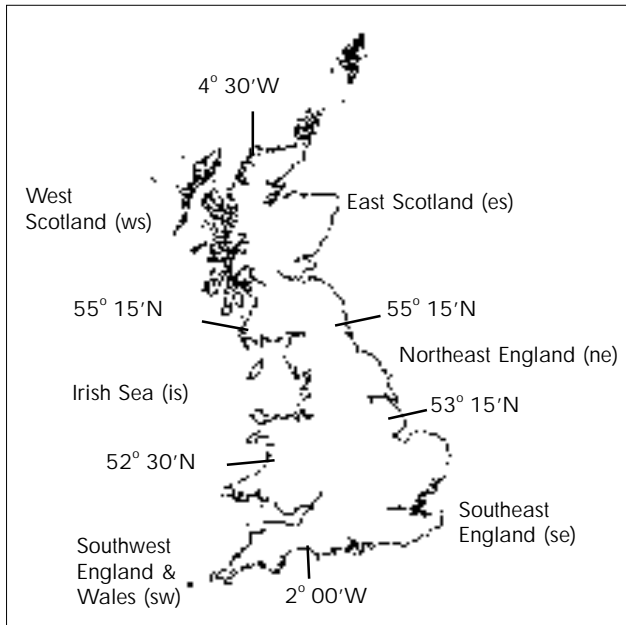
describe the spatial and temporal distribution of mortality amongst wading birds. The scheme covers Britain & Ireland and, each year, approximately 40,000 waders are ringed and over 400 are subsequently reported (eg Clark *et al* 2002). Although the numbers ringed in different areas of the country are not currently recorded electronically, the distribution of reports of dead ringed birds gives an indication of the spatial and temporal distribution of mortality.

Recoveries of six species of wader (Oystercatcher, Grey Plover *Pluvialis squatarola*, Knot *Calidris canutus*, Dunlin *C alpina*, Curlew *Numenius arquata* and Redshank *Tringa totanus*) found dead during January to March, between 1980 and 1999, were extracted from the BTO database to compare the frequency of recoveries in severe and mild (ie all other) winters. To establish if differences between years were due to the number of ringed birds in the population, recoveries of the same six species in the early part of the same winter (October to December) were also extracted. The reports were categorised by area of Britain (Fig 1). The numbers and distribution of dead ringed birds of each of the six species in severe winters (1982, 1985, 1986, 1987 and 1991; Table 1) were compared to the numbers found dead in mild winters. An assessment of the vulnerability of each species to severe weather was made by calculating an index of vulnerability, which is the average number of recoveries

in severe winters divided by the average number of recoveries in mild winters.

## RESULTS

There was no significant difference between mild and severe winters in the number of reports of dead ringed birds, during October to December, for Oystercatcher ( $\chi^2_1 = 0.009$ , NS), Knot ( $\chi^2_1 = 0.15$ , NS), Dunlin ( $\chi^2_1 = 0.51$ , NS) or Curlew ( $\chi^2_1 = 2.86$ , NS), suggesting that any differences in the January to March figures do not result from differences of in the number of ringed birds in the population. There was a significant difference for Redshank ( $\chi^2_1 = 18.18$ ,  $P < 0.0005$ ) but this was strongly influenced by an unusual number of recoveries in December 1981 when there was an early severe spell of weather (Table 1). If this winter is excluded from the comparison, there was no significant difference ( $\chi^2_1 = 2.86$ , NS). The significant difference for Grey Plover ( $\chi^2_1 = 4.74$ ,  $P < 0.05$ ) should be considered with some caution, as the difference in the average number of recoveries reported was small and there were some early winters when no dead ringed birds were reported. The distribution of recoveries of waders found dead in January to March, 1980 to 1991, is shown in Fig 2 and broken down into regions in Fig 3.



**Figure 1.** Regions of Britain used to describe the distribution of wader mortality. Regions are selected to be similar in climate, and boundaries are in areas of low wader numbers.

### Oystercatcher

The number of ringed Oystercatchers found dead in severe winters is slightly higher than in most other winters (Figs 2a & 3a). There are, however, two mild winters with high mortality; 1993 and 1996. These are years in which Oystercatchers wintering on the Wash died following a local shortage of Cockles *Cerastoderma edule* and Mussels *Mytilus edulis* (Atkinson *et al* 2003). When numbers of recoveries during severe and mild winters were compared, there was a significant difference ( $\chi^2_1 = 4.6$ ,  $P < 0.05$ ). However the difference is more significant when the data for 1993 and 1996 are excluded ( $\chi^2_1 = 53.5$ ,  $P < 0.0005$ , Fig 3b).

The regional information on dead ringed Oystercatchers is dominated by data from the east (southeast England, northeast England and eastern Scotland) with significant differences when all areas are compared ( $\chi^2_4 = 75.3$ ,  $P < 0.0005$ , Figs 2a & 3). Data from southeast England are dominated by the birds that died in years of shellfish shortage. A higher number than normal were found dead in the severe weather in 1991 but there is no apparent effect of the other severe spells. In the rest of the east, a similar proportion of the total of dead ringed birds was reported each year, whilst in the west there appear to be increased numbers in some severe weather periods.

### Grey Plover

Reports of dead ringed Grey Plover were significantly higher in severe winters than other winters ( $\chi^2_1 = 269.5$ ,

$P < 0.0005$ , Figs 2b & 3c). As there is little ringing of Grey Plover in Britain & Ireland away from the Wash, nearly all the reports are from the southeast; so a comparison between regions is not possible. There were few reports of dead ringed Grey Plover in the early 1980s with the effects of severe weather only being seen in the severe weather periods in 1986 and 1991. This apparent change may be a result of the increased population levels reported by Moser (1988).

### Knot

Amongst Knot, significantly more dead ringed birds were reported in severe winters, compared to other winters ( $\chi^2_1 = 54.5$ ,  $P < 0.0005$ , Figs 2c & 3d). This is, however, clearly heavily influenced by an unusually large number of dead ringed Knot reported in the severe winter of 1987. These birds were reported largely in the Irish Sea region and most of them died as a result of a pollution incident (BTO data), rather than being victims of severe weather. When the data for 1987 are excluded from the analysis, there are still significantly more Knot found dead in severe winters ( $\chi^2_1 = 15.7$ ,  $P < 0.0005$ ).

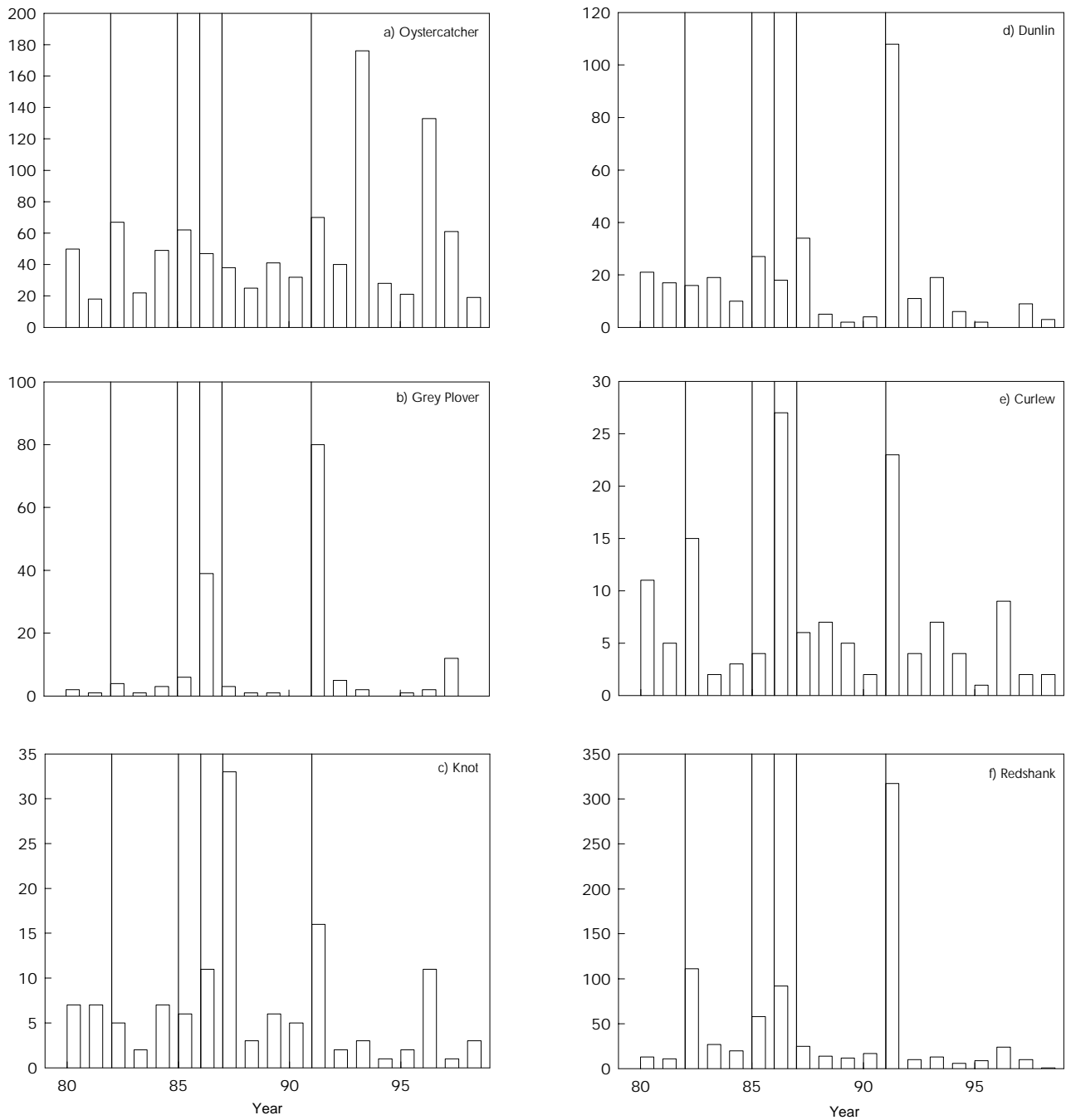
As there were fewer than 30 reports of dead ringed Knot in each of northeast England and eastern Scotland, these two areas were amalgamated for statistical analysis. There were no reports of dead ringed Knot in the southwest or western Scotland regions so these regions were omitted from the analysis. When the regions were compared, a significant difference was found ( $\chi^2_2 = 15.9$ ,  $P < 0.0005$ ). However, it is clear that the 1987 pollution incident dominates the Irish Sea region. The amount of mortality in severe winters differs between areas, with 1991 being a high mortality year in the southeast region, and 1986 in northeast England.

### Dunlin

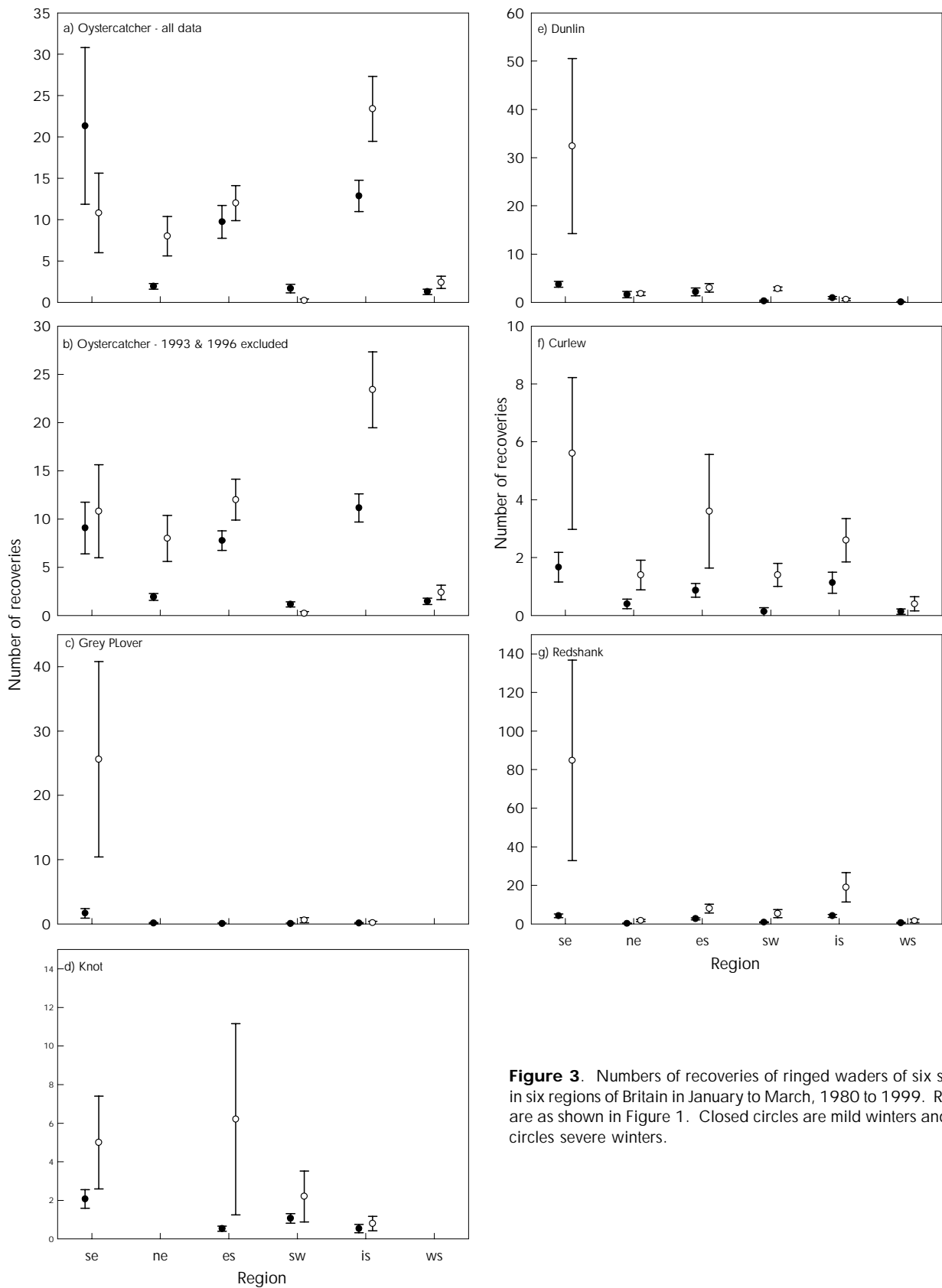
Far more dead ringed Dunlin were found in severe winters than other winters ( $\chi^2_1 = 226.1$ ,  $P < 0.0005$ ) with 1991 being a year with particularly high mortality (Figs 2d & 3e). To allow a statistical comparison between regions, the small sample sizes (30 or less) in the Irish Sea and western Scotland regions were amalgamated, as were those in northeast England and eastern Scotland. There was significant regional variation in severe weather mortality ( $\chi^2_3 = 59.0$ ,  $P < 0.0005$ ), largely as a result of the high mortality in the southeast region in 1991.

### Curlew

An increased number of dead ringed Curlew were reported in the severe winters of 1982, 1986 and 1991, but no increase was apparent in 1985 or 1987 (Fig 2e). Despite this variation, the number of dead ringed Curlew was significantly higher in severe winters than other



**Figure 2.** Number of recoveries of ringed waders in January to March within Britain and Ireland between 1980 and 1999. Vertical lines mark severe winters.



**Figure 3.** Numbers of recoveries of ringed waders of six species in six regions of Britain in January to March, 1980 to 1999. Regions are as shown in Figure 1. Closed circles are mild winters and open circles severe winters.

winters ( $\chi^2_1 = 59.4$ ,  $P < 0.0005$ ). When comparing regions, small sample sizes meant that for statistical purposes all western regions (southwest England, Irish Sea and western Scotland) were amalgamated, as were northeast England and eastern Scotland. There was no significant difference between regions ( $\chi^2_2 = 0.2$ , NS, Fig 3f), although some temporal variation in the effect of severe winters between regions can be seen, with most dead birds reported in the southeast in 1991 and most in the west in 1986.

### Redshank

The increase in the number of dead ringed Redshank reported in severe winters compared to other winters is highly significant ( $\chi^2_1 = 1,093.6$ ,  $P < 0.0005$ , Fig 2f). There is also significant regional variation in mortality ( $\chi^2_3 = 91.0$ ,  $P < 0.0005$ ). There are more reports of dead ringed Redshank in the eastern half of the country, with the reports being dominated by the 290 ringed Redshank found dead in the southeast in 1991 (Fig 3g). The numbers of reports from the northeast were also unusually high in severe winters, particularly in 1991. In eastern Scotland the highest number of reports was in 1982.

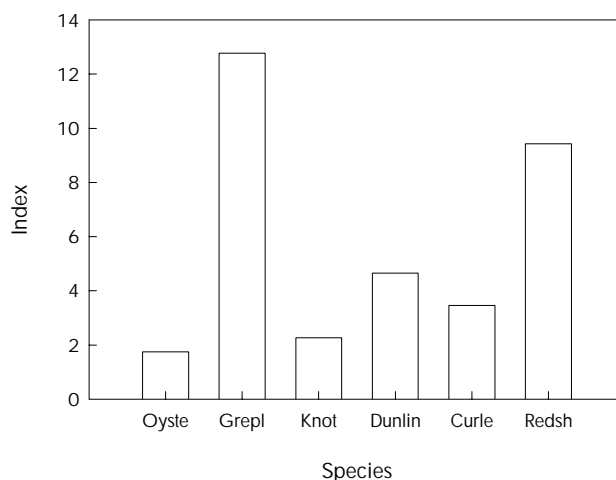
### All species

The index of vulnerability (Fig 4) clearly shows that the effect of severe winters is greatest on Redshank and Grey Plover, with smaller effects on the other species considered.

## DISCUSSION

Severe weather has clear effects on wader mortality, with significantly greater numbers of dead ringed birds being reported in severe winters than mild winters in all six species examined. However, the patterns of wader mortality vary greatly between regions of Britain as well as between species, and mortality occurs for reasons other than severe weather. Examination of numbers of ringed birds found dead confirms the distribution of mortality in severe weather reported in the literature (Table 1).

The periods of severe weather which affected wading birds, and have been confirmed by this analysis, are shown in Table 1. The effect of the short, but particularly cold, severe spell in 1991, which did not trigger a hunting ban, can clearly be seen from the totals of recoveries of dead birds (Fig 2), with the numbers being dominated by those birds found in the southeast (Figs 3a-g). The effects of severe weather on the number of dead ringed birds reported are less clear in other regions and other severe spells.



**Figure 4.** Index of vulnerability to severe weather. The index is the average number of recoveries in severe winters divided by the average number of recoveries in other winters, 1980-99. Sample sizes are given at the top of the graph. The sample size for Oystercatcher excludes 1993 and 1996 and that for Knot excludes 1987; see text for more details.

As in 1991, hunting bans were not always imposed in periods when mortality occurred. The weather in January 1987 met the JNCC criteria for a hunting ban for 13 consecutive days and a ban was imposed (Stroud 1992). After 13 days the temperature rose and, after seven days of milder weather, the ban was revoked. Although an influx of wildfowl from the Continent was observed on the east coast, there were few reports of increased mortality (Stroud 1992). The data on ring recoveries confirm that little increased mortality occurred in this severe weather period, although the total of Dunlin recoveries appears to be higher than normal. The exceptional number of Knot recoveries is due to a pollution incident.

The severe weather in 1986 did not trigger a hunting ban as it occurred towards the end of the shooting season. However there was unusual wader mortality which had most effect on Curlew and Grey Plover. The numbers found are small but, unusually, just over half of the dead ringed Curlew found in this severe spell were from the west (mainly in the Irish Sea), although most of the rest were in the southeast. Few Grey Plover are ringed away from the Wash so regional comparisons for this species are not possible. The recoveries suggest that they did not suffer from severe weather mortality prior to 1986, with the effects of severe weather mortality being seen in 1986 and 1991. This vulnerability to severe weather may be a result of increased numbers of birds being in the area (Moser 1988).

The severe winter weather in 1985 resulted in shooting bans in England and Wales (16-29 January) and Scotland

(18-31 January). There was a small increase in the number of dead ringed birds reported for Oystercatcher, Dunlin and Redshank, although the effect on the other species studied is not clear. When considering the regional distribution of recoveries, an increase in reports of Oystercatchers from the southwest can be seen, although the numbers involved are small. More than half of the Dunlin were found in the southeast and, although increased mortality was seen in all regions for Redshank, the southeast dominated numerically.

Shooting bans were imposed in England and Wales (22 December-5 January and 13-22 January) and Scotland (23 December-5 January and 8-24 January) in winter 1981/82. An increased number of recoveries was recorded for Oystercatcher, Curlew and Redshank in 1982. There were unusually high numbers of Oystercatcher and Redshank recoveries in eastern Scotland (Figs 2 & 3), a result of the severe weather kills at Montrose Basin and on the Moray Firth (Table 1).

The results from recoveries of dead ringed birds largely confirm the patterns of mortality reported in the literature, providing a method of assessing the distribution and level of mortality without instituting new fieldwork. Severe spells have been shown to vary in their effect on different species. Although Knot are found dead in some severe spells, the level of severe weather mortality experienced by this species appears to be low. At the other end of the scale, Redshank, particularly those in the east of Britain, suffer severe weather mortality in all cold spells and have a high vulnerability index (Fig 3). The vulnerability index also shows that Grey Plover experience unusually high mortality in severe periods, although this effect has only been seen since 1986 and may have occurred only as the population levels have increased. Other species seem to experience different levels of mortality both temporally and spatially.

The use of recoveries also demonstrates that the effects of severe weather vary spatially. For example, in 1982, Oystercatchers and Redshank on the east coast of Scotland were badly affected. There appear, however, to be a more even number of reports of dead ringed Oystercatchers across years, particularly in northeast England and eastern Scotland and in the Irish Sea. This may be because this species suffers higher mortality than others in the winter and the background level is being monitored. In 1991 a wider range of species showed unusual mortality in a short but very severe cold spell that did not trigger a shooting ban, but this was largely confined to southeast England. Wader mortality in severe weather then appears to vary spatially with, in general, mortality being low in the west of Britain and birds wintering in the east being more affected.

The effect of severe weather on wading birds should, however, be considered in the context of historic climate patterns and predictions for future climate change. Climate is changing globally and the temperature, particularly in the winter, is increasing, whilst the number of cold periods (temperature less than 0°C or less than -4°C) has declined, with very few particularly cold spells falling in the early part of the winter in the last 100 years (Hulme & Jenkins 1998). Predictions suggest that cold spells will become less frequent in future (Watkinson *et al* in press). An increase in winter temperatures will mean that waders wintering in Britain & Ireland are less likely to encounter severe cold weather which would cause increased mortality. If populations and their distribution have been influenced by the risk of severe weather in the past, this could have important implications for the size and distribution of wader populations in the future.

This paper has demonstrated that recoveries can be used to describe the effects on waders of severe weather without new fieldwork. There will always be a delay from the time birds are found dead to their being reported to the Ringing Unit at BTO HQ. Because of this, and because patterns of recovery reporting vary between groups of individuals and over time and the distribution of ringed birds is not uniform across the country, it is unlikely that recoveries alone could be used to warn of severe weather effects. They could, however, provide confirmation of expected effects as well as giving an indication of spatial differences in unusual mortality. To achieve this, numbers of recoveries could be monitored as soon as JNCC warn of the possibility of a cold spell from the meteorological data, with an increased number of recoveries providing a warning that there may be an increase in mortality. As mortality in severe weather can be regional and the JNCC severe weather alert system is separated only into England & Wales and Scotland (both combining east and west coast estuaries), the numbers of recoveries received by the BTO should be monitored from the start of a possible severe weather event as they may provide an indication of the spatial distribution of mortality.

Although recoveries of all waterfowl should be monitored in cold weather, it is likely that any effects will be seen first amongst Redshank, which are particularly susceptible to the effects of severe weather or Dunlin, which although not so susceptible to severe weather are numerous and widespread. It is therefore important that ringers maintain the level of ringing of waterfowl, and particularly of the more common wader species, to assist in the assessment of any future severe weather periods. The distribution of mortality as shown by recoveries could also be used to compare the

effectiveness of the old and new meteorological measures of severe weather used by JNCC to instigate shooting bans.

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