COLD WEATHER MOVEMENTS OF WATERFOWL AND WADERS: AN ANALYSIS OF RINGING RECOVERIES

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SUMMARY

1. Cold weather movement patterns of 12 species of wildfowl, 11 species of wader and of Heron, Moorhen, Coot and Kingfisher were investigated using recoveries of birds ringed in Britain. Recoveries in Britain of birds ringed abroad were not included. Thus this report is concerned mainly with movements within Britain and with emigration from Britain resulting from severe weather. It is less concerned with cold weather immigration into Britain from the Continent.

2. Data from winters between 1940/41 and 1982/83 were analysed. This period included five cold winters; 1946/47, 1955/56, 1962/63, 1978/79 and 1981/82.

3. The main approach was to compare recovery distributions during cold weather with those during equivalent mild periods. The distributions of recoveries during all mild winters were compared with those during all cold ones. More rigorous analyses, in which the distribution of recoveries during severe spells was compared with that for the same periods in years immediately before and after cold weather, were carried out for those species with sufficient data. Analyses were carried out using the percentage of recoveries reported from each of a series of standard regions and also using distances between ringing and recovery places.

4. Difficulties in interpreting cold weather recovery distributions arise because the effects of changes in bird distributions and of changes in mortality are confounded. This problem and the probable effects of biases in the recovery data are discussed. For most species the extent of cold weather movements was probably underestimated.

5. Comparisons of recovery totals in mild and severe winters provide information on changes in mortality due to cold weather.

6. Movement patterns during mild and severe winters are described for each species. Individual summaries are given at the end of each species account.

7. Some Wigeon, Teal, Shovelers and Tufted Ducks move to France and south Europe during cold weather as does a very small proportion of the Mallard population. Some Gadwalls and Pochard probably also undertake such movements but the mild and cold weather recovery distributions of these species were not significantly different, probably due to small sample sizes.

8. Shelducks move south out of the Waddenzee and northern Britain to southern Britain and France in cold weather.

9. Pintails move to the Irish Sea area and Ireland in cold weather. Pink-footed Geese also show westerly movements to North-west England from North-east Scotland and East England.

10. Most Mute Swans, Canada Geese, Mallards, Moorhens and Coots do not move during cold weather, although a few Canada Geese and Mallards undertake cold weather movements.

11. Some Lapwings, Snipe and Curlews move to France and Iberia in response to severe weather. There is also weak evidence that Knot undertake cold weather movements to France.

12. The ringing recoveries provide no evidence of cold weather movements by Woodcocks, Oystercatchers, Dunlins, Ringed Plovers, Sanderlings and Turnstones. Most Redshanks do not move during cold weather but some British-bred birds may undertake southward movements in cold weather.

13. Herons and Kingfishers do not move during cold weather except for some short north-westerly movements by Scottish Herons.

14. Differences in movement patterns between cold winters were demonstrated for five of the eight species with adequate recovery samples to test this possibility. Longer and more extensive movements generally occurred in colder winters.

15. The extent of Teal movements to the Continent is correlated with the frequency of freezing weather when all winters are considered. For this species at least, cold weather movements represent one extreme of a graduated response to the prevailing weather conditions.

16. Relationships between feeding ecology and cold weather movement patterns are discussed. Those species which are most rapidly deprived of food at the onset of cold weather are those which normally undertake cold weather movements. This group includes ducks that feed on freshwater habitats which become frozen and waders, such as Lapwing and Snipe, that feed in terrestrial habitats.

17. Recovery rates of Mute Swan, Pink-footed Goose, Wigeon, Teal, Mallard and Tufted Duck increased significantly during cold weather while those of Canada Goose, Shelduck, Gadwall, Shoveler and Pochard did not. These increases almost certainly indicate increased mortality although for many waterfowl the proximate cause of the increase was hunting.

18. Recovery rates of Lapwing, Snipe, Redshank, Oystercatcher, Curlew and Ringed Plover increased significantly during cold weather but those of Dunlin, Knot, Sanderling and Turnstone did not. Except for Ringed Plover all of the species which suffered increased mortality are to some extent dependent on field feeding during the winter period.

19. Heron, Mute Swan, Moorhen, Coot, Redshank, Oystercatcher and Kingfisher all experience a marked increased in mortality during cold weather but in general they do not undertake cold weather movements. Possible reasons for this are discussed.

20. For most of the species considered here it is not known whether cold weather mortality causes a reduction in population size. With the present state of knowledge it would be prudent to protect birds which have fled to refuge areas as a result of severe weather.

21. Future research priorities for the description of cold weather movements should include analyses of existing count data and analyses of ringing recoveries on a European basis. Suggestions for ringing priorities within Britain are given.

22. Future research should also aim to assess the impact of cold weather mortality and movements on the population dynamics of the species concerned. Initial approaches to this problem should include studies of population changes using count data and of changes in mortality rates using ringing recoveries.

1 INTRODUCTION

Exceptionally cold winters cause marked increases in the mortality of many bird species (Dobinson and Richards 1964, O'Connor and Cawthorne 1982). A system of cold weather hunting bans was established in Britain in 1979 to alleviate the effects of such conditions on bird populations (Batten and Swift 1982). Similar bans have been introduced in some other European countries during very severe weather, generally on a more ad hoc basis. The objective of such bans is to prevent direct hunting mortality and to reduce disturbance. Some species may need to spend a very high proportion of their time feeding during severe weather, and under such circumstances they may be particularly vulnerable to disturbance.

Many species move in response to cold weather so as to reach areas with milder weather and more readily accessible food supplies. In north-west Europe such movements are generally to the south and west of the normal wintering areas of the populations concerned. Little is known of the condition of such birds following these movements but it is likely that they would benefit from a period of undisturbed feeding in which to replenish their body reserves. Large concentrations of birds gather in some areas during cold weather and may be particularly vulnerable to hunting and to other forms of disturbance. For hunting bans to be fully effective, therefore, it may be necessary for them to cover refuge areas to the south and west of those directly affected by the cold. To assess the likely effectiveness of such measures it is necessary to have a detailed knowledge of how birds alter their movement patterns in relation to cold weather. The Nature Conservancy Council therefore asked the BTO to undertake the present analysis of cold weather movements.

Much qualitative information on cold weather movements has been published, both from direct observations (Dobinson and Richards 1964) and from ringing recoveries (Spencer 1964). However, very few quantitative studies have been published, notable exceptions being analyses of the recoveries of French-ringed Teal (Impekoven 1965), and Dutch-ringed White-fronted Geese (Doude Van Troostwijk 1965). Recoveries of British-ringed Teal, Mallard and Tufted Ducks from the 1978/79 winter have been analysed by Ogilvie (1982), and he has also carried out a detailed analyses of the cold weather movements of Teal ringed in Denmark, Holland, France and Britain (Ogilvie 1981,1983). Baillie (1984) provides a recent review of the cold weather movements of European bird populations.

The objective of the present analysis was to examine the accumulated recoveries of British-ringed waders and wildfowl for evidence of cold weather movements. Recoveries of Herons, Coots, Moorhens and Kingfishers were also examined, as these species occupy freshwater habitats which may be subject to disturbance during cold weather. Heron and Kingfisher breeding populations are markedly depressed following cold winters. The analyses aimed to identify those species which undertake cold weather movements and to identify the areas to which birds move during cold weather. Differences in movement patterns between winters were investigated for those species with sufficient data.

This report is based on recoveries of British-ringed birds and is therefore concerned mainly with movements of populations which breed or winter in Britain. During severe weather on the Continent populations which normally winter there may move into Britain. For example, an influx of Red-necked Grebes and other waterbirds took place during the 1978/79 winter (Chandler 1981) while both in 1978/79 and in 1981/82 Light-bellied Brent Geese from the Svalbard population, which normally winter in Denmark, moved to Lindisfarne in north-east England.

Ringing recoveries also provide information about cold weather mortality. The main emphasis of this report is on movement patterns but where the analyses provide information on mortality this is discussed briefly.

METHODS

2.1 The recovery data

The data used for this analysis were ringing recoveries accumulated under the British Trust for Ornithology ringing scheme. Such recoveries are usually reports of ringed birds which have been killed or found dead, but also include birds found alive away from their place of ringing. Records of birds ringed in Britain and Ireland between 1940 and 1983 were examined for this analysis. The data are held on computer file at the British Trust for Ornithology. The main variables used from each recovery were as follows:

Species
Age when ringed
Date of ringing
Geographical coordinates of ringing place
Date of recovery
Geographical coordinates of recovery place
Distance between ringing and recovery places
Finding condition - whether bird was found dead or alive
Finding circumstances - cause of recovery where this was recorded

Certain other fields were used to exclude unreliable data prior to analysis. The date and place information were used to assign recoveries to particular time periods and regions (below).

2.2 Selection of species

This report covers wildfowl and waders and a few freshwater species, namely Grey Heron, Moorhen, Coot and Kingfisher. The objective of examining cold weather movements was to determine the likely effect of hunting mortality and disturbance on birds which have emigrated from areas affected by cold weather. Thus the emphasis is on quarry species (mainly wildfowl) and other species (mainly waders) occupying habitats likely to be disturbed by hunters. Many passerine species probably undertake cold weather movements, and visible migration by such species as Redwings and Fieldfares has frequently been recorded during severe weather.

The 27 species for which there are sufficient recoveries for at least a preliminary analysis of cold weather movements are listed in Table 2.1. The total numbers ringed and recovered up to the end of 1982 and the number of recoveries available from mild winters and from severe spells are also listed. Other species of wildfowl and waders which winter in Britain and for which the BTO holds some ringing recoveries are listed in Table 2.2, along with the total number ringed up to the end of 1982 and the total number of recoveries for all seasons up to the end of 1982.

The Eider is the only species in Table 2.2 with a large number of cold weather recoveries. Since it is a seaduck at the southern edge of its range, British populations are unlikely to be affected by cold weather. Most of the recoveries are from the breeding population of north-east Britain. These birds undergo seasonal movements within this region but few are recovered from other regions (Baillie 1981, Milne 1965).

2.3 Selection of recovery data

This analysis includes only recoveries of birds ringed in Britain, and does not investigate movements of birds into Britain during severe weather. The recoveries of foreign-ringed birds recovered in Britain are at present being computerised, and it will therefore be possible to include analyses of them in the future (see discussion). All controls (recaptures by other ringers away from the ringing place) of waders were omitted, as it is not possible to interpret them sensibly without data on the numbers ringed. Work currently in progress by Dr. M.W.Pienkowski should make these data available in computerised form in the forseeable future. Dr. Pienkowski's study is concerned with all interestuarine movements of waders and will thus provide a valuable basis for more detailed work on their cold weather movements. Few controls of wildfowl (except Mute Swan) occur during the winter. The distribution of these controls is less biased than for waders and is less affected by large shifts in the distribution of ringing effort between years. Controls of wildfowl were not therefore omitted.

The following categories of recoveries were excluded because the data were thought to be inaccurate or unreliable:

(a) Birds ringed when sick or injured
(b) Ringing date uncertain by more than 14 days
(c) Ringing coordinates uncertain by more than 30 minutes
(d) Finding date uncertain by more than 30 days (but reports with date of letter only have been included in the analyses)
(e) Finding coordinates uncertain by more than 30 minutes
(f) Birds transported or held in captivity when ringed
(g) Recoveries where only the ring was found.

2.4 Weather data

The state of ground at 0900 h at 13 coastal weather stations throughout Britain is used to determine the onset of cold weather hunting bans (Batten and Swift 1982). For this purpose and for the analyses presented here the ground was classified as either frozen (ground states 3 to 9) or not frozen (ground states 0 to 2). These ground state codes are defined by the Meteorological Office as follows:

0 - Surface dry (no appreciable amount of dust or loose sand).
1 - Surface moist.
2 - Surface wet (standing water in small or large pools on surface).
3 - Surface frozen.
4 - Glaze on ground but no snow or melting snow.
5 - Ice, snow or melting snow covering less than one half of ground.
6 - Ice, snow or melting snow covering more than one half of ground (but not completely).
7 - Ice, snow or melting snow covering ground completely.
8 - Loose, dry snow, dust or sand covering more than one half of ground (but not completely).
9 - Loose, dry snow, dust or sand covering ground completely.

Data on the State of Ground were obtained for the months of October to March for each of the winters 1959/60 to 1982/83. The stations used were as follows:

Dyce, Grampian	$57^{o}12'$N	$2^{o}12'$W
Leuchars, Fife	$56^{o}23'$N	$2^{o}52'$W
Abbotsinch, Strathclyde	$55^{o}52'$N	$4^{o}26'$W
Tynemouth, Tyne and Wear	$55^{o}\ 1'$N	$1^{o}25'$W
Kilnsea, Humberside (to 1975/76)	$53^{o}37'$N	$0^{o}\ 9'$E
Binbrook, Lincolnshire (from 1976/77)	$53^{o}27'$N	$0^{o}12'$W
Gorleston, Norfolk	$52^{o}35'$N	$1^{o}43'$W
Manston, Kent	$51^{o}21'$N	$1^{o}21'$E
Carlisle, Cumbria	$54^{o}56'$N	$2^{o}57'$W
Squires Gate, Lancashire	$53^{o}46'$N	$3^{o}\ 2'$W
Aberporth, Dyfed	$52^{o}08'$N	$4^{o}34'$W
Rhoose, South Glamorgan	$51^{o}24'$N	$3^{o}21'$W
Hurn, Dorset	$50^{o}47'$N	$1^{o}50'$W
Mount Batten, Devon	$50^{o}21'$N	$4^{o}\ 7'$W

2.5 Definition of severe winters

This analysis covers the period from 1940/41 to 1982/83. Before 1940 relatively few birds were ringed and thus there are few recoveries from severe winters. Five cold winters fell within the period considered, namely 1946/47, 1955/56, 1962/63, 1978/79 and 1981/82. Other authors (e.g. Ogilvie 1981) have classified additional winters within this period as severe, in particular those of 1953/54 and 1961/62. However the periods of severe weather during these winters were relatively short and for most species involve few recoveries. In some species it is probable that cold weather movements occur only in response to prolonged periods of severe weather.

The dates for the beginning and end of the severe spells in each of the five winters under consideration were taken to be as follows:

1946/47	23rd January - 10th March
1955/56	1st February - 21st February
1962/63	22nd December - 4th March
1978/79	31st December - 1st March
1981/82	8th December - 17th January

Dates for 1946/47 and 1955/56 were taken from published sources (Ticehurst and Hartley 1948, Ogilvie 1981). Dates for the latter three winters were determined from the proportion of the 13 British weather stations at which the ground was frozen at 0900 h (Figure 2.1).

Some of these cold spells include brief periods of slightly milder weather. The few days of milder weather in the middle of the 1981/82 cold spell are a good example of this (Figure 2.1). Such variations in weather conditions probably affect the distribution of birds, but the ringing recovery data are not sufficiently extensive or accurate to measure these changes. Responses to these brief ameliorations in freezing weather are probably small compared with movements over the winter as a whole.

2.6 Definition of seasons and regions

Winter has been taken as the months of November to March. Originally it had been intended to include October, but preliminary mapping of the wildfowl recoveries indicated that many of the birds which winter in Britain are still on passage at this time. For analyses involving the time of ringing the periods April-June (Summer) and July-October (Autumn) were used.

Fifteen standard regions were used for the analyses of the wildfowl recoveries, and for those of other water birds (Figure 2.2). South-east and South-west England were combined for the analyses of estuarine waders (Figure 2.3), while for the analyses of waders ringed during the breeding season, Britain was split into three regions: North, Central and South (Figure 2.4).

2.7 Identification of differences in the distribution of recoveries in mild and severe weather

The main objective of this analysis was to determine whether the geographical distribution of recoveries was affected by severe weather. This was examined both in terms of the numbers of recoveries in each region and in terms of distances between ringing and recovery places. Most analyses use the data for all winters combined, as for many species recovery samples from individual winters were small. However for a few species there were sufficient data to carry out analyses for individual winters (Section 30).

The simplest analysis was a comparison of the percentage of recoveries in each region during all mild winters with the corresponding percentage during all severe winters. This analysis maximises the sizes of the recovery samples, but recoveries from mild spells within severe winters are included. A second analysis was therefore carried out in which the recovery distribution from all mild winters was compared with that from severe spells. This analysis again seeks to maximise the sample sizes, but it does not take into account seasonal changes in the pattern of recoveries between winters. Where such seasonal differences may have affected the results they are discussed in the individual species accounts. The results of these two analyses are set out in each of the species accounts (usually Table 1).

For many of the analyses presented in this report it was necessary to combine data from birds ringed in all regions of Britain over the whole study period. Combining data in this way does not take into account any long-term changes in the geographical distribution of recoveries. Such changes can arise from changes in the regional distribution of ringing effort rather than from a real change in movement patterns. To take some account of this, and of the seasonal biases mentioned above, a further comparison was carried out. Recoveries from individual severe spells were tabulated alongside those from the same dates in the winters immediately before and after the severe one. These tables were then summed over all severe winters to give distributions for severe spells and for the corresponding mild ones. It is much less likely that this analysis will have been affected by changes in ringing effort and in recovery reporting rates between years.

This form of analysis has the further advantage that it is possible to compare numbers of recoveries from individual regions during mild and severe weather independently of the numbers in other regions. Such a comparison assumes that equal numbers of birds were available to be recovered at the beginning of mild and severe periods. It is not possible to check this assumption very precisely, as the estimates of survival which would be necessary to calculate numbers of ringed birds at risk are not available for many of the species considered here. However, it is likely to have been approximately true in most cases.

For a few species it was possible to examine recovery distributions in periods between the end of severe weather and the end of the winter, so as to obtain some indication of whether birds returned to their normal wintering areas immediately following the end of the cold weather. This was done in a way analogous to that described above, by comparing recovery distributions during periods between the end of severe spells and the end of March with the same dates in immediately previous and subsequent winters.

2.8 Interpretation of differences in recovery distributions

The main difficulty in interpreting the data presented here is that the distribution of recoveries during severe weather is affected by changes in mortality and in recovery reporting rates as well as by changes in the geographical distribution of the population. This may be expressed algebraically for the simple case of two regions as follows:

Let

λ = recovery reporting rate
s = survival rate during the period under consideration
1-s = mortality rate during the period under consideration
p = proportion of the population in a particular region
N = number of ringed birds at risk at the start of the winter

subscripts 1 and 2 denote regions
subscripts m and c denote mild and cold periods

For simplification r = recovery rate = $\lambda(1-s)$

Thus

Number of recoveries in region 1 during mild weather = $N_m p_{1m} r_{1m}$
Number of recoveries in region 2 during mild weather = $N_m p_{2m} r_{2m}$
Number of recoveries in region 1 during cold weather = $N_c p_{1c} r_{1c}$
Number of recoveries in region 2 during cold weather = $N_c p_{2c} r_{2c}$

Thus a 2 x 2 contingency table of numbers of recoveries might be constructed as follows:

	Mild weather	Severe weather
Region 1	$N_m p_{1m} r_{1m}$	$N_c p_{1c} r_{1c}$
Region 2	$N_m p_{2m} r_{2m}$	$N_c p_{2c} r_{2c}$

For this type of comparison we can usually assume that approximately equal numbers of ringed birds will be alive at the start of mild and severe winters, and hence the numbers of ringed birds at risk (N) cancel out. However recovery rate and geographical distribution are confounded. To make quantitative estimates of the proportion of the population in each region it is necessary to assume that recovery rates are constant in all regions. This is untrue, and is a well known limitation of studies of population distributions based solely on ringing recoveries. However if we wish to detect changes in the ratio $p_1 : p_2$ we only need to assume that:

$$\frac{r_{1m}}{r_{2m}} \doteq \frac{r_{1c}}{r_{2c}}$$

But again this assumption is unlikely to be true. Cold weather generally increases mortality in the areas that the birds are leaving, and this is likely to cause the extent of cold weather movements to be underestimated. Conversely, voluntary or statutory hunting bans have been implemented in some areas during recent severe winters, and these will bias estimates of cold weather movements upwards, particularly for quarry species. However, over the study period as a whole such bans were not sufficiently frequent to seriously bias the results. Decreased human activity in areas affected by cold weather might reduce recovery rates there, and this would also cause the extent of cold weather movements to be overestimated. Overall it is likely that the first bias will be the strongest, and that the analyses presented in this report have underestimated the extent of cold weather movements.

In the previous section a second way of looking at the results was mentioned, in which, for each region, numbers of recoveries during severe spells are compared with those from the same periods during the immediately previous and subsequent winters. As two mild winters are compared with one cold one a ratio of 2:1 is expected. Thus we consider the ratio:

$$N_m p_{1m} r_{1m} : 2N_c p_{1c} r_{1c}$$

Assuming numbers of ringed birds available to be recovered at the start of each season are equal this reduces to:

$$\frac{p_{1c} r_{1c}}{p_{1m} r_{1m}} = \frac{2 \times \text{recoveries during severe spells}}{\text{recoveries during same periods in years before and after}}$$

We will refer to this ratio as the "Recovery index".

Again, regional distribution and recovery rates are confounded, although in this case the comparison is not confused by the situation in other regions. Thus an index value significantly greater than unity implies that more birds have been recovered in the region concerned during severe weather, either as a result of an increased number of birds being present or of an increase in either mortality (m) or reporting rate (λ). Severe weather is unlikely to give rise to increased reporting rates. Decreased human activity and hunting restraint will tend to reduce reporting rates. An index greater than unity will therefore generally imply that more birds from the population have died in the area under consideration. Thus conservationists would probably wish hunting to be stopped in such an area during cold weather, even if it is not clear whether the increase is due to movement of birds into the area or to mortality of those birds which were present prior to the onset of the cold.

Another important factor which may affect the results of this type of analysis is the timing of cold weather movements relative to the onset of severe weather. In reality the distribution of birds is constantly changing, and it is probable that some birds do not leave their normal wintering areas for several days after the onset of cold weather. This may again cause the proportion of any population visiting an area in response to cold weather to be underestimated. Where redistribution of birds in response to cold weather has continued for several weeks, this is likely to be detected using ringing recovery data, provided that there are sufficient ringed birds at risk. However, brief visits to an area are unlikely to be detected, as few birds will die during such a short period, and hence few ringed birds will be recovered.

2.9 Statistical analysis

Numbers of recoveries in each region during mild and severe weather were compared using 2 x n contingency tables tested with x^2. Adjacent regions were combined where necessary to avoid small expected values (Siegel 1956). In some cases it was necessary to combine regions further than is shown in the tables. When this has been done it can be inferred from the number of degrees of freedom, which for a 2 x n contingency table will be one less than the number of regions used for testing.

Distances between ringing and recovery places were tabulated using the following divisions:

0 - 9 km
10 - 49 km
50 - 99 km
100 km divisions up to 1499 km
1500 - 1999 km
2000 - 2999 km
3000+ km

All mean distances were calculated from the distance distributions rather than from the raw data. Very few recoveries were in the categories over 1500 km and so this will not have lead to any serious inaccuracy. It must be stressed that these distances are only a crude measure of winter movements, as many of the birds were ringed outside the winter period. However, all birds were ringed in Britain.

Tests between paired samples of distance distributions were carried out using Mann-Whitney U-tests, while Kruskall-Wallis one-way analyses of variance were used to test for differences between three or more samples. These non-parametric tests were used because many of the distance distributions were not normal.

TABLE 2.1 Ringing and recovery totals for species included in this report.

Species	Total ringed to end 1982[a]	Total recovered to end 1982[a]	Recoveries used for analysis[b]		
			Mild winters	Cold winters	Cold spells
Grey Heron	12,919	1783	641	115	59
Mute Swan	37,130	12,668	4834	1072	496
Pink-footed Goose	11,846	3491	1849	311	103
Canada Goose	30,651	6371	1257	269	104
Shelduck	5263	526	157	32	18
Wigeon	7807	1337	490	94	37
Gadwall	2302	298	126	56	19
Teal	66,633	11,945	5585	1259	645
Mallard	127,108	21,298	9275	1072	519
Pintail	5263	809	362	49	24
Shoveler	2066	367	164	26	13
Pochard	4701	414	177	64	25
Tufted Duck	14,268	1650	737	153	85
Moorhen	18,737	806	268	68	35
Coot	8795	704	304	123	72
Oystercatcher	75,267	4644	1211	251	131
Ringed Plover	25,672	475	34	13	11
Lapwing	135,489	2586	519	200	145
Knot	61,295	1444	195	30	14
Sanderling	17,857	337	49	20	9
Dunlin	250,183	3839	453	67	37
Common Snipe	24,391	1012	451	155	110
Woodcock	7521	586	79	26	12
Curlew	21,936	988	274	81	50
Redshank	54,461	1660	490	352	243
Turnstone	16,306	446	80	23	9
Kingfisher	11,135	480	133	26	12

a From Mead and Hudson (1983).

b For details of how these recoveries were selected see sections 2.3 and 2.5.

Table 2.2 Ringing and recovery totals for regular wintering species of wildfowl and waders which are not included in this report.

Species	Total ringed in Britain to end 1982	Total recovered to end 1982
Bewick's Swan	1340	155
Whooper Swan	184	19
White-fronted Goose	617	199
Greylag Goose	2302	531
Barnacle Goose	1903	201
Brent Goose	250	38
Mandarin Duck	35	3
Scaup	158	33
Eider	15,956	1936
Long-tailed Duck	17	4
Common Scoter	44	5
Goldeneye	112	11
Red-breasted Merganser	78	8
Goosander	740	112
Ruddy Duck	20	4
Avocet	213	11
Golden Plover	2889	71
Grey Plover	4040	136
Purple Sandpiper	1929	30
Ruff	1892	66
Jack Snipe	2313	61
Black-tailed Godwit	395	10
Bar-tailed Godwit	4605	98
Spotted Redshank	290	12
Greenshank	1241	27
Green Sandpiper	1053	29

Data from Mead and Hudson (1983).

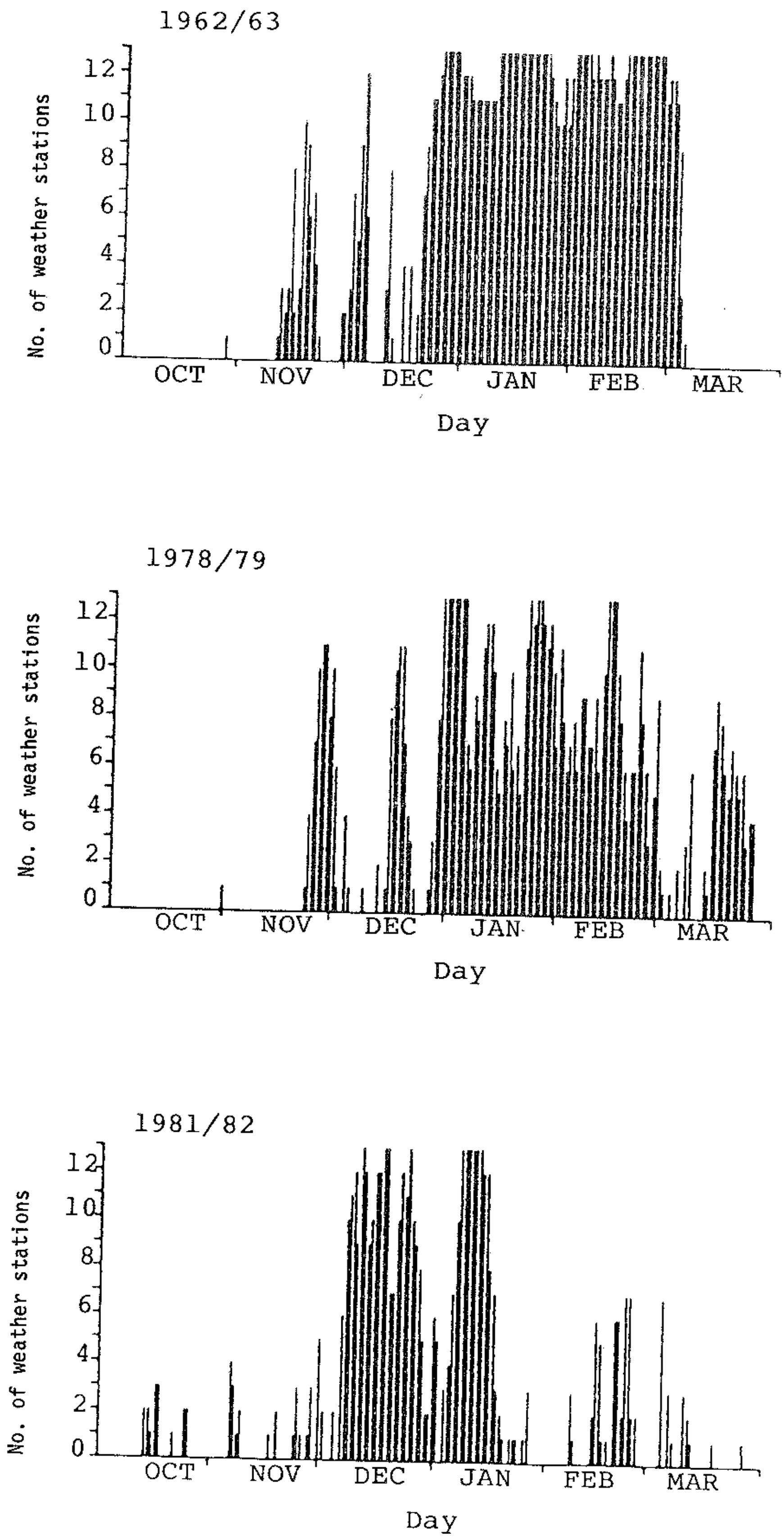


Figure 2.1 Number of the 13 coastal weather stations at which the ground was frozen at 0900h. Daily figures are plotted for the cold winters of 1962/63, 1978/79 and 1981/82. For further details of the locations of the weather stations and of the methods of recording see text.

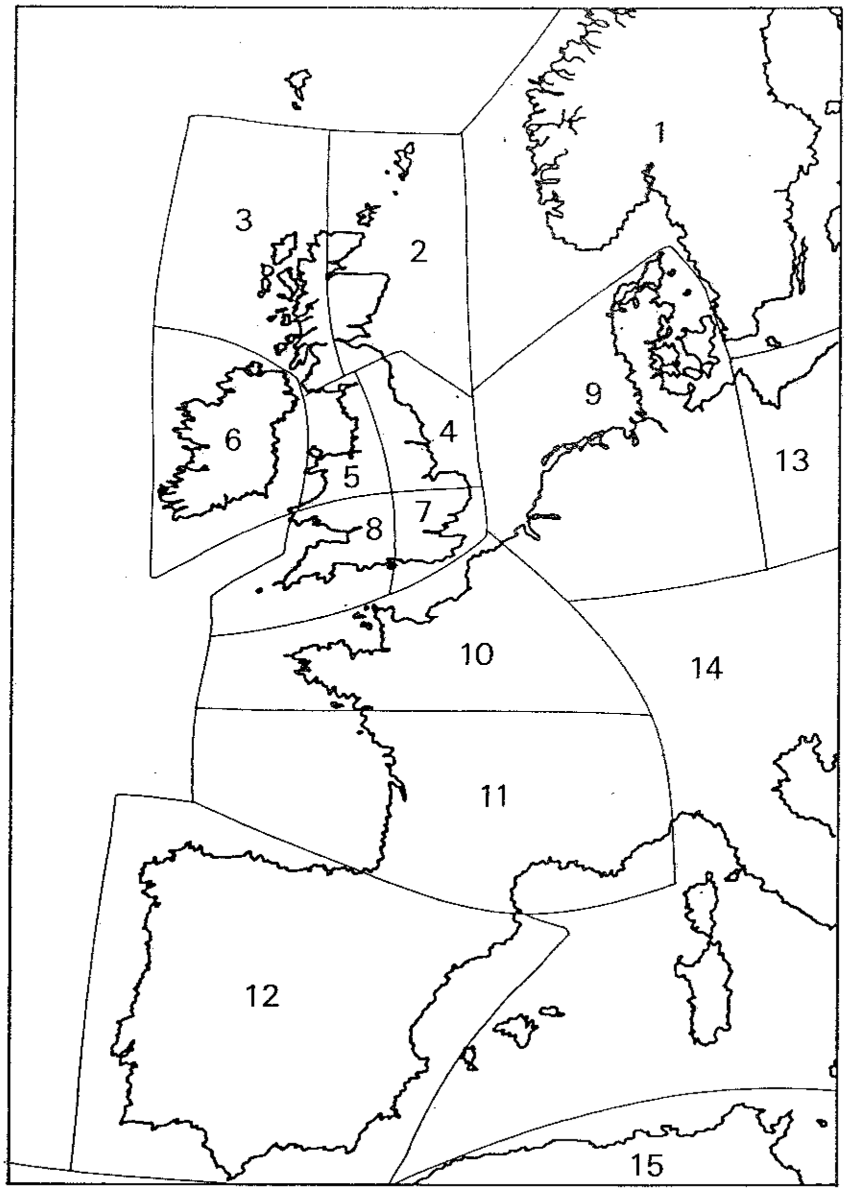


Figure 2.2 Regions used for analyses of wildfowl recoveries

1. Norway and Sweden
2. North-east Scotland
3. North-west Scotland
4. East England
5. Irish Sea
6. Ireland
7. South-east England
8. South-west England
9. Waddenzee
10. North France
11. South France
12. Iberia
13. Central Europe
14. Eastern Europe
15. Africa

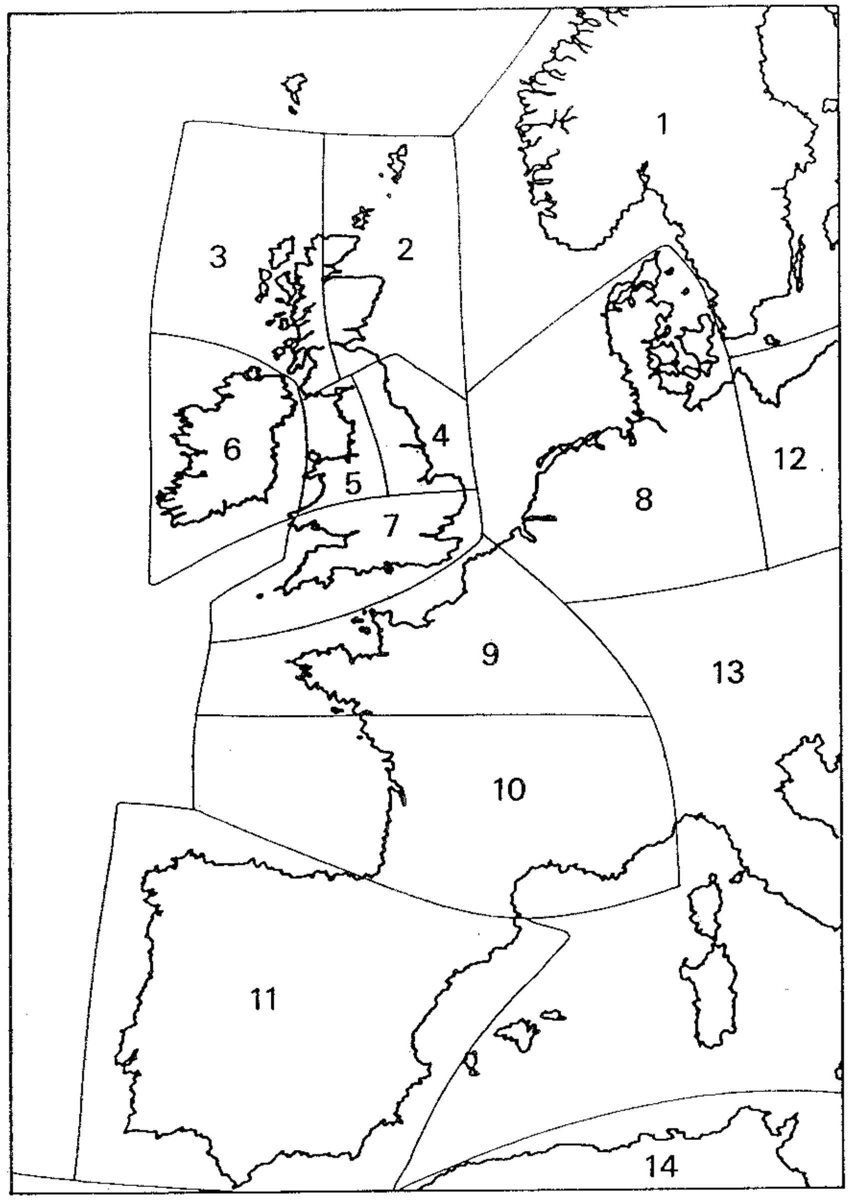


Figure 2.3 Regions used for analyses of recoveries of estuarine waders

1. Norway and Sweden
2. North-east Scotland
3. North-west Scotland
4. East England
5. Irish Sea
6. Ireland
7. South England
8. Waddenzee
9. North France
10. South France
11. Iberia
12. Central Europe
13. Eastern Europe
14. Africa

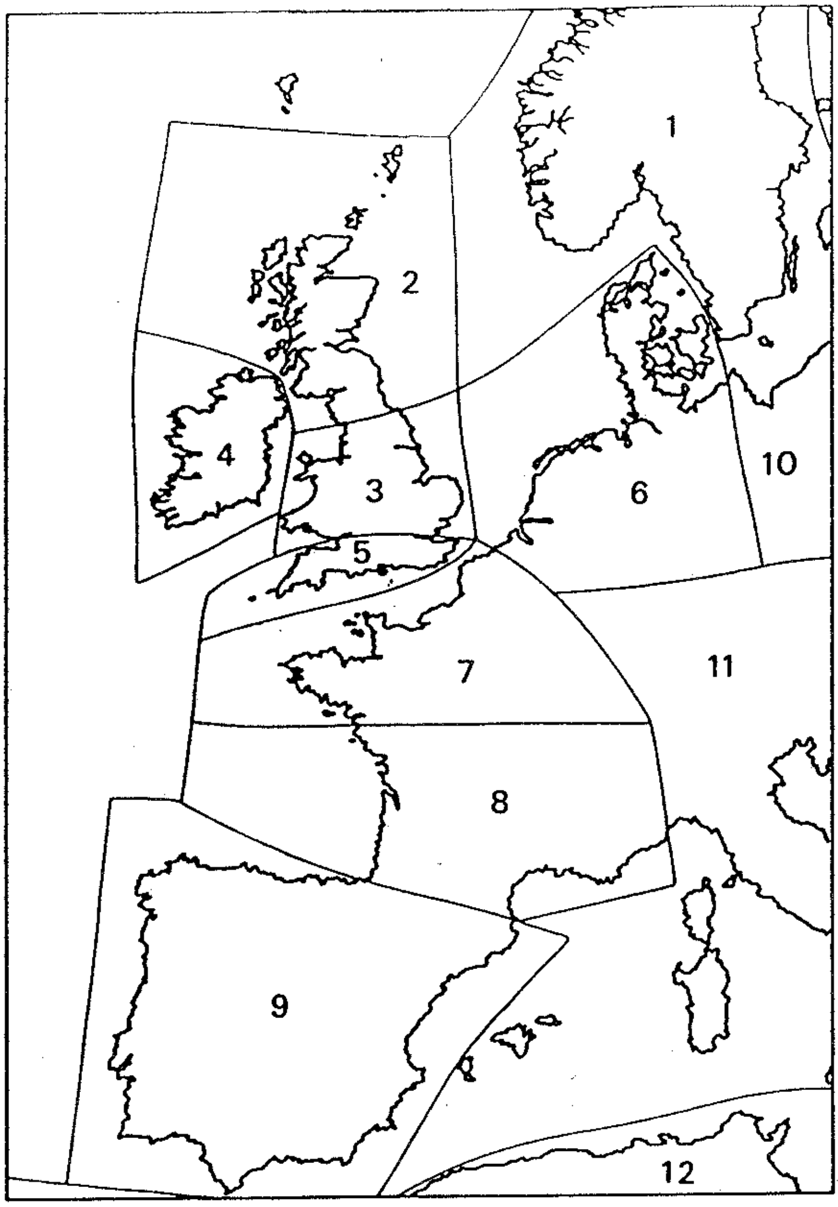


Figure 2.4 Regions used for analyses of recoveries of non-estuarine waders

1. Norway and Sweden
2. North Britain
3. Central Britain
4. Ireland
5. South Britain
6. Waddenzee
7. North France
8. South France
9. Iberia
10. Central Europe
11. Eastern Europe
12. Africa

GREY HERON *Ardea cinerea*

3.1 Normal pattern of movements

The breeding population of Grey Herons in Britain and Ireland is probably between 6500 and 11,500 pairs (Sharrock 1976). The mean population of England and Wales, which has been censused annually since 1928, is 4100 pairs (Reynolds 1979). Most of these birds remain in Britain for the winter and are joined by an unknown number of winter visitors, most of which are from Norway.

The migration patterns of European Heron populations have been analysed in detail by Rydzewski (1956), on the basis of the ringing recoveries which had accumulated to that date. Examination of the foreign recovery totals in the British ringing report for 1981 (Spencer and Hudson 1982) and results from the present analysis suggest that the movements of British and Irish Herons have not altered substantially since Rydzewski's analysis. Both in Britain and in the rest of Europe nearly all Heron ringing has been of nestlings, and thus most birds are of known natal origin. Herons from northern Britain and Northern Ireland usually remain in Britain for the winter, and few birds reach even the south of England. Some birds move from Scotland to Ireland for the winter and in general Scottish birds show a slight tendency to disperse in a south-westerly direction. Mean distances between ringing and recovery places ranged from 133 km for birds recovered in November to 72 km for birds recovered in January (Rydzewski 1956). Birds ringed in the south of England again show considerable dispersal but with no strong directional bias. This results in some birds being recovered in northern Britain and Ireland while others are found in France, with a few reaching Iberia and North Africa.

Only 3.9% of recoveries of British-ringed Herons during mild winters were from abroad, most coming from North France (Table 3.1). The mean distance between ringing and recovery places during mild winters was 94 km, and there were no significant differences between the distances moved by birds ringed in different parts of Britain (Kruskall-Wallis ANOVA, H=2.596, 4 df, ns). Many of the Herons which breed in Norway and smaller numbers from other countries in Scandinavia and north-west Europe visit Britain, especially Scotland, for the winter (Rydzewski 1956). However very few of these birds have been ringed in Britain, and the data presented below concern only Herons from the British and Irish breeding populations.

The impact of cold winters on Grey Heron mortality and population size has been well documented (Reynolds 1979). Declines of 22% after the winter of 1939/40, 34% after the winter of 1946/47 and 52% after the winters of 1961/62 and 1962/63 were recorded. Population recovery times following these declines were about four, three and seven years respectively. Similar declines following the 1978/79 and 1981/82 winters have been reported from Scotland (Marquiss et al. 1983), but the national data have not yet been published. Analysis of ringing recoveries has shown that there is a strong correlation between winter temperatures and the survival of first year Herons (North and Morgan 1979). Thus it appears that the relationship between Heron survival and winter weather is a graded one, although it is most readily seen following periods of severe weather. Most European Heron populations undertake more marked migrations than the British one. Rydzewski (1956) suggested that the extent of these migrations depended on winter weather conditions, although he presented no data to support this. The mean distance moved by 16 Scottish Herons recovered during the 1981/82 cold spell was 86 km, significantly further than the mean of 36 km for 35 recoveries from previous years (Marquiss et al. 1983).

3.2 Ringing effort

Most birds were ringed as nestlings, and hence nearly all of the ringing has been in the period April to June (Table 3.2). The recovery sample is fairly well distributed from north to south, but there has been very little ringing in North-west Scotland, and fewer than 50 winter recoveries are available for birds ringed in Ireland and for birds ringed in South-west England. On average more birds have been ringed since the late 1960s, but annual recovery totals have always fluctuated considerably (Figure 3.1). The population crash which resulted from the winters of 1961/62 and 1962/63 is reflected in reduced numbers ringed and recovered in immediately subsequent years.

3.3 Distribution of recoveries in mild and severe winters

The regional distribution of recoveries during mild winters is significantly different from that during severe winters and during severe spells only (Table 3.1). A similar pattern is also apparent when the regional distribution of recoveries during severe spells is compared with that during the same period in immediately previous and subsequent winters (Table 3.3). The main difference is that during cold weather a higher proportion of recoveries is from South England and West Britain. Both in mild and in severe weather fewer than four percent of recoveries are from abroad. The suggestion of movement within Britain was further examined by analysing the data according to region of ringing (Table 3.4). During all winters a high proportion of Herons were recorded from the region in which they were ringed. Only for Scotland was there a significant increase in the percentage of birds moving out of the region, from 9% during mild winters to 30% during cold ones. There is also a suggestion that more birds may have moved out of East Britain during severe weather, but the data are far from significant.

Cold weather movements are thus rather limited. The overall difference in recovery distributions is probably due to differential changes in recovery rates, perhaps reflecting differences in mortality. The Recovery Index has been calculated for birds ringed in each region (Table 3.5), and shows that four times as many Herons from the South of England were recovered during cold winters as during mild ones. The increase in East and West Britain was about two and a half times, while there was almost no increase in the recovery rate of Herons ringed in Scotland. The difference between Scotland and the South of England is statistically significant (x^2=4.11, P<0.05). Marquiss et al. (1983) also found little increase in the overall recovery rates of Scottish Herons as a result of severe weather, although they did record a marked difference in the seasonal distribution of the mortality.

The lack of an increase in recoveries of Scottish-ringed Herons during cold winters is unexpected and is apparently inconsistent with the observed decline in Scottish Heron populations following such winters (Marquiss et al. 1983). However, a high proportion of recoveries relate to first-year birds, while most Herons do not breed until they are two years old (Cramp and Simmons 1977). It is unlikely that the lack of an increase in recoveries is due to changes in ringing effort, as results for the winters of 1978/79 and 1981/82 are consistent. Very few Scottish recoveries are available for previous cold winters. The failure to detect increased mortality might be due to a change in behaviour or habitat use during cold weather, such as a movement to areas where birds were less likely to be recovered. Further interpretation of the difference in the mortality of Herons from Scotland and Southern England is impossible in the absence of detailed demographic data from the two populations. It may be that Scottish Herons always suffer a high winter mortality, and that the increase due to cold weather is therefore less marked. Alternatively, more of the Scottish birds may occupy coastal feeding areas in winter, in which case they would be less vulnerable to the freezing over of inland water bodies.

Analyses of distances between ringing and recovery places confirm the lack of cold weather movements when Britain as a whole is considered. Mean distances moved were 94 km during mild winters, 91 km during cold winters and 101 km during severe spells. None of these means are significantly different. A similar result was obtained when severe spells were compared with immediately previous and subsequent winters.

3.4 Summary

Most British Grey Herons remain in Britain for the winter, both in mild and in cold winters. Most birds were recovered in the region where they were ringed, distances between ringing and recovery places averaging 94 km during mild winters. Only Herons ringed in Scotland showed evidence of increased movements as a result of cold weather. Mortality appears to have varied markedly between regions, cold weather causing very little change in the recovery rates of Scottish Herons, compared with a four-fold increase in recoveries of birds ringed in the South of England. Herons from Scandinavia and north-west Europe also winter in Britain. However, because very few of these birds have been ringed in Britain, data on their movements were not available for this study.

Table 3.1 Recovery regions of British-ringed Herons in mild and severe winters.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
N.E.Scotland	(1)	59	14	5
N.W.Scotland	(2)	22	5	4
East England	(3)	185	16	6
Irish Sea	(4)	97	14	8
Ireland	(5)	31	7	7
S.E.England	(6)	173	41	21
S.W.England	(7)	49	16	6
Waddenzee	(8)	3	0	0
North France	(9)	15	1	1
South France	(10)	3	1	1
Iberia	(11)	3	0	0
Africa	(12)	1	0	0
Total		641	115	59

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
Scotland (1-2)	12.6	16.5	15.3
East England (3)	28.9	13.9	10.2
West Britain (4-5)	20.0	18.3	25.4
South England (6-7)	34.6	49.6	45.8
Waddenzee (8)	0.5	0.0	0.0
France & S.Europe (9	3.4	1.7	3.4

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=16.168, 4 df, $P<0.01$
Mild winters v severe spells x^2=9.657, 3 df, $P<0.05$

Table 3.2 Ringing periods and regions of British-ringed Herons recovered in winter.

	Ringing period			
	July-October	November-March	April-June	
N.E.Scotland	5	0	97	102
N.W.Scotland	0	0	7	7
East England	10	1	290	301
Irish Sea	4	0	101	105
Ireland	0	1	38	39
S.E.England	7	2	153	162
S.W.England	2	0	38	40
Total	28	4	724	756

Table 3.3 Recovery regions of British-ringed Herons in years before, during and after severe weather.

(a) Number of recoveries

Recovery region		Mild spells: Years before	Mild spells: Years after	Mild spells: Years before +after	Severe spells
N.E.Scotland	(1)	7	7	14	5
N.W.Scotland	(2)	2	3	5	4
East England	(3)	9	2	11	6
Irish Sea	(4)	3	2	5	8
Ireland	(5)	5	0	5	7
S.E.England	(6)	12	5	17	21
S.W.England	(7)	0	1	1	6
North France	(8)	1	0	1	1
South France	(9)	0	0	0	1
Total		39	20	59	59

(b) Percentage of recoveries

Recovery region	Mild spells: Years before	Mild spells: Years after	Mild spells: Years before +after	Severe spells
Scotland (1-2)	23.1	50.0	32.2	15.3
East England (3)	23.1	10.0	18.6	10.2
W. Britain (4-5)	20.5	10.0	16.9	25.4
South England (6-7)	30.8	30.0	30.5	45.8
France (8-9)	2.6	0.0	1.7	3.4

Only recoveries during the period of severe weather are included.
Years before v years after x^2=5.906, 3 df, ns
Severe winters v before+after x^2=8.125, 3 df, P<0.05

Table 3.4 Percentage of Herons recovered in the region where they were ringed during mild and cold winters.

Ringing region	Mild winters		Cold winters		Significance
	%	n	%	n	
Scotland	91	82	70	27	* (P=0.010)
East Britain	58	280	48	21	ns
West Britain & Ireland	79	129	100	15	ns
South Britain	84	150	92	52	ns

Figures for the whole winter have been used to maximise sample sizes. Other analyses as used above gave similar results.

Significance was tested using a Fisher test.
* P<0.05 ns not significant.

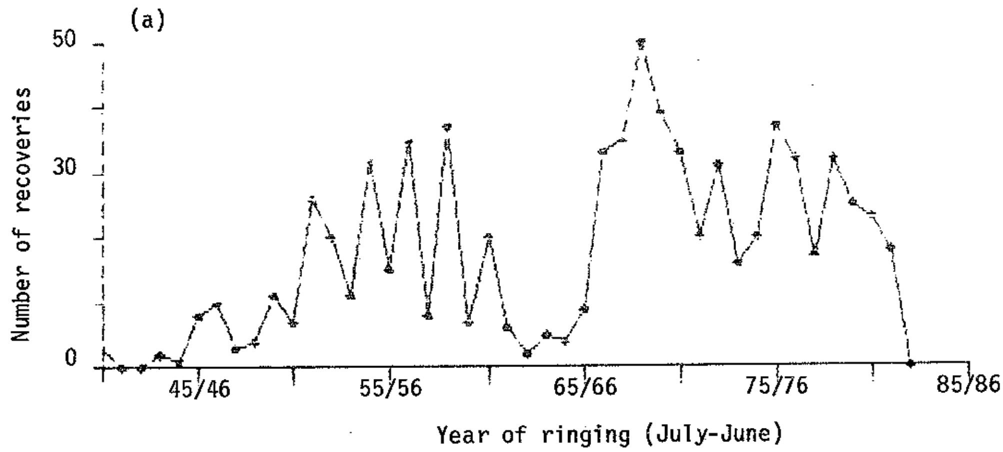
Table 3.5 Recovery Index for Herons according to region of ringing.

Ringing region	Years before and after	Severe spells	Recovery Index	x^2	sig
Scotland	20	13	1.30	0.55	ns
East Britain[a]	6	8	2.67	3.57	ns
West Britain and Ireland	9	11	2.44	4.22	*
South Britain	12	24	4.00	18.00	***

$$\text{Recovery Index} = \frac{2 \times \text{recoveries during severe spells}}{\text{Recoveries in same periods of years before and after}}$$

For further details see methods.
Significance *** P<0.001 * P<0.05 ns not significant

a Data for 1962/63 winter excluded due to very high number of recoveries in 1961/62.



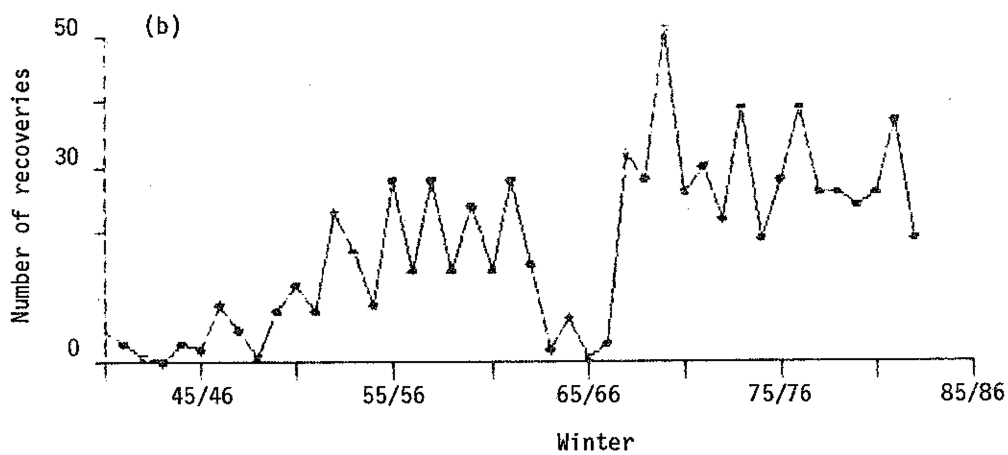


Figure 3.1 Winter recovery totals for Grey Heron

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

MUTE SWAN *Cygnus olor*

4.1 Normal pattern of movements

The most recent published census of British Mute Swans was carried out in the spring of 1978, and gave a population estimate for England, Scotland and Wales of 18,400 birds (Ogilvie 1981). About 6200 of these birds were breeding adults. The population of Ireland has been estimated as 5000-6000 birds (Ogilvie 1972).

Most British Mute Swans are fairly sedentary. In an early analysis of ringing recoveries Ogilvie (1967) reported that 94% were less than 50 km from the ringing place. He found also that only 18.5% of recoveries involved crossings of the watersheds between river systems. The present analysis confirms his conclusions. Eighty-six per cent of winter recoveries were from the region in which the bird was ringed, and only 0.5% were from abroad (Table 4.1). Eighty-nine per cent of recoveries occurred within 50 km of the ringing place. There are suggestions of small scale moult migrations from the Midlands to the Lancashire coast (Minton 1971), and from Durham and Northumberland to Loch Leven and the Montrose Basin (Ogilvie 1972 and pers. obs.). The suggestion that a moult migration takes place to the Uists (Outer Hebrides) (Jenkins *et al*. 1976) was not confirmed by a more detailed study (Spray 1981).

Survival of British Mute Swans decreased during the winter of 1962/63, compared with the average for six mild winters (Ogilvie 1967). There is no published evidence of cold weather movements by British-breeding Mute Swans. However, a small number of observations and ringing recoveries suggest that a few birds from north European populations visit Britain when their normal wintering areas are affected by very severe weather (Harrison and Ogilvie 1967). During severe winters Mute Swans from northern Europe have been recorded in the Netherlands, Belgium, north France, Switzerland and on the Adriatic coast of Italy as well as in Britain (Cramp and Simmons 1977).

4.2 Ringing effort

Since the start of Mute Swan ringing in about 1960 large numbers have been ringed and this, combined with a very high recovery rate, has produced 5906 winter recoveries (Table 4.2). There have been over 2400 recoveries of birds ringed in South-east England, over 1000 of birds ringed in the Irish Sea area and in South-west England, and over 800 recoveries of birds ringed in East England. Less ringing has taken place in Scotland, with only 175 recoveries of birds ringed in North-east Scotland and 148 recoveries of birds ringed in North-west

Scotland. Very little Mute Swan ringing has taken place in Ireland, and there are only 33 recoveries of birds ringed there. Mute Swans can be caught throughout the year, but 50% of recoveries were of birds ringed between July and October. Many cygnets are ringed during this period, and it is also the season when round-ups of moulting flocks take place.

Little Mute Swan ringing took place before 1960. In that year an improved swan ring was introduced, and a six year programme commenced during which the Wildfowl Trust supplied ringers with free swan rings. Mute Swan ringing peaked in the first year of this programme, there being just over 600 winter recoveries of birds ringed in that year. Subsequently, ringing in some areas may have been limited by the high percentage of birds which were already ringed. The high levels of ringing in the early 1960s declined when the Wildfowl Trust withdrew their general subsidy in 1965. However, adequate numbers continue to be ringed, at least in the south of Britain. Since 1970 the number of recoveries per winter has averaged about 200 (Figure 4.1).

4.3 Distribution of recoveries in mild and severe winters

The regional distributions of recoveries during severe winters, and during severe spells only, are both highly significantly different from that for mild winters (Table 4.1). The main differences between mild winters and severe spells are increases in the percentages of recoveries in North-west Scotland and South-west England and decreases in West Britain and South-east England. These differences are confirmed when severe spells are compared with the same periods immediately before and after severe weather, except that there is no longer a decrease in the percentage of recoveries from South-east England (Table 4.3).

Nearly all these recoveries are within Britain and it is not clear whether the above differences reflect changes in the distribution of the birds, or differences in cold weather mortality between regions. Recovery distributions during mild and severe spells were therefore compared for birds ringed in each of five regions: Scotland, East Britain, West Britain and Ireland, South-east England and South-west England (Table 4.4). For all regions, over 70% of recoveries both in mild and in severe weather occurred within the region of ringing. The percentage of birds recovered within their region of ringing did not differ significantly between mild and severe weather. Thus there is no evidence for increased movement between regions as a result of severe weather. The numbers of recoveries of birds ringed in each region in mild and in severe periods indicate increased mortality of birds from all areas except West Britain and Ireland (Table 4.4). The mortality increase indicated for Scotland may be exaggerated, as 29 of the 54 severe weather recoveries occurred in North-west Scotland during the winter of 1978/79, as a result of the Uist study which started in 1978 (Spray 1981).

The lack of movements in response to severe weather is confirmed by analysis of the distances between ringing and recovery places. The mean distance for recoveries during severe spells was 23 km compared with 28 km for recoveries from the same periods in immediately previous and subsequent winters (Mann-Whitney U-test, $t=4.18$, $P<0.001$). This difference is mainly due to an increase in the proportion of birds recovered less than 10 km from their ringing place, from 42% during mild weather to 55% during severe weather.

4.4 Summary

British Mute Swans are generally sedentary, with only 0.5% of winter recoveries from abroad and 89% of birds recovered less than 50 km from their ringing places. The regional distribution of recoveries differs significantly between mild and severe winters but this is due to regional differences in cold weather mortality. British Mute Swans do not show increased movement in response to severe weather but there is some evidence that birds from Northern Europe do so.

Table 4.1 Recovery regions of British-ringed Mute Swans in mild and severe winters.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
Norway	(1)	4	0	0
N.E.Scotland	(2)	128	28	12
N.W.Scotland	(3)	106	53	38
East England	(4)	728	191	88
Irish Sea	(5)	790	121	48
Ireland	(6)	28	10	7
S.E.England	(7)	2044	344	168
S.W.England	(8)	989	324	135
Waddenzee	(9)	11	1	0
North France	(10)	5	0	0
Eastern Europe	(11)	1	0	0
Total		4834	1072	496

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
Norway (1)	0.1	0.0	0.0
N.E.Scotland (2)	2.6	2.6	2.4
N.W.Scotland (3)	2.2	4.9	7.7
East England (4)	15.1	17.8	17.7
West Britain (5-6)	16.9	12.2	11.1
S.E.England (7)	42.3	32.1	33.9
S.W.England (8)	20.5	30.2	27.2
Europe (9-11)	0.4	0.1	0.0

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=103.081, 6 df, P<0.001
Mild winters v severe spells x^2=72.071, 4 df, P<0.001

Table 4.2 Ringing periods and regions of British-ringed Mute Swans recovered in winter.

Ringing region	Ringing period			
	July-October	November-March	April-June	
N.E.Scotland	113	52	10	175
N.W.Scotland	120	16	12	148
East England	433	286	114	833
Irish Sea	568	244	201	1013
Ireland	17	15	1	33
S.E.England	907	1014	497	2418
S.W.England	818	213	255	1286
Total	2976	1840	1090	5906

Table 4.3 Recovery regions of British-ringed Mute Swans in years before, during and after severe weather.

(a) Number of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
N.E.Scotland (1)	6	12	18	12
N.W.Scotland (2)	11	4	15	38
East England (3)	73	55	128	88
Irish Sea (4)	66	55	121	48
Ireland (5)	2	3	5	7
S.E.England (6)	113	101	214	168
S.W.England (7)	69	67	136	135
Waddenzee (8)	1	1	2	0
Total	341	298	639	496

(b) Percentage of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
N.E.Scotland (1)	1.8	4.0	2.8	2.4
N.W.Scotland (2)	3.2	1.3	2.3	7.7
East England (3)	21.4	18.5	20.0	17.7
West Britain (4-5)	19.9	19.5	19.7	11.1
S.E.England (6)	33.1	33.9	33.5	33.9
S.W.England (7)	20.2	22.5	21.3	27.2
Waddenzee (8)	0.3	0.3	0.3	0.0

Only recoveries during the period of severe weather are included.
Years before v years after x^2=6.420, 5 df, ns
Severe winters v before+after x^2=34.977, 5 df, P<0.001

Table 4.4 Movements and mortality of Mute Swans by region of ringing.

Region of ringing	Percentage of recoveries in region of ringing: Mild spells %	n	Severe spells %	n	Recovery index	Sig.
Scotland (1+2)	97	33	91	54	3.37	***
East Britain (3)	84	122	88	88	1.44	**
West Britain & Ireland (4+5)	78	117	71	52	0.89	ns
S.E.England (6)	91	221	96	164	1.48	***
S.W.England (7)	84	135	92	136	2.01	***

n = total number of recoveries of birds ringed in that region

mild spells = recoveries at same times as severe spells in years immediately before and after severe weather.

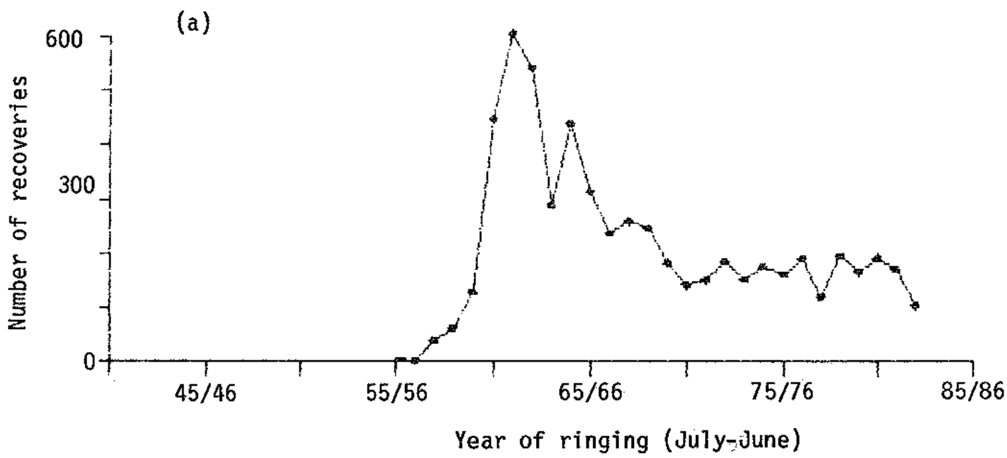
None of the differences in recovery distributions between severe spells and years before and after are significant.

$$\text{Recovery index} = \frac{\text{2 x number of recoveries during severe spells}}{\text{recoveries in years before and after}}$$

With no difference in mortality or movement this index should be 1.0

Sig. x^2 test against an expected ratio of 2:1 for years before and after severe spells:severe spells

*** P<0.001 ** P<0.01 ns not significant



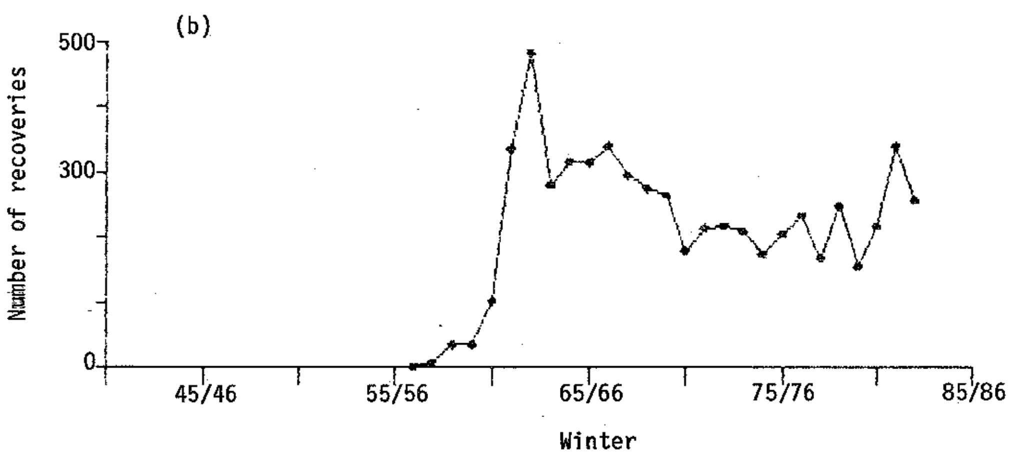


Figure 4.1 Winter recovery totals for Mute Swan

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

PINK-FOOTED GOOSE *Anser brachyrhynchus*

5.1 Normal pattern of movements

The whole of the population of Pink-footed Geese which breeds in Iceland and Greenland winters in Britain. The size of the winter population has increased from 30,000 birds in 1950/51 to 101,000 birds in 1983/84 (Ogilvie 1978, 1984). This has resulted primarily from increased food supply and from increased protection at roost sites, which has led to higher adult survival. The Svalbard breeding population of between 25,000 and 28,000 birds, winters principally in the Netherlands, with only a few of these birds reaching Britain (Madsen 1982).

Pink-footed Geese arrive in Britain in late September and early October, and return to their breeding grounds in the second half of April. Their main wintering areas are in North-east Scotland, the Solway Firth, Lancashire and the Wash. This distribution is reflected in that of mild winter recoveries, with 39% coming from North-east Scotland, 5% from North-west Scotland, 33% from the Irish Sea area and 23% from East England (Table 5.1). Some birds move from North-east Scotland to Lancashire as the winter progresses (Table 5.2). A northward movement from Lancashire to the Solway Firth usually takes place in late January and February and this is followed in March and early April by a further increase in numbers in Scotland prior to spring migration (Ogilvie 1978).

Since the 1950s there have been some marked changes in the distribution of wintering Pink-footed Geese within Britain. Increased protection and an increased food supply led to an increased concentration of birds in Scotland during the 1950s and 1960s. More recently numbers wintering in Lancashire have increased, partly due to increased protection at their roosting sites. Numbers wintering around the Wash declined to only a few birds by about 1966, but have increased again since the mid-1970s. In contrast to these increases, the decline in numbers wintering around the Humber has not been reversed, while the Severn has been deserted since the mid-1960s. Numbers wintering around the Solway Firth have declined, perhaps due to shooting pressure, but some increase in numbers after the end of the shooting season has been recorded since the mid-1970s.

5.2 Ringing effort

The analyses presented here are based on a ringing programme carried out by the Wildfowl Trust during the 1950s. Particularly large numbers were ringed during the autumn and winter of 1957/58, and these eventually gave rise to 482 recoveries. Most catching took place in North-east Scotland shortly after the birds had returned from the breeding grounds, but substantial numbers were also marked around the Wash and in Lancashire (Table 5.3). This ringing programme also included extensive ringing on the Icelandic breeding grounds, but only records of birds ringed in Britain have been used here. Reasonable numbers of recoveries were reported up to the mid-1960s, but after that few ringed birds were left to be recovered (Figure 5.1). Little ringing of Pink-footed Geese has taken place in Britain since 1960.

5.3 Distribution of recoveries in mild and severe winters

Pink-footed Geese normally move out of Scotland and into north-west England during cold weather. The regional distribution of recoveries during mild winters differs significantly from that during severe winters, and during severe spells only (Table 5.1). Seventy-one per cent of recoveries from severe spells are from West and South Britain, compared with only 33% during mild weather. There is a corresponding decrease from 39% to 16% in the percentage of recoveries from North-east Scotland.

This pattern is confirmed when the recovery distribution during severe spells is compared with that in years immediately before and after severe weather (Table 5.4). However, this comparison is complicated because there is a significant difference between the distributions of recoveries in years before and after cold winters. This is because nearly all of the data from years before cold winters are from the winter of 1961/62, which was itself colder than average especially in Scotland (see methods). The 52% of recoveries from the Irish Sea area in years before cold weather is higher than the 37% recorded during years after cold weather, but lower than the 71% during severe spells.

Large numbers of controls made during goose-catching operations could have distorted these patterns. However, there are only 44 winter controls in this data set, and all are from November, with 17 in 1952, 12 in 1953 and 15 in 1954. A further check that the observed patterns were not due to regional variations in ringing effort was made by analysing separately the data for birds ringed in North-east Scotland (Table 5.5). Thirty-six per cent of these birds were recovered in the Irish Sea area between January and March of mild winters compared with 51% during the 1961/62 winter and 69% during the

1962/63 winter. This confirms the pattern described above.

Mean distances between ringing and recovery places were 149 km during mild winters, 148 km during severe winters and 165 km during severe spells. The difference between mild winters and severe spells is significant (Mann-Whitney U test, t=2.46, P<0.05). The mean distance moved in years before cold winters (mainly 1961/62) was 194 km, and was not significantly different from the 165 km recorded during severe spells (Mann-Whitney U-test, t=1.51, ns). The overall mean for years before severe spells and severe spells combined (i.e. mainly 1961/62 and 1962/63) was 180 km, which was significantly greater than the 100 km recorded for years after severe weather (Mann-Whitney U-test, t=4.02, P<0.001).

This pattern of a south-westerly movement from Scotland into north-west England during severe weather was also recorded from count data in the winters of 1978/79 and 1981/82 (Salmon 1979,1982). Cold weather movements by the Spitsbergen population have also been recorded (Holgersen 1960). During severe weather these birds move south from their normal wintering grounds in Denmark and the Netherlands into Belgium and France.

5.4 Summary

The Icelandic and Greenland population of Pink-footed Geese winters in Britain, principally in Scotland and north-west England. Ringing recoveries show a movement from Scotland into north-west England during the winters of 1961/62 and 1962/63. No intensive ringing of Pink-footed Geese has been carried out in Britain since 1960, but count data indicate that similar movements took place in the winters of 1978/79 and 1981/82.

Table 5.1 Recovery regions of British-ringed Pink-footed Geese in mild and severe winters.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
N.E.Scotland	(1)	727	91	16
N.W.Scotland	(2)	86	17	2
East England	(3)	422	64	12
Irish Sea	(4)	608	135	73
Ireland	(5)	1	0	0
S.E.England	(6)	4	3	0
S.W.England	(7)	1	1	0
Total		1849	311	103

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
N.E.Scotland (1)	39.3	29.3	15.5
N.W.Scotland (2)	4.7	5.5	1.9
East England (3)	22.8	20.6	11.7
W. & S.Britain (4-7)	33.2	44.7	70.9

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=18.156, 3 df, P<0.001
Mild winters v severe spells x^2=60.897, 3 df, P<0.001.

Table 5.2 Seasonal variation in the recovery regions of Pink-footed Geese ringed in North-east Scotland and recovered during mild winters.

Recovery region	Nov	Dec	Jan	Feb-Mar
North-east Scotland %	67.2	60.5	39.9	37.6
North-west Scotland %	4.9	7.6	5.1	6.4
East England %	16.4	13.5	19.1	9.9
Irish Sea %	11.6	18.1	35.3	46.1
South England & Ireland %	0.0	0.3	0.5	0.0
Total recoveries	268	304	434	141

$x^2 = 180.00$, 9 df, $P<0.001$

Table 5.3 Ringing periods and regions of British-ringed Pink-footed Geese recovered in winter.

Ringing region	Ringing period			
	July-October	November-March	April-June	
N.E.Scotland	1175	157	0	1332
East England	450	52	0	502
Irish Sea	240	86	0	326
Total	1865	295	0	2160

Table 5.4 Recovery regions of British-ringed Pink-footed Geese in years before, during and after severe weather.

(a) Number of recoveries

Recovery region		Mild spells			Severe spells
		Years before	Years after	Years before +after	
N.E.Scotland	(1)	21	17	38	16
N.W.Scotland	(2)	3	1	4	2
East England	(3)	26	4	30	12
Irish Sea	(4)	55	13	68	73
Total		105	35	140	103

(b) Percentage of recoveries

Recovery region	Mild spells			Severe spells
	Years before[a]	Years after	Years before +after	
Scotland (1-2)	22.9	51.4	30.0	17.5
East England (3)	24.8	11.4	21.4	11.7
Irish Sea (4)	52.4	37.1	48.6	70.9

a Most of these data are from the winter of 1961/62, which was more severe than most "mild" winters (see text).

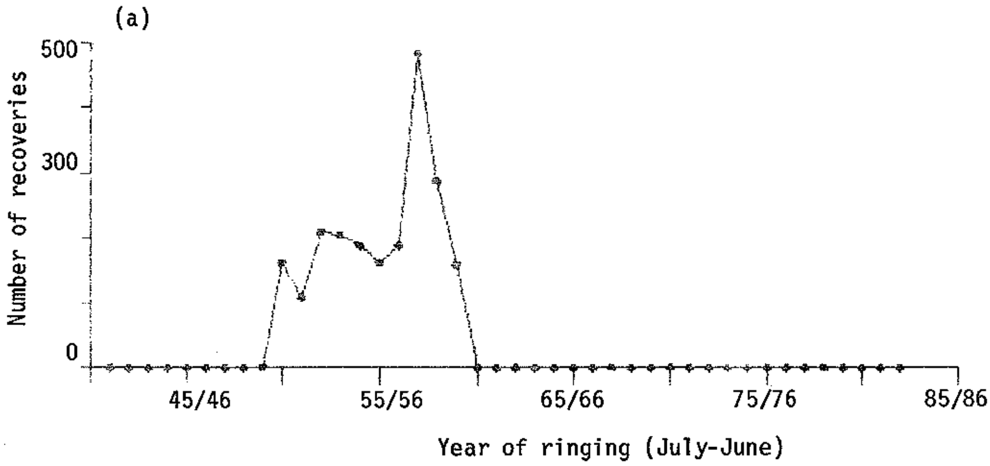
Only recoveries during the period of severe weather are included.
Years before v years after x^2=10.576, 2 df, P<0.01.
Years before V severe spells x^2=8.528, 2 df, P<0.05
Years after V severe spells x^2=16.314, 2 df, P<0.001.

Table 5.5 Recovery regions in 1961/62, 1962/63 and in mild winters of Pink-footed Geese ringed in North-east Scotland.

	1961/62 cold spell	1962/63 cold spell	Mild winters Jan - Mar
North-east Scotland %	20.0	17.6	42.0
North-west Scotland %	1.4	1.5	5.9
East England %	27.1	11.8	15.4
Irish Sea %	51.4	69.1	36.2
South England & Ireland %	0.0	0.0	0.4
Total recoveries	70	68	505

The cold spell in 1962/63 was from 22 December to 4 March and the 1961/62 figures are for the same period. There were no recoveries after the cold spell in 1961/62 and only two in 1962/63.

Mild winters v 1961/62 $x^2 = 18.309$, 2 df, $P<0.001$
1961/62 v 1962/63 $x^2 = 6.054$, 2 df, $P<0.05$



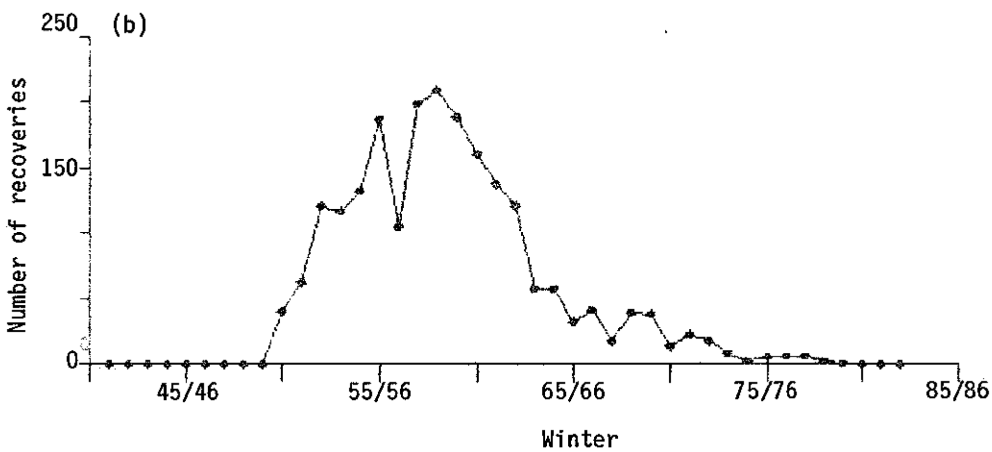


Figure 5.1 Winter recovery totals for Pink-footed Goose.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

CANADA GOOSE *Branta canadensis*

6.1 Normal pattern of movements

The Canada Goose is native to North America and was introduced into Britain in the 17th century. Three censuses of the British population have been carried out, giving totals of 2000-4000 birds in 1953 (Blurton Jones 1956), 10,500 birds in 1967-1969 (Ogilvie 1969) and 19,400 birds in 1976 (Ogilvie 1977). In the 1950s the increase in numbers was assisted by extensive transportation of birds to unoccupied areas but more recently the spread has been due mainly to natural movements, with the birds colonising new habitats such as gravel pits. At present Canada Geese are restricted mainly to England, with only small numbers occurring in South-west England, Wales, Ireland and Scotland.

Census data suggest that the British population can be split into 25 to 30 relatively discrete sub-units (Ogilvie 1977), though the continuing increase in numbers is probably leading to gradual mergers between them. Most birds undertake only short distance movements, 90% of mild winter recoveries of Canada Geese ringed in England and Wales being less than 50 km from the ringing place. The only exception to this pattern of short distance movements is that some birds from North Yorkshire undertake a moult migration to the Beauly Firth (Walker 1970). This movement involves only a small proportion of the British population, but the number of birds involved has increased from 18 in 1950 to 900 in 1976 (Walker 1970, Ogilvie 1978).

6.2. Ringing effort

Most ringing has been done by rounding up moulting birds in June and July while they are flightless (Table 6.2). Birds ringed in North-east Scotland were mostly from the Beauly Firth flock. In England much of the ringing has taken place as part of intensive studies in Yorkshire and in the Midlands, and this is reflected in the high number of recoveries of birds ringed in East England and in the Irish Sea area. An adequate sample of birds from the south of England has also been ringed.

Because of the transportation of birds which took place during the 1950s, birds ringed before 1960 have been excluded from this analysis. Rather little ringing took place before the mid-1960s but after that a reasonable sample of birds has been ringed in most years (Figure 6.1). Because this is a long-lived species (Thomas 1977), and many of the birds were ringed as adults, there was a time-lag between the initial increase in ringing effort and the annual recovery intake reaching a high level. Since the mid-1970s however, over 100 winter recoveries have been reported in most years. A consequence of this pattern of ringing is that most of the information on cold weather movements comes from the winters of 1978/79 and 1981/82.

6.3 Distribution of recoveries in mild and severe winters

Comparison of the distribution of recoveries during mild winters with that during severe winters suggests that a small proportion of the population moves south in response to severe weather (Table 6.1). The proportion of recoveries in North Britain decreased from 59% during mild winters to 49% during cold ones, while the percentage of recoveries from southern England increased from 18% to 27%. Four recoveries were reported from France during cold winters, compared with only one during mild ones. The result of comparing the recovery distribution from mild winters with that from severe spells is similar, and in both cases the distributions of recoveries in mild and cold weather are significantly different.

The distributions of recoveries in years immediately before and after cold winters are significantly different (Table 6.3), mainly due to a high number of recoveries from South-east England during the winter of 1979/80. The distribution of recoveries from years before cold winters is similar to that from all mild winters, and comparing this with the distribution of recoveries during severe spells also shows a significant increase in the proportion of recoveries from southern England and France during mild weather. Comparison of the number of recoveries in years before and after cold weather with the number recorded during cold spells suggests that there was no increase in the mortality of Canada Geese as a result of cold weather (Table 6.3).

The pattern of limited southward movement in response to cold weather was confirmed on analysing records of birds ringed in Central Britain and in South Britain (Table 6.4). Ninety-three per cent of recoveries of birds ringed in Central Britain were in the same region during all mild winters, compared with 83% in cold spells. There was a corresponding increase from 6% to 19% in the proportion of recoveries from South Britain and France. When the distribution of recoveries in years before and after cold weather is compared with that during severe spells a similar difference is found, but it is no longer significant, probably due to the reduced sample size. There is no evidence that birds from South Britain undertake cold weather movements, 94% of severe weather recoveries being from the region of ringing (Table 6.4).

The mean distance between ringing and recovery places was 95 km during cold spells, compared with 55 km during mild winters

(Mann-Whitney U test, $t=3.86$, $P<0.001$). The mean distance moved in years before and after cold winters was 53 km, and it is also significantly different from the 95 km moved during severe spells (Mann-Whitney U-test, $t=2.82$, $P<0.01$; Figure 6.2). These means slightly exaggerate the extent of movements, as they include some records of birds ringed on the Beauly Firth and recovered in Yorkshire. Considering only birds ringed in Central Britain gives mean distances of 31 km in years before and after cold weather, and 58 km during severe spells (Mann-Whitney U-test, $t=2.16$, $P<0.05$). Birds ringed in Southern England show no significant change in distances moved during cold weather.

6.4 Summary

The feral Canada Goose population of Britain is mainly sedentary, with the exception of a moult migration to the Beauly Firth from Yorkshire. Some birds from Central Britain move to South Britain and France during cold weather but even at this time 82% of the birds ringed in Central Britain are recovered there. There is no evidence of cold weather movements by Canada Geese from South Britain. These patterns are confirmed by analyses of the distances between ringing and recovery places. The ringing recovery data do not suggest any increase in Canada Goose mortality as a result of severe weather.

Table 6.1 Recovery regions of British-ringed Canada Geese in mild and severe winters.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
N.E.Scotland	(1)	17	5	1
N.W.Scotland	(2)	1	0	0
East England	(3)	720	127	47
Irish Sea	(4)	298	57	24
S.E.England	(5)	122	42	16
S.W.England	(6)	98	34	12
North France	(7)	1	4	4
Total		1257	269	104

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
N.Britain (1-3)	58.7	49.1	46.2
Irish Sea (4)	23.7	21.2	23.1
S.E.England (5)	9.7	15.6	15.4
S.W.England (6)	7.8	12.6	11.5
North France (7)	0.1	1.5	3.8

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=20.931, 3 df, P<0.001
Mild winters v severe spells x^2=12.459, 3 df, P<0.01

Table 6.2 Ringing periods and regions of British-ringed Canada Geese recovered in winter.

Ringing region	Ringing period			
	July-October	November-March	April-June	
N.E.Scotland	119	0	0	119
East England	564	6	232	802
Irish Sea	194	7	187	388
S.E.England	66	10	40	116
S.W.England	44	12	45	101
Total	987	35	504	1526

Table 6.3 Recovery regions of British-ringed Canada Geese in years before, during and after severe weather.

(a) Number of recoveries

Recovery region		Mild winters			Severe winters	Recovery index[a]
		Years before	Years after	Years before +after		
N.E.Scotland	(1)	1	1	2	1	
N.W.Scotland	(2)	1	0	1	0	
East England	(3)	62	45	107	47	0.88
Irish Sea	(4)	52	20	72	24	0.67
S.E.England	(5)	11	36	47	16	0.68
S.W.England	(6)	8	12	20	12	1.20
North France	(7)	0	0	0	4	
Total		135	114	249	104	0.84

a Recovery index = $\frac{\text{2 x number of recoveries during severe spells}}{\text{number of recoveries in years before and after}}$

x^2 tests against an expected ratio between columns 3 and 4 of 2:1 were all ns

(b) Percentage of recoveries

Recovery region	Mild winters			Severe winters
	Years before	Years after	Years before +after	
N. & E. Britain (1-3)	47.4	40.4	44.2	46.2
Irish Sea (4)	38.5	17.5	28.9	23.1
S.E.England (5)	8.1	31.6	18.9	15.4
S.W.England (6)	5.9	10.5	8.0	11.5
North France (7)	0.0	0.0	0.0	3.8

Only recoveries during the period of severe weather are included.
Years before v years after x^2=29.706, 3 df, P<0.001
Years before v severe spells x^2=9.321, 3 df, P<0.05
Years after v severe spells x^2=7.213, 3 df, ns

Table 6.4 Recovery regions of Canada Geese ringed in Central and South Britain.

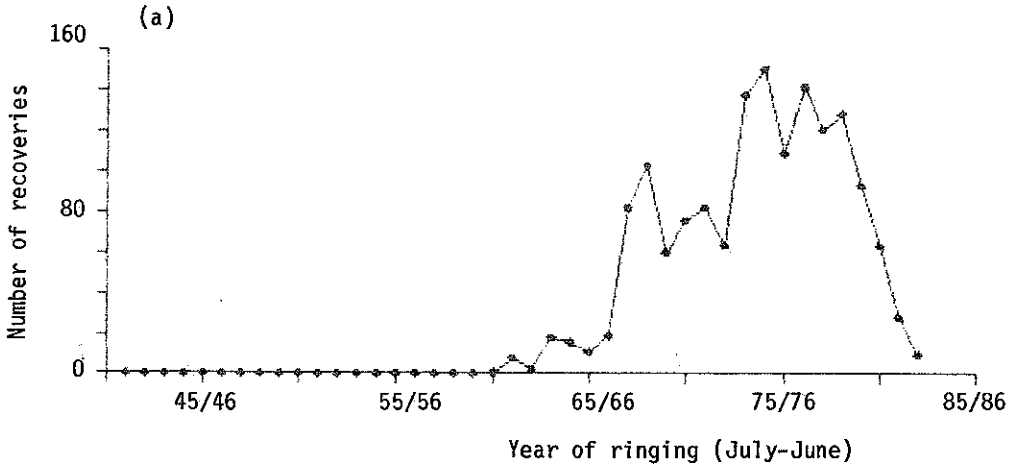
a) Birds ringed in Central Britain

Recovery place	Mild winters		Severe spells
	All mild winters	Years before +after	
Scotland %	0.4	0.5	0.0
Central Britain %	93.4	90.1	81.6
South Britain %	6.2	9.3	13.2
France %	0.0	0.0	5.3
Total recoveries	993	182	76

Mild winters v severe spells x^2=14.062, 1 df, P<0.001
Years before+after v severe spells x^2=3.367, 1 df, ns

b) Birds ringed in South Britain

Recovery place	Mild winters		Severe spells
	All mild winters	Years before +after	
Central Britain %	7.2	5.8	5.6
South Britain %	92.2	94.2	94.4
France %	0.6	0.0	0.0
Total recoveries	167	52	18



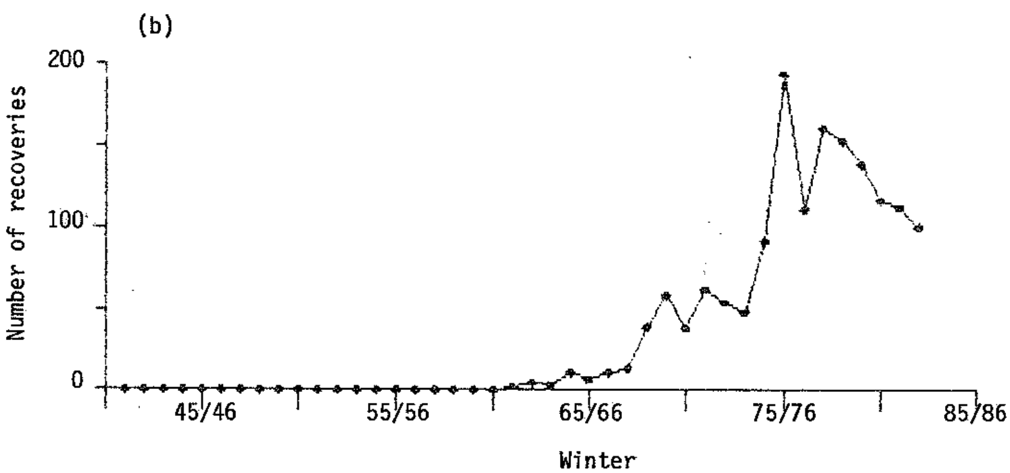


Figure 6.1 Winter Recovery totals for Canada Goose.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

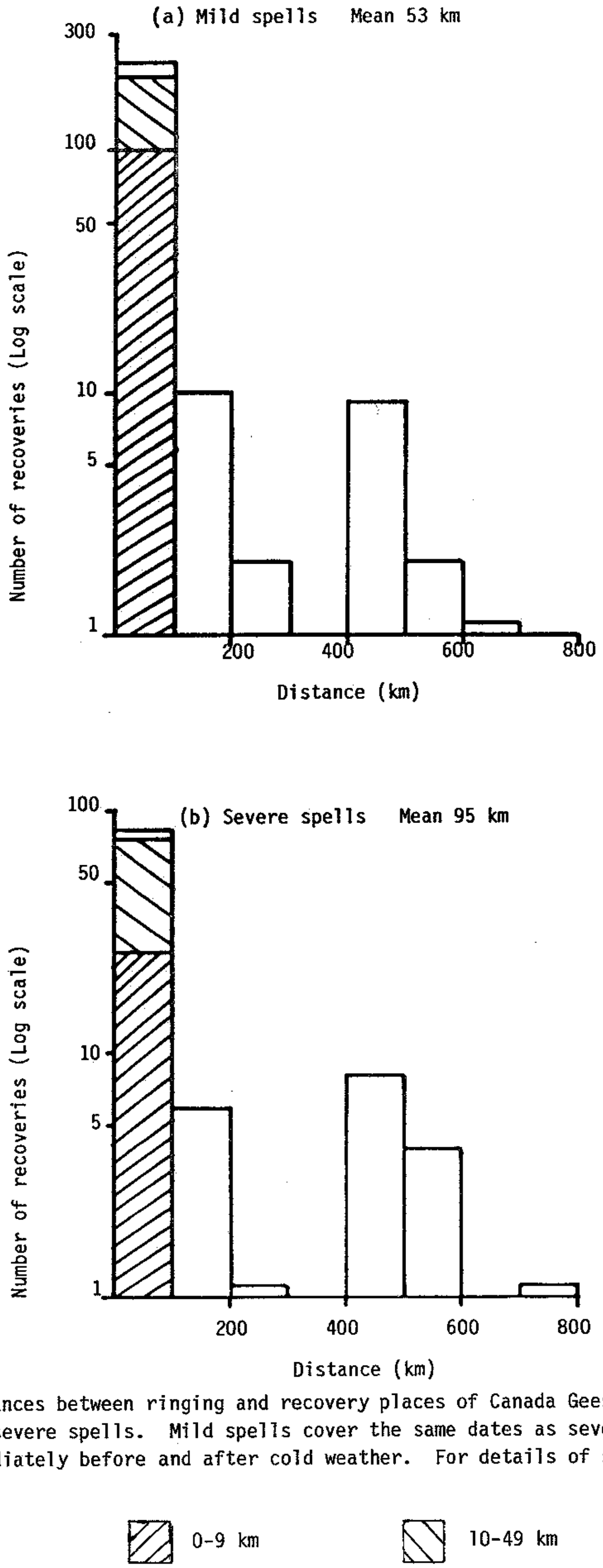


Figure 6.2 Distances between ringing and recovery places of Canada Geese recovered during mild and severe spells. Mild spells cover the same dates as severe ones in years immediately before and after cold weather. For details of severe spells see methods.

SHELDUCK *Tadorna tadorna*

7.1 Normal pattern of movements

Most of the Shelducks which occur in Britain belong to the British breeding population. It is difficult to estimate the exact number of breeding pairs from counts, because of the presence of variable numbers of non-breeders (Patterson 1982). However, Yarker and Atkinson-Willes (1971) estimated from counts that in late winter and spring there were about 50,000 Shelducks in Britain. They suggested that this probably represents about 12,000 breeding pairs.

The main feature of the movement pattern of British Shelducks is their late summer moult migration to the Heligoland Bight, where they moult together with most of the other Shelducks from north-west Europe. About 100,000 Shelducks moult at Heligoland and it has been estimated from ringing recoveries that about half of these birds are from Britain (Atkinson-Willes and Scott 1963). A small but increasing number of Shelducks remain in Britain to moult. Flocks have been reported from Bridgewater Bay (3400 birds, Eltringham and Boyd 1963), the Firth of Forth (2500 birds, Bryant 1978), the Wash (2000 birds, Bryant 1981) and the Humber (150 birds, Tasker 1982).

The migration to Heligoland starts in early July, peak numbers on the moulting grounds occurring in late July and early August. Dispersal from the moulting area takes place in September and October. Most recoveries of British-ringed birds during these months are close to the moulting grounds. Recoveries indicate a subsequent southward movement down the coast of Europe and into southern Britain. This is followed by dispersal towards northern breeding areas during winter and early spring. Wildfowl counts have revealed considerable annual variations in the rate of return from Heligoland, with movement still occurring in December and January. The concentration of winter recoveries of Heligoland-ringed birds in southern England suggests that some European breeders may winter there. Winter recoveries of birds ringed on the Ythan estuary in North-east Scotland are mainly restricted to north-east England and Scotland. Thus more northerly breeding populations may either migrate back directly across the southern North Sea or move very rapidly through southern England. These recovery patterns are described in detail by Patterson (1982).

In mild winters 48% of Shelduck recoveries are from North and East Britain, 13% from South Britain and 24% from the Waddenzee (Table 7.1). This partly reflects the pattern of movements described above but it is also strongly influenced by the concentration of ringing effort in North and East Britain (below). Return migration through the winter leads to a marked difference in the distribution of recoveries between early and late winter (Table 7.2). In November and December 39% of recoveries are from the Waddenzee, while only 16% of recoveries between January and March are from there. The proportion of recoveries in all parts of Britain shows a corresponding increase in late winter.

7.2 Ringing effort

Most Shelduck ringing has been carried out as part of the intensive studies on the Ythan, Forth, Tees and Sheppey. This is the reason for the marked regional bias in the origin of the recovery sample, with 49% of birds ringed in North-east Scotland, 25% in East England and 12% in South-east England (Table 7.3). There is a need for more Shelduck ringing in western Britain.

The main seasons for Shelduck ringing are spring and summer. The November to March category comprises mainly adults trapped in late winter, usually on their breeding grounds. Most of the birds in the July to October sample were ringed as ducklings.

Numbers of recoveries have fluctuated markedly between winters, partly as a result of particular studies (Figure 7.1). There was little ringing before the 1960s. Since then the number of recoveries has fluctuated around an average of about 10 per winter.

7.3 Distribution of recoveries in mild and severe winters

Overall comparison of the regional distribution of recoveries between mild and severe winters shows no significant difference (Table 7.1) but the pattern may be confused by differences between early and late winter (above). When the comparison is restricted to severe spells, a significant difference can be demonstrated, with a lower percentage of recoveries in North and East Britain and the Waddenzee, and an increased percentage in South and West Britain. As severe weather usually occurs in January and February, a better test is obtained by comparing the figures for severe spells (Table 7.1) with those from the second half of mild winters (Table 7.2). This shows a pattern similar to that described above (x^2=7.072, 2 df, $P<0.05$).

Mean distances moved are 267 km in mild winters, 299 km in severe winters and 208 km in severe spells. There are no significant differences between mild and severe weather (Mann-Whitney U-tests: mild v severe t=0.223 ns; mild v severe spells t=0.642 ns). Part of the response to severe weather appears to involve a movement of Scottish birds from the Waddenzee to South Britain, and this will not affect greatly the distance from their ringing site.

The regional distribution of recoveries during severe spells is not significantly different from that in previous and subsequent years (Table 7.4). However, sample sizes are only 22 and 18 respectively. The data again suggest a movement out of the Waddenzee, but the percentage of recoveries in North and East Britain is very similar for both categories (40.9% v 38.9%). However, four of the five recoveries for years before severe winters in North-east Scotland came from 1961, which was itself colder than usual. Movement of birds out of North and East Britain may have been masked by increased mortality in those areas. Marked increases in the observed mortality of Shelducks have been recorded during severe weather (Dobinson and Richards 1964, Hori 1964, Pilcher 1964). This is confirmed by the recovery totals in Table 7.4, which indicate that 1.6 times as many Shelducks were recovered during severe spells compared with equivalent mild periods.

Improved results might be obtained by including recoveries of birds ringed on the German moulting grounds. However, it will probably only be possible to confirm these patterns when more recoveries of British-ringed birds have been accumulated.

7.4 Summary

Most of the Shelducks which occur in Britain belong to the British breeding population. During the winter these birds are either back on their breeding grounds or undergoing a gradual northward return movement, most returning from the German moulting grounds via southern England. There is significant evidence of a movement out of the Waddenzee and Northern Britain during severe weather. However, this pattern was not confirmed when severe spells were compared with the equivalent periods in previous and subsequent years, probably because of small sample sizes.

Table 7.1 Recovery regions of British-ringed Shelducks in mild and severe winters.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
N.E.Scotland	(1)	45	10	6
N.W.Scotland	(2)	2	1	1
East England	(3)	29	1	0
Irish Sea	(4)	6	3	3
Ireland	(5)	8	2	1
S.E.England	(6)	14	4	3
S.W.England	(7)	7	2	2
Waddenzee	(8)	38	6	0
North France	(9)	6	1	1
South France	(10)	1	2	1
Iberia	(11)	1	0	0
Total		157	32	18

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
N. & E.Britain (1-3)	48.4	37.5	38.9
W.Britain (4-5)	8.9	15.6	22.2
S.Britain (6-7)	13.4	18.7	27.8
Waddenzee (8)	24.2	18.7	0.0
France (9-11)	5.1	9.4	11.1

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=3.441, 3 df, ns
Mild winters v severe spells x^2=10.617, 2 df, $P< 0.01$

Table 7.2 Recovery regions of British-ringed Shelducks in early and late winter.

Recovery region	November-December Number	November-December %	January-March Number	January-March %
N. & E.Britain (1-3)	23	41.1	53	52.5
W. Britain (4-5)	3	5.4	11	10.9
S. Britain (6-7)	5	8.9	16	15.8
Waddenzee (8)	22	39.3	16	15.8
France (9-11)	3	5.4	5	5.0
Total	56		101	

Data are from mild winters only.

Table 7.3 Ringing periods and regions of British-ringed Shelducks recovered in winter.

Ringing region	Ringing period: July-October	November-March	April-June	
N.E.Scotland	25	57	11	93
N.W.Scotland	0	0	2	2
East England	29	17	2	48
Irish Sea	7	1	1	9
Ireland	4	0	0	4
S.E.England	10	3	10	23
S.W.England	9	0	1	10
Total	84	78	27	189

Table 7.4 Recovery regions of British-ringed Shelducks in years before, during and after severe weather.

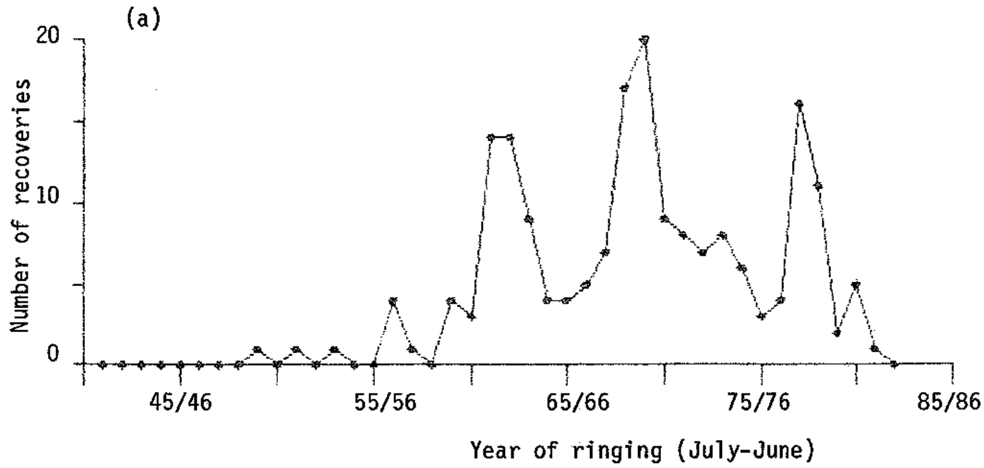
(a) Number of recoveries

Recovery region		Mild spells			Severe spells
		Years before	Years after	Years before +after	
N.E.Scotland	(1)	5	1	6	6
N.W.Scotland	(2)	0	0	0	1
East England	(3)	0	3	3	0
Irish Sea	(4)	1	0	1	3
Ireland	(5)	3	2	5	1
S.E.England	(6)	1	0	1	3
S.W.England	(7)	0	0	0	2
Waddenzee	(8)	1	4	5	0
North France	(9)	0	1	1	1
South France	(10)	0	0	0	1
Total		11	11	22	18

(b) Percentage of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
N. & E. Britain (1-3)	45.5	36.4	40.9	38.9
W. & S. Britain (4-7)	45.5	18.2	31.8	50.0
Waddenzee (8)	9.1	36.4	22.7	0.0
France (9-10)	0.0	9.1	4.5	11.1

Only recoveries during the period of severe weather are included.
Severe winters v before+after x^2=0.764, 1 df, ns



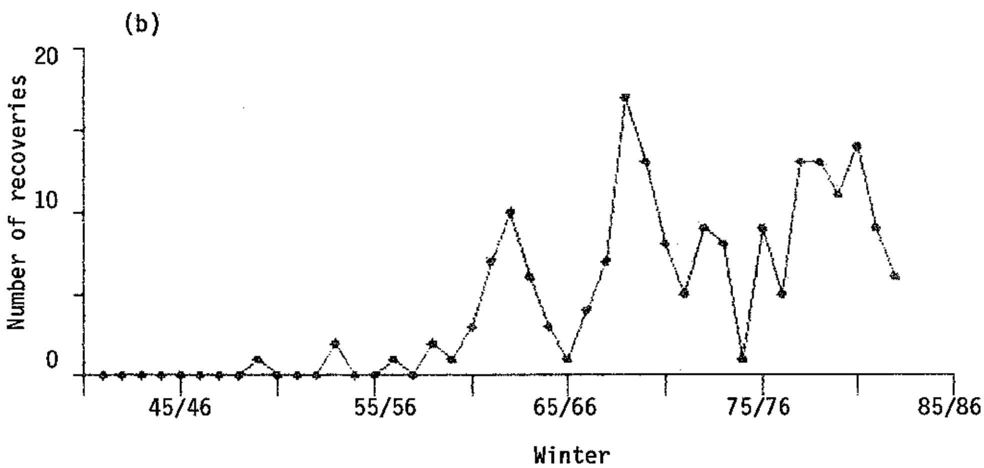


Figure 7.1 Winter recovery totals for Shelduck.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

WIGEON *Anas penelope*

8.1 Normal pattern of movements

A small British breeding population of 300-500 pairs is distributed through Scotland and Northern England (Sharrock 1976). It is thought that most of these birds remain in Britain throughout the year, but insufficient recoveries exist to confirm this. The Icelandic breeding population winters mainly in North Britain and Ireland but few of these birds have been ringed in Britain.

Most of the Wigeon which occur in Britain belong to a wintering population from Fenno-Scandia and the USSR, east to the lower Yenisey basin and south to 50^{O}N. This population also winters in West Germany, the Netherlands, France and, to a lesser extent, Iberia. The winter recovery distribution of British-ringed Wigeon is consistent with their belonging to a population which occupies this winter range. Some 71% of recoveries are from Britain, 15% from the Waddenzee and 14% from France and South Europe (Table 8.1). A small number of long distance recoveries indicate interchange with more distant breeding populations, probably by abmigration.

A large proportion of the Wigeon population is concentrated at a small number of major coastal sites. In Britain these sites are Lindisfarne, the Ouse Washes, Elmley, Cromarty Firth, the Mersey, the Ribble, Abberton Reservoir, the Humber and Dornoch Firth (Owen, Atkinson-Willes and Salmon in press). Important sites in neighbouring continental areas are the Delta region (Netherlands), Terkaplester Polder (Netherlands) and Golfe du Morbihan (France).

8.2 Ringing effort

As Wigeon are mainly winter visitors to Britain, most recoveries are of birds ringed between November and March, although some ringing has also taken place in Autumn. Very few birds have been ringed in Spring. Sixty five per cent of recoveries are of birds ringed in South-east England, with 16% from East England and only small numbers from other regions of Britain (Table 8.2).

Little ringing of Wigeon took place in Britain before the mid-1950s. Since then trapping effort has varied greatly between years. This species is not easily caught in conventional duck traps and sporadic catching with cannon-nets at various sites has resulted in marked fluctuations in the ringing totals. There is a small peak of recoveries in the mid-1950s, relatively few in the 1960s, with increased numbers in the 1970s and 1980s (Figure 8.1).

8.3 Distribution of recoveries in mild and severe weather

The regional distributions of recoveries for all mild winters and for all severe winters do not differ significantly (Table 8.1). However, many of the recoveries in these samples occurred before the onset of severe weather. The recovery distributions for mild winters and severe spells are significantly different. Recoveries from West Britain decreased from 20% to 5%, while recoveries from the Waddenzee decreased from 15% to 3%. There was a corresponding increase in the number of recoveries in France and South Europe from 14% to 38%. The more rigorous comparison of the recovery distribution in severe spells with that in the same period in the previous and subsequent years is also significant (Table 8.3). This analysis confirms the movement out of south Britain, which has 49% of recoveries in mild spells and 38% in severe ones.

Distributions of distances between ringing and recovery places do not differ significantly between mild and severe winters. Mean distances moved were 302 km in mild winters, 259 km in severe winters and 248 km in severe spells (Mann-Whitney U-tests: mild v severe, $t=0.407$, ns; mild v severe spells, $t=0.576$, ns). Comparison of severe spells with years immediately before and after gives mean distances of 248 km and 290 km (Mann-Whitney U-test: $t=0.176$, ns). One possible reason for the lack of differences in these data is that birds recovered from the Waddenzee in mild winters, and France in severe winters, may be similar distances from the main ringing sites in the south of England. Thus distances between ringing and recovery places are poor indicators of cold weather movements in this species.

8.4 Summary

During severe winters significantly fewer Wigeon were recovered in Britain and the Waddenzee, while more were recovered in France and southern Europe. No differences between distances moved could be detected.

Table 8.1 Recovery regions of British-ringed Wigeon in mild and severe winters.

(a) Number of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
N.E.Scotland (1)	22	8	0
N.W.Scotland (2)	1	1	0
East England (3)	56	10	6
Irish Sea (4)	55	5	0
Ireland (5)	41	10	2
S.E.England (6)	149	21	10
S.W.England (7)	23	7	4
Waddenzee (8)	73	11	1
North France (9)	36	16	11
South France (10)	14	3	2
Iberia (11)	4	0	0
Central Europe (12)	12	1	0
Eastern Europe (13)	3	0	0
Africa (14)	1	1	1
Total	490	94	37

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
Scotland and East Britain (1-3)	16	20	16
West Britain (4-5)	20	16	5
South Britain (6-7)	35	30	38
Waddenzee (8)	15	12	3
France and S.Europe (9-14)	14	22	38

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2= 5.829, 4 df, ns
Mild winters v severe spells x^2=17.657, 3 df, P<0.001

Table 8.2 Ringing periods and regions of British-ringed Wigeon recovered in winter.

Ringing region	Ringing period			
	July-October	November-March	April-June	
N.E.Scotland	13	17	5	35
East England	10	79	2	91
Irish Sea	0	35	0	35
Ireland	5	17	0	22
S.W.England	11	10	0	21
S.E.England	123	256	1	380
Total	162	414	8	584

Table 8.3 Recovery regions of British-ringed Wigeon in years before, during and after severe weather.

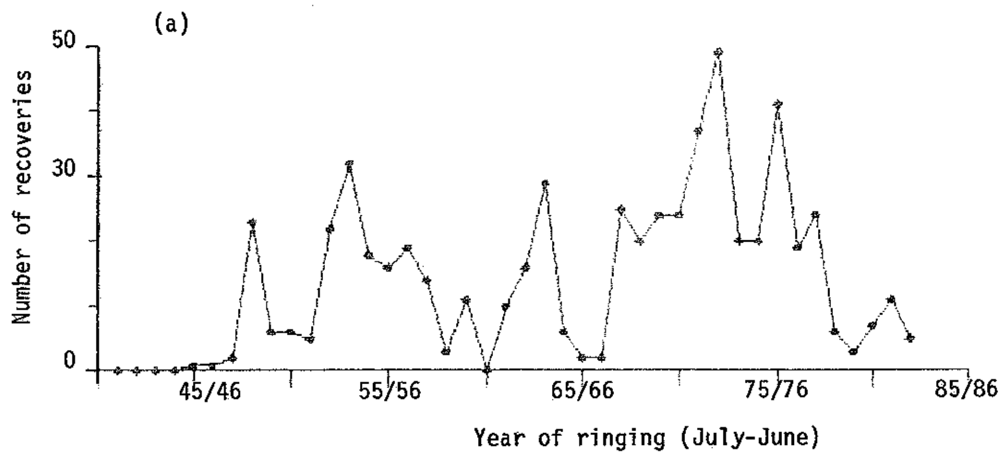
(a) Number of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
N.E.Scotland (1)	2	2	4	0
East England (2)	1	1	2	6
Irish Sea (3)	2	1	3	0
Ireland (4)	4	0	4	2
S.E.England (5)	9	8	17	10
S.W.England (6)	1	3	4	4
Waddenzee (7)	2	2	4	1
North France (8)	1	1	2	11
South France (9)	1	0	1	2
Central Europe (10)	0	2	2	0
Africa (11)	0	0	0	1
Total	23	20	43	37

(b) Percentage of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
N. & W. Britain (1-4)	39	20	30	22
South Britain (5-6)	43	55	49	38
Waddenzee (7)	9	10	9	3
South Europe (8-11)	9	15	12	38

Only recoveries during the period of severe weather are included.
Years before v years after x^2= 0.056, 2 df, ns
Severe winters v before+after x^2=7.546, 2 df, P<0.05



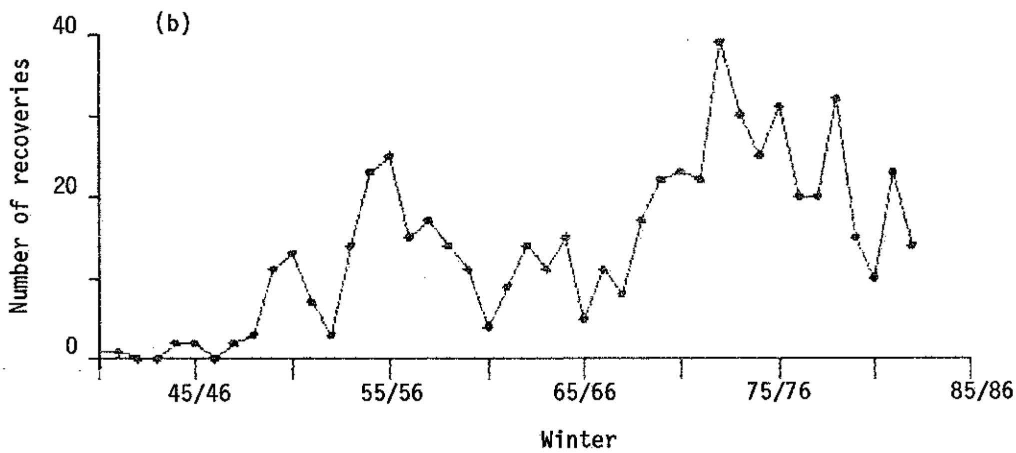


Figure 8.1 Winter recovery totals for Wigeon.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

GADWALL *Anas strepera*

9.1 Normal pattern of movements

Britain has a breeding population of about 500 pairs of Gadwall, most of which are descended from birds released at various times since 1850 (Owen *et al*. in press). Gadwall breeding in Scotland are thought to winter mainly in Ireland, with a few birds migrating south to England. English breeding adults are mainly sedentary. Many of the juveniles from this population disperse in a south-westerly direction in autumn, about 25% of them wintering in France and Iberia (Owen *et al*. in press).

The number of Gadwall wintering in north-west Europe is also small, comprising about 10,000 birds of which over 4000 winter in Britain. These birds include both the Icelandic breeding population and breeders from north Germany, Poland, south Sweden and west-central Russia. Most of the Icelandic population of 200-300 breeding pairs winters in Britain. The birds from northern and eastern Europe winter around the North Sea, mainly in the Netherlands and Britain.

During mild winters 59% of recoveries of British-ringed Gadwall are in Britain, 2% in the Waddenzee and 39% in France and south Europe (Table 9.1). Most of the British recoveries are from East and South-east England, while most of the European recoveries are from France.

9.2 Ringing effort

An approximately equal amount of ringing has taken place during the periods July to October and November to March, while very few birds have been ringed between April and June. Sixty-one per cent of recoveries are of birds ringed in South-east England and 25% are of birds ringed in South-west England. Few birds have been ringed outside these regions.

The earliest recoveries are from 1952/53, and from then until 1976/77 there are usually between one and five recoveries per year. Increased ringing since 1977 has resulted in samples of 16 to 28 recoveries per winter between 1977/78 and 1982/83 (Figure 9.1).

9.3 Distribution of recoveries in mild and severe winters

The recovery data suggest a movement into France and South Europe during severe weather, with 39% of mild winter records coming from these areas compared with 45% for severe winters and 58% when the data are restricted to severe spells (Table 9.1). However, none of these differences are significant, perhaps due to small sample sizes. Distances between ringing and recovery places do not indicate any differences between mild and severe weather, mean distances moved being 357 km in mild winters, 281 km in severe winters and 314 km in severe spells (Mann-Whitney U-tests: mild v severe t=0.250 ns; mild v severe spells t=0.315 ns).

The recovery distributions in years immediately before and immediately after severe winters are significantly different (Table 9.3). In years before severe weather, 12% of recoveries were in France compared with 53% in years after severe winters. The latter figure is closer to the figure of 45% obtained using data from all mild winters (Table 9.1). Thus the significant difference between the recovery distributions for years before severe winters and that for severe spells can only be taken as weak evidence of movement in response to severe weather. The recovery distribution for years immediately after severe winters was not significantly different from that for severe spells.

When the above analysis was repeated using distances between ringing and recovery places there was no significant difference between years before and years after severe weather. The mean distances for severe spells (314 km) and years before and after (319 km) are very similar (Mann-Whitney U-test: t=0.608 ns).

9.4 Summary

The data suggest increased movement into France during severe weather, but more recoveries are needed before this pattern can be statistically confirmed or firmly refuted.

Table 9.1 Recovery regions of British-ringed Gadwall in mild and severe winters.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
N.E.Scotland	(1)	1	0	0
East England	(2)	18	8	1
Irish Sea	(3)	1	0	0
Ireland	(4)	5	2	1
S.E.England	(5)	40	12	4
S.W.England	(6)	9	5	2
Waddenzee	(7)	3	4	0
North France	(8)	23	19	8
South France	(9)	20	6	3
Iberia	(10)	5	0	0
Central Europe	(11)	1	0	0
Total		126	56	19

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
E. & W.Britain (1-4)	19.8	17.9	10.5
S.England (5-6)	38.9	30.4	31.6
Waddenzee (7)	2.4	7.1	0.0
France & S.Europe (8-11)	38.9	44.6	57.9

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=1.103, 2 df, ns
Mild winters v severe spells x^2=1.522, 1 df, ns

Table 9.2 Ringing periods and regions of British-ringed Gadwall recovered in winter.

Ringing region	Ringing period			
	July-October	November-March	April-June	
N.E.Scotland	0	0	6	6
East England	14	4	1	19
S.E.England	60	41	10	111
S.W.England	15	31	0	46
Total	89	76	17	182

Table 9.3 Recovery regions of British-ringed Gadwall in years before, during and after severe weather.

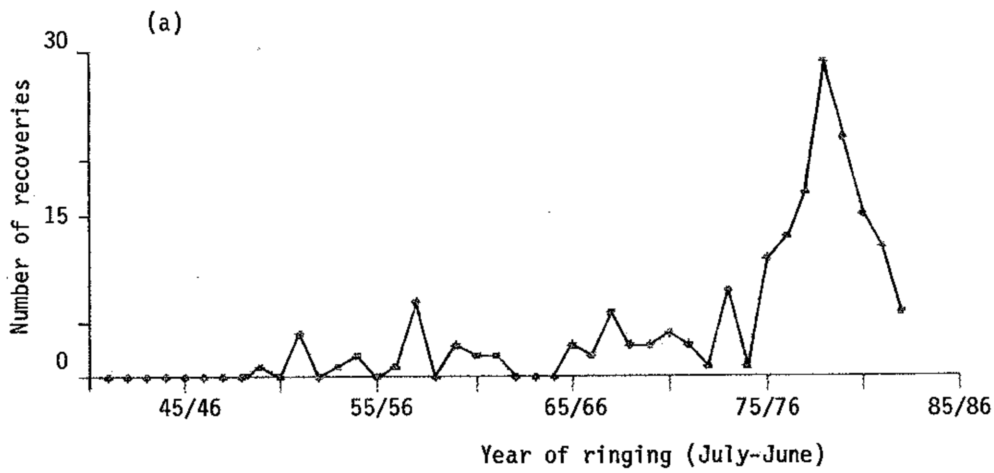
(a) Number of recoveries

Recovery region		Mild spells			Severe spells
		Years before	Years after	Years before +after	
East England	(1)	1	0	1	1
Irish Sea	(2)	1	0	1	0
Ireland	(3)	0	0	0	1
S.E.England	(4)	10	5	15	4
S.W.England	(5)	3	1	4	2
Waddenzee	(6)	0	1	1	0
North France	(7)	1	3	4	8
South France	(8)	0	5	5	3
Iberia	(9)	1	0	1	0
Total		17	15	32	19

(b) Percentage of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
Britain (1-5)	88.2	40.0	65.6	42.1
Waddenzee (6)	0.0	6.7	3.1	0.0
France (7-9)	11.8	53.3	31.2	57.9

Only recoveries during the period of severe weather are included.
Years before v years after x^2=6.220, 1 df, P<0.05.
Years before v severe spells x^2=6.397, 1 df, P<0.05
Years after v severe spells x^2=0.052, 1 df, ns



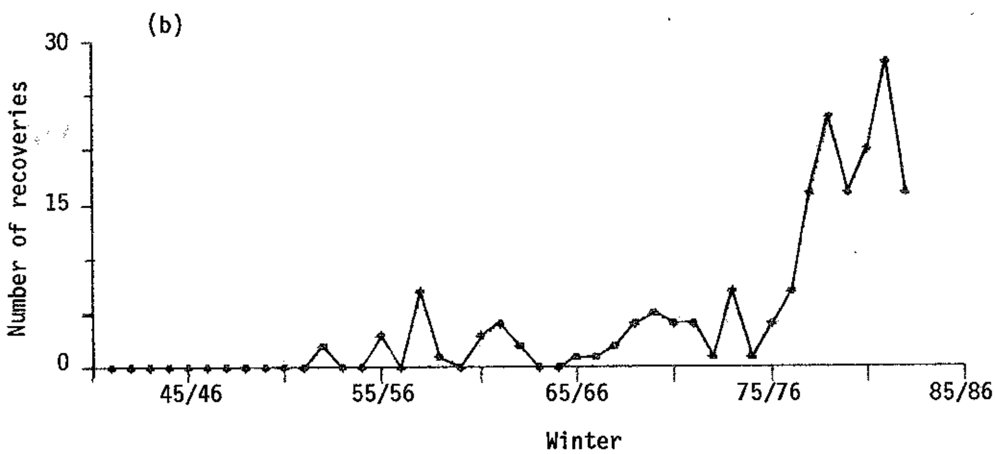


Figure 9.1 Winter recovery totals for Gadwall

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

TEAL Anas crecca

10.1 Normal pattern of movements

The British and Irish breeding population of this species was estimated to be between 3500 and 6000 pairs in 1970 (Sharrock 1976). It is thought to be largely resident. The Icelandic breeding population winters in Britain, mainly in Scotland and Ireland. However, most winter visitors to Britain belong to a population which breeds in north Russia, the Baltic States, Fenno-Scandia, north Germany, north Poland and Denmark. These birds winter in countries around the North Sea, principally the Netherlands and Britain. It is well established that this population moves south during periods of severe weather, with many recoveries from France and Iberia and a few birds reaching North Africa (Ogilvie 1983).

The size of the north-west European wintering population of Teal was estimated as about 200,000 birds in the late 1970s (Scott 1980). The maximum total recorded by Wildfowl and estuaries counts was 102,000 (December 1981) and the peak winter population of Britain and Ireland must be well in excess of 100,000 (Owen et al. in press).

In mild winters 78% of recoveries of British-ringed Teal were from Britain, 4% from the Waddenzee, 15% from France and 2.5% from south Europe (Table 10.1). These data indicate relatively little interchange with those Teal which winter in the Netherlands. Many of the recoveries from France and South Europe are of birds which have moved south in response to relatively short periods of cold weather. Within Britain the distribution of recoveries largely reflects the locations of the main ringing stations in East and South-east England (below), but it also indicates a westward movement, particularly into Ireland, of the birds marked there.

Previous analyses of Teal recoveries include those of Lebret (1947, west European populations), Wolff (1966, Netherlands), Ogilvie (1981, hard weather movements from Britain and the Netherlands), Perdeck and Classon (1982, Netherlands) and Ogilvie (1983, Denmark, Netherlands, Britain and France).

10.2 Ringing effort

The most important British ringing station for Teal is Abberton reservoir in South-east England, where 68% of the 55,152 Teal ringed in Britain between 1949 and 1977 were ringed (Ogilvie 1983). The recovery data illustrate this, with 68% of recoveries being of birds ringed in South-east England (Table 10.2). East England is also an important ringing area for Teal, 17% of winter-recovered birds having been ringed there. Most of the catching in East England has taken place at Borough Fen Decoy in Northamptonshire, Nacton Decoy in Suffolk, and Dersingham Decoy in Norfolk. Extensive ringing of Teal has also been carried out at Slimbridge in South-west England and 10% of winter recoveries are of birds ringed there.

Most ringing has taken place in Autumn and Winter and only 46 Winter recoveries are of birds ringed between April and June. In South-east England the ringing is divided about equally between the Autumn and Winter periods, while in East and South-west England most ringing has taken place between November and March.

Teal ringing before 1945/46 gave rise to fewer than 30 winter recoveries per year. Ringing effort increased from then until the mid-1950s. It remained high until the early 1960s, although numbers ringed varied markedly between years (Figure 10.1). The peak ringing years of 1955/56 and 1959/60 each gave rise to just over 500 winter recoveries. There has been a decline in ringing effort since the mid-1960s and in recent winters numbers of recoveries have averaged about 100. The 53 recoveries from the winter of 1982/83 is the smallest sample since 1948/49. It would be preferable to maintain samples of at least 100 recoveries per year so as to continue the series of annual measurements of cold weather movements and mortality.

10.3 Distribution of recoveries in mild and severe winters

The Teal is a species which shows particularly marked cold weather movements. Hard weather movements of Teal have been examined in detail by Ogilvie (1983) who analysed recoveries from all the north-west European wintering populations, and related them to weather patterns. He found that small scale cold weather movements occurred in moderately cold winters, which have been classified as mild for the purposes of this study. The extent of cold weather movements was related to the duration and severity of the cold weather. The present analysis of Teal recoveries presents the data in a way comparable to that for other species with more limited data sets. Many further analyses of the Teal recoveries could be carried out and some are presented by Ogilvie (1983). An analysis of differences in recovery patterns between winters is presented in section 30.

Recovery distributions from mild and severe winters are significantly different, as are those from mild winters and severe spells (Table 10.1). The main differences are the changes in the percentage of recoveries in France and South Europe, from 17.2% in mild winters to 27.5% in severe winters and to 38.4% when only severe spells are considered. The percentages of recoveries in the Waddenzee, East England and South-east England decline in response to severe weather, while those in Ireland and South-west England show slight increases.

Mean distances moved were 264 km in mild winters, 328 km in severe winters and 411 km during severe spells. These further illustrate the marked movement out of Britain during severe weather.

Comparison of the regional distribution of recoveries during severe spells with that in equivalent periods of the previous and subsequent winters (Table 10.3) confirms the pattern of movements described above. The difference between years before and after severe weather is significant ($P<0.05$) but this is not surprising with such a large sample of recoveries. The magnitudes of the differences between the two distributions are generally small, the main ones being a slight increase in the percentage of recoveries in the Irish Sea, and a decrease in the percentage of recoveries in France in years after severe weather. Separate comparisons of years before and after with severe spells both give highly significant differences.

The Recovery Index has been calculated for birds recovered in each region (Table 10.4). If the severe weather had no effect twice as many recoveries should have occurred in years before and after (2 years) as during severe spells (1 year). The results confirm increases in recoveries from France and Southern Europe during severe spells, ranging from a 2.5-fold increase in North France to a seven-fold increase in South Europe. A decrease in recoveries from the Waddenzee suggests a movement out of that area but is not significant. Within Britain and Ireland there are highly significant increases in Ireland and in South-west England, indicating movement into these areas. The 30% increase in recoveries from South-east England probably indicates increased mortality, as there are unlikely to have been large movements of ringed birds into this area. Taking the data from Britain as a whole the number of recoveries increased by 56%, despite clear evidence that many birds had left the area. Thus those birds which remained in Britain appear to have suffered increased mortality.

Analysis of distances moved during severe spells compared with equivalent periods in previous and subsequent winters also illustrates the increase in long distance movements (Figure 10.2). In this case there was no significant difference between years immediately before and after severe weather (Mann-Whitney U test, $t=0.063$ ns). The mean distance moved in these years was 271 km compared with 411 km during severe spells (Mann-Whitney U-test, $t=7.796$, $P<0.001$).

10.4 Distribution of recoveries following severe weather

Only 85 recoveries from periods between the end of severe spells and the end of March are available for analysis, compared with 645 recoveries from severe spells. Nevertheless this is sufficient to make some assessment of Teal movements following severe spells. The regional distribution of recoveries after severe spells was compared with the data from equivalent periods in previous and subsequent years (Table 10.5). The percentage distributions of the two samples were not significantly different. However, about twice as many recoveries as expected were reported from South Britain and North France after the severe weather. Although some of these may have been late reports of birds which died during the severe weather, the data do suggest that more birds than usual remained in France after the severe spells. However, extensive return movements had taken place also, with no more recoveries than expected from South France and Iberia.

The mean distance moved after severe spells was 314 km compared with 331 km for the equivalent periods in previous and subsequent years (Mann-Whitney U test, t=0.445 ns). When compared with the figure of 411 km calculated from recoveries during severe spells, these figures provide further evidence for a return movement shortly after the end of severe periods.

10.5 Summary

The relatively small British breeding population of Teal is joined in winter by birds from Iceland, and by large numbers of birds from northern and eastern Europe. These populations respond to severe weather by moving south into France and Iberia. Some Teal also move west into south-west Britain and Ireland during cold weather. These patterns are demonstrated by highly significant results from both regional and distance analyses. Many birds return to their normal wintering areas after severe weather but more Teal than expected were recovered from North France at such times. Detailed studies (Ogilvie 1983) have demonstrated complex relationships between movements and weather patterns, with small movements occurring in response to relatively short periods of severe weather.

Table 10.1 Recovery regions of British-ringed Teal in mild and severe winters.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
Norway	(1)	9	2	0
N.E.Scotland	(2)	45	9	2
N.W.Scotland	(3)	8	2	2
East England	(4)	583	77	34
Irish Sea	(5)	323	50	20
Ireland	(6)	763	164	103
S.E.England	(7)	2053	382	142
S.W.England	(8)	609	188	89
Waddenzee	(9)	223	36	4
North France	(10)	512	154	92
South France	(11)	307	121	97
Iberia	(12)	73	68	58
Central Europe	(13)	63	4	1
Eastern Europe	(14)	9	2	1
Africa	(15)	3	0	0
Misc.	(16)	2	0	0
Total		5585	1259	645

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
Norway (1)	0.2	0.2	0.0
Scotland (2+3)	0.9	0.9	0.6
East England (4)	10.4	6.1	5.3
Irish Sea (5)	5.8	4.0	3.1
Ireland (6)	13.7	13.0	16.0
S.E.England (7)	36.8	30.3	22.0
S.W.England (8)	10.9	14.9	13.8
Waddenzee (9)	4.0	2.9	0.6
North France (10)	9.2	12.2	14.3
South France (11)	5.5	9.6	15.0
S.Europe (12	2.5	5.7	9.1
Total	99.8	99.8	99.8

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=128.617, 9 df, P<0.001
Mild winters v severe spells x^2=261.005, 9 df, P<0.001

Table 10.2 Ringing periods and regions of British-ringed Teal recovered in winter.

Ringing region	Ringing period July-October	November-March	April-June	
N.E.Scotland	22	6	9	37
N.W.Scotland	1	0	0	1
East England	393	745	6	1144
Irish Sea	67	15	4	86
Ireland	174	88	1	263
S.E.England	2109	2502	26	4637
S.W.England	111	565	0	676
Total	2887	3921	46	6844

Table 10.3 Recovery regions of British-ringed Teal in years before, during and after severe weather.

(a) Number of recoveries

Recovery region		Mild spells			Severe spells
		Years before	Years after	Years before +after	
N.E.Scotland	(1)	1	2	3	2
N.W.Scotland	(2)	0	0	0	2
East England	(3)	38	24	62	34
Irish Sea	(4)	17	24	41	20
Ireland	(5)	55	35	90	103
S.E.England	(6)	141	79	220	142
S.W.England	(7)	53	34	87	89
Waddenzee	(8)	6	7	13	4
North France	(9)	53	19	72	92
South France	(10)	37	11	48	97
Iberia	(11)	2	4	6	58
Central Europe	(12)	6	4	10	1
Eastern Europe	(13)	0	0	0	1
Total		409	243	652	645

(b) Percentage of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
N. & E.Britain (1-3)	9.5	10.7	10.0	5.9
Irish Sea (4)	4.2	9.9	6.3	3.1
Ireland (5)	13.4	14.4	13.8	16.0
S.E.England (6)	34.5	32.5	33.7	22.0
S.W.England (7)	13.0	14.0	13.3	13.8
Waddenzee (8)	1.5	2.9	2.0	0.6
North France (9)	13.0	7.8	11.0	14.3
South France (10)	9.0	4.5	7.4	15.0
S.Europe (11-12)	2.0	3.3	2.5	9.1
Total	100.0	100.0	100.0	99.8

Only recoveries during the period of severe weather are included.
Years before v years after x^2=19.048, 8 df, P<0.05.
Years before v severe spells x^2=50.621, 8 df, P<0.001.
Years after v severe spells x^2=67.264, 8 df, P<0.001.

Table 10.4 Change in the numbers of Teal recoveries in each region during severe spells.

	Mild spells[a]	Severe spells	Recovery index	x^2	Sig.
N. & E.Britain (1-3)	65	38	1.17	0.59	ns
Irish Sea (4)	41	20	0.98	0.01	ns
Ireland (5)	90	103	2.29	34.86	***
S.E.England (6)	220	142	1.29	5.66	*
S.W.England (7)	87	89	2.05	23.53	***
Waddenzee (8)	13	4	0.62	0.74	ns
North France (9)	72	92	2.56	38.24	***
South France (10)	48	97	4.04	73.50	***
South Europe (11+12)	16	59	7.37	69.36	***

Data are from Table 10.3

a Equivalent dates to severe spells in years immediately before and after severe weather.

With equal recovery probabilities there should be twice as many recoveries in column 1 (2 years) as in column 2 (1 year).

$$\text{Recovery index} = \frac{2 \times \text{number of recoveries during severe spells}}{\text{number of recoveries in years before and after}}$$

x^2 is a test against an expected ratio between columns 1 and 2 of 2:1.

*** P<0.001 * P<0.05 ns not significant

Table 10.5 Recovery regions of British-ringed Teal in periods immediately after severe weather, and in the same periods in the previous and subsequent winters.

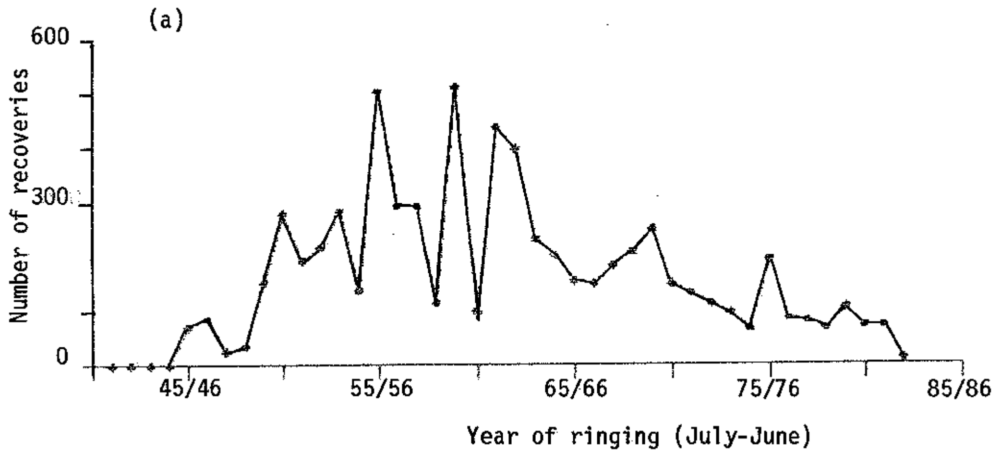
(a) Number of recoveries

Recovery region		After mild spells			After severe spells
		Years before	Years after	Years before +after	
N.E.Scotland	(1)	0	0	0	1
East England	(2)	4	3	7	2
Irish Sea	(3)	1	4	5	3
Ireland	(4)	6	7	13	9
S.E.England	(5)	7	6	13	23
S.W.England	(6)	12	3	15	8
Waddenzee	(7)	1	2	3	1
North France	(8)	12	15	27	32
South France	(9)	11	3	14	3
Iberia	(10)	0	2	2	2
Central Europe	(11)	0	2	2	1
Total		54	47	101	85

(b) Percentage of recoveries

Recovery region	After mild spells			After severe spells
	Years before	Years after	Years before +after	
N. & E.Britain (1-2)	7.4	6.4	6.9	3.5
West Britain (3-4)	13.0	23.4	17.8	14.1
South Britain (5-6)	35.2	19.1	27.7	36.5
Waddenzee (7)	1.9	4.3	3.0	1.2
North France (8)	22.2	31.9	26.7	37.6
South Europe (9-11)	20.4	14.9	17.8	7.1
Total	100.0	100.0	100.0	100.0

Years before v years after x^2=0.216, 1 df, ns.
Severe winters v before+after x^2=0.003, 1 df, ns.



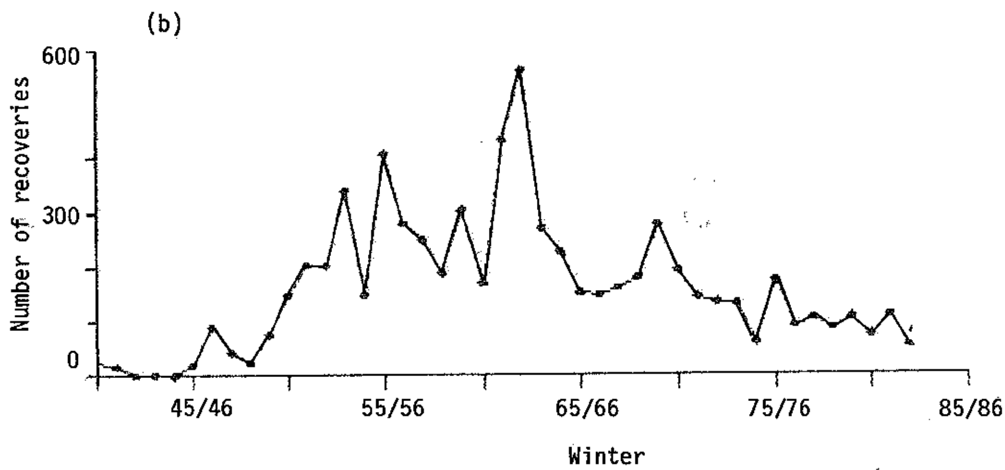


Figure 10.1 Winter recovery totals for Teal

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

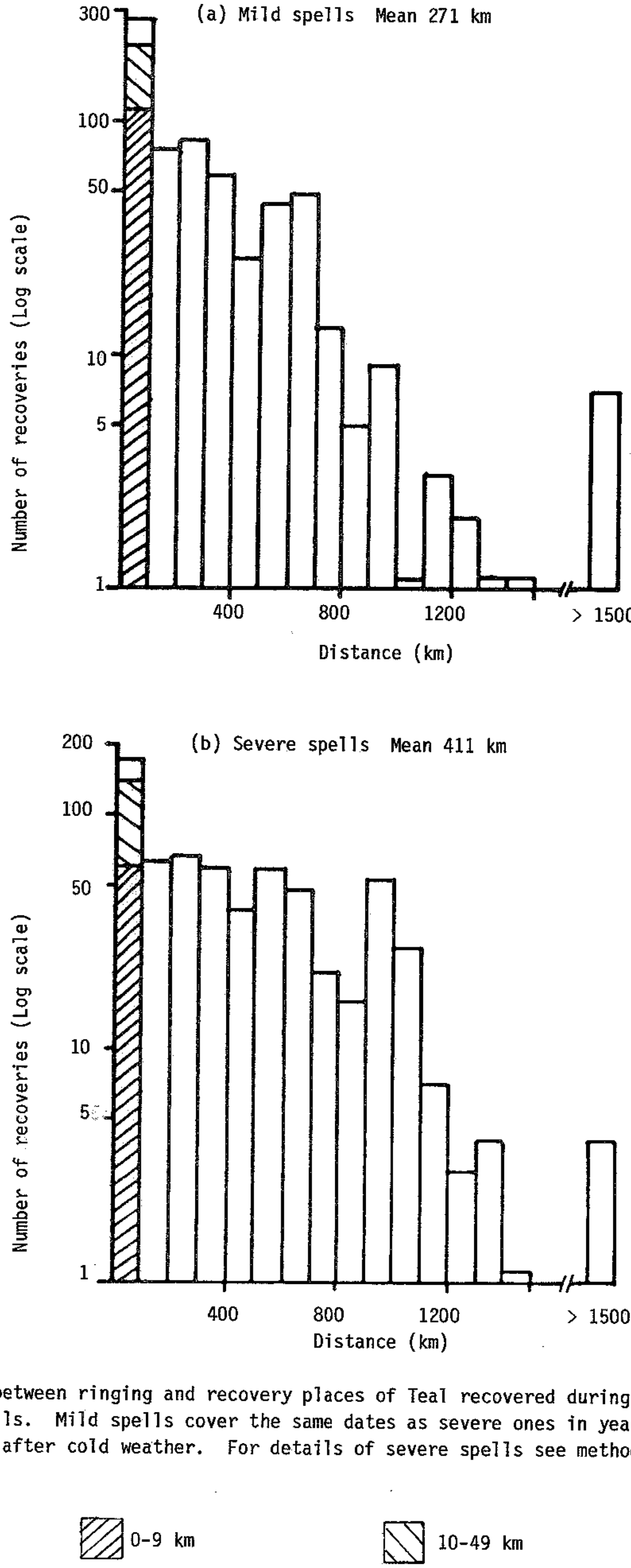


Figure 10.2 Distances between ringing and recovery places of Teal recovered during mild and severe spells. Mild spells cover the same dates as severe ones in years immediately before and after cold weather. For details of severe spells see methods.

MALLARD *Anas platyrhynchos*

11.1 Normal pattern of movements

This is by far the commonest duck breeding in Britain. Total numbers are difficult to estimate, particularly because of large scale introductions by wildfowlers. Thus estimates of the size of the British and Irish breeding population range from 50,000 pairs to 130,000 pairs (Owen *et al*. in press). These British and Irish breeding birds are thought to be largely resident (Boyd and Ogilvie 1961).

These birds are augmented in winter by migrants from Iceland, north-west Russia, Fenno-Scandia, the Baltic States, north Poland, north Germany and Denmark. The winter population of Britain has been estimated as 400,000-500,000 (Owen *et al*. in press) birds and comprises about 20% of the west European total (Atkinson-Willes 1975). Comparisons of winter and summer numbers are difficult, as the picture is complicated by very large-scale releases and by the large numbers shot each autumn.

During mild winters 90.5% of British-ringed Mallard are recovered in Britain, 5.6% from the Waddensee, 2.6% from North France and 1.2% from other parts of Europe (Table 11.1). Within Britain the distribution of recoveries largely reflects the location of the main ringing centres in eastern and southern England.

11.2 Ringing effort

Over 120,000 Mallard have been ringed in Britain and some 10,347 winter recoveries were therefore available for analysis. This very large number of recoveries would repay more detailed treatment than can be attempted here. The largest numbers of recoveries are from East England (4284), South-east England (3625) and South-west England (1710) (Table 11.2). These mainly result from ringing at the Wildfowl Trust ringing stations of Borough Fen, Abberton and Slimbridge respectively. Considering the scale of the ringing programme, north and west Britain are poorly represented, with only 6% of the total recovery sample between them. Most of the ringing has involved the trapping of full-grown birds in autumn (61%) and winter (33%). Only 5.5% of the recoveries are of birds ringed between April and June.

Very little ringing was carried out before 1948/49. Ringing effort built up rapidly from then onwards, and there have been over 100 winter recoveries annually since 1955/56 (Figure 11.1). Ringing effort increased until the late 1960s, with a peak of 713 recoveries in 1969/70. Since then there has been some decline, but adequate annual samples continue to be ringed.

11.3 Distribution of recoveries in mild and severe winters

The regional distributions of recoveries in mild and in severe winters differ very significantly (Table 11.1). This is also true when mild winters are compared with severe spells. The main differences are a slight increase in the proportion of recoveries in South-east England, in France and in South Europe, and a decrease in the Waddenzee. However the differences are relatively small, the high significance levels being due to the large sample sizes. The data appear to reflect mainly a movement out of the Waddenzee, the overall percentage of recoveries on the Continent being 8.8% in mild winters compared with 8.6% in severe spells. Neither is there a difference in the mean distances moved (104 km for mild winters compared with 102 km for severe spells).

Comparison of severe spells with the corresponding periods in previous and subsequent winters again provides evidence of a movement out of the Waddenzee into France and South Europe during severe weather (Table 11.3). With such large samples of recoveries it is possible to compare the numbers of recoveries in each region in mild and severe weather (Table 11.4). These ratios will be affected by mortality as well as by movements. They might also be influenced by changes in the regional distribution of ringing effort between mild and severe winters, but this is probably not a major bias. The most marked result of this analysis is the three-fold increase in the number of recoveries in France and South Europe during severe weather, although again only a small proportion of the total population is involved. The decrease in recoveries from the Waddenzee is not significant, although the number of recoveries was about half that normally expected.

Within Britain, significant increases in the number of recoveries in severe weather occurred in East England, Ireland and South-east England. In eastern England these increases may reflect increased mortality but the 75% increase in the number of recoveries in Ireland during severe spells is probably due to movement. Significant decreases were recorded in the Irish Sea area and in South-west England. It seems unlikely that birds would move out of these relatively mild areas, so the decrease may be due to hunting bans and restraint exercised by wildfowlers. Ogilvie (1982) suggested that during the winter of 1978/79 there was an increase of 10 to 15% in the mortality of British Mallards. The increases in the numbers of recoveries from the major ringing areas of East and South-east England recorded here are broadly consistent with this pattern. Mortality could best be compared by comparing the same season recovery rates for birds ringed in different areas during mild and severe winters. This was beyond the scope of this analysis because regional totals of birds ringed are not readily available.

The mean distance moved during severe spells was 102 km, compared with 85 km during previous and subsequent years (Mann-Whitney U-test, t=0.411 ns). The percentage of recoveries under 10 km was 29% in severe spells, compared with 26% in previous and subsequent years. These figures suggest that most Mallard do not alter their movement patterns during severe weather and that any redistribution of birds which does take place is over relatively short distances.

Some evidence that the response of Mallard to severe weather differs between individual winters is described in section 30.

11.4 Distribution of recoveries following severe weather

The Mallard is one of the few species for which there are sufficient data to examine recovery distributions between the end of the severe weather and the end of March. The data suggest that some birds remain in the areas to which thay have moved even after the cold weather has ended. The regional distribution of recoveries in periods following severe spells is significantly different from that recorded during the same periods of immediately previous and subsequent winters (Table 11.5). The main differences are a marked decrease in the percentage of recoveries from South-east England and increases in the percentage of recoveries in France and the Waddenzee. When numbers of recoveries in individual regions were compared, there were 6 times as many recoveries in France after severe weather (x^2=12.50, 1 df, $P<0.001$), but only 65% of the normal number of recoveries in South-east England (x^2=4.20, 1 df, $P<0.05$). No other individual regional comparisons yielded significant differences.

Analyses of distances between ringing and recovery places confirm this pattern, and suggest that normal late winter movements towards the ringing areas are disrupted following severe weather. Birds recovered in periods after severe spells were significantly further from their ringing places than birds recovered during the same periods in immediately previous and subsequent winters (Means 109 km v 50 km, Mann-Whitney U-test, t=2.549, $P<0.05$, Figure 11.2). This was because recoveries at the end of mild winters were closer to the ringing places than those in mid-winter while the mean distances for recoveries reported during and after severe spells were similar (102 km v 109 km). Further work is needed to clarify this situation.

11.5 Summary

The large British breeding population of Mallard is joined in winter by birds from Iceland, and northern and eastern Europe. In mild winters the vast majority of British-ringed Mallard are recovered in Britain, and this continues to be the case during severe weather, with no evidence of any increase even in local movements. However, the data provide highly significant evidence of movement into France from the Waddenzee, and perhaps also from Britain, by a small proportion of the population. Evidence of movement into Ireland is weaker. The recovery pattern after cold spells indicates that birds do not return immediately to the areas which they left, there being six times as many recoveries in France as during equivalent periods in mild winters.

Table 11.1 Recovery regions of British-ringed Mallard in mild and severe winters.

(a) Number of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
Norway (1)	41	3	0
N.E.Scotland (2)	142	17	6
N.W.Scotland (3)	13	3	0
East England (4)	2740	269	146
Irish Sea (5)	379	42	16
Ireland (6)	316	43	24
S.E.England (7)	3555	408	221
S.W.England (8)	1249	167	61
Waddenzee (9)	519	58	10
North France (10)	242	46	22
South France (11)	38	9	8
Iberia (12)	6	2	2
Central Europe (13)	13	3	3
Eastern Europe (14)	21	2	0
Total	9274	1072	519

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
Norway (1)	0.4	0.3	0.0
Scotland (2-3)	1.7	1.9	1.2
East England (4)	29.5	25.1	28.1
Irish Sea (5)	4.1	3.9	3.1
Ireland (6)	3.4	4.0	4.6
S.E.Engand (7)	38.3	38.1	42.6
S.W.England (8)	13.5	15.6	11.8
Waddenzee (9)	5.6	5.4	1.9
North France (10)	2.6	4.3	4.2
S.Europe (11-13)	0.6	1.3	2.5
East Europe (14)	0.2	0.2	0.0

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=28.105, 9 df, P<0.001
Mild winters v severe spells x^2=52.962, 9 df, P<0.001

Table 11.2 Ringing periods and regions of British-ringed Mallard recovered in winter.

Ringing region	Ringing period: July-October	November-March	April-June	
N.E.Scotland	45	46	52	143
N.W.Scotland	0	2	4	6
East England	2874	1351	59	4284
Irish Sea	110	95	30	235
Ireland	244	71	29	344
S.E.England	2036	1275	314	3625
S.W.England	1004	620	86	1710
Total	6313	3460	574	10347

Table 11.3 Recovery regions of British-ringed Mallard in years before, during and after severe weather.

(a) Number of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
Norway (1)	0	1	1	0
N.E.Scotland (2)	5	4	9	6
East England (3)	132	104	236	146
Irish Sea (4)	19	19	38	16
Ireland (5)	12	16	28	24
S.E.England (6)	178	168	346	221
S.W.England (7)	92	85	177	61
Waddenzee (8)	16	16	32	10
North France (9)	8	10	18	22
South France (10)	1	2	3	8
Iberia (11)	0	0	0	2
Central Europe (12)	2	2	4	3
Total	465	427	892	519

(b) Percentage of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
Norway (1)	0.0	0.2	0.1	0.0
East Britain (2-3)	29.5	25.3	27.5	29.3
West Britain (4-5)	6.7	8.2	7.4	7.7
S.E.England (6)	38.3	39.3	38.8	42.6
S.W.England (7)	19.8	19.9	19.8	11.8
Waddenzee (8)	3.4	3.7	3.6	1.9
France & S.Europe (9-12)	2.4	3.3	2.8	6.7

Only recoveries during the period of severe weather are included.
Years before v years after x^2=2.899, 2 df, ns
Severe winters v before+after x^2=29.347, 5 df, P<0.001

Table 11.4 Change in the numbers of Mallard recoveries in each region during severe spells.

Recovery region	Years before +after	Severe spells	Recovery index	x^2	Sig.
East England (3)	236	146	1.24	4.10	*
Irish Sea (4)	38	16	0.84	0.33	ns
Ireland (5)	28	24	1.71	3.85	*
S.E.England (6)	346	221	1.28	8.13	**
S.W.England (7)	177	61	0.69	6.36	*
Waddenzee (8)	32	10	0.63	1.71	ns
France (9-11)	21	32	3.05	17.44	***

Data are from Table 11.3

With equal recovery probabilities there should be twice as many recoveries in column 1 (2 years) as in column 2 (1 year).

$$\text{Recovery index} = \frac{2 \times \text{number of recoveries during severe spells}}{\text{number of recoveries in years before and after}}$$

x^2 is a test against an expected ratio between columns 1 and 2 of 2:1.

*** P<0.001 ** P<0.01 * P<0.05 ns not significant

Table 11.5 Recovery regions of British-ringed Mallard in periods immediately after severe weather, and in the same periods in the previous and subsequent winters.

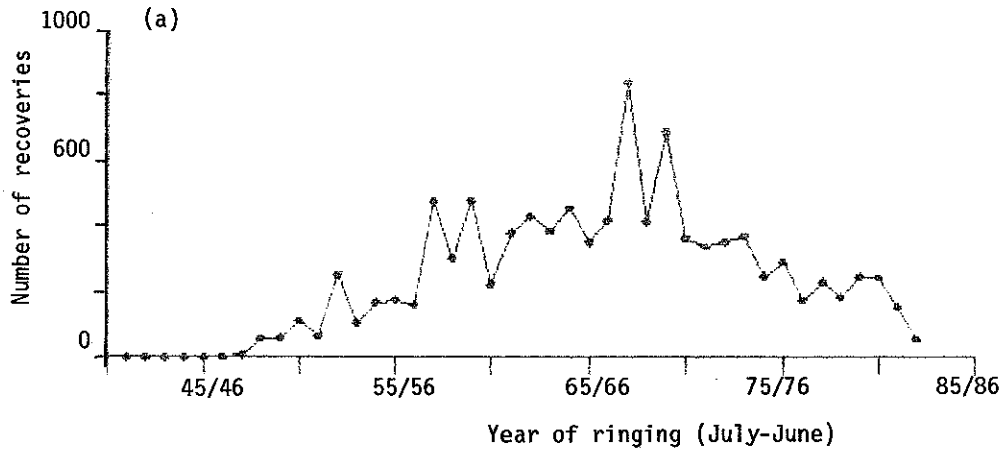
(a) Number of recoveries

Recovery region	After mild spells			After severe spells
	Years before	Years after	Years before +after	
N.W.Scotland (1)	0	0	0	1
N.E.Scotland (2)	3	0	3	1
East England (3)	16	12	28	13
Irish Sea (4)	2	5	7	6
Ireland (5)	2	3	5	4
S.E.England (6)	58	34	92	30
S.W.England (7)	10	14	24	16
Waddenzee (8)	2	2	4	4
North France (9)	3	1	4	11
South France (10)	0	0	0	1
Total	96	71	167	87

(b) Percentage of recoveries

Recovery region	After mild spells			After severe spells
	Years before	Years after	Years before +after	
N. & E.Britain (1-3)	20	17	19	17
West Britain (4-5)	4	11	9	11
S.E.England (6)	60	48	55	34
S.W.England (7)	10	20	14	18
Waddenzee (8)	2	3	2	5
France (9-10)	3	1	2	14

Years before v years after x^2=6.750, 4 df, ns
Severe winters v before+after x^2=19.603, 5 df, $P<0.01$



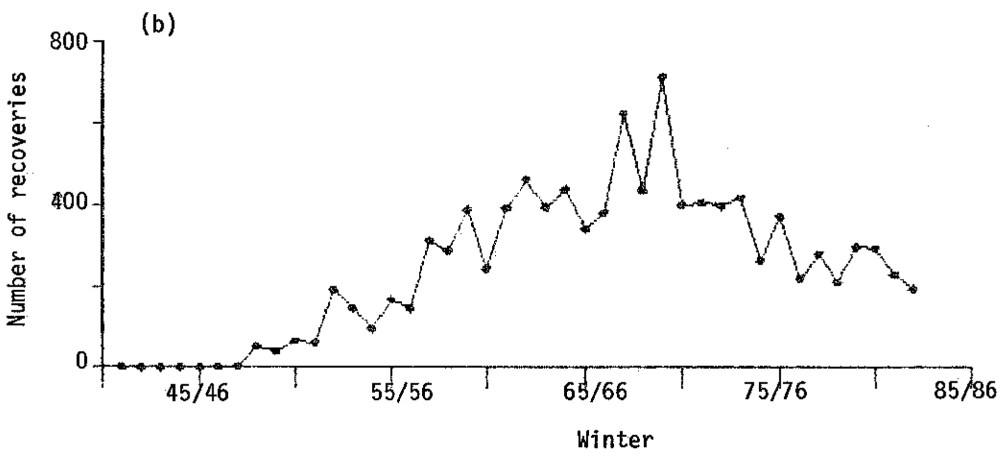
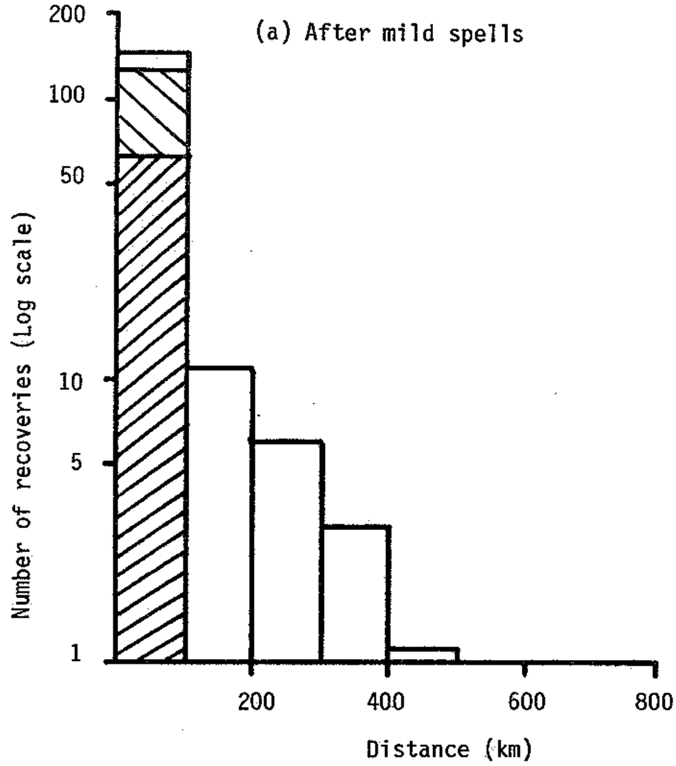


Figure 11.1 Winter recovery totals for Mallard

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
    Years run from 1 July to 30 June
    Winter is defined as November to March



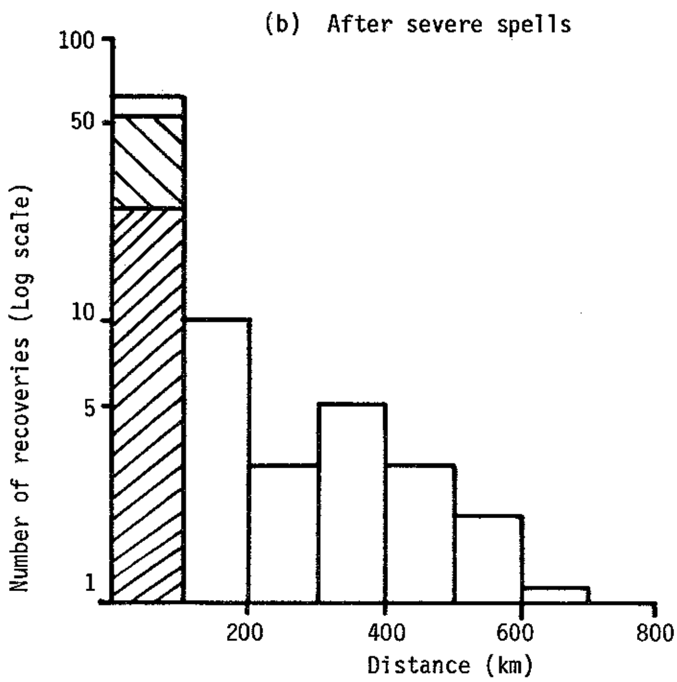


Figure 11.2 Distances between ringing and recovery places of Mallard recovered between the end of mild spells (a) or severe spells (b) and the end of March. Mild spells cover the same dates as severe ones in years immediately before and after cold weather. For details of severe spells see methods.

0-9 km   10-49 km

PINTAIL *Anas acuta*

12.1 Normal pattern of movements

The British and Irish breeding population of Pintail is very small, with probably fewer than 50 pairs breeding in most years (Sharrock 1976). The wintering grounds of these birds are unknown. The Icelandic breeding population, which probably contains fewer than 500 pairs, winters mainly in North Britain and Ireland. Due to the concentration of ringing effort in the south of England, relatively few of these birds have been ringed.

Most of the Pintail wintering in Britain belong to an East European population which breeds from north Russia east to north-west Siberia, Fenno-Scandia and the Baltic. These birds winter mainly in the Netherlands, Britain, and west France. Sixty-four per cent of winter recoveries of British-ringed birds are from Britain, 9% from the Waddenzee and East Europe, 14% from France and 13% from south Europe (Table 12.1). The 32 recoveries from Central Europe mainly occurred in February and March from Italy to the Black Sea. They may represent birds which had joined more easterly breeding populations.

The Pintail is a very mobile species, adapted to taking advantage of rapidly changing areas of suitable habitat. There is significant seasonal variation in the regional distribution of recoveries during mild winters (Table 12.2). In late winter an increased percentage of recoveries are reported from France and South Europe with a corresponding decrease in the percentage of recoveries from Britain. Much of this variation is due to a decline in the number of British recoveries at the end of the hunting season, but there are slightly more recoveries in France and south Europe than earlier in the winter. Cold weather movements from the Netherlands into Britain have been reported (Cramp and Simmons 1977).

The total north-west European wintering population of Pintail contains about 75,000 birds (Scott 1980). Particularly important sites are the Mersey and Dee Estuaries (c.13,000 birds); Osterschelde, Westerschelde and Dordse Biesbosch (Netherlands) and Aiguillon (western France, c.12,000 birds).

12.2 Ringing effort

Most ringing has taken place in South-east England, particularly at Nacton (Table 12.3). Small numbers have been ringed in Ireland and in South-west England but very few have been marked elsewhere. Most of the ringing has been away from the major coastal concentrations of this species and hence the recoveries may not be representative of the wintering population.

Sixty-one per cent of birds were ringed between July and October and most others were ringed between November and March. Most recoveries are of birds ringed since the mid-1960s (Figure 12.1). Numbers of recoveries have fluctuated considerably between years, partly due to fluctuations in trapping success. Winter recovery totals reached a peak in the mid-1970s, and have declined since then.

12.3 Distribution of recoveries in mild and severe winters

Comparison of the overall recovery distributions between mild and severe winters shows a significantly higher percentage of recoveries in West Britain and a lower percentage in South Britain and Europe (Table 12.1). This pattern is shown more clearly when mild winters are compared with severe spells, the percentage of recoveries in North and West Britain increasing from 21% to 58%. The main regions showing an increased proportion of recoveries are the Irish Sea and Ireland. These results are confirmed by the more rigorous comparison of the recovery distribution during severe spells with that during the corresponding periods in the previous and subsequent winters (Table 12.4). The recovery distribution from years immediately before and after severe spells is very similar to that for all mild winters.

Only the direction of Pintail movements is affected by cold weather. Analyses of distance distributions showed no significant differences between mild and severe winters. Mean distances moved were 456 km in mild winters, 287 km in severe winters, 210 km in severe spells and 316 km in years before and after severe weather (Mann-Whitney U-tests of mild winters v severe winters; mild winters v severe spells; and years before and after v severe spells all ns).

12.4 Summary

Most Pintail wintering in Britain belong to a population which breeds in East Europe and Fenno-Scandia, and winters in Britain, Ireland the Netherlands and France. Significant differences between recovery regions in mild and severe winters indicate a movement into west Britain during cold weather. No significant differences in distances moved were detected.

Table 12.1 Recovery regions of British-ringed Pintail in mild and severe winters.

(a) Number of recoveries

Ringing region	Mild winters	Severe winters	Severe spells
N.E.Scotland (1)	2	0	0
N.W.Scotland (2)	2	0	0
East England (3)	16	4	3
Irish Sea (4)	26	6	4
Ireland (5)	31	8	7
S.E.England (6)	119	11	2
S.W.England (7)	34	8	4
Waddenzee (8)	29	3	0
North France (9)	36	3	2
South France (10)	16	4	2
Iberia (11)	7	1	0
Central Europe (12)	32	1	0
Eastern Europe (13)	3	0	0
Africa (14)	7	0	0
Total	360	49	24

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
N. and W. Britain (1-5)	21	37	58
South Britain (6-7)	43	39	25
Europe (8-14)	36	24	17

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=6.193, 2 df, $P<0.05$
Mild winters v severe spells x^2=17.061, 2 df, $P<0.001$

Table 12.2 Recovery regions of British-ringed Pintail in each month during mild winters.

	Nov.	Dec.	Jan.	Feb.	Mar.
N. and E. Britain	3	4	12	2	0
West Britain	17	14	24	9	0
South Britain	47	50	45	39	4
Waddenzee & E. Europe	16	9	5	4	11
France	8	13	9	20	46
S.Europe and Africa	8	9	6	26	39
No. of recoveries	87	90	101	54	28

All figures are percentages except for the last line.

Test between months (Feb.& Mar.combined) x^2=77.681, 15 df, P<0.001
Test between months November to January x^2= 16.724, 10 df, ns

Table 12.3 Ringing periods and regions of British-ringed Pintail recovered in winter.

Ringing region	Ringing period: July-October	November-March	April-June	
East England	4	10	0	14
Irish Sea	1	1	0	2
Ireland	18	32	0	50
S.E.England	214	38	1	253
S.W.England	13	78	1	92
Total	250	159	2	411

Table 12.4 Recovery regions of British-ringed Pintail in years before, during and after severe weather.

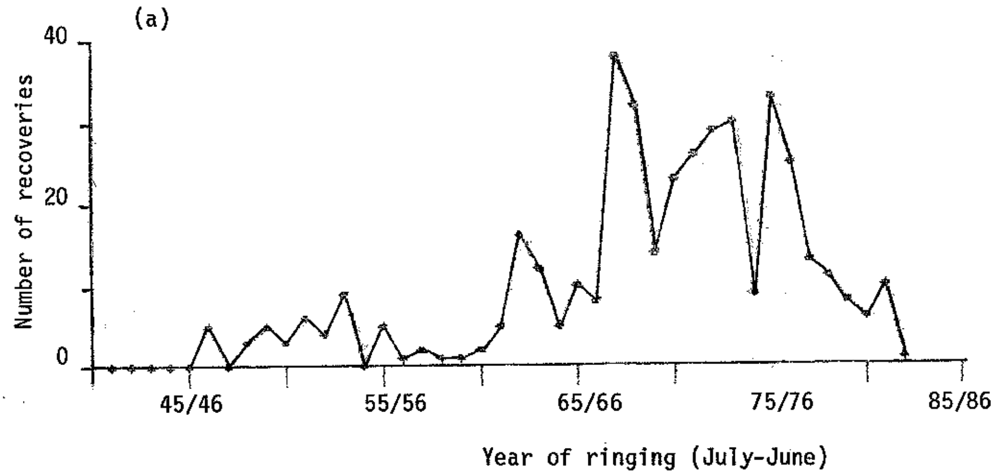
(a) Number of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
East England (1)	0	1	1	3
Irish Sea (2)	1	2	3	4
Ireland (3)	1	2	3	7
S.E.England (4)	6	3	9	2
S.W.England (5)	3	1	4	4
Waddenzee (6)	2	1	3	0
North France (7)	0	3	3	2
South France (8)	2	0	2	2
Central Europe (9)	0	1	1	0
Total	15	14	29	24

(b) Percentage of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
E. and W. Britain (1-3)	13	36	24	58
South Britain (4-5)	60	29	45	25
Europe (6-9)	27	36	31	17

Only recoveries during the period of severe weather are included.
Years before v years after x^2=3.289, 2 df, ns
Severe winters v before+after x^2=6.421, 2 df, P<0.05



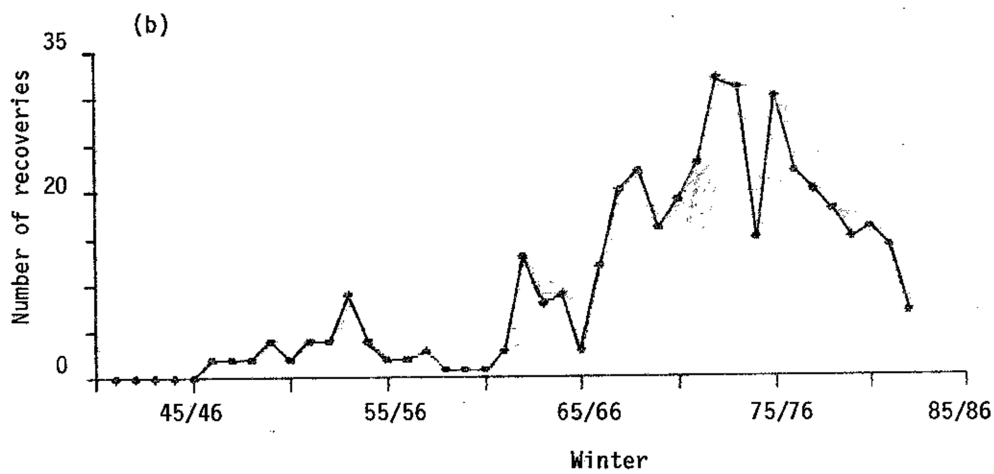


Figure 12.1 Winter recovery totals for Pintail

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

SHOVELER *Anas clypeata*

13.1 Normal pattern of movements

The British and Irish breeding population contains about 1000 pairs (Sharrock 1976). Most of these birds winter in southern France, southern Spain and northern and central Italy, with a few reaching north Africa. Sixty-three per cent of Shovelers ringed between April and June were recovered away from Britain in winter against only 32% for November to March ringed birds (Table 13.1). Sixty-eight per cent of winter recoveries of birds ringed as ducklings are from Europe. Thus although most of the British breeding population moves south for the winter, some birds winter in Britain. Whether some of these have joined the breeding populations which visit Britain for the winter, and are hence showing the movement patterns of continental birds rather than those of British breeders, is open to speculation. As overall sample sizes are small, no attempt was made to separate British breeders in the analyses presented below.

Most of the Shovelers present in Britain during the winter are from the breeding populations of Fenno-Scandia and the USSR east to 60°E and south to 55°N. This population of about 100,000 birds occupies a winter range which extends from Britain and Ireland to the western Mediterranean (Scott 1980).

Forty-eight per cent of winter recoveries of British-ringed Shovelers are from Britain, 3% from the Waddenzee, 32% from France and 17% from south Europe and north Africa (Table 13.2). This sample includes some British breeders but is composed mainly of birds from the continental population which winter in Britain. Some Shovelers probably move out of Britain in late winter, about 40% of recoveries between November and January being from Europe compared with 59% in February and 100% in March (Table 13.3). However, some of this effect may result from the earlier end of the hunting season in Britain.

British Shoveler recoveries have previously been analysed by Ogilvie (1962).

13.2 Ringing effort

Most ringing has taken place in the south of England (74% of recoveries), with some in East England and very little elsewhere (Table 13.4). Fifteen per cent of recoveries are of birds ringed as ducklings. Ringing in Britain has taken place throughout the year but particularly during the period from July to October (58% of recoveries).

There are no trends in the numbers of Shovelers ringed or in the numbers recovered each year (Figure 13.1). The marked fluctuations between years in numbers recovered are probably the result of the small sample sizes. Numbers of winter recoveries vary from 0 to 11.

13.3 Distribution of recoveries in mild and severe winters

The percentage of recoveries in France and south Europe increased from 49% in mild winters to 58% in severe ones, while during severe spells 69% of recoveries were from Europe (Table 13.2). However these differences are not statistically significant. The high number of European recoveries in mild winters is probably due to the high probability of late winter recoveries being from Europe (Table 13.3). Most cold spells occur in mid-winter before this shift in the recovery distribution takes place.

The percentage of recoveries in Europe (including the Waddenzee) was 77% in severe spells compared with 25% in comparable periods from the previous and subsequent winters (Table 13.5). This difference is significant but, as the change is based on small samples, it has wide confidence limits. However, it is clear evidence of a movement of Shovelers out of Britain during severe weather.

Analyses of distances between ringing and recovery places gave results similar to those of the regional analyses. Mean distances moved were 533 km in mild winters, 597 km in severe winters and 605 km in severe spells (Mann-Whitney U-tests: mild v severe $t=1.142$ ns, mild v severe spells $t=1.366$ ns). The difference between severe spells and the same periods in previous and subsequent winters is significant, the mean distances being 605 km and 365 km respectively (Mann-Whitney U-test, $P<0.05$). Only two recoveries (15%) were within 200 km of the ringing site during severe spells compared with 13 (65%) during mild ones (Figure 13.2).

13.4 Summary

Most British breeding Shovelers migrate to France and south Europe for the winter, and are replaced by a wintering population from the Continent. The pattern of recoveries is further complicated by a probable movement out of Britain in late winter. Comparison of severe spells with similar periods in previous and subsequent winters provides evidence of movement out of Britain in severe weather. This is shown by both regional and distance analyses.

Table 13.1 Percentage of Shovelers ringed at different times of year which were recovered in Europe during mild winters.

	Ringing period		
	July-October	November-March	April-June
Percent in Europe	56	32	63
No. of recoveries	96	37	32

Only birds ringed in Britain and recovered between November and March are included.

Test between ringing periods x^2= 7.785, 2 df, $P<0.05$.

Table 13.2 Recovery regions of British-ringed Shovelers in mild and severe winters.

(a) Number of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
N.E.England (1)	1	0	0
N.W.England (2)	1	0	0
East England (3)	6	0	0
Irish Sea (4)	3	1	0
Ireland (5)	15	2	2
S.E.England (6)	28	2	1
S.W.England (7)	24	2	0
Waddenzee (8)	5	4	1
North France (9)	29	6	3
South France (10)	24	6	5
Iberia (11)	15	1	0
Central Europe (12)	9	2	1
Africa (13)	4	0	0
Total	164	26	13

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
N. & W.Britain (1-5)	16	12	15
South Britain (6-7)	32	15	8
Waddenzee (8)	3	15	8
France and S.Europe (9-13)	49	58	69

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2= 4.032, 3 df, ns
Mild winters v severe spells x^2= 2.006, 1 df, ns

Table 13.3 Monthly percentages of British-ringed Shovelers recovered in Europe in mild winters.

	November	December	January	February	March
Percent in Europe	40	42	39	59	100
Number of recoveries	30	36	49	22	27

Test between months $x^2 = 32.083$, 4df, $P<0.001$

Table 13.4 Ringing periods and regions of British-ringed Shovelers recovered in winter.

Ringing region	Ringing period			
	July-October	November-March	April-June	
N.E.Scotland	2	0	2	4
N.W.Scotland	0	0	1	1
East England	27	10	3	40
Irish Sea	2	0	0	2
Ireland	2	0	0	2
S.E.England	52	11	24	87
S.W.England	25	27	2	54
Total	110	48	32	190

Table 13.5 Recovery regions of British-ringed Shovelers in years before, during and after severe weather.

(a) Number of recoveries

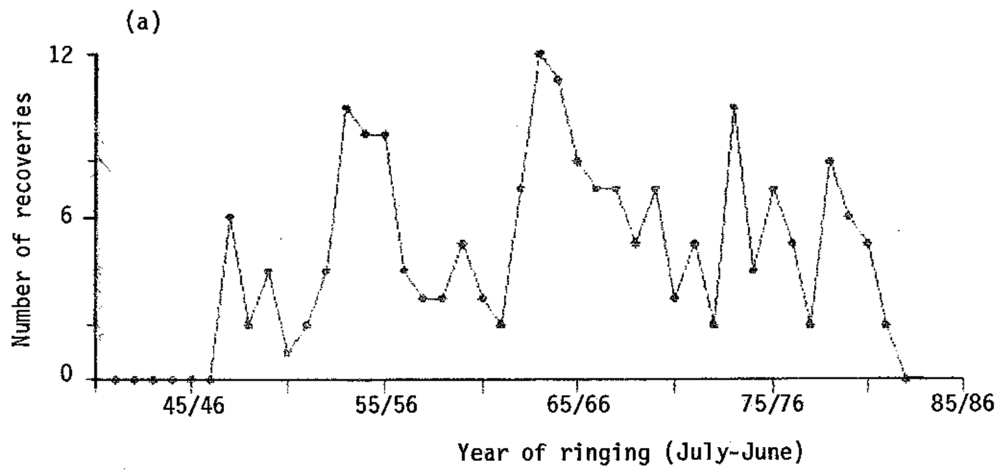
Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
East England (1)	0	1	1	0
Irish Sea (2)	1	0	1	0
Ireland (3)	1	1	2	2
S.E.England (4)	3	2	5	1
S.W.England (5)	4	2	6	0
Waddenzee (6)	0	0	0	1
North France (7)	2	0	2	3
South France (8)	0	0	0	5
Iberia (9)	1	0	1	0
Central Europe (10)	1	1	2	1
Total	13	7	20	13

(b) Percentage of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
Britain (1-5)	69	86	75	23
Europe (6-10)	31	14	25	77

Only recoveries during the period of severe weather are included.

Severe winters v before+after x^2= 6.601, 1 df, P<0.05



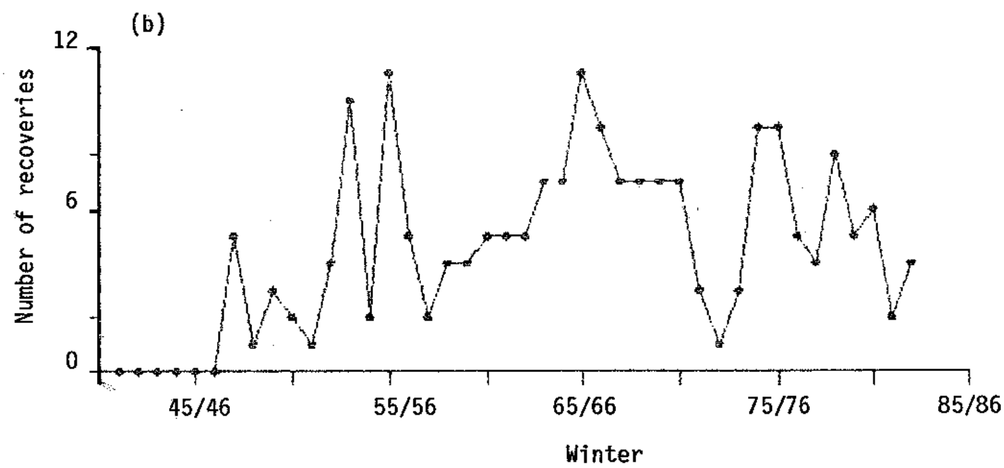


Figure 13.1 Winter recovery totals for Shoveler

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

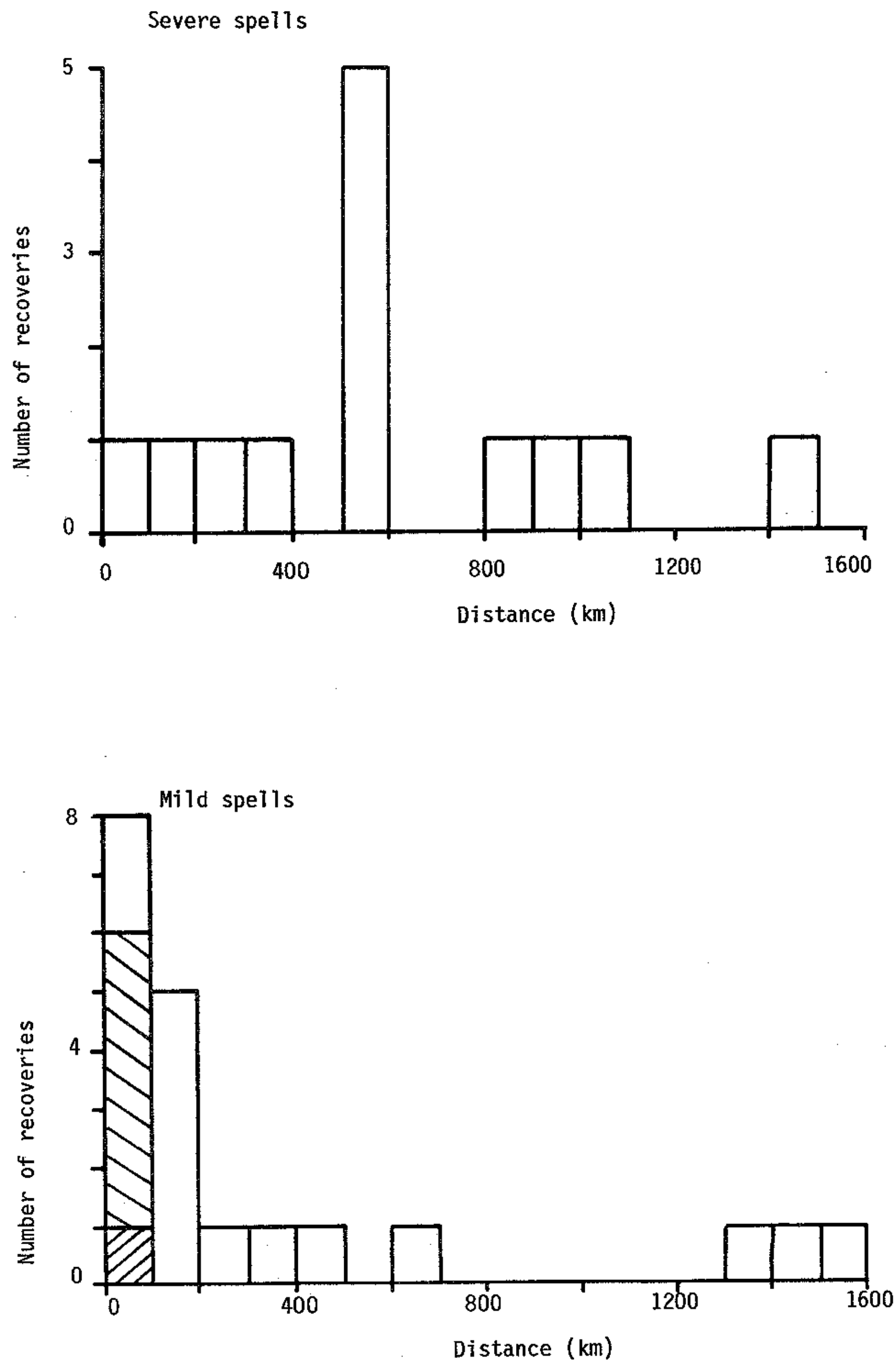


Figure 13.2 Distances between ringing and recovery places of Shovelers recovered during severe spells and in the same periods in adjacent mild winters.

POCHARD *Aythya ferina*

14.1 Normal pattern of movements

The British and Irish breeding population is very small, containing between 200 and 400 pairs in 1970 (Sharrock 1976). Some of these birds are thought to be resident but others may migrate to France and Iberia for the winter. About 50,000 Pochard winter in Britain (Owen *et al*. in press). They belong to a population which breeds in Denmark, Fenno-Scandia, North Germany, Poland, the Baltic States and the USSR between 50^{O}N and 60^{O}N and east to 70^{O}E. This population winters in West Germany, Switzerland, Netherlands, France, Iberia and north-west Africa, as well as Britain (Boyd 1959). The size of the north-west European wintering population of this species has been estimated as 250,000 birds (Scott 1980). In mild winters 68% of recoveries of British-ringed Pochard are in Britain, 10% in the Waddenzee, 17% in France and 6% in Southern Europe (Table 14.1). Thus this population has a more southerly distribution than the Tufted Ducks which winter in Britain.

More easterly breeding populations winter further east in Europe and Asia, and a few recoveries provide evidence of interchange with these populations.

Some male Pochard migrate south in June or July prior to moulting and there are regular moulting flocks at several sites in western Europe. In Britain Abberton Reservoir usually has a moulting flock of 2000-3000 birds. Females arrive in the wintering areas later than males and generally move further south, presumably because habitats in the more northerly areas are already occupied (Salomonsen 1968).

Cold weather movements of birds wintering on the continent have been recorded. Some birds from the Netherlands move into Britain in severe weather (Cramp and Simmons 1977). Pochard wintering in Bavaria and Switzerland have been recorded moving to the Carmargue in response to severe weather in January and February (Bauer and Glutz 1969).

14.2 Ringing effort

Most ringing has taken place in South-east England, with small numbers ringed in East England and South-west England and very few elsewhere (Table 14.2). Most recoveries are of birds ringed in winter but a small number of recoveries are of birds ringed in Autumn and Spring.

Ringing effort was very low until the late 1970s, with fewer than 10 recoveries in most years (Figure 14.1). More recoveries have been reported since 1978 due to increased ringing in South-east and South-west England by the Wildfowl Trust.

14.3 Distribution of recoveries in mild and severe winters

The percentage of Pochard recovered in South Britain decreased from 40% in mild winters to 28% in severe ones, while the percentage of recoveries in France and South Europe increased from 23% to 39% (Table 14.1). Comparing mild winters with severe spells gave no change in the percentage of recoveries in South Britain, while there was a smaller increase in the percentage of recoveries in France and South Europe, from 23% to 32%. The percentage of recoveries from France and South Europe increased from 16% in years immediately before and after cold weather to 32% in severe spells. None of these differences is significant, probably due to small sample sizes. However, the magnitudes of these differences are similar to those for Tufted Ducks, which are based on more recoveries and are significant.

Distances between ringing and recovery places also suggests that longer movements take place in severe weather but, again, the differences are not significant. Mean distances moved were 351 km in mild winters and 414 km in severe ones (Mann-Whitney U-test, t=1.833, ns). Restricting the comparison to years before and after severe weather gives a slightly larger difference, with mean distances of 260 km in mild winters and 344 km in severe spells (Mann-Whitney U-test, t=1.201, ns). The difference between the two distance measures for mild winters is due to seasonal variation in the distance moved, the before and after sample only including periods during winter when cold weather actually occurred (see methods). The mean distance moved in mild winters varies between months, being highest in December (442 km, n=45) and lowest in January (267 km, n=71).

14.4 Summary

The limited recovery data currently available for Pochard provide no statistically significant evidence of movements in response to severe weather. The data suggest that part of the British wintering population moves south during cold weather but more recoveries are needed to confirm this.

Table 14.1 Recovery regions of British-ringed Pochard in mild and severe winters.

(a) Number of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
Norway (1)	1	0	0
N.E.Scotland (2)	1	2	0
N.W.Scotland (3)	1	0	1
East England (4)	22	5	1
Irish Sea (5)	5	2	1
Ireland (6)	19	8	2
S.E.England (7)	59	16	9
S.W.England (8)	11	2	1
Waddenzee (9)	18	4	2
North France (10)	13	11	3
South France (11)	16	5	2
Iberia (12)	5	3	0
Central Europe (13)	2	6	3
Eastern Europe (14)	3	0	0
Africa (15)	1	0	0
Total	177	64	25

(b) Percentage of recoveries

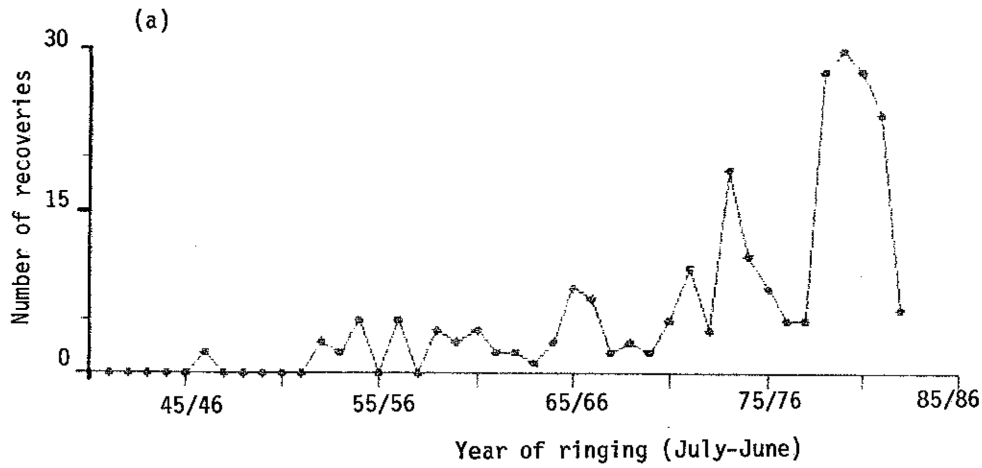
Recovery region	Mild winters	Severe winters	Severe spells
N. & E.Britain (2-4)	14	11	8
West Britain (5+6)	14	16	12
South Britain (7+8)	40	28	40
Waddenzee (9)	10	6	8
France (10+11)	17	25	20
South Europe (12-14)	6	14	12

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2= 8.899, 5 df, ns
Mild winters v severe spells x^2= 0.260, 5 df, ns

Table 14.2 Ringing periods and regions of British-ringed Pochard recovered in winter.

Ringing region	Ringing period			
	July-October	November-March	April-June	
N.E.Scotland	0	1	0	1
East England	7	25	0	32
Irish Sea	2	0	0	2
Ireland	1	6	0	7
S.E.England	30	94	49	173
S.W.England	2	24	0	26
Total	42	150	49	241



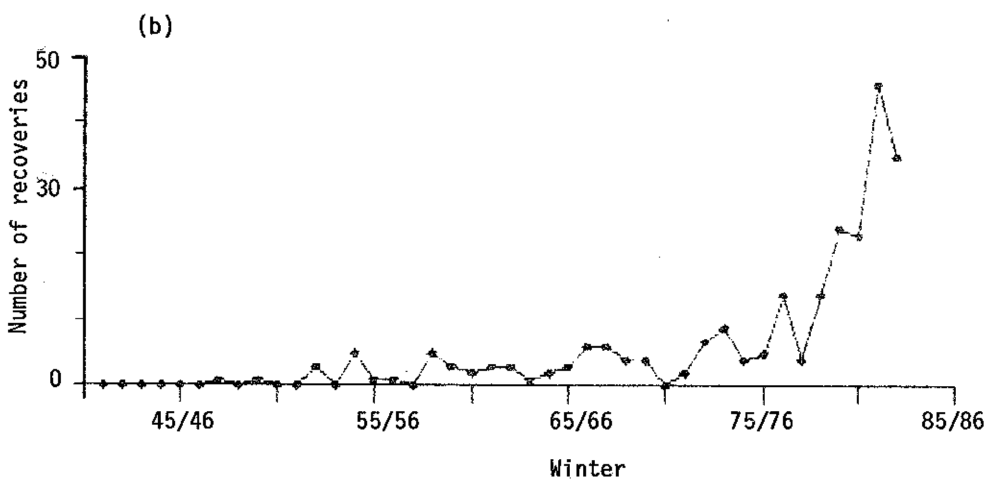


Figure 14.1 Winter recovery totals for Pochard

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

TUFTED DUCK *Aythya fuligula*

15.1 Normal pattern of movements

Britain and Ireland have a small breeding population of about 7000-8000 pairs of Tufted Ducks (Owen *et al.* in press). Breeding numbers have increased greatly over the last 20 years. Most breeding Tufted Ducks from northern Britain move into Ireland for the winter, although a few recoveries indicate movement to South Britain and France. The birds which breed in southern Britain are thought to be largely resident.

About 500,000 Tufted Ducks winter in north-west Europe (Scott 1980), and up to 60,000 of these are in Britain (Owen *et al.* in press). These winter visitors come from three main areas, Iceland, North France and the Netherlands, and Eastern Europe. The Icelandic birds winter mainly in Ireland and few have been ringed. The breeding population of North France and the Netherlands is largely resident but a few of these birds winter in Britain and more may move into Britain during severe weather (Cramp and Simmons 1977). However, most Tufted Ducks wintering in Britain belong to the population which breeds in Fenno-Scandia, north Germany, Poland, the Baltic States and the USSR north of 55^{O}N and east of 65^{O}E (Boyd 1957). This population winters mainly in Britain, Ireland and the Netherlands. Thus, in mild winters, 85% of recoveries of British-ringed Tufted Ducks are from Britain, with 10% from the Waddenzee and 4% from France (Table 15.1). The Tufted Ducks found wintering further south and east in Europe are generally from more northerly and easterly breeding populations.

15.2 Ringing effort

Most winter recoveries are of birds ringed in winter, although there are also substantial numbers from birds ringed in summer and autumn (Table 15.2). Relatively few breeding birds or ducklings have been ringed, with the exception of those ringed in the Loch Leven study in the early 1970s; these account for most of the birds ringed in North-east Scotland. The main winter ringing areas have been East England and South-east England (mainly Abberton Reservoir), the latter area accounting for over half of the total recovery sample.

Little ringing of this species was carried out until the late 1960s. Since then increased ringing effort has resulted in an average of over 40 recoveries per year, compared with fewer than 10 in most years before 1965 (Figure 15.1). The peak of recoveries of birds ringed in the early 1970s is associated with the Loch Leven study. Since the late 1970s the increased recovery totals have largely been due to trapping by the Wildfowl Trust at Abberton Reservoir and at gravel pits in southern England.

15.3 Distribution of recoveries in mild and severe winters

The regional distributions of recoveries in mild and severe winters are significantly different and this pattern also holds when recoveries from severe spells alone are considered (Table 15.1). A lower proportion of recoveries were reported from Scotland, East England, and West Britain during cold spells, whilst a higher proportion were from South England and Europe south of the Waddenzee. When the comparison is restricted to years immediately before and after cold winters the regional distributions of recoveries again differ significantly, but in this case there are similar proportions of recoveries in West Britain, South England and the Waddenzee. This analysis confirms the reduced proportion of recoveries in Scotland, and the increase in Europe south of the Waddenzee (Table 15.3). These data confirm preliminary results from the 1978/79 winter alone, which suggested a movement of Tufted Ducks into France during severe weather (Ogilvie 1982).

Overall distributions of distances moved do not differ significantly between mild and severe winters (Mann-Whitney U tests - mild v severe, t=0.559 ns; mild v severe spells t=0.945 ns). This is surprising in view of the above results, although distances moved are not a direct measure of movements within a particular winter (see methods). However, this overall analysis conceals a difference between winters. During the 1981/82 winter, distances moved were significantly greater than for the previous and subsequent winters (section 30).

15.4 Summary

Some Tufted Ducks emigrate from Britain into France and Southern Europe during severe weather. There are adequate recovery samples only for the winters of 1978/79 and 1981/82. More birds appear to have moved out in 1981/82 than in 1978/79.

Table 15.1 Recovery regions of British-ringed Tufted Ducks in mild and severe winters.

(a) Number of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
Norway (1)	7	1	0
N.E.Scotland (2)	46	4	0
N.W.Scotland (3)	7	0	0
East England (4)	125	9	6
Irish Sea (5)	20	9	6
Ireland (6)	141	13	9
S.E.England (7)	252	71	36
S.W.England (8)	22	8	3
Waddenzee (9)	76	18	11
North France (10)	16	9	6
South France (11)	14	6	5
Iberia (12)	5	3	2
Central Europe (13)	5	2	1
Eastern Europe (14)	1	0	0
Total	737	153	85

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
Scotland (2+3)	7	3	0
East England (4)	17	6	7
West Britain (5+6)	22	14	18
South England (7+8)	38	52	46
Waddenzee (9)	10	12	13
South Europe (10-13)	5	13	16

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=35.713, 5 df, P<0.001
Mild winters v severe spells x^2=27.344, 5 df, P<0.001

Table 15.2 Ringing periods and regions of British-ringed Tufted Ducks recovered in winter.

Ringing region	Ringing period			
	July-October	November-March	April-June	
N.E.Scotland	112	14	39	165
East England	49	133	12	194
Irish Sea	3	27	2	32
Ireland	4	4	2	10
S.W.England	2	8	0	10
S.E.England	120	215	144	479
Total	290	401	199	890

Table 15.3 Recovery regions of British-ringed Tufted Ducks in years before, during and after severe weather.

(a) Number of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
N.E.Scotland (1)	1	1	2	0
East England (2)	8	13	21	6
Irish Sea (3)	4	3	7	6
Ireland (4)	6	9	15	9
S.E.England (5)	16	36	52	36
S.W.England (6)	1	2	3	3
Waddenzee (7)	5	10	15	11
North France (8)	0	3	3	6
South France (9)	1	0	1	5
Iberia (10)	0	0	0	2
Central Europe (11)	0	0	0	1
Total	42	77	119	85

(b) Percentage of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
Scotland and East England (1+2)	21	18	19	7
West Britain (3+4)	24	16	18	16
South England (5+6)	40	49	46	46
Waddenzee (7)	12	13	13	13
South Europe (8-11)	2	4	3	16

Only recoveries during the period of severe weather are included.
Years before v years after x^2=1.721, 3 df, ns
Severe winters v before+after x^2=14.932, 4 df, P<0.01

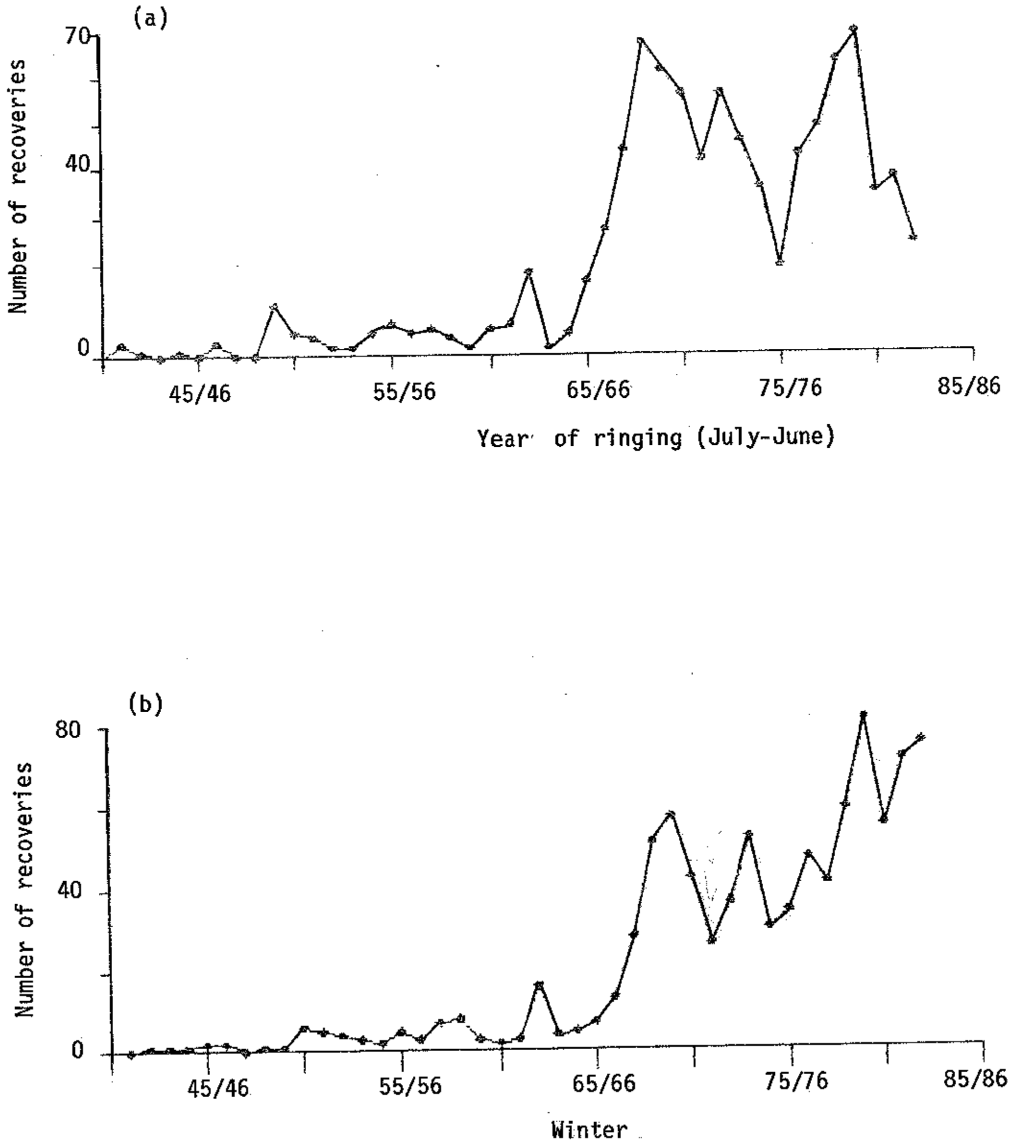


Figure 15.1 Winter recovery totals for Tufted Duck

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

MOORHEN *Gallinula chloropus*

16.1 Normal pattern of movements

Moorhens breed throughout Britain although they are sparsely distributed in the North of Scotland and in mountainous areas. By assuming a density of a quarter of that observed on CBC farmland plots, Sharrock (1976) estimated the breeding population of Britain and Ireland to be about 300,000 pairs. These birds are almost entirely resident. They are joined in winter by an unknown number of immigrants from Norway, Sweden, Denmark, north-west Germany, the Netherlands and Belgium (Cramp and Simmons 1980). Thus most mild winter recoveries are from Britain, with the exception of seven from the Waddenzee area and five from North France (Table 16.1). Moorhens are very vulnerable to cold weather mortality, as the freezing of water bodies deprives them of food. Declines of 16% and 18% in the numbers of pairs breeding on Waterways Bird Survey plots were recorded following the winters of 1978/79 and 1981/82 respectively (Marchant and Hyde 1980, Taylor and Marchant 1983).

16.2 Ringing effort

Approximately equal numbers of winter recoveries are of Moorhens ringed in autumn and winter, but few birds have been ringed between April and June (Table 16.2). Most birds were ringed either in South-east England (42% of recoveries) or in East England (27% of recoveries). Only 22 winter recoveries are of birds ringed in Scotland. Few Moorhens were ringed before the late 1950s, but since then ringing has been sufficient to produce about 10 winter recoveries per year (Figure 16.1). A peak of 37 recoveries from the 1962/63 winter reflects cold weather mortality, as does a lesser peak of 17 recoveries from the 1981/82 winter. No increase in the number of recoveries occurred during the winter of 1978/79.

Most of the Moorhens ringed in Britain probably belong to the British breeding population. Up to 1981 only five per cent of the accumulated 774 recoveries were from abroad (Spencer and Hudson 1982).

16.3 Distribution of recoveries in mild and severe winters

The distribution of recoveries during mild winters is not significantly different from that during severe winters, or during severe spells alone (Table 16.1). No recoveries were reported from abroad during severe weather. Comparison of the distribution of recoveries during severe spells with that from years before and after, shows a significant increase in the percentage of recoveries from South England (Table 16.3), but this was due to mortality and not to movement. Only one of the 35 recoveries from severe spells involved a movement of over 100 km. This bird was ringed in Lincolnshire in September 1961 and recovered in Dorset in January 1963, 263 km to the south-west. The Recovery Index for all regions combined has a value of 2.92 (x^2=17.93, 1 df, P<0.001), providing further evidence that increased mortality of Moorhens takes place in cold weather.

The mean distances between ringing and recovery places were 37 km during mild winters, 20 km in years before and after cold weather, 16 km during cold winters and 18 km during cold spells. There are no significant differences between the mean distances moved in mild and severe weather (Mann-Whitney U-test; mild winters v cold winters, t=0.66, ns; mild winters v severe spells, t=1.44, ns).

16.4 Summary

Britain has a large resident population of Moorhens which is swelled in winter by immigrants from Scandinavia and north-west Europe. It is probable that most of the Moorhens which have been ringed in Britain belong to the British breeding population. The recovery data provide no evidence of cold weather movements but there has been little ringing in northern Britain. Increased mortality of Moorhens takes place in cold weather.

Table 16.1 Recovery regions of British-ringed Moorhens in mild and severe winters.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
N.E.Scotland	(1)	17	3	0
N.W.Scotland	(2)	1	0	0
East England	(3)	66	16	5
Irish Sea	(4)	19	9	3
Ireland	(5)	17	1	1
S.E.England	(6)	108	31	20
S.W.England	(7)	28	8	6
Waddenzee	(8)	7	0	0
North France	(9)	5	0	0
Total		268	68	35

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
N. & E. Britain (1-3)	31.3	27.9	14.3
West Britain (4-5)	13.4	14.7	11.4
South England (6-7)	50.7	57.4	74.3
Europe (8-9)	4.5	0.0	0.0

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=0.313, 2 df, ns.
Mild winters v severe spells x^2=5.119, 2 df, ns.

Table 16.2 Ringing periods and regions of British-ringed Moorhens recovered in winter.

Ringing region	Ringing period			
	July-October	November-March	April-June	
N.E.Scotland	8	11	2	21
N.W.Scotland	1	0	0	1
East England	40	42	9	91
Irish Sea	14	12	2	28
Ireland	14	2	2	18
S.E.England	56	67	18	141
S.W.England	13	22	1	36
Total	146	156	34	336

Table 16.3 Recovery regions of British-ringed Moorhens in years before, during and after severe weather.

(a) Number of recoveries

Recovery region		Mild spells			Severe spells
		Years before	Years after	Years before +after	
N.E.Scotland	(1)	3	0	3	0
East England	(2)	6	4	10	5
Irish Sea	(3)	0	0	0	3
Ireland	(4)	0	0	0	1
S.E.England	(5)	7	2	9	20
S.W.England	(6)	1	0	1	6
North France	(7)	0	1	1	0
Total		17	7	24	35

(b) Percentage of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
N. & E. Britain (1-2)	52.9	57.1	54.2	14.3
W.Britain (3-4)	0.0	0.0	0.0	11.4
S.England (5-6)	47.1	28.6	41.7	74.3
N.France (7)	0.0	14.3	4.2	0.0

Only recoveries during the period of severe weather are included.
Years before v years after x^2=0.069, 1 df, ns
Severe winters v before+after x^2=8.883, 1 df, P<0.01

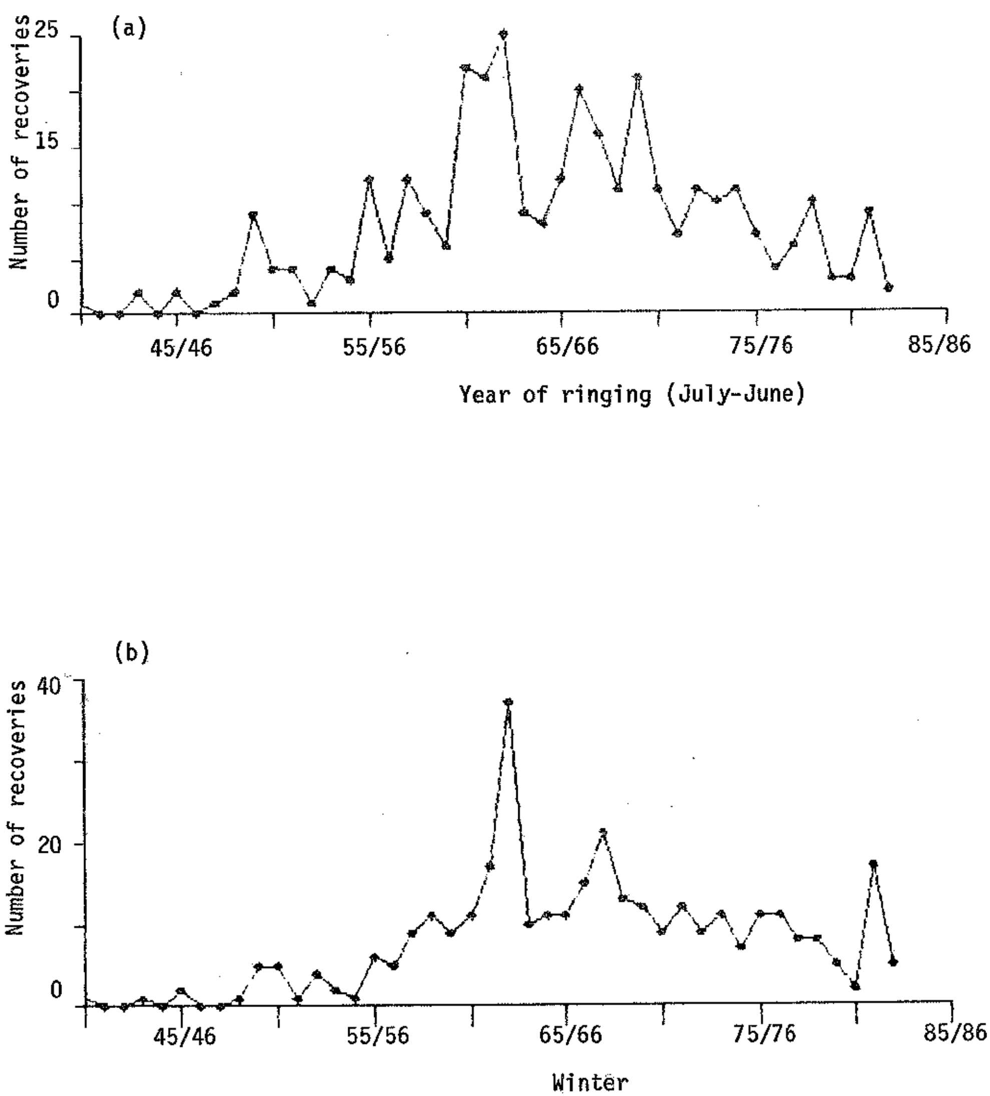


Figure 16.1 Winter recovery totals for Moorhen

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

COOT *Fulica atra*

17.1 Normal pattern of movements

The Coot is a widely distributed breeding species in Britain, being found in most areas with the exceptions of the north of Scotland and areas of high ground (Sharrock 1976). On the basis of the Atlas data it was suggested that the breeding population of Britain and Ireland is close to 100,000 pairs. This largely resident population is swelled by continental immigrants during the winter. Estimates of the wintering population of Britain have not been made. Wildfowl counts reveal high numbers in autumn and early winter, probably due to the congregation of birds during and immediately after moult. Abberton Reservoir (Essex) holds a particularly large moulting flock, and 10,000 were recorded there in October 1983 (Salmon 1984). Wildfowl counts show a sharp fall in January. This is probably due to the dispersal of large flocks to smaller waters which are not included in the survey, rather than to mortality or emigration from the country (Salmon 1984).

Coot wintering in north-west Europe include immigrants from the countries round the Baltic and from the USSR east to Moscow, as well as north-west European breeding populations (Brown 1955, Cramp and Simmons 1980). Autumn passage takes place in October and early November, with a return movement in March. Foreign recoveries of British-ringed Coot are mainly from countries bordering the North Sea from Denmark to France, but there are also four recoveries from countries around the Baltic, five from Poland and four from the Soviet Union (Spencer and Hudson 1982). Seventy-eight per cent of mild winter recoveries were from Britain, 10% from the Waddenzee and 12% from France and South Europe (Table 17.1). Recoveries of Coots ringed while breeding or moulting in Denmark indicate that many of these birds remain in Denmark for the winter, while others move south-west to give recoveries down the coast of Europe as far as Biscay, with a few birds reaching Britain (Fog 1969).

Cramp and Simmons (1980) report marked population fluctuations in many areas due to hard winters although they give no evidence for this. In Britain the small population of Coots covered by the Waterways Bird Survey declined by only 1% following the winters of both 1978/79 and 1981/82 (Marchant and Hyde 1980, Taylor and Marchant 1983). However, even if this is typical for Britain, more marked fluctuations would be expected in countries with more extreme climates to the north and east. Cramp and Simmons (1980) also state that cold weather movements can occur at any time during the winter but again quantitative evidence is lacking.

17.2 Ringing effort

Most Coot ringing takes place as a result of duck trapping, and hence it is concentrated during the Autumn and Winter periods (Table 17.2). Sixty-two per cent of birds recovered in winter were ringed between November and March, 31% between July and October and only 7% between April and June. Thus the breeding population to which most British-ringed Coots belong is uncertain. Sixty per cent of winter recoveries were of birds ringed in South-east England and 27% were from East England, with all other areas being poorly represented. Few Coots were ringed before the early 1950s, and since then numbers caught have varied markedly between years (Figure 17.1). Recovery peaks in 1955/56 and 1962/63 suggest increased mortality but such a pattern is less apparent for 1978/79 and 1981/82.

Coots often become easy to catch during cold weather, but such birds are likely to be in poor condition, and to have a low chance of survival. To exclude records of such birds, all recoveries within 14 days of ringing and within 10 km of the ringing place were omitted from this analysis. Using these criteria 12 recoveries from mild winters and 33 recoveries from cold winters were excluded. Five movements of over 10 km which were reported within 14 days of ringing have been included in the analyses.

17.3 Distribution of recoveries in mild and severe winters

The percentage distributions of recoveries during severe winters and during severe spells do not differ significantly from that for mild winters (Table 17.1). Also the recovery distribution during severe spells is not significantly different from that in years immediately before and after severe weather (Table 17.3). This lack of movement is also demonstrated by the mean distances between ringing and recovery places. Mean distances moved were 174 km during mild winters, 159 km during severe winters and 175 km during severe spells (Mann-Whitney U-tests: mild winters v severe winters, t=1.44, ns ; mild winters v severe spells, t=0.10, ns). The 190 km moved in years before and after severe winters was also not significantly different from the mean of 175 km from severe spells (Mann-Whitney U-test, t=0.14, ns). Although these data suggest that no cold weather movements take place, the relatively small numbers of Coots which have been ringed may not be representative of the whole wintering population.

The Recovery Index for all regions together was 2.44 (x^2=16.90, P<0.001), indicating a marked increase in mortality due to cold weather. The Recovery Index for recoveries in Britain was 2.21, and for recoveries from abroad 3.25, but these two values are not significantly different (x^2=0.235, 1df, ns). Most of the British recoveries are from the South of England, while most of the foreign recoveries are from the Waddenzee and North France. Thus the increased cold weather recovery rate on the continent is more likely to be due to increased mortality than to movement out of Britain.

17.4 Summary

The largely resident breeding population of British Coots is joined in winter by immigrants from the Soviet Union, the Baltic countries and north-west Europe. The recovery data provide no evidence of cold weather movements by British-ringed Coots but they do indicate increased mortality during cold weather.

Table 17.1 Recovery regions of British-ringed Coots in mild and severe winters.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
N.E.Scotland	(1)	6	1	1
N.W.Scotland	(2)	1	0	0
East England	(3)	71	12	6
Irish Sea	(4)	14	2	1
Ireland	(5)	8	1	1
S.E.England	(6)	110	42	17
S.W.England	(7)	20	8	5
Waddenzee	(8)	28	11	6
North France	(9)	22	8	4
South France	(10)	8	3	3
Iberia	(11)	1	0	0
Central Europe	(12)	1	0	0
Eastern Europe	(13)	2	1	0
Africa	(14)	1	0	0
Total		293	89	44

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
N. & E.Britain (1-3)	26.6	14.6	15.9
West Britain (4-5)	7.5	3.4	4.5
South England (6-7)	44.4	56.2	50.0
Waddenzee (8)	9.6	12.4	13.6
France & S.Europe (9-14)	11.9	13.5	15.9

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=8.600, 4 df, ns
Mild winters v severe spells x^2=3.594, 4 df, ns

Table 17.2 Ringing periods and regions of British-ringed Coots recovered in winter.

Ringing region	Ringing period			
	July-October	November-March	April-June	
N.E.Scotland	2	7	1	10
East England	37	62	4	103
Irish Sea	3	10	0	13
Ireland	4	4	0	8
S.E.England	66	144	19	229
S.W.England	5	11	3	19
Total	117	238	27	382

Table 17.3 Recovery regions of British-ringed Coots in years before, during and after severe weather.

(a) Number of recoveries

Recovery region		Mild spells			Severe spells
		Years before	Years after	Years before +after	
N.E.Scotland	(1)	0	0	0	1
East England	(2)	5	6	11	6
Irish Sea	(3)	0	4	4	1
Ireland	(4)	1	0	1	1
S.E.England	(5)	5	7	12	17
S.W.England	(6)	0	0	0	5
Waddenzee	(7)	2	0	2	6
North France	(8)	1	4	5	4
South France	(9)	0	0	0	3
Central Europe	(10)	0	1	1	0
Total		14	22	36	44

(b) Percentage of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
E. & W. Britain (1-4)	42.9	45.5	44.4	20.5
South England (5-6)	35.7	31.8	33.3	50.0
Waddenzee (7)	14.3	0.0	5.6	13.6
France (8-10)	7.1	22.7	16.7	15.9

Only recoveries during the period of severe weather are included.
Years before v years after x^2=0.058, 2 df, ns
Severe winters v before+after x^2=6.241, 3 df, ns

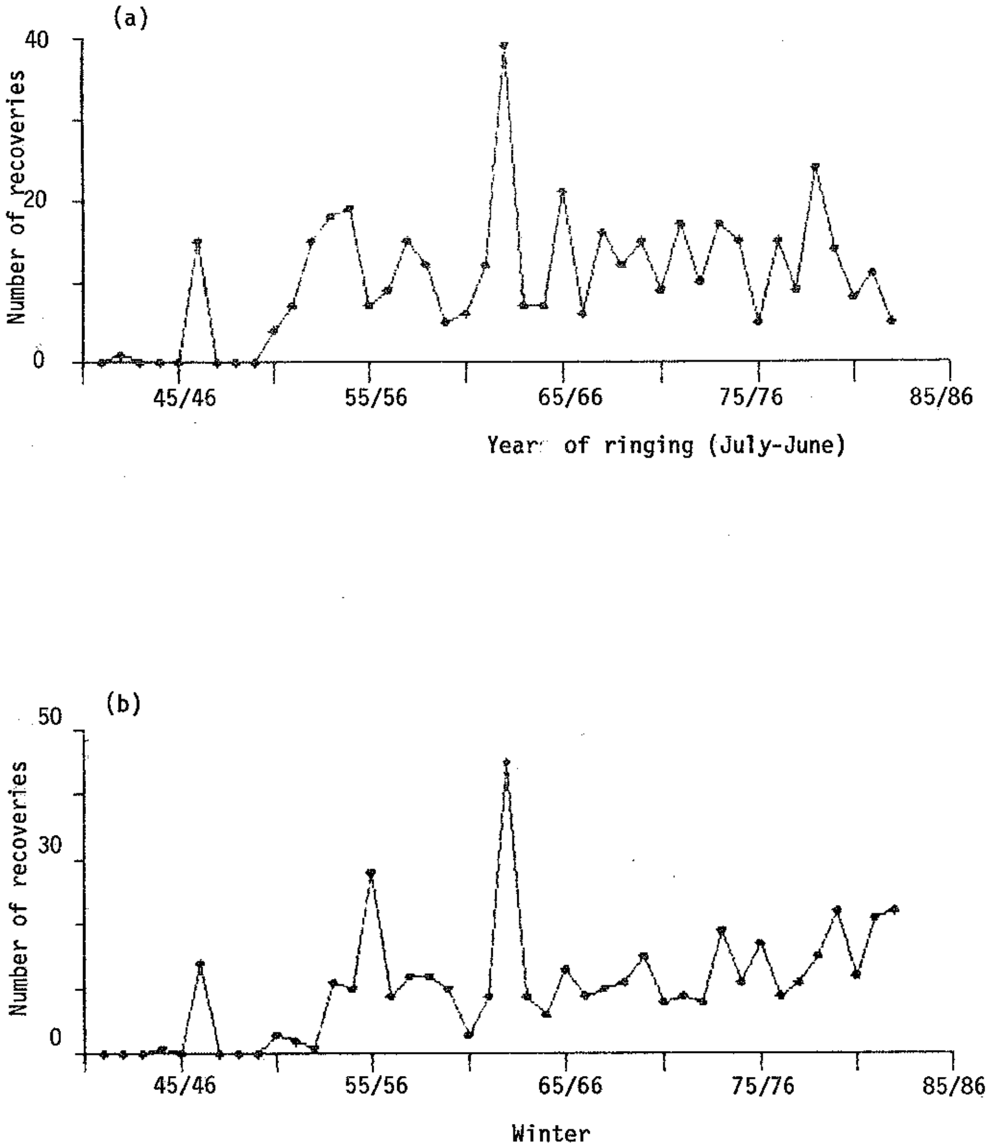


Figure 17.1 Winter recovery totals for Coot.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

OYSTERCATCHER Haematopus ostralegus

18.1 Normal pattern of movements

Oystercatchers breed throughout Scotland and Northern England, while in the rest of Britain and Ireland breeding is restricted to coastal areas. Their breeding population has increased markedly during this century and was estimated as 30,000 to 40,000 pairs during the 1960s and 1970s (Dare 1966, Sharrock 1976). These birds usually move south of their breeding areas for the winter but most remain within Britain. Some migrate further south to France, Iberia and occasionally Morocco (Cramp and Simmons 1983, Table 18.1). Many of the Oystercatchers which breed in Scotland winter in the Irish Sea area (Dare 1970).

About 250,000 Oystercatchers winter in Britain, with a further 30,000 to 35,000 in Ireland (Cramp and Simmons 1983) and these birds comprise about 36% of the European wintering population (Prater 1981). About half of the Oystercatchers wintering in Britain are concentrated in the Irish Sea area, while the rest are split about equally between other parts of the west coast and the south and east coasts. Those wintering on the west coast are mainly from Scotland, the Faeroes and Iceland, with only a few from Norway (Dare 1970). Oystercatchers wintering in the Firth of Forth are nearly all from Scotland (Symonds and Langslow 1984). In contrast birds wintering on the Wash are mainly from Norway, with a small number from other countries in north-west Europe and from Britain (Anderson and Minton 1978).

Several studies have shown that Oystercatchers wintering on British estuaries are extremely site-faithful, both within and between winters (Davidson 1967, Dare 1970, Anderson and Minton 1978, Goss-Custard and Durell 1984, Symonds et al. 1984). In the most detailed of these studies, which was carried out on the Exe estuary in Devon, between 80 and 90% of colour marked individuals returned to the estuary in subsequent winters, survival rates being highest in birds which were three or more years old (Goss-Custard and Durrell 1984). Oystercatchers arrive on their wintering grounds in August and September, and leave again in February and March. Timing of the return to the breeding areas is dependent on geographical location and habitat, with birds starting to return to breeding areas in southern England in late January, while the Norwegian breeding areas are not occupied until mid-March (Dare 1966). Thus some recoveries from birds on return passage will have been included in the November to March winter period used for this analysis.

High mortality of Oystercatchers as a result of severe weather has been recorded from North-east Scotland (Heppleston 1971, Baillie 1980, Clark 1982) and from the Waddenzee (Swennen and Duiven 1983). In Britain as a whole there is a highly significant positive correlation between the number of winter recoveries and the number of days of freezing weather, once years in which culling took place have been excluded from the analysis (O'Connor et al. 1982). However, it is not clear whether such mortalities are sufficiently large to result in changes in numbers in the following winter. The index of numbers of Oystercatchers present on British estuaries increased by 20% between 1977/78 and 1979/80, but decreased by 13% between 1980/81 and 1982/83. A few cases of Oystercatchers moving out of particular areas in response to cold weather have been reported (Pilcher 1964, Van Eerden 1977, Baillie 1980) but in other similar situations no such movement was recorded (Clark 1982, Swennen and Duiven 1983).

18.2 Ringing effort

Nearly all of the 219 winter recoveries of Oystercatchers ringed as chicks were of birds ringed in North and Central Britain (Table 18.2), reflecting the breeding distribution of this species. Similar numbers of chicks have been ringed in most years since the 1940s. Annual recovery totals are too small to show meaningful differences in mortality between years (Figure 18.1). The very marked peak in recoveries for birds ringed in 1962 probably reflects mortality due to the 1962/63 winter, perhaps combined with some increase in ringing effort.

Most ringing of full-grown Oystercatchers has been carried out on their wintering grounds during the Autumn and Winter periods (Table 18.4). Reasonable numbers of recoveries are available for birds ringed in most areas, except North-west Scotland and Ireland. Nearly half of the recoveries are of birds ringed in the Irish Sea area, partly due to intensive studies by MAFF during the late 1960s. Very few full-grown Oystercatchers were ringed before the early 1960s, but since then there have been over 40 recoveries in most winters (Figure 18.2). The intensive MAFF catching programmes referred to above were responsible for the particularly large numbers which were ringed in the winters of 1962/63, 1963/64 and 1968/69. Three of the four peaks in numbers recovered reflect the results of cold weather. The 1963/64 peak is probably due to food shortage caused by shellfish mortality in the previous winter (Murton 1971), although increased ringing is also involved. Peaks in 1978/79 and 1981/82 reflect direct cold weather mortality, which was particularly severe in Scotland (below). Large numbers of ringed birds were recovered in a cull of about 11,000 individuals which was carried out on the Burry Inlet during the winters of 1973/74 and 1974/75. These records could not be excluded easily from the analysis because culled birds are not always reported as shot.

18.3 Distribution of recoveries in mild and severe winters

The recovery distributions for Oystercatchers ringed as chicks and recovered during severe winters and during severe spells do not differ significantly from the recovery distribution for mild winters (Table 18.1). Similarly, there is no significant difference between recovery distributions during severe spells and in years immediately before and after cold weather (Table 18.3). In all cases fewer than 17% of recoveries were from abroad. The mean distances between the ringing and recovery places of Oystercatchers ringed as chicks were 353 km during severe spells and 407 km in the same periods of immediately previous and subsequent winters (Mann-Whitney U-test, d=0.67, ns). These data suggest that British Oystercatchers do not undertake cold weather movements, but larger recovery samples are needed to confirm this.

Interpretation of the recoveries of birds ringed when full-grown is complicated by regional variations in ringing effort and in mortality. The data from each ringing region have therefore been analysed separately. Mild winters cannot be directly compared with severe spells, as the whole winter period includes a few birds which are undertaking their return migration. However, even when the whole winter period is considered, over 79% of birds were recovered from their region of ringing both in mild and in cold winters (Table 18.5). The only exception is East England, where 64% were recovered in the same region during mild winters and 70% during cold ones. The recovery distributions for birds ringed in North-east Scotland and East England differed significantly between mild and cold winters and, in both cases, a slightly higher percentage of recoveries during severe weather were from the ringing area. Thirteen per cent of mild winter recoveries of birds ringed in East England were from northern Europe (mostly Norway), compared with none during severe ones. Most of these recoveries occurred in late February and March and the lack of such records from severe winters suggests a delayed return to the breeding grounds. When severe spells are compared with the same periods in immediately previous and subsequent years, there are no significant differences between the distributions of recoveries in mild and severe weather (Table 18.6).

Mean distances between ringing and recovery places confirm the conclusion that there is no increase in movement as a result of severe weather (Table 18.7). In most cases mid-winter mean distances were less than 100 km in both mild and cold weather. Birds ringed in East England and recovered over the whole winter moved further than this, as the sample includes some individuals on their way back to the breeding grounds. In only two cases was there a significant difference between the distances moved in mild and cold weather, and in both the distance moved in cold weather was shorter.

As most birds remain within their normal wintering areas both in mild and in severe weather, it is possible to compare the cold weather mortality of birds ringed in different areas using the Recovery Index (Table 18.8). For full-grown birds only data from the winters of 1978/79 and 1981/82 were used. The large changes in ringing effort in the early 1960s preclude the use of data from the 1962/63 winter. Large fluctuations in the numbers of chicks ringed have not taken place, so data from all cold winters were included. The number of recoveries of birds ringed in East England was inflated by a cull in 1979/80 and results for 1981/82 alone are therefore presented. Recovery rates of birds from all regions increased in severe weather but the increase was significant only in North-east Scotland and the Irish Sea area. The lack of significant results from other areas is probably due to small sample sizes. The mortality increase resulting from cold weather was greatest in North-east Scotland, and least in South England.

18.4 Summary

British breeding Oystercatchers winter mainly on the west coast of Britain, where they are joined by birds from the Faeroes and Iceland. Most birds wintering on east coast estuaries are from Norway and other parts of north-west Europe. Oystercatchers are extremely faithful to their wintering sites, and ringing recoveries provide no evidence of increased movements in response to severe weather. An increase in mortality rate occurs in cold weather and is more severe in North-east Scotland than in South England.

Table 18.1 Recovery regions of Oystercatchers in mild and severe winters: birds ringed as chicks.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
North Britain	(1)	50	12	6
Central Britain	(2)	72	15	7
Ireland	(3)	22	1	0
South Britain	(4)	12	2	1
North France	(5)	10	4	1
South France	(6)	6	1	0
Iberia	(7)	10	1	0
Africa	(8)	1	0	0
Total		183	36	15

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
North Britain (1)	27.3	33.3	40.0
Central Britain (2)	39.3	41.7	46.7
Ireland & S.Britain (3-4)	18.6	8.3	6.7
Europe (5-8)	14.8	16.7	6.7

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=2.367, 3 df, ns
Mild winters v severe spells x^2=2.717, 2 df, ns

Table 18.2 Ringing periods of Oystercatchers ringed as chicks and recovered in winter.

Ringing region	No. of recoveries
North Britain	147
Central Britain	68
Ireland	3
South Britain	1
Total	219

Table 18.3 Recovery regions of Oystercatchers in years before, during and after severe weather: birds ringed as chicks.

(a) Number of recoveries

Recovery region		Mild spells		Severe spells
	Years before	Years after	Years before +after	
North Britain (1)	2	0	2	6
Central Britain (2)	2	9	11	7
Ireland (3)	1	0	1	0
South Britain (4)	1	1	2	1
North France (5)	0	1	1	1
South France (6)	0	1	1	0
Iberia (7)	1	0	1	0
Total	7	12	19	15

(b) Percentage of recoveries

Recovery region		Mild spells		Severe spells
	Years before	Years after	Years before +after	
N.Britain (1)	28.6	0.0	10.5	40.0
C. & S.Britain (2-4)	57.1	83.3	73.7	53.3
Europe (5-7)	14.3	16.7	15.8	6.7

Only recoveries during the period of severe weather are included.
Severe winters v before+after x^2=2.575, 1 df, ns

Table 18.4 Ringing periods and regions of Oystercatchers recovered in winter: birds ringed as full-grown.

Ringing region	Ringing period			
	July-October	November-March	April-June	
N.E.Scotland	67	41	14	122
N.W.Scotland	2	4	0	6
East England	153	64	23	240
Irish Sea	207	378	20	605
Ireland	7	9	0	16
South England	175	68	11	254
Total	611	564	68	1243

Table 18.5 Recovery regions of Oystercatchers ringed as full-grown in different parts of Britain and recovered in mild or cold winters.

Ringing region	Recovery region	Mild winters n	Mild winters %	Cold winters n	Cold winters %
N.E.Scotland	N.E.Scotland	56	84.8	56	100.0
	Rest Britain	9	13.6	0	0.0
	Europe	1	1.5	0	0.0
	Total	66		56	
East England	N.Europe	25	12.8	0	0.0
	Scotland	3	1.5	0	0.0
	E.England	126	64.3	31	70.5
	W. & S. Brit.	8	4.1	5	11.4
	S.Europe	34	17.3	8	18.2
	Total	196		44	
Irish Sea	Scotland	45	8.5	11	14.1
	Irish Sea & Ireland	442	83.9	62	79.5
	E.England	3	0.6	0	0.0
	S.England	16	3.0	2	2.6
	Europe	21	4.0	3	3.8
	Total	527		78	
South England	Scotland	14	6.1	0	0.0
	Central Brit.	10	4.4	3	11.5
	S.Britain	190	83.3	21	80.8
	Europe	14	6.1	2	7.7
	Total	228		26	

For definitions of mild and cold winters see methods.

Tests between recovery distributions in mild and cold winters:

Ringed in N.E.Scotland $x^2=7.339$, 1 df, $P<0.01$
Ringed in E.England $x^2=7.528$, 2 df, $P<0.05$
Ringed in Irish Sea area $x^2=2.506$, 2 df, ns
Ringed in S.England $x^2=0.003$, 1 df, ns

Table 18.6 Recovery regions of Oystercatchers ringed as full-grown in different parts of Britain and recovered in years before during and after severe weather.

Ringing region	Recovery region	Mild spells[a]		Severe spells	
		n	%	n	%
N.E.Scotland	N.E.Scotland	10	100.0	32	100.0
East England	E.England	31	81.6	21	80.8
	W. & S. Brit.	1	2.6	2	7.7
	S.Europe	6	15.8	3	11.5
	Total	38		26	
Irish Sea	Scotland	2	2.0	0	0.0
	Irish Sea & Ireland	89	90.8	37	94.9
	E.England	2	2.0	0	0.0
	S.England	5	5.1	2	5.1
	Total	98		39	
South England	Central Brit.	2	9.1	1	6.7
	S.England	19	86.4	13	86.7
	Europe	1	4.5	1	6.7
	Total	22		15	

a Equivalent dates to severe spells in years immediately before and after severe weather.

Tests between recovery distributions in severe spells and in years before and after:

Ringed in East England x^2=0.060, 1 df, ns
Ringed in Irish Sea area x^2=0.194, 1 df, ns
Ringed in South England x^2=0.215, 1 df, ns

Table 18.7 Mean distances (km) between ringing and recovery places for Oystercatchers ringed as full-grown.

Ringing region	Mild winters	Cold winters	Sig.	Mild spells[a]	Severe spells	Sig.
N.E.Scotland	96 (66)	15 (56)	**	29 (10)	14 (32)	ns
East England	229 (196)	164 (44)	ns	88 (38)	77 (26)	ns
Irish Sea	107 (527)	119 (78)	ns	58 (98)	27 (39)	***
South England	95 (228)	112 (26)	ns	78 (22)	111 (15)	ns

a Equivalent dates to severe spells in years immediately before and after severe weather.

Sample sizes are given in parentheses.
Tests between means were carried out using Mann-Whitney U-tests.

Table 18.8 Recovery Index for Oystercatchers ringed in different parts of Britain

Ringing region	Mild spells[a]	Severe spells	Recovery Index	x^2	Sig
N.E.Scotland	10	32	6.40	34.71	***
East England	38	26	1.37	1.53	ns
East England (81/82)	6	8	2.67	3.57	ns
Irish Sea	17	23	2.71	10.51	**
South England	11	9	1.64	1.23	ns
Ringed as pulli throughout Britain	19	15	1.58	1.78	ns

a Equivalent dates to severe spells in years immediately before and after severe weather.

For details of Recovery Index see methods.

Data are from the winters of 1978/79 and 1981/82, except for birds ringed as pulli where recoveries from all cold winters are included. 1981/82 results for East England are shown separately, because the 1978/79 results from this area appear to be biased (see text).

Significance *** P<0.001 ** P<0.01 ns not significant

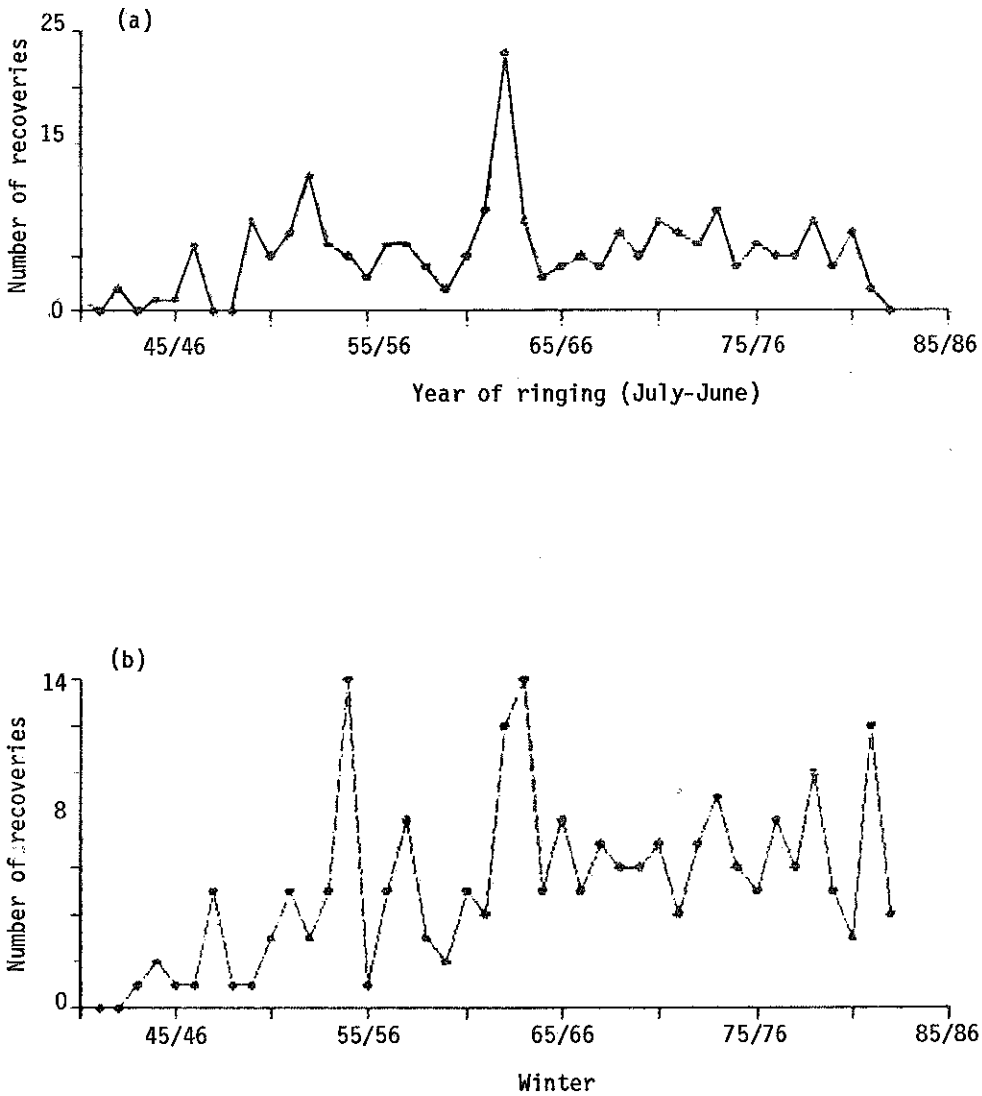
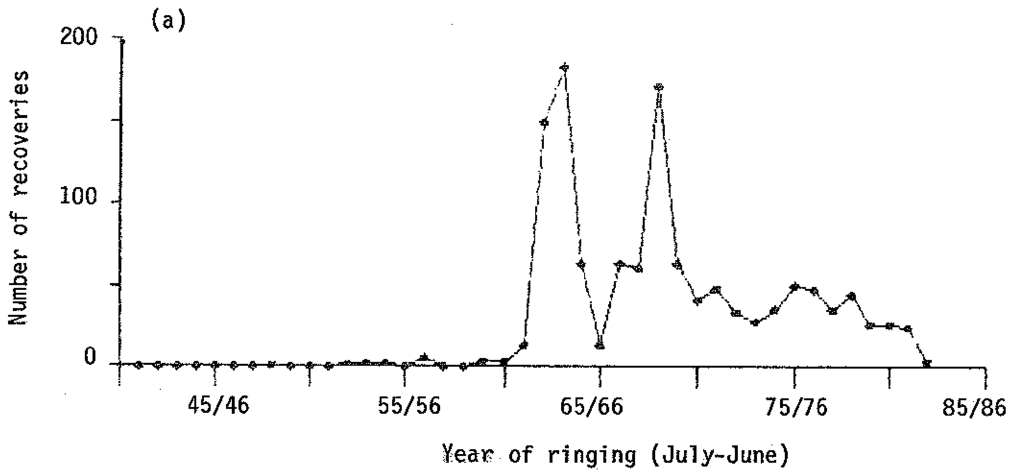


Figure 18.1 Winter recovery totals for Oystercatchers ringed as chicks.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March



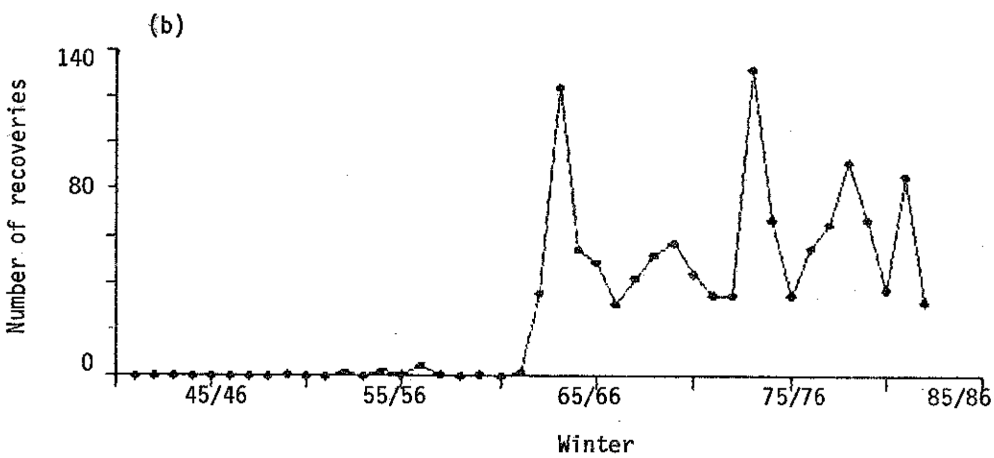


Figure 18.2 Winter recovery totals for Oystercatchers ringed as full-grown.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

RINGED PLOVER *Charadrius hiaticula*

19.1 Normal pattern of movements

The British breeding population of Ringed Plovers has been estimated at between 5800 and 6300 pairs (Prater 1976). Most of these birds winter in Britain but some move south into France and Spain. The British and Irish wintering population was estimated at between 10,000 and 12,500 birds by Prater (1981), but data from the 1984/85 Winter Shorebird Count suggest that the population may be twice this size (Moser in prep.). The wintering population contains most of the British and Irish breeding birds together with small numbers of winter visitors from southern Scandinavia, the Netherlands and Germany (Taylor 1980, Prater 1981).

Large numbers of Ringed Plovers migrate through Britain in autumn and spring, particularly at Morecambe Bay and on the Dee, Solway and Severn estuaries in West Britain. Prater (1981) suggested that this passage involved about 15,000 birds. Most of these passage Ringed Plovers breed in north-east Canada and Greenland and winter in West Africa. Icelandic breeding birds are also involved in this passage, and probably also winter in west Africa. Some passage birds from Europe and the northern USSR occur on the East coast of Britain (Taylor 1980, Cramp and Simmons 1983).

Fifty-three per cent of mild winter recoveries of British-ringed Ringed Plovers are in Britain, 21% in Europe and 26% in Africa (Table 19.1). The African recoveries relate to passage populations which winter too far south to be affected by severe winters.

19.2 Ringing effort

The total recovery sample is very small, with only 47 winter recoveries. The main ringing regions were East England, the Irish Sea area and South England (Table 19.2). Sixty-two per cent of recoveries are of birds ringed in Autumn, when British breeders are augmented by passage birds from more northerly breeding populations. Sample sizes are too small to separate these populations.

Almost no ringing took place before the mid-1950s (Figure 19.1). Between then and the early 1970s a few recoveries were reported in most years. Some increase in ringing has taken place since then but with the maximum of only 5 recoveries in 1981/82, many more data are needed to provide a good description of the cold weather movement patterns of this species.

19.3 Distribution of recoveries in mild and severe winters

The distribution of recoveries during mild winters differs significantly from that during severe winters and from that during severe spells alone (Table 19.1). During severe weather more recoveries were reported from Britain and fewer from Africa. However, the African recoveries should be excluded as they relate to birds ringed on passage, and if this is done the differences in the distributions are no longer significant (mild v severe x^2=2.508, 2df, ns ; mild v severe spells x^2=2.827, 2df, ns). There is also no difference in the percentage distribution of recoveries during severe spells and during the same periods in immediately previous and subsequent winters (Table 19.3). However, the ratio of these two sets of recoveries does differ significantly from the expected 2:1 ratio (x^2=6.12, $P<0.05$) with 2.4 times as many recoveries in severe spells as in the corresponding mild ones. A slightly larger increase, of 3.3 times, is obtained when recoveries in Britain alone are considered (x^2=6.12, $P<0.05$). Thus although there is no evidence of cold weather movements by this species, there is evidence of increased mortality.

19.4 Summary

Only 13 Ringed Plover recoveries were from severe winters and only 11 occured during severe spells. These very limited data provide no evidence of cold weather movements, but they do indicate increased mortality during cold winters.

Table 19.1 Recovery regions of British-ringed Ringed Plovers in mild and severe winters.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
N.E.Scotland	(1)	1	1	0
N.W.Scotland	(2)	0	1	1
E. England	(3)	4	1	1
Irish Sea	(4)	4	2	1
Ireland	(5)	2	1	1
S. England	(6)	7	6	6
Waddenzee	(7)	1	0	0
N. France	(8)	4	0	0
S. France	(9)	0	1	1
Iberia	(10)	1	0	0
E. Europe	(11)	1	0	0
Africa	(12)	9	0	0
Total		34	13	11

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
E. & W.Britain (1-5)	32.4	46.2	36.4
S. Britain (6)	20.6	46.2	54.5
Europe (7-11)	20.6	7.7	9.1
Africa (12)	26.5	0.0	0.0

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=6.747, 2 df, P<0.05
Mild winters v severe spells x^2=6.529, 2 df, P<0.05

Table 19.2 Ringing periods and regions of British-ringed Ringed Plovers recovered in winter.

Ringing region	Ringing period			
	July-October	November-March	April-June	
N.E.Scotland	2	2	0	4
N.W.Scotland	1	0	0	1
E. England	9	2	0	11
Irish Sea	5	3	5	13
Ireland	1	0	0	1
S. England	11	2	4	17
Total	29	9	9	47

Table 19.3 Recovery regions of British-ringed Ringed Plovers in years before, during and after severe weather.

(a) Number of recoveries

Recovery region		Mild spells			Severe spells
		Years before	Years after	Years before +after	
N.E.Scotland	(1)	1	0	1	0
N.W.Scotland	(2)	0	0	0	1
E. England	(3)	0	0	0	1
Irish Sea	(4)	1	2	3	1
Ireland	(5)	0	1	1	1
S. England	(6)	0	1	1	6
N. France	(7)	1	0	1	0
S. France	(8)	0	0	0	1
Africa	(9)	0	2	2	0
Total		3	6	9	11

(b) Percentage of recoveries

Recovery region		Mild spells			Severe spells
		Years before	Years after	Years before +after	
E. & W.Britain	(1-5)	66.7	50.0	55.6	36.4
S. England	(6)	0.0	16.7	11.1	54.5
Europe & Africa	(7-9)	33.3	33.3	33.3	9.1

Only recoveries during the period of severe weather are included.
Severe winters v before+after x^2=0.165, 1 df, ns

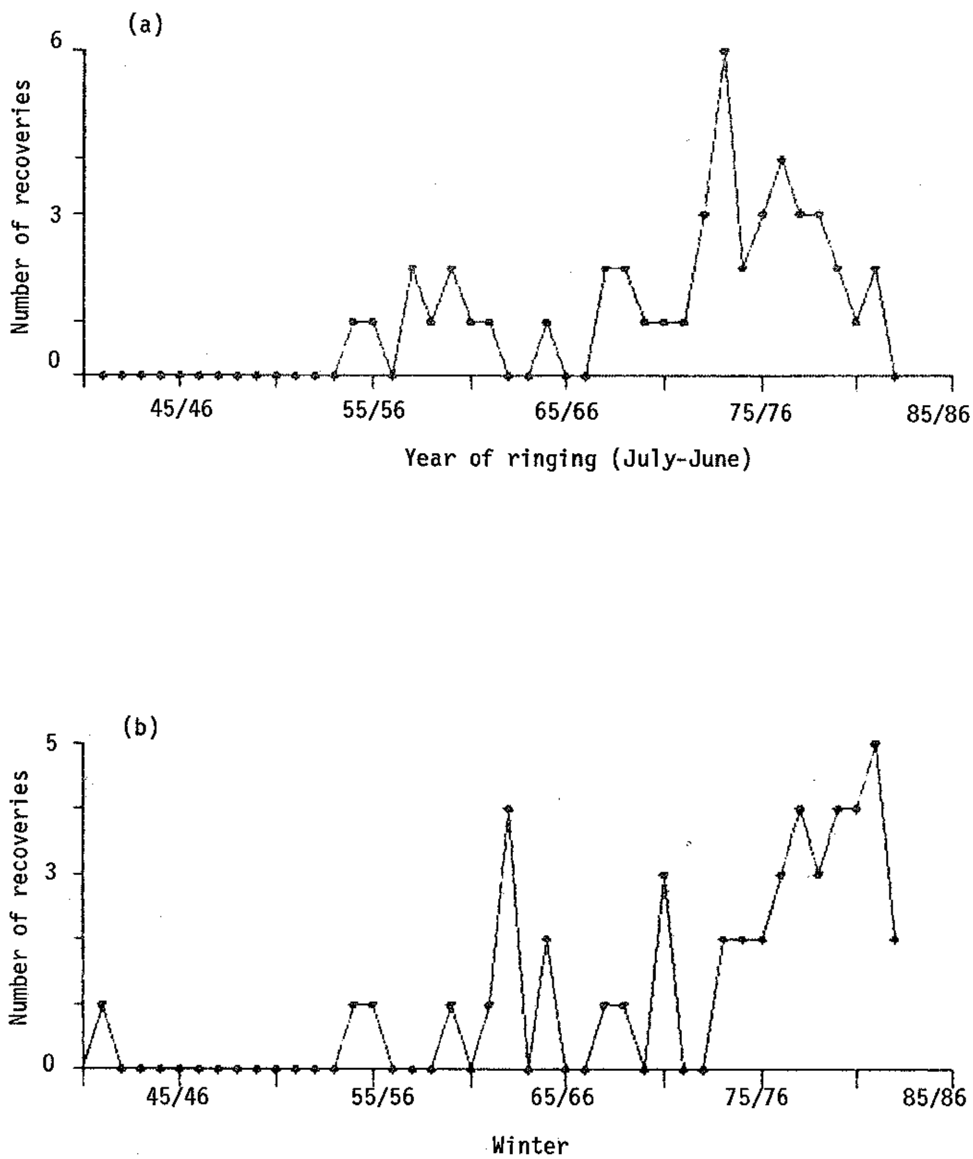


Figure 19.1 Winter recovery totals for Ringed Plover.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

LAPWING *Vanellus vanellus*

20.1 Normal pattern of movements

Britain has a large breeding population of Lapwings, which has been estimated as between 100,000 and 1,000,000 pairs (Parslow 1973, Sharrock 1976). Some of these birds remain close to their natal areas for the winter, while others migrate west to Ireland or south to France and Iberia. The proportion of birds migrating to these different areas varies regionally within Britain, and also with age (Imboden 1974). Thirty-four per cent of mild winter recoveries of Lapwings ringed in North Britain were from Ireland, compared with 15% of recoveries of birds ringed in Central Britain and none from South Britain (Table 20.1). In contrast, 39% of mild winter recoveries of Lapwings ringed in North Britain were from countries to the south of Britain, compared with 54% of recoveries from Central Britain and 84% of recoveries from South Britain. This pattern is further complicated by seasonal variation in the distribution of birds during mild winters (Table 20.2). Migration is still taking place in November and December, as indicated by the higher percentage of recoveries from Britain recorded during this period than in January and February. This may be a direct response to the increased frequency of colder weather in mid-winter. It may be better to consider Lapwing movements as a continuing redistribution of the population in relation to weather conditions, rather than as a migration largely determined by time of year (below). Most birds have returned to the breeding grounds by March, with over 60% of birds ringed in North and Central Britain recovered from Britain. Only eight recoveries of birds ringed in South Britain were reported during March. While most Lapwings born in Britain return to their natal areas to breed, some join other European breeding populations (Evans 1966, Mead *et al*. 1968). Irish breeding Lapwings are probably resident, but very few ringing recoveries are available.

No precise estimates of the numbers of Lapwings wintering in Britain have been made, although Prater (1981) suggested that several million Lapwings winter in Europe, with at least a million in Britain. Lapwings visiting Britain for the winter are mainly from the Low Countries, Denmark, South Norway and South Sweden (Imboden 1974). Few of these birds have been ringed in Britain, and the analyses presented below concern only birds ringed in Britain as chicks.

Lapwings are vulnerable to cold weather. A 56% decline in numbers breeding on British farmland Common Birds Census plots was recorded following the 1962/63 winter (Bailey 1967). However, declines were not recorded following the less severe winters of 1978/79 and 1981/82 (Marchant and Hyde 1980, Marchant 1983). Because their normal inland feeding areas are very vulnerable to freezing, Lapwings frequently undertake cold weather movements in response to relatively short periods of cold weather (Eastwood 1967, Fuller and Youngman 1979). Those Lapwings remaining in Britain during cold weather generally move to estuarine areas, and even in these habitats declines of over 50% were recorded in estuary counts made during the winters of 1978/79 and 1981/82 (Marchant 1982). Extensive Lapwing movements out of Britain into France, Iberia and Ireland were recorded during the 1962/63 winter (Dobinson and Richards 1964). In that winter a large influx of Lapwings occurred in North Africa (Smith 1965), and some of these may have been British birds. Exceptionally Lapwings have been recorded crossing the Atlantic, and in December 1927 hundreds reached Canada, including one individual which had been ringed as a chick in Britain (Cramp and Simmons 1983).

20.2 Ringing effort

This analysis is restricted to birds ringed in Britain as chicks, as these have given rise to nearly all of the recoveries reported to date. Over 250 recoveries are available for Lapwings ringed in both North and Central Britain, but only 76 recoveries are of birds ringed in South Britain and only three are of birds ringed in Ireland (Table 20.3).

Numbers of Lapwing chicks ringed in Britain increased from about 500 per year in 1940 to over 2000 by 1952. This level was maintained until the 1962/63 winter, after which fewer birds were available to be ringed. Ringing totals increased again during the 1960s and 1970s, corresponding to the recovery of the population, and over 3000 Lapwing chicks have been ringed in most years since 1972. The graph of numbers of winter recoveries of Lapwings ringed in each year follows this pattern, except that there is no increase in recoveries following the 1962/63 decline (Figure 20.1). This is because Lapwing recovery rates have declined in recent years mainly due to fewer hunting recoveries being reported from France and Iberia. Until 1970 about 0.5% of Lapwings ringed as chicks were recovered between November and March of their first winter, but since then this figure has averaged about 0.1%.

Numbers of recoveries reported from each winter show marked peaks corresponding to the winters of 1961/62 and 1962/63 (Figure 20.1). Peaks corresponding to the winters of 1946/47, 1955/56, 1978/79 and 1981/82 are less marked, but in all cases these involve at least a doubling in the numbers of recoveries compared with adjacent years.

20.3 Distribution of recoveries in mild and cold winters

Significantly more Lapwings from North and Central Britain were recovered in Europe during cold winters than during mild ones (Table 20.1). The percentage of recoveries in Ireland did not increase in cold winters. Lapwings ringed in South Britain did not show a significant difference in recovery distributions between mild and cold winters, although the percentage of recoveries from Britain dropped from 14% during mild winters to 5% during cold ones, in line with the changes recorded for the other populations.

These comparisons between mild and cold winters may be affected by seasonal variations in recovery patterns (Table 20.2). Recovery distributions from severe spells were therefore compared with those from January to February of all mild winters, as well as with equivalent periods in years immediately before and after cold weather (Table 20.4). Comparisons between January-February totals for all mild winters and for severe spells do not give significant differences for any region, although in all cases there is a small increase in the percentage of recoveries in Europe during cold weather. When data from all regions were combined, there was a significant difference between January to February of mild winters and severe spells (x^2=13.04, 3df, P<0.01). Comparing recovery distributions during severe spells with those in the same periods in years immediately before and after cold weather gave significant differences for North Britain and for all regions combined. Both this and the previous comparison indicate increased movement to Europe during cold weather, but no movement into Ireland. The results all relate to British-breeding Lapwings, many of which winter in Europe during mild winters. A sample of British wintering Lapwings would probably show a more marked redistribution during cold weather.

Cold weather movements are also demonstrated by mean distances between ringing and recovery places. The mean distances moved were 870 km in years before and after cold weather and 1010 km during severe spells (Mann-Whitney U-test, t=2.07, P<0.05). Very few recoveries occurred within 300 km of the ringing place during cold spells (Figure 20.2). Data from North Britain alone gave similar results, with mean distances of 919 km in years before and after cold weather and 1195 km during severe spells (Mann-Whitney U-test, t=2.27, P<0.05). Similar comparisons for Central and South Britain were not significant, illustrating the lesser extent of cold weather movements by these populations.

Three times as many recoveries were reported during cold spells as during equivalent mild periods (Table 20.5). This probably indicates some increase in mortality but movement to areas with higher recovery rates may also be involved. In contrast to the results presented above, nearly four times as many recoveries were reported from Ireland during cold weather. The lack of any increase in recoveries from Britain further suggests that many birds emigrated. Significant increases in cold weather recovery rates also occurred in France and particularly in Iberia, where 4.5 times as many Lapwings were recovered during cold spells as in equivalent mild ones. These results support the occurrence of increased movements into Europe, probably coupled with increased mortality of the birds which migrated there.

20.4 Summary

Lapwings wintering in Britain include some British breeding birds but also many immigrants from the Low Countries and Scandinavia. However, recovery data were available only for birds ringed in Britain as chicks. Some of these birds remain in Britain for the winter, but most migrate either west to Ireland or south to France and Iberia. The proportion of Lapwings which migrates to Ireland in winter is highest in Northern Britain, while more birds from the south of Britain migrate south into Europe. Seasonal variation in the distribution of recoveries occurs between November and March, with the highest proportion of birds being absent from Britain in January to February. More Lapwings move to Europe during cold weather, but there is little evidence of increased movement into Ireland by British breeding populations. Lapwings from North Britain more often remain in Britain during mild winters, and consequently more northerly populations show more marked cold weather movements. Increased mortality of Lapwings takes place during cold weather, with three times as many recoveries reported from cold spells than from equivalent mild periods.

Table 20.1 Recovery regions of Lapwings ringed as chicks in different parts of Britain and recovered in mild or cold winters.

Ringing region	Recovery region	Mild winters		Cold winters	
		n	%	n	%
N.Britain	Norway	1	0.5	0	0.0
	N.Britain	48	23.0	8	11.4
	C. & S.Britain	7	3.3	1	1.4
	Ireland	71	34.0	24	34.3
	N.France	16	7.7	4	5.7
	S.France	32	15.3	11	15.7
	Iberia and Africa	34	16.3	22	31.4
	Total	209		70	
C.Britain	N.Britain	1	0.4	1	0.9
	C.Britain	71	28.3	10	9.1
	S.Britain	3	1.2	3	2.7
	Ireland	38	15.1	18	16.4
	Waddenzee and C.Europe	2	0.8	1	0.9
	N.France	24	9.6	21	19.1
	S.France	44	17.5	15	13.6
	Iberia and Africa	68	27.1	41	37.3
	Total	251		110	
S.Britain	C.Britain	1	1.8	0	0.0
	S.Britain	7	12.5	1	5.0
	Waddenzee	1	1.8	0	0.0
	N.France	12	21.4	7	35.0
	S.France	13	23.2	4	20.0
	Iberia and Africa	22	39.3	8	40.0
	Total	56		20	

Tests of mild winters v cold winters:

Ringed in N.Britain $x^2 = 10.240$, 3df, $P<0.05$
Ringed in C.Britain $x^2 = 17.884$, 4df, $P<0.001$
Ringed in S.Britain $x^2 = 1.297$, 2df, ns

Table 20.2 Seasonal variation in the recovery regions of Lapwings ringed as chicks in different parts of Britain and recovered during mild winters.

Ringing region	Recovery region	Percentage of Recoveries		
		Nov.-Dec.	Jan.-Feb.	March
N.Britain	Norway	0.0	0.0	3.2
	Britain	36.7	11.0	64.5
	Ireland	38.3	39.0	6.5
	N.France	8.3	6.8	9.7
	S.France	8.3	19.5	12.9
	Iberia and Africa	8.3	23.7	3.2
Total number of recoveries		60	118	31
C.Britain	Britain	36.7	18.7	66.7
	Ireland	18.3	16.1	5.6
	Waddenzee & C.Europe	0.0	0.6	2.8
	N.France	13.3	9.0	5.6
	S.France	20.0	18.1	11.1
	Iberia and Africa	11.7	37.4	8.3
Total number of recoveries		60	155	36
S.Britain	Britain	13.3	9.1	37.5
	France	60.0	36.4	62.5
	Iberia and Africa	26.7	54.5	0.0
Total number of recoveries		15	33	8

Tests for differences between periods:

N.Britain $x^2 = 52.182$, 8df, $P<0.001$
C.Britain $x^2 = 45.462$, 8df, $P<0.001$
S.Britain $x^2 = 9.400$, 2df, $P<0.01$

Table 20.3 Ringing regions of Lapwings ringed as chicks and recovered in winter.

Ringing region	No. of recoveries
North Britain	279
Central Britain	361
Ireland	3
South Britain	76
Total	719

Table 20.4 Recovery regions of Lapwings ringed as chicks in different parts of Britain and recovered during severe spells and during equivalent mild periods.

Ringing region	Recovery region	Mild winters Jan.-Feb.		Years before and after(1)		Severe spells	
		n	%	n	%	n	%
N.Britain	Britain	13	11.0	5	14.7	1	2.2
	Ireland	46	39.0	10	29.4	14	30.4
	France	31	26.3	13	38.2	12	26.1
	Iberia and Africa	28	23.7	6	17.6	19	41.3
	Total	118		34		46	
C.Britain	Britain	29	18.7	8	15.1	6	7.1
	Ireland	25	16.1	3	5.7	12	14.1
	C.Europe	1	0.6	0	0.0	1	1.2
	France	42	27.1	24	45.3	29	34.1
	Iberia and Africa	58	37.4	18	34.0	37	43.5
	Total	155		53		85	
S.Britain	Britain	3	9.1	1	12.5	0	0.0
	France	12	36.4	3	37.5	7	50.0
	Iberia and Africa	18	54.5	4	50.0	7	50.0
	Total	33		8		14	

(1) Only periods when severe weather occurred in the corresponding cold winter are included.

Tests between Jan.-Feb. of mild winters and severe spells:

North Britain x^2 = 7.261, 3df, ns
Central Britain x^2 = 6.801, 3df, ns
South Britain x^2 = 1.763, 2df, ns

Tests between years before + after and severe spells:

North Britain x^2 = 8.525, 3df, $P<0.05$
Central Britain x^2 = 6.014, 3df, ns
All regions x^2 = 12.125, 4df, $P<0.05$

Table 20.5 Recovery Index for Lapwings ringed in Britain as chicks and recovered in different regions.

Recovery region	Mild spells (i)	Severe spells	Recovery Index	x^2	sig.
Britain	14	7	1.00	0.00	ns
Ireland	14	26	3.71	18.05	***
N.France	15	22	2.93	11.36	***
S.France	25	26	2.08	7.15	**
Iberia & Africa	28	63	4.50	52.77	***
All regions	96	145	3.02	78.08	***

(i) Equivalent dates to severe spells in years immediately before and after cold weather.

$$\text{Recovery Index} = \frac{\text{2 x number of recoveries during severe spells}}{\text{number of recoveries in years before and after}}$$

for further details see methods

Significance *** P<0.001 ** P<0.01 ns not significant

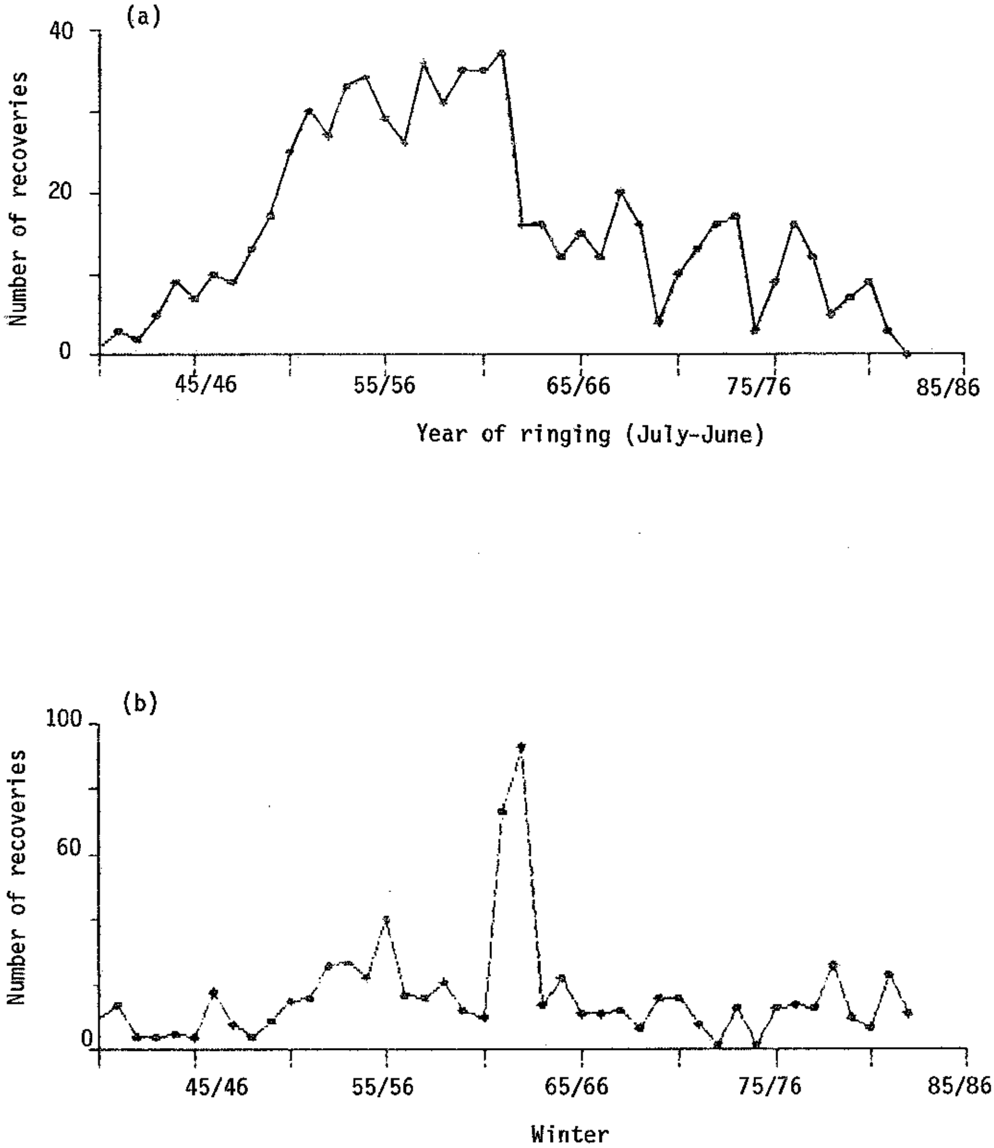


Figure 20.1 Winter recovery totals for Lapwings ringed as chicks.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

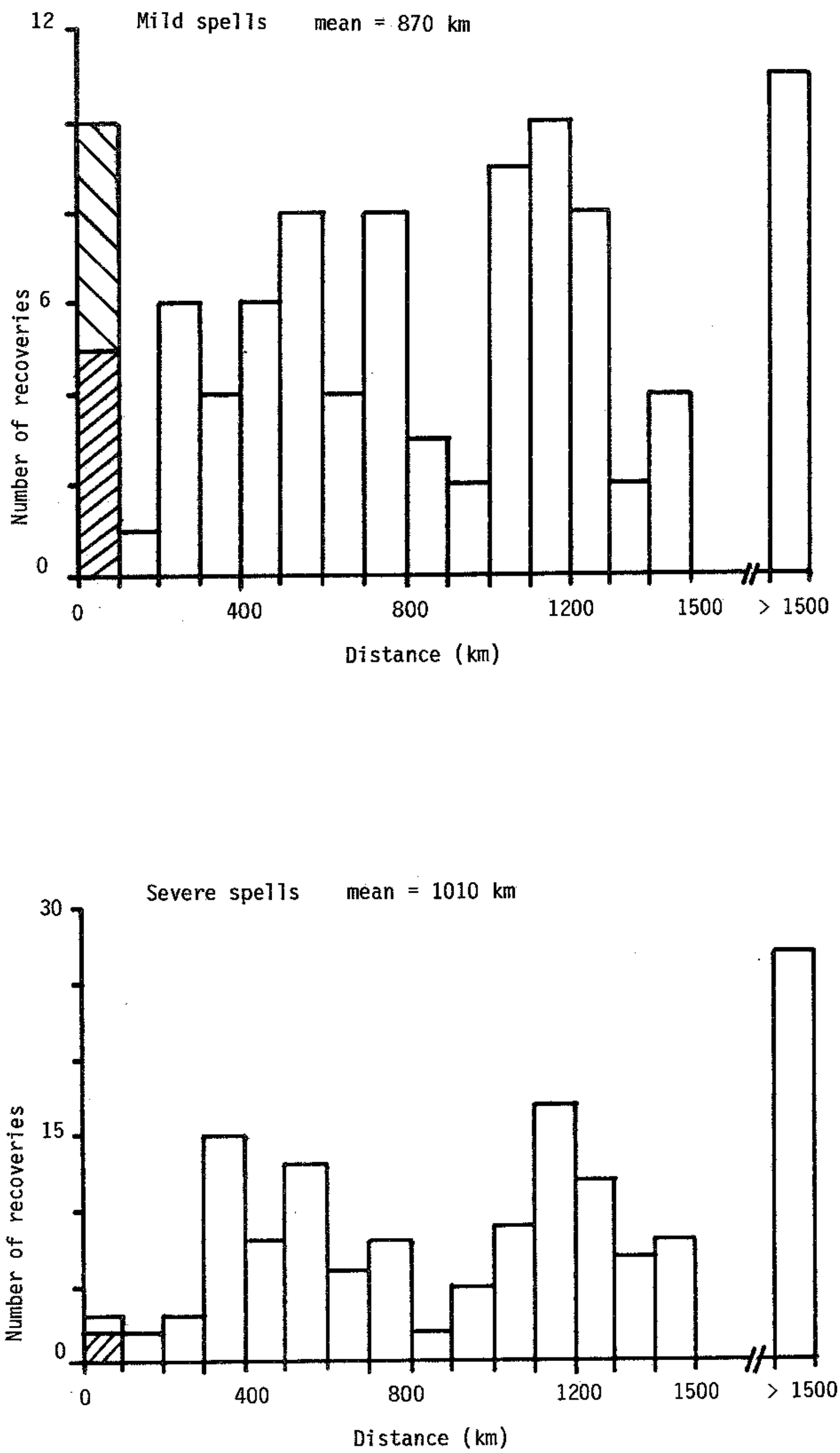


Figure 20.2 Distances between ringing and recovery places of Lapwings recovered during severe spells and in equivalent periods during adjacent mild winters.

0-9 km

10-49 km

KNOT *Calidris canutus*

21.1 Normal pattern of movements

All of the Knot wintering in Britain belong to the population which breeds in Greenland and north-east Canada and winters in north-west Europe, principally in Britain and Ireland, the Netherlands and France (Dick *et al*. 1976). Small numbers of Siberian Knot occur in Britain on passage, mainly in autumn. This population winters in west and south Africa and only occurs in Europe on passage in spring and autumn (Dick *et al*. 1976, Dick 1979).

It has been estimated that Britain and Ireland hold about 300,000 Knot in mid-winter (Prater 1981) but there has been a slight decline in the population since this estimate was made (Moser in prep.). These birds comprise about 65% of the European and west African wintering birds. Numbers are concentrated on a few major estuaries, Morecambe Bay, the Wash and the Ribble each holding over 50,000 birds. In late autumn many Knot which have moulted on the Waddenzee move into Britain while some of the birds which have moulted on the Wash move to the west coast of Britain. Following this autumn increase in numbers Knot are found on many of the smaller British estuaries during the mid-winter period. A return movement to the Waddenzee, which is used as a pre-migratory fattening area, takes place in March. Inter-estuarine movements of Knot are complex, and are not fully understood (Prater 1981, Cramp and Simmons 1983).

Seventy-two per cent of mild winter recoveries of British-ringed Knot are from Britain, most of the remainder being from the Waddenzee, France and Iberia (Table 21.1). The main recovery areas within Britain correspond to the main ringing areas in East England and the Irish Sea area. The three birds recovered in Africa probably belonged to the Siberian population (above).

21.2 Ringing effort

Sixty per cent of the winter recovery sample were ringed in East England, principally on the Wash (Table 21.2). In this area numbers ringed were split about equally between Autumn and Winter. Thirty-three per cent of winter recovered birds were ringed in the Irish Sea area, mostly in Morecambe Bay. In contrast to the Wash, most of these birds were ringed in Winter. Very few Knot have been ringed in Spring.

No recoveries are available before the mid-1950s and there are few between the mid-1950s and the mid-1960s. Forty-one per cent of the recovery sample comes from ringing in the years 1968/69 to 1970/71 (Figure 21.1), when wader ringers were particularly successful at catching Knot. Smaller numbers have been ringed since then and during the late 1970s and early 1980s only about 10 recoveries per year were reported.

21.3 Distribution of recoveries during mild and severe winters

The distributions of recoveries during mild and severe winters are not significantly different (Table 21.1). However, there is a significant difference when mild winters are compared with severe spells, with 43% of recoveries in Europe during severe spells compared with 17% during mild winters. This difference is still present when severe spells are compared with the same periods in immediately previous and subsequent winters, but sample sizes are smaller and the difference is no longer significant (Table 21.3). The data in Table 21.3 do not suggest any increase in recovery rates during severe winters.

Analyses of distance distributions do not show any increase in movements during severe weather. Mean distances between ringing and recovery places were 241 km during mild winters, 133 km during severe winters and 200 km during severe spells (Mann-Whitney U-tests: mild winters v severe winters, t=0.56, ns; mild winters v severe spells, t=0.68, ns). The mean distance moved during severe spells (200 km) is not significantly different from that during the same periods in immediately previous and subsequent winters (Mann-Whitney U-test, t=0.14, ns).

21.4 Summary

There is weak statistical evidence for a movement of Knot from Britain into France during severe weather. However, it is based on only 14 recoveries from severe spells, and confirmatory data are needed. Recovery rates of Knot did not increase during severe weather.

Table 21.1 Recovery regions of British-ringed Knot in mild and severe winters.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
N.E.Scotland	(1)	6	2	1
N.W.Scotland	(2)	1	0	0
E. England	(3)	78	17	5
Irish Sea	(4)	53	3	1
Ireland	(5)	6	1	0
S. England	(6)	16	1	1
Waddenzee	(7)	9	2	2
N. France	(8)	10	4	4
S. France	(9)	9	0	0
Iberia	(10)	3	0	0
Africa	(11)	3	0	0
Misc.	(12)	1	0	0
Total		195	30	14

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
N. & E.Britain (1-3)	43.6	63.3	42.9
W. & S.Britain (4-6)	38.5	16.7	14.3
Europe (7-11)	17.4	20.0	42.9

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=5.740, 2 df, ns
Mild winters v severe spells Fisher test, P=0.032.

Table 21.2 Ringing periods and regions of British-ringed Knot recovered in winter.

Ringing region	Ringing period			
	July-October	November-March	April-June	
N.E.Scotland	1	5	0	6
N.W.Scotland	2	0	0	2
E. England	64	67	3	134
Irish Sea	16	56	2	74
Ireland	2	0	0	2
S. England	0	7	0	7
Total	85	135	5	225

Table 21.3 Recovery regions of British-ringed Knot in years before, during and after severe weather.

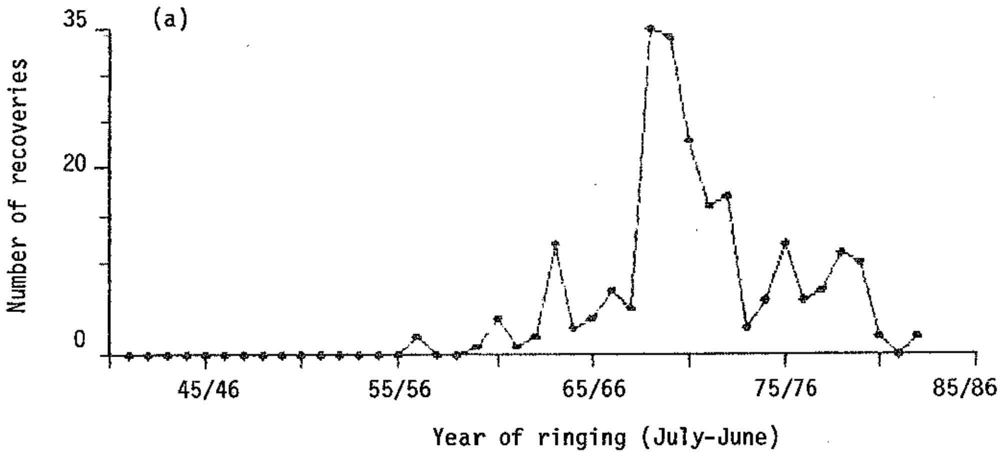
(a) Number of recoveries

Recovery region		Mild spells			Severe spells
		Years before	Years after	Years before +after	
N.E.Scotland	(1)	1	2	3	1
N.W.Scotland	(2)	0	1	1	0
E. England	(3)	3	7	10	5
Irish Sea	(4)	2	2	4	1
Ireland	(5)	0	1	1	0
S. England	(6)	1	0	1	1
Waddenzee	(7)	0	2	2	2
N. France	(8)	0	2	2	4
S. France	(9)	1	0	1	0
Africa	(10)	0	1	1	0
Total		8	18	26	14

(b) Percentage of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
N. & E.Britain (1-3)	50.0	55.6	53.8	42.9
W. & S.Britain (4-6)	37.5	16.7	23.1	14.3
Europe	12.5	27.8	23.1	42.9

Only recoveries during the period of severe weather are included.
Severe winters v before+after x^2=0.884, 1 df, ns



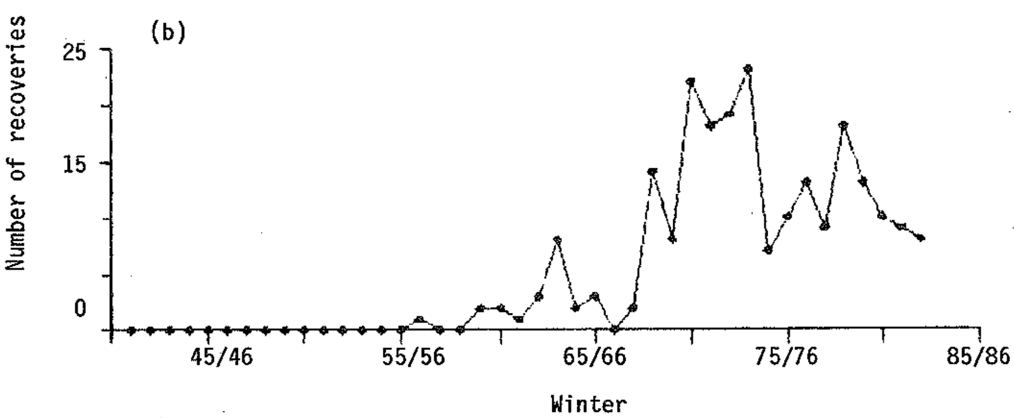


Figure 21.1 Winter recovery totals for Knot.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

SANDERLING *Calidris alba*

22.1 Normal pattern of movements

The number of Sanderling wintering in Britain has been estimated as about 10,300 birds (Prater and Davies 1978) but the Winter Shorebird Count carried out in the 1984/85 winter suggests that the total may be somewhat higher than this (Moser in prep.). Ireland has a further 2000 wintering birds, and together Britain and Ireland hold about 63% of the Sanderling wintering in Europe (Prater 1981). Large numbers occur on passage in May, and again in July and August, and studies to determine the size of these populations are in progress.

Currently available data suggest that British wintering birds mainly breed in Siberia, while most of the passage birds breed in Greenland and winter in west and south Africa. However, the situation is more complex than this, with at least some mixing between the two populations (Cramp and Simmons 1983).

High return rates of Sanderling colour-marked in winter (Evans 1981, Myers and McCaffery 1980) indicate high site fidelity both within and between winters, at least in some areas. However, some populations appear to wander over a relatively large winter range. For example, ringing studies suggest that there is extensive movement between the Ribble, Alt, Mersey and Dee estuaries in winter.

Forty-nine per cent of winter recoveries of British-ringed Sanderling are from Britain, with small numbers of recoveries from other parts of western Europe and 35% of recoveries from Africa (Table 22.1). These latter recoveries relate mostly to birds ringed on passage (below).

22.2 Ringing effort

Forty-eight of the 69 winter recoveries are of birds ringed in East England, most of which were marked on the Wash or the Tees (Table 22.2). The only other region where extensive ringing has taken place is the Irish Sea area, with 17 winter recoveries of birds ringed there. The total of only 69 winter recoveries reflects both the relatively small numbers ringed and the low recovery rate for small waders. Seventy-two per cent of birds were ringed in either Autumn or Spring and many of these belonged to the passage population which winters in Africa.

Few Sanderling were ringed before the late 1960s (Figure 22.1). Since then there have been a few recoveries each winter, with peaks of 11 and 9 recoveries during the severe winters of 1978/79 and 1981/82.

22.3 Distribution of recoveries in mild and severe weather

Recoveries in Africa were excluded from the calculations of regional percentages, as these birds occur in Britain only on spring and autumn passage. The recovery distribution for mild winters was not significantly different from that for severe winters, or for severe spells only (Table 22.1). Neither was the recovery distribution for severe spells significantly different from that for equivalent periods in immediately previous and subsequent winters (Table 22.3). In all samples over 70% of recoveries were from Britain. However, sample sizes are very small and the data are not sufficient to conclude that Sanderling do not undertake cold weather movements.

22.4 Summary

The small sample of ringing recoveries currently available provides no evidence for cold weather movements by Sanderlings wintering in Britain. Considerably more data are needed to confirm this pattern.

Table 22.1 Recovery regions of British-ringed Sanderling in mild and severe winters.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
E. England	(1)	16	15	6
Irish Sea	(2)	5	1	1
S. England	(3)	3	1	0
Waddenzee	(4)	2	0	0
N. France	(5)	2	1	1
Iberia	(6)	3	1	1
Central Europe	(7)	1	0	0
Africa	(8)	17	1	0
Total		49	20	9

(b) Percentage of recoveries[a]

Recovery region		Mild winters	Severe winters	Severe spells
Britain	(1-3)	75.0	89.5	77.8
Waddenzee	(4)	6.3	0.0	0.0
S.Europe	(5-7)	18.8	10.5	22.2

a African recoveries were excluded when calculating these percentages, as these birds belong to populations which only occur in Britain on spring and autumn passage.

For definitions of mild and severe winters see methods.

Mild winters v severe winters Fisher test, ns
Mild winters v severe spells Fisher test, ns

Table 22.2 Ringing periods and regions of British-ringed Sanderling recovered in winter.

Ringing region	Ringing period: July-October	November-March	April-June	
N.E.Scotland	1	0	0	1
E. England	23	18	7	48
Irish Sea	8	0	9	17
S. England	0	1	2	3
Total	32	19	18	69

Table 22.3 Recovery regions of British-ringed Sanderling in years before, during and after severe weather.

(a) Number of recoveries

Recovery region		Mild spells			Severe spells
		Years before	Years after	Years before +after	
E. England	(1)	3	2	5	6
Irish Sea	(2)	1	0	1	1
Waddenzee	(3)	1	0	1	0
N. France	(4)	0	0	0	1
Iberia	(5)	0	0	0	1
Africa	(6)	0	1	1	0
Total		5	3	8	9

(b) Percentage of recoveries[a]

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
Britain & Waddenzee (1-3)	100.0	100.0	100.0	77.8
France & Iberia (4-5)	0.0	0.0	0.0	22.2

a African recoveries were excluded when calculating these percentages, as these birds belong to populations which only occur in Britain on spring and autumn passage.

Mild spells v severe spells Fisher test P=0.457, ns

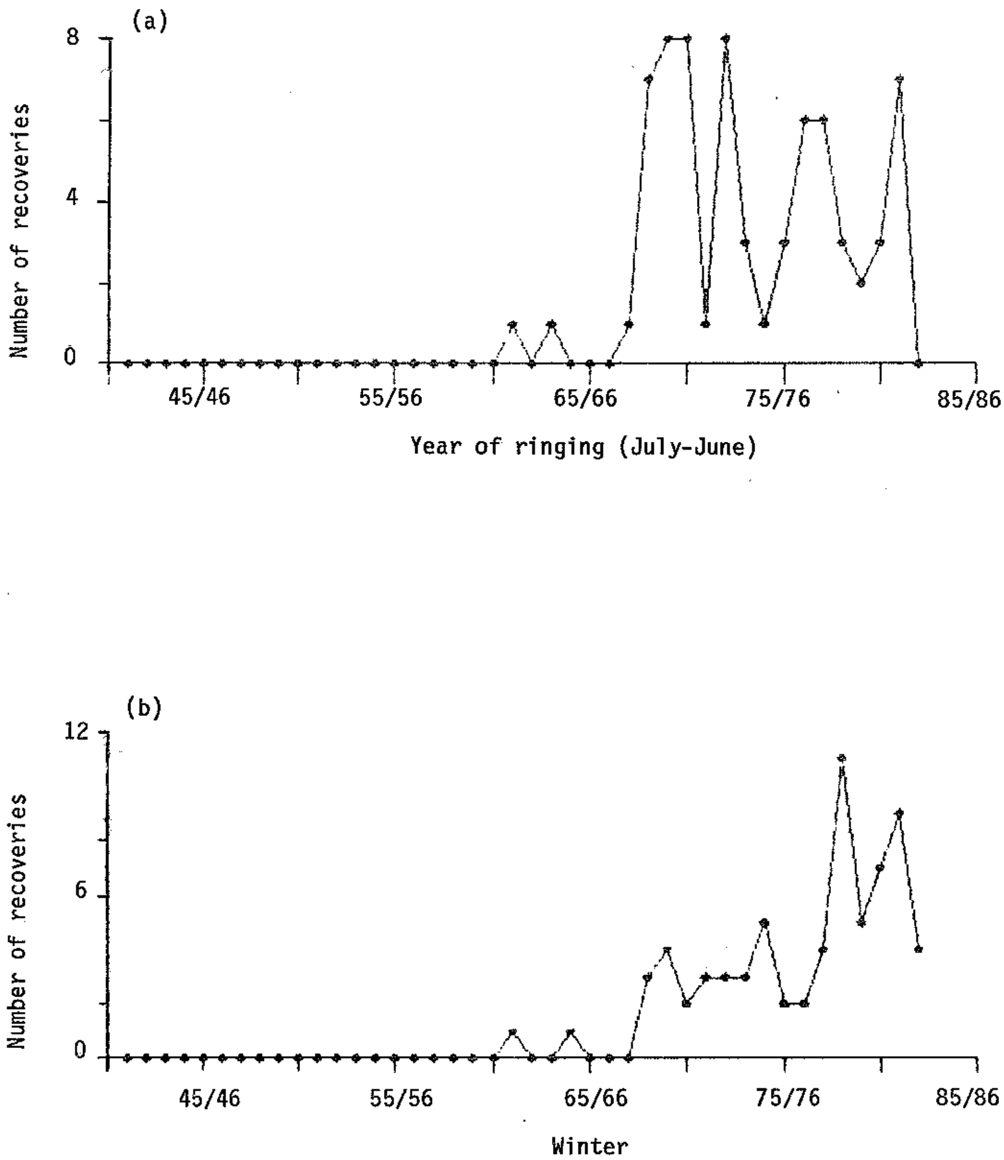


Figure 22.1 Winter recovery totals for Sanderling.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

DUNLIN *Calidris alpina*

23.1 Normal pattern of movements

The British breeding population of Dunlin is very small in comparison to the large numbers which winter here. It has recently been estimated as 9000 pairs (T.Reed *pers. comm.*), including over 2000 pairs in the Outer Hebrides (Green 1984). The precise location of the wintering grounds of the British breeding population is unknown. They belong to the race *Calidris alpina schinzii* which breeds in south-east Greenland, Iceland, the Faeroes and western Europe north to south Scandinavia and south-west Finland. Dunlin of this race pass through Britain in autumn and spring on migration to and from their wintering grounds in south Europe and north-west Africa, principally Mauritania. The race *C. a. arctica* which breeds in north-east Greenland and probably also winters in west Africa has a similar pattern of occurrence in Britain, but in much smaller numbers. Spring passage of both races occurs mainly on the west coast of Britain (Pienkowski and Dick 1975, Hardy and Minton 1980).

The wintering population of Britain and Ireland has been estimated as 665,000 out of a total of 1,300,000 birds wintering in Atlantic Europe (Cramp and Simmons 1983). However, the wintering population of Britain has declined substantially since these estimates were made (Moser in prep.). The Dunlin which winter in Britain and Ireland belong to the nominate race *C. a. alpina* and breed in northern Fenno-Scandia and the USSR east as far as the White Sea. Other populations of this race breed and winter further east. Some *alpina* Dunlin arrive in Britain from July onwards and moult here, particularly on the East coast. Others moult in the Dutch Waddenzee and move into Britain in October (Hardy and Minton 1980). Numbers on British estuaries peak in January, with return movements taking place between February and April, some via the Waddenzee (Prater 1981). Within and between winters, Dunlin appear to be largely faithful to their wintering sites, but detailed patterns of movement between estuaries in early and late winter are probably complex.

Sixty-three per cent of mild winter recoveries are from Britain, 3.5% from the Waddenzee, 21% from France and 9% from Iberia (Table 23.1). The 14 recoveries from Africa were probably *C. a. schinzii* ringed in Britain on Spring or Autumn passage (above).

23.2 Ringing effort

The main ringing areas of British-ringed Dunlin recovered in winter have been East England (46%), South England (33%) and the Irish Sea area (17%) (Table 23.2). Very few recoveries are of birds ringed elsewhere, and the need for further ringing in Scotland and Ireland is apparent. Ringing on the East Coast, principally the Wash, has taken place mainly in Autumn as there are good opportunities to catch the birds which moult there. Most recoveries of Dunlin ringed in South England and the Irish Sea are of Winter-ringed birds.

There are no recoveries before the mid 1950s, and ringing reached an adequate level only from the early 1960s onwards (Figure 23.1). Since then annual recovery totals have fluctuated markedly around a figure of about 20 per winter. A further increase took place during the 1970s, but numbers were lower again in the winters of 1981/82 and 1982/83.

23.3 Distribution of recoveries in mild and severe winters

The recovery distributions for severe winters and for severe spells alone both differ significantly from that for mild winters (Table 23.1). The main reason for these differences is an increase in the percentage of recoveries from North and East Britain during severe weather, probably as a result of increased mortality. The percentage of recoveries in Europe was 34.7 during mild winters, 21.2 during severe winters and 21.6 during severe spells. Mild winters differ significantly from severe winters (x^2=4.135, P<0.05) but not from severe spells (x^2=2.061, ns). These figures suggest an increase in the mortality of Dunlin wintering in Britain relative to those wintering in more southerly parts of Europe.

The more rigorous comparison of the recovery distribution during severe spells with that during the same periods in immediately previous and subsequent winters gives no significant difference (Table 23.3). The percentage of recoveries from North and East Britain is still higher during severe spells but comparisons of recovery rates in individual regions showed no significant changes during severe spells. The absence of movements in severe weather is confirmed by the comparison of distances between ringing and recovery places for birds recovered during severe spells (mean = 279 km) and birds recovered during the same periods in immediately previous and subsequent winters (mean = 334 km) (Mann-Whitney U-test, t=0.95, ns).

23.4 Summary

The recovery data provide no evidence for cold weather movements by Dunlin. There is weak evidence for increased mortality of this species in North and East Britain during severe weather.

Table 23.1 Recovery regions of British-ringed Dunlin in mild and severe winters.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
Norway	(1)	1	0	0
N.E.Scotland	(2)	9	2	2
N.W.Scotland	(3)	1	0	0
E. England	(4)	81	21	13
Irish Sea	(5)	70	7	6
Ireland	(6)	17	1	0
S. England	(7)	108	21	8
Waddenzee	(8)	16	4	0
N. France	(9)	52	5	4
S. France	(10)	42	0	0
Iberia	(11)	40	5	4
Central Europe	(12)	1	0	0
E. Europe	(13)	1	0	0
Africa	(14)	14	1	0
Total		453	67	37

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
Norway (1)	0.2	0.0	0.0
N. & E.Britain (2-4)	20.1	34.3	40.5
W. Britain (5-6)	19.2	11.9	16.2
S. England (7)	23.8	31.3	21.6
Waddenzee (8)	3.5	6.0	0.0
S. Europe (9-12)	29.8	14.9	21.6
Africa (14)	3.1	1.5	0.0

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=11.691, 3 df, P<0.01
Mild winters v severe spells x^2=8.935, 3 df, P<0.05

Table 23.2 Ringing periods and regions of British-ringed Dunlin recovered in winter.

Ringing region	Ringing period			
	July-October	November-March	April-June	
N.E.Scotland	3	8	0	11
N.W.Scotland	1	1	0	2
E. England	186	50	5	241
Irish Sea	15	63	10	88
Ireland	5	3	0	8
S. England	57	103	10	170
Total	267	228	25	520

Table 23.3 Recovery regions of British-ringed Dunlin in years before, during and after severe weather.

(a) Number of recoveries

Recovery region		Mild spells			Severe spells
		Years before	Years after	Years before +after	
N.E.Scotland	(1)	2	2	4	2
E. England	(2)	10	6	16	13
Irish Sea	(3)	3	9	12	6
Ireland	(4)	1	2	3	0
S. England	(5)	15	12	27	8
Waddenzee	(6)	0	2	2	0
N. France	(7)	2	1	3	4
S. France	(8)	0	4	4	0
Iberia	(9)	4	1	5	4
Africa	(10)	3	0	3	0
Total		40	39	79	37

(b) Percentage of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
N. & E.Britain (1-2)	30.0	20.5	25.3	40.5
W.Britain (3-4)	10.0	28.2	19.0	16.2
S. England (5)	37.5	30.8	34.2	21.6
Waddenzee (6)	0.0	5.1	2.5	0.0
S.Europe (7-9)	15.0	15.4	15.2	21.6
Africa (10)	7.5	0.0	3.8	0.0

Only recoveries during the period of severe weather are included.
Years before v years after x^2=4.447, 3 df, ns
Severe winters v before+after x^2=3.359, 3 df, ns

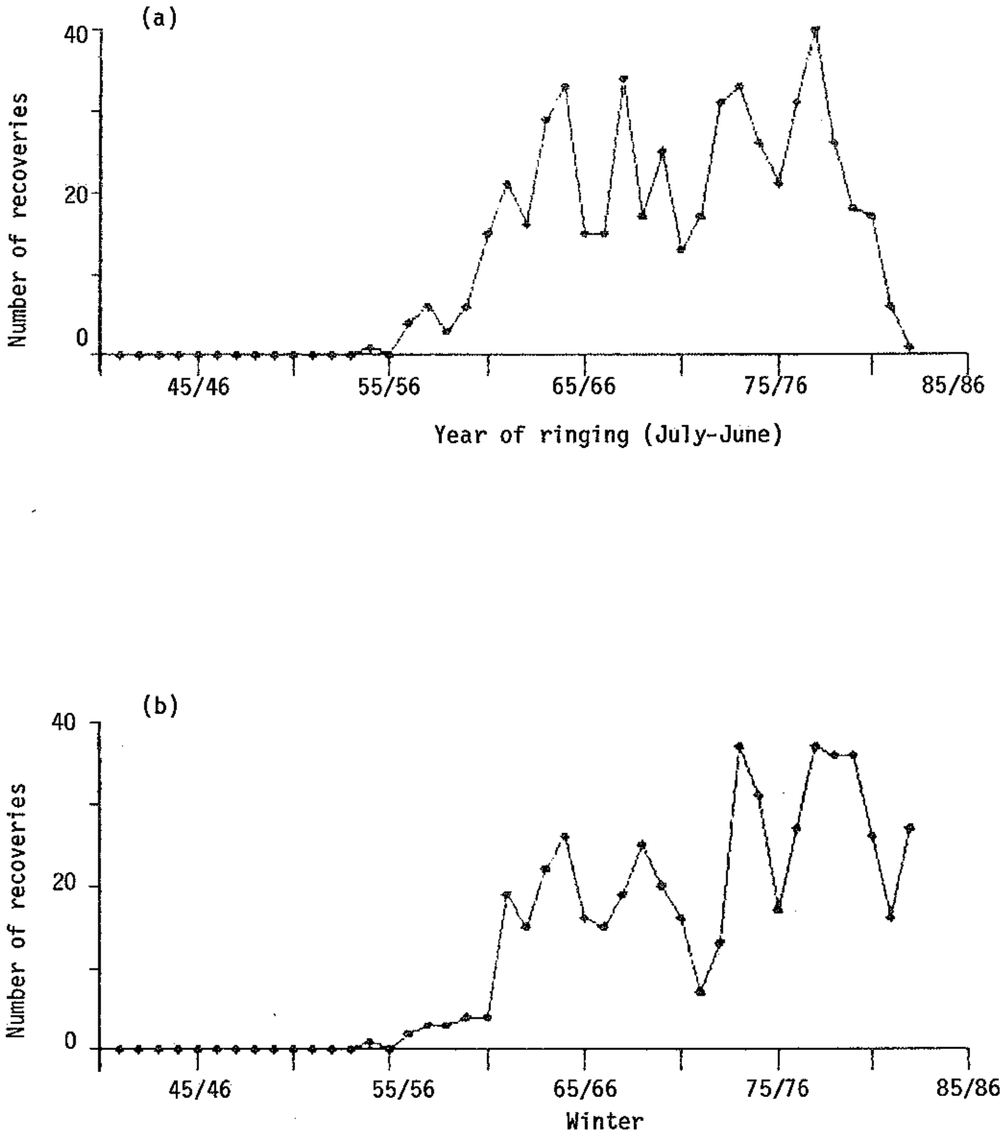


Figure 23.1 Winter recovery totals for Dunlin.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

SNIPE *Gallinago gallinago*

24.1 Normal pattern of movements

The Snipe is a widespread breeding species in Britain and Ireland but the population is now considerably lower than Sharrock's (1976) estimate of between 80,000 and 110,000 pairs. Only 1979 pairs were found during a recent survey of lowland grasslands in England and Wales (Smith 1983) and 48% of these were concentrated at five sites. The breeding populations of other habitats have not been surveyed in detail. British-breeding Snipe are partial migrants. Most of those breeding in Scotland and Northern England migrate to Ireland for the winter, where they join the largely resident Irish breeding population. Birds breeding in the rest of Britain disperse in a south or south-westerly direction and a few reach the continent (Cramp and Simmons 1983).

The movements of Snipe within Europe are complex and there is need for a detailed analysis of the accumulated recoveries. The following is based on the summary account in Cramp and Simmons (1983). Most Icelandic Snipe winter in Ireland, with some migrating to north-west Scotland. Relatively few of these birds have been ringed (below). Many of the Snipe breeding in Fenno-Scandia and north-west Russia winter in Britain. Forty-four per cent of winter recoveries of birds ringed on passage in Norway were from Britain and Ireland, compared with 17% for birds ringed in Sweden and 22% for birds ringed in Finland. Recovery data also indicate that some of the breeding birds from West Germany and Poland through to the USSR winter in Britain. This forms part of a south-westerly migration by European breeding populations. Continued passage from Britain of birds from some of the above populations is illustrated by records of winter-ringed Snipe from Britain subsequently recovered in France, Iberia, Italy and Morocco. Detailed interpretation of these recovery patterns is difficult, because few Snipe of known breeding origin have been ringed. Estimates of the relative proportions of the different populations wintering in Britain and of overall wintering numbers have not been made.

The mild winter distribution of recoveries is consistent with the patterns outlined above, 69% of recoveries being from Britain, 1.6% from the Waddenzee area, 19% from France and 10% from south Europe and Africa (Table 24.1). The single bird recovered from Norway in November was probably a late migrant.

24.2 Ringing effort

Few Snipe chicks have been ringed in Britain and so this analysis refers to birds ringed as full-grown. The main ringing areas were Central and South Britain (Table 24.2). Few recoveries of birds ringed in North Britain were reported and there were only three recoveries of birds ringed in Ireland. The sample is divided about equally between birds ringed in Autumn and in Winter. Very few have been ringed between April and June.

Little Snipe ringing took place before 1950. Ringing effort increased until 1960 and has since remained at a fairly constant level (Figure 24.1). Fewer birds were ringed in the early 1980s. Peaks of recoveries in 1962/63 (91 records) and 1978/79 (44 records) are associated with severe weather. The lack of a peak in 1982/83 may be because too few ringed birds were available to be recovered. The peak in the graph of ringing years in 1961/62 reflects high mortality of this cohort during the 1962/63 winter.

24.3 Distribution of recoveries in mild and severe winters

The recovery distribution during mild spells did not differ significantly from that for either severe winters or for severe spells (Table 24.1). The distance distributions for mild and severe weather were similarly not significantly different. Mean distances between ringing and recovery places were 337 km during mild winters, 371 km during severe winters and 373 km during severe spells.

Comparison of severe spells with the same periods in immediately previous and subsequent winters also gave no significant difference (Table 24.3). Corresponding mean distances between ringing and recovery places were 373 km and 395 km respectively (Mann-Whitney U-test, t=1.60, ns). However, this lack of differences masks an increase in recovery rates in most areas during severe weather (Table 24.4). This increase in recovery rates, of over three times in North and Central Britain and over five times in South Britain, must largely reflect increased mortality. The small increase in recovery rates in Ireland was not statistically significant. A doubling of the number of recoveries in France and a quadrupling of the number in Iberia and Africa almost certainly represent cold weather movements to these areas. One caveat is that over half the data relate to the 1962/63 winter. However the 3.2-fold increase in the number of recoveries from Europe is very similar to the 3.0-fold increase obtained for the winter of 1978/79, the only other winter with an adequate sample of recoveries.

24.4 Summary

Comparison of percentage distributions of recoveries and of mean distances between ringing and recovery places provides no evidence of cold weather movements. However, this appears to be because movement to some areas is balanced by increased mortality in others. Increased recovery rates in Britain imply higher than usual mortality there during cold winters, while increased recovery rates from France and Iberia suggest a southerly migration of other birds.

Table 24.1 Recovery regions of British-ringed Snipe in mild and severe winters.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
Norway	(1)	1	0	0
North Britain	(2)	8	2	1
Central Britain	(3)	178	64	41
Ireland	(4)	41	11	7
South Britain	(5)	85	31	26
Waddenzee	(6)	7	1	0
North France	(7)	47	18	14
South France	(8)	39	7	6
Iberia	(9)	37	16	12
Central Europe	(10)	2	1	0
Eastern Europe	(11)	1	1	1
Africa	(12)	5	3	2
Total		451	155	110

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
Norway (1)	0.2	0.0	0.0
N. & C.Britain (2-3)	41.2	42.6	38.2
Ireland (4)	9.1	7.1	6.4
South Britain (5)	18.8	20.0	23.6
Waddenzee & E.Europe (6+11)	1.8	1.3	0.9
France (7-8)	19.1	16.1	18.2
S.Europe (9+10+12)	9.8	12.9	12.7

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=2.420, 4 df, ns
Mild winters v severe spells x^2=2.881, 4 df, ns

Table 24.2 Ringing periods and regions of British-ringed Snipe recovered in winter.

Ringing region	Ringing period			
	July-October	November-March	April-June	
North Britain	20	7	0	27
Central Britain	241	181	8	430
Ireland	1	2	0	3
South Britain	45	100	1	146
Total	307	290	9	606

Table 24.3 Recovery regions of British-ringed Snipe in years before, during and after severe weather.

(a) Number of recoveries

Recovery region		Mild spells			Severe spells
		Years before	Years after	Years before +after	
North Britain	(1)	1	0	1	1
Central Britain	(2)	14	8	22	41
Ireland	(3)	5	5	10	7
South Britain	(4)	7	3	10	26
North France	(5)	6	3	9	14
South France	(6)	2	4	6	6
Iberia	(7)	4	2	6	12
Eastern Europe	(8)	0	0	0	1
Africa	(9)	0	1	1	2
Total		39	26	65	110

(b) Percentage of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
N. & C.Britain (1-2)	38.5	30.8	35.4	38.2
Ireland (3)	12.8	19.2	15.4	6.4
South Britain (4)	17.9	11.5	15.4	23.6
Eastern Europe (8)	0.0	0.0	0.0	0.9
France (5-6)	20.5	26.9	23.1	18.2
S.Europe (7+9)	10.3	11.5	10.8	12.7

Only recoveries during the period of severe weather are included.
Years before v years after x^2=1.367, 3 df, ns
Severe winters v before+after x^2=5.465, 4 df, ns

Table 24.4 Increase in the number of Snipe recoveries in each region during severe spells.

	Mild spells[a]	Severe spells	Recovery index	x^2	sig.
N. & C. Britain	23	42	3.65	28.62	***
Ireland	10	7	1.40	0.47	ns
S.Britain	10	26	5.20	24.50	***
N.France	15	20	2.67	8.93	**
Iberia & Africa	7	14	4.00	10.50	**

Data from Table 24.3

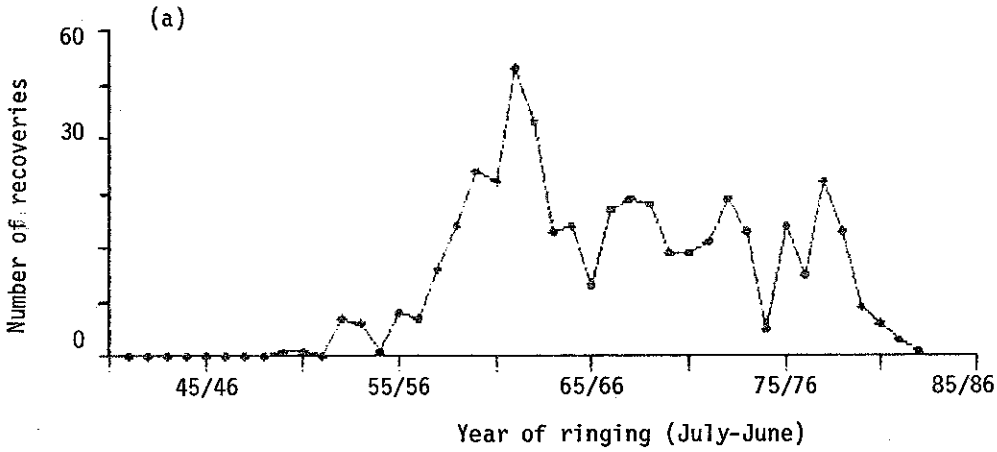
a Same dates as severe spells in winters immediately before and after severe ones.

$$\text{Recovery Index} = \frac{2 \times \text{number of recoveries during severe spells}}{\text{number of recoveries in years before and after}}$$

x^2 is a test against an expected ratio between columns 1 and 2 of 2:1

*** P<0.001 ** P<0.01 ns not significant

For further details of the Recovery Index see methods.



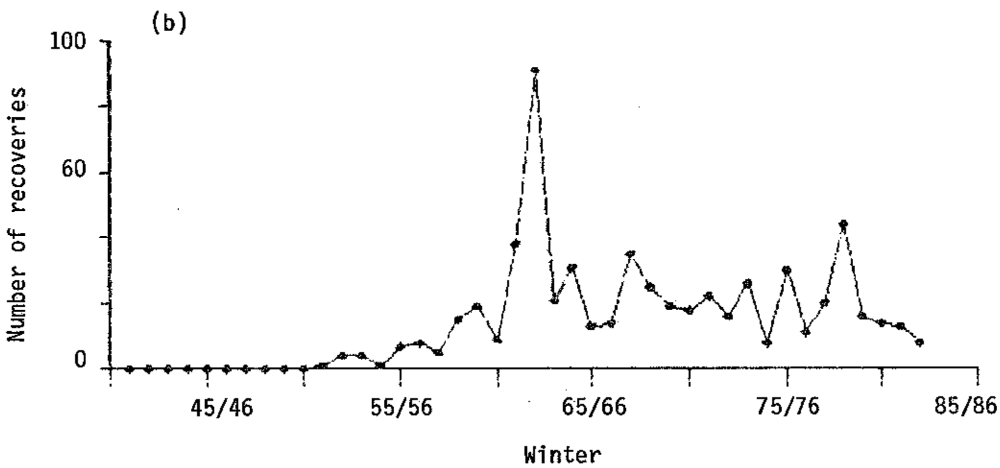


Figure 24.1 Winter recovery totals for Snipe.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

WOODCOCK *Scolopax rusticola*

25.1 Normal pattern of movements

The Woodcock is a widespread breeding species in Britain with a population of probably between 10,000 and 50,000 (Sharrock 1976). Movements of British birds based largely on recoveries reported before the starting date for this analysis are summarised by Alexander (1945-1947). Most birds move less than 80 km but some Woodcock from Scotland and northern England winter in Ireland. A few birds from all parts of Britain migrate south to winter in Belgium, France and Iberia.

In winter the British breeding population is joined by a large but unknown number of immigrants from Scandinavia, Russia and Germany (Clausager 1974, Kalchreuter 1974). Most winter visitors are probably from the western end of this range. Forty-three per cent of foreign recoveries of Norwegian-ringed Woodcock were from Britain, compared with 28% from Sweden and 15% from Finland. Southerly and westerly cold weather movements by these Fenno-Scandian populations have been reported (Cramp and Simmons 1983). Such movements may result in immigration into Britain during severe weather. A few recoveries indicate interchange between the various breeding populations mentioned above.

Mild winter recoveries of British-ringed birds fit the pattern described above, 81% being from Britain and Ireland, 9% from the Waddenzee area and 9% from France (Table 25.1). The single recovery from Norway probably represents a bird which was still on passage when recovered, as Woodcock do not winter there. The mean distance moved by birds recovered during mild winters was 252 km, 44% of recoveries being less than 50 km from the ringing place.

25.2 Ringing effort

All the birds included in this analysis were ringed as full-grown. Very few Woodcock ringed as chicks have been recovered in winter. Forty-one per cent of recoveries were of birds ringed in Central Britain, the rest being spread equally between the other regions (Table 25.2). Fifty-nine per cent of birds were ringed in Winter, with an approximately equal amount of ringing in Summer and Autumn. Very small numbers of recoveries have been reported since the mid-1940s. Most of the data presented here were accumulated since the early 1970s (Figure 25.1).

25.3 Distribution of recoveries in mild and severe winters

The percentage distributions of recoveries from severe winters and from severe spells do not differ significantly from those for mild winters (Table 25.1). Moreover, there is no significant difference when the regional distribution of recoveries during severe spells is compared with that from the severe periods in immediately previous and subsequent winters (Table 25.3). The data in Table 25.3 indicate an increase in the recovery rate during severe weather but this is not significant (x^2=2.42).

The lack of cold weather movements is supported by analyses of distances between ringing and recovery places. Mean distances were 252 km during mild winters, 298 km during severe winters and 175 km during severe spells (Mann-Whitney U-tests: mild winters v severe winters t=0.60 ns; mild winters v severe spells t=0.51 ns). The mean distance for recoveries from the same periods as severe spells in immediately previous and subsequent winters was 240 km (Mann-Whitney U-test v severe spells, U=89.5, ns).

Thus the limited recovery data available for this species provide no evidence of cold weather movements.

25.4 Summary

The recovery data for Woodcock are very limited, with only 26 recoveries from severe winters, only 12 of which were reported during severe spells. These data provide no evidence of cold weather movements. There is an indication of increased mortality in cold weather, but the increase in the number of recoveries is not significant.

Table 25.1 Recovery regions of British-ringed Woodcock in mild and severe winters.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
Norway	(1)	1	0	0
N. Britain	(2)	6	3	1
Central Britain	(3)	29	9	4
Ireland	(4)	17	7	3
S. Britain	(5)	12	5	4
Waddenzee	(6)	7	1	0
N. France	(7)	6	1	0
S. France	(8)	1	0	0
Total		79	26	12

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
Norway (1)	1.3	0.0	0.0
N. & C. Britain (2-3)	44.3	46.2	41.7
Ireland & S.Britain (4-5)	36.7	46.2	58.3
Europe (6-8)	17.7	7.7	0.0

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=1.739, 2 df, ns
Mild winters v severe spells x^2=0.264, 1 df, ns

Table 25.2 Ringing periods and regions of British-ringed Woodcock recovered in winter.

Ringing region	Ringing period July-October	November-March	April-June	
N. Britain	6	8	9	23
Central Britain	15	21	7	43
Ireland	4	16	2	22
S. Britain	4	16	2	22
Total	25	62	18	105

Table 25.3 Recovery regions of British-ringed Woodcock in years before, during and after severe weather.

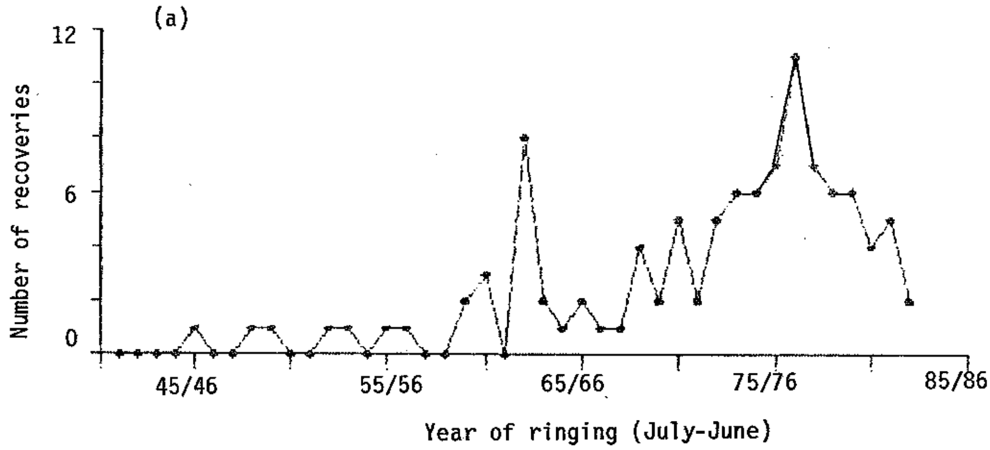
(a) Number of recoveries

Recovery region		Mild spells: Years before	Mild spells: Years after	Mild spells: Years before +after	Severe spells
N. Britain	(1)	0	0	0	1
Central Britain	(2)	2	1	3	4
Ireland	(3)	1	4	5	3
S. Britain	(4)	2	1	3	4
N. France	(5)	0	2	2	0
Total		5	8	13	12

(b) Percentage of recoveries

Recovery region		Mild spells: Years before	Mild spells: Years after	Mild spells: Years before +after	Severe spells
N. & C.Britain	(1-2)	40.0	12.5	23.1	41.7
Ireland and S.Britain	(3-4)	60.0	62.5	61.5	58.3
N. France	(5)	0.0	25.0	15.4	0.0

Only recoveries during the period of severe weather are included.
Severe winters v before+after x^2=0.321, 1 df, ns



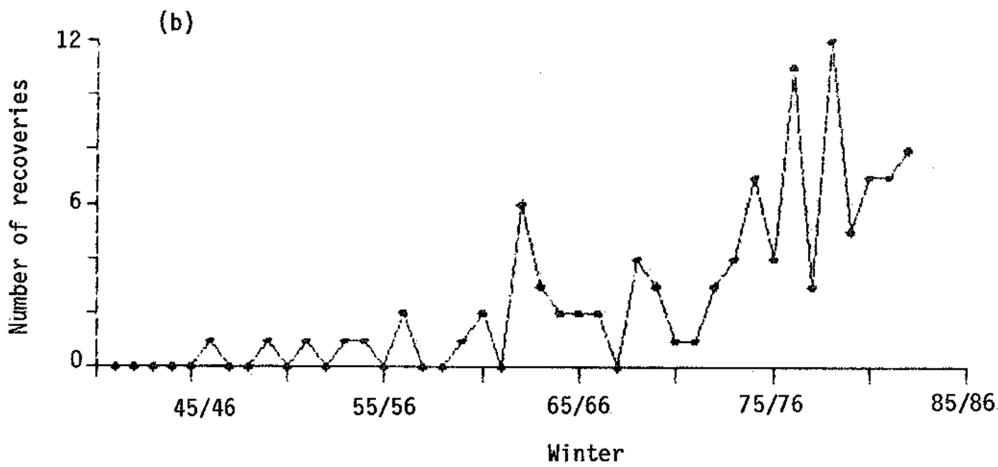


Figure 25.1 Winter recovery totals for Woodcock.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

CURLEW *Numenius arquata*

26.1 Normal pattern of movements

Curlews breed throughout Britain but they are sparsely distributed in East and South-east England. The population was estimated at between 40,000 and 70,000 pairs from the Breeding Atlas data (Sharrock 1976). Birds breeding in Scotland winter in West Britain and Ireland, while those from the South of England move south to winter in France and Iberia. Populations breeding in Northern England show an intermediate pattern of migration, with some moving to Ireland while others migrate south (Bainbridge and Minton 1978). Irish breeders are thought to be sedentary but there are few data on their movements.

Large numbers of continental Curlews winter in Britain. These birds originate mainly in coastal Norway, the countries around the Baltic and central western Europe. Considerable numbers of Curlews from the U.S.S.R. may also be involved but there are few ringing recoveries. Norwegian birds winter mainly in northern Britain and Ireland, while those from Sweden and Finland winter throughout Britain and Ireland. Most recoveries of Curlews ringed in central western Europe are from southern England and south Wales (Bainbridge and Minton 1978).

Most British and Irish breeding Curlews move from their breeding areas to the coast by late July. Adult continental birds arrive from late June through to August but most juveniles do not appear until mid-September. Most birds moult and winter at the same site, to which they return in subsequent years. Declines in numbers counted on estuaries during the mid-winter period are due mainly to increased field feeding rather than to long distance movements. Eighty-one per cent of winter recoveries of autumn- and winter-ringed Curlews are within 30 km of their ringing site, and this pattern holds both within and between years (Bainbridge and Minton 1978). Departure for the breeding grounds takes place from February onwards.

Declines in the numbers of Curlews breeding in Hertfordshire, Worcestershire, Scotland and Ireland were recorded following the 1962/63 winter (Dobinson and Richards 1964) but few quantitative data on the impact of cold winters on breeding numbers are available. Movements into west England and Ireland and south to the Channel Islands and France were recorded during the 1962/63 winter (Dobinson and Richards 1964) as was emigration from Hampshire (Ash 1964). Some westerly movement may also have taken place in the winter of 1981/82, when increased numbers were recorded in North Wales (Clark 1982).

26.2 Ringing effort

Ninety-seven winter recoveries of Curlews ringed as chicks were available for this analysis, nearly all from the main breeding areas in North and Central Britain (Table 26.1). Annual recovery totals are too small to reflect differences in mortality (Figure 26.1). Ringing of Curlew chicks declined between the 1950s and 1960s and this is reflected by recovery totals of 42 and 25 respectively. There has been an increase in the ringing of Curlew chicks since the late 1970s but this is not shown by the recovery totals, perhaps due to a decrease in recovery rates.

Most full-grown Curlews have been ringed in East and South England during the Autumn and Winter periods and there are few recoveries of birds ringed in other parts of Britain (Table 26.2). Almost no full-grown birds were ringed before the late 1950s but since then similar numbers have been ringed in most years, except for 1961/62 which was a particularly successful season (Figure 26.2). A marked peak in recoveries is associated with the 1962/63 winter but no such peak is apparent in relation to the winters of 1978/79 or 1981/82.

26.3 Distribution of recoveries in mild and severe winters

The recovery distributions for Curlews ringed as chicks do not differ significantly between mild and severe winters, or between mild winters and severe spells (Table 26.3). In both periods fewer than 16% of recoveries were outside Britain and Ireland. Too few recoveries from years immediately before and after cold winters are available to compare them with severe spells. Mean distances between ringing and recovery places were 327 km during mild winters, 360 km during severe winters and 312 km during severe spells. Neither of the last two figures differs significantly from that for mild winters (Mann-Whitney U-tests). These birds normally winter in west Britain and Ireland, the areas which are least severely affected by cold weather. The lack of cold weather movements is consistent with the use of such mild wintering areas.

In contrast, Curlews ringed as full-grown undertake cold weather movements out of eastern and perhaps southern England. The recovery distribution for mild winters is significantly different from that during severe winters and during severe spells only (Table 26.4). Comparing mild winters with severe spells the percentage of recoveries from North and East Britain drops from 46% to 19% while that in south Europe increases from 3% to 24%. These results are confirmed by a comparison of severe spells with years immediately before and after cold weather (Table 26.5). The mean distance between ringing and recovery places of birds recovered during mild winters was 56 km, significantly less than the 142 km for all cold winter recoveries (Mann-Whitney U-test, $t=2.545$, $P<0.05$) and the 172 km for severe spells only (Mann-Whitney U-test, $t=2.417$, $P<0.05$). A similar pattern is apparent when severe spells are compared with the same periods in immediately previous and subsequent winters. However, the means of 172 km for severe spells and 52 km for years before and after severe winters are not significantly different (Mann-Whitney U-test, $t=1.512$), probably due to the reduced sample size.

26.4 Summary

Curlews breeding in northern Britain winter in western Britain and Ireland, while those from southern Britain winter in southern England and on the Continent. These birds winter in relatively mild areas and there is no evidence that they undertake cold weather movements. Curlews breeding in various parts of north-west Europe, particularly Sweden and Finland, winter throughout Britain, but most ringing of these birds has taken place on the East and South coasts of England. Recoveries indicate that these birds are extremely faithful to their wintering sites both within and between winters, but that some individuals move south to France and Iberia in severe winters.

Table 26.1 Ringing regions of Curlews ringed as chicks and recovered in winter.

Ringing region	No. of recoveries
North Britain	56
Central Britain	39
South Britain	2
Total	97

Table 26.2 Ringing periods and regions of Curlews recovered in winter: birds ringed as full-grown.

Ringing region	Ringing period			
	July-October	November-March	April-June	
N.E.Scotland	4	4	2	10
N.W.Scotland	1	1	1	3
East England	80	23	4	107
Irish Sea	29	14	1	44
Ireland	4	1	0	5
South England	57	29	3	89
Total	175	72	11	258

Table 26.3 Recovery regions of Curlews in mild and severe winters: birds ringed as chicks.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
North Britain	(1)	9	4	4
Central Britain	(2)	21	6	2
Ireland	(3)	36	4	2
South Britain	(4)	2	3	3
North France	(5)	4	2	2
South France	(6)	3	0	0
Iberia	(7)	2	1	0
Total		77	20	13

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
N. & C.Britain (1-2)	39.0	50.0	46.2
Ireland & S.Britain (3-4)	49.4	35.0	38.5
Europe (5-7)	11.7	15.0	15.4

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=0.664, 1 df, ns
Mild winters v severe spells x^2=0.101, 1 df, ns

Table 26.4 Recovery regions of Curlews in mild and severe winters: birds ringed as full-grown.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
N.E.Scotland	(1)	6	1	0
N.W.Scotland	(2)	2	2	0
East England	(3)	82	16	7
Irish Sea	(4)	26	8	4
Ireland	(5)	6	3	3
South England	(6)	66	19	13
Waddenzee	(7)	3	2	1
North France	(8)	6	6	5
South France	(9)	0	3	3
Iberia	(10)	0	1	1
Total		197	61	37

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
N. & E.Britain (1-3)	45.7	31.1	18.9
West Britain (4-5)	16.2	18.0	18.9
South England (6)	33.5	31.1	35.1
Waddenzee (7)	1.5	3.3	2.7
S.Europe (8-10)	3.0	16.4	24.3

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=15.552, 3 df, $P<0.01$
Mild winters v severe spells x^2=24.892, 3 df, $P<0.001$

Table 26.5 Recovery regions of Curlews in years before, during and after severe weather: birds ringed as full-grown.

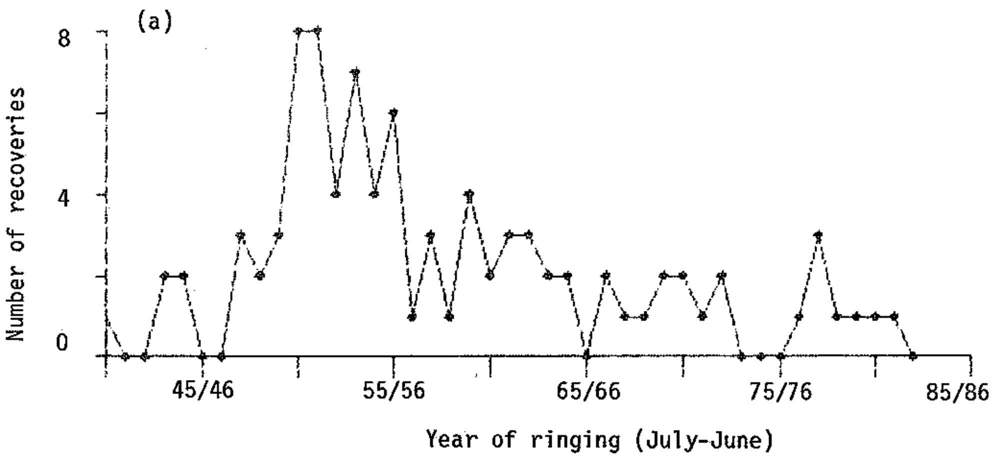
(a) Number of recoveries

Recovery region		Mild spells			Severe spells
		Years before	Years after	Years before +after	
N.E.Scotland	(1)	1	0	1	0
East England	(2)	6	8	14	7
Irish Sea	(3)	3	3	6	4
Ireland	(4)	0	0	0	3
South England	(5)	3	3	6	13
Waddenzee	(6)	0	0	0	1
North France	(7)	1	1	2	5
South France	(8)	0	0	0	3
Iberia	(9)	0	0	0	1
Total		14	15	29	37

(b) Percentage of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
N. & E.Britain (1-2)	50.0	53.3	51.7	18.9
West Britain (3-4)	21.4	20.0	20.7	18.9
South England (5)	21.4	20.0	20.7	35.1
Europe (6-9)	7.1	6.7	6.9	27.0

Only recoveries during the period of severe weather are included.
Years before v years after x^2=0.037, 1 df, ns
Severe winters v before+after x^2=10.077, 3 df, $P<0.05$



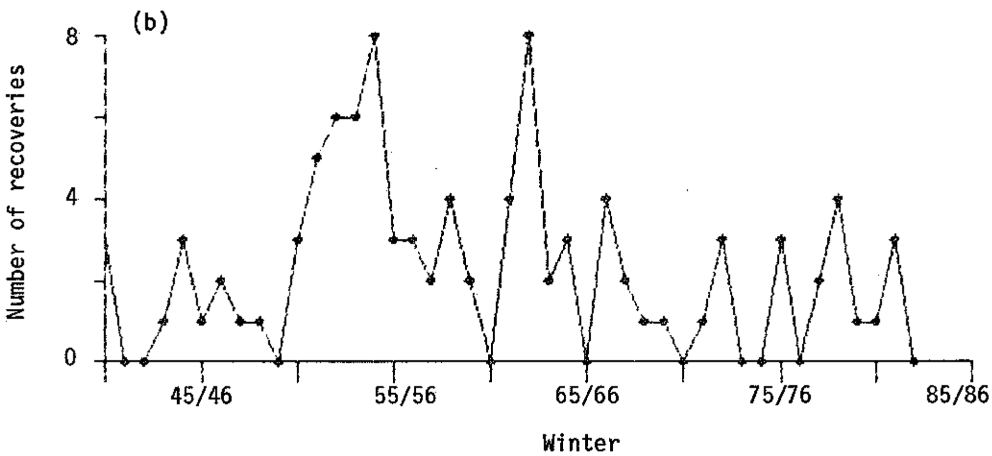


Figure 26.1 Winter recovery totals for Curlews ringed as chicks.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

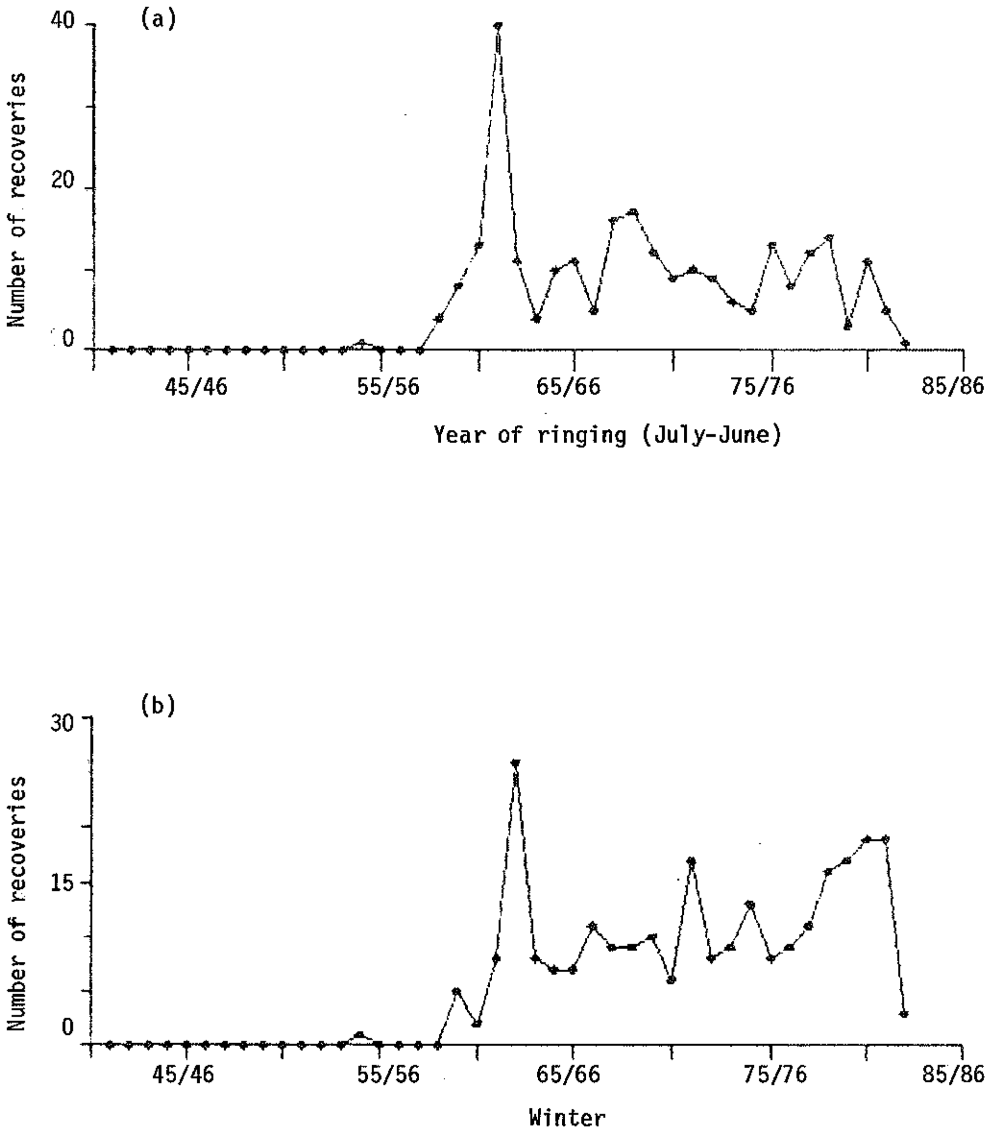


Figure 26.2 Winter recovery totals for Curlews ringed as full-grown.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

REDSHANK *Tringa totanus*

27.1 Normal pattern of movements

Redshanks breed throughout Britain and Ireland, but the main concentration of breeding birds is in Scotland and the North of England. The British and Irish breeding population was estimated to contain 38,000 to 48,000 pairs from the Breeding Atlas data (Sharrock 1976). These birds generally move south for the winter, most remaining within Britain but some reaching France, Iberia and occasionally North Africa (Hale 1973). Redshanks from northern Britain generally move south for the winter, while those from southern Britain often remain close to their breeding areas. On average first year birds move slightly further than adults. During mild winters 67% of recoveries of Redshanks ringed as chicks were within Britain.

Most of the Redshanks which breed in Iceland and the Faeroes visit Britain for the winter. Small numbers of Icelandic breeders remain in Iceland for the winter, while some others reach north-west Europe, particularly the Low Countries. A single recovery of an Icelandic Redshank in Morocco is exceptional (Cramp and Simmons 1983). Icelandic Redshanks winter on both the east and west coasts of Britain and recoveries indicate that the population is about equally divided between the two areas (Cramp and Simmons 1983). Wing-length data also suggest this, and indicate that fewer Icelandic birds winter on the south coast of Britain (Furness and Baillie 1981). Average wing-lengths of Icelandic birds are longer than those of British breeders (Hale 1971). Cramp and Simmons (1983) reported that the total number of Redshanks wintering in Atlantic Europe was about 143,000, of which 100,000 were in Britain and a further 14,500 in Ireland. However, these figures do not take account of the substantial decline in numbers wintering in Britain which has taken place in recent years (Moser in prep.). Most of these birds belong to the Icelandic or British breeding populations. Redshanks breeding in Scandinavia move further south to winter in Iberia and North Africa.

British breeders move to coastal areas from late June onwards, and usually return to their breeding grounds in February or March. Icelandic birds arrive in Britain in July and August, and leave again between late March and early May.

Redshanks are particularly vulnerable to cold weather mortality, perhaps because they are unable to accumulate sufficient body reserves to withstand long periods of cold weather (Davidson 1982). Several large cold weather mortalities have been recorded (Pilcher 1964, Baillie 1980, Clark 1982). Substantial declines in the populations of Redshanks breeding in some areas of England were noted following the 1962/63 winter (Dobinson and Richards 1964). The Waterways Bird Survey suggested a decline in Redshank breeding populations following the winter of 1978/79 but not following that of 1981/82 (Marchant and Hyde 1980, Taylor and Marchant 1983). Some evidence of cold weather movements within Britain has been recorded but these may have been over relatively short distances. Concentrations of Redshanks on the south coast of England were noted during the 1962/63 cold winter (Dobinson and Richards 1964), while departures of Redshanks in response to cold weather have been recorded on the Ythan estuary in North-east Scotland (Baillie 1980, Clark 1982) and on the Tees estuary in Cleveland (Davidson 1982). Two marked birds from the Ythan were recorded on the Firth of Forth and one reached the Clyde.

27.2 Ringing effort

Most chicks have been ringed in North and Central Britain, reflecting the breeding distribution of the species (Table 27.1). Ringing effort for chicks has remained at a low and fairly constant level, except for a period of increased ringing from 1959-1961. Five or less recoveries were reported from all winters except that of 1962/63, when 22 were reported (Figure 27.1).

Ringing of full-grown Redshanks has mainly involved birds caught on estuaries during the Autumn and Winter periods (Table 27.2). Reasonable numbers of recoveries are available from birds ringed in North-east Scotland, East England, the Irish Sea and South England but relatively little ringing has been carried out in North-west Scotland and Ireland (Table 27.2). Very little ringing of full-grown Redshanks was carried out before the early 1960s and a further increase in ringing effort took place in the mid to late 1970s. Conspicuous recovery peaks are associated with the cold winters of 1962/63, 1978/79 and 1981/82 (Figure 27.2).

27.3 Distribution of recoveries in mild and severe winters

The mild winter recovery distribution for Redshanks ringed as chicks differs significantly from that during cold winters, and during severe spells only (Table 27.3). Because more birds were recovered abroad in November and March of mild winters, the mild winter sample has been restricted to the period from December to February. Insufficient recoveries were available from years immediately before and after severe winters for comparison with the recovery distribution during severe spells. The large number of recoveries in the South of England during cold weather is mainly due to high mortality of locally bred birds during the 1962/63 winter. Ten such recoveries relate to birds ringed between 1959 and 1962, only two of these records involving movements of over 50 km. However, there is weak evidence of increased southward movement by birds from North and Central Britain as a result of severe weather. Seven out of 14 birds ringed in these regions were recovered south of their region of ringing during mild winters, compared with 14 out of 16 during severe ones (Fisher test P=0.046). Mean distances between ringing and recovery places of Redshanks ringed as chicks in these areas were 292 km during mild winters and 370 km during cold ones (Mann-Whitney U-test, ns).

Recovery distributions for Redshanks ringed as full-grown have been tabulated by recovery regions, because comparisons using the data for the whole of Britain together are complicated by regional differences in mortality (below). Recovery distributions during cold winters do not differ significantly from those during mild ones (Table 27.4), and for all regions over 80% of recoveries are from the region of ringing. Comparison of recovery distributions during cold spells with those from immediately previous and subsequent winters gives similar results (Table 27.5). The only significant difference is that 100% of recoveries of birds ringed in the Irish Sea area were from the region of ringing during cold spells compared with only 75% during mild ones. This might suggest less movement during cold weather, but it is probably due to an increased probability of recovery in the area of ringing due to cold weather mortality.

Combining data for Britain as a whole mean distances between ringing and recovery places were 83 km during mild winters and 49 km during cold ones (Mann-Whitney U-test, t=0.140, ns). Similarly for recoveries during severe spells the mean distance moved was 48 km compared with 83 km for recoveries from the same period in immediately previous and subsequent winters. These results all indicate that Redshanks are faithful to their wintering areas in both mild and cold winters. Thus the movements of birds out of some northern estuaries during cold weather probably represent regional redistributions of birds rather than long distance movements.

Redshanks in all parts of Britain experience greatly increased mortality during cold weather (Table 27.6). As expected from climatic conditions, the mortality increase is greatest in North-east Scotland and least in the Irish Sea area and in the South of England. The high Recovery Index for birds ringed as chicks is due to the large number of recoveries in southern England during the 1962/63 winter (above). It suggests that southern British breeding birds may be more vulnerable to severe weather than Icelandic and perhaps northern British ones but this hypothesis requires further testing.

27.4 Summary

Many British breeding Redshanks winter in Britain, although some move south to France and Iberia. The majority of the Icelandic and Faeroese Redshank populations also winter in Britain. There is weak evidence that Redshanks ringed as chicks in Northern and Central Britain move further south during severe winters. Redshanks ringed on estuaries in Autumn and Winter are faithful to their wintering areas in both mild and cold weather, and there is no evidence of increased movement in response to severe weather. Throughout Britain the mortality of Redshanks is greatly increased by cold weather.

Table 27.1 Ringing regions of Redshanks ringed as chicks and recovered in winter

Ringing region	No. of recoveries
North Britain	30
Central Britain	20
South Britain	16
Total	66

Table 27.2 Ringing periods and regions of Redshanks recovered in winter: birds ringed as full-grown.

Ringing region	Ringing period			
	July-October	November-March	April-June	
N.E.Scotland	97	67	5	169
N.W.Scotland	16	19	3	38
East England	211	66	12	289
Irish Sea	51	58	22	131
Ireland	8	8	2	18
South England	67	46	18	131
Total	450	264	62	776

Table 27.3 Recovery regions of Redshanks in mild and severe winters: birds ringed as chicks.

(a) Number of recoveries

Recovery region		Mild winters[a]	Severe winters	Severe spells
North Britain	(1)	4	0	0
Central Britain	(2)	5	5	2
Ireland	(3)	1	1	0
South Britain	(4)	3	17	14
Waddenzee	(5)	1	3	1
North France	(6)	1	2	2
South France	(7)	0	2	1
Iberia	(8)	1	0	0
Total		16	30	20

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
N. & C.Britain (1-2)	56.3	16.7	10.0
Ireland & S.Britain (3-4)	25.0	60.0	70.0
Europe (5-8)	18.8	23.3	20.0

For definitions of mild and severe winters see methods.

a Data from mild winters are from December to February only (see text).

Mild winters v severe winters x^2= 8.146, 2 df, P<0.05
Mild winters v severe spells x^2= 9.830, 2 df, P<0.01

Table 27.4 Recovery regions of Redshanks ringed as full-grown in different parts of Britain and recovered in mild or cold winters.

Ringing region	Recovery region	Mild winters n	Mild winters %	Cold winters n	Cold winters %
N.E.Scotland	N.E.Scotland	58	93.5	102	95.3
	N.W.Scotland	0	0.0	2	1.9
	E.England	0	0.0	3	2.8
	S.England	2	3.2	0	0.0
	Waddenzee	2	3.2	0	0.0
	Total	62		107	
East England	N.E.Scotland	3	1.6	0	0.0
	E.England	160	86.0	87	84.5
	Irish Sea	3	1.6	1	1.0
	S.England	9	4.8	10	9.7
	Waddenzee	1	0.5	1	1.0
	France	8	4.3	4	3.9
	Iberia & Africa	2	1.1	0	0.0
	Total	186		103	
Irish Sea	N.W.Scotland	1	1.1	0	0.0
	E.England	2	2.2	0	0.0
	Irish Sea	83	90.2	38	97.4
	S.England	3	3.3	1	2.6
	Waddenzee	1	1.1	0	0.0
	France	2	2.2	0	0.0
	Total	92		39	
South England	N.E.Scotland	1	1.3	0	0.0
	E.England	0	0.0	2	3.7
	Irish Sea	1	1.3	0	0.0
	S.England	68	88.3	46	85.2
	France	5	6.5	6	11.1
	Iberia & Africa	2	2.6	0	0.0
	Total	77		54	

For definitions of mild and cold winters see methods

Tests between recovery distributions in mild and cold winters:

Ringed in N.E.Scotland $x^2=0.020$, 1 df, ns
Ringed in E.England $x^2=0.034$, 1 df, ns
Ringed in Irish Sea area $x^2=1.130$, 1 df, ns
Ringed in S.England $x^2=0.068$, 1 df, ns

Table 27.5 Recovery regions of Redshanks ringed as full-grown in different parts of Britain and recovered in years before during and after severe weather.

Ringing region	Recovery region	Mild spells[a]		Severe spells	
		n	%	n	%
N.E.Scotland	N.E.Scotland	12	100.0	80	96.4
	N.W.Scotland	0	0.0	1	1.2
	E.England	0	0.0	2	2.4
	Total	12		83	
East England	E.England	26	89.7	49	77.8
	Irish Sea	0	0.0	1	1.6
	S.England	2	6.9	9	14.3
	Waddenzee	0	0.0	1	1.6
	France	0	0.0	3	4.8
	N.Africa	1	3.4	0	0.0
	Total	29		63	
Irish Sea	Irish Sea	12	75.0	28	100.0
	S.England	2	12.5	0	0.0
	Waddenzee	1	6.3	0	0.0
	France	1	6.3	0	0.0
	Total	16		28	
South England	E.England	0	0.0	2	5.1
	Irish Sea	1	7.1	0	0.0
	S.England	13	92.9	33	84.6
	N.France	0	0.0	4	10.3
	Total	14		39	

a Equivalent dates to severe spells in winters immediately before and after cold ones.

Fisher tests between recovery distributions in severe spells and in years before and after:

Ringed in N.E.Scotland P=0.999
Ringed in E. England P=0.250
Ringed in Irish Sea P=0.013
Ringed in S.England P=0.660

Table 27.6 Recovery Index for Redshanks ringed in different parts of Britain

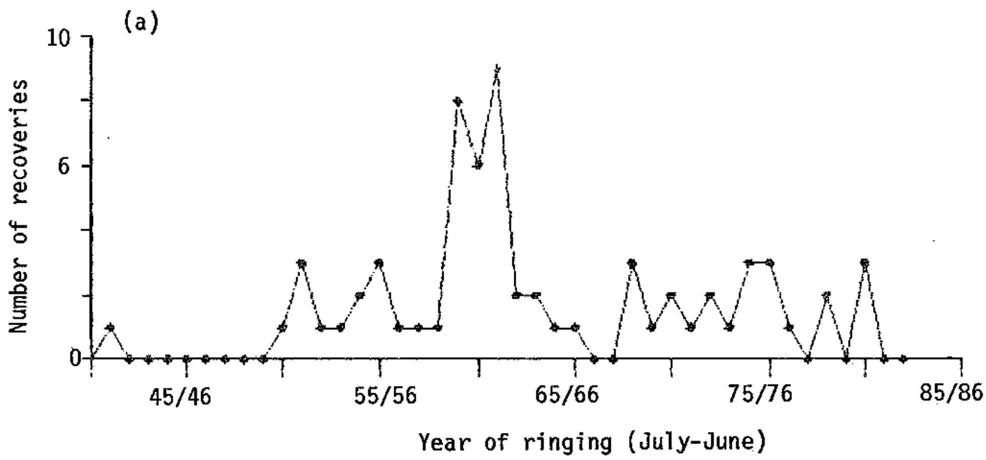
Ringing region	Mild spells[a]	Severe spells	Recovery Index	x^2	Sig.
N.E.Scotland	12	83	13.83	124.82	***
E.England (all)	29	63	4.34	51.14	***
E.England (ex.78/79)	11	50	9.09	64.93	***
Irish Sea (all)	16	28	3.50	18.18	***
Irish Sea (ex.78/79)	6	15	5.00	13.71	***
S.England	14	39	5.57	38.64	***
Pulli throughout Britain	2	20	20.00	32.82	***

a Equivalent dates to severe spells in winters immediately before and after cold ones.

For details of Recovery Index see methods.

Unusually large numbers of recoveries occurred in East England and the Irish Sea area during the 1977/78 winter. Therefore results excluding data relating to the 1978/79 winter are also given for these regions.

Significance *** $P<0.001$



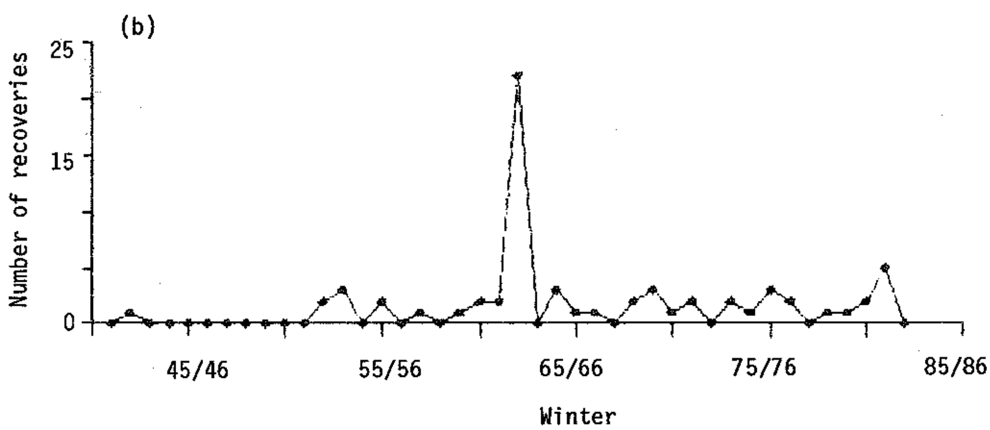


Figure 27.1 Winter recovery totals for Redshanks ringed as chicks.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

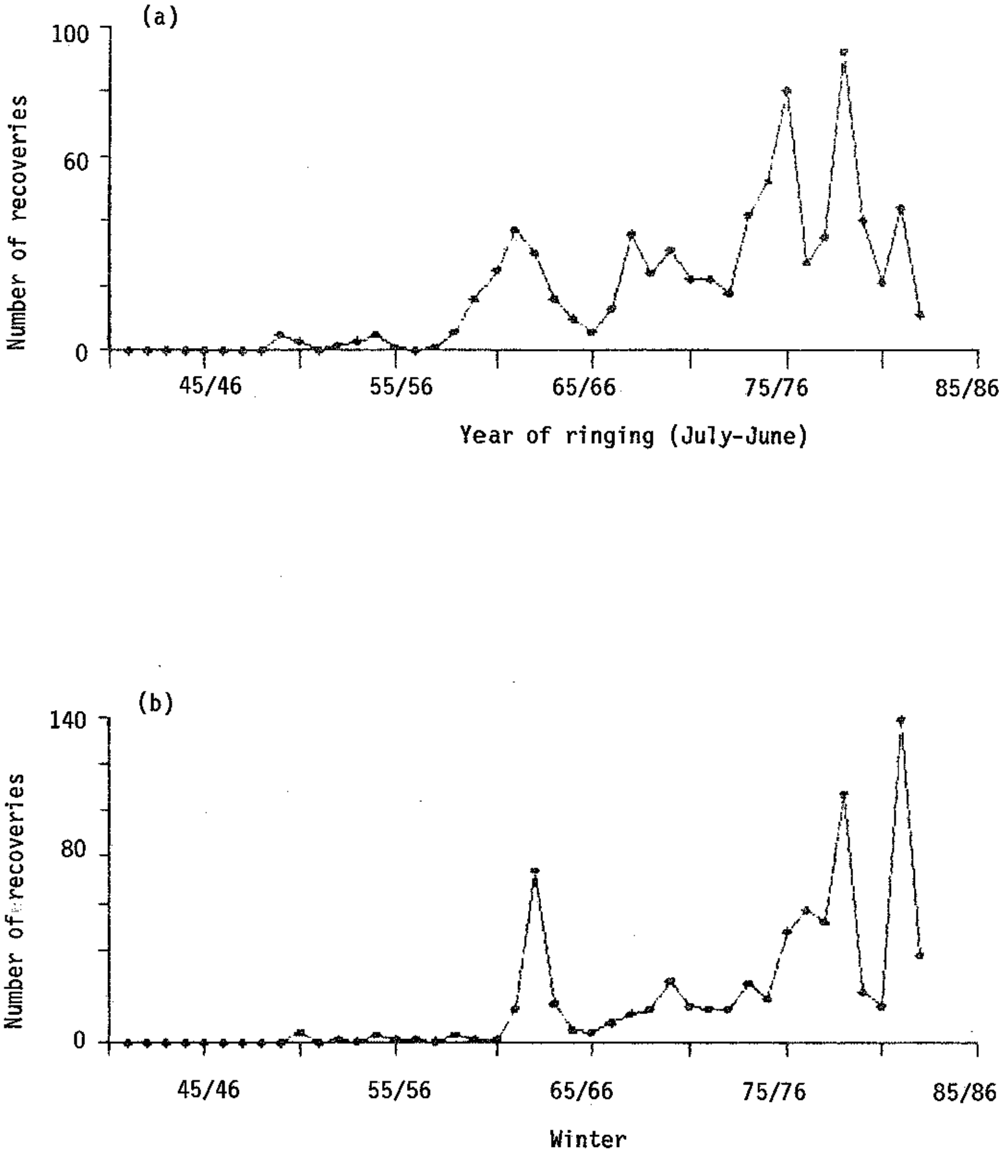


Figure 27.2 Winter recovery totals for Redshanks ringed as full-grown.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

TURNSTONE *Arenaria interpres*

28.1 Normal pattern of movements

Two populations of Turnstones occur regularly in Britain. Breeding birds from north-east Canada and Greenland winter in Britain and along the coast of north-west Europe from the North Sea to Iberia, with only a few individuals reaching north-west Africa (Branson *et al*. 1978). In contrast, Turnstones from Fenno-Scandia and west Russia occur in Britain and western Europe on passage to and from moulting and wintering grounds in Africa south of latitude 20°N. Prater (1981) suggested that about 25,000 Turnstones winter in Britain, with at least a further 5000 in Ireland (Hutchinson 1979). However, results from a census of the non-estuarine coastline of Britain carried out during the winter of 1984/85 (Moser and Summers 1984) indicate that the true British figure may be almost twice the previous estimate (Moser in prep.).

Several studies have demonstrated a strong fidelity of Turnstones to both passage and wintering sites (Evans 1966, Branson *et al*. 1978, Clapham 1979). On the Wash, where extensive ringing was caried out at many sites throughout the estuary, 92% of Turnstone retraps were at the exact site where they were ringed. An exception to the tendency of Turnstones to remain at the same sites throughout the winter is that there appears to be an exodus of juveniles from the Wash in winter, with a return movement by the same birds in the following spring (Branson *et al*. 1978).

Eighty-seven per cent of mild winter recoveries of British-ringed Turnstones were from Britain, with only 3.8% from other areas of Europe (Table 28.1). Recoveries from Africa account for 8.7% but most of these birds were ringed while on passage. Thus most winter recoveries are of Turnstones belonging to the population which normally winters in Britain.

28.2 Ringing effort

Of the 103 winter recoveries available for this analysis, 45% were of birds ringed in East England and 36% were of birds ringed in the Irish Sea area. Fifty-seven per cent of the birds were ringed in Autumn, 29% in Winter and only 14% in Spring.

Few Turnstones were ringed before the late 1960s. Increased ringing from then onwards has resulted in the present level of about eight recoveries per winter (Figure 28.1). High numbers of recoveries in the winters of 1978/79 and 1981/82 were probably related to ringing effort rather than to the severe weather. In each case numbers of recoveries were also high in an adjacent mild winter.

28.3 Distribution of recoveries in mild and severe winters

The recovery distribution for mild winters does not differ significantly from that for severe winters or for severe spells (Table 28.1). There is also no significant difference between the recovery distribution from severe spells and that from the same periods in immediately previous and subsequent years (Table 28.3). However, with such a small number of recoveries available for analysis only very marked movements would be detected. The data in Table 28.3 show only a slight and non-significant increase in the number of recoveries during severe weather. Thus there is no evidence for increased mortality of this species during severe weather.

28.4 Summary

Most of the 103 winter recoveries of Turnstones which were available for analysis were of birds from the population which winters in Britain. There is no evidence of cold weather movements or of increased mortality in this species. These conclusions must be tentative, as there are only 23 recoveries from severe winters, only 9 of which occurred during severe spells.

Table 28.1 Recovery regions of British-ringed Turnstones in mild and severe winters.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
N.E.Scotland	(1)	7	4	3
N.W.Scotland	(2)	1	0	0
East England	(3)	34	6	1
Irish Sea	(4)	22	12	4
Ireland	(5)	1	0	0
South England	(6)	5	1	1
Waddenzee	(7)	1	0	0
North France	(8)	2	0	0
Africa	(9)	7	0	0
Total		80	23	9

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
N. & E.Britain (1-3)	52.5	43.5	44.4
W. & S.Britain (4-6)	35.0	56.5	55.6
Europe (7-8)	3.8	0.0	0.0
Africa (9)	8.7	0.0	0.0

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=1.305, 1 df, ns
Mild winters v severe spells x^2=0.283, 1 df, ns

Table 28.2 Ringing periods and regions of British-ringed Turnstones recovered in winter.

Ringing region	Ringing period			
	July-October	November-March	April-June	
N.E.Scotland	6	4	1	11
N.W.Scotland	1	0	0	1
East England	30	13	3	46
Irish Sea	17	11	9	37
Ireland	1	0	0	1
South England	4	2	1	7
Total	59	30	14	103

Table 28.3 Recovery regions of British-ringed Turnstones in years before, during and after severe weather.

(a) Number of recoveries

Recovery region		Mild spells			Severe spells
		Years before	Years after	Years before +after	
N.E.Scotland	(1)	0	1	1	3
East England	(2)	3	1	4	1
Irish Sea	(3)	0	5	5	4
South England	(4)	0	1	1	1
Africa	(5)	2	0	2	0
Total		5	8	13	9

(b) Percentage of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
N. & W.Britain (1-2)	60.0	25.0	38.5	44.4
W. & S.Britain (3-4)	0.0	75.0	46.2	55.6
Africa (5)	40.0	0.0	15.4	0.0

Only recoveries during the period of severe weather are included.
Severe winters v before+after x^2=0.026, 1 df, ns

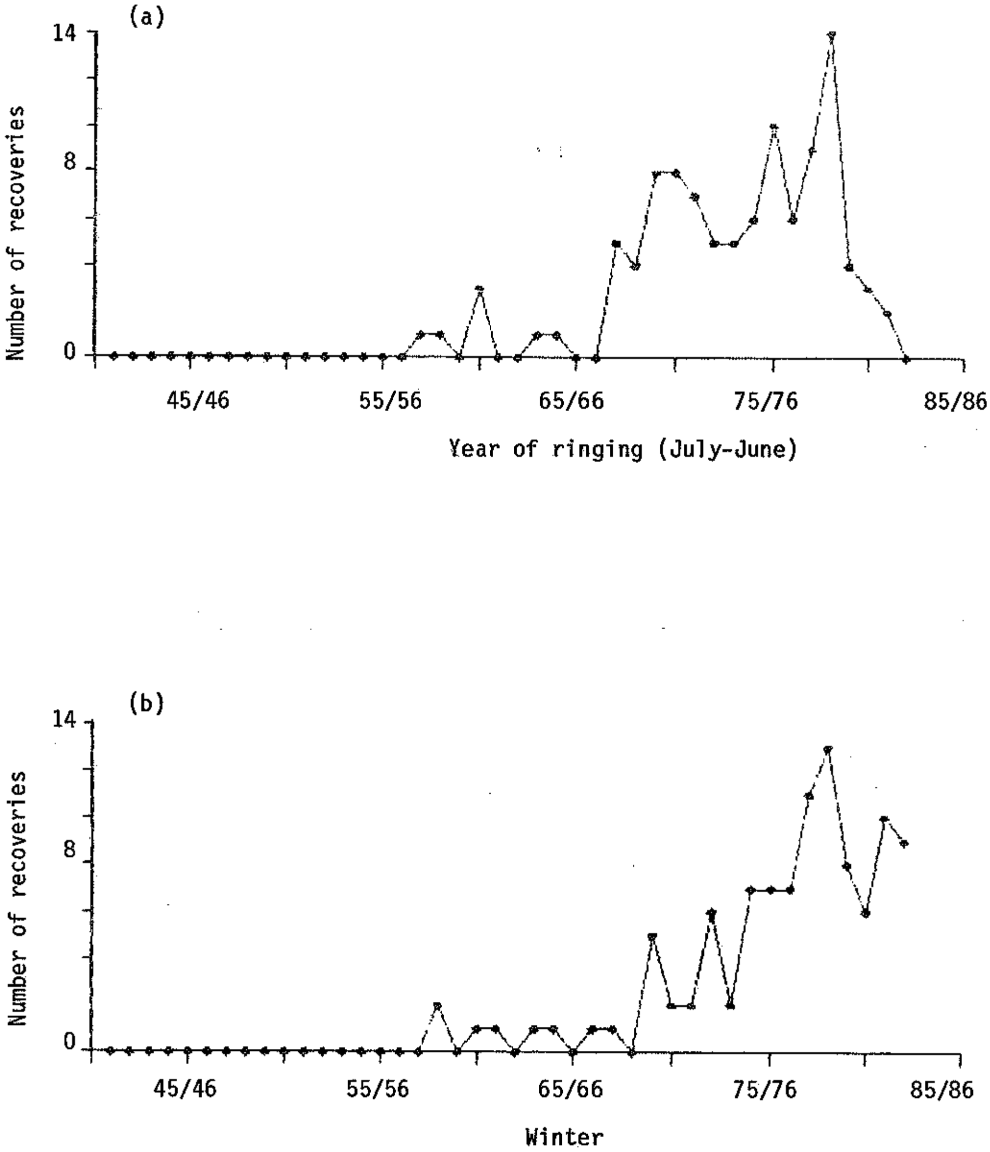


Figure 28.1 Winter recovery totals for Turnstone.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

KINGFISHER *Alcedo atthis*

29.1 Normal pattern of movements

The British Kingfisher population is probably between 5000 and 9000 pairs (Sharrock 1976). The species is distributed throughout Britain and Ireland, except that it is largely absent from the North of Scotland. Kingfisher populations decline very severely as a result of cold winters (Dobinson and Richards 1964, Taylor and Marchant 1984) but due to the species' high reproductive rate numbers usually return to normal after a few years (Venables and Wykes 1943, Meadows 1972).

British Kingfishers are largely sedentary, 85% of recoveries being within 50 km of the ringing place (Morgan and Glue 1977). The few longer distance movements occur mainly in autumn and appear to represent a random post breeding dispersal, particularly of juveniles. Some movements to the coast occur during cold weather. Out of 454 British Kingfishers recovered up to the end of 1981 only four were from abroad, one from Belgium, one from the Channel Islands and two from France (Spencer and Hudson 1982). The only foreign-ringed Kingfishers recovered in Britain are one from Belgium and one from France. Thus there is no evidence for regular migrations by British Kingfishers. Continental populations migrate south and west for the winter (Morgan and Glue 1977) but few of these birds appear to reach Britain.

The winter recoveries used for this analysis were all within Britain (Table 29.1), their distribution reflecting that of ringing effort. During mild winters 55% of recoveries were less than 10 km from the ringing place, and only 3 were over 100 km.

29.2 Ringing effort

Most Kingfisher ringing has taken place in the south of England, with 59% of birds being ringed in South-east England and 16% in South-west England. Most of the rest were ringed in East England (Table 29.2). Seventy-two per cent of recoveries were of birds ringed in Autumn. Some recoveries are available from the mid-1950s onwards but most of the recovery sample used here relates to birds ringed in the 1970s and 1980s (Figure 29.1). The peak of recoveries in the winter of 1975/76 probably reflects ringing effort rather than exceptional mortality.

29.3 Distribution of recoveries in mild and severe winters

The distribution of recoveries during mild winters does not differ significantly from that for severe winters or for severe spells only (Table 29.1). Comparison of severe spells with the same period in immediately previous and subsequent years also shows no significant difference (Table 29.3). Numbers of recoveries in years before severe winters and in severe winters are similar, but very few recoveries were reported after severe winters. Thus although cold weather mortality is not shown by an increased number of cold weather recoveries, the population decline is reflected by the lack of birds available to be recovered in years following cold weather. It is surprising that recovery rates of Kingfishers do not rise in cold weather but perhaps Kingfishers which die of starvation are unlikely to be found. The discrepancy is not readily explained by the recovery circumstances of Kingfishers. Morgan and Glue (1977) reported that 51% of recoveries were simply recorded as found dead, while the remainder were spread amongst a range of causes such as road casualties and cat predation.

Distances between ringing and recovery places confirm the lack of cold weather movements. Eighty-nine per cent of recoveries during severe winters were less than 50 km from the ringing place, while during severe spells there were no recoveries over 50 km.

29.4 Summary

The recovery data provide no evidence of cold weather movements by Kingfishers. Despite clear evidence of heavy cold weather mortality from census data, recovery rates do not rise during severe weather. These conclusions are based on only 26 recoveries from severe winters, only 12 of which occurred during severe spells. Thus more data are needed to confirm them.

Table 29.1 Recovery regions of British-ringed Kingfishers in mild and severe winters.

(a) Number of recoveries

Recovery region		Mild winters	Severe winters	Severe spells
East England	(1)	24	7	5
Irish Sea	(2)	7	1	1
Ireland	(3)	1	0	0
S.E.England	(4)	80	15	6
S.W.England	(5)	21	3	0
Total		133	26	12

(b) Percentage of recoveries

Recovery region	Mild winters	Severe winters	Severe spells
E. & W.Britain (1-3)	24.1	30.8	50.0
S.Britain (4-5)	75.9	69.2	50.0

For definitions of mild and severe winters see methods.

Mild winters v severe winters x^2=0.225, 1 df, ns
Mild winters v severe spells x^2=2.606, 1 df, ns

Table 29.2 Ringing periods and regions of British-ringed Kingfishers recovered in winter.

Ringing region	Ringing period July-October	November-March	April-June	
East England	24	2	3	29
Irish Sea	3	1	5	9
Ireland	1	0	0	1
S.E.England	66	10	18	94
S.W.England	20	1	5	26
Total	114	14	31	159

Table 29.3 Recovery regions of British-ringed Kingfishers in years before, during and after severe weather.

(a) Number of recoveries

Recovery region		Mild spells			Severe spells
		Years before	Years after	Years before +after	
East England	(1)	4	1	5	5
Irish Sea	(2)	2	0	2	1
S.E.England	(3)	5	0	5	6
S.W.England	(4)	0	1	1	0
Total		11	2	13	12

(b) Percentage of recoveries

Recovery region	Mild spells			Severe spells
	Years before	Years after	Years before +after	
E. & W. Britain (1-2)	54.5	50.0	53.8	50.0
South Britain (3-4)	45.5	50.0	46.2	50.0

Only recoveries during the period of severe weather are included.

Severe winters v before+after x^2=0.043, 1 df, ns

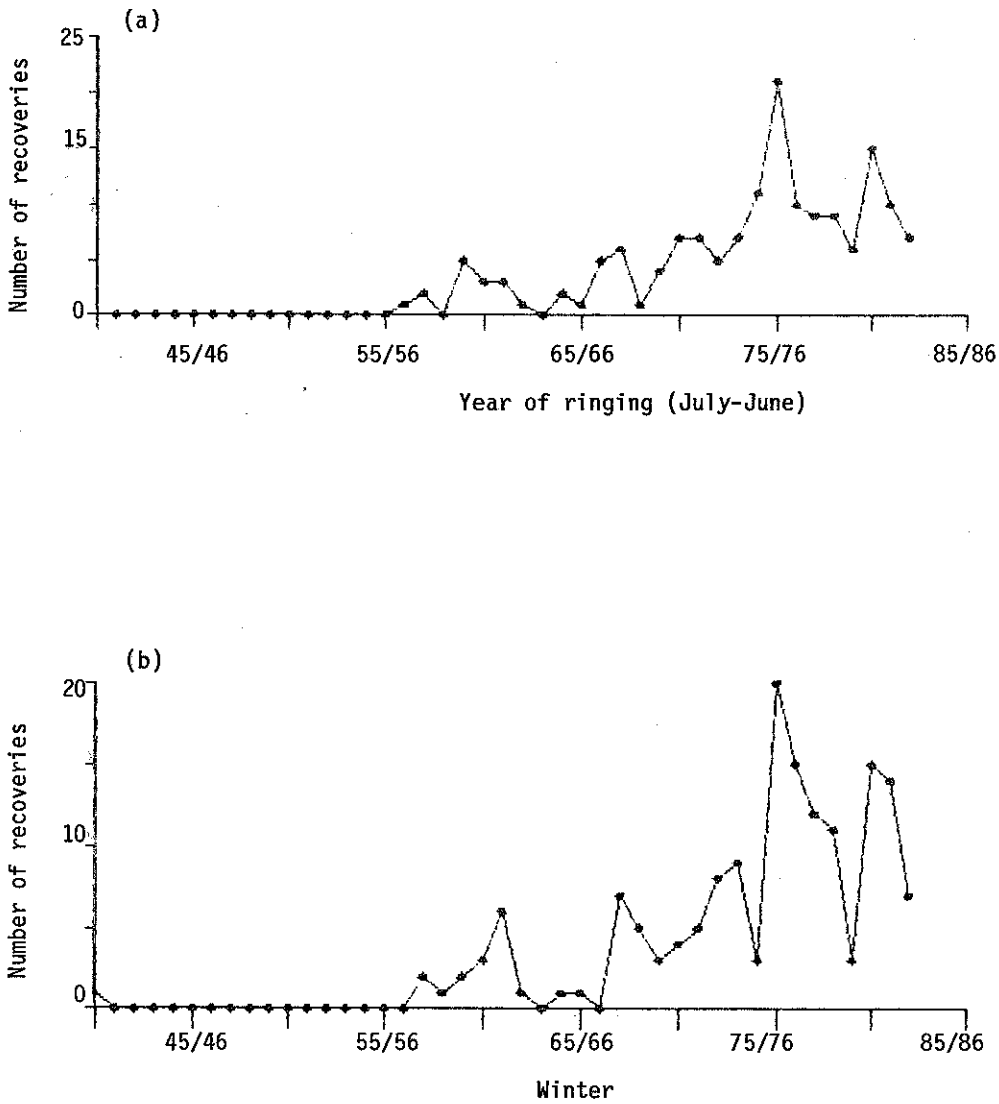


Figure 29.1 Winter recovery totals for Kingfisher.

(a) Number of winter recoveries of birds ringed in each year
(b) Number of recoveries in each winter
Years run from 1 July to 30 June
Winter is defined as November to March

30 DIFFERENCES IN RECOVERY PATTERNS BETWEEN COLD WINTERS

Cold winters differ markedly in the timing and duration of freezing weather and also in the geographical areas most severely affected by the cold. For example, during the 1962/63 winter over half of the 13 British sample weather stations recorded frozen ground for a continuous period of 74 days while in 1978/79 the cold weather was interspersed with warmer periods, the longest period of freezing weather at over half the weather stations being only 12 days. Such differences are likely to cause variations in movement patterns between cold winters.

Analyses of differences between winters were restricted to those data sets with at least 10 recoveries in two or more severe spells. Of the 13 such species Grey Heron, Mute Swan, Coot, Oystercatcher and Redshank do not undertake cold weather movements (above). The remaining eight species are considered below.

30.1 Pink-footed Goose

Sufficient data were available for the winters of 1955/56 (10 recoveries) and 1962/63 (92 recoveries). The recovery distributions in these two severe spells were not significantly different (x^2=2.49). However, there was a significant difference between the recovery distributions of Pink-footed Geese recorded during the winters of 1961/62 and 1962/63 (section 5). The 1961/62 winter was colder than usual, especially in Scotland, although it has not been classified as severe for the purposes of this report. Movement patterns of Pink-feet in 1961/62 were intermediate between those recorded in 1962/63 and in mild winters.

30.2 Canada Goose

Only Canada Geese from Central Britain were shown to undertake cold weather movements (section 6) and only these birds are considered here. Forty-nine recoveries were reported during the severe spell of 1978/79 and 23 during the cold spell of 1981/82. The recovery distributions from these two periods were not significantly different (x^2=0.02, 1df).

30.3 Teal

This is the species with most recoveries. There was highly significant heterogeneity between the recovery distributions for the five severe spells considered in this report (Table 30.1). In the winters of 1956/57 and 1962/63 over 20% of recoveries were from southern France and Iberia while in the other three winters fewer than

10% of recoveries showed movement as far south as this. The percentage of recoveries from Ireland varied between 30% in 1946/47 and 7% in 1955/56. Mean distances between ringing and recovery places also illustrate variations in movement patterns. They varied from 483 km in 1955/56 to 188 km in 1978/79 (Table 30.2).

These differences are difficult to interpret without detailed analyses of weather patterns. Such an analysis of Teal movements has been carried out by Ogilvie (1983) and it is apparent from his work that the relationships involved are complex. However, Teal clearly moved further south in the winter of 1962/63 compared with the somewhat less severe ones of 1978/79 and 1981/82. The response of Teal to cold weather is unlikely to be an all or nothing one, the extent of movements probably varying with the extent and severity of the cold. This was investigated by examining the relationships between Teal movements and the number of freezing days at selected weather stations. Other weather factors such as wind speed might also be important in determining the extent of cold weather movements but a full-scale analysis of meteorological data was beyond the scope of this report. The relationship between freezing weather at the 15 selected stations and the extent of cold weather movements is of particular applied interest, as these data are used as the criteria for cold weather hunting bans in Britain. Teal were used to examine the potential of this type of analysis because of the large annual samples of recoveries.

The state of ground at 0900 at the 13 sample weather stations (see methods) was used as a measure of the frequency of freezing weather. Records between October and March for the winters of 1959/60 to 1982/83 were used. The state of ground was recorded simply as either frozen or not frozen. These data were summed to give the total number of freezing days at each weather station over the whole of each winter. Most stations give a similar assessment of the relative severity of different winters. Correlations between the frequency of freezing days at the different weather stations were mostly over 0.8 (Table 30.3). Correlations between those stations which are far apart were less good than those between stations which are close together. The Humber shows a relatively poor correlation with the other stations, probably because the recording site was changed during the study period.

Large numbers of Teal have been ringed in East England, in South-east England and in South-west England. These three populations were considered separately. Teal ringed in other parts of Britain were excluded from the analysis. Only winters with at least 10 recoveries of birds ringed in a particular region were included. This gave 22 years of data for birds ringed in East England, 24 years for birds ringed in South-east England, and only eight years for birds ringed in South-west England. Two measures of bird movements were used, the percentage of recoveries from abroad (outside Britain and Ireland) and the mean distance between ringing and recovery places. The arcsine transformation was used throughout to normalize the percentage of recoveries from abroad. Bivariate relationships between the percentage of recoveries from abroad and weather or year were examined initially using the test for a trend in linear proportions (Snedecor and Cochran 1980). This is a linear regression weighted by sample size to ensure that spurious trends cannot be caused by changes in sample size. The percentage of recoveries from abroad and the mean distance moved were not very strongly correlated (East England r=0.61, South-east England r=0.59, South-west England r=0.75), and both were therefore used in the following analyses.

Correlations between the extent of movement by the three populations were generally poor (Table 30.4), although sample sizes for correlations involving South-west England were small. The correlation between the percentage recovered abroad from East England and South-east England was significant (r=0.59, P<0.01) but it accounts for only 35% of the variation between years. Thus real differences in the annual movement patterns of the different populations probably exist.

Only weather data from Norfolk, Cardiff, Kent, Bournemouth and Plymouth were used to examine correlations between winter severity and movements, as these stations were closest to the areas where the birds were ringed, and where they normally winter. The Humber is in East England but it was excluded for the reason given above. Positive correlations between mean distance moved and the number of days of freezing weather were obtained for birds ringed in South-east England and in South-west England but none of them were significant (Table 30.5).

For birds ringed in South-East and in South-West England there are significant relationships between the percentage of birds recovered from abroad and the number of freezing days recorded at the five weather stations (Table 30.5), the only exception being the relationship between the weather in Plymouth and the percentage of birds from South-West England which were recovered abroad. There are no significant relationships between the percentage of birds from East England which were recovered abroad and weather. However, if the period of analysis is restricted to the years 1970/71-1981/82 there are significant positive relationships between the percentage of birds recovered abroad and the number of freezing days in Cardiff, Kent and Norfolk.

In 1962/63 the percentage of recoveries of Teal ringed in East England which were from abroad was much lower than expected. This might be due to increased mortality in Britain before the birds could leave, or to hunting restraint on the continent. Alternatively there may have been some difference in the sample of Teal ringed in East England in that year. If 1962/63 is excluded from the analysis, the relationship between the percentage of recoveries of Teal ringed in East England which were from abroad and the weather in Norfolk becomes significant (b=0.305, Z=2.134, P<0.05). The relationships between the percentage of recoveries from abroad and the number of freezing days in Norfolk are plotted for birds ringed in South-east and East England in Figure 30.1.

These analyses are further complicated for birds ringed in South-east England and in South-west England because there was a significant decline in both the mean distance moved (South-east r=-0.60, 31df, P<0.001; South-west r=-0.90, 7df, P<0.001) and in the percentage of recoveries from abroad (South-east: b=-0.630, Z=-6.953, P<0.001; South-west: b=-0.51, Z=-3.293, P<0.001) between 1950/51 and 1982/83. If the analysis is restricted to the period 1959/60 to 1982/83, which was used for the weather analyses, similar trends are present but only the results for birds ringed in South-east England remain significant (distance: r=-0.62, 22df, P<0.01; per cent recovered abroad: b=-0.81, Z=6.021, P<0.001).

Relationships between movements, weather and year were further examined using stepwise multiple regression. Variables were included in the regression equation only if they gave rise to a significant increase in the variance explained. The percentage of recoveries from abroad was arcsine transformed as above. For Teal ringed in South-east England 70% of the variance in the annual percentages of recoveries from abroad could be explained by a combination of the weather in Norfolk and Plymouth and year (Table 30.6). It has already been shown that the correlation between the percentage of recoveries from abroad and freezing weather is not significant unless the exceptionally low value for 1962/63 is excluded. If the analysis is restricted to the period 1970/71 to 1981/82 53% of the variation in the percentage of recoveries from abroad is explained by a combination of the number of freezing days in Norfolk and Plymouth. This is very similar to the results obtained for South-east England. Plymouth does not add significantly to the variance explained but the overall multiple regression equation is significant. Similar results but with a slightly lower coefficient of determination are obtained if the data for 1959/60 to 1981/82 are analysed excluding 1962/63.

This analysis has demonstrated a reasonably good relationship between Teal movements and freezing weather over the range of values experienced in all winters. It could be extended by using different combinations of the freezing weather data, and by using different time periods. Other weather parameters such as wind chill could also be considered. Such an approach but using comparisons between individual time periods with the long-term average rather than correlations is presented by Ogilvie (1983). The best results in the above analysis were obtained for South-east England, from where annual recovery samples usually exceeded 50, and in the 1960s were generally over 100. In only three winters were there more than 50 recoveries of Teal ringed in East England. Thus this type of analysis is only appropriate when large annual samples of recoveries are available. There are no other species of waders of wildfowl which undertake marked cold weather movements and for which annual samples of at least 50 recoveries are available over a period of 10 or more winters.

30.4 Mallard

A preliminary analysis indicated significant heterogeneity in the distributions of Mallard recoveries during the severe spells of 1962/63, 1978/79 and 1981/82 (x^2=31.051, 6df, P<0.001). However, when the data for birds ringed in each region were analysed separately no significant differences between severe spells were found for birds ringed in East England and South-west England (Table 30.7). For birds ringed in South-east England a chi-squared test showed no significant differences between the winters of 1962/63, 1978/79 and 1981/82. The 1955/56 data could not be included in this test, due to the presence of small expected values. The 1955/56 distribution was significantly different to that during the other three severe spells (Fisher test, P=0.018), with a higher percentage of recoveries in Europe. However, little importance can be attached to this difference as the 1955/56 sample comprised only 13 recoveries. Distances between ringing and recovery places showed no significant differences between severe spells (Table 30.8). Only a very small proportion of Mallard undertake cold weather movements (section 11). Thus it is not surprising that there is little evidence of differences in movement patterns between severe spells.

30.5 Tufted Duck

Large samples of Tufted Ducks have been ringed annually only in recent years, so it is possible to compare only the winters of 1978/79 and 1981/82. November to March recovery distributions differ significantly between the two winters (x^2=8.819, 3df, P<0.05). However, this difference is no longer significant when data from severe spells alone are used (x^2=2.651, 2df) perhaps due to reduced sample sizes. Comparisons of the recovery distribution during the severe spell with that for the same period in immediately previous and subsequent years indicate that a cold weather movement of Tufted Ducks took place in 1981/82 but not in 1978/79 (Table 30.9). This is well illustrated by the distributions of distances between ringing and recovery places (Figure 30.2). It is not possible to identify the factor which was responsible for the emigration which took place in 1981/82 but it may have been the more continuous nature of the cold weather.

30.6 Lapwing

The distributions of recoveries of Lapwings ringed as chicks show significant heterogeneity between the five severe spells (Table 30.10). A high percentage of recoveries were reported from Iberia and North Africa in the winters of 1955/56 and 1962/63 but not in the other three winters, a similar pattern to that shown for Teal.

However, these results must be treated with caution. The proportion of the recoveries which were of birds ringed in different parts of Britain varied between years and Lapwings from different parts of Britain differ in their migration patterns (section 20). Most ringed chicks were from Central Britain. When the data from these birds were analysed alone they showed the same pattern as that described above but the differences were no longer statistically significant (Table 30.11).

30.7 Snipe

Sufficient Snipe recoveries were available only to compare the severe spells of 1962/63, 1978/79 and 1981/82, and even then the 1981/82 sample was only eight recoveries. A higher percentage of recoveries were from abroad during the 1962/63 cold spell (Table 30.12), but the differences between the three years were not significant (x^2=1.88, 2df).

30.8 Curlew

Again the data suggest a more marked movement during the winter of 1962/63 than in either 1978/79 or 1981/82 (Table 30.13), but they are insufficient to demonstrate it statistically.

30.9 Summary

Sufficient data for an analysis of differences in cold weather movements between severe winters are available for eight species. Pink-footed Goose, Teal, Mallard, Tufted Duck and Lapwing provide statistical evidence of differences between winters, although for Mallard and Lapwing the evidence is weak. No significant differences between cold winters could be detected for Canada Goose, Snipe and Curlew. Where differences occurred, longer and more extensive movements took place in colder winters. Teal, Lapwing, and perhaps also Snipe and Curlew, appear to have moved further in 1962/63 than in more recent cold winters.

Many species continually adjust their dispersion in relation to prevailing weather conditions, and it is simply the extremes of this variation which are recorded in severe winters, and classified as "cold weather movements". This is demonstrated for Teal, for which data from all winters shows a continuous relationship between the frequency of freezing weather in Britain and the percentage of recoveries from abroad. At present there are insufficient recoveries of the other species of waders and wildfowl which undertake cold weather movements to carry out similar analyses.

Table 30.1 Recovery distributions of British-ringed Teal during five severe spells.

	46/47	55/56	62/63	78/79	81/82
Britain %	56.5	34.2	45.4	54.1	53.4
Ireland %	30.4	6.7	16.6	16.2	24.1
Waddenzee & E. Europe %	0.0	2.0	0.6	0.0	1.7
N.France %	8.7	24.2	9.6	21.6	17.2
S.France %	4.3	24.8	14.9	8.1	3.4
S.Europe %	0.0	8.1	13.0	0.0	0.0
Number of recoveries	46	149	355	37	58

For dates of severe spells see methods.

Test for differences between severe spells x^2=72.591, 12df, P<0.001

Table 30.2 Mean distances between ringing and recovery places of Teal recovered during five severe spells

	46/47	55/56	62/63	78/79	81/82
Mean distance (km)	216	483	459	188	233
Number of recoveries	46	149	355	37	58

Kruskall-Wallis ANOVA for differences between years
H=53.88, 4df, P<0.001

Table 30.3 Correlations between the number of freezing days in each winter at the 13 sample weather stations.

	Ab	Fi	Gl	Ty	Cl	Bl	Hu	No	WW	Cd	Ke	Bo
Fi	.94											
Gl	.83	.88										
Ty	.85	.89	.90									
Cl	.82	.86	.90	.89								
Bl	.80	.84	.91	.94	.91							
Hu	.50	.59	.67	.64	.70	.67						
No	.65	.73	.86	.91	.79	.91	.66					
WW	.73	.80	.88	.92	.84	.96	.59	.90				
Cd	.72	.80	.89	.92	.85	.93	.79	.93	.93			
Ke	.73	.77	.87	.92	.86	.96	.68	.95	.93	.93		
Bo	.65	.75	.78	.89	.75	.87	.58	.89	.93	.92	.88	
Pl	.61	.64	.80	.85	.75	.89	.59	.91	.92	.90	.91	.92

The total number of days between October and March when the ground was freezing at 0900 has been taken as a measure of the severity of the winter at each station.

Data are from the winters 1959/60 to 1982/83.

The stations are those listed under methods, and are shown above as follows:

Ab	Aberdeen	Fi	Fife	Gl	Glasgow
Ty	Tynemouth	Cl	Carlisle	Bl	Blackpool
Hu	Humber	No	Norfolk	WW	West Wales
Cd	Cardiff	Ke	Kent	Bo	Bournemouth
Pl	Plymouth				

Table 30.4 Correlations between the winter movements of three British Teal populations.

(a) Mean distances between ringing and recovery places

		East England	South-east England
South-east England	r	0.34	
	df	20	
South-west England	r	0.25	0.80 *
	df	6	6

(b) Percentage of recoveries from abroad

		East England	South-east England
South-east England	r	0.59 **	
	df	20	
South-west England	r	0.38	0.29
	df	6	6

Regions are those in which the birds were ringed.
Only winters between 1959/60 and 1982/83 with more than 10 recoveries of birds ringed in a particular region are included.
Percentages of recoveries from abroad were arcsine transformed before calculating the correlation coefficients.

** $P<0.01$ * $P<0.05$ All other values not significant.

Table 30.5 Correlations between the winter movements of Teal and the amount of freezing weather at five stations in southern Britain.

	Ringed in E.England		Ringed in S.E.England		Ringed in S.W.England	
	dist.	% abroad	dist.	% abroad	dist	% abroad
Norfolk	-0.12	0.40	0.30	0.62 ***	0.51	0.39 *
Cardiff	-0.12	0.33	0.21	0.45 ***	0.32	0.36 *
Kent	-0.11	0.33	0.31	0.53 ***	0.55	0.46 *
Bournemouth	-0.03	0.26	0.38	0.54 ***	0.47	0.41 *
Plymouth	-0.18	0.15	0.31	0.40 ***	0.39	0.34
df	20	712	22	3019	6	195

Data are from the winters 1959/60 to 1982/83. Only winters with samples of more than 10 recoveries of birds ringed in a particular region are included.

To allow comparison of the strengths of the different relationships all are presented as correlation coefficients. Significance levels for the relationships involving the percentage of recoveries from abroad were calculated using the test for a trend in linear proportions (Snedecor and Cochran 1980) and <u>not</u> from the correlation coefficients.

*** P<0.001   * P<0.05   All other values not significant.

Table 30.6 Multiple regression analysis of percentage of Teal recovered abroad against weather and year.

Teal ringed in South-east England: recoveries from 1959/60 to 1982/83

Step 1	Number of freezing days in Norfolk	38% of variance explained
Step 2	Number of freezing days in Plymouth	53% of variance explained
Step 3	Year	70% of variance explained

% abroad=0.60N -0.59P -0.37Y +51.10

Teal ringed in East England: recoveries from 1970/71 to 1981/82

Step 1	Number of freezing days in Norfolk	45% of variance explained
Step 2	Number of freezing days in Plymouth	53% of variance explained

% abroad= 0.56N -0.46P +21.57

All percentages were arcsine transformed.
For birds ringed in East England step 2 does not significantly increase the variance explained. It is included for comparison with South-east England.

Table 30.7 Distribution of Mallard recoveries during different severe spells

(a) Ringed in East England	62/63	78/79	81/82
E.England %	62.9	67.3	76.9
W.Britain %	7.9	4.1	0.0
S.E.England %	22.9	20.4	0.0
Europe %	6.4	8.2	23.1
No. of recoveries	140	49	13

b) Ringed in South-East England	55/56	62/63	78/79	81/82
S.E.England %	61.5	84.1	87.5	91.1
Rest Britain %	7.7	7.9	6.9	0.0
Europe	30.8	7.9	5.6	8.9
No. of recoveries	13	63	72	45

(c) Ringed in South-west England	62/63	78/79
S.W.England %	67.2	66.7
Rest Britain %	29.5	16.7
France %	3.3	16.7
No. of recoveries	61	12

Tests for differences between severe spells:
East England x^2=8.89, 4df, ns
South-east England x^2=4.04, 4df, ns
(excluding 1955/56 due to small expected value)
South-west England x^2=0.00, 1df, ns

Table 30.8 Mean distances between ringing and recovery places of Mallard recovered during different severe spells

Ringing region		55/56	62/63	78/79	81/82
E.England	km	-	101	100	253
	n		140	49	13
S.E.England	km	181	71	69	37
	n	13	63	72	45
S.W.England	km	-	113	107	-
	n		61	12	

When less than 10 recoveries were available the mean distance is omitted.

Kruskall-Wallis tests for differences between severe spells:
East England H=3.75, 2df, ns
South-east England H=1.20, 3df, ns

Table 30.9 Distribution of Tufted duck recoveries in the winters of 1978/79 and 1981/82, and in the years immediately before and after those winters.

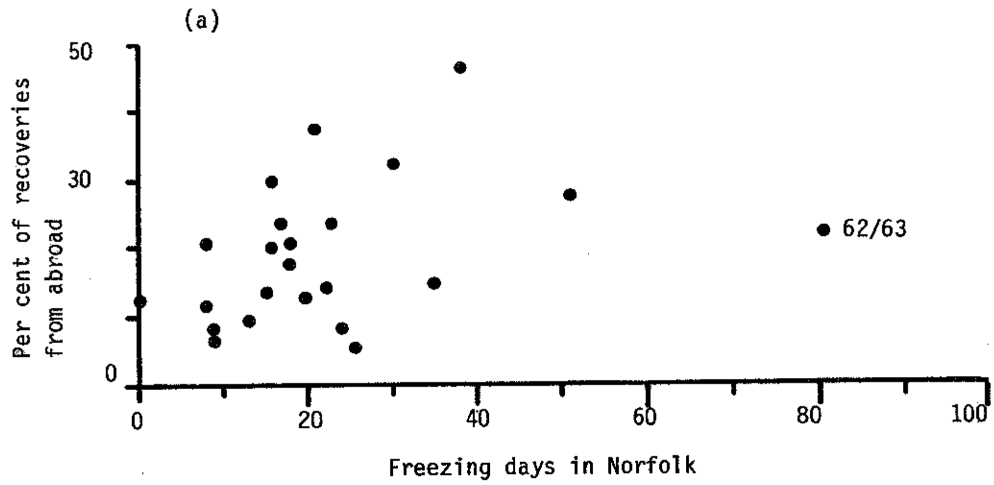
Recovery region	77/78+ 79/80	78/79	80/81+ 82/83	81/82
Britain and Ireland %	83.9	81.8	84.6	61.1
Europe %	16.1	18.2	15.4	38.9
No. of recoveries	62	33	52	36

77/78 + 79/80 v 78/79 x^2= 0.06, 1df, ns
80/81 + 82/83 v 81/82 x^2= 6.27, 1df, $P<0.05$

Table 30.10 Recovery distributions of Lapwings ringed as chicks and recovered during five severe spells

Recovery region	46/47	55/56	62/63	78/79	81/82
Britain %	0.0	5.3	3.8	5.0	13.3
Ireland %	36.4	15.8	11.3	30.0	26.7
France %	36.4	31.6	28.8	45.0	46.7
Iberia & Africa %	27.3	47.4	56.3	20.0	13.3
No. of recoveries	11	19	80	20	15

Test for differences between severe spells x^2= 17.85, 8df, $P<0.05$.



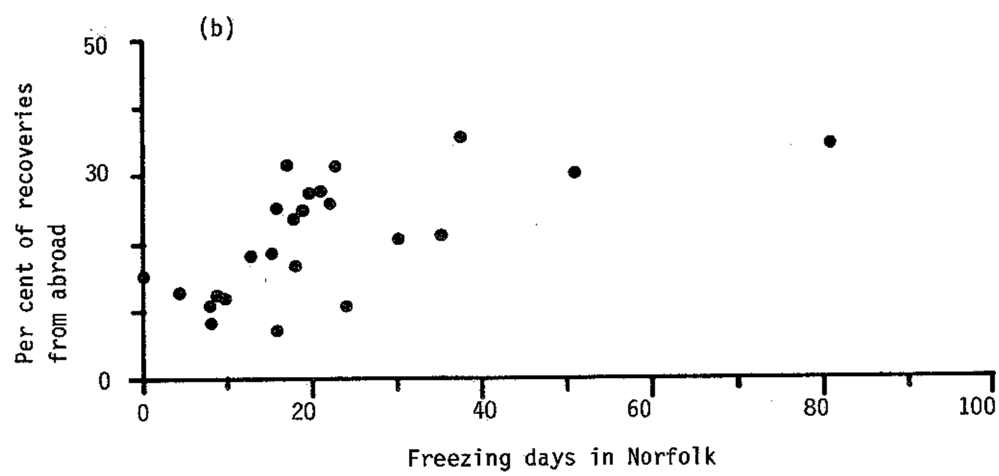


Figure 30.1 Percentage of Teal recovered abroad against the number of freezing days in Norfolk.

(a) Birds ringed in East England

(b) Birds ringed in South-east England

Each point represents one winter between 1959/60 and 1982/83.
The number of freezing days was calculated from the ground state at 0900 h (see methods).

Tests for a linear trend in proportions:

East England $b = 0.147$ $Z = 1.591$ ns
East England (excluding 1962/63) $b = 0.305$ $Z = 2.134$ $P < 0.05$
South-east England $b = 0.225$ $Z = 7.005$ $P < 0.001$

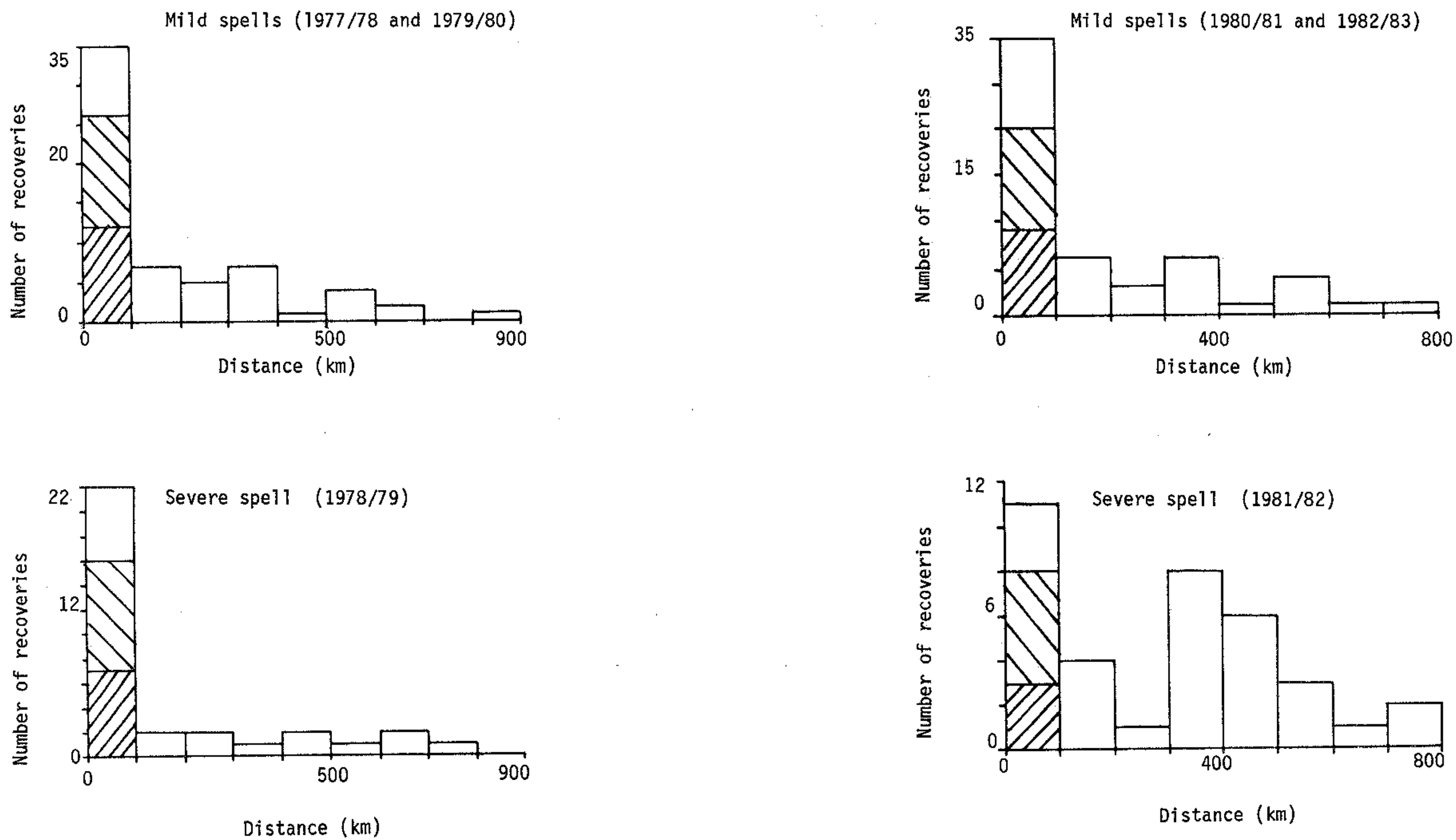


Figure 30.2 Distances between ringing and recovery places of Tufted Ducks recovered during the severe spells of 1978/79 and 1981/82 and in equivalent mild spells of the immediately previous and subsequent winters.

0-9 km   10-49 km

31 DISCUSSION

31.1 Energy reserves

The wildfowl and waders which winter in Britain and Ireland show a wide range of cold weather movement strategies. Some species, such as Lapwing and Teal, move south in large numbers during cold weather while others, such as Redshank and Oystercatcher, remain on their normal wintering grounds during cold weather, despite suffering severely increased mortality in doing so. Cold weather mortality is usually caused by starvation and not by exposure (Beer and Boyd 1963, Marcstrom and Mascher 1979, Davidson and Evans 1982). Thus cold weather movements take place in response to total deprivation of food or to food shortage that is sufficiently severe to prevent birds from balancing their energy budgets. Most waders and wildfowl carry increased fat reserves during the mid-winter period (Owen and Cook 1977, Pienkowski et al. 1979, Johnson 1985), in part as an insurance against periods of severe weather. Thus most individuals are probably able to survive for a few days without food, by utilising their fat reserves. Grey Plovers on the Tees have been shown to recover condition following severe weight loss caused by a period of cold weather (Dugan et al. 1981) and this is probably also true for Dunlins on the Wash (Pienkowski et al. 1979).

Faced with the onset of a period of cold weather a bird must "decide" either to use its reserves to survive in situ, in the hope of a fairly rapid improvement in conditions, or to use them as fuel for a journey to better feeding grounds elsewhere. Both strategies have potential costs and benefits. Birds that undertake cold weather movements always risk failing to find alternative feeding grounds, in which case they will probably starve. Individuals which move out in response to very brief periods of cold weather may expend unnecessary energy on migration and may also lose in competition for preferred feeding sites on their normal wintering areas. Conversely, birds which remain in an area affected by a prolonged cold spell will probably die. Individuals that attempt to stay will reach a point where they no longer have the option of migrating because they lack sufficient reserves. If the weather does not improve within a very short time, such birds will die.

31.2 Relationship between feeding ecology and movement patterns

The effect of freezing weather and snow on the energy balance of birds depends on habitat, on the type of food being taken and on foraging methods. Birds feeding on inland pastures or on fresh water are often deprived totally of food by cold weather. Under these circumstances emigration is usually the best survival strategy. In Britain total food deprivation is less frequent amongst species feeding in coastal habitats because the sea rarely freezes. Cold weather may cause their energy budgets to be in deficit but, except under the most extreme conditions, they can survive for substantially longer than inland feeding species. Under these circumstances the advantages of staying or moving are more finely balanced.

The species covered in this report can be divided into three broad groups based on their feeding ecology:

1. Wildfowl, Moorhen and Coot - principally aquatic herbivores.
2. Waders and Shelduck - terrestrial and estuarine invertebrate feeders
3. Heron and Kingfisher - fish eaters.

Different energetic considerations are associated with each of these main groups. The efficiency with which plant material is digested is relatively poor, so wildfowl need generally to consume large volumes of plant food, and to feed for a high proportion of the day, in order to achieve this. This is particularly true of those species that feed almost exclusively on foliage, such as geese and Coot. Tufted Duck and Moorhen take a higher proportion of animal food and may thus need to spend less time feeding. Waders are generally smaller than wildfowl, and hence heat loss will be relatively greater because of their high surface area to volume ratio. Waders feed almost exclusively on invertebrates in winter and so are able to obtain more energy per unit feeding time. They normally spend a high proportion of the low tide period feeding but many species are unable to feed during the high tide period. Both for waders and wildfowl the contribution of night-time feeding to total energy intake is poorly understood.

<u>Wildfowl, Moorhen and Coot</u>

Cold weather movements have been demonstrated for eight of the 13 species of waterfowl considered above and the data strongly suggest such movements for a further two species (Table 31.1). Substantial proportions of the populations of most of these species are deprived of food when inland waters freeze over and when fields become snow-bound. Eight of the 13 species experience significantly increased recovery rates during severe weather. However, all but Moorhen, Coot and Mute Swan are quarry species, and so the recovery totals will reflect increased vulnerability to hunters during cold weather as well as direct cold weather mortality. Both recovery causes suggest that many of the birds are in poor condition.

Grazing species are deprived of food immediately their feeding areas become snow-bound. Wigeon move out of Britain under such conditions, while Pink-footed Geese move to milder areas in western Britain. Wigeon feed extensively on mud-flats and salt-marshes, which should be less severely affected by cold weather. However, despite their mainly coastal distribution 46% of feeding Wigeon occur on inland habitats (Owen and Williams 1976). Large scale emigration of Wigeon from the Ouse Washes was recorded during the 1978/79 cold spell (Von Kanel 1981). Cold weather movements of other species of geese have also been recorded both in Britain and on the continent (Beer and Boyd 1964, Doude van Troostwijk 1965, van den Bergh et al. 1981, Salmon 1982). The Canada Goose is exceptional because it is an introduced species that still obtains a substantial amount of food from man in some areas. Nevertheless, limited cold weather movements of Canada Geese from Central Britain were detected. This species does not experience increased mortality in cold weather, probably due to the combined effects of its large body size and its feeding association with man.

Mortality both of Moorhen and Coot increases markedly in cold weather, yet neither species shows evidence of cold weather movements. Both species inhabit mainly inland freshwater areas which are liable to freeze over, Moorhens preferring smaller, more overgrown waters and Coots more open areas. Coots feed almost exclusively on water plants while Moorhens take a wide range of foods including plants, seeds, berries and invertebrates. The ringed samples of both species are probably composed largely of British birds although Continental immigrants of both species are present in Britain during the winter (Cramp and Simmons 1980). Mute Swans also suffer increased cold weather mortality and fail to undertake cold weather movements. The mortality increase is surprising because this species is extensively fed by man and because Canada Geese, which are in a similar situation, do not suffer increased mortality. However, Canada Geese generally move about more and exploit a wider range of feeding areas than do Mute Swans. Thus there is a higher chance that at least some of their feeding areas will remain accessible during cold weather. Competition for food during cold weather may cause some individual Mute Swans to be excluded from areas where the birds are fed by man. Other populations of Mute Swans undertake cold weather movements. These include immigration to Britain by birds probably from the Baltic and Sweden (Harrison and Ogilvie 1964).

Gadwall and Shoveler both depend largely on shallow inland waters and have more southerly breeding and wintering ranges than most of the other wildfowl that winter in Britain. Gadwall feed mainly on submerged plants while Shoveler filter plankton close to the surface. Both species move south to France during severe weather and mortality is not markedly increased in either species by severe weather.

Teal, Pintail and Mallard all feed principally on seeds although plants and invertebrates are also taken in quantity. However, these species differ markedly in other aspects of their feeding ecology and consequently in their movements in response to severe weather. Teal is primarily an estuarine species, although about 15% of the British population feeds on shallow lakes and on flooded fields (Prater 1981). They feed mainly in shallow water with muddy sediments from which they filter the seeds of water plants. Although they are estuarine feeders they feed on salt-marshes and other areas which may not be covered by the tide sufficiently often to prevent them from freezing. Teal are very small ducks and hence their energy requirements in cold weather are high. They emigrate to France and Iberia in large numbers during severe weather. Such emigrations take place even during relatively short cold spells (Ogilvie 1983). The extent of Teal emigration in each winter is correlated with the frequency of freezing weather (section 30).

Pintail are also an estuarine species, feeding on seeds and on small invertebrates such as Hydrobia. Over the last 20 years they have started feeding on cereal stubbles and potatoe fields, sometimes in company with Mallard. Pintail are a highly mobile species, moving in rapidly to exploit new feeding areas such as recently flooded fields. British wintering Pintail do not move south in response to severe weather but there is a movement onto milder west coast estuaries.

Mallard are the largest of the seed eating ducks and are also notable for their very high adaptability to different feeding situations. At least nine different foraging methods are used (Cramp and Simmons 1977). This species is closely associated with man and many birds feed from artifical sources. Mallard occupy a very wide range of habitats, from small inland ponds to large estuaries. Inland-wintering birds are often deprived of their normal food sources during freezing weather but most seem able to switch to other forms of food. There is only a very small, though statistically significant, increase in recovery rate during severe weather and only 2% of recoveries indicate emigration to France and South Europe.

Tufted Duck and Pochard are both diving species that inhabit similar inland waters and both species are similarly affected when these habitats freeze over. Tufted Ducks feed mainly on benthic invertebrates taken from depths between 3 and 14 m, while Pochard are mainly plant feeders, usually diving to only about 3 m (Cramp and Simmons 1977). Both species emigrate to France and South Europe during cold weather, although only for Tufted Duck are there sufficient recoveries to demonstrate this statistically.

Waders and Shelduck

Only five of the 12 species in this category showed evidence of cold weather movements (Table 31.2). Six of the 12 species suffered increased mortality during cold weather. Cold weather movements and increased mortality were both associated with the use of inland feeding areas. Freezing weather or snow rapidly deprive these species of access to such food sources.

Three species, Lapwing, Snipe and Woodcock, are largely dependent on inland habitats for feeding. Lapwings feed mainly on grass fields, while Snipe are restricted to marshy areas. A high proportion of the wintering populations of both species emigrate to France and Iberia during severe spells. Almost the entire Lapwing population of some areas moves out during cold weather (Fuller and Youngman 1979, Milsom et al. 1985). Over three times as many recoveries of both species were reported during cold spells as in equivalent mild periods. Although some of this increase is attributable to shooting on the Continent, both species undoubtedly suffer a marked mortality increase during cold weather. Woodcock show only a small and non-significant increase in recoveries during cold weather and no evidence of any change in movement patterns. However, the recovery sample is small. Observations suggest that Woodcock from the Continent move into Britain during severe weather (Dobinson and Richards 1964, Cramp and Simmons 1983).

Redshank, Oystercatcher and Curlew are all primarily estuarine feeders but all rely on winter field feeding to some extent. Some Curlews feed exclusively in fields during the winter, although they may be forced onto coastal feeding grounds during severe weather (Elphick 1979, Townshend 1981). The patterns of field use by Curlews wintering in coastal areas are complex. Four different patterns of field use are shown by individual Curlews wintering in the vicinity of the Tees Estuary (Cleveland) (Townshend 1981). Some individuals feed exclusively in one habitat, the females more often selecting estuaries while the males are more frequently found on fields. A third category of birds feeds exclusively on mud-flats in autumn but then switches exclusively to field feeding in mid-winter, before changing back again in spring. Birds in the fourth category feed on the estuary at low water and supplement their intake by feeding in fields over the high tide period. This pattern of field-feeding is similar to that shown by Oystercatchers and Redshanks (below). The effect of cold weather on individual Curlews will depend on the patterns of habitat use which they adopt. Those Curlews that undertake southward movements in cold weather are presumably the individuals that are most dependent on field feeding. Males, which have shorter bills, use fields more than females (Elphick 1979, Townshend 1981). One testable prediction, therefore, is that those Curlews undertaking cold weather movements should include a high proportion of short-billed birds.

Oystercatchers and Redshanks wintering on British estuaries rarely undertake cold weather movements. However, emigration of both species from particular estuaries has been observed during severe weather (Pilcher 1964, Van Eerden 1977, Baillie 1980, Clark 1982, Davidson 1982). These birds probably moved short distances to nearby estuaries or to coastal habitats which were less affected by freezing. Both species suffer markedly increased mortality during cold weather, with six times as many Redshank recoveries and three times as many Oystercatcher recoveries reported during cold spells as during mild periods. This mortality increase is highest in North Britain where conditions are most severe and the time available for diurnal feeding in mid-winter is shortest. On the Ythan estuary in North-east Scotland, Redshanks (Goss-Custard 1969) and Oystercatchers (Heppleston 1971) must feed in fields over the high tide period and on the estuary at night in order to maintain an adequate rate of food intake. The frequency of field feeding is less in milder areas. In mid-winter about 80% of Oystercatchers on the Ythan estuary feed on fields over the high tide period (Heppleston 1971) against only 25% of those wintering on the Exe Estuary in Devon (Goss-Custard and Durrell 1984).

Dunlin, Knot, Shelduck and Ringed Plover feed almost exclusively on estuaries. Dunlin and Knot are mainly tactile feeders, foraging on mud-flats. When necessary they can forage close to the tide edge in the areas that are most likely to remain unfrozen. Neither species suffers increased mortality as a result of cold weather. Dunlin do not undertake cold weather movements, while Knot show only slight evidence of such movements. Knot have a complex pattern of interestuarine movements in all winters and this needs to be understood in more detail before the response of this species to cold weather can be properly assessed. Ringed Plovers do not appear to undertake cold weather movements but their mortality does increase in severe weather. They generally feed higher up the shore than the previous two species and thus their feeding areas may be more vulnerable to freezing. They also rely on visual cues to detect their prey, so reduced prey activity during cold weather reduces their rates of prey capture (Pienkowski 1983).

During cold weather 1.6 times as many recoveries of Shelducks were reported as in equivalent mild periods but this increase was not significant. However, large observed mortalities of this species have been reported during cold weather (Pilcher 1964, Hori 1964), and the lack of statistical evidence of increased mortality from the ringing recovery data is probably due to the small sample size. Shelduck undertake cold weather movements but interpretation of these is complex because they occur before the completion of the return movement from the moulting areas in the Waddenzee to the British breeding grounds. Shelducks still on the Waddenzee at the onset of cold weather probably move south rapidly, while birds that would have moved north from southern Britain may delay their return until after the cold weather. Shelduck feed mainly by sieving small invertebrates from shallow water and wet mud. Such feeding areas away from the tide edge may freeze during cold weather, and hence reduce the total area in which the birds can forage.

Both Sanderling and Turnstone feed predominantly on beaches, Sanderling being restricted largely to sand and shingle areas while Turnstones frequently forage on rocky shores. Both species do much of their feeding close to the tide edge in areas which are least likely to freeze over during cold weather. Neither species shows any evidence of cold weather movements or of increased mortality during cold weather.

Heron and Kingfisher

These two species are specialist fish-eaters, both foraging mainly in shallow freshwater areas. A minority of Grey Herons are estuarine or coastal foragers. When freshwater areas freeze over, both species are rapidly deprived of their food supply. In coastal areas some Herons may switch to feeding on the coast but this option is available only to a small proportion of the population. Both species suffer increased mortality during cold weather and substantial declines in their breeding populations usually follow severe winters (Reynolds 1979, Marchant and Hyde 1980, Taylor and Marchant 1983). A few Scottish Herons undertake cold weather movements to the south and west but apart from this neither species undertakes cold weather movements.

To summarise, species that feed inland, either in terrestrial habitats or on freshwater areas, are more severely affected by cold weather than those which occupy coastal areas. During cold weather ice may make fresh water inaccessible, while field-feeding waders may be unable to extract invertebrates from frozen ground. Snow cover frequently deprives grazing species of access to food. These effects apply not only to individuals which do all their feeding in such habitats but also to those that supplement estuarine or coastal feeding by feeding inland over the high tide period. Nearly all of the species affected in this way suffer increased mortality during cold weather, although for some the proximate cause of the increase may be hunting rather than direct starvation. Only some of these species move out of areas affected by cold weather. Cold weather movements are most pronounced in wildfowl and in inland feeding waders, which are often totally deprived of their food supplies under such conditions.

31.3 Why do some species not emigrate in cold weather?

One apparent paradox of these results is that some species suffer high cold weather mortality and yet do not undertake cold weather movements. The main examples from this study are Moorhen, Coot, Mute Swan, Redshank, Oystercatcher, Heron and Kingfisher. This is particularly surprising because populations of several of these species elsewhere in Europe are migratory and undertake cold weather movements. Indeed, the Redshanks and Oystercatchers which show such a lack of movements are themselves migratory at other times of year.

Possible explanations of why these populations do not undertake cold weather movements can be split into two groups; those which make it impossible for individuals to move and those which involve assessment by individuals of the costs and benefits of moving and staying.

Reasons why birds may be unable to move

1. The birds are physiologically incapable of long distance movements.

2. The birds lack sufficient energy reserves to undertake a long movement.

3. The population is genetically programmed to be sedentary for reasons unconnected with cold weather. Strong selection for sedentary behaviour at other times of year, perhaps brought about by advantages of familiarity with feeding or breeding areas, might result in a population which could not migrate at other times.

Of these three explanations physiological inability to migrate can be rejected for all seven species as these or other populations of the same species undertake long distance movements or migrations.

Many species of birds carry increased fat reserves during the mid-winter period as an insurance against periods of cold weather (Pienkowski et al. 1979, Dugan et al. 1981). Such species should have sufficient reserves for at least a short movement at the onset of cold weather. Oystercatchers wintering on the Wash increase in weight between early and mid-winter but unlike other waders the increase continues after mid-winter, probably in preparation for the early spring migration of this population (Johnson 1985). Redshanks on the Wash also increase in weight in autumn and maintain high weights between October and January but they lose weight rapidly between January and February (Johnson 1985). Redshanks in north-east Britain have very low lipid indices in January and February and the mid-winter weights of Redshanks on east coast estuaries are lower than those predicted from the relationship between weight and mean air temperature for south and west coast birds (Davidson 1982). This suggests that Redshanks have difficulty in maintaining adequate body reserves in mid-winter, at least in the more severe conditions experienced on the East coast. Thus many Redshanks probably lack the reserves necessary to move out of an area affected by cold weather.

Moorhens in North-east Scotland increase in weight between July and December but weights decline subsequently to reach their lowest level of the year in February (Anderson 1975). Thus this species may also have difficulty in maintaining adequate reserves in late winter. Kingfishers wintering in southern England increase in weight by 23% between autumn and mid-winter (Reynolds 1975). Some of this increase must be necessary to allow them to survive the longer and colder nights in mid-winter since this small species, with its energetically costly foraging methods, must experience a high energy demand in cold weather. Nevertheless, some reserves which could be used for movement at the start of cold weather should be available.

Genetically controlled sedentary behaviour is most likely to be a feature of populations that do not show seasonal movements and which do not disperse during the winter. Mute Swan, Moorhen and Kingfisher are all highly sedentary with mean dispersal distances of less that 50 km during mild winters. Grey Heron, Coot, Oystercatcher and Redshank are slightly more mobile with mild winter dispersal distances ranging from 83 km (Redshank) to 174 km (Coot). Oystercatcher and Redshank also migrate between wintering and breeding areas.

Reasons why it may be disadvantageous for birds to move

1. Individuals lack knowledge of suitable feeding areas further south, particularly if they are normally sedentary during the winter period and are faithful to a particular wintering area. Under such circumstances it may be a better risk to remain on the normal wintering area, particularly if most cold spells end fairly rapidly.

2. Competition for food at feeding sites in milder areas is severe. In these circumstances there might be little advantage in undertaking cold weather movements.

Information about alternative feeding areas can be obtained only by individuals that are mobile during the course of mild winters or that visit possible alternative wintering sites on migration. Thus those species that are more mobile during mild winters are those that are most likely to "know" about alternative feeding grounds. Most of the ducks which undertake cold weather movements have mean mild winter dispersal distances of over 250 km. Some of the Shovelers that winter in Britain probably move south to France at the end of normal winters. Thus individuals over one year old which move to France in cold weather may have visited the French feeding grounds previously. Some individually marked Grey Plovers visit the Tees estuary only during severe winters and probably winter on the Waddenzee in mild ones (Townshend 1982). Thus individuals of at least one species visit the same areas during subsequent cold winters, presumably because this enables them to move directly to a reliable feeding area. One may even speculate that knowledge of the location of potential cold weather feeding areas will allow birds to assess whether they have sufficient reserves for the journey before setting off.

Most of the species that do not undertake cold weather movements but that suffer high cold weather mortality are highly site-faithful both within and between mild winters. Over 90% of mild winter recoveries of all the species listed above are within Britain and Ireland, except for Coot for which the figure is 78%. Distances between ringing and recovery places show that within Britain most individuals move only short distances (above). Intensive studies of Oystercatchers and Redshanks confirm the site-fidelity of these species (Furness and Galbraith 1980, Goss-Custard and Durrell 1984, Symonds et al. 1984). Thus individuals of those species which usually fail to undertake cold weather movements will generally lack knowledge of alternative feeding areas. Under these circumstances the risks of emigration will be much greater.

For most of these species little is known of the effects of competition on feeding rates. The possibility that wintering populations are limited by competition for food has been studied in greatest detail in waders (Goss-Custard 1980, Evans and Dugan 1984) but even for this group the regulation of wintering populations is not well understood. Increasing competition for food as bird density increases may result in reduced rates of food intake by individuals, either because prey populations are depleted or because of interference effects that reduce foraging efficiency (Goss-Custard 1980). Depletion of the invertebrate food of estuarine waders over the whole winter may range from 25% to 45% on the main feeding areas (Goss-Custard 1980) but it is unlikely that predation would be sufficiently intensive to reduce substantially prey availability during cold spells which usually last for a few weeks. However, different considerations may apply to grazing waterfowl. On the Lauwerzee (Netherlands) Wigeon grazing on Salicornia exerted 80% of their annual grazing pressure on particular areas in only 11 nights. The total annual grazing pressure resulted in the removal of 50 - 70% of the total seed stock (Van Eerden 1984).

The rates of food intake of Oystercatchers, Redshanks and Curlews can be reduced by interference (Goss-Custard 1980). On the Wash the proportions of Knot and Oystercatchers feeding on less preferred feeding areas increase as bird density increases (Goss-Custard 1977). Thus waders moving to alternative feeding areas during cold weather might be forced to use sub-optimal feeding grounds and might also be unable to forage efficiently due to interference from other individuals. Such effects will reduce the advantages of undertaking cold weather movements.

Grey Herons occupy feeding territories on the Ythan estuary in autumn (Cook 1978). It is probable that they continue to occupy feeding territories throughout the winter but detailed studies have not been published. If the best feeding areas are already occupied by territorial individuals, the potential advantages of cold weather movements would be reduced. Movement would involve not only the cost of flight but probably also that of the aggressive encounters which would be necessary in order to gain access to a suitable feeding area.

It is not possible to distinguish between these alternatives on the basis of present data. Unfortunately most are not amenable to direct experimental testing. Increased understanding is most likely to come from detailed studies of the feeding behaviour and demography of populations of the same species which do and do not undertake cold weather movements, and of populations within which some individuals move while others do not.

31.4 Conservation implications

Many species of wildfowl and waders experience increased mortality during cold weather. For most species we do not know whether such mortality is directly compensated by density dependent adjustments to mortality at other times of year, or whether it results in population decline. Populations of many species of passerines and of Grey Herons and Kingfishers decline following severe winters and population recovery times are between one and four years (see review by Baillie 1984). It is important that the demographic implications of cold weather mortality should be properly assessed. In the absence of such knowledge it would be prudent to minimise the mortality increases which take place in cold weather.

Protection of those species that undertake cold weather movements should extend both to their normal wintering areas and to refuge areas used during cold weather. Many are quarry species and it would be advisable to stop hunting of them in severe weather, as is already the case in Britain. The main refuge areas used by birds that normally winter in Britain are in France, Iberia and the Republic of Ireland. Current information is not sufficiently detailed to describe how bird movements are related to the distribution of cold weather within Britain. Wildfowl are the main quarry species which undertake cold weather movements and duck ringing has been concentrated in southern Britain. However, many of these species disperse widely within Britain in both mild and severe weather, and it would be prudent therefore to retain the present system of country-wide hunting bans.

This study is concerned principally with cold weather movements by populations that normally winter in Britain. However, severe weather on the Continent in known to cause immigration into Britain by some species. The Svalbard population of Light-bellied Brent Geese normally winters in Denmark but the whole of this population moved to Lindisfarne (north-east England) in the winters of 1978/79 and 1981/82 (Salmon 1982). Immigration of Mute Swans, Bewick's Swans, White-fronted Geese, Bean Geese, Shelduck and Smew into Britain has also been recorded during cold weather (Harrison and Ogilvie 1967, Evans 1979, Doude van Troostwijk 1965, Salmon 1982). Some waders also move into Britain during cold weather. Increases in the numbers of Bar-tailed Godwits on the east coast during the winters of 1981/82 and 1984/85 were probably due to immigration from the Waddenzee (Marchant 1982, M.Moser pers. comm.). Increased numbers of Woodcocks have also been recorded in Britain during severe weather (Dobinson and Richards 1964, Marchant 1982). Detailed investigations of these movements require analyses of counts and ringing recoveries on a European basis (below). However, it is clear that under certain conditions some parts of Britain are used as refuge areas by birds fleeing from cold weather on the continent. Under these circumstances it is important that these refuge areas should be protected from hunting and from excessive disturbance.

None of the species which suffer increased mortality during cold weather but which do not undertake cold weather movements are quarry species. These birds all have extreme difficulty in balancing their energy budgets during severe cold weather and it is important therefore that disturbance of their feeding areas should be kept to a minimum at such times.

31.5 Future research priorities

This analysis describes the cold weather movements of populations of waders and wildfowl which winter in Britain, as far as is possible from the ringing recovery data currently available. It does not provide information on populations which move into Britain from the Continent during cold weather and yet the protection of these populations is also of concern to British conservationists. Many bird populations wintering in Britain and in adjacent continental areas are not discrete. Several of the analyses presented here show extensive cold weather movements out of the Waddenzee by many duck species (Table 31.3). Thus there is a strong case for considering cold weather movements in a European context.

The second limitation of this, and most other studies of the effects of cold weather on the movements and mortality of non-passerines, is that it does not provide information on the effect of cold weather mortality on the population sizes of the species concerned. These two themes, a European approach and an increased emphasis on the demographic effects of cold weather, should form the basis for future work. Some detailed suggestions are outlined below.

Description of cold weather movements

(1) Analyses of count data to complement the work on ringing recoveries presented here are now needed. Such analyses should preferably be on a European basis, although in many areas the frequency of counts may be insufficient for such an approach. Appropriate British count data are mainly those gathered by the Wildfowl Counts and the Birds of the Estuaries Enquiry. The Wildfowl Count scheme started in 1947 while the Birds of the Estuaries Enquiry has been running since 1970. Both schemes should include good count coverage from the three most recent cold winters of 1978/79, 1981/82 and 1984/85 along with suitable "control" periods from mild winters. It should also be possible to use the count data to identify sites which are used as cold weather refuge areas.

(2) The present analyses should be extended to include the recoveries of other European ringing schemes. This would provide information on populations which move into Britain during cold weather. It would also provide more data for species such as Lapwings which have been extensively ringed on their breeding grounds but not on their wintering grounds in Britain. Ogilvie (1983) has already carried out such an analysis for Teal. Examination of the recoveries in Britain of birds ringed abroad might provide some information on movements into Britain, but the data cannot be interpreted properly without knowing the proportions of different recovery samples which were in Britain, or the proportion of the total number of birds ringed in each area which was recovered here.

(3) The gaps in our knowledge of cold weather movements would be filled most quickly if British ringing programmes were assigned the priorities outlined below, though in practice these must compete with priorities assigned for other reasons. For many species of ducks, doubling the number of recoveries currently available for analysis would substantially improve our knowledge of cold weather movements. This is readily achievable since it is only in recent years that worthwhile numbers of many of these species have been ringed. Present ringing programmes for these species should be maintained at present levels or extended where possible. For only two species, Mallard and Teal, are there more than enough recoveries to provide a general description of cold weather movements. Cold weather movements by British-wintering Mallard are slight, and continued ringing is unlikely to provide much new information about them. However, the Mallard data-set will probably be very valuable for studies of cold weather and hunting mortality. Only for Teal are there sufficient data for analyses of movements on an annual basis (Section 30). Continued Teal ringing should aim to produce at least 50 recoveries per year. As there are differences in movement patterns between ringing areas, it would be better to have 50 recoveries of birds ringed in one area than 25 recoveries from each of two areas. Small

scale ringing of this species in southern England is unlikely to provide new information.

The most serious deficiency in the duck recovery data is the almost total lack of data for Scottish birds. The establishment of one or more duck ringing stations in this area could provide new and useful information on cold weather movements. Such a station should preferably be in North-east Scotland, as cold weather emigration is likely to be most marked there. Target species must be those likely to undertake cold weather movements (not Mallard) and which can be caught in reasonable numbers.

Increased catching of Wigeon, and perhaps also Shelduck, throughout Britain should also be considered. Both species can be caught in cannon-nets and there are several ringing groups that could be encouraged to catch these species as part of a co-operative project. It should be possible to increase Wigeon ringing sufficiently to provide adequate annual recovery samples.

With the exception of controls, recovery rates for Waders are very low. This is reflected in the very small samples available for some species. Data from controls can only be interpreted when the numbers caught in different areas are known. Such an approach is currently being tried in a general analysis of the inter-estuarine movements of waders, data from recaptures being combined with sightings of dye marked birds (Pienkowski and Pienkowski 1983). For waders this approach is likely to be far more productive than simply attempting to obtain more recoveries of dead birds through increased ringing.

For specific studies of cold weather movements these methods might be applied most effectively by colour marking birds which have moved into areas as a result of cold weather and then tracing their subsequent movements. Suitable areas could be identified from count data from previous cold winters. When such a set of data had been obtained it would also be necessary to obtain control data from one or more mild winters. The Wader Study Group has established a computerised archive of wader ringing data in connection with the project on wader movements mentioned above. They intend to continue to update this archive and this will enable future analyses of wader recoveries to include data from controls.

There has been little ringing of waders that winter inland within Britain. Field-feeding species such as Lapwing and Golden Plover are less at risk from destruction of their wintering areas than estuarine species. It is partly for this reason that ringing of these species has been given lower priority. Nevertheless, increased ringing of these species should be encouraged where possible.

Many of these suggestions concerning ringing effort could be achieved without further financial resources, by encouraging amateur ringers to undertake particular types of ringing. The main exception to this is the need for increased duck ringing in Scotland, which would probably require professional involvement.

The effect of cold weather on population dynamics

We have shown that for many species more recoveries are reported during periods of cold weather than during equivalent mild spells. From this we infer that more birds die during such periods. However, we do not know whether such increases in mortality result in an increase in the annual mortality of the species concerned. Reduced mortality later in the year might compensate for the increase caused by cold weather. This problem could be investigated by comparing annual mortality estimates from ringing recoveries for years with and without severe cold weather.

If cold weather does result in increased mortality during particular winters, there may be a decline in the breeding population in the following summer. This will depend on whether those individuals affected by the increased mortality were breeders or pre-breeders and whether increased losses are compensated by density dependent recruitment. Such declines will be detectable only for a few of the species discussed, as many breed in arctic areas where they are not censused. However, large declines may still be detectable from counts made in the following winter. Such effects may be buffered by density dependent breeding success and so, where it can be obtained, information on the proportion of juveniles in the winter population will be helpful for interpreting the counts. Thus, the second set on analyses that should be carried out is an examination of count data to determine whether wintering populations are reduced following cold winters and of the recovery times of any populations so reduced.

Table 31.1 Summary of mortality and movement patterns of wildfowl, Moorhen and Coot.

	Recovery Index (1)	Cold weather movements (2)
GRAZERS		
Wigeon	1.72 *	19% shift from Britain to France and S.Europe
Pink-footed Goose	1.47 **	34% shift from N.E.Scotland and E.England to N.W.England
Canada Goose	0.84 ns	9% shift from C.Britain to S.Britain and France
WATER PLANTS TAKEN FROM SURFACE OR BY UP-ENDING		
Moorhen	2.92 ***	None
Coot	2.44 ***	None
Gadwall	1.19 ns	Possible 24% shift from S.England to France (3)
Mute Swan	1.55 ***	None
MAINLY SEED-EATERS ALTHOUGH OTHER PLANT MATTER ALSO TAKEN		
Teal	1.98 ***	19% shift from England to France and S.Europe. Also movement to S.W.England and Ireland
Pintail	1.66 ns	25% shift to West Britain and Ireland
Mallard	1.16 **	2% shift from Britain to France and S.Europe
PLANKTON FROM NEAR SURFACE		
Shoveler	1.30 ns	52% shift from S.England to France.
BOTTOM FEEDERS		
Tufted Duck	1.43 *	13% shift from Britain to France and S.Europe
Pochard	1.14 ns	Possible 9% shift from England to France and S.Europe (3)

(1) Values greater than one indicate increased mortality. Significance is a test of the null hypothesis of equal numbers of recoveries in mild and cold weather:
*** $P<0.001$ ** $P<0.01$ * $P<0.05$ ns not significant.
For further details see methods.

(2) % shift is the percentage change between mild and cold weather recovery distributions. Because of various biases this is only a very approximate measure of the percentage of the population which moved. For further discussion see methods.

(3) Data not statistically significant, probably due to small sample.

Table 31.2 Summary of mortality and movement patterns of waders and Shelduck.

	Recovery Index (1)	Cold weather movements (2)
INLAND FEEDING SPECIES		
Lapwing	3.05 ***	British bred birds show increased movement to France and Iberia (3)
Snipe	3.38 ***	Movement from Britain to France and Iberia. Probably c. 27% shift.
Woodcock	1.85 ns	None
ESTUARY FEEDERS WITH SUPPLEMENTARY USE OF FIELDS		
Redshank	6.32 ***	None (4)
Oystercatcher	3.27 ***	None
Curlew	2.55 ***	20% shift from S. and E. England to France and Iberia
ESTUARY TACTILE AND FILTER FEEDERS		
Dunlin	0.94 ns	None
Knot	1.08 ns	Possible 17% shift from E.England to France (5)
Shelduck	1.64 ns	25% shift from Waddenzee and N.Britain to France and S.Britain
ESTUARY VISUAL FEEDER		
Ringed Plover	2.44 *	None
BEACHES AND ROCKY SHORES		
Sanderling	2.25 ns	None
Turnstone	1.38 ns	None

(1) Values greater than one indicate increased mortality. Significance is a test of the null hypothesis of equal numbers of recoveries in mild and cold weather:
*** P<0.001 ** P<0.01 * P<0.05 ns not significant.
For further details see methods.
(2) % shift is the percentage change between mild and cold weather recovery distributions. Because of various biases this is only a very approximate measure of the percentage of the population which moved. For further discussion see methods.
(3) Only 10% shift but even in mild winters many of these birds winter abroad.
(4) There is weak evidence that Redshanks ringed as chicks in North and Central Britain move further south in cold winters.
(5) Only weak statistical evidence.

Table 31.3 Percentage of recoveries of British-ringed ducks from the Waddenzee during mild and severe spells.

Species	Percentage of recoveries from the Waddenzee			
	mild spells		severe spells	
	%	n	%	n
Shelduck	22.7	22	0.0	18
Wigeon	9.3	43	2.7	37
Gadwall	3.1	56	0.0	19
Teal	2.0	652	0.6	645
Mallard	3.6	892	1.9	519
Pintail	10.3	49	0.0	24
Shoveler	0.0	20	7.7	13
Pochard	13.6	44	8.0	25
Tufted	12.6	119	12.9	85

n is the total number of recoveries in the sample.
For dates of severe spells see methods.
Mild spells are the same dates as severe spells in years immediately before and after cold weather.

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REFERENCES

Alexander, W.B. (1945-1947). The Woodcock in the British Isles. Ibis, 87, 512-550, 88, 1-24, 159-179, 271-286, 427-444, 89, 1-28.

Anderson, A. (1975). A method of sexing Moorhens. Wildfowl, 26, 77-82.

Anderson, K.R. and Minton, C.D.T. (1978). Origins and movements of Oystercatchers on the Wash. Brit. Birds, 71, 439-447.

Ash, J.S. (1964). Observations in Hampshire and Dorset during the 1963 cold spell. Brit. Birds, 57, 221-241.

Atkinson-Willes, G.L. (1975). The numerical distribution of ducks, swans and coots as a guide to assessing the importance of wetland in midwinter. Proceedings of the International Conference on Wetlands and Waterfowl, Heiligenhafen, 199-271.

Atkinson-Willes, G.L. and Scott, P. (Eds.) (1963). Waterfowl in Great Britain. H.M.S.O., London.

Bailey, R.S. (1967). An index of bird population changes on farmland. Bird Study, 14, 195-209.

Baillie, S. (1980). The effect of the hard weather of 1978/79 on the wader population of the Ythan estuary. Wader Study Group Bull., 28, 16-17.

Baillie, S.R. (1981). Population dynamics of the Eider (Somateria mollissima) in North-east Scotland. Unpublished Ph.D. thesis, University of Aberdeen.

Baillie, S.R. (1984). The movements of migratory birds in periods of severe cold weather. CST Commissioned Research Report, Nature Conservancy Council.

Bainbridge, I.P. and Minton, C.D.T. (1978). The migration and mortality of the Curlew in Britain and Ireland. Bird Study, 25, 39-50.

Batten, L.A. and Swift, J.A. (1982). British criteria for calling a ban on wildfowling in severe weather. Proc. second technical meeting on Western Palearctic migratory bird management, Paris 1979. 181-189.

Baur, K.M. and Glutz von Blotzheim, U.N. (1969). Handbuch der Vogel Mitteleuropas Volume 3. Frankfurt am Main.

Beer, H.V. and Boyd, H. (1964). Deaths of wild White-fronted Geese at Slimbridge in January 1963. Wildfowl Trust Ann. Rep., 15, 40-44.

Blurton Jones, N.G. (1956). Census of breeding Canada Geese 1953. Bird Study, 3, 135-170.

Boyd, H. (1957). Summer recoveries of Wigeon, Pintail, Shoveler and Tufted Duck ringed in Britain. Wildfowl Trust Ann. Rep., 8, 47-51.

Boyd, H. (1959). Movements of marked sea and diving ducks in Europe. Wildfowl Trust Ann. Rep., 10, 59-70.

Boyd, H. and Ogilvie, M.A. (1961). The distribution of Mallard ringed in southern England. Wildfowl Trust Ann. Rep., 12, 125-136.

Branson, N.J.B.A., Ponting, E.D. and Minton, C.D.T. (1978). Turnstone migrations in Britain and Europe. Bird Study, 25, 181-187.

Brown, R.G.B. (1955). The migration of the Coot in relation to Britain. Bird Study, 2, 135-142.

Bryant, D.M. (1978). Moulting Shelducks on the Forth Estuary. Bird Study, 25, 103-108.

Bryant, D.M. (1981). Moulting Shelducks on the Wash. Bird Study, 28, 157-158.

Chandler, R.J. (1981). Influxes into Britain of Red-necked Grebes and other waterbirds during winter 1978/79. Brit. Birds, 74, 55-81.

Clapham, C. (1979). The Turnstone populations of Morecambe Bay. Ringing and Migration, 2, 144-150.

Clark, N.A. (1982). The effects of the severe winter in December 1981 and January 1982 on waders in Britain. Wader Study Group Bull., 34, 5-7.

Clausager, I. (1974). Migration of Scandinavian Woodcock (Scolopax rusticola) with special reference to Denmark. Dan. Rev. Game Biol., 8, No. 8.

Cook, D.C. (1978). Grey Herons Ardea cinerea holding feeding territories on the Ythan Estuary. Bird Study, 25, 11-16.

Cramp, S. and Simmons, K.E.L. (Eds.) (1977). The Birds of the Western Palearctic Volume 1. Oxford University Press, Oxford.

Cramp, S. and Simmons, K.E.L. (Eds.) (1980). The Birds of the Western Palearctic Volume 2. Oxford University Press, Oxford.

Cramp, S. and Simmons, K.E.L. (Eds.) (1983). The Birds of the Western Palearctic Volume 3. Oxford University Press, Oxford.

Dare, P.J. (1966). The breeding and wintering populations of the Oystercatcher Haematopus ostralegus in the British Isles. Fishery Invest. Ser. II, 25, No. 5.

Dare, P.J. (1970). The movements of Oystercatchers Haematopus ostralegus visiting or breeding in the British Isles. Fishery Invest. Ser. II, 25, No. 9.

Davidson, N.C. (1982a). The effects of severe weather in 1978/79 and 1981/82 on shorebirds at Teesmouth: a preliminary view. Wader Study Group Bull., 34, 8-10.

Davidson, N.C. (1982b). Changes in the body-condition of Redshanks during mild winters: an inability to regulate reserves? Ringing and Migration, 4, 51-62.

Davidson, N.C. and Evans, P.R. (1982). Mortality of Redshanks and Oystercatchers from starvation during severe weather. Bird Study, 29, 183-188.

Davidson, P.E. (1967). A study of the Oystercatcher (Haemotopus ostralegus L.) in relation to the fishery for cockles (Cardium edule L.) in the Burry Inlet, South Wales. Fishery Invest. Lond. Ser. II, 25, No. 7.

Dick, W.J.A. (1979). Results of the WSG project on the spring migration of Siberian Knot Calidris canutus 1979. Wader Study Group Bulletin, 27, 8-13.

Dick, W.J.A., Pienkowski, M.W., Waltner, M. and Minton, C.D.T. (1976). Distribution and geographical origins of Knot Calidris canutus wintering in Europe and Africa. Ardea, 64, 22-47.

Dobinson, H.M. and Richards, A.J. (1964). The effects of the severe winter of 1962/63 on birds in Britain. Brit. Birds, 57, 373-434.

Doude Van Troostwijk, W.J. (1965). The European White-fronted Goose (Anser a. albifrons) during the winter 1962-63. Proc. 6th. Int. Congress Game Biologists, 275-284.

Dugan, P.J., Evans, P.R., Goodyer, L.R. and Davidson, N.C. (1981). Winter fat reserves in shorebirds: disturbance of regulated levels by severe weather conditions. Ibis, 123, 359-363.

Eastwood, E. (1967). Radar Ornithology. Methuen, London.

Elphick, D. (1979). An inland flock of Curlews in mid-Cheshire, England. Wader Study Group Bulletin, 26, 31-35.

Eltringham, K. and Boyd, H. (1963). The moult migration of the Shelduck to Bridgewater Bay, Somerset. British Birds, 56, 433-444.

Evans, M.E. (1979). The effects of weather on the wintering of Bewick's Swans Cygnus columbianus bewickii at Slimbridge, England. Ornis Scand., 10, 124-132.

Evans, P.R. (1966). Wader migration in north-east England. Trans. N.H.S. Northumb., Durham and Newcastle-upon-Tyne, 16, 126-151.

Evans, P.R. (1981). Migration and dispersal of shorebirds as a survival strategy. pp. 275-290 in Jones, N.V. and Wolff, W.J. (Eds.), Feeding and survival strategies of estuarine organisms. Plenum Press, New York and London.

Evans, P.R. and Dugan, P.J. (1984). Coastal birds: numbers in relation to food resources. pp. 8-28 in Evans, P.R. , Goss-Custard, J.D. and Hale W.G. (Eds.) Coastal waders and wildfowl in winter. Cambridge University Press, Cambridge.

Fog, J. (1969). (Studies on the Coot (Fulica atra) in the Marshland Vejlerne, North Jutland, and on the migration of Danish breeding populations.) Dansk. Orn. Foren. Tidsskr., 63, 1-18.

Fuller, R.J. and Youngman, R.E. (1979). The utilisation of farmland by Golden Plovers in southern England. Bird Study, 26, 37-46.

Furness, R.W. and Baillie, S.R. (1981). Wing-length and moult as indicators of the population structure of Redshank wintering on British estuaries. Ringing and Migration, 3, 123-132.

Furness, R.W. and Galbraith, H. (1980). Numbers, passage and local movements of Redshanks Tringa totanus on the Clyde Estuary as shown by dye-marking. Wader Study Group Bulletin, 29, 19-22.

Goss-Custard, J.D. (1969). The winter feeding ecology of the Redshank Tringa totanus. Ibis, 111, 338-356.

Goss-Custard, J.D. (1977). The ecology of the Wash. III Density-related behaviour and the possible effects of a loss of feeding grounds on wading birds (Charadrii). J.appl.Ecol., 46, 21-35.

Goss-Custard, J.D. (1980). Competition for food and interference among waders. Ardea, 68, 31-52.

Goss-Custard, J.D. and Durell, S. (1984). Feeding ecology, winter mortality and the population dynamics of Oystercatchers on the Exe estuary. pp. 190-208 in Evans, P.R., Goss-Custard, J.D. and Hale, W.G. (Eds.) Coastal waders and wildfowl in winter. Cambridge University Press, Cambridge.

Green, G.H. (Ed.) 1984. A survey of waders breeding on the west coast of the Uists and Benbecula (Outer Hebrides). 1983. Report published jointly by the Wader Study Group and the Nature Conservancy Council. 9pp.

Hale, W.G. (1971). A revision of the taxonamy of the Redshank Tringa totanus. Zool. J. Linn. Soc., 50, 199-268.

Hale, W.G. (1973). The distribution of the Redshank Tringa totanus in the winter range. Zool. J. Linn. Soc., 53, 177-236.

Hardy, A.R. and Minton, C.D.T. (1980). Dunlin migration in Britain and Ireland. Bird Study, 27, 81-92.

Harrison, J.G. and Ogilvie, M.A. (1967). Immigrant Mute Swans of south-east England. Wildfowl Trust Ann. Rep., 18, 85-87.

Heppleston, P.B. (1971). The feeding ecology of Oystercatchers (Haematopus ostralegus L.) in winter in northern Scotland. J. Anim. Ecol., 40, 651-672.

Holgersen, H. (1960). Wanderungen und Winterquartiere der Spitsbergen Kurzschnabelganse. Proc. Int. Orn. Congr., 12, 310-316.

Hori, J. (1964). Shelduck food supplies in severe weather. Wildfowl Trust Ann. Rep., 15, 44.

Hutchinson, C.D. (1979). Ireland's wetlands and their birds. Irish Wildbird Conservancy, Dublin.

Imboden, Ch. (1974). (Migration, dispersal and breeding period of the Lapwing Vanellus vanellus in Europe). Orn. Beob., 71, 5-134.

Impekoven, M.Z.ZT. (1965). Verbrectung und fluchtmigration von krickenten in den kalten wintern 1956 und 1962/63 eine verleichende analyse von ruchmeldungen in la Tour du Valat (Sudfrankreich) beringter tiere. Trans. Conf. Int. Union. Game Biol., 6, 293-307.

Jenkins, D., Newton, I. and Brown, C. (1976). Structure and dynamics of a Mute Swan population. Wildfowl, 27, 77-82.

Johnson, C. (1985). Patterns of seasonal weight variation in waders on the Wash. Ringing and Migration, 6, 19-32.

Kalchreuter, H. (1974). (Migration of the Woodcock (Scolopax rusticola) from recoveries of European banded birds). Vogelwarte, 27, 153-166.

Lebret, T. (1947). The migration of the Teal, Anas crecca crecca L., in western Europe. Ardea 35, 79-131.

Madsen, J. (1982). Observations on the Svalbard population of Anser brachyrhynchus in Denmark. Aquila, 89, 133-140.

Marchant, J.H. (1982). Waders. pp. 32-48 in Salmon, D.G. (Ed.) Wildfowl and Wader counts 1981/82. Wildfowl Trust, Slimbridge.

Marchant, J.H. (1983). Bird population changes for the years 1981-82. Bird Study, 30, 127-133.

Marchant, J.H. and Hyde, P.A. (1980a). Bird population changes for the years 1978-79. Bird Study, 27, 173-178.

Marchant, J.H. and Hyde, P.A. (1980b). Population changes for waterways birds 1978/79. Bird Study, 27, 179-182.

Marcstrom, V. and Mascher, J.W. (1979). Weights and fat in Lapwings Vanellus vanellus and Oystercatchers Haematopus ostralegus starved to death during a cold spell in spring. Ornis Scand., 10, 235-240.

Marquiss, M., Nicoll, M. and Brockie, K. (1983). Scottish Herons and the 1981/82 cold winter. BTO News, 125, 4-5.

Mead, C.J., Flegg, J.J.M. and Cox, C.J. (1968). A factor inhibiting subspecific differentiation in the Lapwing. Bird Study, 15, 105-106.

Mead, C.J. and Hudson, R.H. (1983). Report on Bird-Ringing for 1982. Ringing and Migration, 4, 281-319.

Meadows, B.S. (1972). The recovery of the Kingfisher in London after the 1962/63 hard winter. London Bird Report, 36, 60-65.

Milne, H. (1965). Seasonal movements and distribution of Eiders in North-east Scotland. Bird Study, 12, 170-180.

Milson, T.P., Holditch, R.S. and Rochard, J.B.A. (1985). Diurnal use of an airfield and adjacent agricultural land by lapwings Vanellus vanellus. J. appl. Ecol., 22, 313-326.

Minton, C.D.T. (1971). Mute Swan Flocks. Wildfowl, 22, 71-88.

Morgan, R.A. and Glue, D.E. (1977). Breeding, mortality and movements of Kingfishers. Bird Study, 24, 15-24.

Moser, M. and Summers, R. (1984). Winter Shorebird Count. BTO News, 134, 3.

Murton, R.K. (1971). Man and birds. Collins, London.

Myers, J.P. and McCaffery, B.J. (1980). Opportunism and site-faithfulness in wintering Sanderlings. Wader Study Group Bulletin, 28, 43.

North, P.M. and Morgan, B.J.T. (1979). Modelling Heron survival using weather data. Biometrics, 35, 667-681

O'Connor, R.J. and Cawthorne, R.A. (1982). How Britain's birds survived the winter. New Scientist, 93, 786-788.

O'Connor, R.J., Cawthorne, R.A. and Mead, C.J. (1982). The effects of severe winter weather on British bird populations. CST Commissioned Research Report, Nature Conservancy Council.

Ogilvie, M.A. (1962). The movements of Shoveler ringed in Britain. Wildfowl Trust Ann. Rep., 13, 65-69.

Ogilvie, M.A. (1967). Population changes and mortality of the Mute Swan in Britain. Wildfowl Trust Ann. Rep., 18, 64-73.

Ogilvie, M.A. (1969). The status of the Canada Goose in Britain. Wildfowl, 20, 79-85.

Ogilvie, M.A (1972). Distribution, numbers and migration. pp. 29-55 in Scott, P. and the Wildfowl Trust, The Swans. London.

Ogilvie, M.A. (1977). The numbers of Canada Geese in Britain, 1976. Wildfowl, 28, 27-34.

Ogilvie, M.A. (1978). Wild Geese. T. and A.D. Poyser, Berkhamsted.

Ogilvie, M.A. (1981). The Mute Swan in Britain, 1978. Bird Study, 28, 87-106.

Ogilvie, M.A. (1981). Hard weather movements of Anas crecca ringed in western Europe - a preliminary computer analysis. Proc. IWRB Symp. Alushta, USSR., 119-135.

Ogilvie, M.A. (1982). Winter 1978/79 hard weather movements and mortality of ducks ringed in the United Kingdom. Proc. second technical meeting on Western Palearctic migratory bird management, Paris 1979, 174-180.

Ogilvie, M.A. (1983). A migration study of the Teal (Anas crecca) in Europe using ringing recoveries. Unpublished Ph.D. thesis, University of Bristol.

Ogilvie, M.A. (1984). Numbers of Geese in Britain and Ireland, 1983-84. Wildfowl, 35, 180.

Owen, M. (1977). Wildfowl of Europe. MacMillan, London.

Owen, M., Atkinson-Willes, G. and Salmon, D.G. in press. Wildfowl of Great Britain. Cambridge University Press, Cambridge.

Owen, M. and Cook, W.A. (1977). Variation in the body weight, wing length and condition of Mallard Anas platyrhynchos and their relationship to environmental changes. J. Zool. Lond., 183, 377-395.

Owen, M. and Williams, G. (1976). Winter distribution and habitat requirements of Wigeon in Britain. Wildfowl, 27, 83-90.

Parslow, J. (1973). Breeding birds of Britain and Ireland. T. and A.D. Poyser, Berkhamsted.

Patterson, I.J. (1982). The Shelduck, a study in behavioural ecology. Cambridge University Press, Cambridge.

Perdeck, A.C. and Classon, C. (1982). Flyways of anatidae ringed in Holland. An analysis based on ringing recoveries. pp. 65-88 in Scott, D.A. and Smart, M. (Eds.). Proc. second technical meeting on Western Palearctic migratory bird management, Paris. 11-13 Dec. 1979. Slimbridge, I.W.R.B.

Pienkowski, M.W. (1983). Changes in the foraging pattern of Plovers in relation to environmental factors. Anim. Behav. 31, 244-264.

Pienkowski, M.W. and Dick, W.J.A. (1975). The migration and wintering of Dunlin, Calidris alpina, in north-west Africa. Ornis Scand., 6, 151-167.

Pienkowski, M.W., Lloyd, C.S. and Minton, C.D.T. (1979). Seasonal and migrational weight changes in Dunlins. Bird Study, 26, 134-148.

Pienkowski, M.W. and Pienkowski, A.E. (1983). WSG project on the movement of wader populations in western Europe: eighth progress report. Wader Study Group Bulletin, 38, 13-22.

Pilcher, R.E.M. (1964). Effects of the cold winter of 1962-63 on birds of the north coast of the wash. Wildfowl Trust Ann. Rep., 15, 23-26.

Prater, A.J. (1976). Breeding population of Ringed Plover in Britain. Bird Study, 23, 155-161.

Prater, A.J. (1981). Estuary birds of Britain and Ireland. T. and A.D.Poyser, Calton.

Prater, A.J. and Davies, M. (1978). Wintering Sanderlings in Britain. Bird Study, 25, 33-38.

Reynolds, A. (1975). Kingfishers at Rye Meads. Ringing and Migration, 1, 48-51.

Reynolds, C.M. (1979). The heronries census: 1972-1979 population changes and a review. Bird Study, 26, 7-12.

Rydzewski, W. (1956). The nomadic movements and migrations of the European common Heron, Ardea cinerea L. Ardea, 44, 71-188.

Salmon, D.G. (1982). Wildfowl. pp. 5-30 in Salmon, D.G. (Ed.) Wildfowl and Wader counts 1981/82. Wildfowl Trust, Slimbridge.

Salmon,D.G. (1984). Wildfowl. pp. 3-26 in Salmon, D.G. and Moser, M.E. (1984). Wildfowl and wader counts 1983-84. Wildfowl Trust, Slimbridge.

Salomonsen, F. (1968). The moult migration. Wildfowl, 19, 5-24.

Scott, D.A. (1980). A preliminary inventory of wetlands of international importance for waterfowl in West Europe and North West Africa. I.W.R.B. Spec. Publ. 2, I.W.R.B., Slimbridge.

Sharrock, J.T.R. (1976). The Atlas of Breeding Birds in Britain and Ireland. T. and A.D. Poyser, Calton.

Siegel, S. (1956). Nonparametric statistics for the behavioural sciences. McGraw-Hill, New York.

Smith, K.D. (1965). On the birds of Morocco. Ibis, 107, 493-526.

Smith, K.W. (1983). The status and distribution of waders breeding on wet lowland grasslands in England and Wales. Bird Study, 30, 177-192.

Snedecor, G.W. and Cochran, W.G. (1980). Statistical Methods. Seventh Edition, Iowa State University Press, Iowa, U.S.A.

Spencer, R. and Hudson, R. (1982). Report on bird-ringing for 1981. Ringing and Migration, 3, 65-128.

Spray, C.J. (1981). An isolated population of Cygnus olor in Scotland. pp. 191-208 in Mathews, G.V.T. and Smart, M. (Eds.) Proceedings Second International Swan Symposium, Japan 1980. I.W.R.B., Slimbridge.

Swennen, C. and Duiven, P. (1983). Characteristics of Oystercatchers killed by cold-stress in the Dutch Wadden Sea area. Ardea, 71, 155-159.

Symonds, F.L. and Langslow, D.R. (1984). Geographical origins and movements of shorebirds using the Firth of Forth. Ringing and Migration, 5, 145-152.

Symonds, F.L., Langslow, D.R. and Pienkowski, M.W. (1984). Movements of wintering shorebirds within the Firth of Forth: species differences in usage of an intertidal complex. Biological Conservation, 28, 187-215.

Tasker, M.L. (1982). Moulting Shelducks on the Humber. Bird Study, 29, 164-166.

Taylor, K. and Marchant, J. (1984). Waterways bird survey, 1982-83 Index results and recent news. BTO News, 133, 8-9.

Taylor, K. and Marchant, J.H. (1983). Population changes for waterways birds, 1981-82. Bird Study, 30, 121-126.

Taylor, R.C. (1980). Migration of the Ringed Plover Charadrius hiaticula. Ornis Scand., 11, 30-42.

Ticehurst, N.F. and Hartley, P.H.T. (1948). Report on the effect of the severe winter of 1946-47 on bird life. Brit. Birds, 41, 322-334.

Thomas, C.B. (1977). The mortality of Yorkshire Canada Geese. Wildfowl, 28, 35-47.

Townshend, D.J. (1981). The importance of field feeding to the survival of wintering male and female Curlews. pp. 261-273 in Jones, N.V. and Wolff, W.J. (Eds), Feeding and survival strategies of estuarine organisms. Plenum Press, New York and London.

Townshend, D.J. (1982). The Lazarus syndrome in Grey Plovers. Wader Study Group Bull., 34, 11-12.

Van Eerden, M. (1977). Vortvlucht van watervogels door het oostelijk deel van de Nederlandse Waddenzee op 30 December 1976. Watervogels, 2, 11-14.

Van Eerden, M.R. (1984). Waterfowl movements in relation to food stocks. pp. 84-100 in Evans, P.R. , Goss-Custard, J.D. and Hale W.G. (Eds.) Coastal waders and wildfowl in winter, Cambridge University Press, Cambridge.

Walker, A.F.G. (1970). The moult migration of Yorkshire Canada Geese. Wildfowl, 21, 99-104.

Wolff, W.J. (1966). Migration of Teal ringed in the Netherlands. Ardea, 54, 230-270.

van den Bergh, L.M.J., Dirksen, S., Ebbinge, B., van Haperen, A., Lok, C.M., Phillippona, J., Rooth, J. and Timmerman, Azn. A. (1981). Resultaten van de ganzentellingen in Nederland in het winterhalfjaar 1979-80. Watervogels, 6, 119-142.

Venables, L.S.V. and Wykes, U.M. (1943). An index of the Thames Kingfisher recovery. Brit. Birds, 36, 153-155.

Von Kanel, A. (1981). Winter feeding ecology of Wigeon Anas penelope at the Ouse Washes, England. Ibis, 123, 438-449.

Yarker, B. and Atkinson-Willes, G.L. (1971). The numerical distribution of some British breeding ducks. Wildfowl, 22, 63-70.