WINTER STATUS AND DISTRIBUTION OF CORMORANTS, GOOSANDERS AND RED-BREASTED MERGANSERS IN GREAT BRITAIN WITH SPECIFIC REFERENCE TO THE NORTH WEST NRA REGION

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1.0 EXECUTIVE SUMMARY

1.1 A recent increase in the number of complaints from fishermen to NRA regarding fish-eating birds, particularly Cormorants, in North West England prompted the work presented in this report. The aims of this project were: to provide estimates of national and North West NRA regional populations of Cormorants, Goosanders and Red-breasted Mergansers; to describe current distribution patterns and highlight the most important sites; to examine changes in populations and distribution over time; and, to investigate patterns of habitat use. A prediction of likely future trends, and an assessment of the implications of predation by these birds on freshwater fisheries was made, as a first step to investigating the complaints from fishermen.

1.2 The current available literature was reviewed for the Cormorant, Goosander and Red-breasted Merganser, concentrating on status and distribution. This was followed by some basic analyses of National Waterfowl Counts (NWC) data for Great Britain as a whole, and for the North West NRA region. The NWC counts are undertaken by experienced ornithologists once in each month, mainly between September and March. For Britain as a whole, around 6,000 sites have been counted at least once since the NWC started, and approximately 2,000 sites are currently counted annually. Whilst coverage of most wetlands is relatively comprehensive, there are fewer counts available for rivers. For the Goosander and Red-breasted Merganser, count data from the 1960/61 to 1990/91 period (31 seasons) were analyzed. Fewer data were used for the Cormorant since this species has only been included in the NWC scheme since 1986/87.

1.3 Cormorants are predominantly coastal nesting birds, but they may move inland during the winter. Their diet consists almost entirely of fish, normally the locally dominant species. Goosanders mostly nest on rivers, while Red-breasted Mergansers tend to breed on the lower stretches of rivers, on lakes and sea lochs. In winter, Red-breasted Mergansers mainly occupy coastal habitats, whilst Goosanders are found on inland sites throughout the year. Both Goosanders and Red-breasted Mergansers feed on small fish and crustaceans. The species taken is dependent on habitat and availability, but is usually the most abundant species of less than 10cms in length.

1.4 The first record of Goosanders breeding in Britain was in 1871 when a pair nested in Perthshire. There was an increase in the Goosander population over the next hundred years, and birds spread throughout Scotland and then into northern England during the 1950s and 1960s. Goosanders had colonised Wales by the 1970s, and a few pairs are now breeding as far south as Devon. Red-breasted Mergansers were widespread in the highlands of Scotland during the last century. They began to expand their range during the 1880s and have spread slowly south during the present century, reaching Wales 10-15 years before Goosanders. During the 19th century, widespread persecution reduced Cormorant numbers considerably and led to the extinction of many colonies. However, numbers have increased throughout the present century, and most colonies are still expanding. Between 1969 and 1985, colonies in England and the Isle of Man have increased by about 30%.

1.5 Based on winter counts from the NWC (1986/87 and 1990/91), British wintering populations were estimated at 16,800 Cormorants, 5,500 Goosanders and 8,100 Red-breasted Mergansers. Some 12-19% of these birds, depending on species, were counted in the North

West NRA region. All species were widely distributed throughout Britain, though there were a small number of key resorts for each species which held a high proportion of the population. The Goosander and Red-breasted Merganser were recorded at only about 15% of the NWC sites counted, and generally occurred in small numbers. In the North West NRA region, Morecambe Bay and the Solway Estuary were nationally important for Cormorants, as was the River Eden for Goosanders, and Morecambe Bay and the Duddon Estuary for Red-breasted Mergansers.

1.6 As far as can be determined from NWC data, there appears to have been little change in the British distribution of Goosanders or Red-breasted Mergansers as a result of protection under the Wildlife and Countryside Act (1981). However, there were more records from most areas during the more recent seasons, which may be due to the coverage of more sites and a greater degree of dispersion across sites for both species.

1.7 The number of Cormorants counted in Britain increased markedly since they were first included in the NWC scheme in 1986/87. On sites counted in every season between 1986/87 and 1990/91, numbers have increased by approximately 18% each year. Since the early 1960s there have been significant long-term, national increases in both the numbers and the dispersion (measured as the proportion of sites occupied) of Goosanders and Red-breasted Mergansers in all months. Closer examination of these long-term trends suggests that Goosanders increased during the 1969/70 to 1979/80 period only, whilst Red-breasted Mergansers increased between 1962/63 and 1979/80. The counts of both species revealed neither an increase nor a decrease since 1981/82.

1.8 In the North West NRA region, there was an increase in the numbers of Cormorants counted between 1987/88 and 1989/90, but the number counted fell in 1990/91. There was also an increase in the proportion of sites occupied in the region between 1987/88 and 1989/90. The number of Goosanders counted in the North West NRA region changed relatively little up until 1984/85, but appears to have increased significantly since 1981/82, mainly because of high counts between 1985/86 and 1990/91. The number of Red-breasted Merganser counted increased from 1963/64 to 1976/77, but appears to have declined since, though there were high counts in 1987/88 and 1989/90. For both species, there was no change in the proportions of sites occupied over the period.

1.9 All three species have occurred in all wetland habitat types covered for the NWC scheme, but Red-breasted Mergansers were mainly confined to the coast. During the winter, Cormorants moved onto inland sites. In September, 75% of Cormorants counted were on coastal sites, but this fell to only 50% by February.

1.10 Nationally, Cormorants appear to have increased more rapidly on inland sites than in coastal waters, whilst Goosanders appear to have increased significantly in most habitat types, but especially gravel pits. The numbers of Red-breasted Mergansers counted on lakes and coastal habitats has increased.

1.11 Cormorants, Goosanders and Red-breasted Mergansers use wetlands differently during the year and, if they do effect freshwater fisheries in North West NRA region, their relative impacts are likely to differ. Cormorants are the most abundant of these species on inland sites during the winter months, with a ratio of 23:2:10 Cormorants to Red-breasted Merganser to Goosanders. Goosanders and Red-breasted Mergansers are most abundant during the summer with a ratio of 2:15:10 Cormorants to Red-breasted Mergansers to Goosanders.

1.12 National and regional trends in numbers counted over the last 10 years or so suggests that the numbers of Goosander and Red-breasted Merganser are likely to remain constant in the North West NRA region, whilst Cormorants are more likely to increase. The proportion of the Cormorant population wintering on inland sites is also increasing, and they are already the most numerous piscivore there. Thus increasing concern from fishermen over predation by Cormorants on fish stocks in winter could be expected. Goosanders are very mobile and usually conspicuous. Both sexes are present on rivers during the spring salmon smolt runs and, later in the summer, females and their broods often congregate together in good feeding areas. Thus, concerns of game fishermen are likely to be focused on Goosanders during the spring, when the males are visible, and later in the summer when relatively large flocks of females and young may be seen.

2.0 INTRODUCTION

Several species of piscivorous waterfowl occur within Great Britain, but only seven species frequent inland waters. These are the Little Grebe (*Tachybaptus ruficollis*), Great Crested Grebe (*Podiceps cristatus*), Grey Heron (*Ardea cinerea*), Cormorant (*Phalacrocorax carbo*), Smew (*Mergus albellus*), Red-breasted Merganser (*M. serrator*) and Goosander (*M. merganser*). Inland, the grebes and the Smew are most frequently associated with standing waters, and rarely occur in large numbers; indeed, the Smew resorts to Britain in relatively large numbers only in the coldest of winters (Owen *et al.* 1986). Herons typically are perceived to be a problem by fishery managers where fish are held at high densities, for example at garden ponds and fish farms. Here, relatively simple measures can be taken to prevent major losses (van Vessem 1981). The remaining species are different in that they are relatively large, highly mobile and sometimes numerous. They often frequent rivers where angling is a major activity, and this brings them to the attention of fishermen and fishery managers. Again, with all of these species, the conflicts between fishery managers and piscivorous birds are based on perception of impacts. The scales of any impact on fish are largely unknown, especially on river systems.

It is because of an increase in the number of complaints from fishermen in North West England, and especially on the River Ribble, that the work presented here has been undertaken. These complaints have been directed mainly towards Cormorants, but there are also problems with Goosanders and Red-breasted Mergansers in some areas. The aims of this project were: to provide estimates of national and North West NRA regional populations; to describe current distribution patterns and highlight the most important sites; to examine changes in populations and distribution over time; and, to investigate patterns of habitat use. This is done for each species in turn, whilst the overall discussion includes some predictions about likely future trends, and a discussion of the implications for freshwater fisheries in the North West NRA Region.

3.0 METHODS USED TO ANALYSE NWC DATA

Data on winter numbers and distribution these species in Great Britain were obtained from the National Waterfowl Counts programme (NWC), organised by The Wildfowl & Wetlands Trust in order to monitor the distribution and abundance of all wildfowl species. Instigated in 1947, these counts are undertaken by experienced volunteers once in each month, mainly between September and March (the counting "season") (Figure 1), usually on the Sunday nearest the middle of the month (Owen *et al.* 1986, Kirby *et al.* 1991). The majority of counts are made during the late morning or early afternoon. All wetland habitat types are included, but especially estuaries and coastal bays, lakes, reservoirs, gravel pits, freshwater marshes, rivers and canals, but these were classified into five major types for our analyses: gravel pits (includes other mineral workings *e.g.* clay pits), lakes, reservoirs, coastal waters (estuaries/coastal bays) and rivers/freshwater marshes (including canals and floodlands). Some 6,000 British sites have been counted at least once since the NWC started, and between 1,600 and 2,300 sites are currently counted, varying according to month (Table 1, Figure 2). For further methodological details and comprehensive analyses of the counts up to 1981/82 see Owen *et al.* (1986), and for recent summaries see the annual reports (*e.g.* Kirby *et al.* 1991).

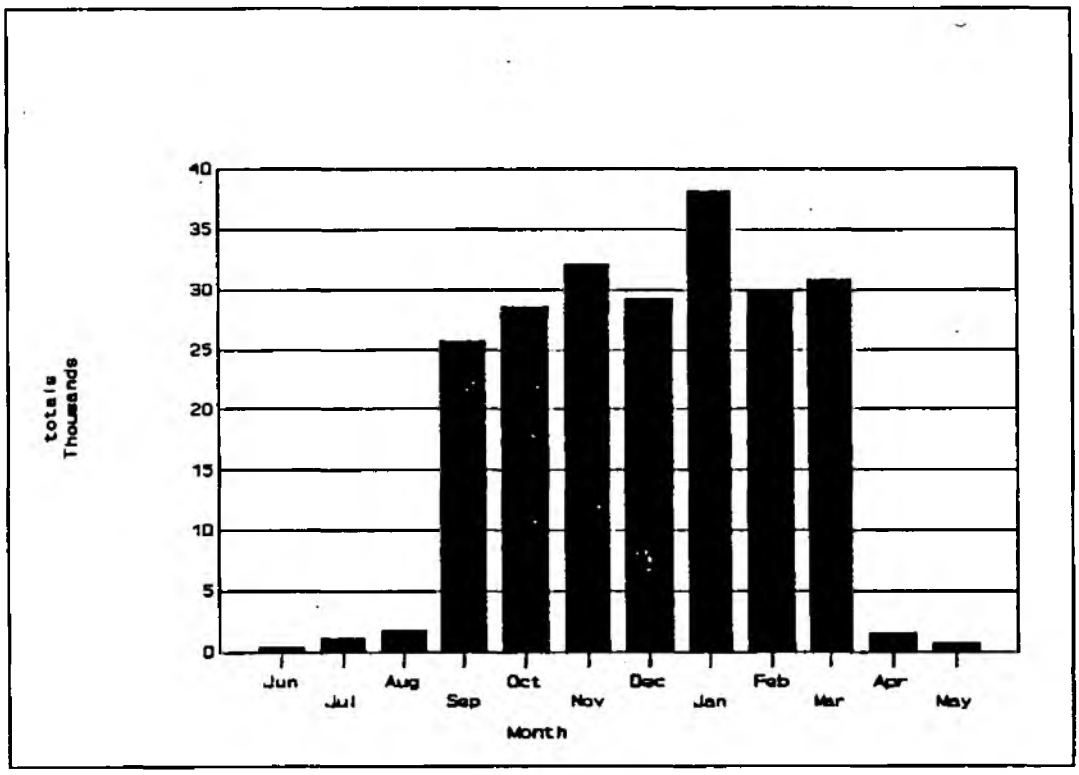
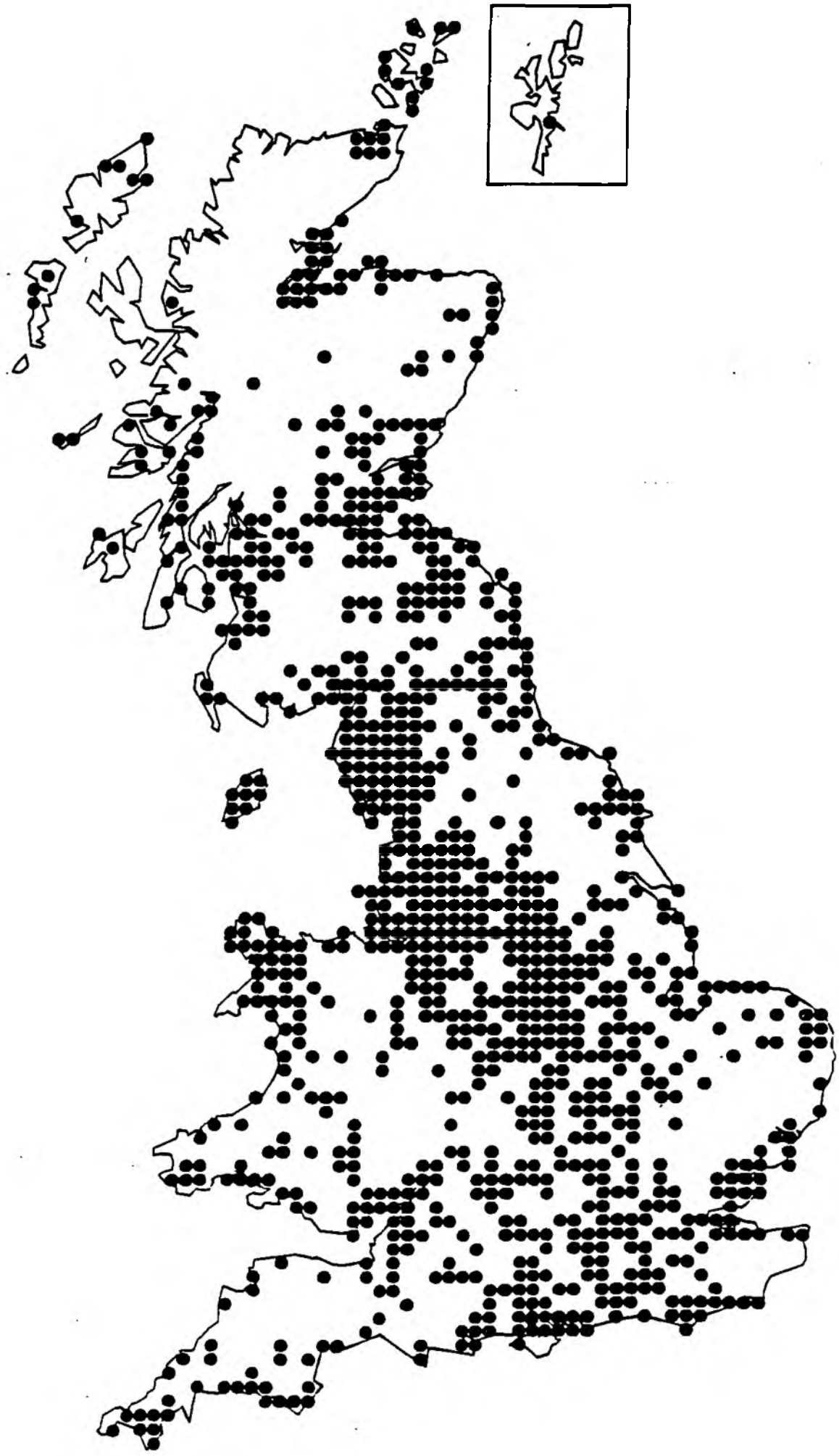


Figure 1. No. of National Waterfowl Counts made in each month, 1960/61 to 1990/91.

Figure 2. Coverage by 10-km grid squares for the National Waterfowl Counts in 1990/91.



For the Goosander and Red-breasted Merganser, analyses of count data from the 1960/61 to 1990/91 period (31 seasons) are presented here. Fewer data were used for the Cormorant since this species has only been included in the NWC scheme since 1986/87. This has meant that some of the results of analyses presented for the Cormorant differ from those for the other species.

Table 1. Number of wetland sites counted during September to March for the NWC scheme.

A. North West NRA Region, 1986/87 to 1990/91
B. Great Britain, 1986/87 to 1990/91
C. On different habitat types in Great Britain 1990/91

	Sep	Oct	Nov	Dec	Jan	Feb	Mar
A.							
1986/87	122	130	138	134	152	141	137
1987/88	112	110	125	129	143	129	133
1988/89	104	108	120	118	118	108	107
1989/90	119	126	134	130	152	129	130
1990/91	261	274	298	293	653	307	308
B.							
1986/87	1377	1403	1486	1505	1653	1522	1486
1987/88	1272	1338	1463	1472	1680	1497	1460
1988/89	1239	1323	1391	1399	1609	1379	1362
1989/90	1329	1402	1429	1111	1696	1456	1446
1990/91	1598	1692	1748	1778	2270	1769	1719
C.							
Reservoirs	173	180	187	187	215	186	192
Lakes	573	602	642	637	939	623	632
Gravel Pits	172	179	186	186	214	185	191
Rivers/ freshwater marshes	118	131	137	145	239	145	137
Coastal Waters	363	395	398	425	438	430	362

3.1 Winter status and distribution

The analyses used to describe winter status and distribution were based largely on data from the 1986/87 to 1990/91 period only (5 seasons) and thus provide an indication of the current situation. An estimate of the size of the current British winter population was made by summing monthly average counts (1986/87 to 1990/91) for each site and selecting the highest of these, following the method of Owen *et al.* (1986). This is referred to as the "estimated total population".

For the Goosander and Red-breasted Merganser, distribution maps were produced for two time periods (1976/77 to 1980/81 and 1986/87 to 1990/91), to allow investigation of the patterns before and after the introduction of the Wildlife and Countryside Act (1981) under which Goosander and Red-breasted Merganser were protected. The distribution map for Cormorants was based on data from the latter period only. Key sites were selected as those having attained national recognition over the 1986/87 to 1990/91 seasons. As such, these sites regularly held average seasonal maxima of 50 or more Goosanders, 100 or more Red-breasted Mergansers, and 200 or more Cormorants (representing 1% of the national population levels listed in Kirby *et al.* 1991 and Lack 1986). Those sites in the North West NRA region where this number of each species has been recorded are also identified.

The changes in abundance of each species from month to month was also examined by including data from only those sites counted in all seven months (September to March), and expressing the number counted in each month as a percentage of the peak number present in that season. For presentation purposes, these were averaged to show the general pattern for the 31 seasons. These analyses were repeated for various regions of Great Britain, using the water catchments described by Owen *et al.* (1986). For each region, the consistency of the monthly patterns across seasons were tested using Friedman's two way analysis of variance, and assessed the overall measure of agreement by calculating Kendall's Coefficient of Concordance (Sokall & Rohlf 1981). Small sample sizes precluded such detailed regional analysis for Cormorants.

3.2 Long-term trends

Trends in the abundance of Goosander and Red-breasted Merganser were examined using the technique proposed by Underhill (1989). This technique allows data from several months to be used to generate an overall population trend, and allows the estimation of missing values and confidence limits. The annual population index is given by the year factor, which is simply a ratio of the population size in one year to that in the base year. If there are no missing data the index will be exact. More usually, missing and incomplete data are estimated using an iterative algorithm and the index recalculated. Further details are found in Appendix 1 and Underhill (1989).

Long-term trends in abundance were examined for the whole of Great Britain and for the individual regions defined by Owen *et al.* (1986) (Figure 3). In considering the North West region, we examined trends for an area equivalent to that covered by the NRA (North West NRA region). This included the counties of Cumbria, Lancashire, Greater Manchester, Merseyside and Cheshire. Because there were fewer data for Cormorant, the Underhill technique was not applied to data for this species. Instead, overall changes in abundance were examined using 107 sites that held Cormorants that had been counted in all seasons between 1987/88 and 1990/91. Any missing counts from particular sites were estimated by calculating an average of the counts made in previous and subsequent months; less than 10% of counts had to be estimated in this way. Changes in Cormorant abundance between years were tested using a Kruskal-Wallis analysis of variance (Sokall & Rohlf 1981). To examine the changes in the North West NRA region in more detail, the peak counts at 'key' sites in each season were tabulated.

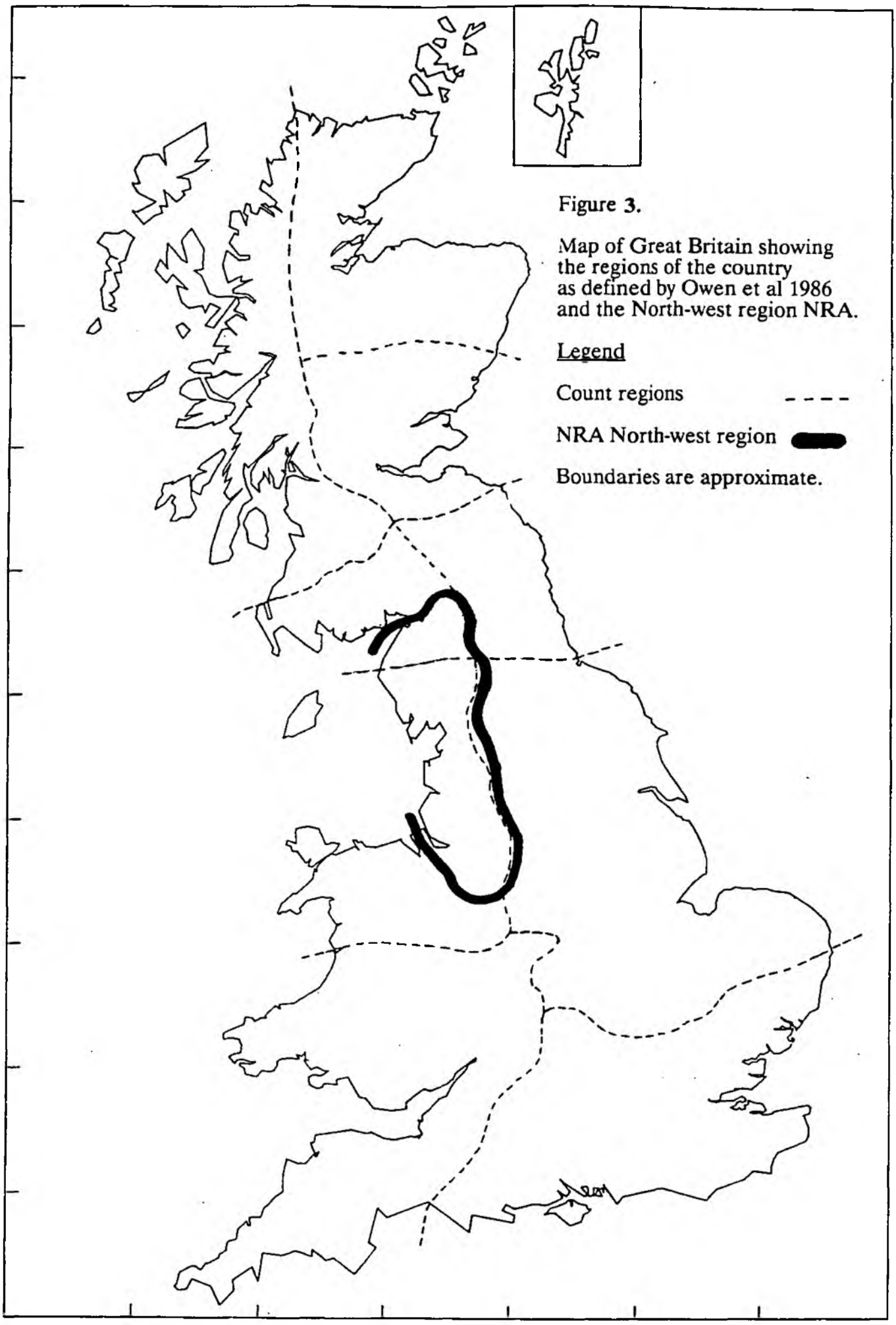


Figure 3.

Map of Great Britain showing the regions of the country as defined by Owen et al 1986 and the North-west region NRA.

To complement investigations of long-term trends in numbers, the 'dispersion' of each species was examined by calculating the proportion of the sites counted at which the species occurred in each count season. A General Linear Models regression procedure (on arcsine-transformed data) was used to see whether there had been any trend for greater or less dispersion over time.

3.3 Habitat use

NWC sites have traditionally been selected by the volunteer counters themselves, usually on the basis of their total wildfowl interest. The sample of sites monitored is therefore not a random one, and may not provide equally comprehensive assessments of the wildfowl populations on each habitat type. Without a comprehensive register of wetlands in Great Britain, we do not know what proportion of the available wetlands of various habitat types are covered by the NWC scheme. Figures 4 to 8 show the distribution of sites of each habitat type that have been counted during the 1960/61 and 1990/91 period. The coverage achieved of most major wetland types reflects well the distribution of the available habitat, but that for rivers/freshwater marshes is more restrictive. It is clear also that the river count sites are generally short in length, and no river system is routinely counted along its entire length.

An indication of the relative importance of each habitat type was gained by calculating the proportion of sites of different habitats that held the species in each month. Also calculated was the proportion of the total British count in each month attributable to sites of each habitat type, but this will be biased because of the variation in coverage between habitats.

Similar analyses to those used to investigate regional patterns (involving Friedman's and Kendall's tests) were performed to investigate monthly patterns of abundance on different habitats. For Goosander and Red-breasted Merganser, long-term trends in the use of different habitats were examined using the Underhill method, applying the site selection criteria described in Appendix 1. This was not possible for Cormorants and so comparisons were made of the total number counted on each habitat type on 390 sites counted in both September 1987 and September 1990, and on 405 sites counted in both January 1987 and January 1991.

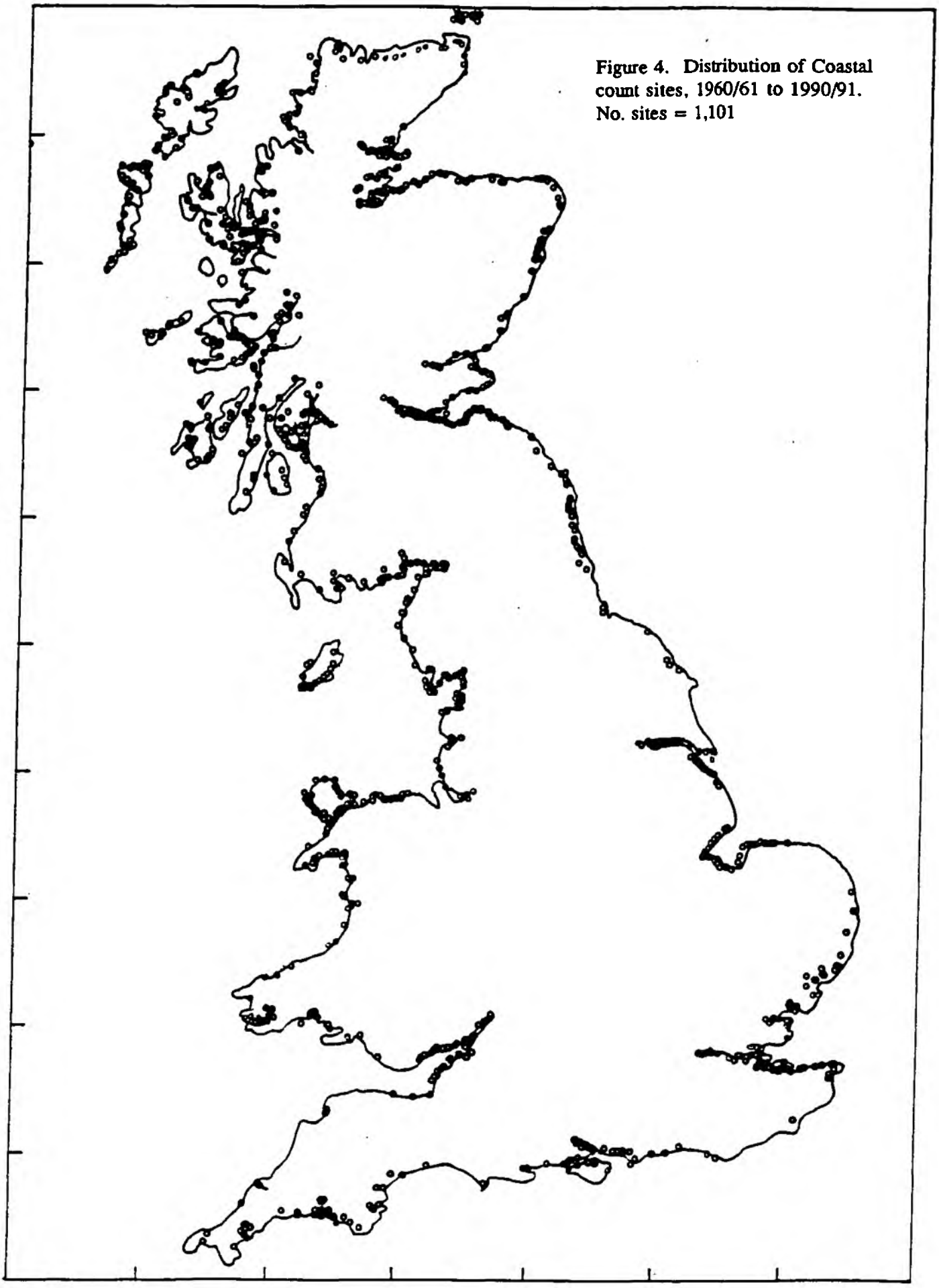


Figure 4. Distribution of Coastal count sites, 1960/61 to 1990/91. No. sites = 1,101

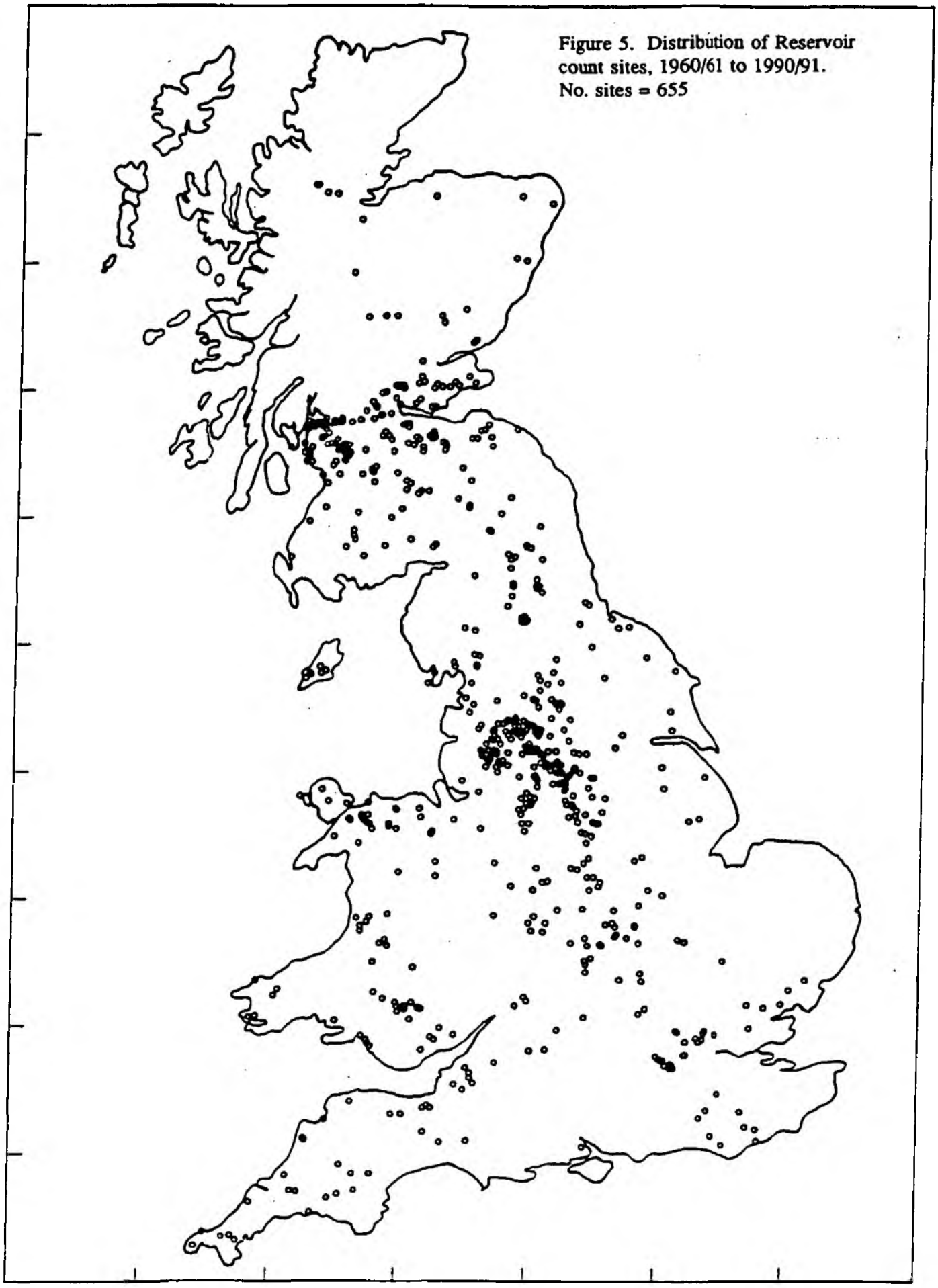


Figure 5. Distribution of Reservoir count sites, 1960/61 to 1990/91. No. sites = 655

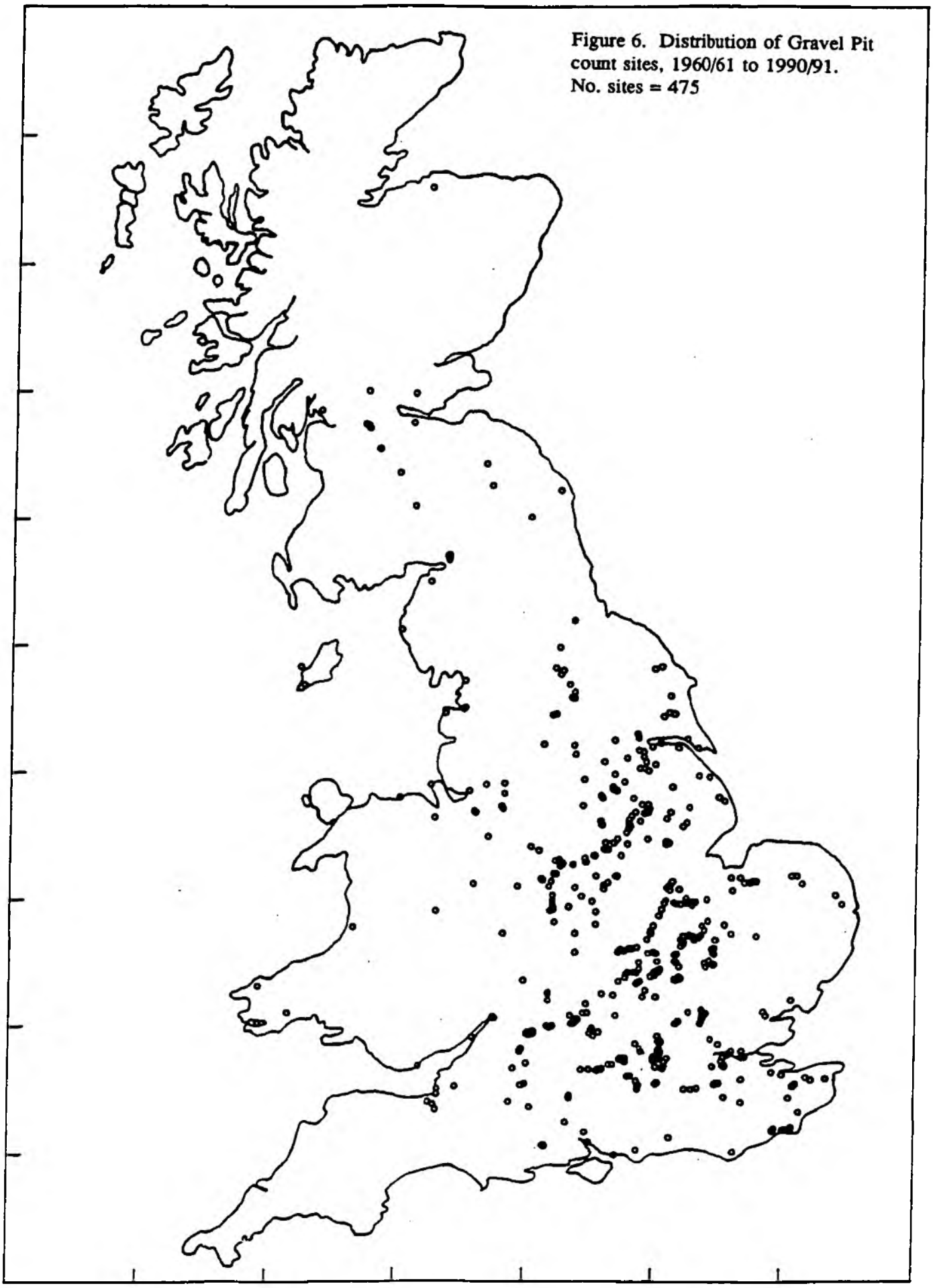


Figure 6. Distribution of Gravel Pit count sites, 1960/61 to 1990/91. No. sites = 475

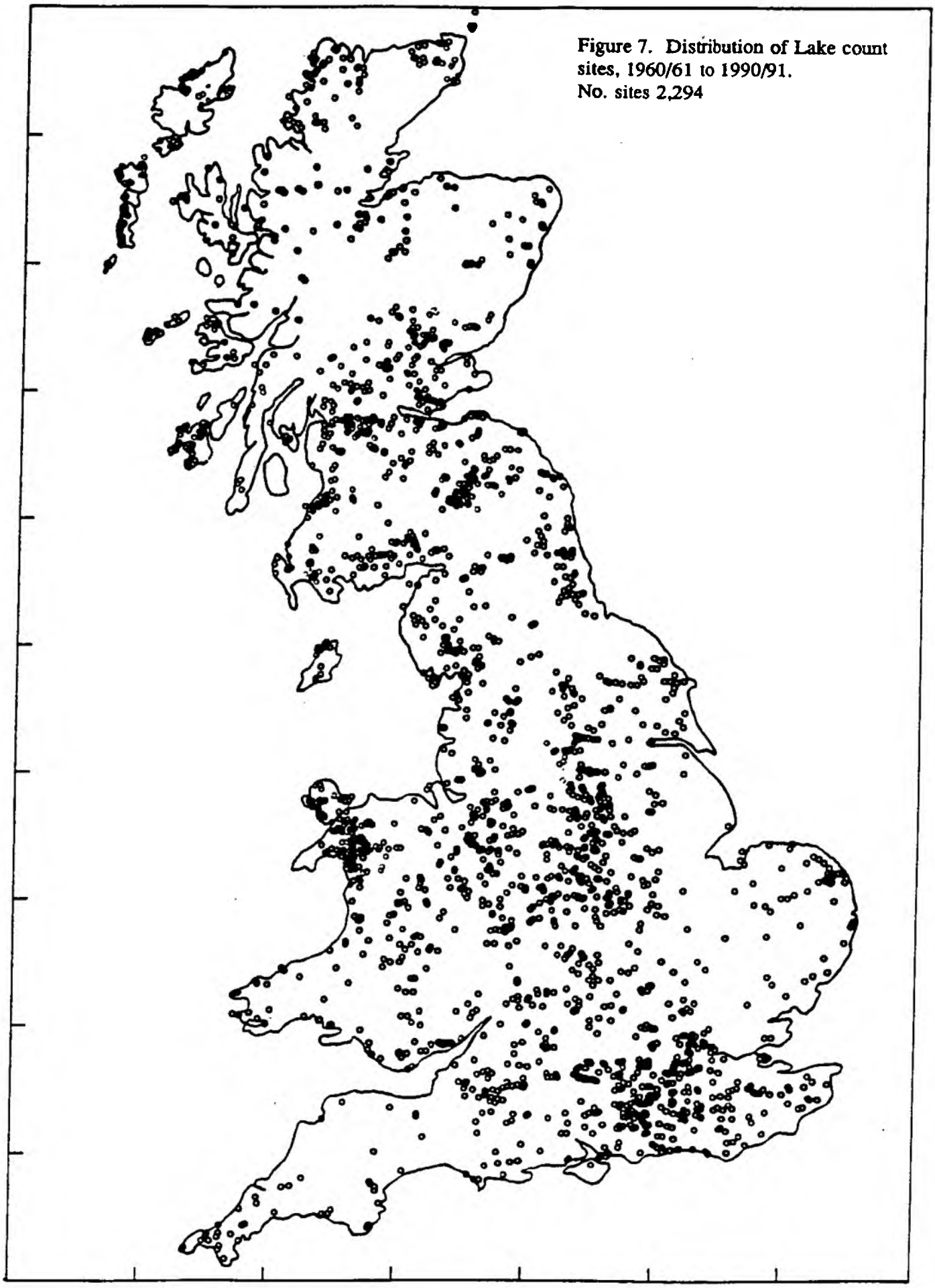


Figure 7. Distribution of Lake count sites, 1960/61 to 1990/91.
No. sites 2,294

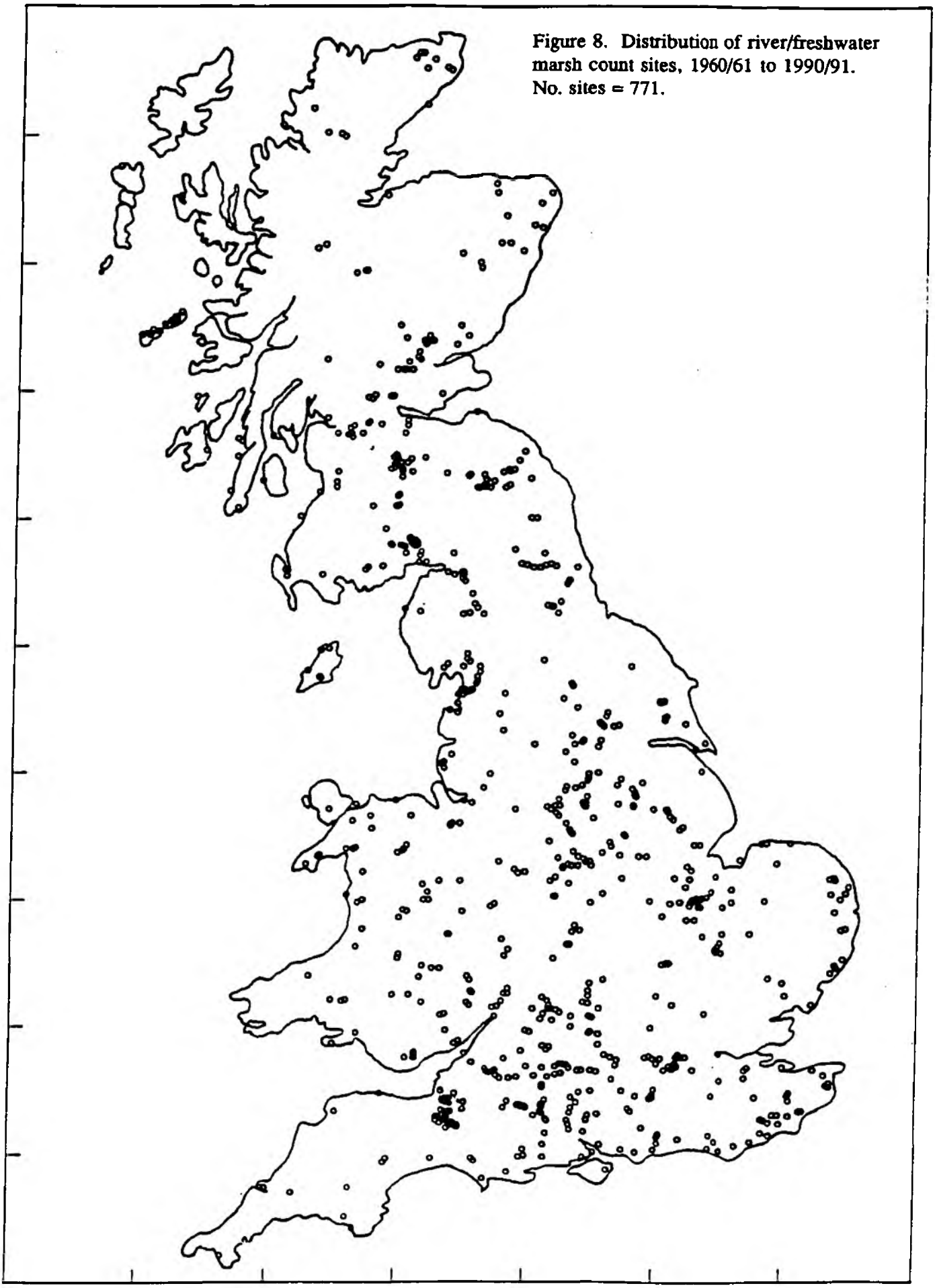


Figure 8. Distribution of river/freshwater marsh count sites, 1960/61 to 1990/91. No. sites = 771.

4.0 CORMORANT

4.1 INTRODUCTION

The Cormorant is a large conspicuous seabird which is found on coasts, estuaries and inland waters throughout the year. In Britain and Ireland, Cormorants breed almost exclusively in small coastal colonies, although they will nest in trees on inland sites. Birds may be present on the breeding colonies from mid-March to mid-September, but eggs are not laid until late April or early May. Both parents incubate the eggs and care for the young after hatching. The fledging period is approximately 50 days but young may return to the nest site to be fed for a further 40-50 days until reaching independence. After the breeding season, Cormorants disperse widely from their colonies (Summers & Laing 1990). They are equally at home in fresh, brackish or saltwater, and some birds travel long distances inland into central Asia and Europe. Cormorants very rarely fly over open sea. In the North Sea for example, they are exclusively coastal (Tasker *et al.* 1987). Analysis of British and Irish ringing recoveries reported up to 1964 show that birds from different breeding areas tend to exhibit different patterns of dispersal (Coulson & Brazendale 1968). The majority of the Cormorants breeding in Britain and Ireland are residents or only move locally.

Cormorants feed almost entirely on fish, pursuing them underwater in shallow dives, propelled by their large feet. They normally feed during daylight and the prey captured are taken to the surface to eat. A wide range of fish species are taken, and Cormorants are regarded by some as a competitor for fish stocks and a pest species.

About 14% of the Cormorants in Europe breed in Britain and Ireland, but this proportion is likely to vary according to the persecution pressures on the species in other countries. Some breeding populations have increased following recolonisation (Sweden, Denmark) or reintroduction (Belgium), but most fluctuate in response to disturbance and nest destruction during the breeding season, and shooting during the winter (Lloyd *et al.* 1991).

Cormorants breed on all coasts of Britain and Ireland, particularly on rocky western and northern coasts and there are some inland colonies, mainly in the west of Scotland, Wales and west of Ireland. Between 1969 and 1987, regional changes in numbers of coastal breeding Cormorants reveal increases in England, Wales, south-east Scotland and Ireland, with a slight reduction in numbers in the north and west of Scotland. The increases were particulary noticeable in the north of England, south-east Scotland and in the north-east and southern half of Ireland (Lloyd *et al.* 1991). Many of these breeding colonies have continued to increase between 1986 and 1990 (Walsh *et al.* 1990, 1991), although the rate of increase was less between 1989 and 1990. Little is known about the Cormorant's food supply, whether it has altered during the last 15-20 years or whether this has influenced numbers.

Cormorants have only been incorporated in the NWC scheme since 1986/87. In 1989/90 the total number recorded reached a maxima of 11,401 in Britain and 2,333 in Ireland. At about half the sites, the peak numbers in 1989-90 exceeded those of the previous seasons and at six sites, including the top two, the numbers have increased consistently from year to year since 1986/87 (Kirby *et al.* 1990). This increase may be due to reduced human persecution. Similar increases have been seen in other countries, for example in France (Debout 1987).

Persecution during the 19th century led to the extinction of a number of colonies, notably those in trees in Norfolk, but also on several parts of the British coast. Since the end of the 19th century, the Cormorant apparently continued to decrease in some areas though, because of its habit of shifting breeding site from time to time, it was not always certain whether reduced numbers at one colony reflected a genuine decrease or meant that the birds had moved elsewhere. Disturbance and persecution by man is an important factor in the control of numbers and nesting success throughout most of the Cormorant's range. The species has increased and spread in France, for instance, this having occurred since widespread protection was enforced in 1973 (Debout 1987).

In Britain, although the Cormorant is protected under the Wildlife and Countryside Act (1981), it may be killed under licence "for the purpose of preventing serious damage to fisheries" (HMSO 1981); the exact definition of "serious damage", however, has yet to be established by a court. Licences have been issued to riparian fisheries in Scotland, but at present no licences have been issued to fish farmers. However, a survey of salmon and shellfish farms in Scotland reported that over 2,000 Cormorants and Shags were shot illegally or died tangled in nets each year, about 53% of which were Cormorants (Ross 1988). The licensing situation in England and Wales is unclear, but much shooting occurs; for instance about 15% of the recoveries of Cormorants ringed at a colony in South Wales were reported as shot, although there has been a decline in shooting since the 1940's (Summers & Laing 1990). In Ireland, the Cormorant receives complete legal protection under the 1976 Wildlife Act although some birds are killed illegally. Before the Act was passed, shooting Cormorants was encouraged by a bounty scheme organised by the Department of Fisheries and large numbers of birds were killed each year. Between 1973 and 1976, for example, 3,527 Cormorants were shot (Macdonald 1987). The contrast between the stable population in Britain (5% increase 1969-87), and the growing one in Ireland (142% increase during 1969-87), reflects the difference in the degree of protection that the birds receive.

The Cormorant's habit of gathering into large fishing flocks on sealochs or on inland freshwaters favoured by fishermen has meant that they are widely regarded as a pest. Studies of diet seeking to establish whether the birds take significant numbers of commercial fish have shown that wrasses, sandeels and flatfish, such as the Dab (*Limanda limanda*) are the most important foods at sea, as is the Roach (*Leuciscus rutilus*), Perch (*Perca fluvatilis*) and Eel (*Anguilla anguilla*) in freshwater (West *et al.* 1975). Game fisheries studies in the west of Ireland show that the birds take up to 9% of the migrating Atlantic Salmon (*Salmo salar*) and Brown Trout (*S. trutta*) in some lakes (Macdonald 1987). Results from these and other studies show that the main prey taken is usually the locally dominant species. Also, Cormorants feeding in rivers where hatchery reared smolts were released, were highly selective, feeding almost entirely on hatchery smolts (Kennedy & Greer 1988). Over-exploitation of salmon stocks by commercial fisheries, rather than increased predation by the growing Irish Cormorant population, was concluded to have been the prime cause of low recruitment rates in Salmon between 1970 and 1985. Up to 80% of Salmon trying to return and spawn in Irish lakes and rivers were netted at sea, and many of the survivors bore scars from nets when they reached freshwater (Macdonald 1987).

4.2 DATA ANALYSIS

4.2.1 *Winter status and distribution*

The average peak British count of Cormorants over the 1987/88 to 1990/91 period, when the species was first widely included in the NWC scheme, was 10,586 (sd=1,472, range=7,966-14,172). The maximum count, of 14,172, was made in November 1990. The estimated total population was 16,800, implying that approximately 63% of Cormorants were counted on NWC sites at any one time.

In North West NRA region, the average peak count since 1987/88 was 1,973 (sd=674, range=1,121-2,742), with the maximum recent count occurring in September 1989. This suggests that around 19% of the birds regularly counted in Britain were recorded in the North West NRA region.

Cormorants have been recorded on up to 46% of the NWC sites counted in Britain during the 1986/87 and 1990/91 period. The species was widely dispersed, with approximately 60% of sites holding less than 10 birds and only 5% of sites with more than 100 individuals. Figure 9 shows their geographical distribution across NWC sites since 1986/87. Most of the large flocks were on estuarine sites, although large numbers were recorded in some inland areas across the English Midlands and south-east England, particularly in and around London, and along the Ouse and Trent rivers.

Twenty-three sites in Britain and Northern Ireland have held average maxima of 200 or more birds in recent seasons (Table 2). One of these, Morecambe Bay, falls entirely within the North West NRA region, whilst the Solway is located on its northern boundary. Morecambe Bay has been the principal British wintering site for Cormorants supporting an average of over 800 birds in recent seasons; it was matched only by Loughs Neagh and Beg in Northern Ireland. Large concentrations were also found on the Medway, Clyde and Forth estuaries, and in the Inner Moray Firth (Table 2). The principal inland site was Queen Mary Reservoir in Surrey, but large numbers also occurred on Rutland Water, Abberton Reservoir and Grafham Water.

Cormorants were most abundant on NWC sites in autumn and early winter. The highest British counts were made in September 1986/87 and 1990/91, in October in 1988/89 and 1989/90, and in November in 1987/88. In the North West NRA region, maximum counts have been recorded in September in each season from 1986/87 onwards, with numbers generally declining steadily thereafter.

4.2.2 *Long-term trends*

On the sites counted in every season between 1987/88 and 1990/91, the number of Cormorants counted has increased in six out of seven months (September to March) between 1987/88 and 1988/89; in five between 1988/89 and 1989/90; and in five between 1989/90 and 1990/91 (Table 3). Across all months, the average percentage increase between seasons has varied from 15% to 22%. A region-by-region comparison of sites counted in 1987/88 and 1990/91, for September and January separately (Table 4), indicated Cormorants have increased

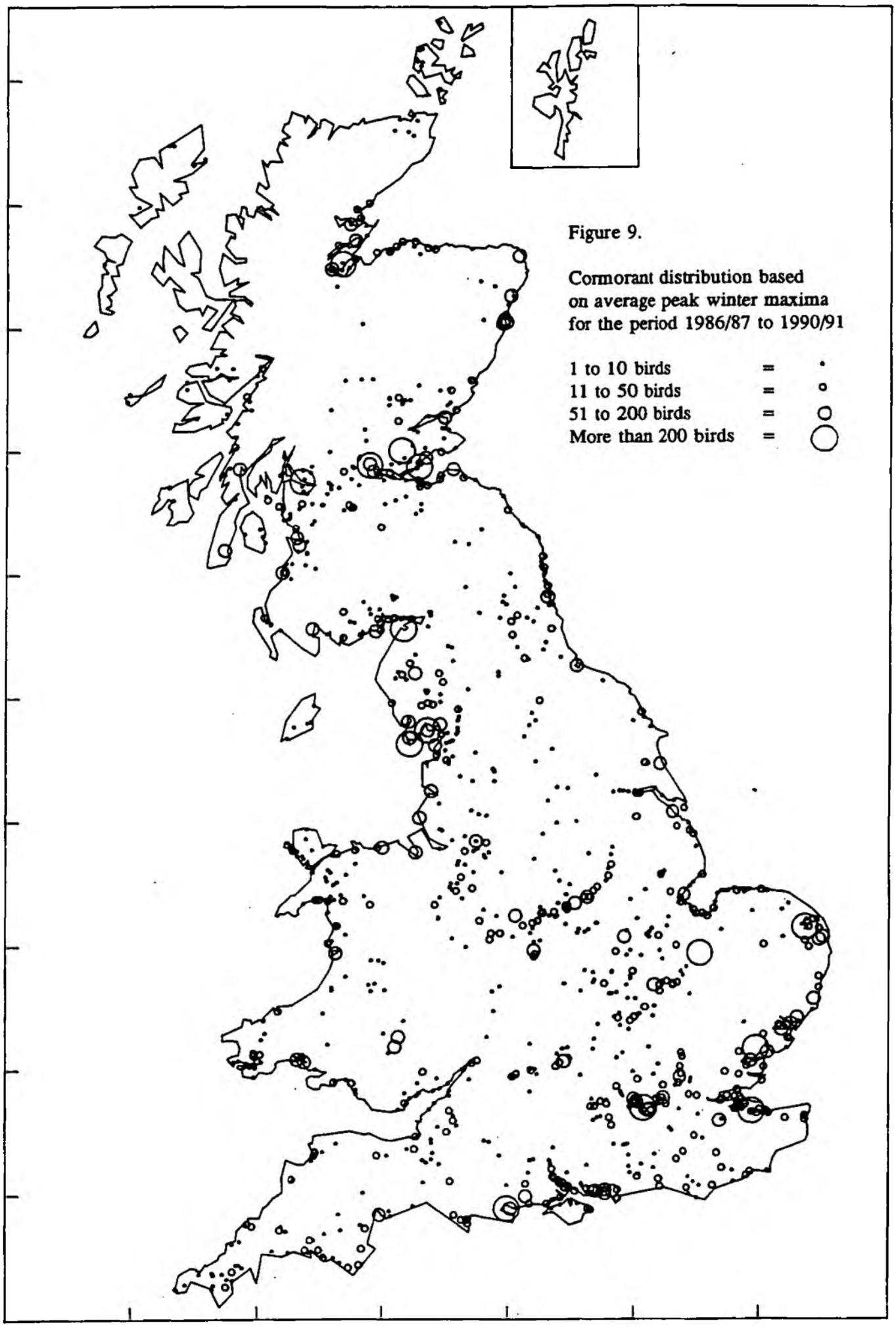


Figure 9.

Cormorant distribution based on average peak winter maxima for the period 1986/87 to 1990/91

in all regions except for north Cumbria/south-west Scotland and north-east Scotland. The largest increases appear to have occurred in southern and central England and in north-east England/south-east Scotland.

Table 2. Cormorant: seasonal maxima at main resorts, 1986/87 to 1990/91.

	86/87	87/88	88/89	89/90	90/91	Month	Average
Loughs Neagh/Beg	-	-	591	951	904	Dec	815
Morecambe Bay	303	544	733	1497	992	Sep	814
Medway Estuary	-	219	415	920	1280	Feb	709
Forth Estuary	(145)	414	479	766	962	Nov	655
Inner Clyde	-	-	-	663	408	Jan	536
Inner Moray Firth	685	940	641	229	112	Oct	521
Solway Estuary	527	374	483	550	492	Sep	485
Poole Harbour	436	426	615	232	417	Oct	425
Queen Mary Reservoir	-	278	438	315	467	Feb	375
Ranworth/ Cocksfoot Broads	267	354	368	325	329	Jan	329
Loch Leven	91	117	270	330	800	Feb	322
Abberton Reservoir	233	117	-	570	320	Sep	310
Rutland Water	-	-	280	250	350	Feb	293
Dee Estuary (Eng./Wales)	-	210	290	291	286	Sep	269
Tees Estuary	-	144	113	337	480	Sep	269
Ouse Washes	286	169	182	533	163	Mar	267
Swale Estuary	136	301	394	228	263	Oct	264
Blackwater Estuary	-	252	345	219	208	Nov	256
Grafham Water	158	200	325	74	450	Feb	241
Belfast Lough	68	-	235	369	284	Nov	239
Outer Ards	61	374	379	197	153	Feb	233
Wash	188	194	294	224	263	Oct	233
Upper Lough Erne	182	181	131	316	192	Feb	200

Month = month of peak count in 1990/91. Incomplete counts are bracketed.

Table 3. Total numbers of Cormorant recorded on 107 British sites counted in each month of 1987/88 to 1990/91.

Season	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Average % change between seasons
1987/88	1366	1601	1797	2192	2288	2304	1821	
1988/89	1589	2273	2462	2790	2689	2527	1714	+22
1989/90	2137	2292	2292	2535	2837	2696	2681	+15
1990/91	2442	3714	3714	3355	3277	3358	2290	+19

Table 4. Total numbers of Cormorant counted in September and January in each region of Great Britain on sites counted in both 1987/88 and 1990/91.

Region	Season	September	% change	January	% change
SW England & S Wales	1987/88	302		289	
	1990/91	659	+118	349	+20
S & SE England	1987/88	907		818	
	1990/91	1751	+93	2209	+176
E & C England	1987/88	511		1384	
	1990/91	1011	+98	2107	+52
N Wales & NW England	1987/88	335		533	
	1990/91	398	+35	815	+52
Teesdale, Tyneside & Borders	1987/88	160		141	
	1990/91	498	+211	252	+78
N Cumbria & SW Scotland	1987/88	131		121	
	1990/91	80	-38	90	-25
SE Scotland: Forth & Tay	1987/88	216		471	
	1990/91	482	+123	724	+53
NE Scotland	1987/88	189		266	
	1990/91	188	0	190	-6
NW Scotland	1987/88	428		82	
	1990/91	453	+6	180	+119

In the North West NRA region, there were increases in the numbers of Cormorants counted in all months between 1987/88 and 1989/90 (Table 5). However, the counts were lower in 1990/91 than in 1989/90. This pattern of an early increase followed by a decline in 1990/91 was evident at inland sites and in Morecambe Bay. There was evidence of declines on the Ribble and Duddon Estuaries since 1988/89.

Table 5. Total counts of Cormorant for sites counted in each year in the North West NRA Region. In addition to the grand totals, separate totals are given for all inland sites combined, for the Duddon Estuary, Ribble Estuary and Morecambe Bay.

Season	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Inland sites combined							
1987/88	430	262	229	148	233	327	83
1988/89	482	291	310	228	364	276	364
1989/90	544	524	342	429	517	545	336
1990/91	87	134	135	196	284	231	117
Duddon Estuary							
1987/88	-	-	-	-	-	-	-
1988/89	156	146	85	81	-	-	-
1989/90	-	-	59	31	47	48	22
1990/91	115	54	63	28	15	15	19
Ribble Estuary							
1987/88	123	112	133	132	170	158	119
1988/89	137	100	207	162	177	118	242
1989/90	105	161	129	155	175	176	153
1990/91	157	94	117	172	116	84	73
Morecambe Bay							
1987/88	544	-	-	220	277	192	237
1988/89	733	-	531	357	-	-	-
1989/90	1497	1324	700	489	680	487	421
1990/91	991	710	648	333	335	320	347
TOTALS							
1987/88	*1097	**374	**362	*500	*688	*677	*439
1988/89	1588	**537	1133	1201	*588	*394	**606
1989/90	*2118	*2009	1230	1104	1419	1256	932
1990/91	1350	992	963	729	750	650	556

Each '-' and '*' denotes a missing count.

Nationally, there have been increases in the proportions of NWC sites which held Cormorants in all months between 1987/88 and 1989/90, and in September and October only between 1989/90 and 1990/91 (Table 6). In the North West NRA region, the proportions of sites with Cormorants between 1987/88 and 1989/90 also increased (Table 6), but fell 1990/91 because considerably more sites than usual were counted, many of them small upland lakes where Cormorants are absent.

Table 6. The proportion of sites with Cormorants in the 1987/88 to 1990/91 period: Great Britain and the North West NRA region.

	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Great Britain							
1987/88	24.9	25.9	27.3	27.4	25.6	28.9	28.8
1988/89	33.6	33.1	32.2	33.3	22.1	34.3	30.8
1989/90	32.9	34.4	36.6	38.5	37.8	39.9	36.9
1990/91	33.4	35.6	34.7	34.5	31.3	30.1	33.3
North West NRA region							
1987/88	15.2	18.1	18.8	30.0	31.3	35.8	39.8
1988/89	12.8	15.9	25.3	22.5	24.5	29.8	35.5
1989/90	28.2	27.2	35.0	34.8	33.5	36.5	39.9
1990/91	15.2	12.3	13.8	16.8	12.8	16.8	25.8

Table 7. A comparison of Cormorant counts for each habitat type using sites counted in September and January of 1987/88 and 1990/91.

Habitat	September	% change	January	% change
Reservoirs				
1987/88	547		588	
1990/91	1417	+159	1794	+205
Lakes				
1987/88	374		884	
1990/91	452	+19	1027	+16
Gravel Pits				
1987/88	169		568	
1990/91	404	+139	1187	+108
Rivers/ freshwater marshes				
1987/88	106		332	
1990/91	235	+121	675	+103
Coastal Waters				
1987/88	1920		1702	
1990/91	2857	+48	2305	+35

4.2.3 *Habitat use*

Cormorants were most widespread on coastal sites (occurring at 50-82% of sites depending on month), whilst inland they have occupied mostly gravel pits (15-59%). They have been recorded at 5-31% of lakes, 10-37% of rivers/freshwater marshes and 5-42% of reservoirs, varying according to month.

The largest counts on coastal sites were made in September (Figure 10) and in mid or late winter (January/February) on inland sites. Between, 71-75% of the total British count of Cormorants in September came from coastal sites, 10-14% from reservoirs, 8-6% from lakes, 4-5% from gravel pits and 2-3% from rivers/freshwater marshes. However, during February, the proportion on coastal sites had fallen to around 50%, whilst up to 20% occurred on reservoirs, 16-20% on lakes, up to 10% on gravel pits and between 4-5% on rivers/freshwater marshes. It would appear, therefore, that Cormorants gradually move inland during the course of the winter.

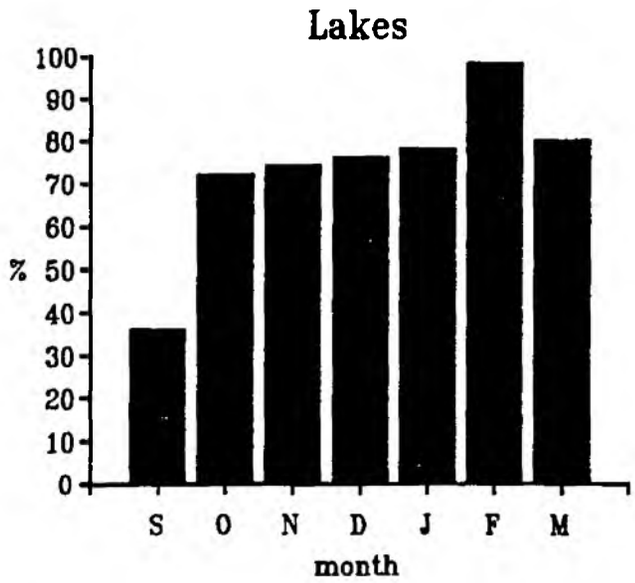
A comparison of sites counted in both 1987/88 and 1990/91 suggests that there has been a greater increase in the number of Cormorants recorded on inland sites, particularly reservoirs and gravel pits, than on coastal sites (Table 7). This indicates that a greater proportion of the population were wintering on inland sites in 1990/91 than in 1987/88.

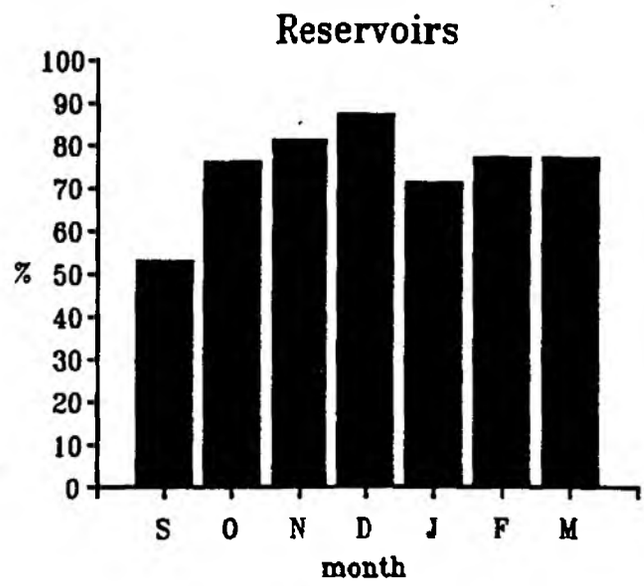
4.3 SUMMARY

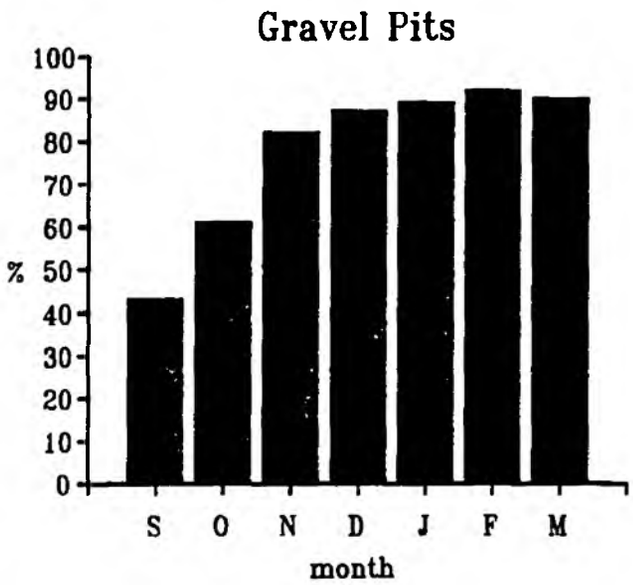
A maximum of around 10,600 wintering Cormorants have been counted at any one time across the whole of Britain for the NWC scheme, with about 19% of these in the North West NRA region. The species was widely dispersed and has been recorded at 46% of NWC sites overall. However, 60% of these held less than 10 birds. The largest concentrations were in estuarine areas, though the London reservoirs and several river systems held relatively large groups. Twenty-three U.K. sites held numbers of national significance, with Morecambe Bay, in the North West NRA region, being the premier British site. Also, bordering the North West NRA region is the Solway Estuary, which held nationally important numbers. Numbers generally peaked in 1989/90 and were lower in 1990/91.

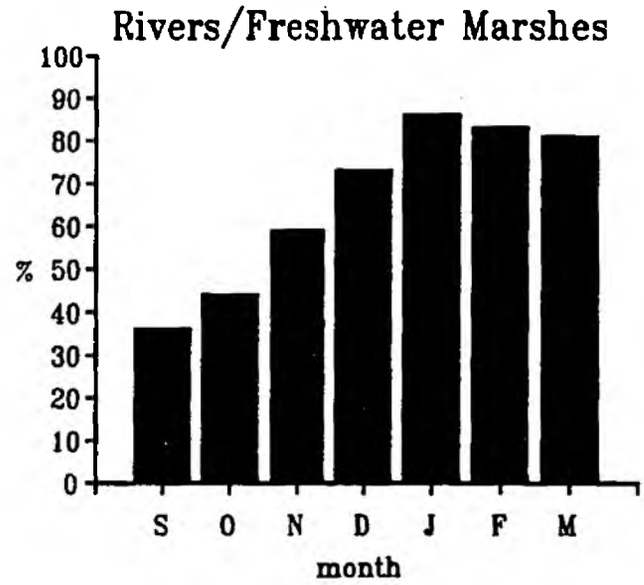
The number of Cormorants counted, and the proportion of sites occupied by them, has increased over recent years, and the largest increases have occurred in southern and central England and north-east England/south-east Scotland. In the North West NRA region, the numbers counted increased between 1987/88 and 1989/90 but was lower in 1990/91. There was a increase in the proportion of sites occupied by Cormorants in the North West NRA Region up until 1989/90.

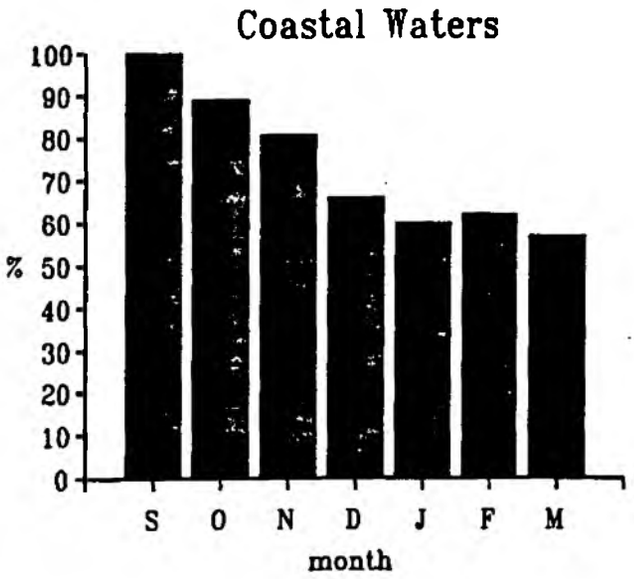
Cormorants have been recorded most frequently in coastal waters, but were also abundant on reservoirs and lakes. Maximum counts were recorded earlier in the year on the coast than at inland sites, suggesting movement inland through the winter. Recently, Cormorants appear to have increased more rapidly on inland sites, particularly at reservoirs and gravel pits, than in coastal waters, suggesting that more birds are moving inland and now wintering on freshwater sites.











Lakes	$\chi^2 = 18.69$,	$P<0.0001$,	$W = 0.623$
Reservoirs	$\chi^2 = 12.34$,	$P<0.0001$,	$W = 0.411$
Gravel Pits	$\chi^2 = 19.20$,	$P<0.0001$,	$W = 0.640$
Rivers\ freshwater marshes	$\chi^2 = 23.83$,	$P<0.0001$,	$W = 0.794$
Coastal waters	$\chi^2 = 24.17$,	$P<0.0001$,	$W = 0.806$

Figure 10. Seasonal changes in habitat use by Cormorants. In each case, bars show mean percentage of seasonal (September to March) maxima calculated for the period 1986/87 to 1990/91. The consistency of percentages across years was tested using Friedman's Chi-squared and Kendall's Coefficient of Concordance (W).

5.0 GOOSANDER

5.1 INTRODUCTION

Goosanders favour freshwater and breed on the upper stretches of clean large fast flowing rivers and on lakes. The nest site is most commonly a hole in a tree, although birds will nest amongst boulders and holes in banks. These are generally close to water. Eggs are laid during April and May. Males abandon incubating females to move to moulting grounds. The young can swim and feed for themselves soon after hatching, and are cared for by the female who broods them at night.. Broods often amalgamate and frequently feed in flocks.

Dye-marking and ringing in the Borders and Northumberland has demonstrated the existence of a moult migration from there to north Norway with drakes leaving British waters in late May or early June (Little & Furness 1985). Estimates of the size of breeding and winter populations suggest that almost all drake Goosanders in western Europe moult in this one area. They return to the British breeding areas from late October onwards, with some perhaps gathering in the Moray Firth prior to dispersal in January/February (Aspinall & Dennis 1988).

Goosanders feed primarily on small fish but also crustaceans, insect larvae, worms, molluscs and frogs, preferring water no deeper than 4m (Cramp & Simmons 1977). They hunt by surface diving using their legs for propulsion returning to the surface to swallow prey. They may hunt in pairs or flocks driving fish forward or into shallow water (Mills 1962a). They can be opportunistic feeders, taking dead or dying fish caught in turbines (Timken & Anderson 1969). The prey taken is normally of less than 10cms and the species varies, depending on habitat and availability.

The Goosander occurs throughout the Northern Hemisphere, breeding mainly between 50°N and the Arctic Circle. Over most of its range, it is either resident or moves short distances between breeding and wintering areas. The western European population of Goosanders has shown a tendency to increase since 1967, as proved by the results of censuses in several Central European countries: however, the lack of a consistent series of data from the main wintering area prevents a definitive statement about the status of the Goosander population at present.

In Britain, Goosanders are almost always found on inland sites (Owen *et al.* 1986). The first breeding record was in 1871, when a pair nested in Perthshire. Over the next hundred years, the population increased and birds spread throughout Scotland and south into England. They were nesting in most parts of Cumbria and Northumberland by the late 1960s and the first record for Wales was in 1972. The British total was then assessed as 1-2,000 pairs (Sharrock 1976), up to 100 pairs (5-10%) of which were in the North West NRA region. A detailed survey in 1975 placed the British total between 914 and 1,245 pairs (Meek & Little 1977) with 35-135 pairs, or 3.8-9.2% of the British population, in the North West NRA region. The Welsh population has continued to increase through the 1970s and 1980s (Tyler *et al.* 1988) and a survey there in 1990 suggested a 72% increase in total numbers since 1985 (Tyler 1986, Griffin 1990). The NWC indicated an increase between 1960/61 and 1981/82 which was particularly rapid during 1972-1982 (Owen *et al.* 1986). However the number at most sites is extremely variable from year to year, as the birds sometimes disperse to feeding sites during the day which are not counted. The Beauly Firth normally holds the largest winter

numbers (1,241-1,900) but, in 1989/90, the peak reached only 273 (Kirby *et al.* 1991). Because of their diet and abundance on salmon and trout waters, Goosanders have long been regarded as a pest species. However, while many studies have tried to determine the effects on salmonid populations the published information is contradictory. Some authors conclude they are a threat to salmonid fisheries (White 1939, 1957, Elson 1962) while others considered them harmless (Munro & Clements 1937, Timken & Anderson 1969). Wood (1987) estimates that, on certain rivers in eastern Vancouver Island, Goosander broods consumed the equivalent of 24-65% of the observed Coho Salmon *Oncorhynchus kisutch* fry but, because other mortality factors had a greater impact, concluded that it seemed unlikely that Goosander broods could limit Salmon production on these rivers.

The number of Goosanders killed at Scottish fish farms is probably much less than that killed under licence on rivers in Scotland in an attempt to protect wild Salmon stocks (estimated to be 850 birds in 1983 and 1984; Anon 1985). However the number killed at farms may be locally important. On Loch Awe, Argyll, for example, seven drakes were shot between 1986 and 1988. As only sixteen drakes were counted in the whole of Argyll during the 1987 British Trust for Ornithology's Sawbill Survey (BTO 1987), and no more than twenty-two have ever been recorded in recent years, those on Loch Awe probably represent a direct loss to the breeding population as they were shot during the period of pair formation and incubation.

5.2 DATA ANALYSIS

5.2.1 *Winter status and distribution*

The average peak British count of Goosanders for the 1986/87 to 1990/91 period was 3,470 (sd=684, range=2,496-4,340), with the maximum of 4,340 occurring in February 1986. The estimated total population was 5,500 birds, suggesting that approximately 63% of Goosanders were counted on NWC sites in the 1986/87 to 1990/91 period.

The average peak count in the North West NRA region (1986/87 to 1990/91) was 401 (sd=188, range=232-725), with the maximum of 725 being recorded in January 1991. This indicates that around 12% of the birds counted in Britain were in the North West NRA region. It should be noted that considerably more sites than usual were counted in the North West NRA region in the 1990/91 season (Table 1). Indeed, the 1990/91 peak total count (of 725) was probably close to a complete population estimate for Goosanders in the region and does not indicate a dramatic increase in the population.

Goosanders have been recorded at a maximum of 15% of all British NWC sites. The majority of these (88%) have held fewer than 10 birds, and only 1-2 birds have been recorded at 58% of sites. Thus, the species was very widely dispersed. Figures 11 and 12 show the distribution of Goosanders across NWC sites, for the 1976/77 to 1980/81 and 1986/87 to 1990/91 periods. The species occurred widely throughout much of lowland Scotland and England, and was relatively widespread in Wales also. Most records of the larger flocks were from the east Midlands, northern England and eastern Scotland. There was little obvious difference in overall distribution between the two time periods. There were more records from most areas during the second period, and especially so in Wales.

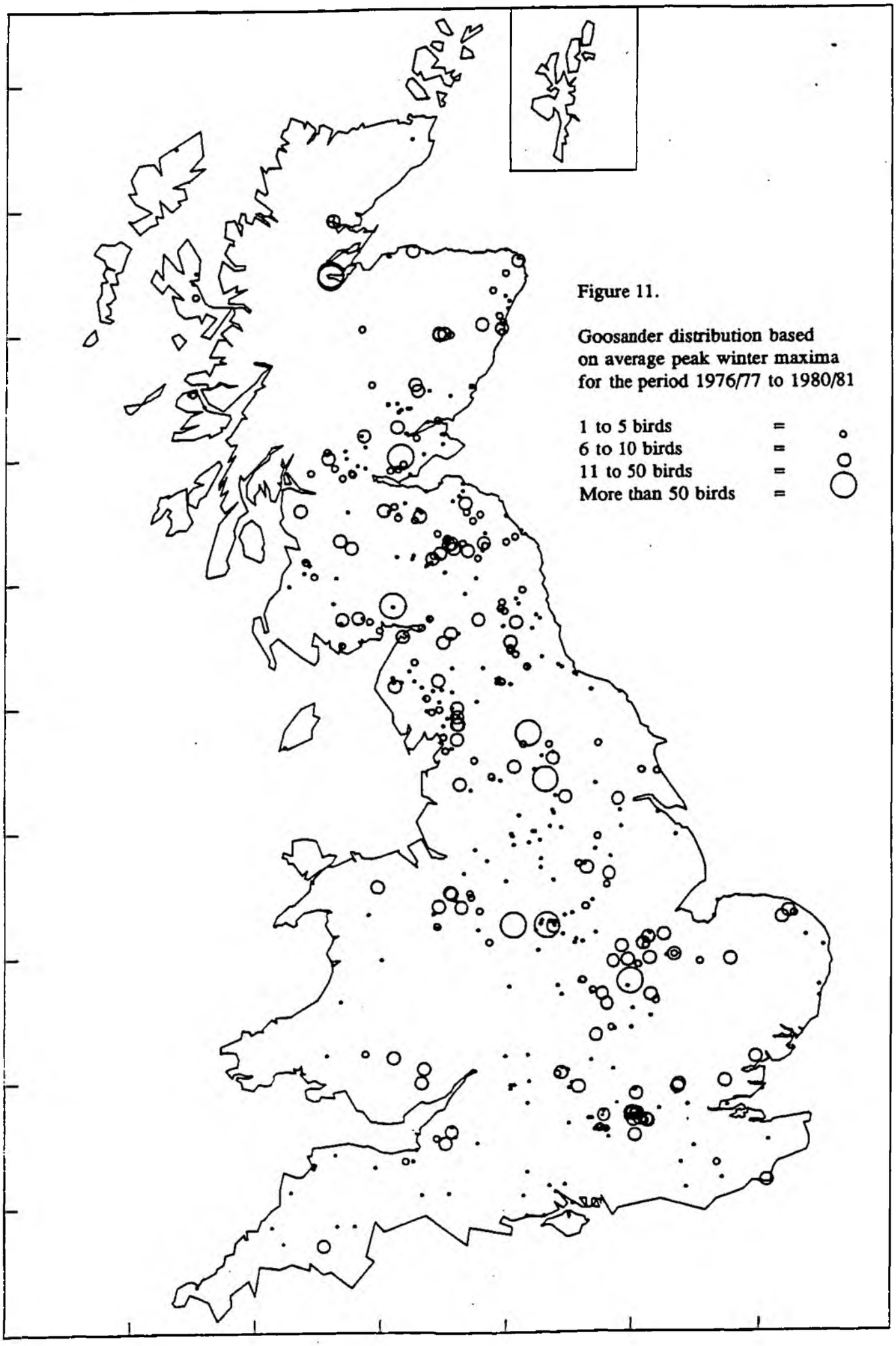


Figure 11.

Goosander distribution based on average peak winter maxima for the period 1976/77 to 1980/81

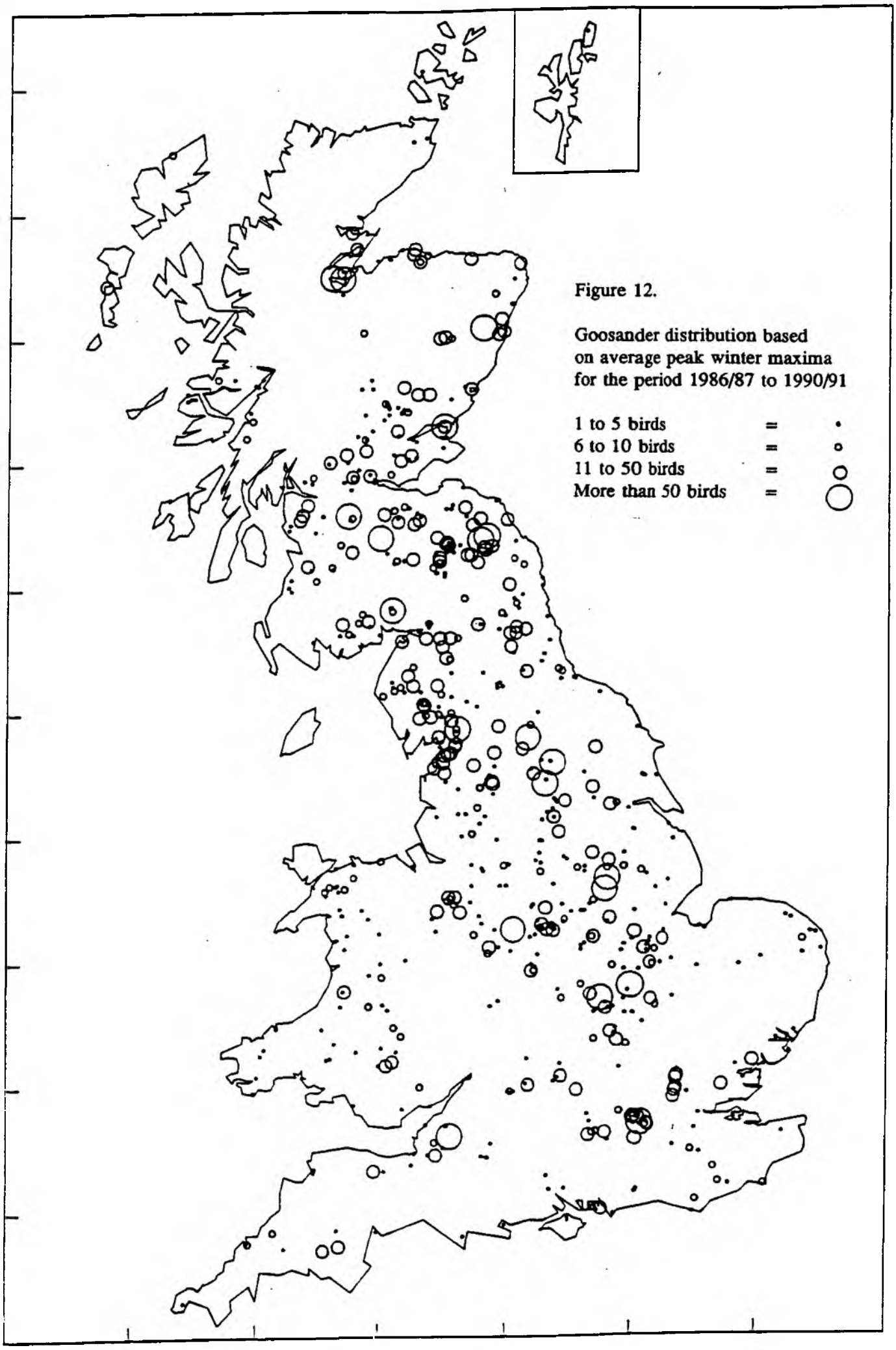


Figure 12.

Goosander distribution based on average peak winter maxima for the period 1986/87 to 1990/91

Twenty-one British sites have supported average seasonal maxima of 50 or more Goosanders, qualifying them for national recognition for this species (Table 8). The Inner Moray Firth supports by far the largest concentration. There was only one nationally important site in the North West NRA region: the River Eden (counted from Rockcliffe and Armathwaite). More than 50 Goosanders were occasionally recorded at a further four sites within the North West NRA region (Table 9).

The number of Goosanders counted in Britain increased during the winter with peak numbers almost always occurring in January or February; 1965/66 provided the only exception, when the winter peak occurred in December. This seasonal pattern has been significantly consistent across all 31 count seasons (Friedmans's χ^2=26.5, df=6, P<0.001).

The patterns of seasonal change in Goosander numbers (Figure 13) were not significantly different between regions. Peak numbers were recorded in January or February in most regions. There appeared to be a sharper increase in the November and December mean counts in southern and central England compared to northern England and Scotland.

5.2.2 *Long-term trends*

Examination of national long-term trends revealed significant increases in all months between 1960/61 and 1990/91 (Table 10). The rate of increase appeared to be have been the greatest in the autumn and early winter (September to November). A trend based on all seven months combined (Figure 14) revealed a sharp reduction in numbers between 1960/61 and 1963/64, followed by a period of little change until 1968/69, and then a gradual and significant increase up until 1979/80 (r^2=0.386, F=6.7, P<0.05). Indeed, the population appeared to have increased by approximately two and a half times during this period. Since 1980/81, the population has fluctuated between seasons and has neither increased nor decreased (r^2=0.341, F=4.4, P=0.07).

The pattern of change in winter numbers has varied regionally (Table 11). Statistically significant increases have occurred in five of the regions: in south-west England/south Wales, east/central England, north-east England, north-east Scotland and north-west Scotland.

In the North West NRA region, there appeared to be relatively little change up until 1984/85, except for noticeable peaks in 1973/74 and 1976/77 (Figure 15). There has been a significant increase since 1981/82 (r^2=0.847, F=38.9, P<0.001), due mostly to high counts between 1985/86 to 1990/91.

Table 8. Goosander: seasonal maxima at main resorts, 1986/87 to 1990/91.

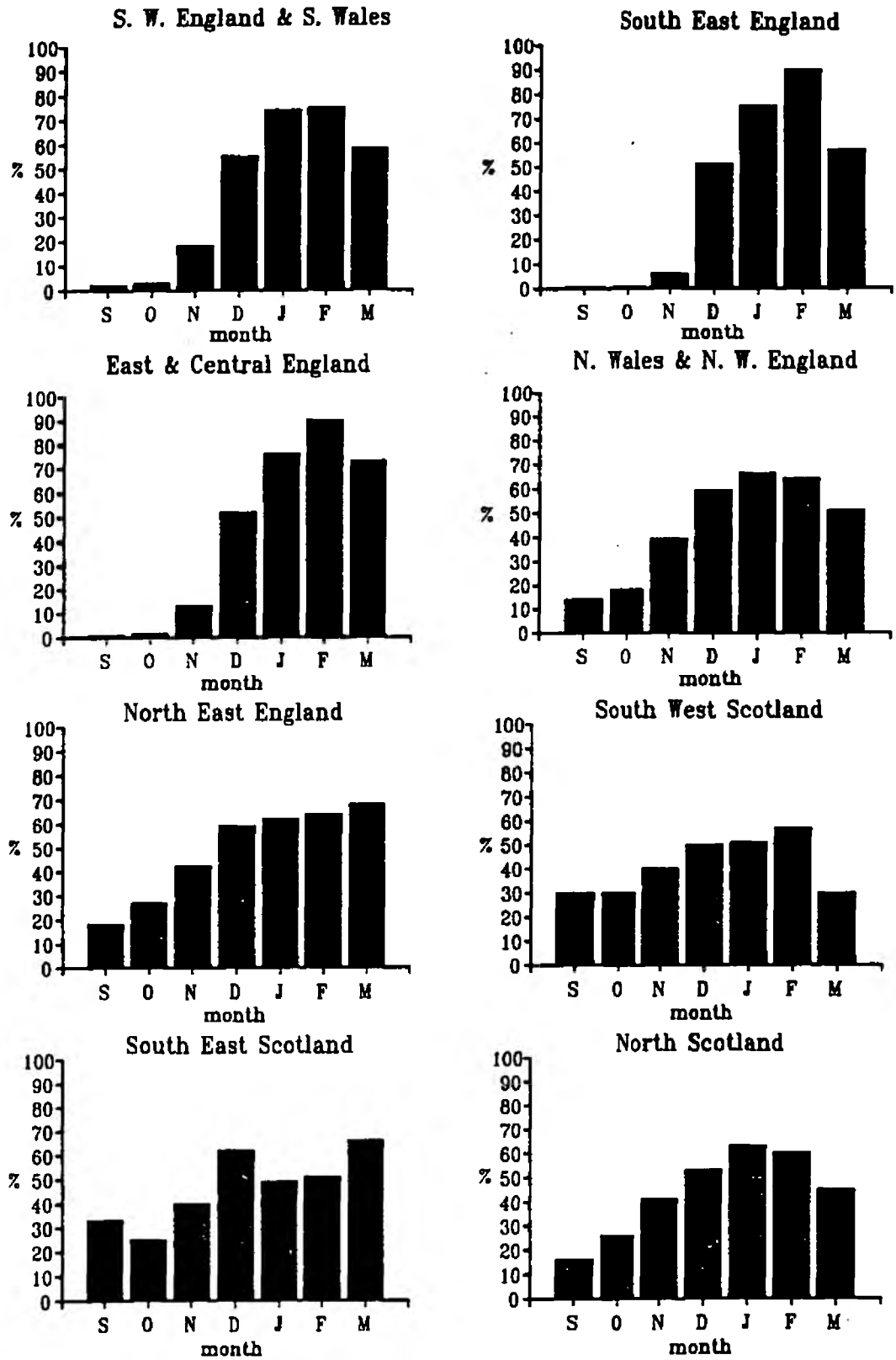
	86/87	87/88	88/89	89/90	90/91	Month	Average
Inner Moray Firth	1241	1900	1490	273	610	Nov	1103
Hirsel Lake	35	79	124	202	290	Oct	146
R.Tweed: Kelso/Coldstream	145	102	91	88	147	Feb	115
Thrapston Gravel Pit	174	66	101	44	149	Feb	107
Tentsmuir	70	225	8	-	-	-	101
Chew Valley Lake	105	55	107	110	163	Feb	98
Tay Estuary	1	225	8	26	206	Sep	93
Hay-a-Park Gravel Pit	15	25	53	195	166	Dec	91
Eccup Reservoir	108	62	105	55	101	Feb	86
Castle Loch	120	81	82	69	52	Feb	81
R.Eden: Rockcliffe/Armathwaite	95	29	60	11	110	Jan	81
Leighton/ Roundhill Reservoir	90	65	82	-	-	-	79
Castle Howard Lake	120	57	95	25	84	Dec	76
Loch of Skene	61	92	-	99	40	Feb	73
Hamilton Low Parks	94	97	65	68	42	Dec	73
Blithfield Reservoir	80	48	73	61	88	Jan	70
Besthorpe/ Girton Gravel Pits	67	97	55	44	-	-	66
Rutland Water	55	44	56	45	89	Feb	58
Pitsford Reservoir	71	46	27	69	67	Jan	56
Loch Leven	12	16	73	79	94	Oct	55
Hoselaw Loch	164	6	23	38	25	Sep	51

Month = month of peak count in 1990/91. A '-' denotes a missing count.

Table 9. Maximum seasonal counts of Goosander on key sites in the North West NRA region. Refer to Figure 24 for the locations of these sites.

Season	Stocks Reservoir	Wyndhammere Reservoir	Kilmere Reservoir	Killington Reservoir	River Eden
1960/61	-	-	-	-	-
1961/62	-	-	-	-	-
1962/63	-	-	-	-	-
1963/64	-	11	2	84	-
1964/65	-	-	-	35	-
1965/66	-	35	-	62	-
1966/67	64	-	-	45	-
1967/68	37	32	30	38	-
1968/69	87	-	4	10	-
1969/70	48	7	22	38	-
1970/71	80	55	12	1	-
1971/72	23	20	-	-	-
1972/73	20	25	-	-	-
1973/74	30	6	-	-	-
1974/75	8	1	3	3	-
1975/76	-	12	9	6	80
1976/77	-	4	5	56	30
1977/78	-	-	-	-	12
1978/79	6	-	-	-	14
1979/80	7	3	1	38	14
1980/81	9	43	39	7	12
1981/82	18	33	20	8	6
1982/83	21	7	13	3	6
1983/84	25	3	9	7	-
1984/85	18	6	7	-	26
1985/86	18	8	18	4	20
1986/87	16	7	63	3	95
1987/88	6	-	-	1	29
1988/89	12	-	-	-	60
1989/90	7	-	-	-	111
1990/91	3	-	-	-	110

A '-' denotes a missing count.



S.W. England & S.Wales	χ^2=122.0	P<0.001,	W=0.666	S. E. England	χ^2=157.1,	P<0.001,	W=0.846
E. & Central England	χ^2=166.2,	P<0.001,	W=0.866	N.W. England/N.Wales	χ^2=77.1,	P<0.001,	W=0.429
N.E. England	χ^2=70.53,	P<0.001,	W=0.373	S.W. Scotland	χ^2=22.8,	P<0.001,	W=0.119
S.E. Scotland	χ^2=46.2	P<0.001,	W=0.248	Northern Scotland	χ^2=48.5,	P<0.001,	W=0.324

Figure 13. Seasonal changes in abundance of Goosander in eight regions of Great Britain. In each case, bars show mean percentage of seasonal (September to March) maxima calculated for the period 1960/61 to 1990/91. The consitency of percentages values across years was tested using Friedman's Chi-squared and Kendall's Coefficient of Concordance (W).

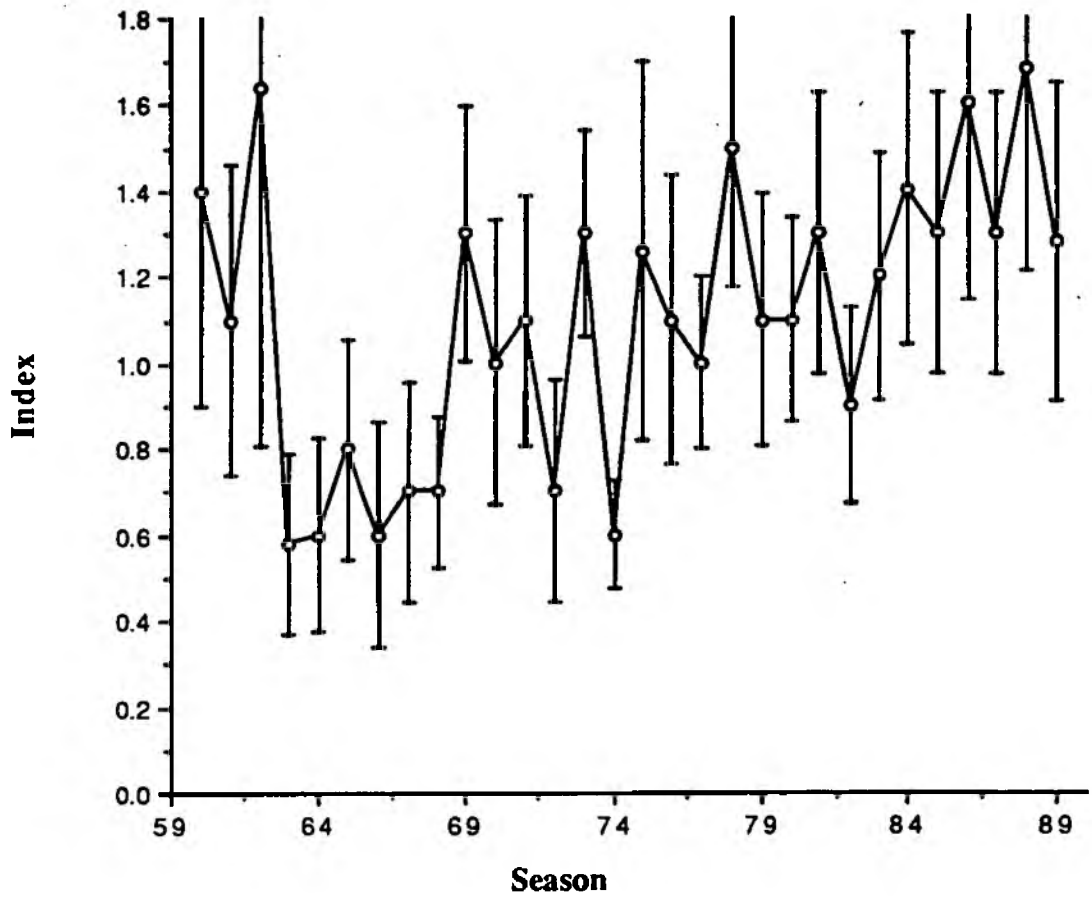


Figure 14. Underhill index of abundance for Goosander for Great Britain . No. of sites=490, counts=9105, imputed values=6097 . Vertical lines give 95% Confidence limits.

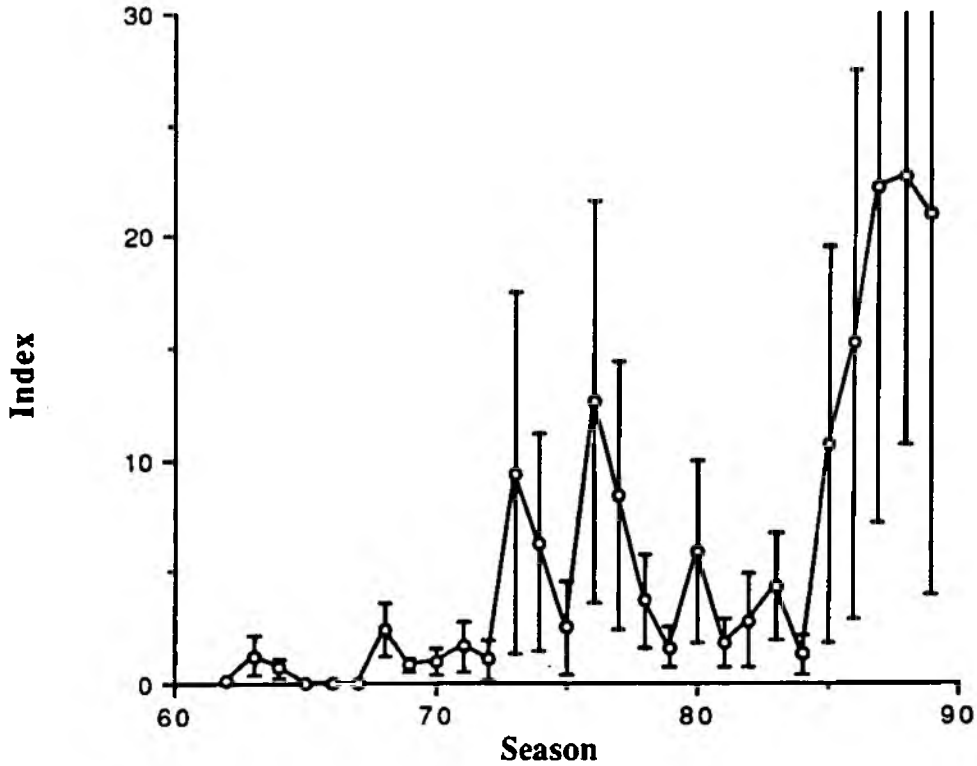
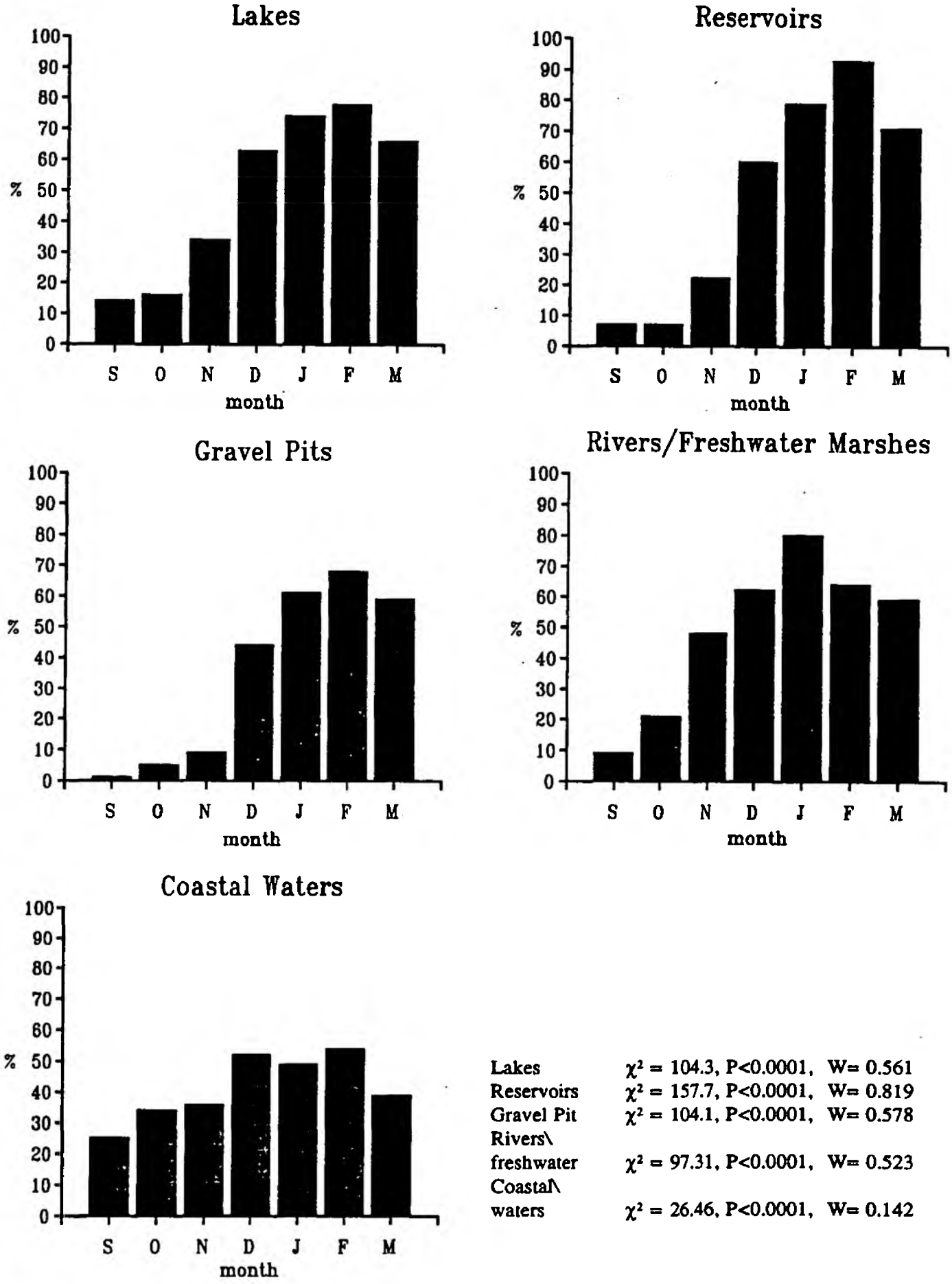


Figure 15. Underhill index for Goosander in North-west region. No. of site=19, counts=240, imputed values=316. Vertical lines give 95% confidence limits.



Lakes	χ^2 = 104.3, P<0.0001, W= 0.561
Reservoirs	χ^2 = 157.7, P<0.0001, W= 0.819
Gravel Pit	χ^2 = 104.1, P<0.0001, W= 0.578
Rivers\ freshwater	χ^2 = 97.31, P<0.0001, W= 0.523
Coastal\ waters	χ^2 = 26.46, P<0.0001, W= 0.142

Figure 16. Seasonal changes in habitat use by Goosander. In each case, bars show mean percentage of seasonal (September to March) maxima calculated for the period 1960/61 to 1990/91. The consistency of percentages across years was tested using Friedman's Chi-squared and Kendall's Coefficient of Concordance (W).

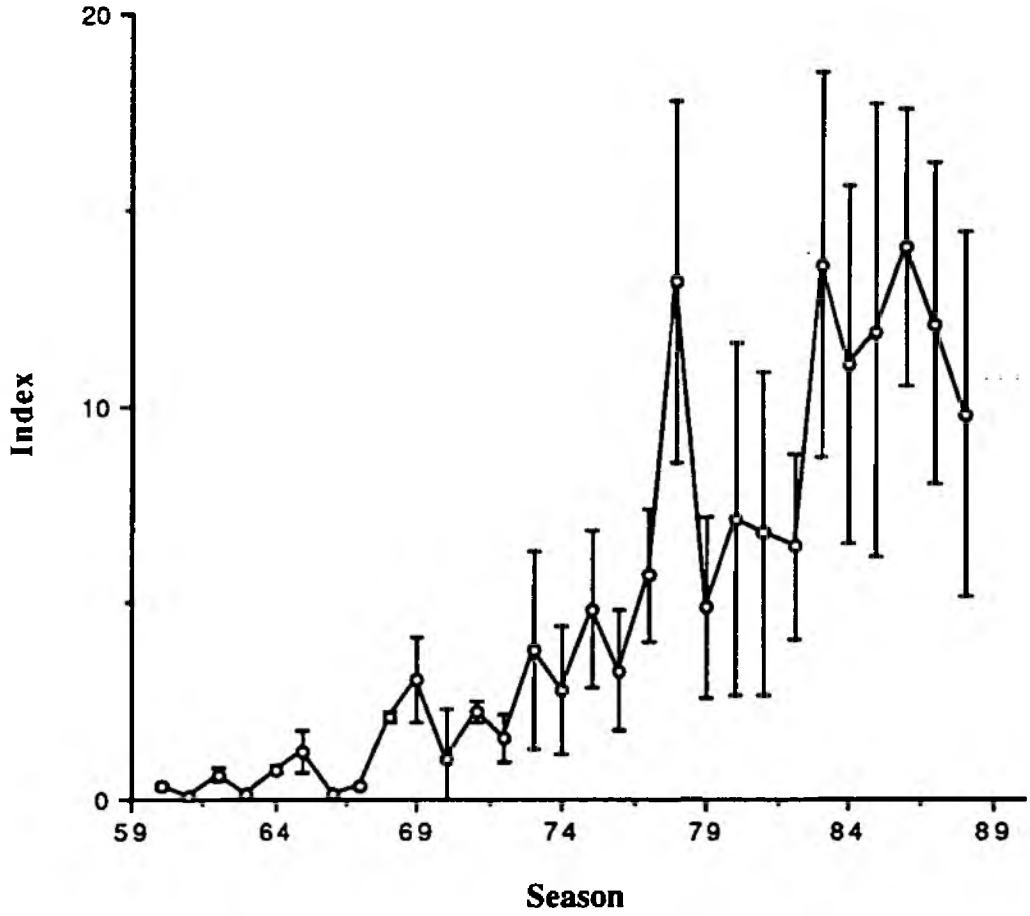


Figure 17. Plot of Underhill index for Goosanders for gravel pits. No. sites=38, counts=647, imputed values=1378. Vertical lines give 95% confidence limits.

Table 10. Regression coefficients, the proportion of the variance accounted for (r^2) and F-statistics for the regression of British Goosander indices against year in the months of September to March, 1960/61 to 1990/91. Indices were log-transformed.

Month	Coefficient	r^2	F	P
September	+0.057	0.314	12.8	0.001
October	+0.058	0.500	28.0	0.001
November	+0.076	0.566	53.4	0.001
December	+0.024	0.264	10.0	0.004
January	+0.020	0.264	8.9	0.006
February	+0.018	0.235	8.6	0.007
March	+0.018	0.176	5.9	0.021

Table 11. Regression coefficients, the proportion of the variance accounted for (r^2) and F-statistics for the regression of regional Goosander indices against year, 1960/61 to 1990/91. Indices were log-transformed.

Region	Coefficient	r^2	F	P
SW England & S Wales	+0.080	0.752	85.0	0.001
S & SE England	+0.009	0.030	0.854	*
E & C England	+0.017	0.262	9.83	0.004
N Wales & NW England	+0.020	0.103	3.232	*
Teesdale, Tyneside & Borders	+0.021	0.196	6.844	0.014
N Cumbria & SW Scotland	+0.034	0.071	2.13	*
SE Scotland: Forth & Tay	+0.011	0.034	0.97	*
NE Scotland	+0.080	0.068	59.7	0.001
NW Scotland.	+0.108	0.213	7.5	0.010

* = Not significant.

Examination of the proportions of British sites on which Goosanders were recorded revealed significant increases in all months (Table 12), indicating that there has been a spread onto new sites. Depending on the month, Goosanders were recorded on 1-12% (mean=6.4, sd=3.9, n=7) of sites counted in 1960/61 and on 4-15% (mean=10.4, sd=4.5, n=7) of the sites counted in 1990/91. During January, they were recorded on an average of 8% of sites during the 1960/61 to 1964/65 period, compared with an average of 12% of sites during 1986/87 to 1990/91. There was no corresponding increase in the proportion of sites occupied by Goosanders in the North West NRA region.

Table 12. Regression coefficients, the proportion of the variance accounted for (r^2) and F-statistics for the regression of the proportion of sites at which Goosander were recorded in each month against year, 1960/61 to 1990/91. Indices were arcsine-transformed.

Month	Coefficient	r^2	F	P
September	+0.110	0.798	114.8	0.0001
October	+0.145	0.851	165.5	0.0001
November	+0.224	0.728	77.7	0.0001
December	+0.173	0.416	20.6	0.0001
January	+0.163	0.391	18.6	0.0001
February	+0.170	0.379	17.7	0.0001
March	+0.209	0.549	34.8	0.0001

More than 50 Goosanders have been recorded at five sites in the North West NRA region (Table 9). At two of these, namely Stocks Reservoir and Killington Reservoir, there was evidence of a long-term decline in Goosander numbers, whilst there have been some particularly high counts in recent years on the River Eden. On the remaining sites, there was no overall trend in abundance.

5.2.3 *Habitat use*

Goosanders occurred on all wetland types included in the NWC scheme. For example, in the 1990/91 season, they were recorded on 7-24% of reservoirs, 3-14% lakes, 1-14% of gravel pits, 7-22% of rivers/freshwater marshes and 4-7% of coastal waters. Lakes supported between 13-50% of the total British count in any one month, reservoirs between 13-38%, gravel pits between 3-18%, rivers/freshwater marshes between 14-22% and coastal waters between 5-40%.

The patterns of seasonal abundance in different habitats are shown in Figure 16. Similar patterns were evident for most habitats, with peak numbers occurring mostly in February. The exception was rivers/freshwater marshes, where peak numbers occurred in January. Such monthly patterns were significantly consistent across all seasons within each habitat (Kendall's W=0.654, P<0.001), and there were no significant differences in the pattern of use between different habitat types.

Long-term national trends calculated for each habitat separately revealed significant increases on all habitat types, with the exception of rivers/freshwater marshes (Table 13). The greatest increases have been on gravel pits, where the population appears to have increased five-fold since 1970/71 (Figure 17).

Table 13. Regression coefficients, the proportion of the variance accounted for (r^2) and F-statistics for the regression of British Goosander indices calculated for each habitat type against year, 1960/61 to 1990/91. Indices were log-transformed.

Habitat	Coefficient	r^2	F	P
Lakes	+0.026	0.462	24.09	0.000
Reservoirs	+0.019	0.154	5.09	0.032
Gravel Pits	+0.453	0.743	80.9	0.000
Rivers/ freshwater marshes	+0.085	0.085	2.5	*
Coastal Waters	+0.025	0.313	12.75	0.001

* = Not significant.

5.3 SUMMARY

Some 3,500 wintering Goosanders have been counted in Britain for the NWC scheme, with about 12% of these in the North West NRA region. The total wintering population was estimated to be in the region of 5,500 birds. They were widely dispersed, but were restricted to relatively few sites (15% of those counted), and mostly occurred in small numbers (58% of sites held only 1-2 birds). Twenty-one sites held numbers of national significance, with the Inner Moray Firth being the premier site. In the North West NRA region, the River Eden was nationally important. Numbers invariably peaked in January or February and there was no statistically significant difference in seasonality between regions.

There was a reduction in the Goosander population between 1960/61 and 1963/64 followed by a period of little overall change up until 1968/69. There followed a significant increase up until 1979/80, after which the population has neither increased nor decreased. Regionally, significant long-term increases have occurred in five of ten regions. There was a significant long-term increase in the proportion of sites occupied by Goosanders in all months during 1960/61 and 1990/91. In the North West NRA region, there has been a significant increase in numbers since 1981/82, but no increase in the proportion of sites occupied.

Goosanders have occurred on all wetland habitat types counted for the NWC scheme, and there were no significant differences in the seasonal use of different habitats. There have been significant increases in the use of most habitats over the 1960/61 to 1990/91 period. Numbers on gravel pits have increased five-fold since 1970/71.

6.0 RED-BREASTED MERGANSER

6.1 INTRODUCTION

Red-breasted Mergansers are highly specialised ducks which feed mainly on small fish and crustaceans. In Britain, they spend the winter at the coast but move inland to breed, some to standing waters, but many to the lower reaches of rivers.

Red-breasted Mergansers move onto freshwaters in April; their numbers reach a peak at the end of April or in May, and fall thereafter. Many birds are in pairs when first recorded, but they do not breed until late spring, females laying eggs in May and beginning incubation in late May and in June. Most ducklings hatch in July and fledge in September, rapidly dispersing soon afterwards. Drakes abandon the incubating females, leaving the rivers in June and congregating to moult on the sea nearby in July and August. Few Mergansers are seen on rivers from late October through to mid-February.

Red-breasted Mergansers feed on small fish by surface diving but, unlike Goosanders, they use their wings as well as feet for propulsion. In spring, adults in Scotland take a variety of fish, including trout, eel, Brook Lamprey (*Lampetra planiern*), Stickleback (*Gasterosterus aculeatus*), Sandeel (*Ammodytes sp.*), Goby (*Gobius sp.*) and Flounder (*Platichthys flesus*), but 50-66% of the fish found in stomachs examined for a Scottish study were juvenile Salmon (Feltham & Marquiss 1989, Feltham 1990). This study also provided evidence that Red-breasted Mergansers were taking fish in relation to availability rather than abundance.

The Red-breasted Merganser is a Holarctic species breeding between 45 and 75°N. The provisional estimate of 75,000 for Western Europe by Ruger *et al.* (1986) was increased to 100,000 by Nygard *et al.* (1988). However, difficulties in censusing the population and problems with inadequate coverage of key areas need to be overcome before the status of Red-breasted Mergansers in Western Europe is clarified (Monval & Pirot 1989).

Red-breasted Mergansers were widespread in the highlands of Scotland during the last century. They began to expand their range during the 1880s and have spread slowly south during the present century. Breeding was first confirmed in England in 1950 and in Wales in 1953. Since then they have slowly colonised most of northern England and parts of north and central Wales (Lovegrove *et al.* 1980, Tyler *et al.* 1988, Griffin 1990). The population in Wales appears to have remained stable since 1980 (Tyler *et al.* 1988).

Most of the British breeding birds probably winter locally, but there appears to be a mid-winter influx of continental birds during January (Owen *et al.* 1986). The NWC indicated a steady increase in numbers between 1960 and 1982 (Owen *et al.* 1986). The breeding population in Britain was estimated to be in the region of 1,000-2,000 in the 1960s (Atkinson-Willes 1963) and between 1,500-2,200 pairs in the mid-1970s (Sharrock 1976, Owen *et al.* 1986). Taking productivity and the influx of continental birds into account the winter population was estimated to be in the range 6,000-10,000 (Owen *et al.* 1986).

On the River North Esk in eastern Scotland, Red-breasted Mergansers are abundant during May when salmon smolts are migrating downstream to the sea. Studies of these fish which involved fitting them with external tags, have resulted in many being recovered from the stomachs of Red-breasted Mergansers shot under licence, although it is likely that tagged fish are more easy to catch because they are essentially 'tame' and also easier to see (Feltham 1990). However it has been suggested that these ducks could consume enough smolts to reduce significantly the number of adult Salmon returning to home waters, and thus reduce the Salmon harvest (Shearer *et al.* 1987).

Licences are granted under the Wildlife and Countryside Act (1981) to enable commercial fish hatcheries and farms to protect their stock. In Scotland, between October 1982 and December 1983, 520 Red-breasted Mergansers were shot under licence (Kear 1991). However, Carss (1989) concluded that in Argyll, where they are resident all year, Red-breasted Merganser predation was not a problem on fish farms although they are resident all year.

6.2 DATA ANALYSIS

6.2.1 *Winter status and distribution*

The average peak British count of Red-breasted Mergansers during the 1986/87 to 1990/91 period was 4,191 (sd=1,116, range=2,855-5,723). The maximum count, of 5,723, was made in January 1987. The estimated total population was 8,100 birds, implying that 52% of Red-breasted Mergansers were counted at any one time.

The average peak count of Red-breasted Mergansers in the North West NRA region was 531 (sd=199, range=401-754), with the peak count (754) being made in December 1989. Thus around 13% of all Red-breasted Mergansers counted in Great Britain were counted in the North West NRA region.

Red-breasted Mergansers have been recorded at a maximum of 15% of NWC sites in Britain, with only 8% holding more than 50 birds, and the majority (64%) with fewer than 10. Thus, the species was widely dispersed. Figures 18 and 19 show the distribution of Red-breasted Mergansers across NWC sites during the 1976/77 to 1980/81 and 1986/87 to 1990/91 periods. They were recorded in small numbers around most of the British coast. Relatively large concentrations occurred in only a few estuaries around the Scottish coast, in the Irish Sea and in south and south-east England. There was evidence of smaller numbers in Orkney and larger numbers in Morecambe Bay and the Wash in later period.

The principal winter concentration was the Inner Moray Firth (Table 14) which is an internationally important site since the average seasonal maxima exceeds 1,000 birds. However, there appears to have been a decline at this site since the mid-1980s. Sixteen sites have held an average seasonal maxima of 100 or more Red-breasted Mergansers, the qualifying level for national importance (Table 14). Two of these, Morecambe Bay and the Duddon Estuary, are situated in the North West NRA region.

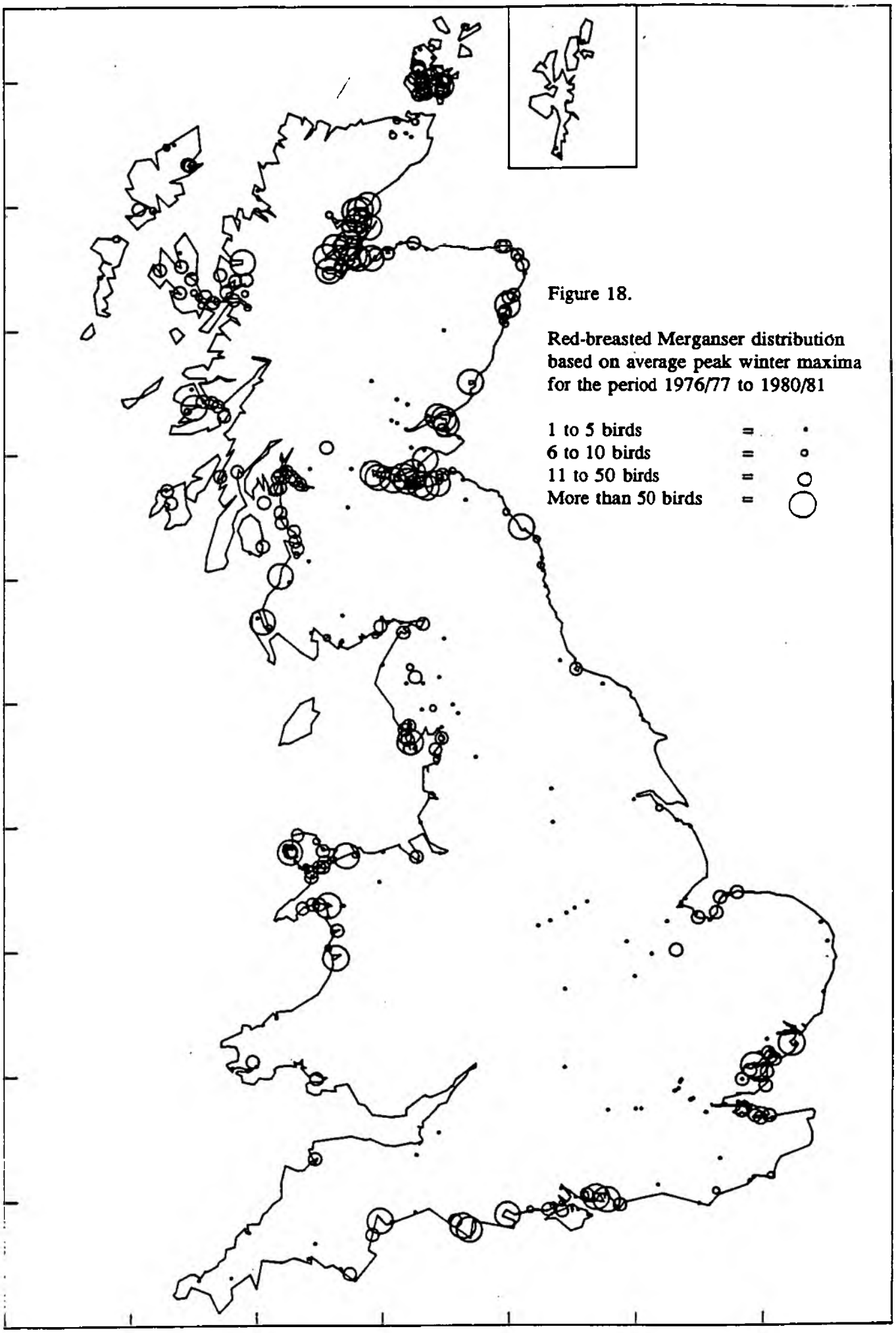


Figure 18.

Red-breasted Merganser distribution based on average peak winter maxima for the period 1976/77 to 1980/81

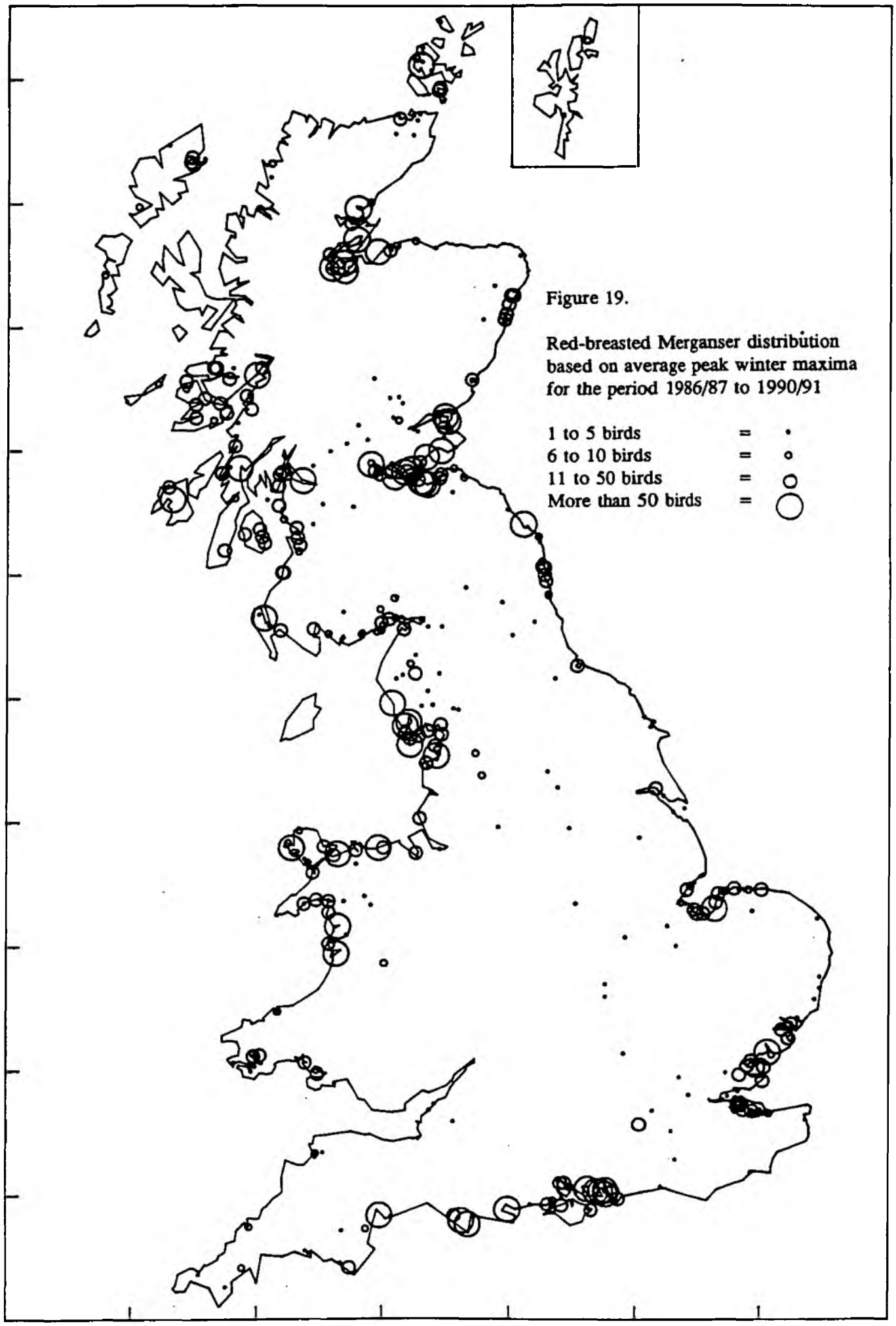


Figure 19.

Red-breasted Merganser distribution based on average peak winter maxima for the period 1986/87 to 1990/91

Table 14. Red-breasted Merganser: seasonal maxima at main resorts, 1986/87 to 1990/91.

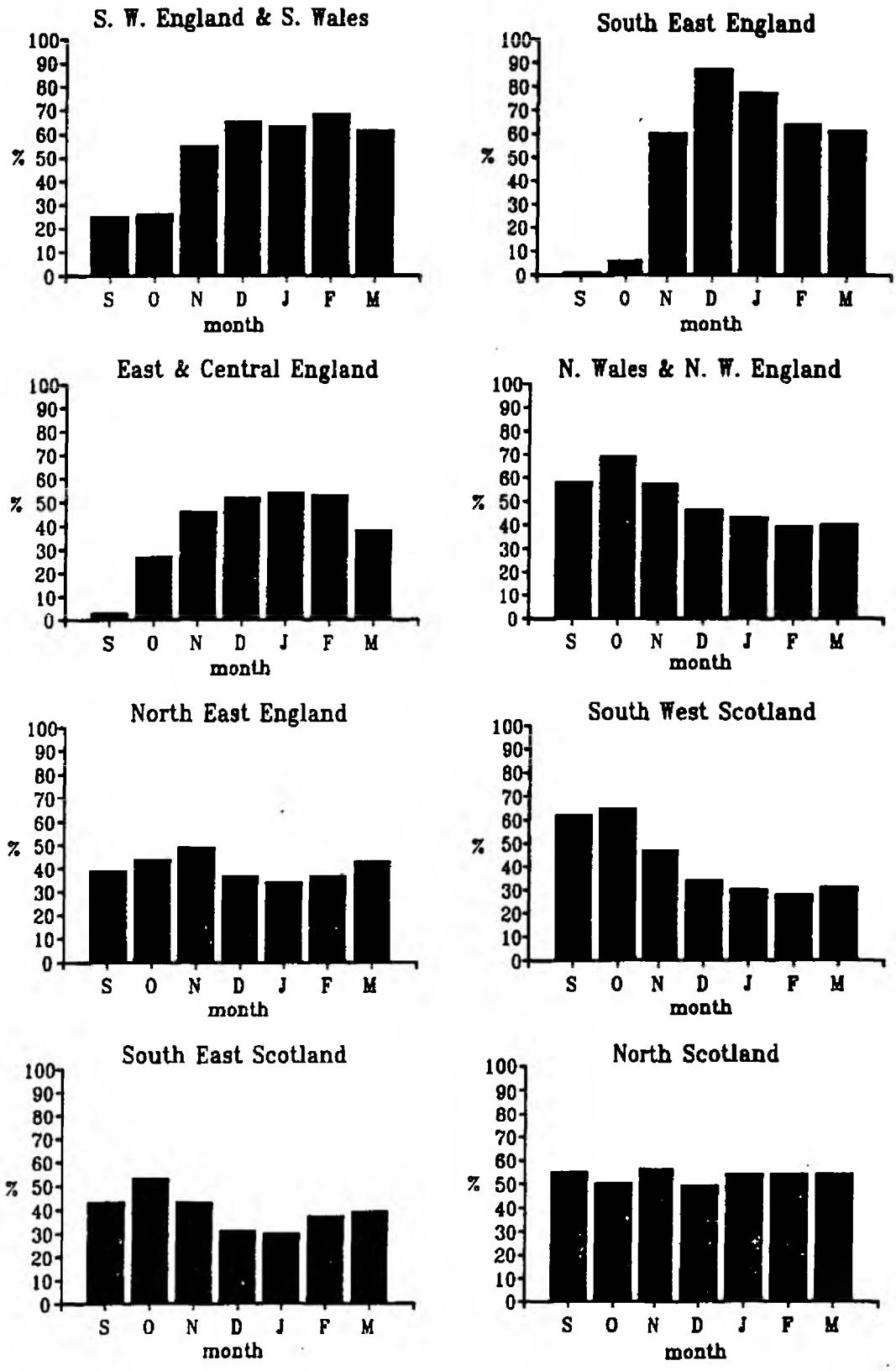
	86/87	87/88	88/89	89/90	90/91	Month	Average
Inner Moray Firth	3063	1374	1076	1080	658	Oct	1450
Tentsmuir	600	1102	420	200	220	Sep	508
Forth Estuary	546	316	437	472	478	Oct	450
Cromarty Firth	615	584	332	194	340	Dec	413
Poole Harbour	302	309	387	168	338	Nov	301
Strangford Lough	183	213	371	303	274	Oct	269
Morecambe Bay	177	222	250	371	256	Dec	255
Duddon Estuary	178	267	262	281	271	Aug	252
The Fleet/Wey	285	144	-	259	280	Feb	242
Lough Ryan	210	460	50	104	130	Oct	191
Langstone Harbour	131	214	234	185	186	Dec	190
Lindisfarne	217	310	198	132	81	Aug	188
Belfast Lough	92	209	181	234	204	Feb	184
Larne Lough	92	165	181	218	125	Sep	156
Dundrum Bay	104	93	255	119	196	Sep	153
Inner Clyde	-	253	118	112	113	Feb	149

Month = month of peak count in 1990/91. A '-' denotes a missing value.

The pattern of seasonal change in numbers appeared to vary across Britain (Figure 20), though no statistically significant differences between regions were found. The graphs indicate that the numbers in northern Scotland remained relatively constant throughout the winter. In southern Scotland and northern England, peak numbers occurred in early winter with a gradual decline in numbers subsequently. In southern England, there was a marked midwinter peak, suggesting a southerly migration or an influx from the continent during the course of the winter.

6.2.2 *Long-term trends*

Examination of long-term national trends (1960/61 to 1990/91) revealed significant increases in the numbers of Red-breasted Mergansers in all months (Table 15). The rate of increase was similar between months. A trend based on all months combined showed that there had been a steady and consistent increase from a low point in 1962/63, with distinctive peaks in the trend in 1969/70, 1979/80 and 1988/89 (Figure 21). The trend suggests that the wintering population has increased two to three fold since 1965/66. Red-breasted Mergansers appear to have continued to increase in numbers since 1981/82, although the increase was not found to be statistically significant (r^2=0.403, F=4.7, P<0.06).



S.W. England & S. Wales	$\chi^2 = 55.7$,	P<0.001,	W=0.300	S. E. England	$\chi^2 = 136.4$,	P<0.001,	W = 0.734
E. & C. England	$\chi^2 = 61.8$,	P<0.001,	W=0.333	N.W. England/N.Wales	$\chi^2 = 24.6$,	P<0.001,	W = 0.142
N.E. England	$\chi^2 = 5.82$	P=0.243,	N.S	S.W. Scotland	$\chi^2 = 35.8$	P<0.001,	W = 0.212
S.E. Scotland	$\chi^2 = 16.8$	P<0.01,	W=0.248	N. Scotland	$\chi^2 = 9.4$	P=0.196,	W = 0.051

Figure 20. Seasonal changes in abundance of Red-breasted Merganser in eight regions of Great Britain. In each case, bars show mean percentage of seasonal (September to March) maxima calculated for the period 1960/61 to 1990/91. The consistency of percentages across years was tested using Friedman's Chi-squared and Kendall's Coefficient of Concordance (W).

Table 15. Regression coefficients, the proportion of the variance accounted for (r^2) and F-statistics for the regression of British Red-breasted Merganser indices against year in the months of September to March, 1960/61 to 1990/91. Indices were log-transformed.

Month	Coefficient	r^2	F	P
September	+0.052	0.275	10.62	0.003
October	+0.066	0.577	38.22	0.001
November	+0.063	0.698	64.61	0.001
December	+0.043	0.532	31.88	0.001
January	+0.043	0.536	32.35	0.001
February	+0.059	0.820	127.7	0.001
March	+0.059	0.820	127.1	0.001

There have been statistically significant increases in six of the ten regions over the 1960/61 to 1990/91 period; south-west England/south Wales, north-west England/north Wales, south-west Scotland, south-east Scotland, north-east Scotland and north-west Scotland (Table 16). However, the interpretation of these trends is complicated by the patchy winter distribution of Red-breasted Merganser, with some regions holding relatively few birds in some winters.

Table 16. Regression coefficients, the proportion of the variance accounted for (r^2) and F-statistics for the regression of regional Red-breasted Merganser indices against year, 1960/61 to 1990/91. Indices were log-transformed.

Region	Coefficient	r^2	F	P
SW England & S Wales	+0.066	0.881	207.8	0.000
S & SE England	-0.024	0.006	0.17	*
E & C England	-0.018	0.006	0.14	*
N Wales & NW England	+0.019	0.152	5.0	0.033
Teesdale, Tyneside & Borders	+0.015	0.007	0.18	*
N Cumbria & SW Scotland	+0.023	0.134	4.33	0.047
SE Scotland: Forth & Tay	+0.023	0.285	11.17	0.002
NE Scotland	+0.023	0.285	11.17	0.002
NW Scotland	+0.024	0.173	5.85	0.020

* = Not significant.

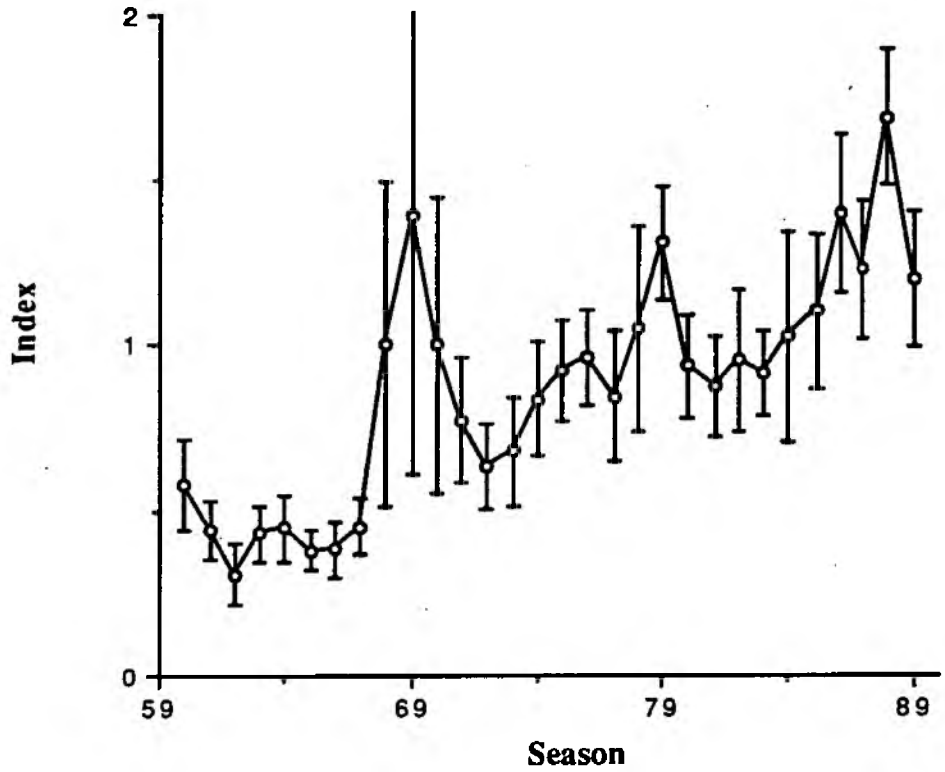


Figure 21. Plot of Underhill index for Red-breasted Merganser in Great Britain. No. sites=217 , counts=4250, imputed values=3234. Vertical lines give 95% confidence limits.

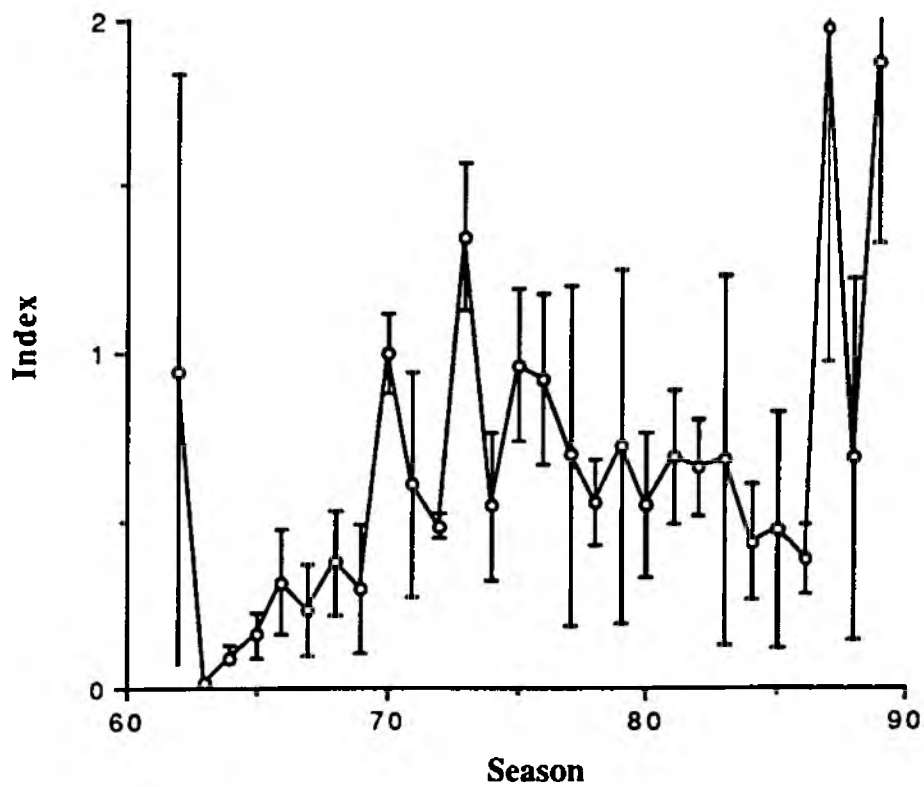


Figure 22. Underhill index for Red-breasted Mergansers in the North-west region. No. of sites=9 , counts=190, imputed values=198. Vertical lines give 95% confidence limits.

The Red-breasted Merganser population in the North West NRA region has fluctuated considerably over the 1960/61 to 1990/91 period (Figure 22), perhaps partly due to the small number of sites involved. After an apparent drop in numbers in the early 1960s, there was a significant increase between 1963/64 and 1976/77, and then a general decline, with noticeable peaks in 1987/88 and 1989/90.

Examination of the proportions of sites on which Red-breasted Mergansers were recorded revealed significant long-term increases in all months (Table 17), suggesting a spread into new sites. Red-breasted Mergansers were recorded on 7-9% (mean=7.2, sd=1.3, n=7) of sites counted in 1960/61 and on 9-12% (mean=10.5, sd=1.2, n=7) of those counted in 1990/91. There has been no equivalent change in the proportion of sites on which Red-breasted Mergansers were recorded in the North West NRA region.

In the North West NRA region, large flocks of Red-breasted Mergansers were found in Morecambe Bay and in the Duddon Estuary. At the latter site, recent maximum winter counts have been considerably higher than in earlier seasons (Table 18). On Morecambe Bay there have been large fluctuations, with the maxima of recent seasons being similar to the levels recorded in 1969/70 and 1972/73 (Table 18).

Table 17. Regression coefficients, the proportion of the variance accounted for (r^2) and F-statistics for the regression of the proportion of sites with Red-breasted Mergansers in each month against year in the months of September to March, 1960/61 to 1990/91. Indices were arcsine-transformed.

Month	Coefficient	r^2	F	P
September	+0.106	0.451	19.2	0.0001
October	+0.146	0.531	32.9	0.0001
November	+0.146	0.530	32.5	0.0001
December	+0.116	0.465	16.33	0.0001
January	+0.104	0.385	10.45	0.003
February	+0.187	0.479	26.45	0.0001
March	+0.171	0.595	36.91	0.0001

6.2.3 *Habitat use*

During September to March, Red-breasted Mergansers were most abundant in coastal waters and were only infrequently recorded in relatively large numbers at inland sites. In 1990/91, 25-58% of coastal sites, 2-3% of lakes, 0-1% of gravel pits, 0-2% of rivers/freshwater marshes held the species in particular months. The majority (90%-97%) of the total British counts in any one month derived from coastal sites; 3-8% from lakes and less than 1% from each of the remaining habitats.

Table 18. Maximum seasonal counts of Red-breasted Merganser on key sites in the North West NRA region and on the Ribble Estuary. Refer to Figure 24 for the locations of these sites.

Season	Morecambe Bay	Duddon Estuary	Ribble Estuary
1963/64	16	-	-
1964/65	2	-	-
1965/66	62	-	-
1966/67	32	3	-
1967/68	52	4	-
1968/69	58	14	-
1969/70	315	7	-
1970/71	84	1	-
1971/72	101	20	-
1972/73	302	16	-
1973/74	134	2	-
1974/75	-	1	-
1975/76	172	7	-
1976/77	155	32	-
1977/78	-	-	-
1978/79	127	3	-
1979/80	86	19	-
1980/81	71	1	2
1981/82	130	-	12
1982/83	38	10	4
1983/84	93	10	5
1984/85	263	59	5
1985/86	267	89	4
1986/87	166	78	2
1987/88	222	267	-
1988/89	245	262	-
1989/90	371	287	-
1990/91	256	87	-

A '-' denotes a missing count.

Investigation of the seasonal use of each habitat revealed a gradual increase in the numbers on coastal sites to reach a maximum in December, and February maxima on rivers/freshwater marshes and gravel pits (Figure 23). Long-term British trends calculated for each habitat separately revealed significant increases on lakes and coastal sites, no overall change on gravel pits or rivers/freshwater marshes, and a significant decrease on reservoirs (Table 19). However, because of the scarcity of Red-breasted Mergansers in winter on all inland NWC sites, most of these trends are based on a very small number of sites.

Table 19. Regression coefficients, the proportion of the variance accounted for (r^2) and F-statistics for the regression of British Red-breasted Mergansers calculated for each habitat type against year in the months of September to March, 1960/61 to 1990/91. Indices were log-transformed.

Habitat	Coefficient	r^2	F	P
Lakes	+0.018	0.239	8.8	0.006
Reservoirs	-0.136	0.190	6.5	0.016
Gravel Pits	-0.021	0.004	0.105	0.748
Rivers/freshwater marshes	*	*	*	*
Coastal Waters	+0.064	0.808	117.734	0.000

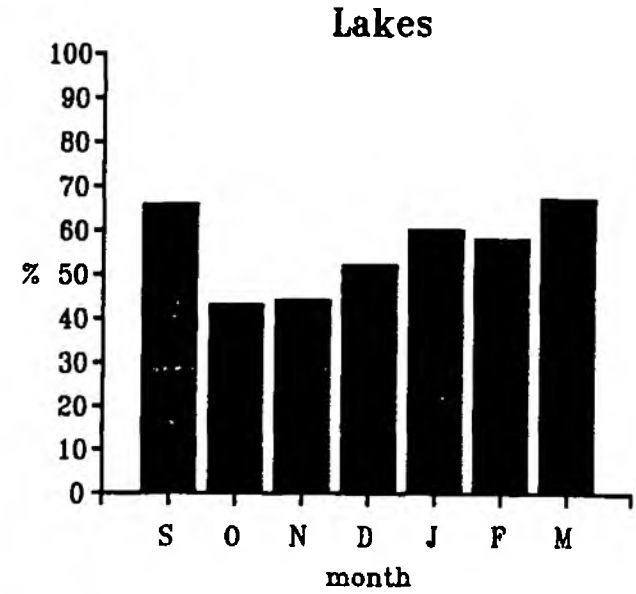
* = Insufficient data

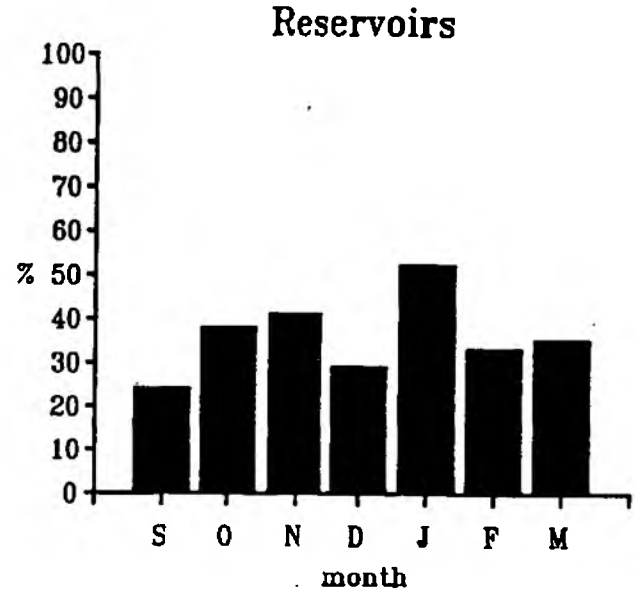
6.3 SUMMARY

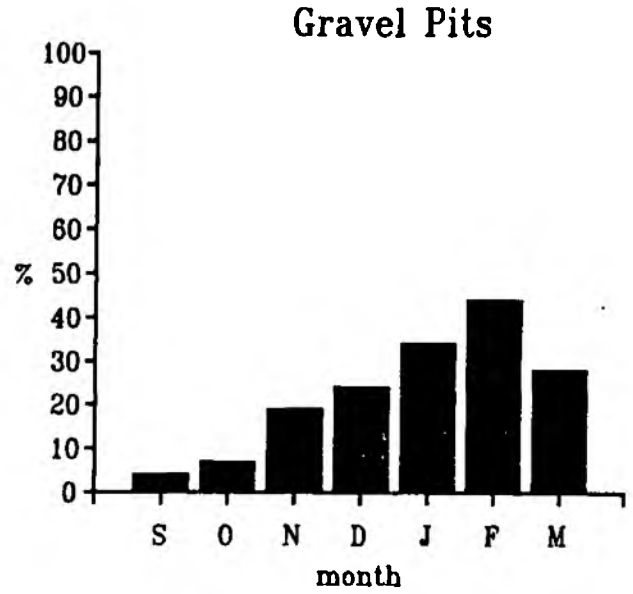
Some 4,200 wintering Red-breasted Mergansers were counted in Britain for the NWC scheme, with about 13% of these in the North West NRA region. They were widely dispersed around the coast, but were restricted to relatively few sites (15% of those counted), and mostly occurred in small numbers (64% held fewer than 10 birds). Sixteen sites held numbers of national significance, with the Inner Moray Firth being the most important site. Two nationally important sites, Morecambe Bay and the Duddon Estuary, were in the North West NRA region.

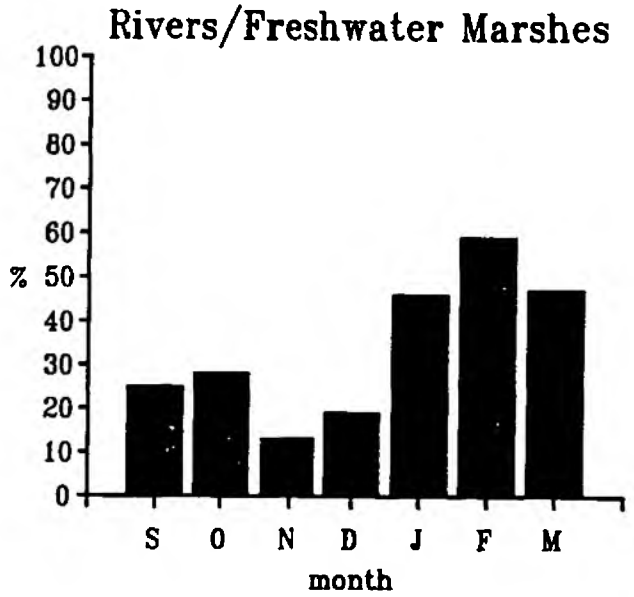
There was no statistically significant difference in the pattern of seasonal abundance between regions. However, maximum counts occurred in early winter in southern Scotland and in northern England, but occurred later to the south. There have been significant long-term increases in Red-breasted Merganser numbers, and the proportion of sites they occupy, in all months. There has been a consistent increase in numbers from 1962/63, but the population has changed relatively little since 1981/82. Significant increases have occurred in six of ten regions. In the North West NRA region, there was a significant increase between 1963/64 and 1976/77, but this was followed by a decline. There was no long-term increase in the proportion of sites occupied in the region.

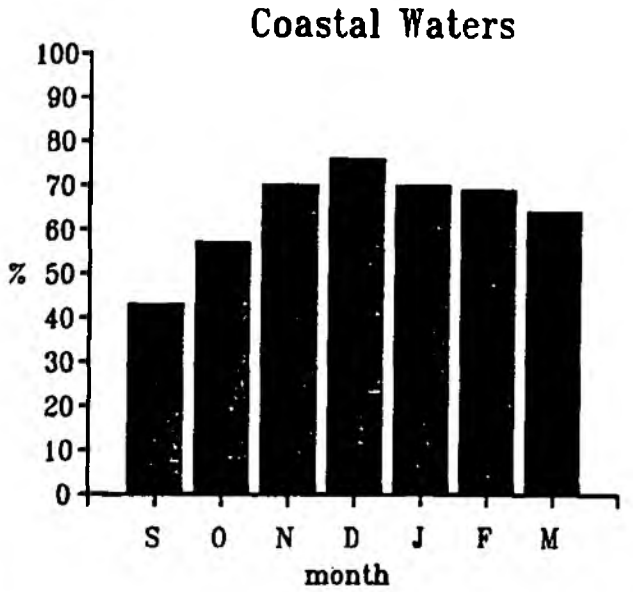
Red-breasted Mergansers have occurred on all wetland habitat types counted for the NWC scheme, but were by far the most numerous in coastal waters. Here, there was a gradual increase through the autumn to reach a December peak, and a decline thereafter. There appear to have been long-term increases on lakes and coastal habitats only.









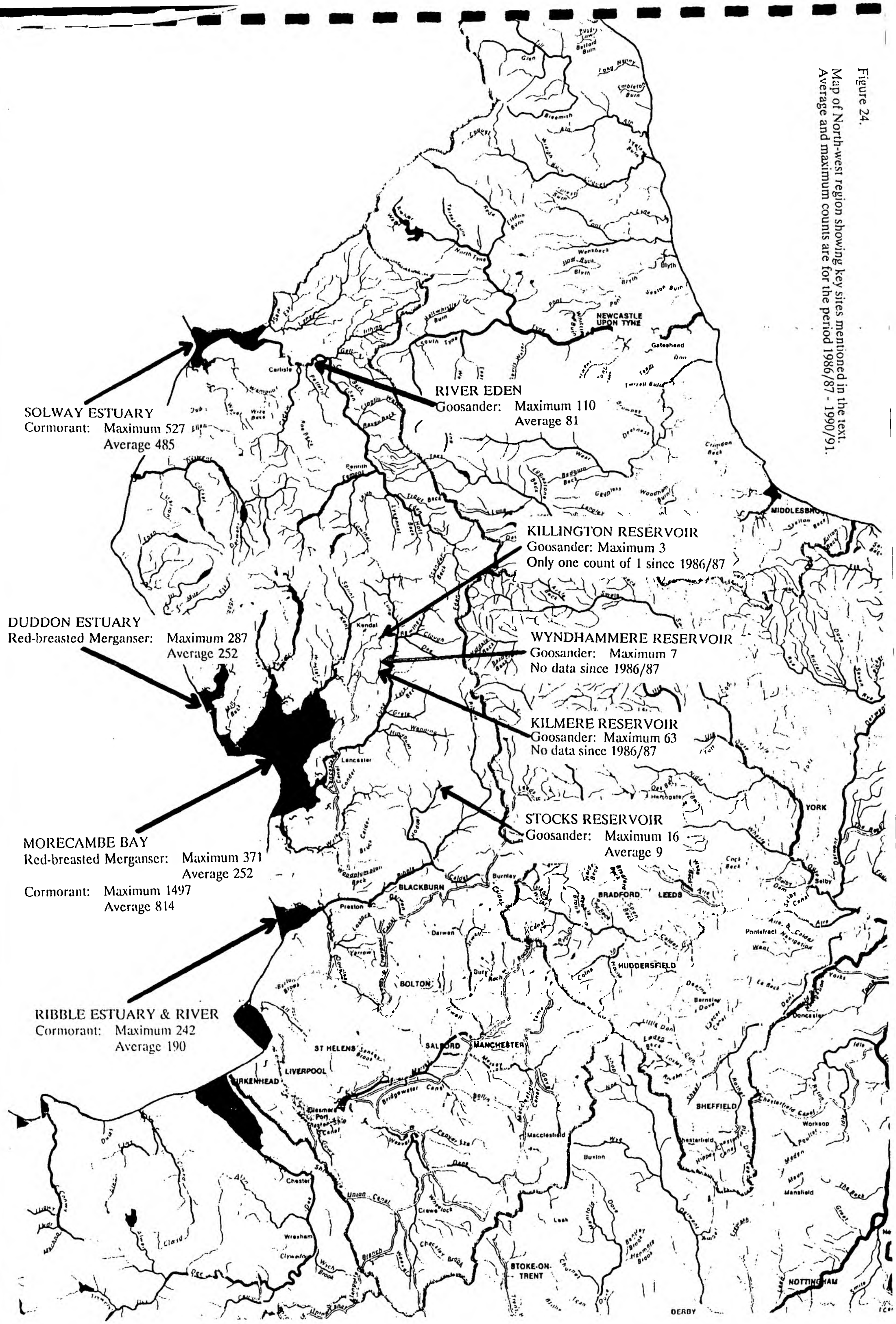


Lakes	$\chi^2 = 18.79$,	$P<0.01$, $W= 0.101$	
Reservoirs	$\chi^2 = 7.00$,	$P=0.32$, $W= 0.039$	N.S.
Gravel Pits	$\chi^2 = 17.38$,	$P<0.05$, $W= 0.111$	
Rivers\ freshwater marshes	$\chi^2 = 25.10$,	$P<0.001$, $W= 0.199$	
Coastal\ waters	$\chi^2 = 41.06$,	$P<0.001$, $W= 0.221$	

Figure 23. Seasonal changes in habitat use by Red-breasted Merganser. In each case, bars show mean percentage of seasonal (September to March) maxima calculated for the period 1960/61 to 1990/91. The consistency of percentages across years was tested using Friedman's Chi-squared and Kendall's Coefficient of Concordance (W).

Figure 24.

Map of North-west region showing key sites mentioned in the text.
Average and maximum counts are for the period 1986/87 - 1990/91.



7.0 DISCUSSION

Based on winter counts from the NWC scheme (1986/87 and 1990/91), the wintering population of Cormorants in Great Britain was estimated to be in the region of 16,800 birds. Counts at breeding colonies made between 1985-87 indicate that the British breeding population of Cormorants of around 7,000, which would suggest a wintering population of 18,200 (Lloyd *et al.* 1991). Given the wide dispersal of Cormorants outside the breeding season, and the fact that some large areas of coastal habitat are not covered the NWC scheme, these estimates are remarkably similar. The total wintering population of Goosander was estimated to be around 5,500. This is considerably less than the 8,000 suggested by Lack (1986), but not inconsistent with the estimate of Owen *et al.* (1986) of 5,000. The estimate of a winter population of 8,100 Red-breasted Mergansers is in the middle of the range (6,000 to 10,000) suggested by Owen *et al.* (1986), but lower than the estimate of 9,500 put forward by Lack (1986).

Approximately 19% of Cormorants, 12% of Goosanders, and 13% of Red-breasted Mergansers counted on the NWC scheme in Britain were recorded in the North West NRA region. These provide only a crude indication of the size of the region's populations of each species, since there are some fairly large areas of Britain not yet covered by the NWC scheme and many of the rivers and smaller waters frequented by these species are not well covered. Also, Goosanders, in particular, are highly mobile, often moving from roosting sites on standing waters to daytime feeding sites on rivers, and this may result in many birds being missed during the NWC scheme, either because the river was not counted or because the birds were absent during the counts.

All three species were widely distributed throughout Britain, but the Goosander and Red-breasted Merganser were restricted to only 15% of the NWC sites counted. They generally occurred in small numbers, with 58% of sites holding fewer than three Goosanders and 64% of sites holding fewer than 10 Red-breasted Mergansers. Cormorants were recorded at 46% of NWC sites overall, although 60% of these held fewer than 10 birds. For all three species, there were some important concentrations however. Indeed, 34% of estimated total population of Cormorants, 37% of Goosanders and 53% of Red-breasted Mergansers were found on the top ten British sites for each species. Clearly, the protection of these relatively few sites would safeguard a high proportion of their populations. However, because all three species also occur in small numbers on a large number of sites, the protection of just a few key sites would only bring limited benefits to these species. Wider countryside conservation policies would be needed to maintain the range of these species in Britain.

Rather than conserve these species, there may be calls for controlling their numbers in future years. Their wide dispersion patterns would pose problems in any control programmes, as considerable effort may be required to control even a small number of birds on the wintering grounds. Goosander and Red-breasted Merganser populations could not be controlled effectively by actions during the breeding season, though the birds may be removed from particular rivers by intensive and persistent shooting regimes. In contrast, it is certainly possible to have a significant impact on the Cormorant population by management of their, rather few, breeding colonies. However, without detailed knowledge of the winter dispersion of Cormorants from each colony, control on their breeding sites may have little affect on the wintering population on any particular river system.

Nationally, Cormorant numbers peaked on NWC sites between September and November, Goosander numbers in midwinter and for Red-breasted Mergansers it was variable. The sharp increase in numbers of Goosanders between November and December was almost certainly due to males returning from their moulting areas in Scandinavia and the influx of immigrants (Venables & Venables 1955, Boyd 1959, Owen *et al.* 1986) into southern England. The relatively constant numbers of Red-breasted Merganser in northern Scotland through the winter was indicative of a relatively stable there, while in southern Scotland and northern England, peak numbers occurred in early winter with a gradual decline thereafter. In southern England, Red-breasted Mergansers reached were most abundant in midwinter, suggesting there was an influx of birds from further north in Britain or from Scandinavia (Lack 1986) as the winter progressed.

During the winter there was a gradual movement of Cormorants inland. In September, only 25% of Cormorants were recorded on inland sites but this increased to 50% by February. Such increases were particularly evident on reservoirs, lakes and gravel pits, where peak numbers were generally recorded in March. Peak numbers of Goosander occurred in February on most habitats. On rivers/freshwater marshes, however, peak numbers occurred in January.

Since the early 1960s there have been significant long-term (1960/61 to 1990/91) increases in both numbers and the dispersion (measured as the proportion of sites occupied) of Goosanders and Red-breasted Mergansers in all months in Britain. The period of greatest increase in numbers was between 1969/70 and 1979/80 for the Goosander, and between 1962/63 and 1979/80 for the Red-breasted Merganser. Both species have neither increased nor decreased significantly since 1981/82. There have been marked increases in numbers of Cormorant counted in Britain since they were included in the NWC scheme in 1986/87. On sites that have been counted in every season, Cormorant numbers have increased by approximately 18% per annum.

Increases in all three species have been evident in the majority of British regions where each species regularly winters. Cormorant numbers appear to have increased more rapidly on inland sites, particularly reservoirs and lakes, than in coastal waters. Goosander numbers appear to have increased significantly on most habitats, but particularly on gravel pits. Long-term increases were apparent for Red-breasted Mergansers on lakes and coastal habitats. Goosanders and Cormorants, in common with other wildfowl, for example Gadwall (*Anas strepera*), appear to have benefited from the provision of artificial wetlands by man, particularly reservoirs and gravel pits (Fox & Salmon 1989). The stocking of these man-made wetlands with fish is likely to have further encouraged use of these wetlands by piscivorous birds. In regions with an expanding area of flooded gravel pits, for example most of southern England, one may well expect an increase in winter numbers of Goosanders as they move in to exploit these new wetlands.

The long-term increase in the abundance of wintering sawbills is likely to be due to an increase in breeding numbers and possibly a greater influx of birds onto NWC sites (Kirby *et al.* 1991). Breeding Red-breasted Mergansers appear to have expanded into England and Wales some 10-15 years before the southward spread of Goosanders into northern England during the 1960s and 1970s (Lack 1986, Meek & Little 1977). Goosanders probably bred in Wales as early as 1968 (Lovegrove 1978) since when numbers have increased (Griffin 1990)

and they have bred in Devon since 1980 (Sitters 1988).

Given the increase in the breeding population of Cormorants (Lloyd *et al.* 1991, Walsh *et al.* 1990, 1991) it is not surprising to find increases in their winter numbers. The large increases in numbers on inland sites seems to be a result of a greater proportion of the increasing population moving to winter on inland sites. Whether this is a result of a decrease in winter food supplies in coastal waters, perhaps through competition with other species or commercial fisheries, or a result of an increase in available food on inland sites is uncertain. Given the colonial nature of the species the role of cultural transmission of winter dispersion patterns cannot be ruled out. If such a process does occur then one may expect the proportion of Cormorants moving inland during the winter to continue to increase.

In the North West NRA region, there have been increases in all months in the number of Cormorants counted between 1987/88 and 1989/90, but the counts were lower in 1990/91 than in 1989/90. This occurred despite an large increase in the number of sites counted in the 1990/91 compared with earlier seasons. The number of Goosanders counted in the North West NRA region has increased significantly since 1981/82, mostly due to high counts between 1985/86 and 1990/91, but there has been no increase in the proportion of sites occupied. The number of Red-breasted Mergansers in the North West NRA region appeared to increase during 1963/64 to 1976/77, then declined, but the counts were high in 1987/88 and 1989/90. There was no long-term change in the proportion of sites occupied by Red-breasted Mergansers in the region.

There have been marked increases in the breeding population of Cormorants close to the North West NRA region. Between 1969 and 1987 Cormorant colonies in North Wales increased by 17%, those on the Isle of Man and elsewhere in the north-west by 114%, while those in south-west Scotland decreased by 7% (Lloyd *et al.* 1991). In 1987, there were approximately 1,280 breeding pairs of Cormorants along the west coast between North Wales and southern Scotland, which would mean a wintering population of approximately 3,200. It is possible that the majority of Cormorants congregating in Morecambe Bay in the autumn and moving inland during the winter are from these colonies.

The origin of Goosanders wintering in the North West NRA region is unknown, but both immigrants and locally bred birds are likely to be involved. Given the documented westward dispersion of young Goosanders from Northumberland (Meek & Little 1977), this seems a likely source of at least a proportion of the birds. There are no published studies on the recent breeding population of Goosanders in north-west England, so it is impossible to estimate the contribution of local birds to the recent increase in numbers. Previous estimates of the breeding population (Sharrock 1976, Meek & Little 1977) suggest little change between 1968-72 and 1975. The decline in peak counts of Goosander at Stocks and Killington Reservoirs is opposite to national and regional trends in numbers. Several possibilities need to be examined. There may have been long-term changes in the suitability of these wetlands for Goosanders, for example increased levels of disturbance, or a decline in food supply. Also, a change in the time of day that recent NWC were conducted, perhaps due to changes in counters at these sites, could mean the birds were absent from these traditional sites when the counts were made. It is also possible that there has been a general shift northward in the wintering distribution of Goosanders, with more birds wintering in the north of the region in recent years, for example on the River Eden where numbers have increased.

The origin of Red-breasted Mergansers wintering in Morecambe Bay and the Duddon Estuary is not known, therefore we cannot speculate on whether recent high counts reflect a particularly successful breeding season in the North West NRA region or a greater influx of birds from elsewhere.

Limitations to data

While the NWC scheme represents the largest available data set on the numbers of waterfowl in United Kingdom, covering *ca* 2,000 sites annually, there are a number of problems which need to be remembered when considering the results of these analyses. Furthermore, these problems will affect each species differently, and so it is difficult to gain a good idea of the accuracy of the data (*e.g.* for producing population estimates) for particular species. There are gaps in the coverage achieved for the NWC scheme, particularly in north and eastern Wales, eastern England and throughout some regions of Scotland. These gaps will be most significant for species that are widely distributed through these areas. The coverage of most habitat types is relatively comprehensive, but there are relatively few sites on rivers, and thus counts for species using this habitat extensively (*e.g.* Goosanders) are likely to be conservative. Also, because habitats are not sampled in proportion to their occurrence by the NWC scheme, there may be some biases with respect to habitat use, and the relative importance of each habitat type to particular species. The timing of the counts, as well as the geographical spread of count sites, may also be important to the counts obtained for species that are highly mobile, like the Goosander. Indeed, in many areas, they feed away from the standing waters, on which they roost, during the day, and thus may be absent when the majority of counts are made. Also, because the counts are normally made on a Sunday, the data from sites subject to disturbance from weekend recreation activities, may suggest lower numbers than those collected during the week when disturbance is reduced. Also counts made only once in a month, as are NWC counts, may miss large numbers between count dates, the chances of this being greater for species which are highly mobile. With regard to Cormorants, there are no data available to be analysed prior to 1986/87; there are counts of Cormorants from some NWC sites prior to this, but these data have yet to be verified and entered onto the NWC computer database.

Future trends

While the numbers of Cormorants in many colonies appears to have stabilized or even decreased between 1989 and 1990 (Walsh *et al.* 1991), the overall pattern is one of continued increase (Lloyd 1991, Walsh *et al.* 1991). Thus, if the increase in the proportion of Cormorants wintering inland continues, we are likely to see more Cormorants using freshwater wetlands outside the breeding season. There is no information to predict future increases in the population of Goosanders in the North West NRA region. Without detailed surveys during the breeding season, and the marking of birds, it is impossible to know what proportion of the wintering population breeds within the area, and whether this population is static, decreasing or increasing. However, assuming a good proportion of the wintering population is made up of immigrants, then would expect to continue to see large fluctuations in wintering numbers.

The population of Red-breasted Mergansers is probably stable or slowly increasing as the species continues to expand its breeding range. However, a dramatic increase in the wintering population within the next few years seems unlikely. While in the North West NRA region there have been some high winter counts in recent seasons, the population is probably stable.

Implications for predation of freshwater fisheries in the North West NRA region.

While this study cannot begin to assess the impact of piscivorous birds on fishery stocks, it is possible to indicate areas where further research may be best directed. We estimated that the North West NRA region held approximately 19% of the Cormorants, 13% of Red-breasted Mergansers and 12% of Goosanders that are counted in Great Britain; this equates to approximately 3,200 Cormorants, 1,100 Red-breasted Mergansers and 700 Goosanders. Using these figures, the ratio of abundance of these species in the North West NRA region is 24:8:5, Cormorants to Red-breasted Mergansers to Goosanders.

These three species use wetlands differently during the year and, if they do affect freshwater fisheries, their relative impacts are likely to differ. To allow discussion of the relative levels and potential type of predation, very crude estimates of the numbers of each species on freshwater habitats in the North West NRA region in summer (April-August) and winter (September-March) can be calculated. However, the following figures should not be taken as an indication of actual numbers, but rather as a comparison of possible predation pressures on freshwater and provide guidance for further research.

In winter, Cormorants tend to move inland and, by February, 50% of those in the North West NRA region may be on inland wetlands (1,600 birds). The majority of Red-breasted Mergansers winter on coastal sites, with perhaps 10% of those counted on inland sites (110 birds). Whilst Goosanders may move from rivers to lakes, reservoirs and gravel pits during the winter the majority of those in the North West NRA region are on freshwater (700 birds). This suggests there may be 2,300 piscivores on freshwater sites during the winter months in the North West NRA region, approximately 20% more than in the summer, with a ratio of 23:2:10 Cormorants to Red-breasted Merganser to Goosanders.

In summer, Cormorants in the north-west breed in coastal colonies from North Wales to the Solway and on the Isle of Man. Some non-breeding juveniles may summer on inland sites (perhaps 10% of the number inland in winter, 160 birds). Red-breasted Mergansers (1,100 birds) and Goosanders (700 birds) generally breed on the rivers in the region. Thus, in spring (April/May), there are possibly 1,960 piscivores on freshwater habitats in the North West NRA region, occurring in a ratio of 2:15:10 Cormorants to Red-breasted Mergansers to Goosanders. As soon as incubation begins, male sawbills leave the rivers to moult, reducing the numbers on the rivers until the young hatch and congregate in suitable feeding areas.

Evidence from national and regional trends suggest that the population of Goosanders and Red-breasted Mergansers is likely to remain constant in the North West NRA region, whilst Cormorant numbers are perhaps more likely to rise. The proportion of the Cormorants counted wintering on inland sites, where they are already the most numerous piscivore, is also increasing. Thus increasing concern from coarse fishermen over predation by Cormorants of fish stocks could be expected. This is especially so since Cormorants are most abundant

during the coarse fishing season. Goosanders are very mobile and easily spotted even by casual observers. Both sexes are present on rivers during the spring salmon smolt runs and, later in the summer, females and their broods often congregate together in good feeding areas. Thus, the concerns of game fishermen regarding Goosanders, are likely most focused during spring, when the males are present, and later in the summer when females and young may be seen in relatively large flocks.

Further Research on piscivore populations

With regard to fisheries in the North West NRA region, an investigation into the impacts of Cormorants on fish stocks would seem to be a priority, particularly with respect to fisheries during the winter months. There is need for detailed research into the abundance and distribution of Cormorants on inland wetlands in the North West NRA region and particularly their use of river systems. Ringing studies would also be useful in order to establish where the Cormorants wintering in the North West NRA region breed. There is also a need for detailed studies to provide an accurate estimate of the breeding population of Goosanders and Red-breasted Mergansers in the North West NRA region and an insight into the relationship between the wintering and breeding populations. This could involve ringing and dye marking breeding birds, combined with extensive winter surveys of whole rivers systems. The movement of Goosanders between rivers and still water roosting sites may have a large impact on winter estimates of the population, and the methodology to resolve this potential source of error needs to be developed and tested.

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APPENDIX

Trends in the abundance of Goosander and Red-breasted Merganser were examined using the technique proposed by Underhill (1989). This technique allows data from several months to be used to generate an overall population trend, and allows the estimation of missing values and confidence limits. It is based on the assumption that the count at a given site in a given year and month can be modelled as follows:

$$X_{ijk} = S_i Y_j M_k$$

where S_i is the factor for site i, Y_j is the factor for year j, and M_k is the factor for month k. If the year and month factors are constrained to equal 1 for a base year (we used 1970) and month respectively, then the site factors may be interpreted as the expected counts in this year and month. The annual population index is given by the year factor, which is simply a ratio of the population size in one year to that in the base year. If the there are no missing data the index will be exact. More usually, missing and incomplete data are imputed from an iterative algorithm, and bootstrap methods enable approximate confidence intervals to be found. Further details, and an illustration of its applicability and advantages over other indexing techniques, can be found in Underhill (1989).

The sites included in the indexing procedure were those for which there was at least 60% of the potential counts from the 31 seasons, higher than the 50% cutoff recommended by Underhill (1989). In imputing missing values, the maximum number of iterations used was 50 and the convergence criterion (the average difference in imputed values between successive cycles) was 0.1. The number of simulations used in the bootstrapping procedure was 200 and 95% confidence intervals were estimated.

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