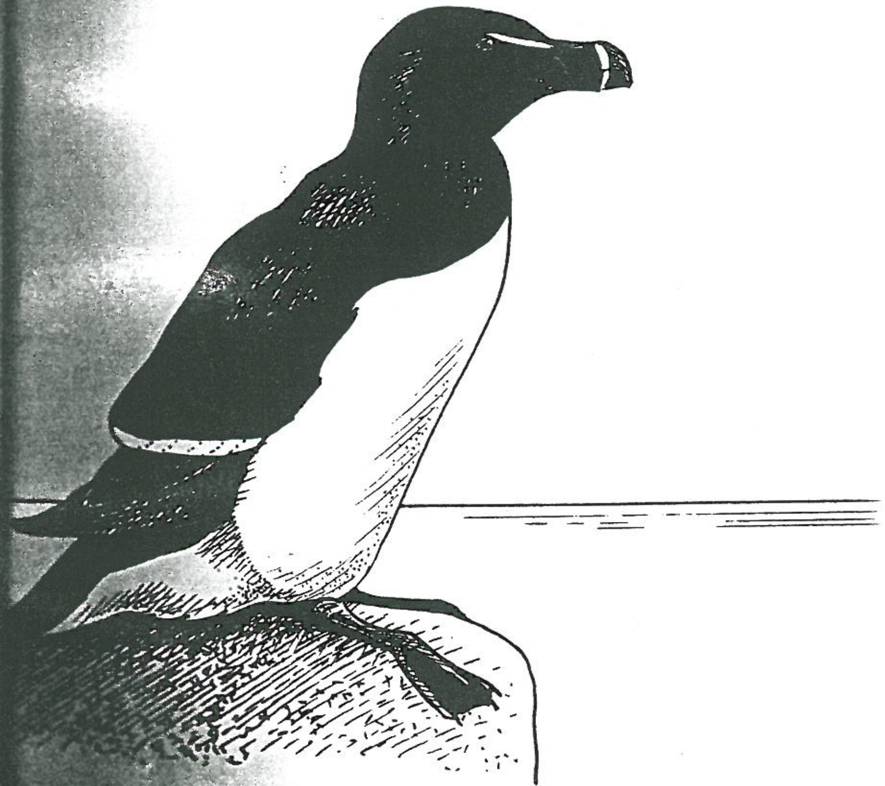
STOWE 1982

BEACHED BIRD SURVEYS and SURVEILLANCE OF CLIFF-BREEDING SEABIRDS



J. Stowe

RSPB

Nature Conservancy Council Contract HF3/03/141

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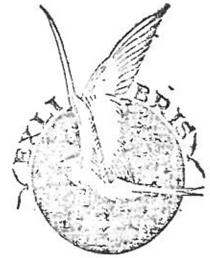

Report prepared for

The Nature Conservancy Council

by

The Royal Society for the Protection of Birds

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January 1982

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PART I BEACHED BIRD SURVEYS

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Background and aims

The sporadic occurrence of large numbers of seabird corpses on British beaches had been noted over a century ago (Gray 1871, Anon. 1876), whilst the Proceedings of the Glasgow Natural History Society (February 1872) contained an early reference of the potential threat to seabirds presented by oil pollution, in this case by paraffin. Subsequently, the Royal Society for the Protection of Birds (RSPB) drew attention to the numbers of oiled birds washed ashore during the First World War, and observations on the occurrence of oiled birds in the early 1920s were used as evidence to promote the first oil pollution legislation (Anon. 1922). In subsequent years numerous reports of oiled birds were received regularly by the RSPB (Anon. 1929) and others (Adam 1936). After the 1939-45 war more comprehensive surveys of the routine occurrence of oiled birds were organised in conjunction with the British Section of the International Committee for Bird Preservation (Barclay-Smith 1956), but throughout the early years few observations were published on the occurrence of unoiled corpses.

In 1966, in conjunction with the newly formed Seabird Group, the RSPB extended national Beached Bird Surveys, encouraging volunteers to make more frequent counts, whilst the February counts were timed to coincide with those already taking place in Belgium and the The Netherlands (Bourne & Bibby 1975 & references therein). Variations in the frequency and extent of the surveys made analysis of the counts difficult, and since 1971 improved results have been obtained from five systematic counts per year on specific weekends.

In 1977, Beached Bird Surveys were formally incorporated into the Nature Conservancy Council's (NCC) contingency plans to deal with major pollution incidents. Subsequently, NCC contracted RSPB to provide a programme to attempt to monitor the impact of oil pollution on birds in the United Kingdom.

The objectives of the Beached Bird Survey are:

(a) to monitor seabird mortality and the frequency of oiled birds as reflected by the occurrence of dead or sick birds on beaches.

(b) to assess the numbers, species and distribution of birds affected in major mortality incidents, especially those caused by oil pollution.

To assist in the interpretation of the surveys experimental work has been carried out.

Part I of this report, under contract HF3/03/141, describes Beached Bird Survey methods and organisation, and presents the results of routine and incident surveys and one beaching experiment. The report considers trends over time in the proportion of birds found oiled and in the observed mortality, and investigates to what extent these were linked to the effects of cold weather and onshore winds (Bourne & Bibby 1975, Royal Commission on Environmental Pollution 1981).

Methods

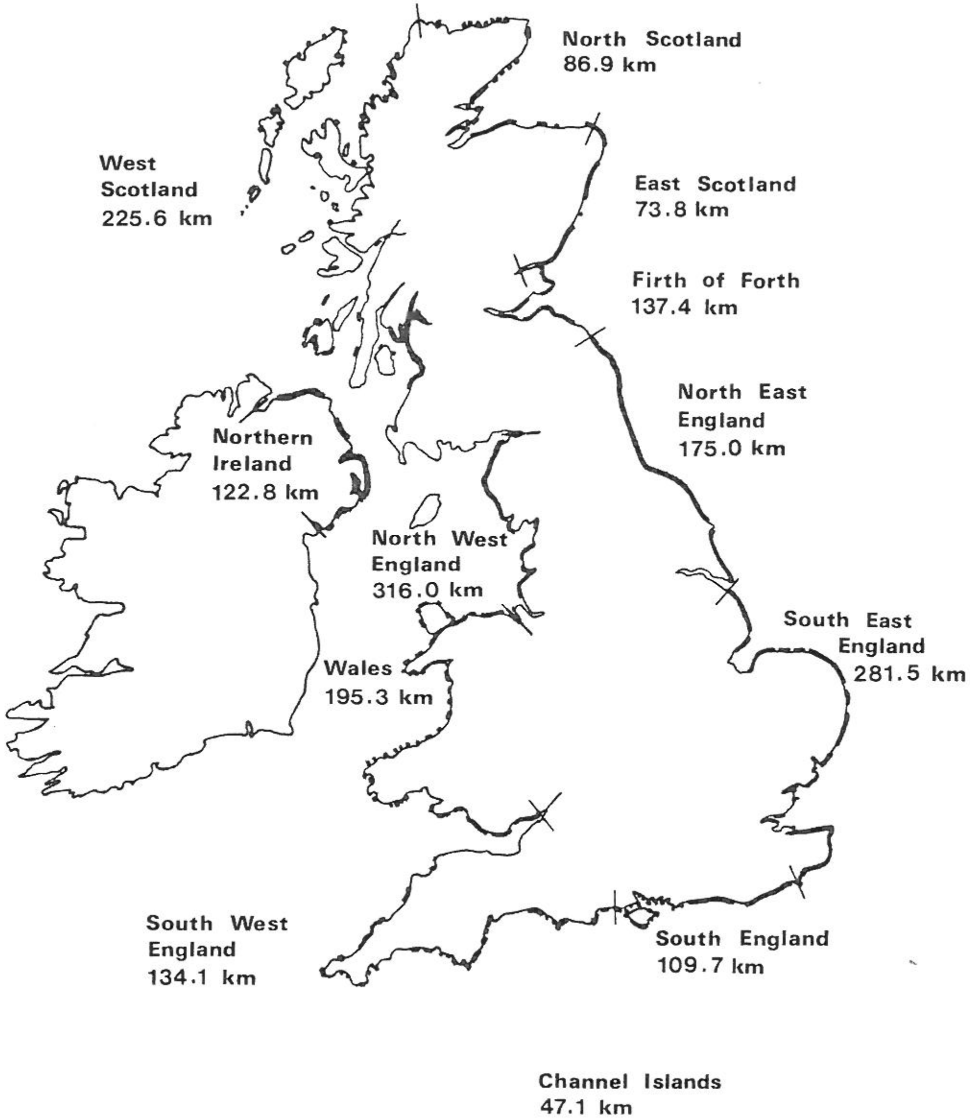
1. Systematic surveys

(a) Data collection

The selection of beaches was largely determined by ease of access, whether beaches were suitable for walking (rocky shores were usually avoided), and the proximity to the participant. Hence, a greater proportion of the coastline was surveyed in south and east England than in north and west Scotland (Fig.1). Beaches were walked on five pre-arranged occasions during the autumn and winter, the period previously established as experiencing the highest amounts of oil pollution and bird mortality (Bibby in Bourne 1976). The surveys were made within a period of up to seven days before or after a specific weekend, usually the last, in the months of September, November, January, February and March. Participants searched beaches in one direction only, walking along the most recent strand line and looking above and below it. For each beach the number of corpses and number of sick birds and the numbers showing signs of oil contamination were recorded on separate cards for each survey (Appendix B1). An oiled bird was defined as one showing the presence of oil on its plumage. Counters were asked to record slightly and heavily oiled corpses separately, and to indicate whether there was oil on the beach. Once corpses had been recorded they were removed, or buried at the top of the beach. In early years of the survey, corpses judged to be 'old' were noted separately, but because of the subjective nature of this assessment, and the differences in the 'survival' of corpses (Hope Jones 1980) the distinction was abandoned. From 1978 information was collected on the numbers of bird wings that had become detached from the rest of the corpse.

After each count the cards were returned to the local organiser, (normally one local organiser per county) who forwarded them with others from the area to RSPB Research Department. In 1980/81 about 750 volunteers participated in the survey, returning between 500 and 600 cards per count. All cards were checked by Research Department staff and were entered on computer. Methods of storage and retrieval of data are given in Appendix B2.

Figure 1 Beached Bird Survey cover, regional divisions and average monthly distance of beaches walked 1971-79.



In Orkney, surveys once per lunar month were started in March 1976, and results for 1976-78 have already been examined elsewhere (Hope Jones 1980). In Shetland, monthly surveys have been conducted by Shetland Oil Terminal Environmental Advisory Group from August 1978. Few counts had been obtained from either area before the start of these surveys. Counts from these islands have not been included because the greater frequency of surveys may have led to the removal of corpses that would otherwise have been found during the September, November and January counts, thereby reducing recorded densities.

Sea temperatures and wind speeds and directions for 1971-79 were obtained from the Meteorological Office. The original wind data, consisting of hourly wind speeds (knots) and directions for eight coastal stations (Fig.2), were resolved to give daily easterly and notherly components at each station. Monthly sea temperatures (°C) were estimated for eight points located regionally around the British coast and one in the middle of the North Sea (Fig.2) from Meteorological Office maps of mid-month isotherms based on five day running means. Data representing land temperature were provided by the British Association for Shooting and Conservation, having been extracted from the Meteorological Office records for another purpose. These data were available only for the winter months, and were condensed to represent the number of days in each month when more than half of 13 coastal meteorological stations (Fig.2) recorded frozen or snow covered ground at 9 am.

(b) Shortcomings

The effectiveness of the search for corpses is known to vary with local conditions and observer effort. During surveys in Orkney, mainly on rocky beaches, Hope Jones (1980) recorded up to 20% of the corpses during the return survey, having overlooked them on the outward walk. Beaches in the national survey were walked in one direction only, and some corpses may have been missed. Corpses may be difficult to find because they become buried under the tideline debris or blown sand, or hidden in rock crevices. The quantity of debris on beaches, especially tide wrack, appears in general to be greatest in the extreme north and west. Elsewhere, there is usually insufficient debris to bury corpses.

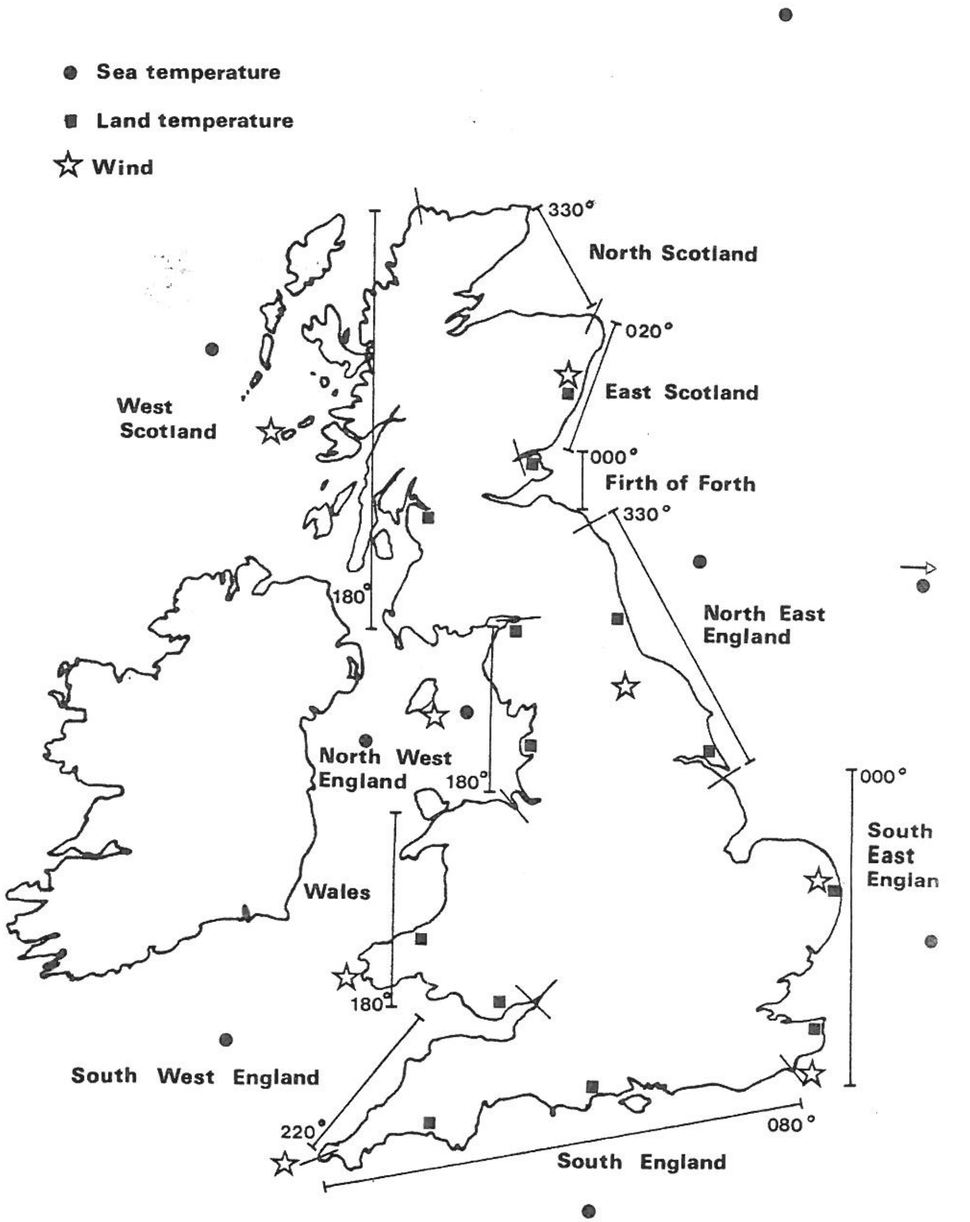
The stage of tidal cycle was not taken into account in the timing of the surveys (cf. Hope Jones 1980) although the fifteen day period included at least one spring tide. The influence of the tidal cycle on finding rates is not known, but it is only likely to have an effect on beaches where strand lines are widely spaced and there is sufficient debris to obscure corpses.

Corpses of some species, e.g. gulls, appear to disintegrate more quickly than those of others, e.g. divers and auks (Hope Jones 1980). It has been suggested that a heavily oiled corpse is less prone to removal or destruction by predators (Bourne 1976). However, gulls are capable of feeding on such corpses. The numbers of corpses removed by predators (birds and mammals including man) is not known in general, but results of some experimental work are discussed later and in Appendix B7. There is presumably a bias towards the finding of larger corpses since these are more conspicuous, and may be less prone to removal by predators or burial by debris. Counts of corpses on beaches are clearly underestimates of the numbers that had beached (see Appendix B7) and there may be some regional variation. No distinction has been attempted between the numbers of birds found dead from oil pollution and those oiled after death. Some experimental evidence is discussed later. However, I have no evidence to suggest that any of these influences have changed since 1971 in any systematic way that would invalidate comparison of the results over the period.

Where a card indicated there was oil on the beach, the precise length polluted was not recorded. Consequently any method of analysis of the beach pollution recorded by the survey is open to bias by cards which refer to above - or below - average distances. This was not considered a serious difficulty, except in NW England and the Channel Islands where data were not analysed because, on occasions, single cards were returned for 242 km and 41 km of beach respectively.

The survey aims to cover a sample of beaches. However, in several years all available beaches were surveyed in some counties (e.g. Isle of Wight, Cumbria) and very few in others (e.g. Western Isles). To be statistically representative, survey beaches need to be randomly distributed. This has not been the case, but to attempt to provide a reasonable sample of beaches the analysis has been carried out at a regional level (Fig. 1).

Figure 2 Weather sample stations and bearings of the lines of coast assigned to each region. For the examination of the effects of weather the S England/SW England regional division was positioned at Lands End (cf. Fig 1).



(c) Preparation and analysis.

Data were analysed, using computer programs prepared by Cambridge Interactive Systems Ltd. (CIS), initially on the CIS computer at Cambridge and then from May 1981 at RSPB, Sandy, and at Rothamsted Experimental Station, Harpenden. At the start of the investigation into the effects of weather (autumn 1980), the wind data for 1980 were not available from the Meteorological Office and counts for 1980/81 have not been placed on computer. As a result the main analysis does not include data for 1980 or 1981.

Over 18,000 record cards were received for counts between September 1971 and December 1979. Count results were examined by regions (Fig. 1). Details of regional boundaries are given in Appendix B4.

Most species were examined by family group, except Fulmar which was combined with other members of its order, and Kittiwake Rissa tridactyla which was examined separately because of its more pelagic distribution compared with the common Larus gulls. Wildfowl were divided into two groups: (a) seaducks (comprising Scaup Aythya marila, Eider Somateria mollissima, scoters Melanitta spp., Goldeneye Bucephala clangula, Long-tailed duck Clangula hyemalis and sawbills Mergus spp.) and (b) other wildfowl. Coot Fulica atra and Moorhen Gallinula chloropus were also included in this category.

Totals of slightly and heavily oiled birds were added to give numbers of oiled birds. Counts of wings were not examined. Because of the small numbers of some species, it was considered appropriate to calculate regional proportions of oiled birds and densities as (total oiled corpses x 100)/total corpses, and total birds/distance covered respectively. Proportions were not used where a total of less than 50 birds had been found in the period. Densities were not normally distributed, so for statistical tests logarithmic values (base e) were used to correct this. Small values (0.001 birds/km) were substitued for any zeros. Proportions of oiled beaches were calculated by dividing the length of all beaches where oil was found by the total distance walked in the region. Attention should be drawn to the possibility that some results of statistical tests may be spurious where the tests were repeated many times, as was necessary with the volume of data.

The densities were examined to determine whether an oil spillage known to have killed birds (Andrews & Standring 1979) or another identified mortality incident, such as a botulism outbreak (Lloyd et al. 1976, Macdonald & Standring 1978), coincided with an abnormally high value. Such values were excluded on these occasions, although this may not have fully removed the effect of an incident since corpses may have continued to come ashore for several weeks after incident surveys had ceased. The densities affected were those of auks in NW England in January 1974 (weather wreck, Lloyd et al. 1974) and NE England in February 1978 (oil spillage, Stowe 1979a), and Manx Shearwaters Puffinus puffinus in Pembrokeshire in September 1974 (oil spillage, RSPB unpublished data). Density values were also excluded on occasions where the sample of beaches walked was unusually small (less than 25% of average monthly distance). Only for Larus gulls and auks were sufficient numbers of birds found to allow a detailed regional examination.

The examination of the effects of weather was also limited to two species groups: Larus gulls, and the larger auks, comprising Razorbill Alca torda and Guillemot Uria aalge. These groups were chosen because they included the most numerous beached bird species and also because of the contrast in the habitats they frequent; healthy auks not normally being found on beaches. The regional divisions (Appendix B4) were altered slightly for this section of the analysis. The south facing section of coast of the SW England region was included in S England region since it was of similar aspect to the rest of that coast. Data for the Channel Islands and Northern Ireland were excluded since too few birds were found. In addition to the exclusions already mentioned, density values were also excluded for individual beaches where wind data from the appropriate meteorological station were not available. For purposes of clarity further details on the methods of investigation are given with results in Section 5.

Trends and patterns in densities were examined by regression and analyses of variance. Trends in the proportions oiled were examined by the test for linear trend in proportion (Snedecor & Cochran 1967), except where stated (see Results, section 5). A significance level of $P < 0.05$ was used in all tests. Preliminary examination of the data had shown calculations in some months to be disproportionately influenced by one or two values and results were not particularly consistent. To overcome these difficulties data were combined for September and November (autumn) and for January, February and March (winter). It was not considered appropriate to combine all five months because of differences in densities and proportions oiled between autumn and winter (see later). Differences between the combined months were subsequently examined.

2. Mortality incidents

When a mortality incident was suspected or confirmed, survey volunteers were asked to search the appropriate beaches. RSPB and NCC staff assisted, especially during weekdays when many volunteers were not available. The findings of these surveys were collated at RSPB, Sandy. In presenting the information, an arbitrary distinction was made between small kills and 'background mortality', and those kills involving a total of more than 50 birds. The total may comprise dead or captured live oiled birds of all species, and also live but free oiled divers, grebes and auks. Care was taken to avoid duplicate counts, or counts of live birds which subsequently may have been found dead. The last category, live but free, was included since the chances of recovery of these species was thought to be poor. However, slightly oiled auks have been recorded successfully removing small quantities of oil from their plumage (Birkhead et al. 1973). In contrast, live but free oiled birds of some species not included may subsequently have perished from the toxic effects of oil ingested during preening.

The geographical extent and the duration of a pollution incident have not been defined because of the difficulties inherent in so doing. Since 1975, chemical analyses of oil samples have been undertaken by the Laboratory of the Government Chemist on behalf of RSPB to attempt to provide better evidence of the extent of some incidents. This has been successful but results have frequently revealed the additional occurrence of other oils in the vicinity of a known pollution source, e.g. the wreck of the Amoco Cadiz in 1978, presumably because other vessels have discharged oil hoping to pass undetected (Stowe 1979a). Consequently, the effects of a publicised spillage have been difficult to separate from the effects of other discharges which followed as a direct consequence. The extent and

duration of each incident has thus been assessed on the information available at the time.

3. International Beached Bird Surveys

Single counts similar to those in Britain were made in up to eight other European countries in late February or early March each year. The number of countries participating each year has varied, but only in recent years have data been received from Norway and Spain. In some years insufficient information was received to calculate the proportions of birds oiled or densities and these counts have been excluded from the analysis where appropriate.

Results

1. Cover

Forty-two systematic counts were made in the United Kingdom and Channel Islands between September 1971 and December 1979, covering a total of 80,013.8 km. For each count between 400 and 500 cards were returned giving an average national total of 1905 km. The approximate extent of cover and average regional monthly distances are given in Figure 1. Regional distances surveyed have differed between months (Appendix B3) and years but the national total for the five counts has changed little after the first year (Table 1).

Table 1. Total distances (km) covered per season during the systematic Beached Bird Surveys, September 1971 - December 1979.

71/2	72/3	73/4	74/5	75/6	76/7	77/8	78/9	79 2 cts.	Total
6998.2	9225.3	8630.2	10098.9	10321.9	10000.2	9526.7	11079.4	4133.0	80013.8

2. Densities of corpses

(a) Species occurrence

The most numerous species found on the survey are given in Table 2, and the numbers of the different species groups in Table 3. The numbers of individual species in the species groups can be determined from Tables 2 and 3, e.g. Fulmars Fulmarus glacialis comprise c.95% of the group Procellariiformes.

Table 2. The 25 most numerous species recorded on the Beached Bird Survey from September 1971 to December 1979 and the proportions found oiled. Data are from five counts per annum for Britain (excl. Orkney and Shetland), Northern Ireland, Isle of Man and Channel Islands. Counts were excluded where specific mortality incidents appeared to have increased the numbers of birds found (see text).

Total distance surveyed 80,013.8 km.

	Species	Total dead	% oiled
1.	Herring Gull Larus argentatus	9850	8.9
2.	Guillemot Uria aalge	8415	58.3
3.	Black-headed Gull Larus ridibundus	3749	8.7
4.	Razorbill Alca torda	3055	60.8
5.	Common Gull Larus canus	2233	11.0
6.	Greater Black-backed Gull Larus marinus	2053	10.3
7.	Oystercatcher Haematopus ostralegus	1815	14.6
8.	Kittiwake Rissa tridactyla	1785	18.1
9.	Fulmar Fulmarus glacialis	1461	12.9
10.	Cormorant Phalacrocorax carbo	1305	16.9
11.	Gannet Sula bassana	1289	29.1
12.	Shag Phalacrocorax aristotelis	1121	15.4
13.	Eider Somateria mollissima	735	26.9
14.	Redshank Tringa totanus	698	4.0
15.	Common Scoter Melanitta nigra	688	50.7
16.	Curlew Numenius arquata	528	1.9
17.	Lesser Black-backed Gull Larus fuscus	526	8.9
18.	Shelduck Tadorna tadorna	508	5.7
19.	Pink-footed Goose Anser brachyrhynchus	402	1.0
20.	Dunlin Calidris alpina	309	3.6
21.	Mallard Anas platyrhynchos	303	4.6
22.	Red-throated Diver Gavia stellata	283	66.8
23.	Pufin Fratercula arctica	279	47.0
24.	Wigeon Anas penelope	252	4.0
25.	Greylag Goose Anser anser	242	1.7

Table 3 Monthly total of beached birds for each species group, ranked by overall proportions that were oiled.

	September		November		January		February		March		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
Divers	9		12		107	62.6	182	66.5	83	67.5	393	64.4
Auks	965	33.7	1331	49.4	2880	59.1	4421	64.7	2441	58.1	12029	57.9
Grebes	33		21		47		111	45.0	44		256	45.7
Seaduck	476	21.8	180	21.1	140	32.1	230	37.0	263	39.2	1289	29.1
Kittiwake	310	4.5	160	13.8	238	22.7	640	20.9	437	22.7	1785	18.1
Cormorant/ Shag	357	9.2	405	8.1	498	20.3	739	18.7	431	20.6	2430	16.2
Procellariiformes	438	7.8	155	8.4	156	15.4	428	18.7	363	14.9	1540	13.3
Larus gulls	4944	7.3	3374	4.9	3414	10.9	4820	12.9	3070	11.2	19622	9.5
Other wildfowl	175	4.6	438	1.1	550	5.6	835	8.4	377	8.0	2375	6.1
Waders	520	2.7	552	2.0	761	4.7	1322	4.9	736	3.5	3891	3.9
Total distances(km)	16221.7		17803.5		15381.7		17530.8		12076.1		80013.8	

The species composition for different regions is shown in Figure 3. Larus gulls were the most numerous species except in two regions, NE England and SW England, where auks were more numerous. A total of 142 species of birds was found during the systematic surveys between 1971 and 1979. Amongst these were three species of divers, five species of grebes, five species of Procellariiformes including Little Shearwater Puffinus assimilis, 22 species of waders, nine species of gulls including Sabines Gull Larus sabini, six species of auks including Brunnich's Guillemot Uria lomvia and 55 species of landbirds including diurnal birds of prey (six spp.) and owls (four spp.).

(b) Regional variation

The mean regional densities for all species groups in February (the month with the highest densities of birds - see below) are shown in Figure 4. Densities of most species were generally higher in the east coast regions than in the west. The highest densities in six of the 10 species groups in February were recorded in E Scotland, and for auks the density was nearly twice that of any other region.

Many of the wildfowl recorded may have been shot, and densities may thus be influenced by the frequency of wildfowling. The wader densities partly reflect the extent in surveys in major estuaries, e.g. no surveys were made in the Severn estuary.

Corpse densities for some species, notably divers, grebes and Gannets Sula bassana were exceptionally low (often less than one corpse per 100 km), and the beaching of a few extra corpses of these species may have disproportionately influenced results. The comparatively high densities of divers found in SE England presumably reflect the numbers believed to winter off that coast (Seago 1980).

(c) Seasonal variation

The densities of corpses of several species groups were highest in winter e.g. divers and grebes, Cormorant Phalacrocorax carbo and Shag

Figure 3 Species composition of beached bird corpses 1971-79.

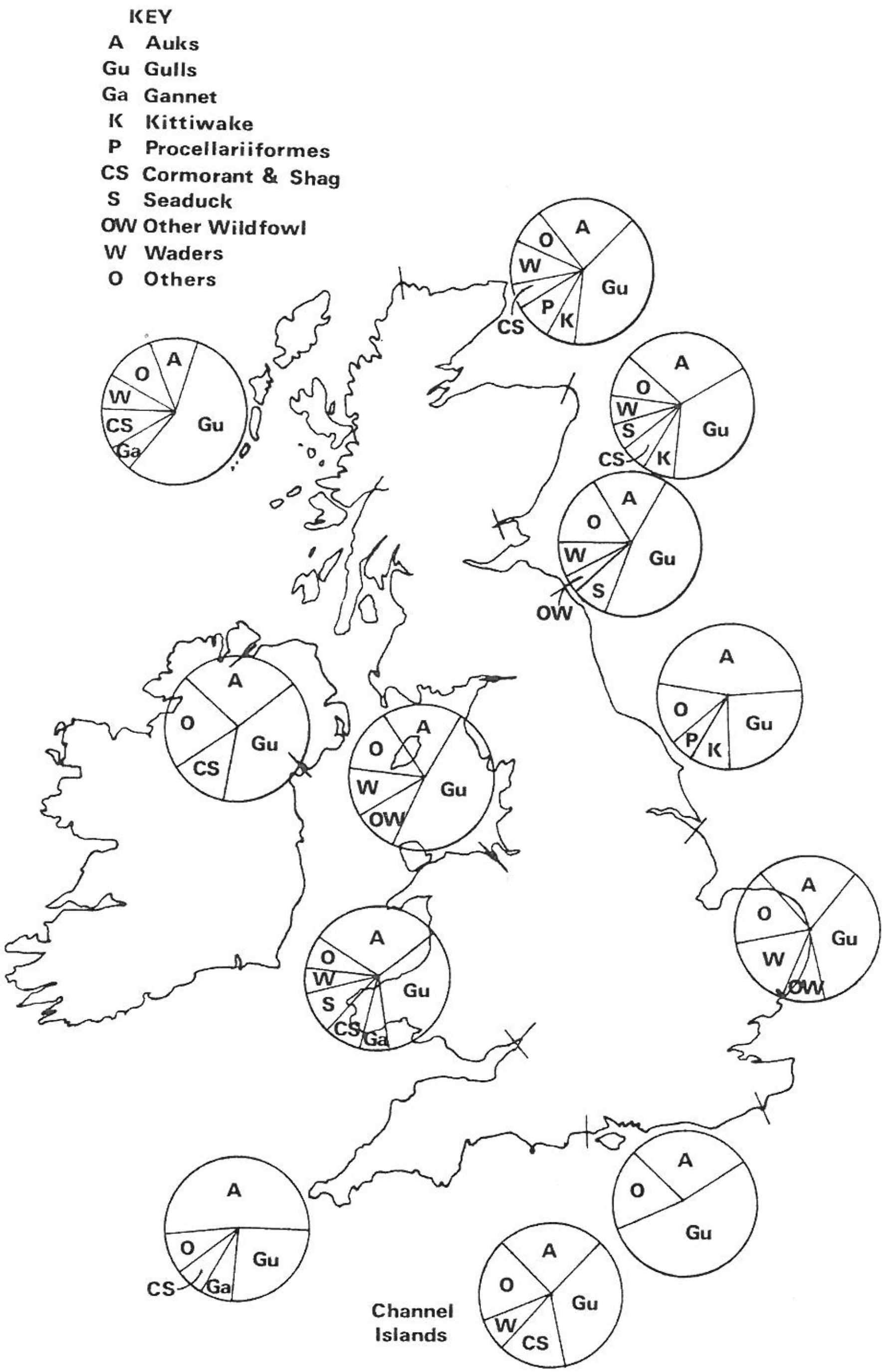


Figure 4 Regional mean February densities of beached bird corpses of different species groups 1972-79.

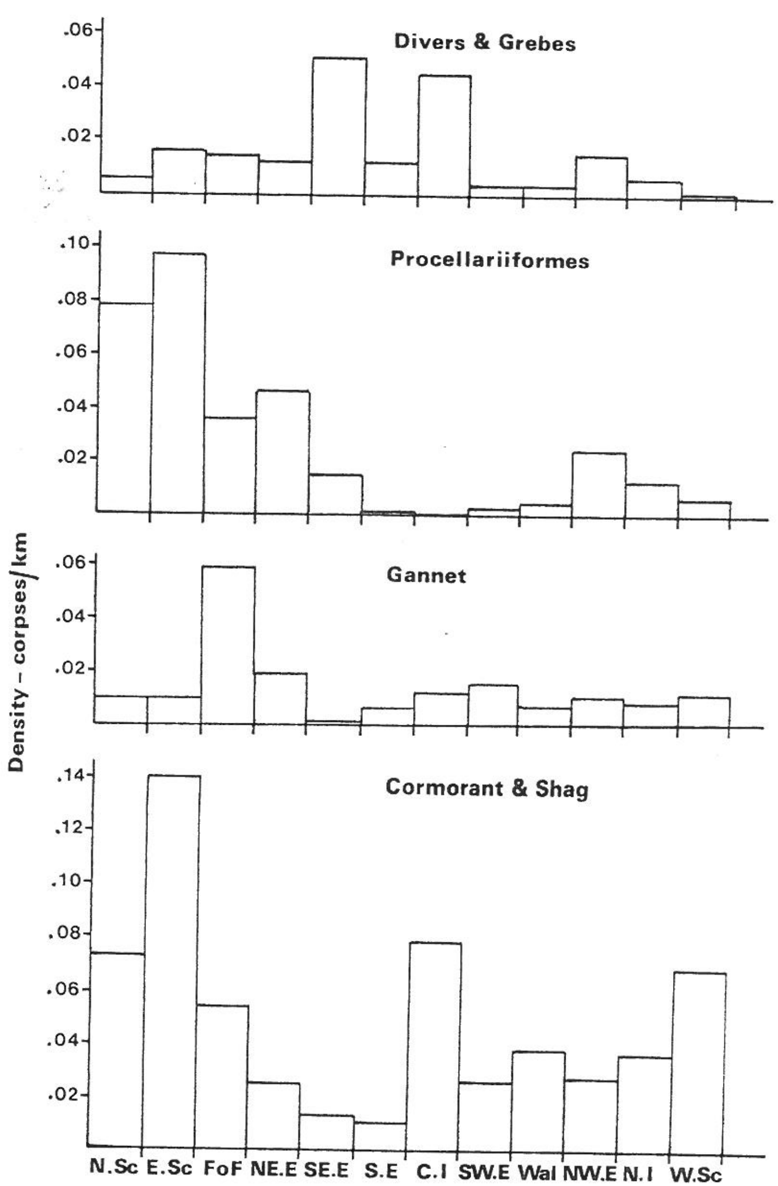
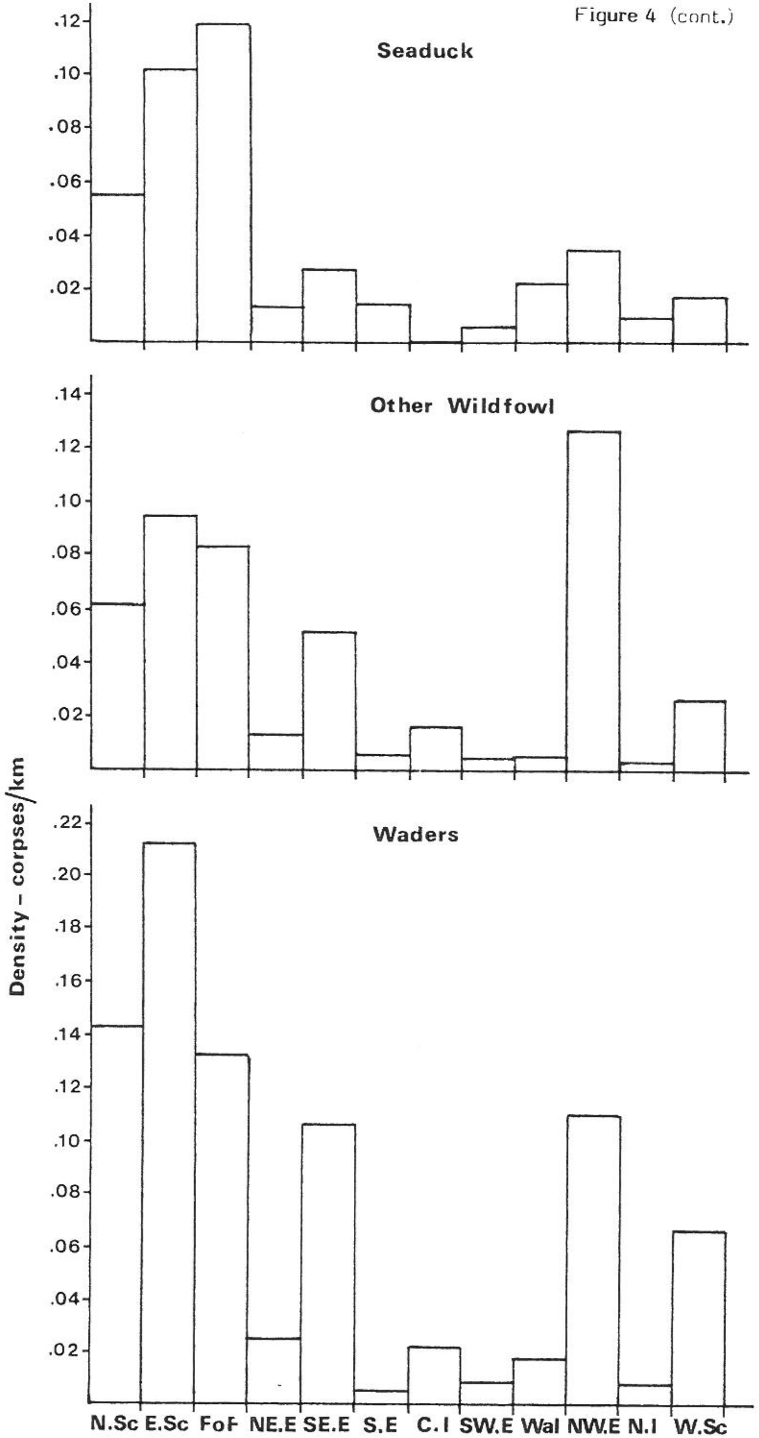


Figure 4 (cont.)



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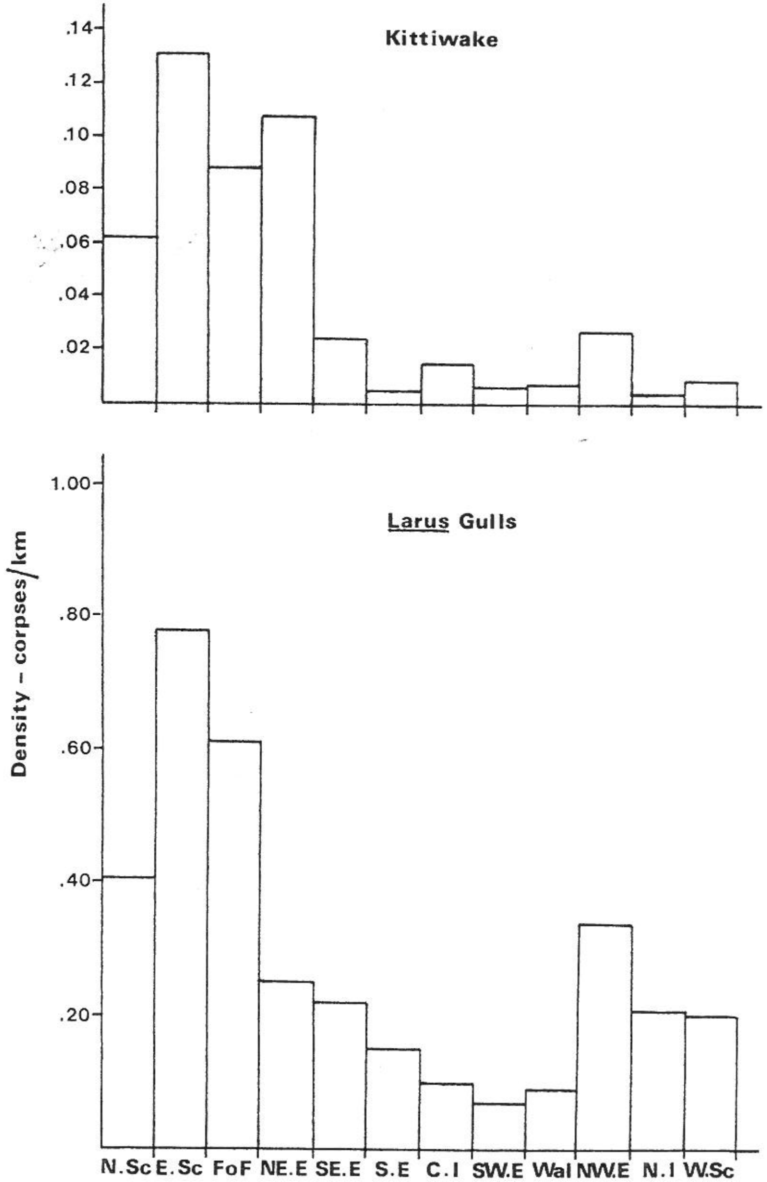

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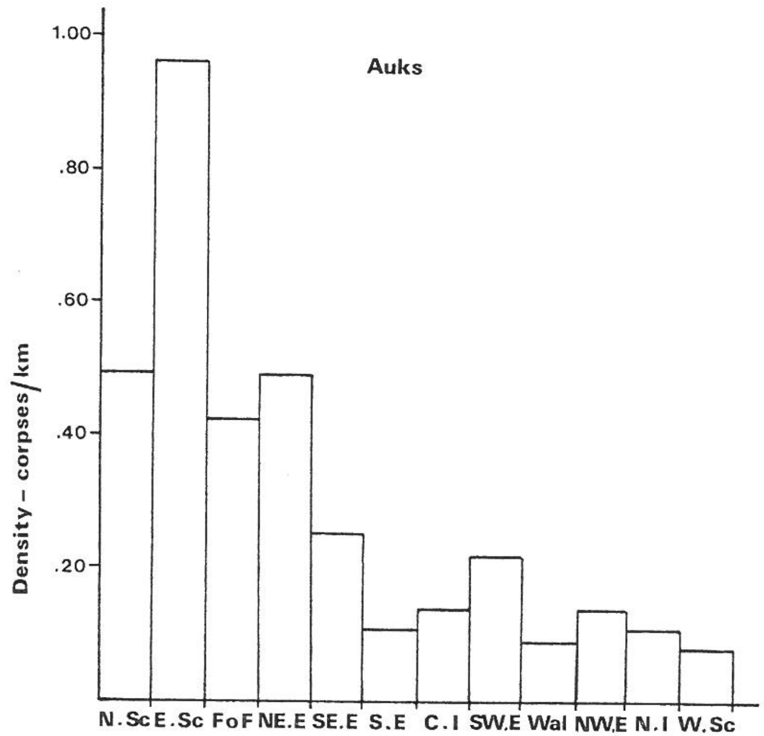


P.aristotelis, seaducks, other wildfowl, waders and auks (Fig. 5), whilst other species whose migration patterns differ from the first group show the highest densities of corpses in September and March (Procellariiformes and Gannet). Kittiwake and Larus gulls show a combination of both patterns. The high densities in September were presumably caused by juvenile mortality, but information on the age of corpses was not collected. Overall, and for six of the 10 species groups, the greatest densities were found in February, the month generally experiencing the most severe winter weather.

Seasonal patterns were examined by region for Larus gulls and auks. For Larus gulls, statistically significant regional patterns were only found in N Scotland, E Scotland and NE England. Patterns for the last two regions were similar to the national pattern (Fig. 5) except that the February peak exceeded the September one. In N Scotland a high average density was recorded in September (0.9 corpses/km) whilst lower densities (0.4 corpses/km) were recorded for all other months. For auks, there was significant variation between the five months in all regions, except W Scotland where the seasonal pattern showed little change in average density, and the density in all months was less than 0.1 corpses/km. In all other regions the regional pattern was similar to the national pattern (Fig. 5).

3. Proportions of birds found oiled

(a) Species variation

Divers, grebes and auks show the highest proportions of bird corpses found oiled (Table 3), presumably because they spend most of their time on the surface of the sea and are thus particularly vulnerable to floating oil. More aerial species, e.g. Procellariiformes and Kittiwake, show lower proportions, whilst waders which are generally unlikely to come into contact with floating oil show the lowest proportions. The high proportion of Gannets found oiled in comparison with Cormorants and Shags may partly be caused by oil being more readily detectable on the adult Gannets' white plumage.

Figure 5 National mean monthly densities of beached bird corpses of different species groups 1971-79.

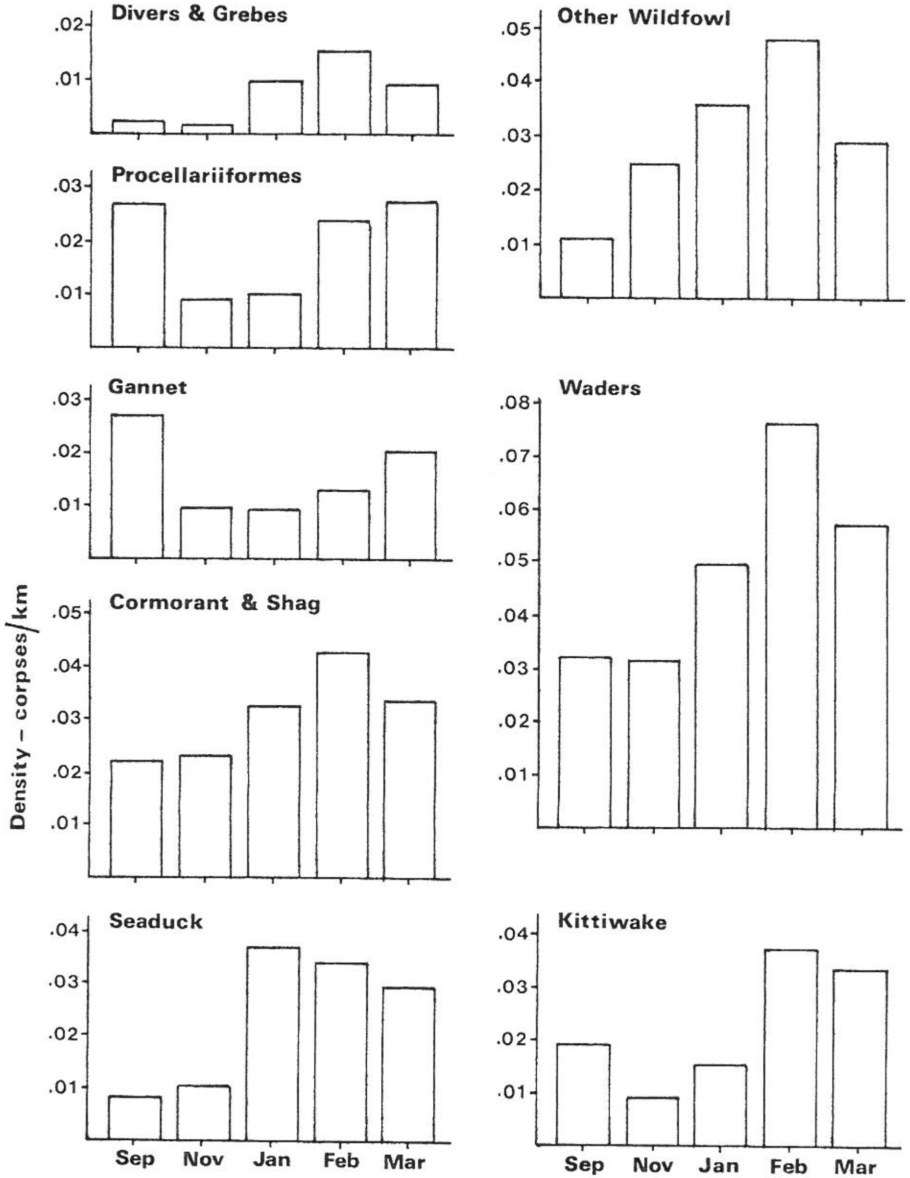


Figure 5 (cont.)

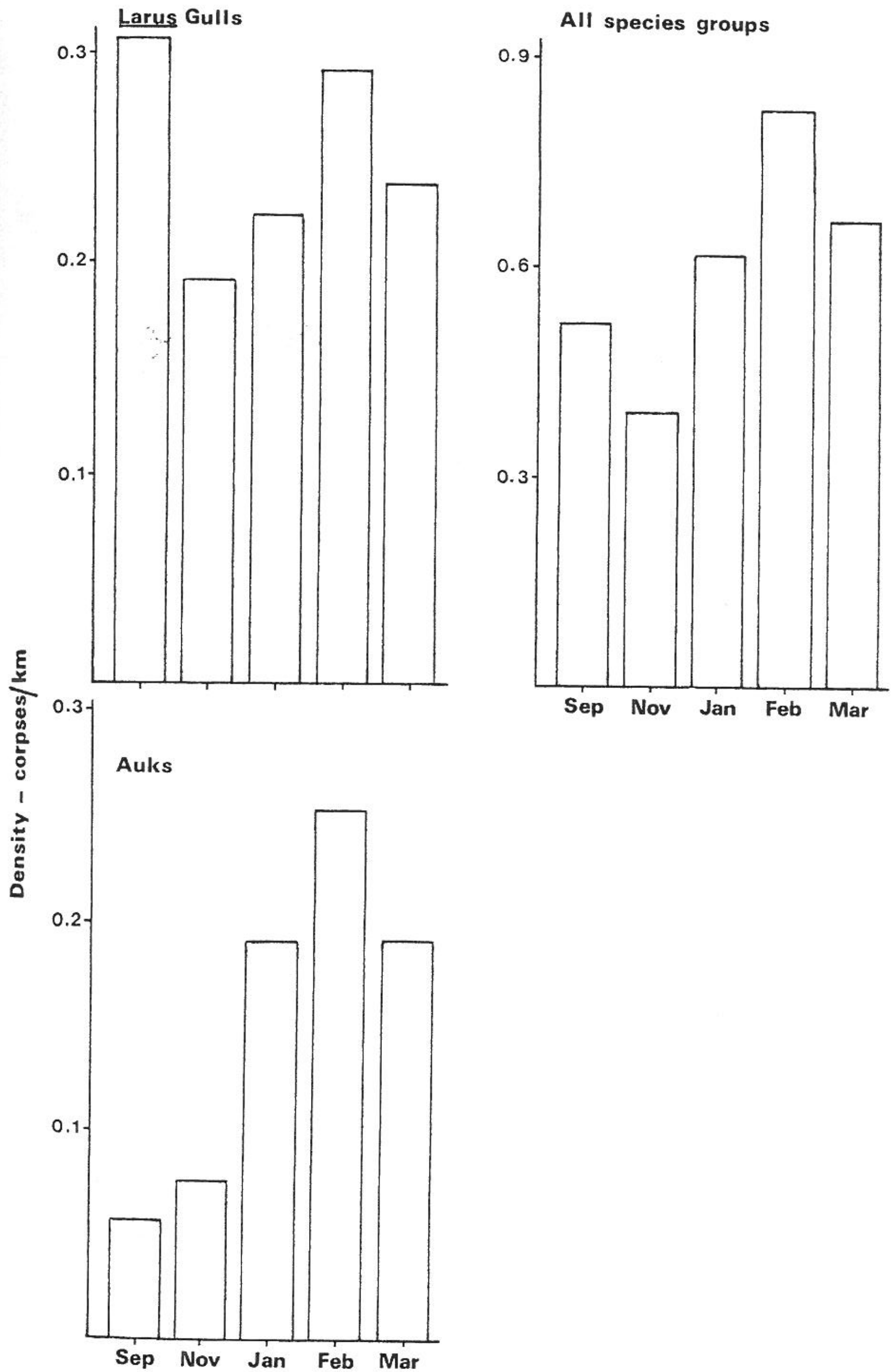
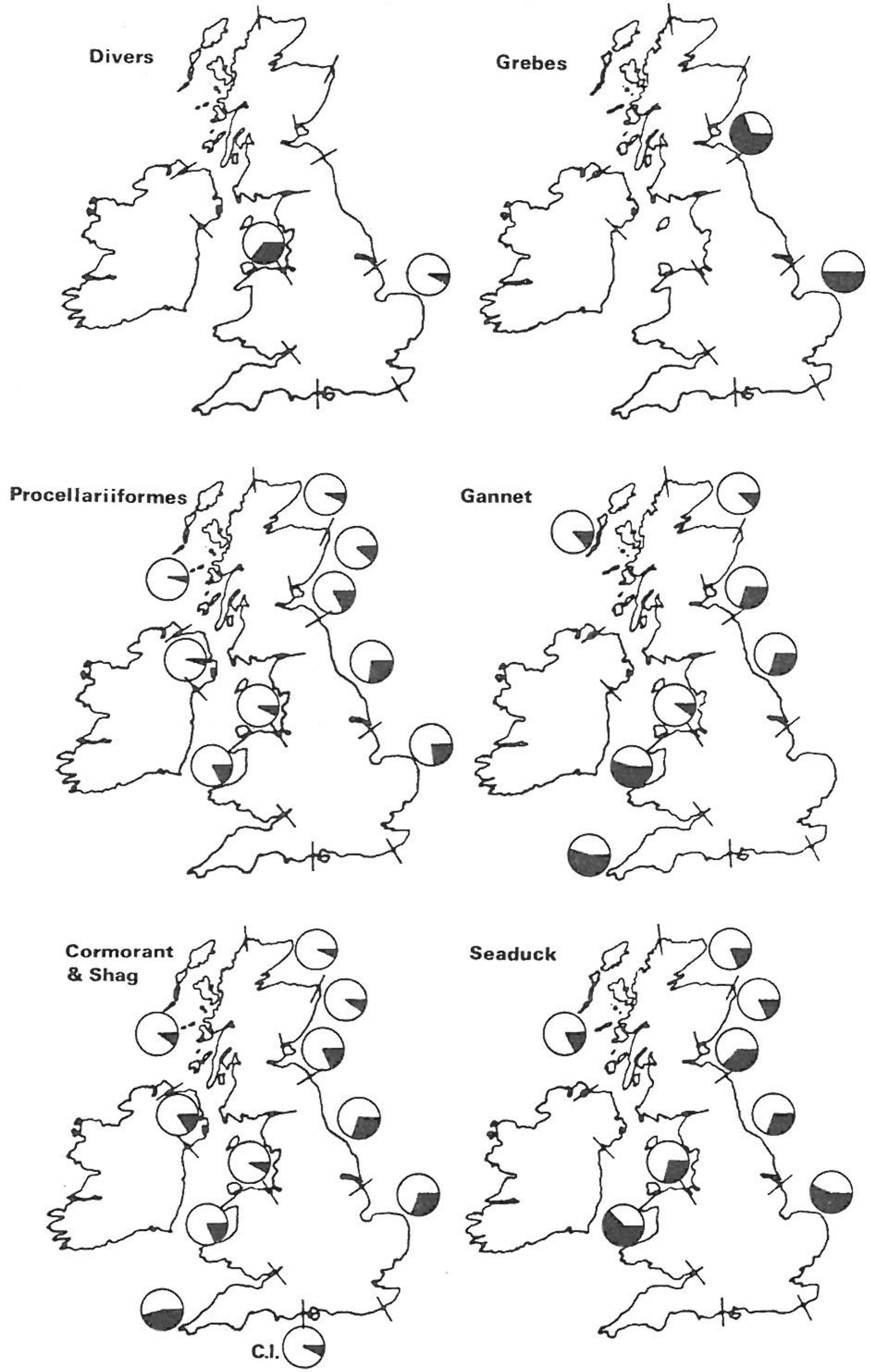


Figure 6 Regional mean proportions of beached bird corpses of different species groups found oiled 1971-79. Proportions are not shown for regions where fewer than 50 corpses were found.



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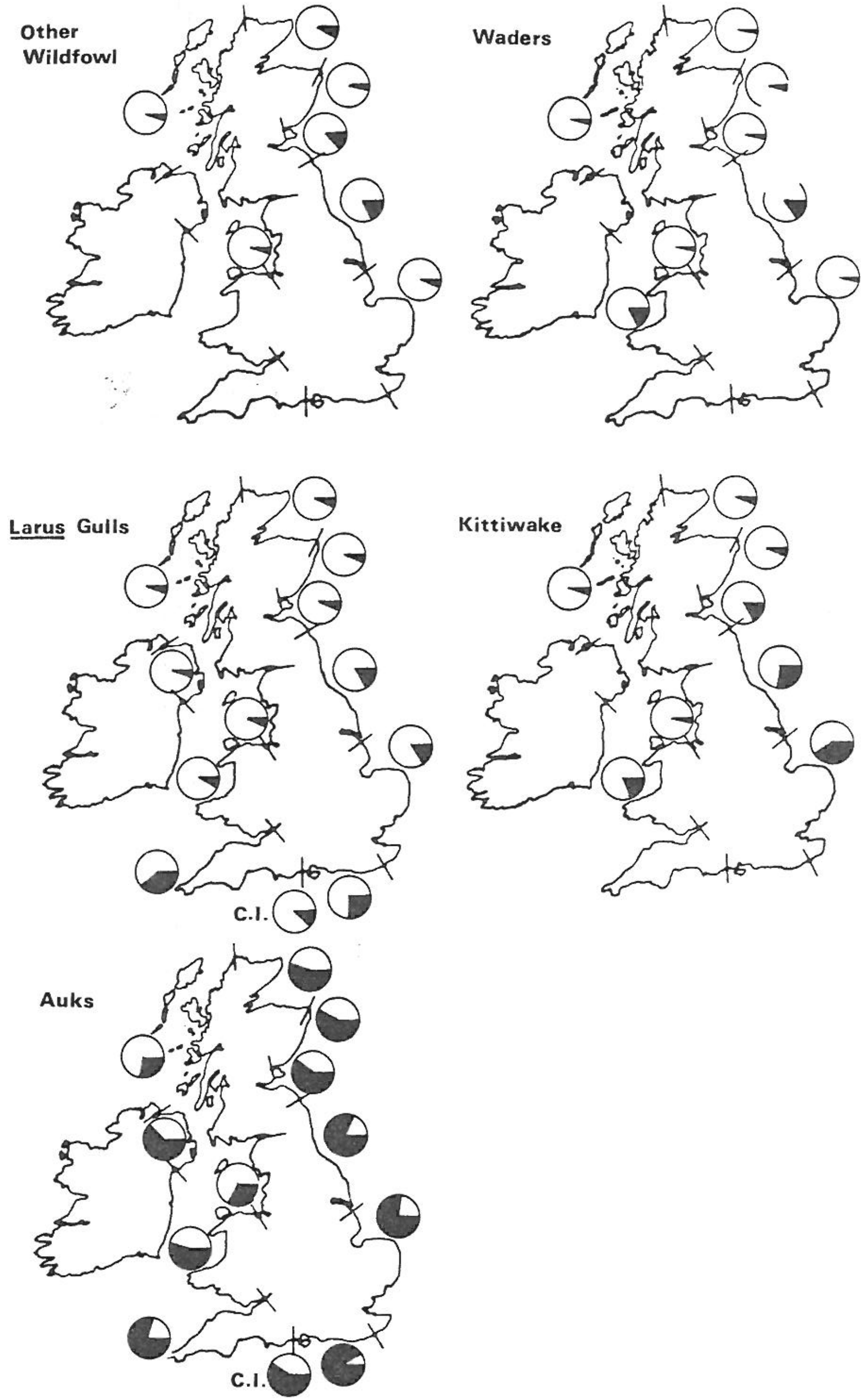


The most numerous species (Table 2) generally show similar proportions oiled to other members of their respective groups although Puffins Fratercula arctica are less frequently found oiled than Guillemots ($X^2 = 13.8$, $P < 0.005$). Scoters are much more frequently found oiled than Eiders ($X^2 = 83.5$, $P < 0.005$), perhaps because scoters are more frequently found in southern waters where oil pollution, as determined by the proportion of other birds oiled, appears more common (see below).

(b) Regional variation

The overall regional proportions of birds found oiled are shown for all species groups in Figure 6. Results are excluded for regions where fewer than 50 birds were found. The highest proportions for most species occurred between SW and NE England inclusive, the regions which border the busiest shipping lanes.

Proportions of auks oiled in these regions ranged from 77.2% to 89.9% and only in two regions, W Scotland and NW England, was the proportion less than 50%. Northern Ireland shows a notably higher proportion oiled than the nearest regions in England and Scotland. For Larus gulls the highest proportion was 39.9% (SW England) whilst in other west coast regions and N and E Scotland the proportions were less than 10%.

(c) Seasonal variation

For all species groups the national proportions of oiled birds (Fig. 7) were higher in winter (January, February, and March) than in autumn (September and November). Over the two autumn months, seaduck, Kittiwake and auks showed increases in their respective proportions oiled whilst other species showed only slight changes. Fewer than 50 divers were found in September and November, hence proportions are not displayed. Regional examination showed there was generally little variation between regions in the seasonal pattern of oiling for Larus gulls although the February peak in SE England was more marked than in the national pattern. For auks all regions showed patterns similar to the national pattern (Fig. 7).

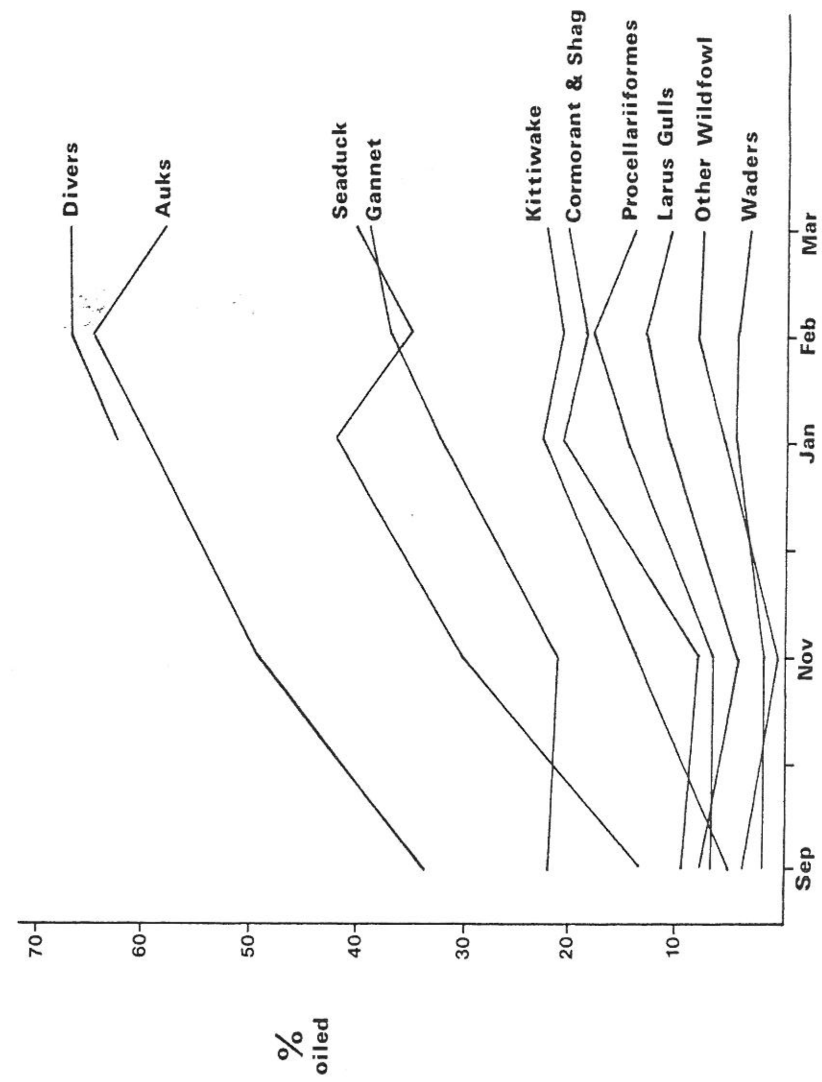


Figure 7 National mean monthly proportions of beached bird corpses of different species groups found oiled 1971-79. Proportions are not shown where fewer than 50 corpses were found.

4. Proportion of beaches oiled

(a) Regional variation

The highest proportions of beaches recorded oiled were in SW and S England (Fig. 8). In contrast to the regional pattern for oiled auks (Fig. 6) and several other species groups, there was general similarity between overall proportions oiled on the east and west coasts, at least south of Scotland. However, in February alone there was evidence of an east-west coast difference (Table 4). As with all the species groups the proportions generally decreased with increasing latitude.

(b) Seasonal variation

The national pattern (excluding data for the Channel Islands and NW England) showed that the highest proportions of beaches oiled were found in February (Fig. 9). Similar patterns were found for beaches at a regional level, except that the proportion for Northern Ireland was highest in January and for E Scotland and S England in March. In comparison to bird corpses the pattern of beach oiling most resembles that for Larus gulls (Fig. 7).

5. Relationship between densities and the proportions oiled, and weather

(a) Selection of parameters

Wind and temperature were considered the most relevant weather variables. Since several measures of both were available, investigations were initially carried out to determine which were most suitable. For the purposes of clarity, the methods of investigations of each parameter are presented here.

(i) Wind. Several measures of wind were examined. An onshore wind vector measuring the average strength of the wind at 90° to the bearing of the line of coast (Fig. 2) was calculated for each beach for periods between three and 30 consecutive days before the date on which it was

Figure 8 Regional mean proportions of beaches recorded oiled 1971-79. Proportions for the Channel Islands and NW England are not shown for reasons given in the text.

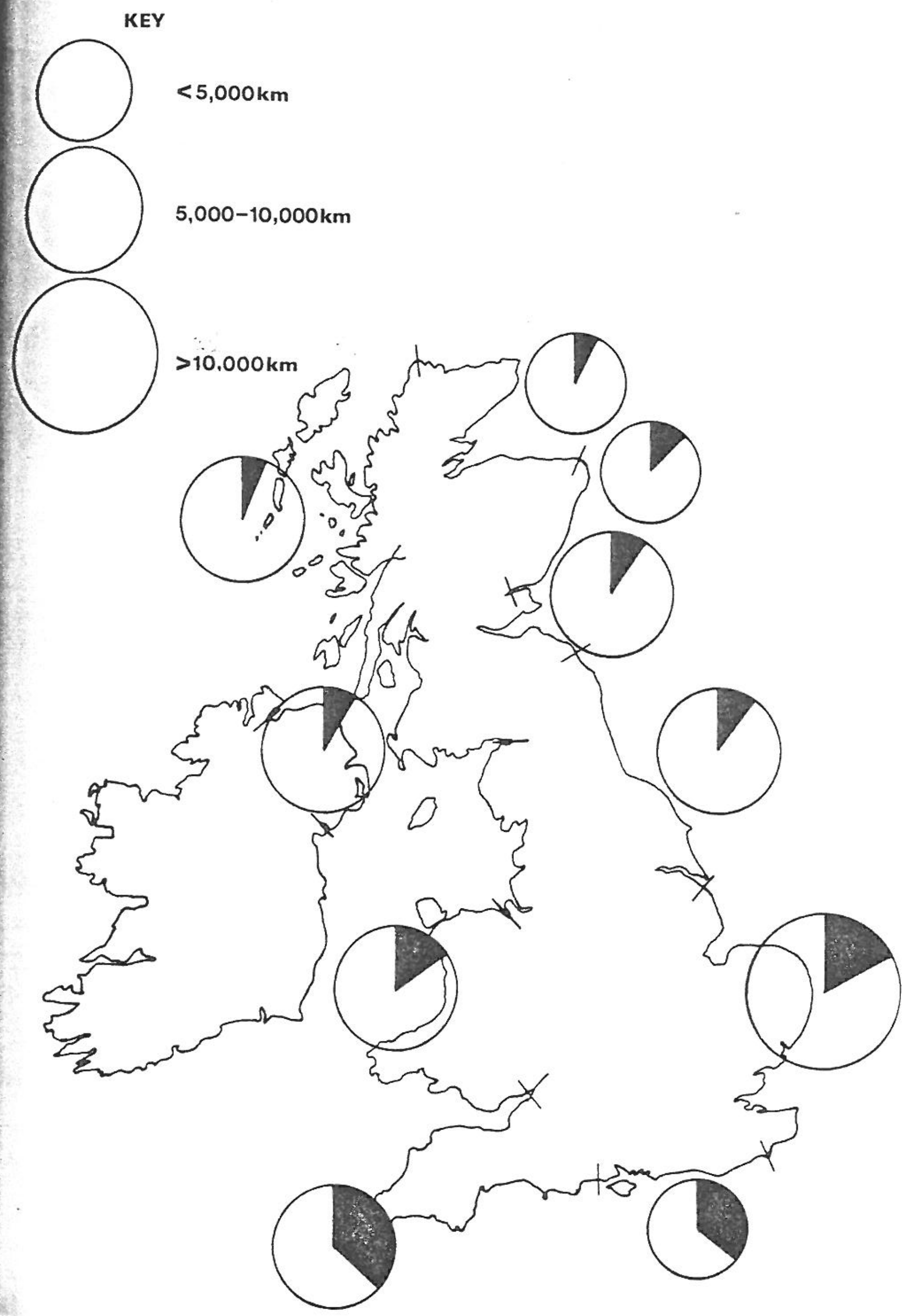
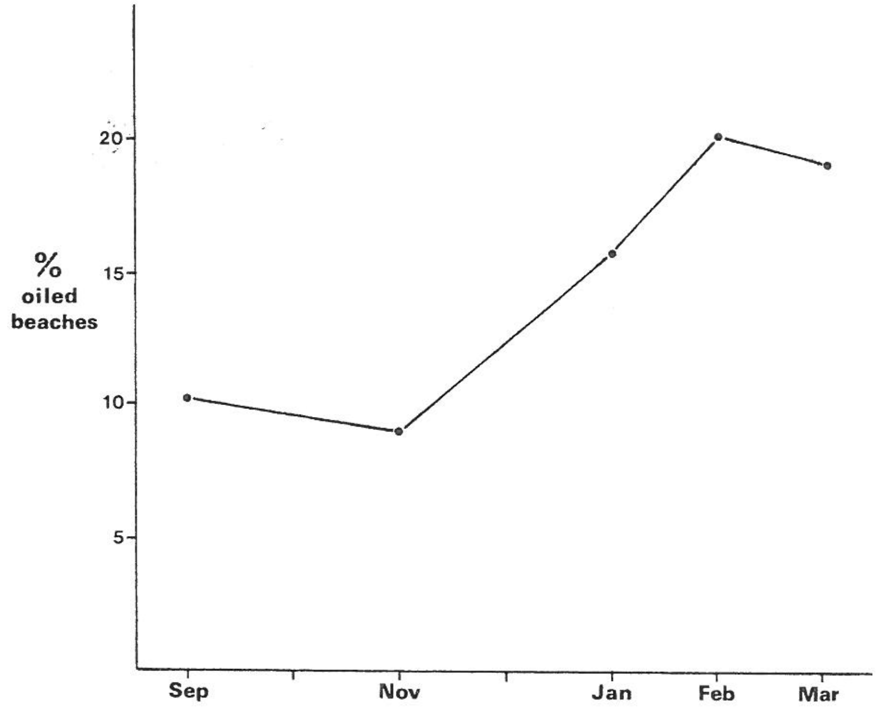


Table 4. East coast - west coast variation in the regional proportion of beaches recorded oiled in February (cf. fig. 8). Results for the Channel Islands and North West England are excluded for reasons given in the text.

	West coast			East coast	
	%	km		%	km
			North Scotland	10.1	914.7
West Scotland	8.1	2260.8	East Scotland	14.2	850.1
Northern Ireland	8.7	870.0	Firth of Forth	13.0	1329.4
North West England	-	-	North East England	15.5	1546.6
Wales	18.6	1700.4	South East England	29.0	2684.8
South West England	47.3	1234.2	South England	35.5	962.3

Figure 9 National mean monthly proportions of beaches recorded oiled 1971-79.



surveyed. Since beaches were surveyed on different dates within the survey period, the mean vector of all beaches within a month and region was calculated. Then, for each species group, the correlations were calculated between log density and wind strengths.

For Larus gulls, a 12 day period before the date of the survey produced the greatest number of regions in both autumn and winter with significant correlation coefficients (Fig. 10), while for the larger auks the best period was 15 days (Fig. 11). Only in two of 40 sets of analyses, both involving auks densities were significant correlations obtained only at other periods (SE England in autumn, 21 days; SW England in winter, three days).

Since the bearing of the line of coast was assigned by eye and may not have been the most appropriate, the bearing was altered in units of 10°, up to 90°, in either direction and new wind vectors calculated for each angle.

Correlations between these vectors and corpse densities showed improvement in some regions (Fig. 12). However, results were only considered reasonably consistent in one region, E Scotland, where wind from the north east was better correlated with density than wind directly onshore (east south-east). Overall onshore wind, as initially described, was considered preferable to wind from other angles.

To investigate the effect of longshore wind, the daily wind speeds parallel to the line of coast were summed, ignoring the direction of the wind, to measure the total displacement.

Most correlations were lower than those for onshore wind (Fig 13). Only four results were significant (3 positive, 1 negative) and two of these were for E Scotland, the region where densities were better correlated with winds not directly onshore. Hence, longshore wind was not considered further.

Finally, vectors were calculated with the first one to 10 consecutive days omitted from the period over which the calculations had been made to check whether 'recent' winds were too recent to have had an effect by the time of the counts.

Figure 10 Coefficients of correlation between regional densities of gulls in autumn and in winter and periods of onshore wind of 3 to 24 days duration. Coefficients are shown for every third day.

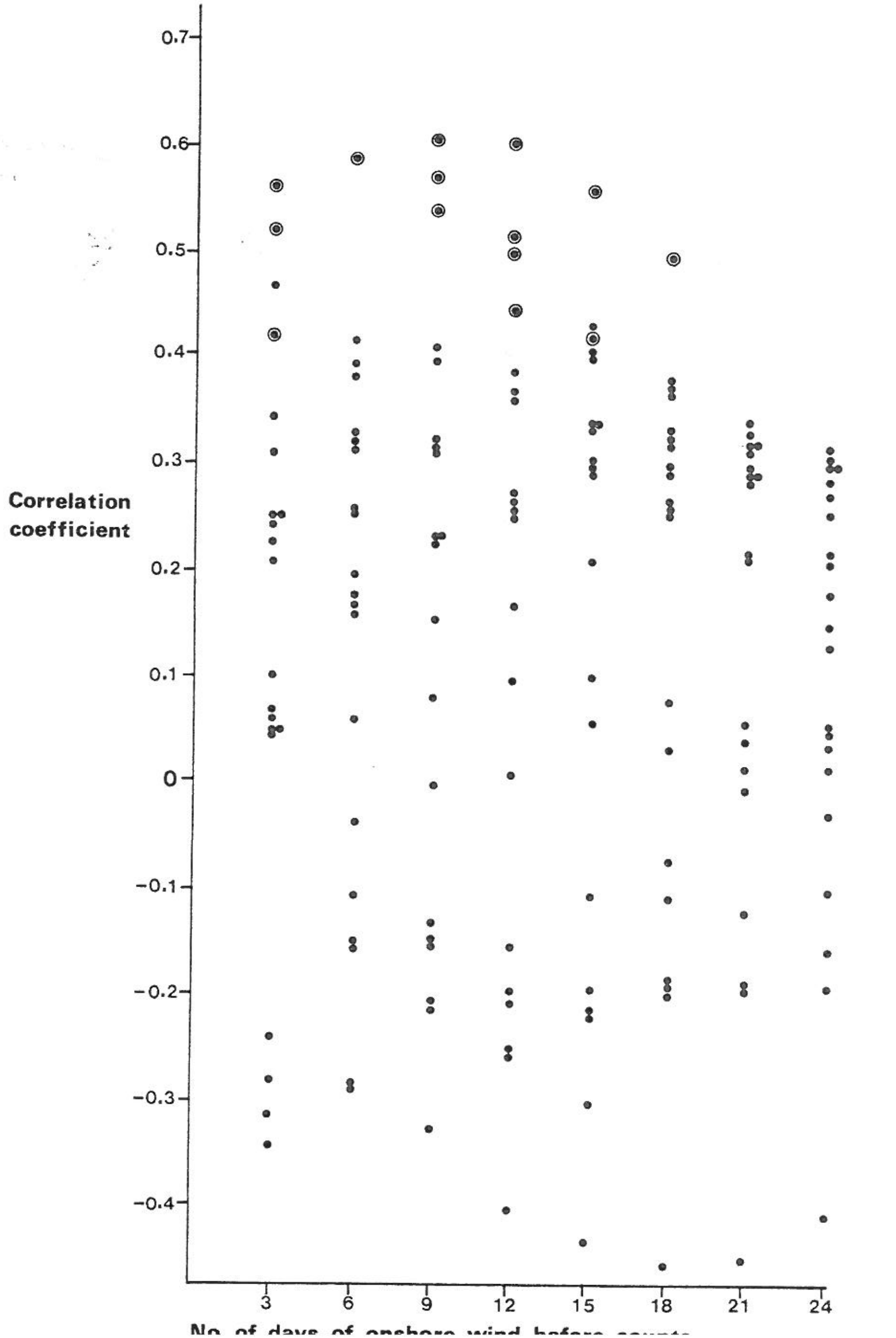


Figure 11 Coefficients of correlation between regional densities of auks in autumn and winter and periods of onshore wind of up to 3 to 24 days duration. Coefficients are shown for every third day.

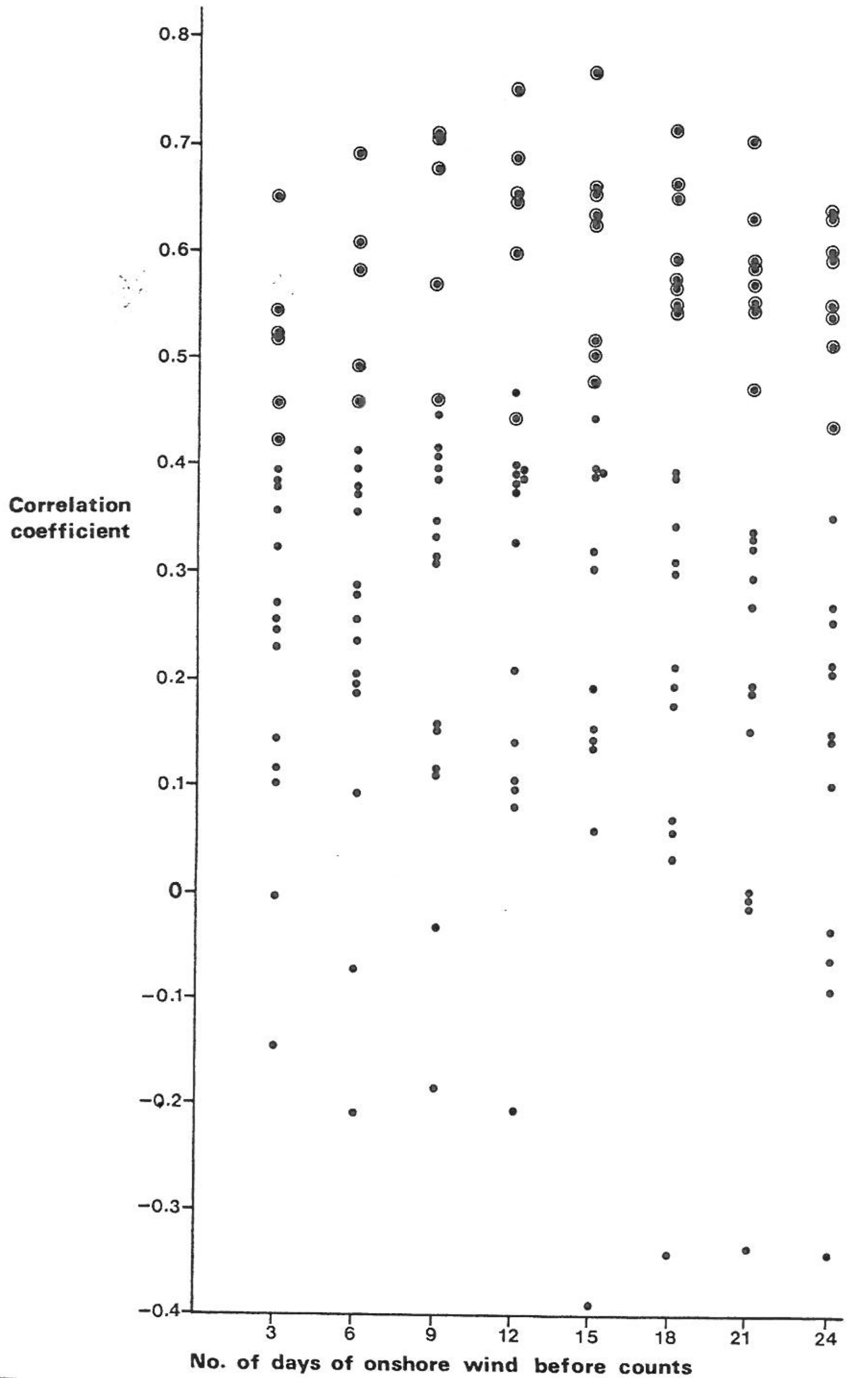


Figure 12 ` Improvements (greater than 0.5) in the coefficients of correlation r, between corpse density for Larus gulls and the larger auks in autumn and winter (n = 40) and onshore wind when the angle from which the wind was calculated was altered by up to 90° in either direction (see text). Zero degrees represents onshore wind at right angles to the bearing of the line of coast (see Fig. 2). Figures in parentheses show initial values and new values of r respectively. Thirteen points are plotted. Seven are for regions where the assigned bearing did not fit the coastline well, i.e. Wales, Firth of Forth and W Scotland and in the last two regions improvements occurred when changes of angle in opposite directions. The new coefficients for Wales (one case) and two other regions (S and SE England) remained low (and non significant). Only in one region, E Scotland (3 cases), were results sufficiently consistent to indicate that densities may be better related to wind from another angle (north east) rather than wind directly onshore (110°, south south-east).

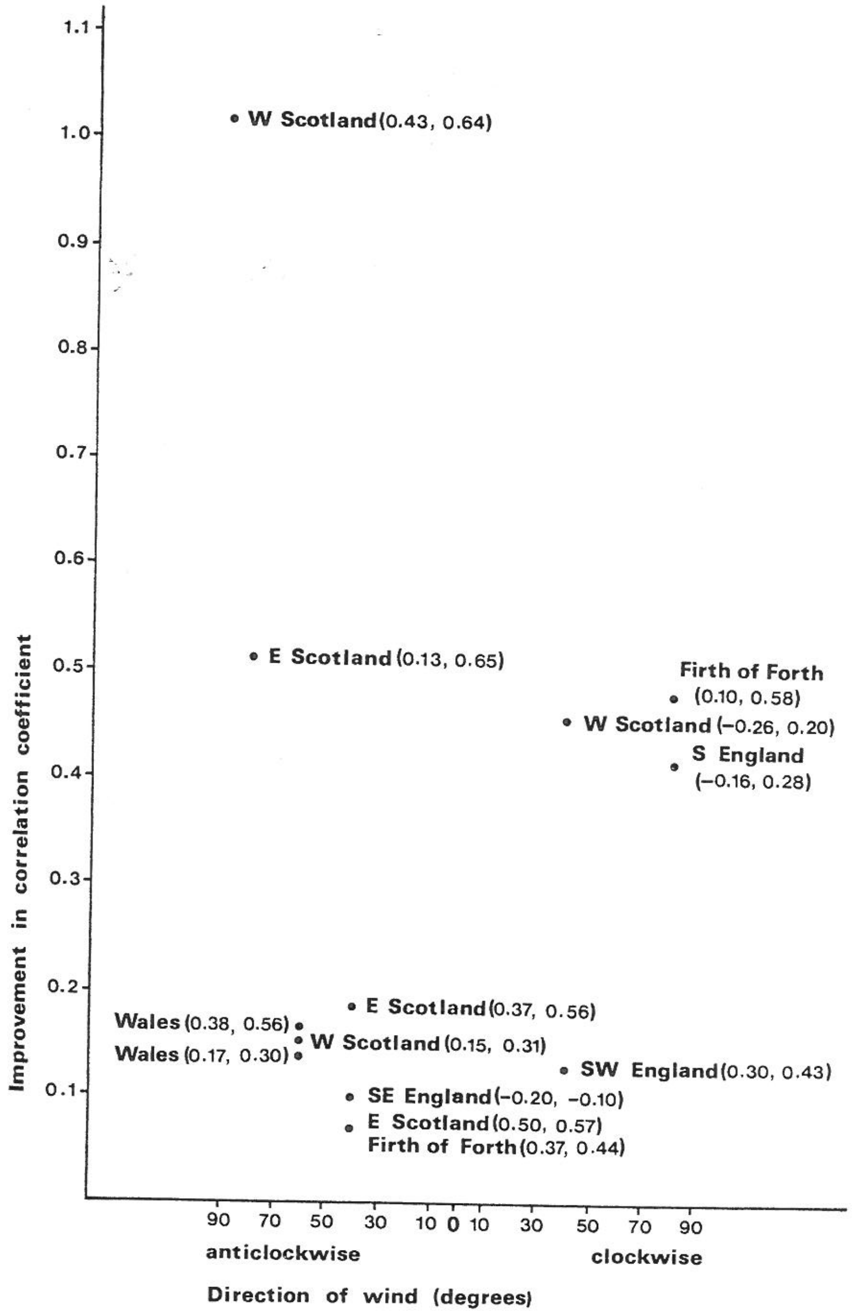
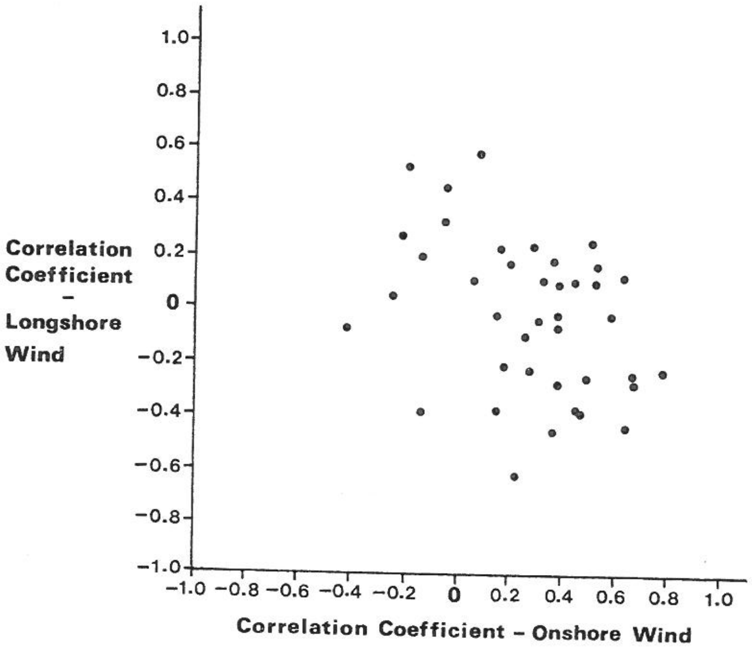


Figure 13 Coefficients of correlation between density and longshore wind plotted against those between density and onshore wind for Larus gulls and the larger auks in autumn and winter (n = 40). As plotted, there is some evidence of a weak relationship, suggesting that as the correlation with onshore wind decreases, that with longshore wind increases. However, when species groups are plotted separately for each period, the relationship is not present. Since onshore and longshore wind are related, a weak relationship between their respective correlation coefficients is not unexpected.



The new vectors generally produced similar or lower correlations (Fig. 14). The original onshore wind vectors were therefore selected as the best of the wind parameters. As expected, the frequency of onshore winds in winter (Table 5) was considerably less on the east coast (NE England) than on the west coast (NW England).

(ii) Temperature. The parameters of sea and land temperature described earlier were used in an attempt to reflect the severity of the weather in any one month. Correlations for January, February and March between regional densities and the national land temperature parameter were lower than those between densities and sea temperature (Table 6). Perhaps surprisingly, regional densities of corpses were better correlated with sea temperature off north Scotland than sea temperature at the nearest sampling point (Table 7) or in the middle of the North Sea. Hence a national rather than regional measure of sea temperature was selected as a measure of coldness of winter weather.

(b) Density models.

For each region and each group of months (autumn and winter) regression models involving onshore wind, sea temperature and month were fitted to the log density of corpses. The models were built up as follows. First, regressions were fitted against each of the environmental variables (wind and sea temperature) to discover which gave the best relationship. Then both were fitted simultaneously to see whether this gave a significant improvement. Finally, to determine whether there were any monthly differences in density that could not be explained by the environmental differences between months, parallel regressions were calculated (with identical regression coefficient(s) of sea temperature/wind but a different intercept for each month) as well as separate regressions with both the intercept and the regression coefficients differing for each month.

The resulting equations are listed in Tables 8-11. Dashed lines indicate that no significant regressions were obtained. The percentage variance accounted for, defined as 100 x (total mean square - residual mean square)/total mean square, measures the percentage of the variation in log density that is explained by the regression model.

Figure 14 Improvements (greater than 0.05) in the coefficients of correlation between corpse density for Larus gulls and the larger auks in autumn and winter (n = 40) and onshore wind when up to the first eight consecutive days were omitted from the period used to calculate the wind (see text).

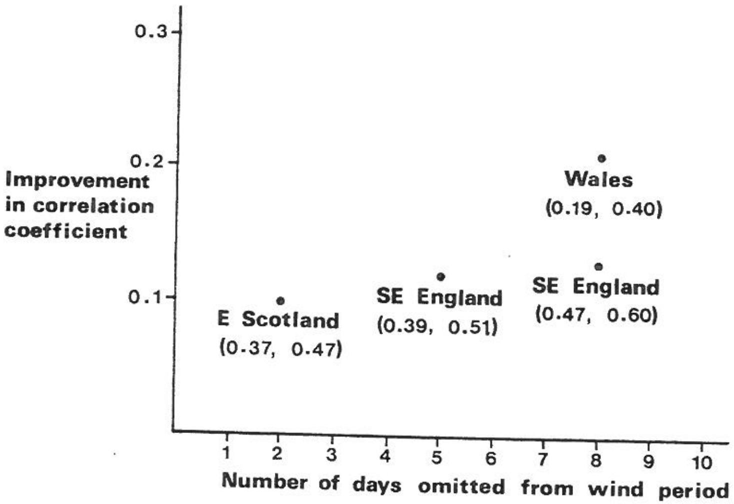


Table 5

Number of days of onshore wind in winter for NE England and NW England.

Region	Month	72	73	74	75	76	77	78	79	Mean
		Year								
NE England	Jan	14	6	2	0	8	13	7	12	7.8
	Feb	12	3	6	11	12	12	15	14	10.6
	Mar	11	6	20	19	16	12	3	10	12.1
	Total	37	15	28	30	36	37	25	36	30.5
NW England	Jan	10	14	21	30	24	17	24	17	19.6
	Feb	6	24	19	6	14	9	8	8	11.8
	Mar	13	23	12	14	11	17	27	24	17.6
	Total	29	61	52	50	49	43	59	49	49.0

Table 6

Moduli values of the coefficients of correlation, r, between corpse density in winter and the national parameters of land and sea temperature. Values of r are only shown for regions where a lowering of temperature was correlated with an increase in density. Coefficients in the other regions were less than |0.29|, with one exception (SW England, gulls, land temp., - 0.60).

	Razorbill and Guillemot		*Larus* gulls	
	Land temp.	Sea temp.	Land temp.	Sea temp.
	r	r	r	r
N Scotland	0.16	0.41	0.25	0.26
E Scotland	0.40	0.76	0.50	0.27
Firth of Forth	0.32	0.78	0.49	0.49
NE England	0.53	0.80	0.58	0.51
SE England	0.30	0.40	0.59	0.42
S England			0.51	0.48
SW England				
Wales			0.21	0.34
NW England	0.23	0.06	0.06	0.41
W Scotland			0.29	0.29

Table 7

Coefficients of correlation, r, between corpse density in winter and regional and national sea temperature parameters. Results for North Scotland and East Scotland and not shown since the same sampling point was used for the national and the regional measure.

	Razorbill and Guillemot		*Larus* gulls	
	Regional Sea temp.	National Sea temp.	Regional Sea temp.	National Sea temp.
	r	r	r	r
Firth of Forth	-0.71	-0.78	-0.21	-0.49
NE England	-0.61	-0.80	-0.34	-0.51
SE England	-0.32	-0.40	-0.49	-0.42
S England	-0.14	0.33	-0.24	-0.48
SW England	-0.17	0.08	-0.23	0.0
Wales	0.10	0.16	-0.31	-0.34
NW England	0.29	-0.06	-0.12	-0.41
W Scotland	0.09	0.22	-0.20	-0.29

Table 8

Relationship between autumn density of Larus gulls and weather parameter(s). Dashed lines indicate regression results were not significant ($P < 0.05$)
D= density of birds (log base e), S = sea temperature (°C), $\overline{W}$ = mean onshore wind speed (knots per day).

Region	parameter(s)	% variance accounted for	Equation
N Scotland	Wind	30.8	Log D = -0.004 + 0.074 W
E Scotland	Wind	19.7	Log D = -0.263 + 0.032 W
Firth of Forth	-	-	-
NE England	Sea temp.*	34.3	Log D = -1.985 + 0.077 S
SE England	-	-	-
S England	-	-	-
SW England	-	-	-
Wales	-	-	-
NW England	-	-	-
W Scotlad	-	-	-

* positive coefficient for sea temperature

Table 9

Relationship between autumn density of larger auks and weather parameter(s) Dashed lines indicate regression results were not significant ($P < 0.05$).
D = density of birds (log base e), S = sea temperature (°C), $\overline{W}$ = mean onshore wind speed (knots per day).

Region	parameter(s)	% variance accounted for	Equation
N Scotland	-	-	-
E Scotland	Wind	34.7	Log D = -0.788 + 0.052 W
Firth of Forth	-	-	-
NE England	-	-	-
SE England	Sea temp.*	38.2	Log D = -3.641 + 0.161S
S England	Sea temp.	32.5	Log D = 0.368 - 0.188 S
SW England	Wind	34.0	Log D = 0 -2.130 + 0.081 W
Wales	-	-	-
NW England	Sea temp.	46.8	Log D = 0.376 - 0.114 S
W Scotland	-	-	-

* positive coefficient for sea temperature

Table 10

Relationship between winter density of Larus gulls and weather parameter(s) Dashed lines indicate regression results were not significant ($P < 0.05$). D = density of birds (log base e), S = sea temperature (°C), W = mean onshore wind speed (knots per day).

Region	parameter(s)	% variance accounted for	Equation
N Scotland	-	-	-
E Scotland	Sea temp.*	32.1	(Jan Log D = 0.681 - 0.126 S (Feb Log D = 0.771 - 0.126 S (Mar Log D = 0.333 - 0.126 S
Firth of Forth	Sea temp.	20.8	Log D = 0.979 - 0.189 S
NE England	Sea temp.	23.0	Log D = 0.460 - 0.174 S
SE England	Sea temp. & Wind*	36.0	(Jan Log D = 0.631 - 0.157 S + 0.230 W (Feb Log D = 0.385 - 0.157 S + 0.230 W (Mar Log D = 0.288 - 0.157 S + 0.230 W
S England	Sea temp. & Wind*	54.6	(Jan Log D = 0.307 - 0.160 S + 0.020 W (Feb Log D = 0.118 - 0.160 S + 0.020 W (Mar Log D = 0.096 - 0.160 S + 0.020 W
SW England	Wind*	30.0	(Jan Log D = -1.857 + 0.030 W (Feb Log D = -1.265 + 0.030 W (Mar Log D = -1.121 + 0.030 W
Wales	-	-	-
NW England	Sea temp.	12.7	Log D = 0.296 - 0.108S
W Scotland	-	-	-

* different intercepts (but not slopes) were required for each month

Table 11

Relationship between winter density of larger auks and weather parameter(s). Dashed lines indicate regression results were not significant ($P < 0.05$) D = density of birds (log base e), S = sea temperature (°C), W = mean onshore wind speed (knots per day).

Region	parameter(s)	% variance accounted for	Equation
N Scotland	Wind	41.3	Log D = -0.259 + 0.092 W
E Scotland	Sea temp.	55.8	Log D = 2.299 - 0.349 S
Firth of Forth	Sea temp. & Wind	74.9	Log D = 2.300 - 0.398 S + 0.066 W
NE England	Sea temp. & Wind	67.1	Log D = 2.026 - 0.335 S + 0.043 W
SE England	Sea temp. & Wind*	51.1	(Jan Log D = 1.399 - 0.262 S + 0.107 W (Feb Log D = 0.741 - 0.262 S + 0.107 W (Mar Log D = 0.907 - 0.262 S + 0.107 W
S England	Wind	21.8	Log D = -0.922 + 0.047 W
SW England	-	-	-
Wales	-	-	-
NW England	Wind	23.6	Log D = -0.930 + 0.023 W
W Scotland	-	-	-

* different intercepts (but not slopes) were required for each month.

As expected, in winter the corpse density increased in most regions (14 out of 20 cases) as the amount of onshore wind increased or the sea temperature decreased. However, four regions showed no significant relationship for one or both species groups. Where results were significant, the proportion of variance accounted for ranged from 22% - 75% for the larger auks and 13% - 55% for Larus gulls.

In autumn, only one region (E Scotland) showed a significant relationship for both species groups. In NE England (Larus gulls) and SE England (auks), densities were correlated with increasing temperature and results are presumably spurious. Where results were significant, for Larus gulls 20% - 31% of the variance was accounted for; for auks the proportion was 34% - 47%.

For regions where corpse density was related to weather the regression coefficients showed some degree of similarity (sea temperature 0.077 - 0.398; wind 0.020 - 0.107 with one region 0.230).

(c) Proportion oiled models

For the analysis of binomial data the log transformation is not suitable. For such data the variance of an observation, $np(1 - p)$, will vary with the value of p and a transformation is necessary to stabilise the variance for all the values of p. Further, the size of an effect of wind or temperature may not be constant over the scale of measurement, particularly for very high or low values of p, and a transformation is needed to give additivity. The logit transformation*, $y = \log_e (p/(1 - p))$, overcomes both these problems and forms the link between the linear model of the regression and the proportion oiled. After transforming the data the regression models were built up as described in the previous section.

*Tables of logits normally use the $y = \frac{1}{2} \log_e(p/(1 - p))$. Hence the value of y, calculated from the equations presented in Tables 12-15, should be halved before looking up in logit tables.

The resulting equations are listed in Tables 12-15. Dashed lines indicate that no significant regressions were obtained. Fourteen of the 40 cases showed significant relationships with either wind or sea temperature, or both, but inspection of the coefficients for wind showed six to be positive (ie the proportion oiled increased with increasing onshore wind), three to be negative and one case (S England, autumn, gulls) where the coefficient was positive in one month and negative in the other. For sea temperature two coefficients were negative (i.e. the proportion oiled increased as temperature decreased), and three were positive.

In general no pattern emerged from the results. Only two regions, both on the east coast, showed some degree of consistency within each region, although between the regions the effects of weather were opposite. In NE England the proportion of auks oiled increased with decreasing amounts of onshore wind in autumn and increased with increasing sea temperature in winter, i.e. the proportions were reduced by lower temperatures or onshore winds, which may have brought more unoiled corpses onto the beach. In SE England the proportion of gulls oiled increased with increasing amounts of onshore wind in both autumn and winter, whilst the proportion of auks oiled increased with decreasing sea temperature in autumn, i.e. the proportions were increased by lower temperatures and onshore wind, which alternatively may have brought more oil nearer the shore, or more oiled birds onto the beach.

6. Time trends

(a) Densities

Regional trends over time were examined for the autumn (September and November 1971-79) and the winter (January, February and March 1972-79) months combined, for Larus gulls and the larger auks. Densities were similar in most combined months. However, there were six occasions during the 48 tests conducted (12 regions x 2 species groups x 2 periods) when significant differences were detected (Larus gulls : N Scotland and NE England in autumn and E Scotland in winter; auks: SW and NW England and Northern Ireland in autumn). These differences may have reduced the likelihood of identifying a statistically significant trend.

Table 12

Relationship between proportion of *Larus* gulls found oiled in autumn and weather parameter(s). Dashed lines indicate regression results were not significant. Y is the logit transformation of the proportion oiled, p. Predicted values of p can be calculated directly using $p = e^y/(1 + e^y)$ or from logit tables for $\frac{1}{2}y$ (see text). S = sea temperature (°C), W = mean onshore wind speed (knots per day).

Region	Parameter		Equation
N Scotland	-		-
E Scotland	-		-
Firth of Forth	-		-
NE England	-		-
SE England	Wind		y = -2.236 + 0.144W
S England	Wind**	(Sept (Nov	y = -1.430 - 0.172 W y = -0.869 + 0.212 W
SW England	-		-
Wales	-		-
NW England	Wind		y = -1.880 - 0.161 W
W Scotland	-		-

** different intercepts and slopes required for each month

Table 13

Relationship between the proportion of larger auks found oiled in autumn and weather parameter(s). Dashed lines indicate regression results were not significant. Y is the logit transformation of proportion oiled, p. Predicted values of p can be calculated directly using $p = e^y/(1 + e^y)$ or from logit tables for $\frac{1}{2}y$ (see text). S = sea temperature (°C), W = mean onshore speed (knots per day).

Region	Parameter(s)		Equation
N Scotland	-		-
E Scotland	-		-
Firth of Forth	Wind		y = -1.138 - 0.176 W
NE England	Wind*	(Sept (Nov	y = -0.648 - 0 .223 W y = -0.343 - 0.223 W
SE England	Sea temp.*	(Sept (Nov	y = 28.3 - 2.187 S y = 23.2 - 2.187 S
S England	-		-
SW England	-		-
Wales	Wind*	(Sept (Nov	y = 0.324 + 0.121 W y = -1.170 + 0.121 W
NW England	-		-
W Scotland	Sea temp.		y = 2.175 - 0.390 S

* different intercepts (but not slopes) required for each month.

Table 14

Relationship between the proportion of Larus gulls found oiled in winter and weather parameter(s). Dashed lines indicate regression results were not significant. Y is the logit transformation of proportion oiled, p. Predicted values of p can be calculated directly using $p = e^y/(1 + e^y)$ or from logit tables for ½y (see text).
S = sea temperature (°C), W = mean onshore wind speed (knots per day).

Region	Parameter(s)	Equation
N Scotland	Sea temp. & wind	y = -10.24 + 1.045 S + 0.184 W
E Scotland	-	-
Firth of Forth	-	-
NE England	-	-
SE England	Wind	y = -1.163 + 0.660 W
S England	-	-
SW England	-	-
Wales	-	-
NW England	-	-
W Scotland	-	-

Table 15

Relationship between the proportion of larger auks found oiled in winter and weather parameter(s). Dashed lines indicate regression resultsd were not significant. Y is the logit transformation of proportion oiled, p. Predicted values of p can be calculated directly using $p = e^y/(1 + e^y)$ or from logit tables for ½y (see text).
S = sea temperature (°C), W = mean onshore wind speed (knots per day).

Region	Parameter(s)	Equation
N.Scotland	Wind*	(Jan y = 1.390 + 0.148 W (Feb y = 0.400 + 0.148 W (Mar y = 0.485 + 0.148 W
E Scotland	-	-
Firth of Forth	-	-
NE England	Sea temp.*	(Jan y = -3.38 + =.510 S (Feb y = -2.27 + =.510 S (Mar y = -2.98 + =.510 S
SE England	-	-
S England	-	-
SW England	-	-
Wales	-	-
NW England	Wind**	(Jan y = -0.987 + 0.074 W (Feb y = -0.107 + 0.037 W (Mar y = -1.066 + 0.368 W
W Scotland	Sea temp.*	(Jan y = -3.960 + 0.361 S (Feb y = -3.130 + 0.361 S (Mar y = -3.670 + 0.361 S

* different intercepts (but not slopes) require for each month

** different intercepts and slopes required for each month

Observed densities of Larus gull corpses were found to show a linear increase in seven of 12 regions in both autumn and winter (Fig. 15). No decreases were detected. For auks (Fig. 15) no significant changes were identified on the west coast. Increases were found only in regions between Fraserburgh, Grampian and the Humber estuary, and on the Channel Islands. One decrease was found; in SE England in autumn.

These results should be interpreted with caution, since only a linear model was fitted, and it is likely that a more complex pattern exists. Inspection of the winter densities of Larus gulls and the larger auks showed considerable differences between two east coast (E Scotland and NE England) and two west coast (NW England and W Scotland) regions (Fig. 16). On the east coast, auks and to a lesser extent Larus gulls showed greater variations in densities; the number of corpses clearly increasing from low values in mild winters to high values in the severe winter of 1979. On the west coast both species groups showed a rather different pattern with less variation and which undulated, with a trough falling between the years of 1975 and 1977.

However, the data were re-examined. After the two weather variables had been fitted to the density of corpses (as previously described) linear, quadratic and cubic functions of year were added to determine whether there were any trends that could not be explained by yearly differences in the weather. Except for two occasions, regression results were only significant where no relationship with the weather parameters had been demonstrated (11 cases (n = 40) in four regions, one on the east coast (Firth of Forth) and three (Wales, NW England, W Scotland) on the west). The two exceptions were Firth of Forth (Larus gulls in winter) and NW England (auks in winter) where there were weak but significant relationships with weather parameters (Tables 10 and 11 respectively). Since there was evidence of a linear trend over time in the weather (e.g. Table 16), these results were not considered to be evidence of any genuine trends in densities. In addition, inspection of the residual densities plotted against year revealed that, on all occasions, one to three points were disproportionately influencing results. In west coast regions, low values in 1976-78 coupled with high values in 1979 were largely responsible for the significant results with the cubic function of wind. In conclusion no convincing trends over time were identified once the effects of weather had been removed.

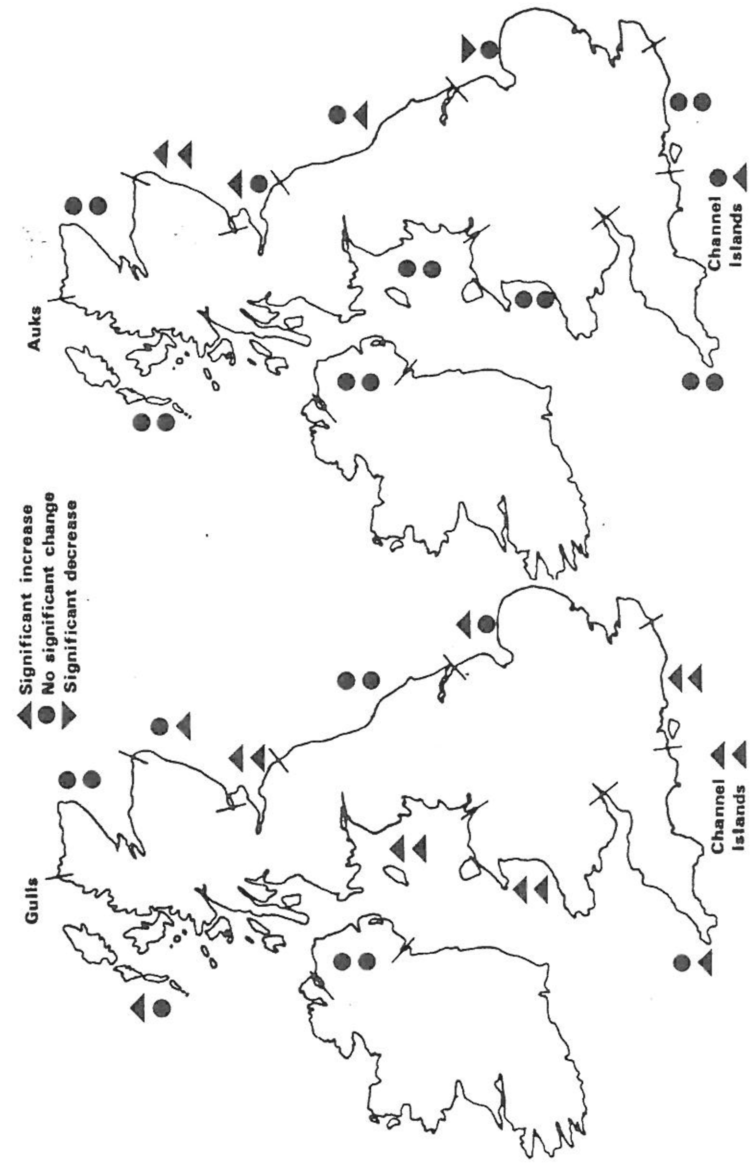


Figure 15 Linear trends 1971-79 in the observed regional densities of corpses of Larus gulls and the larger auks in autumn (upper symbol) and winter (lower symbol). (When the effects of weather had been removed no reliable trends were detected - see text.)

Figure 16 Densities of Larus gulls and the larger auks in winter 1972-79 in E Scotland, NE England, NW England and W Scotland.

Larus gulls

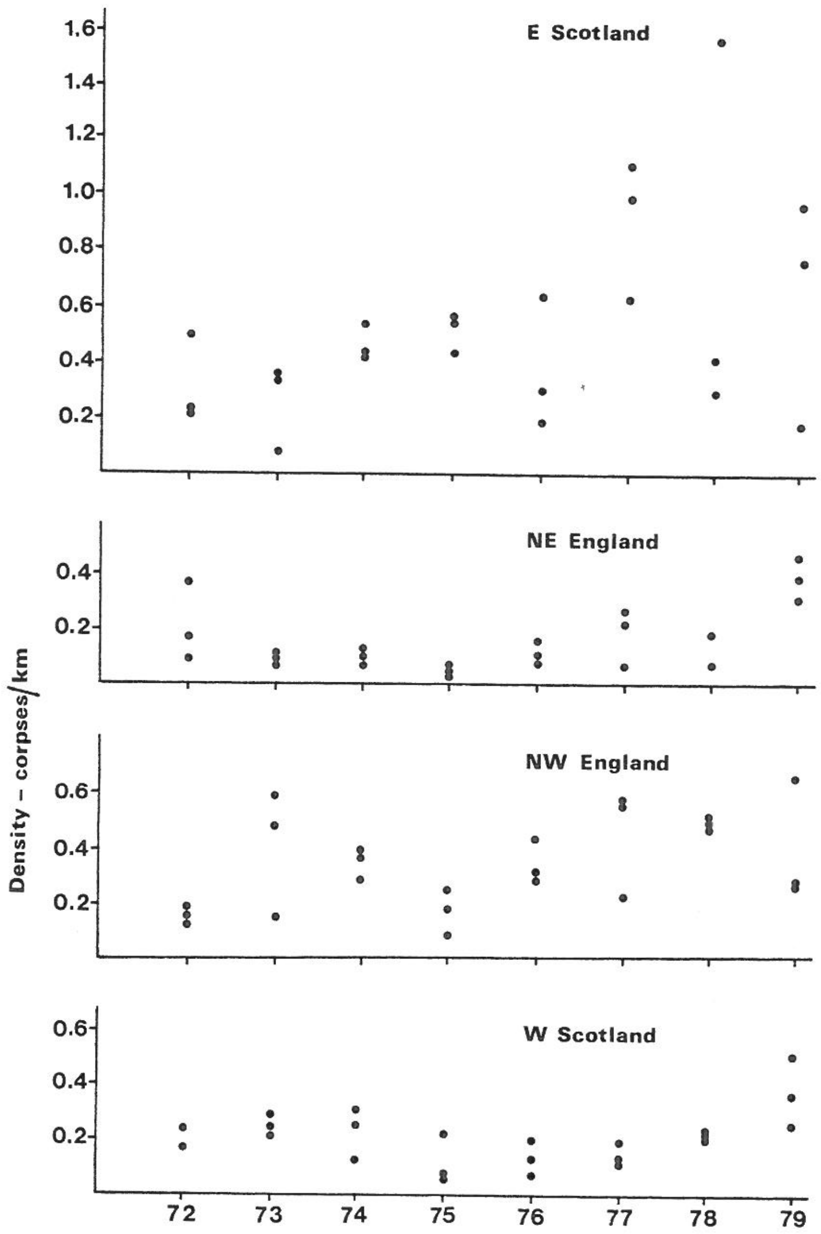


Figure 16 (cont.)

Larger auks

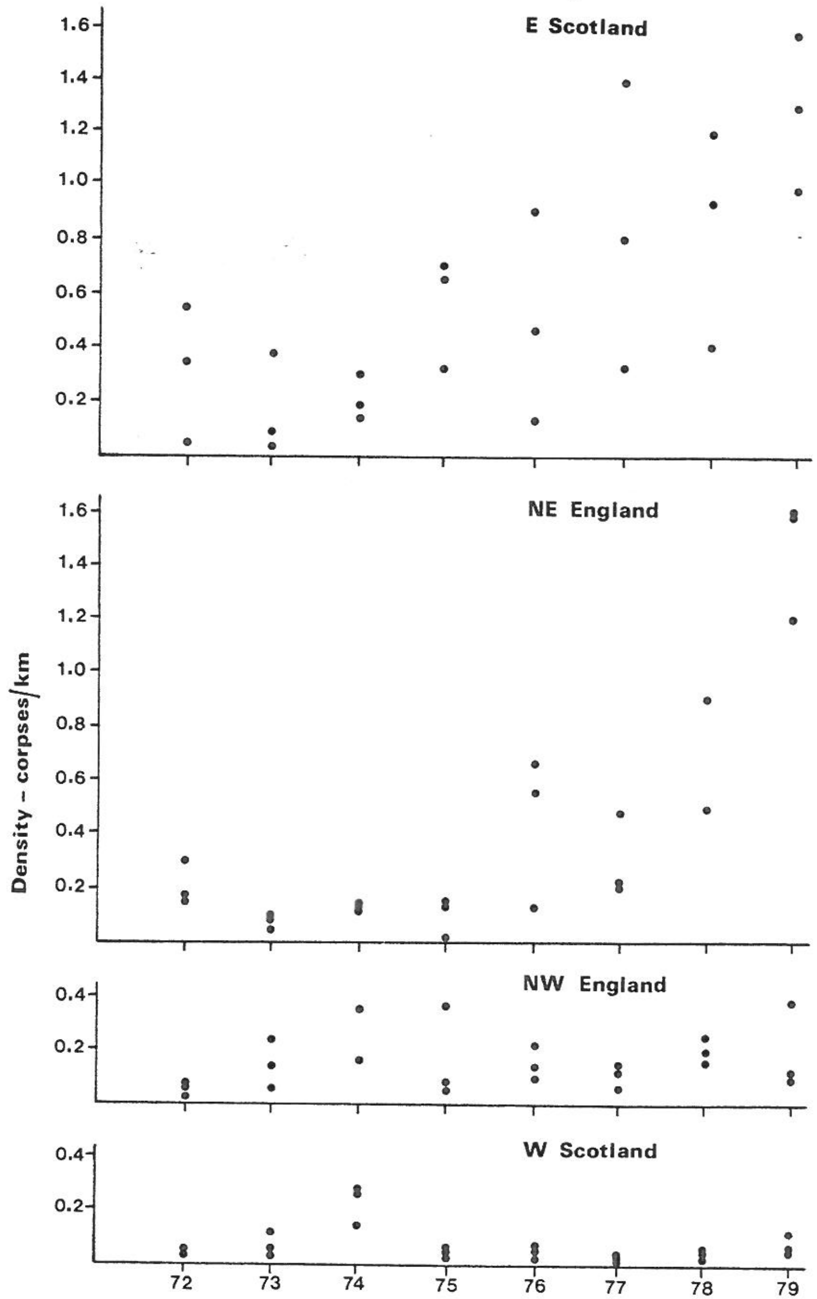


Table 16

Monthly sea temperatures (°C) off North Scotland 1972-79 (Sampling point is given in Fig. 2). There is a significant linear decreasing trend over time (Student's t test: $P < 0.001$, $r = -0.7$, $n = 24$).

Month	1972	1973	1974	1975	1976	1977	1978	1979
January	8.7	9.5	8.2	8.8	8.1	7.5	8.1	6.7
February	7.6	7.8	8.2	8.2	7.9	6.4	6.7	6.2
March	7.6	8.1	9.0	7.7	6.7	6.9	6.9	6.2
Mean	8.0	8.5	8.5	8.2	7.6	6.9	7.2	6.4

b) Proportions of birds oiled

Linear trends over time in the regional proportions of birds found oiled were examined for _Larus_ gulls and the larger auks in autumn and in winter. Eighteen of the 20 significant results (n = 48) were decreases (Fig. 17). Only one region (S England) showed similar results for autumn and winter for both species groups. Increases were only identified in the Channel Islands (auks in winter) and SW England (_Larus_ gulls in autumn). In both cases small numbers of birds were found.

As with densities care is needed in interpreting these results, since not only may the proportion be related to a pattern more complex than a linear trend, but also it is dependent on the numbers of both oiled and unoiled birds. Inspection of the winter proportions (Fig. 18) showed higher proportions oiled on the two east coast regions (E Scotland and NE England) than on the west (NW England and W Scotland), for both species groups. Proportions of _Larus_ gulls found oiled showed a tendency for greater fluctuations on the east coast than on the west but this was not the case for the larger auks (Fig. 18).

These trends were also re-examined. After the weather variables had been fitted to the proportion oiled (as previously described), linear, quadratic and cubic functions of year were added to determine whether there were any trends that could not be explained by yearly differences in weather. In eight cases (three for _Larus_ gulls and five for the larger auks) regression results were statistically significant. In four of these (NE England in autumn and SE England, Wales and NW England in winter) no relationship with the weather parameters had been demonstrated and since there was evidence of a linear trend in the weather parameters, these results were not considered evidence of genuine trends. Further, in these and in the other cases (NE England and Wales in autumn and NE England and SE England in winter) plots of proportions or residuals showed that 1-2 data points were largely responsible for the significant results. However, in most plots there was a tendency for the higher proportions to occur in the early and late years of the period, with a trough generally falling between 1974 and 1976, but some points did not fit this pattern. Overall I concluded there were no convincing trends in the proportions of birds found oiled between 1971-79.

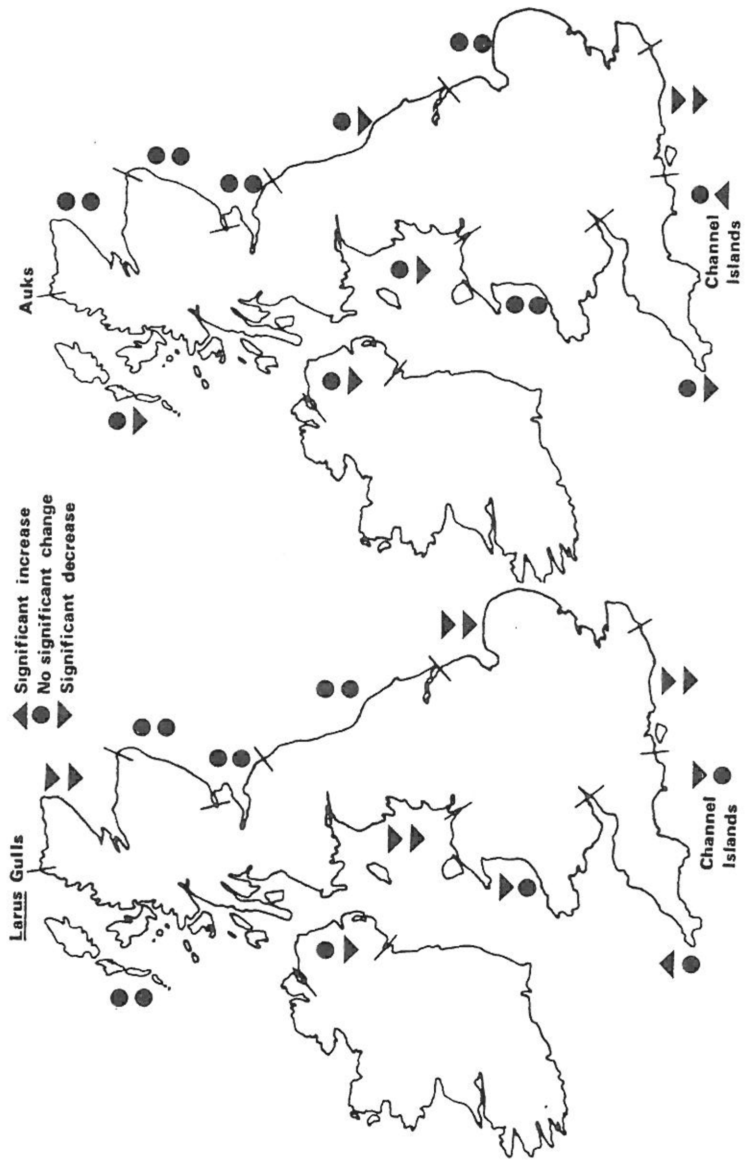


Figure 17 Linear trends 1971-79 in the proportions of corpses of Larus gulls and larger auks found oiled in autumn (upper symbol) and winter (lower symbol). (When the effects of weather had been removed no reliable trends were detected - see text).

Figure 18 Proportions of Larus gulls and the larger auks found oiled in winter 1972-79 in E Scotland, NE England, NW England and W Scotland.

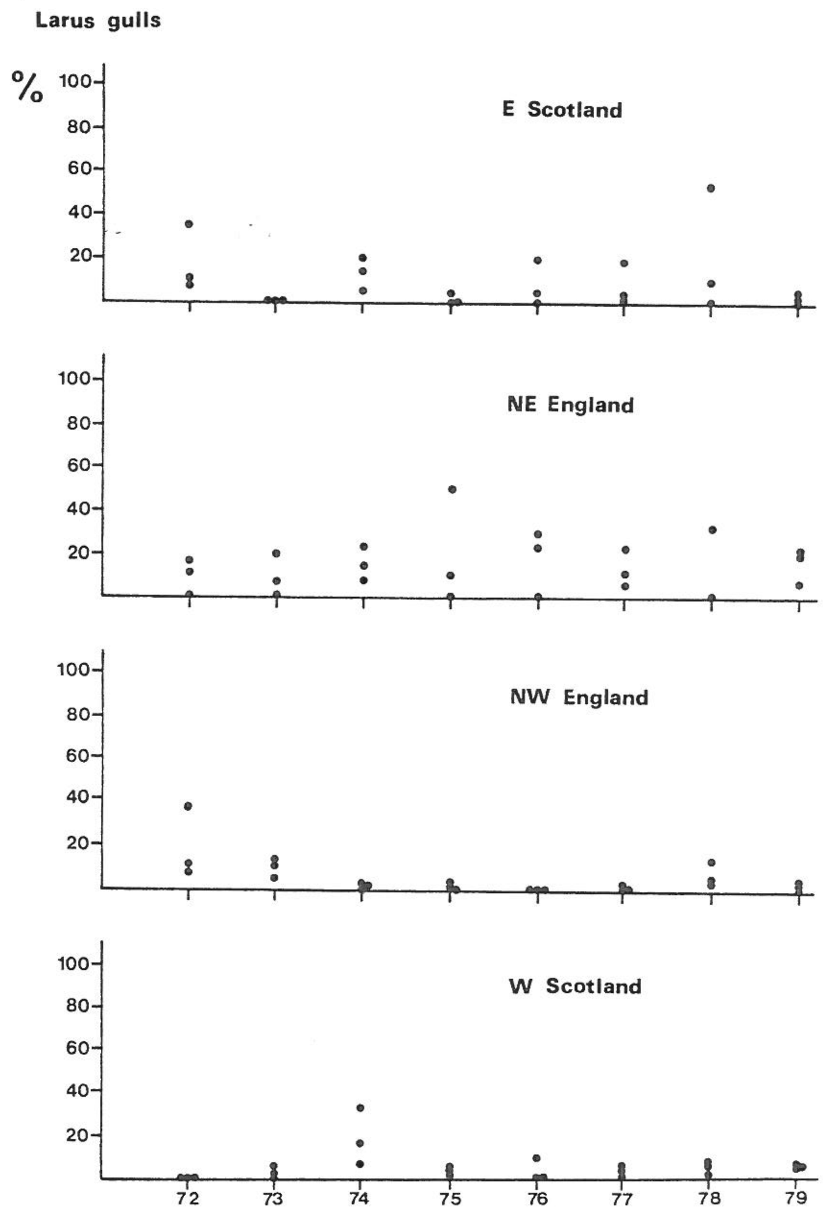
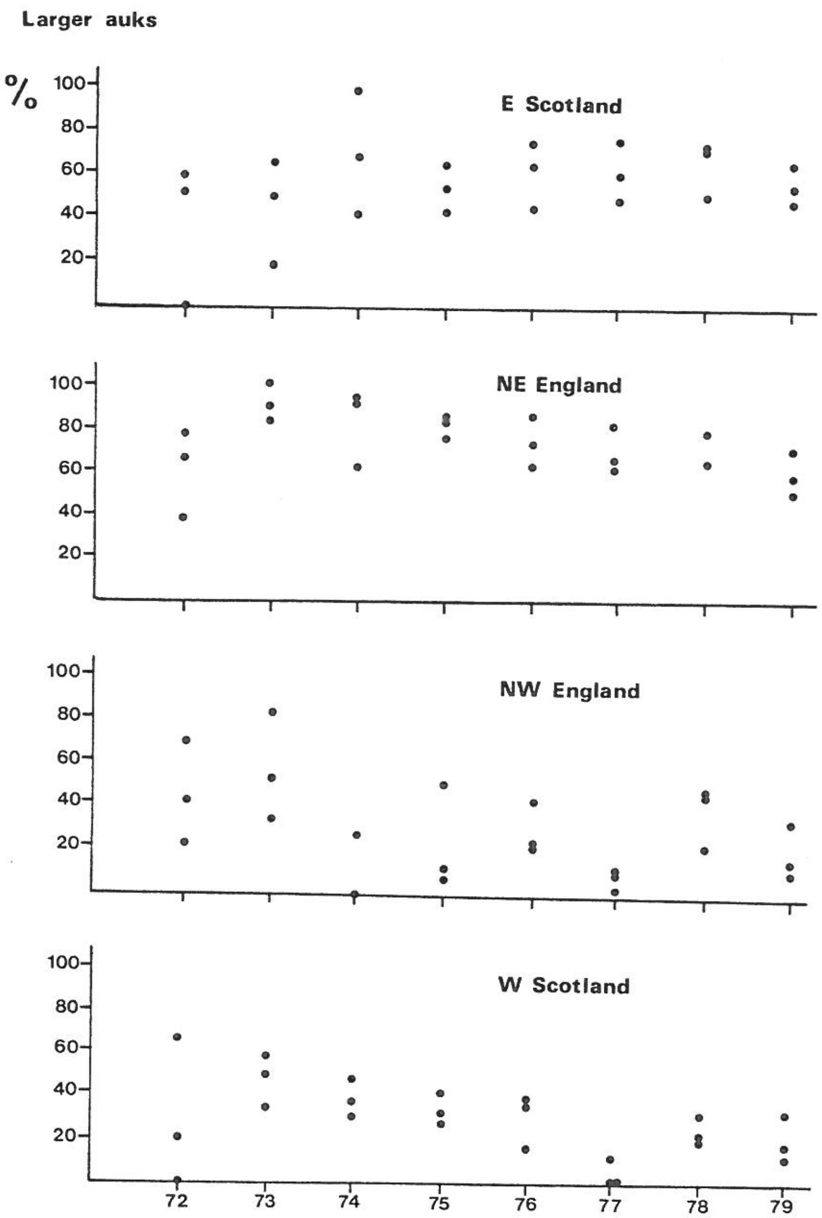


Figure 18 (cont.)



(c) Proportions of beaches oiled

Regional linear trends over time were examined for the autumn and winter periods. Results suggest that in general the number of beaches oiled decreased in the south and west, but increased in the east and north (Fig. 19). Again, caution is advised in the interpretation of these results since trends were tested only for a linear pattern, and the true situation is likely to be more complex.

7. Surveys during mortality incidents

A list of the 100 oil pollution incidents affecting more than 50 birds in the period 1st July 1971 to 30th June 1981 is given in Table 17 and the locations of the incidents are mapped in Figure 20. The totals of birds affected are described as 'minimum numbers' to emphasise that no correction factor has been applied in attempts to estimate total mortality (cf. Barrett 1979). The largest incidents (over 1000 birds affected) have all occurred since 1976. North west England and W Scotland have suffered relatively few incidents in the last ten years, whilst in NE England and the Firth of Forth combined incidents have occurred at an average rate of over two per year. Several incident 'blackspots' have emerged, all on the east coast, viz Orkney/Pentland Firth, Firth of Forth/NE England and E Norfolk.

The number of incidents per year and numbers of birds affected is given in Figure 21. The peak of incidents in 1978/79 coincided with both the hardest winter since that of 1962/3 and the disastrous first few months of operation of the Sullom Voe oil terminal in Shetland (e.g. see Heubeck & Richardson 1980). In all years the majority of the casualties were auks (Fig. 21 and Table 18). The series of incidents in north Scotland was responsible for the unusually large numbers of Shags, seaducks and Black Guillemot Cepphus grylle in 1978/79. The category 'others' largely comprised either birds that could not be assigned to a particular species or species group, or birds for which species information was not available.

Figure 19 Linear trends 1979-79 in the proportions of beaches recorded oiled in autumn (upper symbol) and winter (lower symbol). Results for the Channel Islands and NW England are excluded for reasons given in the text.

▲ **Significant increase**
● **No significant change**
▼ **Significant decrease**

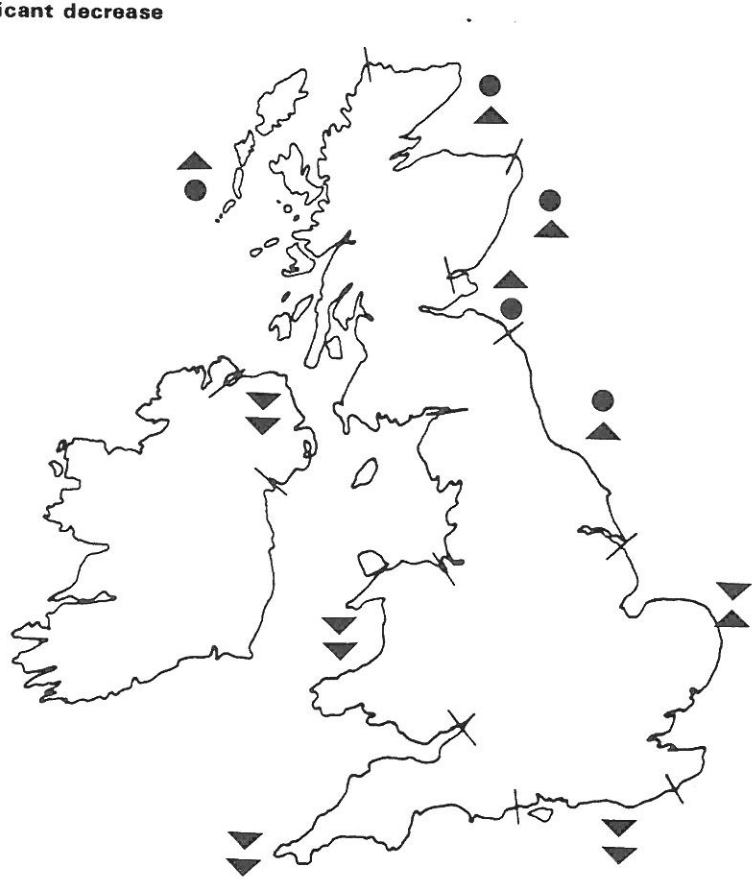


Table 17

Oil pollution incidents affecting more than 50 birds, July 1971 - June 1981.
See text for definition of casualties.

No.	Date	Minimum number of casualties	County	Source of oil and cause of spillage	Oil type
	1971				
1.	November 17	89	Gwynedd		
2.	December 14	92	Hampshire, Dorset		
	1972				
3.	January 1	100+	Norfolk		
4.	14	170	Dorset		lube & crude
5.	18	57	Suffolk		
6.	February 4	281	Lothian		diesel
7.	7	104	Northumberland		
8.	16	110	Cornwall		
9.	18	141	Cumbria		
10.	-	200+	Co.Down		
11.	March 7	223	Cornwall		fuel
12.	11	318	Borders		
13.	April 2	150	Gwynedd		animal, fuel & crude
14.	October 15	93	Co.Wexford		
15.	November 10	342	Dyfed		
16.	26	268	Gwynedd, Clwyd		
17.	December 19	294	Cornwall		
18.	20	100+	Devon		crude
19.	24	300+	Norfolk		

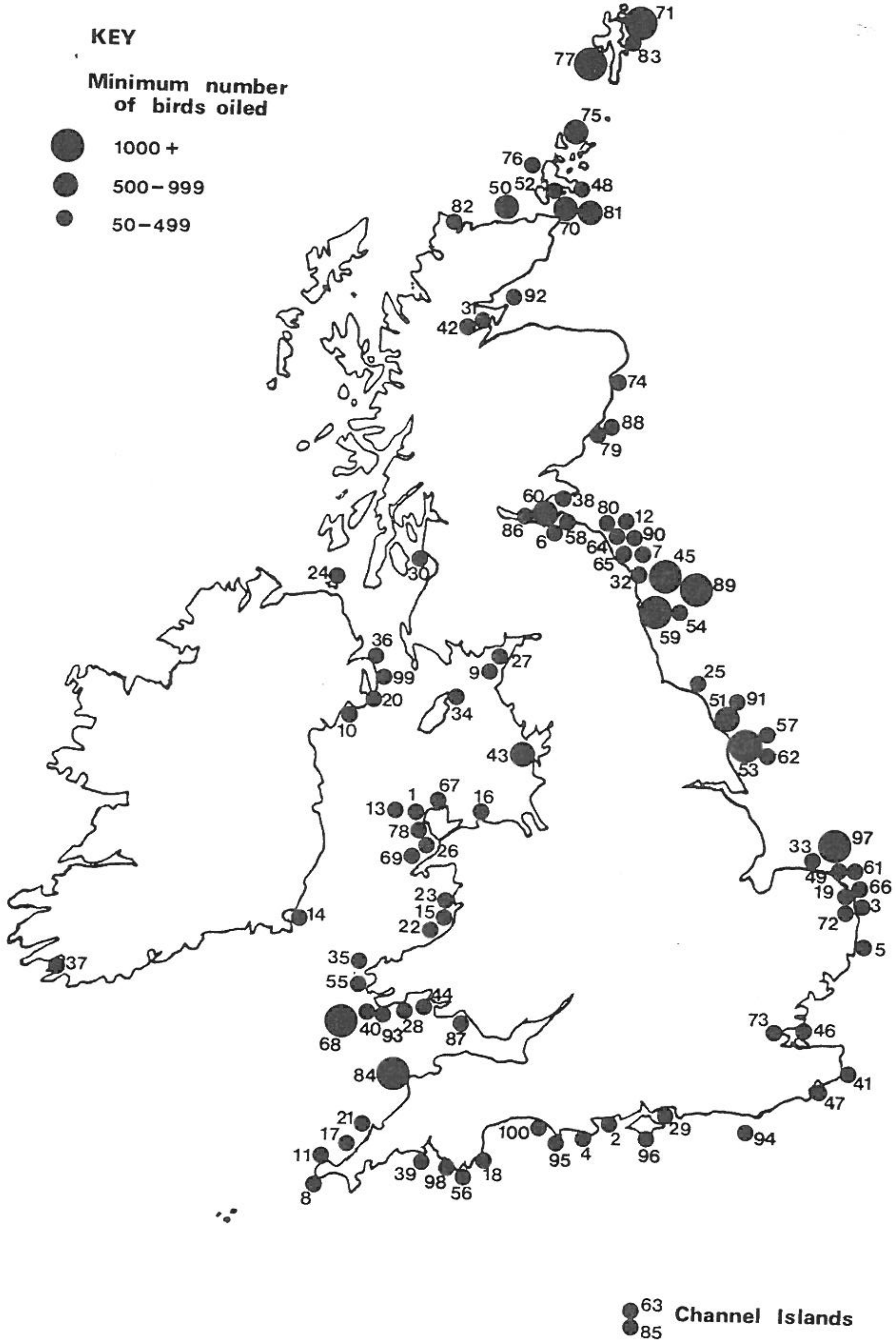
No.	Date	Minimum number of casualties	County	Source of oil and cause of spillage	Oil type
	1973				
20.	January -	200+	Co.Down		
21.	29	76	Cornwall		
22.	March -	50	Dyfed		
23.	April -	70	Dyfed		
24.	June 10	125	Co.Antrim		
25.	October 2	100+	North Yorkshire		
26.	November -	60+	Gwynedd		crude
27.	December 10	95	Cumbria		
	1974				
28.	January 1	325	Dyfed		fuel
29.	6	105	Hampshire		crude
30.	26	443	Strathclyde		fuel
31.	30	166	Highland	Distillery	fuel
32.	March 26	179	Northumberland	Clydebank; collison	fuel
33.	April 12	458	Norfolk		
34.	September -	100+	Isle of Man		
35.	7	104	Dyfed		
36.	October 25	135	Co.Antrim, Co.Down	ICI plant, Kilroot	fuel
	1975				
37.	January 10	150+	Co.Cork	Afran Zodiac; collision	fuel
38.	30	125	Fife		diesel
39.	February 28	145	Devon, Cornwall		
40.	May 1	189	Dyfed	Esso Tenby; hull defect	fuel
41.	November 11	100+	Kent	Olympic Alliance & Achilles; collison	crude
42.	12	115	Highland	Rnas Olna at terminal	
43.	27	800+	Lancashire	Victorious Colocotronis; hull defect	crude

No.	Date	Minimum number of casualties	County	Source of oil and cause of spillage	Oil type
	1976				
44.	January 22	246	Dyfed		fuel
45.	30	1644	Northumberland		lube & fuel
46.	February 5	86	Essex	Mosscliff; hull defect	fuel
47.	7	101	Kent		
48.	18	200+	Orkney		fuel
	1977				
49.	January 1	300+	Norfolk		fuel
50	February 13	513	Highland	HMS Vulcan (shore base)	fuel
51.	16	920	Humberside		
52.	March 5	110	Orkney	Nacella at Flotta terminal	North Sea crude
53.	April 8	1455	Humberside		crude
54.	May 26	50	Northumberland		
55.	September 5	364	Dyfed		fuel
56.	December 7	300+	Cornwall, Devon, Dorset		fuel
	1978				
57.	January 13	70	Humberside		
58.	24	88	Lothian	Onshore installation	fuel
59.	26	5044	Northumberland		lube & fuel
60.	February 3	802	Lothian, Fife	ICI fertiliser plant	fuel
61.	25	204	Norfolk		
62.	March 5	120	Humberside		
63.	16	423	Channel Islands	Amoco Cadiz; grounding, & other vessels	2 crudes & 6 fuels
64.	March 18	246	Northumberland, Borders, Lothian		lube & (probable) fuel
65.	May 1	248	Northumberland	Crude oil cargo tank residues	crude

No.	Date	Minimum number of casualties	County	Source of oil and cause of spillage	Oil type
66.	May 6	203	Norfolk, Suffolk, Kent	Eleni V & Roseline; collison	fuel
67.	October 10	233	Gwynedd, Clwyd	Litopia & Amlwych terminal	crude
68.	12	2541	Dyfed, West Glamorgan, Devon	Christos Bitas; grounding	crude
69.	November 19	142	Gwynedd		
70.	December 8	573	Orkney, Highland	Crude oil cargo tank residues	3 crudes
	1979				
71.	January 3	3704	Shetland	Esso Bernicia at Sullom Voe terminal	fuel
72.	2	129	Norfolk		fuel & crude
73.	27	181	Essex	Tanker at Mobil Coryton terminal	fuel
74.	28	100+	Grampian		fuel
75.	February 9	504	Orkney		fuel & crude
76.	24	331	Orkney	Crude oil cargo tank residues	crude
77.	28	1765	Shetland		fuel & crude
78.	March 6	220	Gwynedd		fuel
79.	31	50	Grampian		
80.	April 4	355	Borders, Northumberland	Baron Venture; tank cleaning	crude
81.	10	792	Orkney, Highland		crude
82.	June 20	227	Highland		fuel
83.	December 12	177	Shetland		crude & fuel
84.	30	2990	Cornwall, Devon		fuel
	1980				
85.	January 2	59	Guernsey, Channel Islands		
86.	31	425	Lothian, Fife		
87.	February 10	100	West Glamorgan	Switha; grounding & other vessels	fuel
88.	17	104	Tayside	Industrial premises	fuel
89.	March 19	2122	Northumberland, Tyne & Wear, Durham, Cleveland		
90.	April 25	85	Northumberland		
91.	May 2	60	North Yorkshire		
92.	4	164	Highland		

No.	Date	Minimum number of casualties	County	Source of oil and cause of spillage	Oil type
93.	December 15	250	Dyfed		
94.	21	351	Kent, Sussex, Hampshire		
95.	29	241	Dorset		fuel
	1981				
96.	January 1	350	Isle of Wight		
97.	30	1500	Norfolk	Ems & Undine; collison	fuel & crude
98.	February 28	147	Devon		
99.	March 7	75	Co.Down		fuel
100.	8	175	Dorset		fuel

Figure 20 Oil pollution incidents which affected more than 50 birds, July 1971-June 1981. Numbers refer to individual incidents which are listed in Table 17.



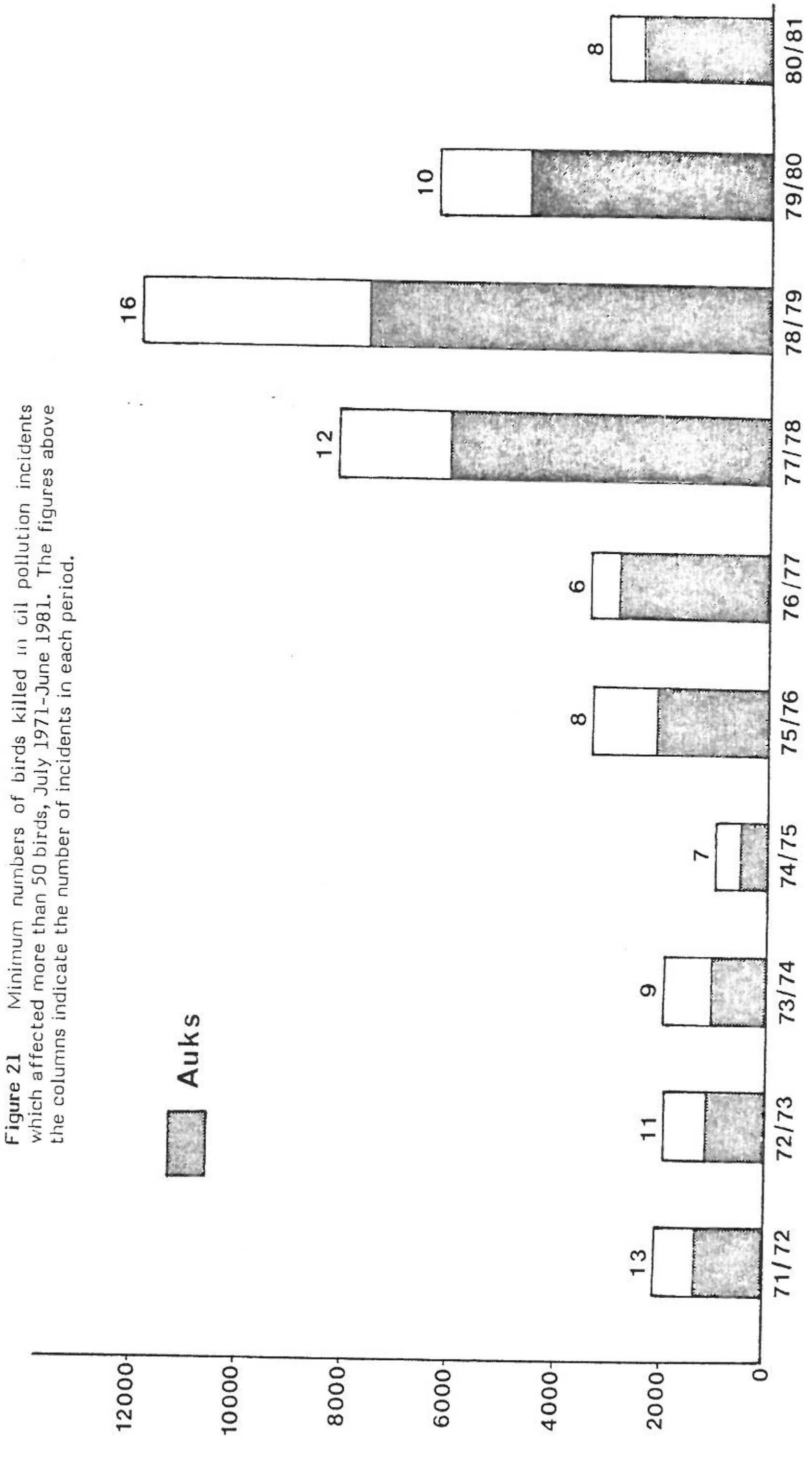


Figure 21 Minimum numbers of birds killed in oil pollution incidents which affected more than 50 birds, July 1971-June 1981. The figures above the columns indicate the number of incidents in each period.

Table 18 Species composition of casualties in oil pollution incidents affecting more than 50 birds. See text for definition of casualties

	71/72	72/73	73/74	74/75	75/76	76/77	77/78	78/79	79/80	80/81
No. of incidents	13	11	9	7	8	6	12	16	10	8
Total Auks	1252	1075	1017	463	2096	2864	6088	7576	4543	2398
Inc. Guillemot	819	607	464	216	1700	2687	5432	5205	3213	1930
Razorbill	191	197	300	25	79	156	381	1259	637	151
Puffin	2	1	8	10	1	3	193	137	24	13
Black guillemot	-	-	5	7	-	15	-	714	1	-
Total Seaducks	68	35	371	27	301	97	405	1000	157	9
Inc. Eider	54	-	46	21	22	63	191	588	116	-
Scoter	10	34	312	3	276	-	18	61	41	9
Long-tailed duck	2	-	-	1	-	34	1	311	-	-
Scaup	1	-	-	1	1	-	130	1	-	-
Goldeneye	1	1	13	1	2	-	65	3	-	-
Divers	11	4	12	11	9	2	61	192	14	6
Grebes	12	38	-	-	7	2	266	60	53	2
Fulmar	5	-	11	-	1	-	55	113	27	4
Gannet	8	39	19	56	1	-	133	279	88	2
Shag/Cormorant	39	5	17	9	10	15	67	792	46	2
Other wildfowl	212	3	161	88	74	1	104	26	74	-
Waders	-	-	3	-	44	13	192	87	7	1
Gulls	83	29	112	24	54	48	411	517	55	8
Others	345	690	208	270	695	306	328	1205	1222	657
TOTAL	2035	1918	1931	948	3292	3348	8112	11847	6286	3089

Oil pollution incidents affecting birds are most frequent in winter (Fig. 22). During the 10 year period none occurred in July or August but subsequently two have been recorded in August (RSPB 1981 unpublished data).

8. International Beached Bird Surveys

Full results from nine European countries, including the United Kingdom, for 1972-81 are given in Appendix B5. Counts for the United Kingdom are presented by four regions (E Britain, S Britain, W Britain and Northern Ireland) and for the Channel Islands. In some years counts were not received from some countries and 1981 results are still incomplete. Counts were first made in Norway and Spain in 1980.

The species composition for each country (Fig. 23) reflects the known winter distributions of some species, e.g. for seaduck corpses the high proportions of found in Denmark, West Germany and The Netherlands and the low proportion elsewhere. Larus gulls formed a substantial proportion of the totals in all countries. The proportions that were auks were generally lowest in the north east, and higher in the west and south west, with the highest proportion, 51.9%, in S Britain. Proportions are not shown for Norway since fewer than 50 birds were found on the one count available (1980), or for Biscay since, in one year (1978) of the two for which data were available, proportions were distorted by the occurrence of a Puffin wreck (Appendix B5) and in the other fewer than 50 birds were found.

Mean densities of corpses show considerable differences between countries/regions. The densities of some species or species groups (Fulmar, Larus gulls, Kittiwake particularly and auks) were strongly influenced by the counts for 1981 when the survey followed several prolonged periods of north westerly winds, during which weather wrecks and oil pollution incidents brought unusually large numbers of birds ashore along the continental coast from the Channel northwards (e.g.Camphuysen 1981). Thus, in West Germany and The Netherlands, densities excluding 1981 results are also presented in Figure 24 for the four species groups. Counts for 1981 have not yet been received for Denmark or Belgium.

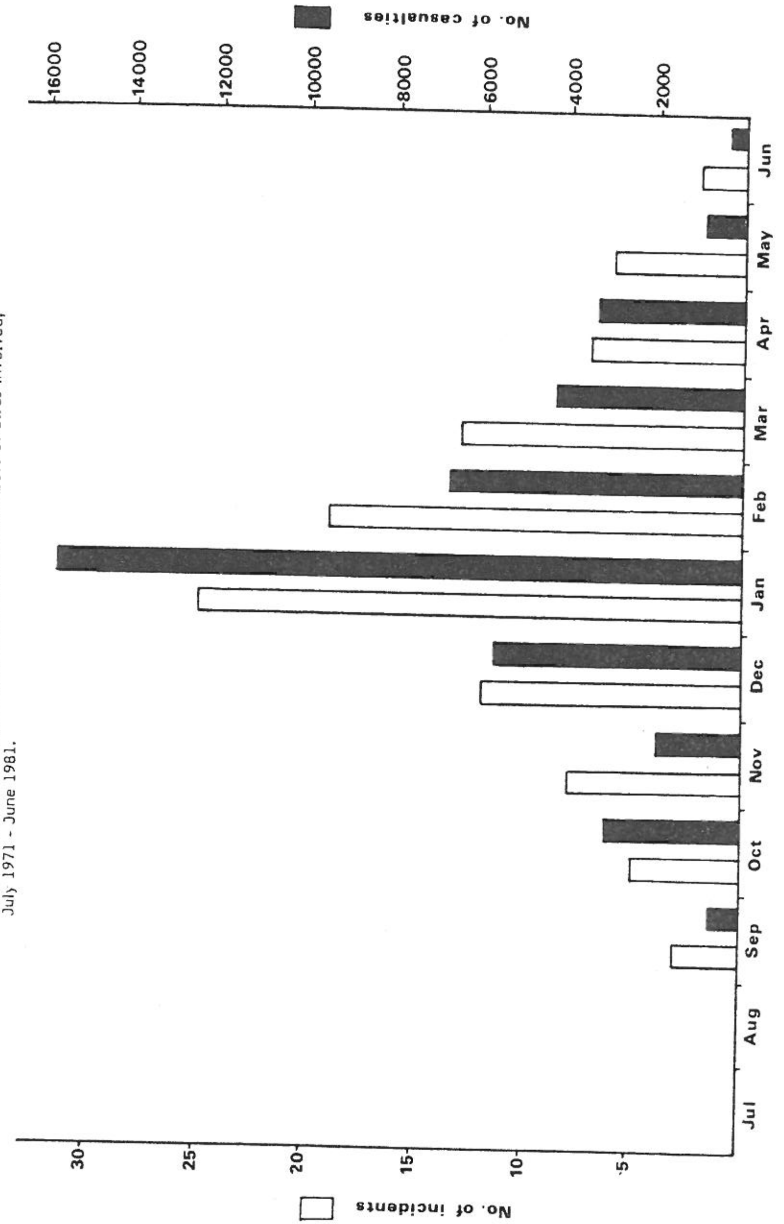


Figure 22 Distribution by month of the number of oil pollution incidents which affected more than 50 birds and minimum numbers of birds involved, July 1971 - June 1981.

Figure 23 Species composition of corpses found on International Beached Bird Surveys 1971-81.

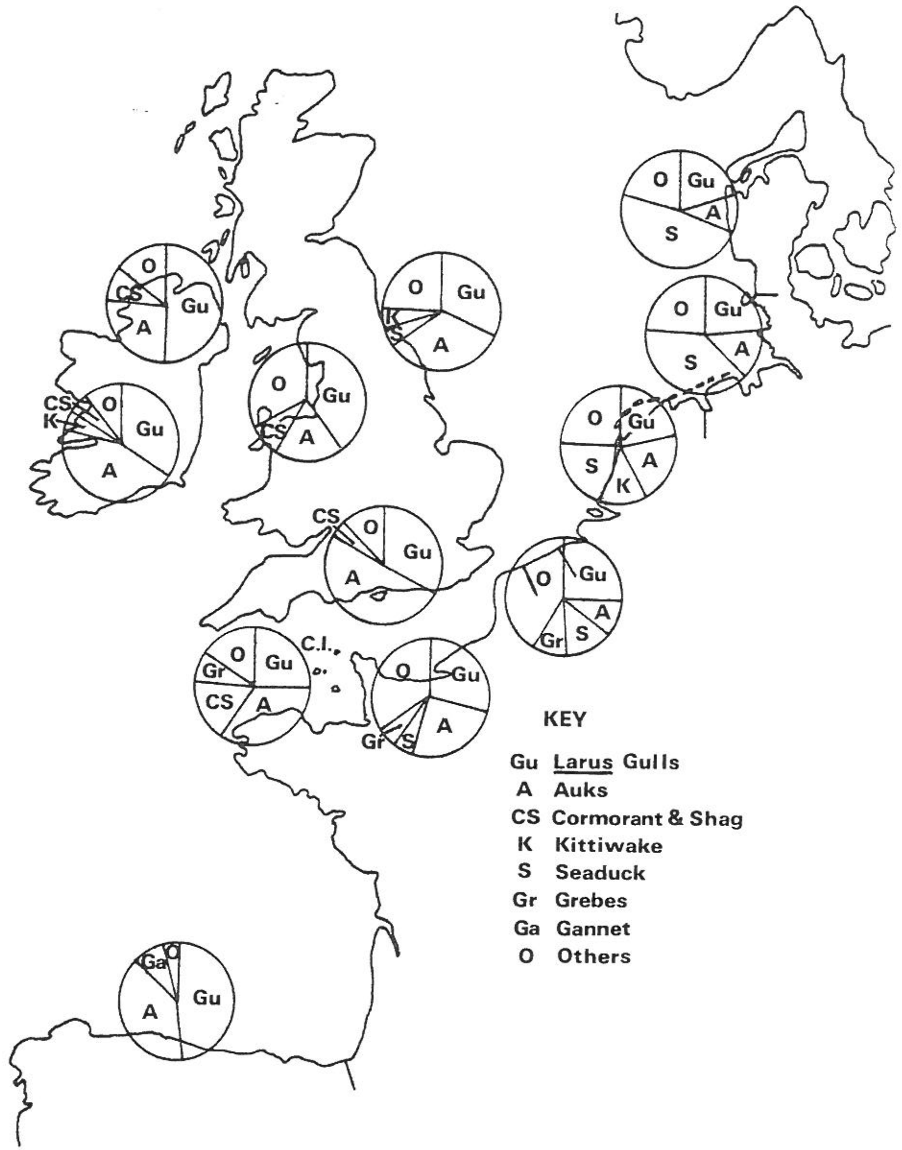
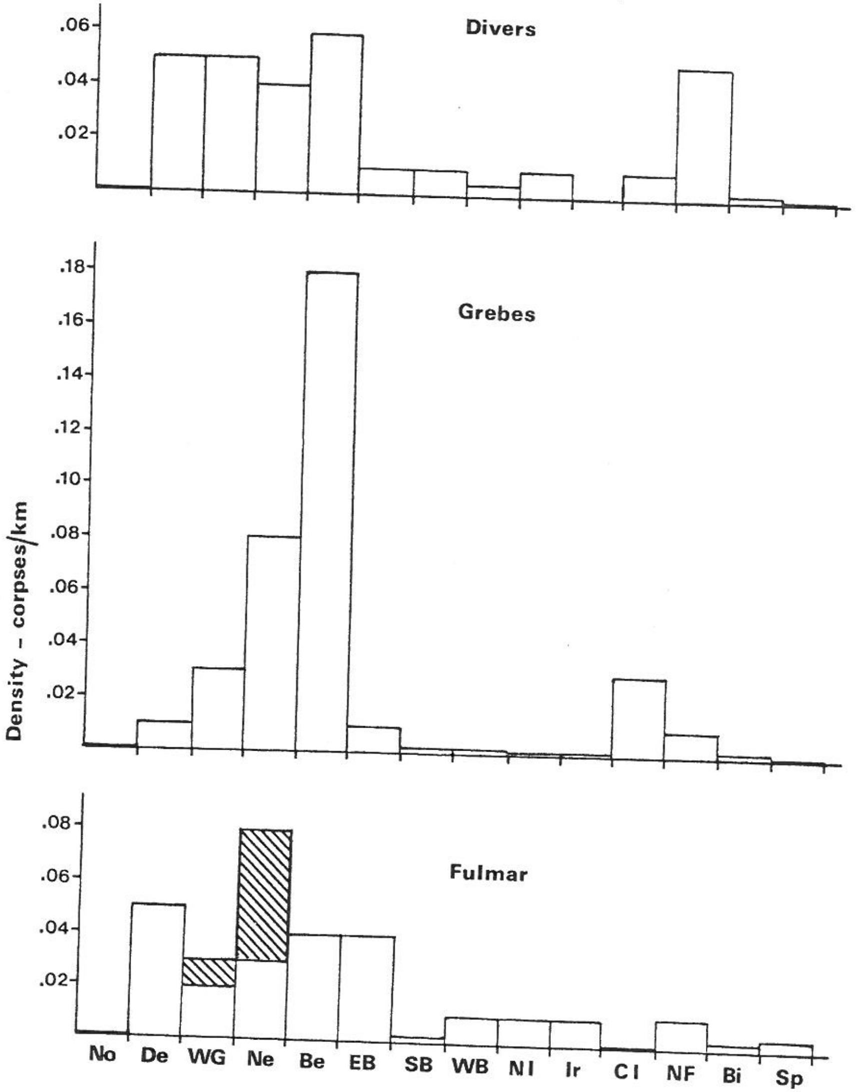


Figure 24 Mean densities of beached bird corpses of different species groups found during International Beached Bird Surveys 1971-81. Densities in some regions were disproportionately influenced by one year's counts (indicated by shading) - see text for explanation.

No	Norway	WB	West Britain
De	Denmark	NI	Northern Ireland
WG	West Germany	Ir	Ireland
Ne	The Netherlands	CI	Channel Islands
Be	Belgium	NF	North France
EB	East Britain	Bi	Biscay
SB	South Britain	Sp	Spain



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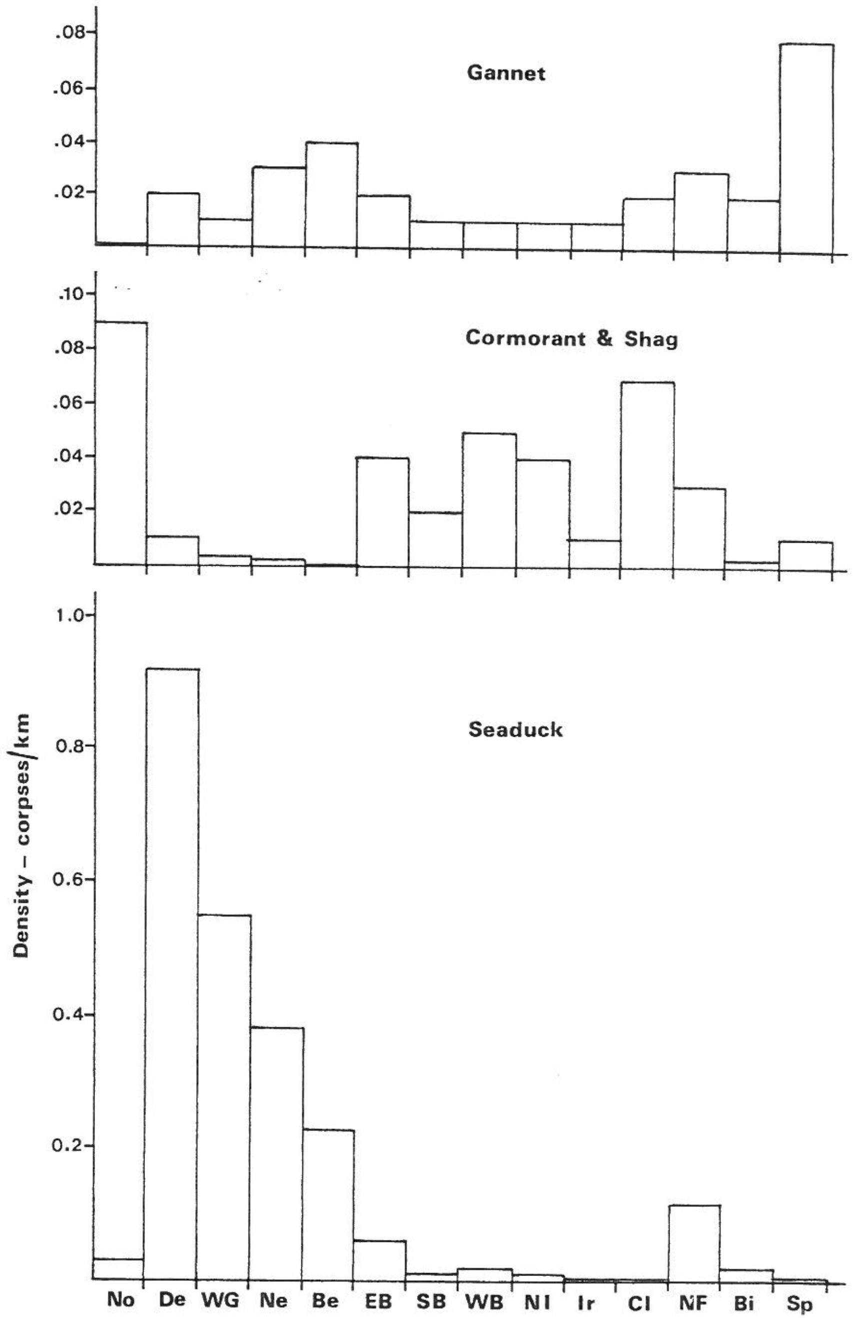

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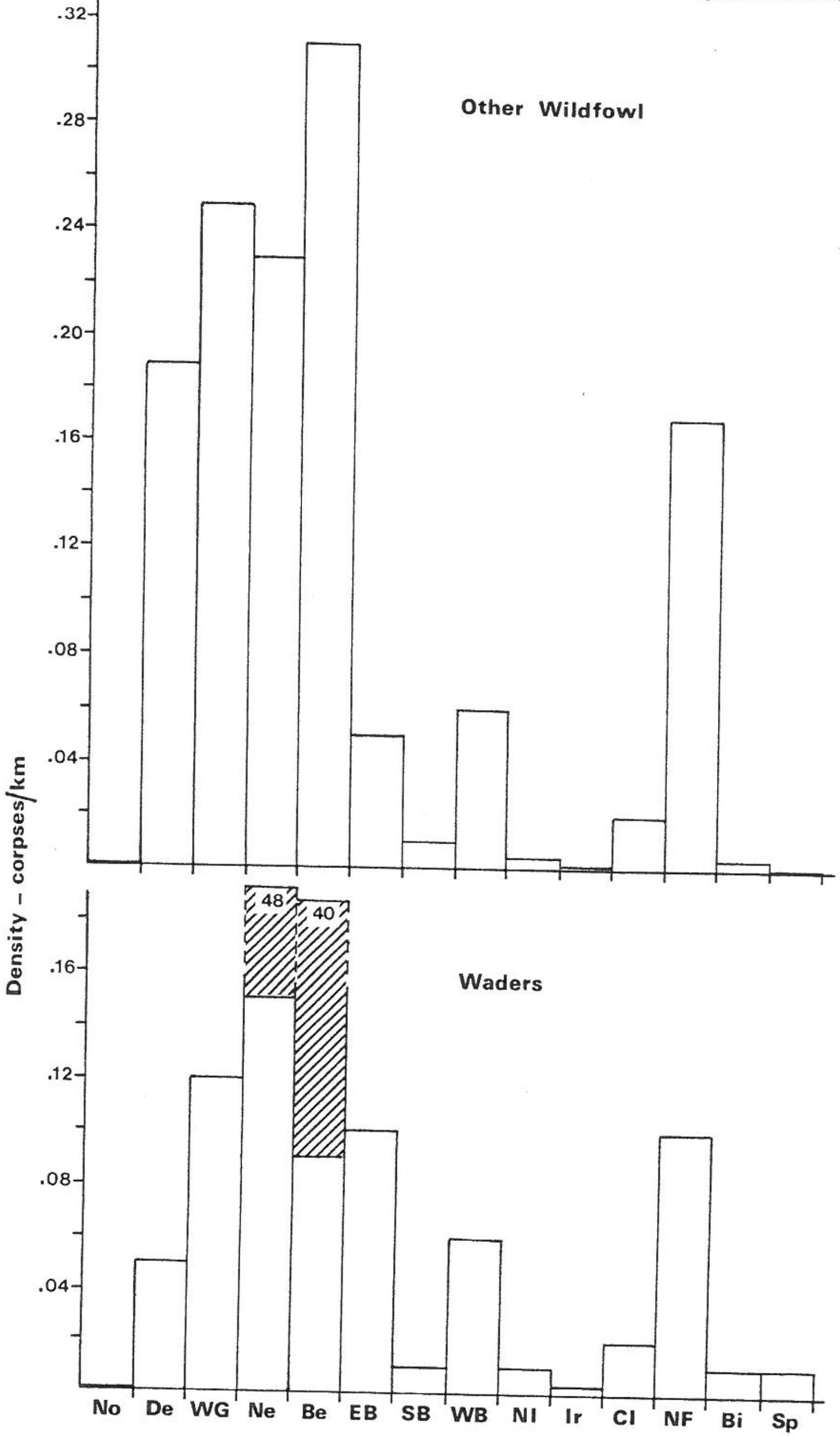

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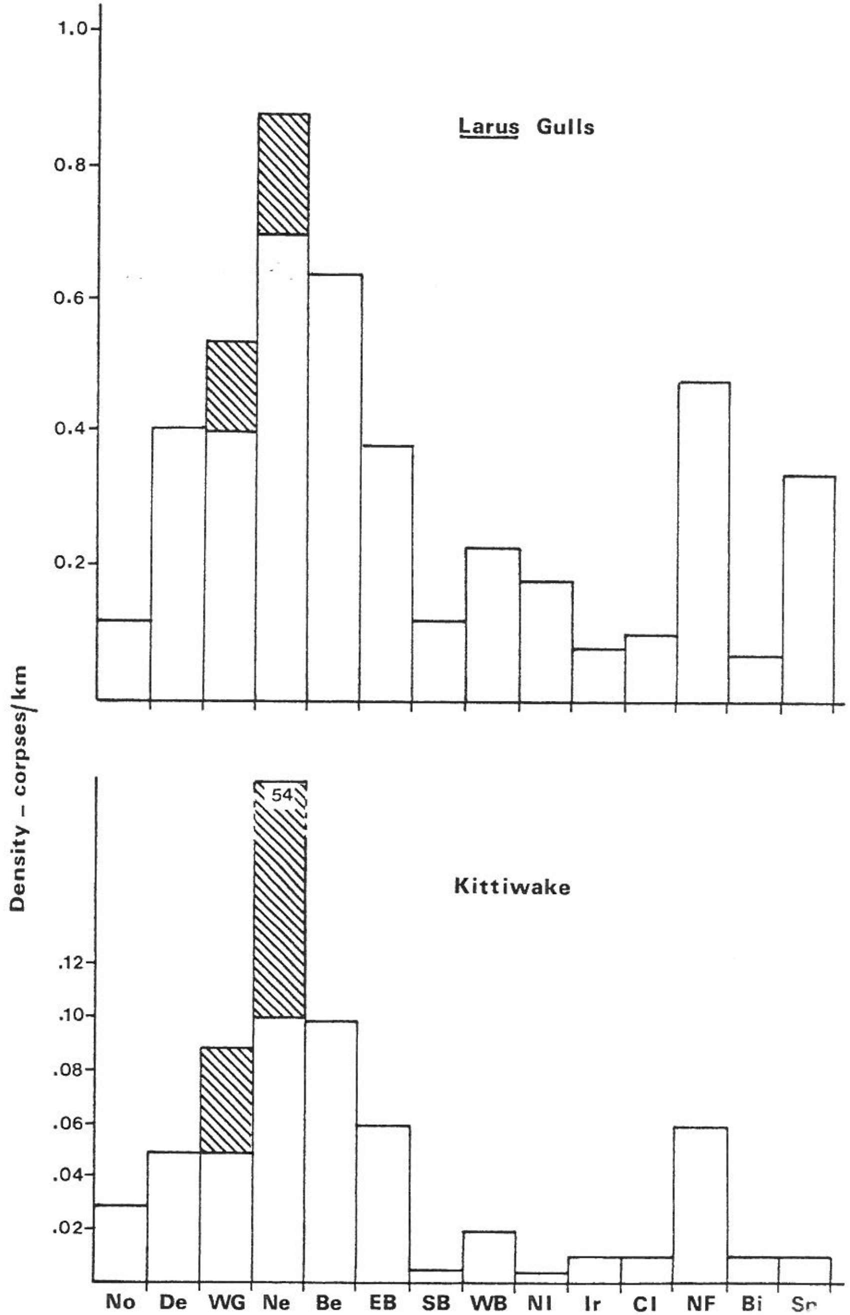
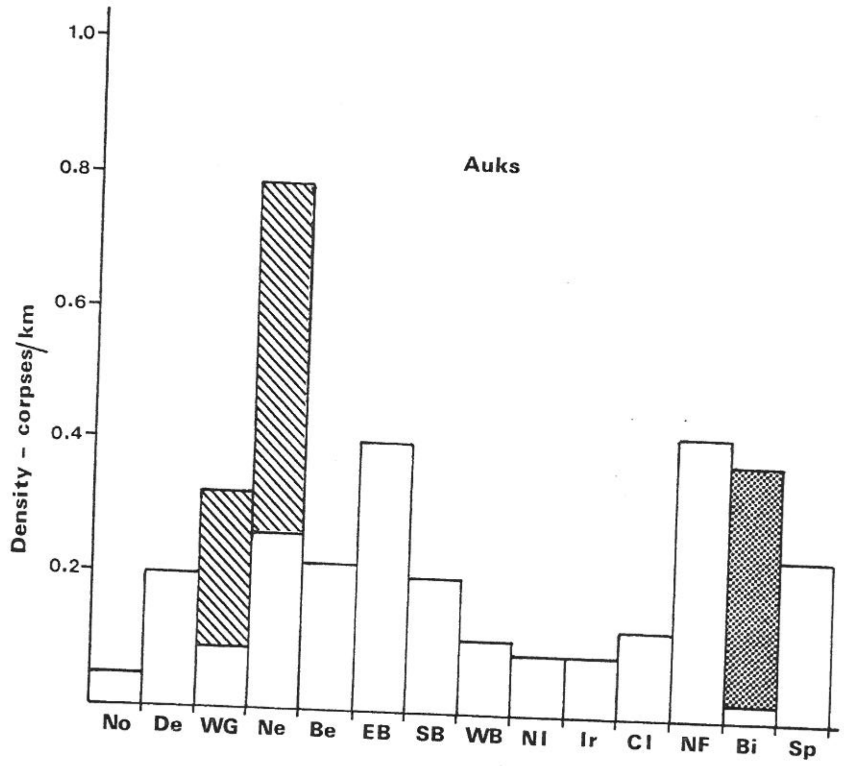


Figure 24 (cont.)



Results for other areas or species groups were not disproportionately influenced by the 1981 counts.

Densities show that corpses of divers were as much as five times more numerous on beaches from Denmark to North France than elsewhere, whilst the density of grebe corpses (0.18 birds/km) found on the short Belgian coast was particularly high.

Comparatively high densities of Gannet corpses were recorded from Spain in 1980 and 1981 as might be expected from the known distribution of the species in winter. However a longer series of data is needed to confirm that these densities are 'normal' and a similar caveat applies to the comparatively high density of Cormorants and Shags in Norway where only one year's data have been received. The high densities of seaduck corpses reflect the distribution of the large winter flocks in Denmark, West Germany and The Netherlands, Counts in 1975 for West Germany (Lloyd 1976) and in 1976 for The Netherlands (R.Luntz in lit.) have been excluded from Figure 24 since these coincided with oil pollution incidents which affected large numbers of seaduck. The densities of other wildfowl and waders may reflect numbers on estuaries and also the frequency of shooting. Shooting was considered by survey participants in North France to be the cause of death of many wildfowl and some waders. Wader densities in Belgium and The Netherlands were greatly influenced by the 1976 counts. The respective national organisers of the survey both considered the increased mortality to be due to severe frosts. The densities excluding 1976 counts are also shown in Figure 24.

The density of auk corpses in E Britain was one of the highest recorded, but overall densities of beached birds in Britain and Ireland were generally lower than those on the Continent. A Puffin wreck in Biscay in 1978 greatly increased the densities of auks and the density excluding 1978 is also shown in Figure 24.

The proportion of Larus gulls found oiled (Fig. 25) was higher in the Channel and the continental North Sea coast than elsewhere. In The Netherlands, the proportion was influenced by the 1981 counts, but nevertheless with 1981 data excluded it was still the highest recorded (66.5%). The proportion of auks found oiled (Fig. 26) showed a pattern similar to gulls, with the highest proportion, not on this occasion influenced by 1981 counts, again occurring in The Netherlands.

Figure 25 Mean proportions of gull corpses found oiled during International Beached Bird Surveys 1971-81. Proportions are not shown for Norway, Biscay (France) and Spain since fewer than 50 birds were found.

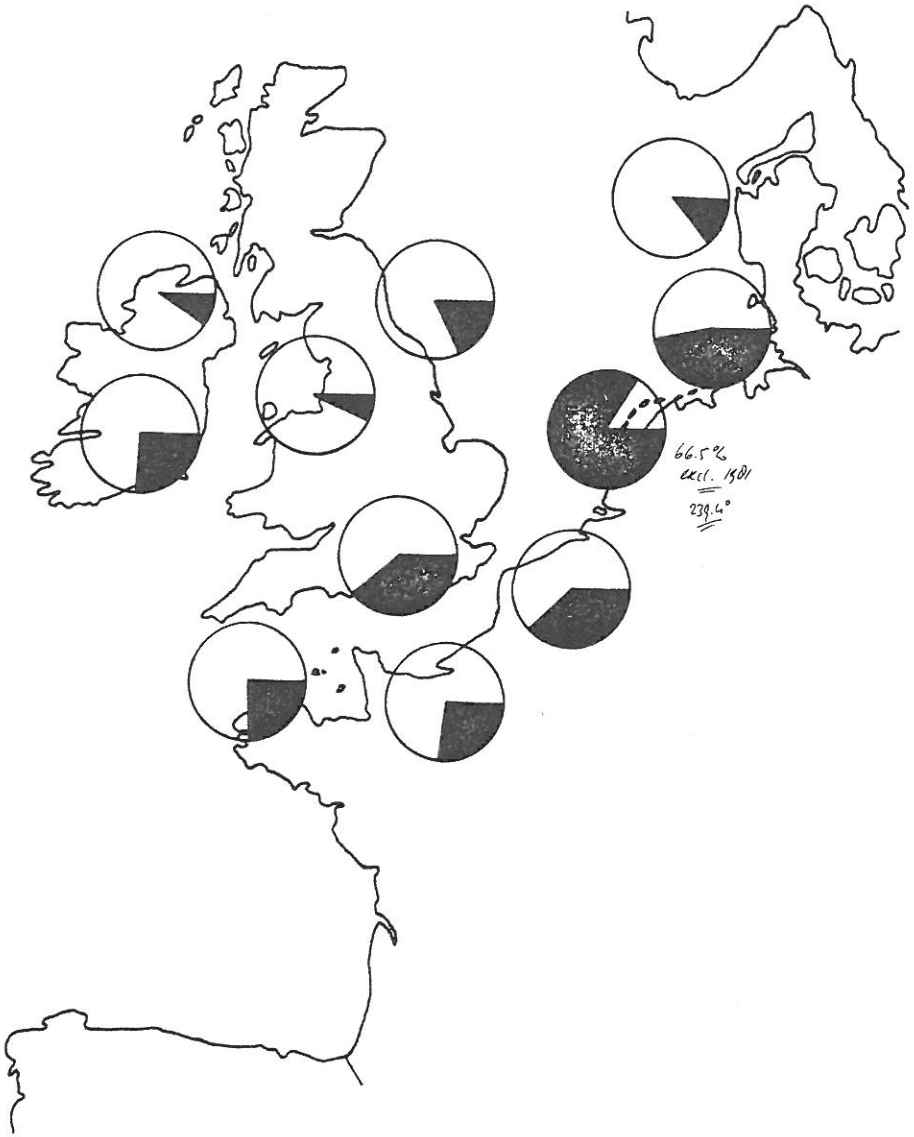
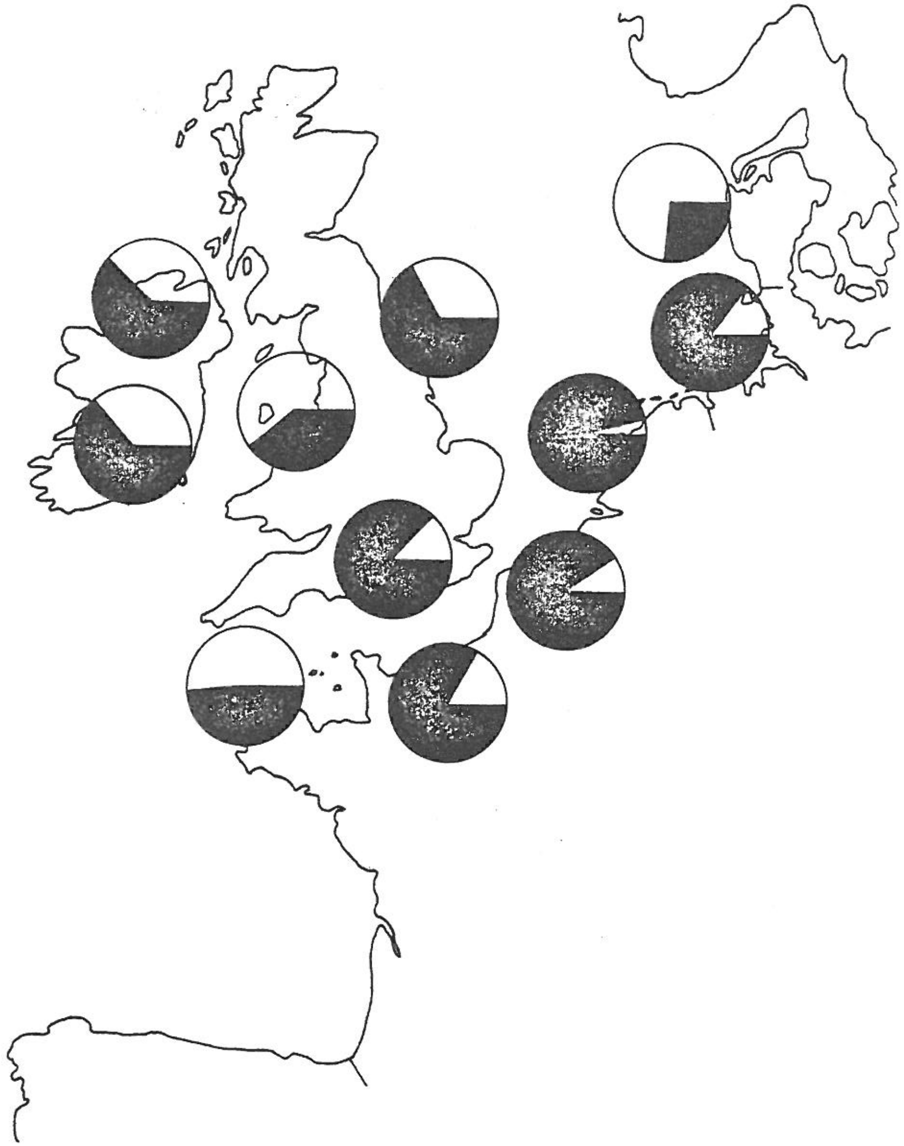


Figure 26 Mean proportions of auk corpses found oiled during International Beached Bird Surveys 1971-81. Proportions are not shown for Norway, Biscay (France) and Spain since fewer than 50 birds were found.



Discussion

The influence of weather on the densities of corpses

Severe winter weather is known to cause extensive mortality amongst some passerine species, e.g. Wren (Hawthorn & Mead 1975) and Dartford Warbler (Bibby & Tubbs 1975) and to increase mortality in other birds such as waders and wildfowl (Goss Custard 1977, Pilcher et al. 1974). However for birds living at sea weather may produce two effects. Low temperatures may exert a direct influence on bird mortality by affecting the birds' daily energy balance, or the distribution and accessibility of prey, or by prolonging the period of time that oil floats on the sea surface in a state dangerous to marine birds (Bourne & Bibby 1975). In severe weather the distribution of birds may also change (e.g. Chandler 1981) altering the pool from which deaths come. Second, the effect of prolonged periods of onshore wind, although perhaps influencing mortality either in extreme conditions, (e.g. gales) or through increasing heat loss, may increase the numbers of corpses coming ashore without any increase in the actual mortality. Experiments have shown that bird corpses drift at between 2%-4% of the wind speed (Hope Jones et al. 1970, Bibby & Lloyd 1977, Bibby in press) and that the general distribution of the recoveries can be explained as a downwind movement of corpses. The temperature effect may thus be a genuine increase in mortality whilst the wind produces a spurious effect. Changes in temperature and wind are related, notably on the east coast where cold spells in winter are frequently produced by an easterly (onshore) airstream.

Examination of the effects of onshore wind and sea temperature shows that these two parameters account for widely ranging proportions (0% - 75%) of the regional variation in corpse density of both Larus gulls and the larger auks. Many factors are liable to obscure the relationship. Not all the birds found dead on beaches have died at sea. Birds purposely seeking the shore, e.g. roosting gulls or oiled auks, have a greater likelihood of being found dead irrespective of the weather conditions. The models fit auk densities slightly better than gull densities presumably because auks are more pelagic and in normal circumstances are not found on beaches. The densities of auks recorded in September and November were lower than in winter and the arrival of a few 'extra' corpses may

have disproportionately distorted the pattern. Also, in each of the autumn counts, a greater time period was available since the preceding survey for corpses to beach under conditions not considered by the models, perhaps reducing the detectability of the effects of weather. Although the counts were best correlated with wind over the 12 or 15 day period, the interval between surveys may have contributed to the better fit of the models in winter than in autumn.

In the open sea there seems no reason to suppose that birds did not drift downwind, perhaps with some displacement due to currents. Nearer the shore, however, the effects of currents and tides are likely to be greater, and probably act to delay beaching. N. Hammond (pers. comm. in Bibby & Lloyd 1977) reported that a line of flotsam, sometimes containing bird corpses, is commonly found off the Cumbrian coast. Apparently only a small proportion is beached at each tide. The magnitude and frequency of such phenomena will vary locally, but presumably the effects will be greatest on severely indented (high energy) coasts. Under moderate onshore wind conditions experimental evidence suggests birds would normally beach (Appendix B7) but once ashore they may be washed off and beached elsewhere. This was recorded for two corpses by Bibby & Lloyd (1977) and for one corpse in Norfolk (Appendix B7).

The failure of the weather parameters to account for any variation in the corpse densites in Wales and W Scotland may partly be due to the nature of the coast. In W Scotland, the majority of counts were made in areas not directly exposed to the onshore (west) wind, notably the Clyde estuary. Clearly, the bearing assigned to the line of coast in both regions did not fit all parts of the coastline well. Further, it is conceivable that in areas with many islands and promontories, corpses can be beached only under certain conditions of wind and tide. Nevertheless, if a strong wind or temperature effect was present it should have been detected. In E Scotland, where the bearing assigned to the line of coasts did not provide the best correlation between density and onshore wind, a relationship with sea temperature was nevertheless clearly demonstrated.

The importance of sea temperature in some regions and not in others requires consideration since cold weather generally tends to affect the country as a whole. As a measure of the coldness of the weather, sea temperature tends to change slowly and should be less influenced by brief cold spells than the land temperature measure. In winter sea temperature was a better predictor of densities on the east coast than on the west, perhaps because easterly winds (onshore on the east coast) tend to bring the coldest weather. The explanation cannot be so simple since wind would otherwise have been more strongly related to densities on the east coast than was shown. There was considerably less year to year variation in densities in west coast regions than in the east and I suspect that variations due to weather may have been insufficiently large to be detected on the west coast.

In many regions the numbers of corpses of gulls and auks observed on beaches have increased over the period. These increases can largely be explained by the effects of the two weather parameters, suggesting that 'background mortality' has not changed between 1971/2 and 1979. The populations of several seabirds have increased over the period (e.g. Stowe in press) so it seems likely that the mortality rates have actually decreased.

Does the Beached Bird Survey monitor seabird mortality?

Bird corpses can arrive on beaches by two methods - those which drift ashore under the influence primarily of wind, but also tides and currents - and those arising from live but presumably sick birds which die in situ. If the numbers of corpses arriving by the latter method is assumed to be low, observed corpse density must, in some way, be related to wind.

However, since many variables obscure the relationship (including the occurrence of bird mortality) it is preferable to walk beaches to assess numbers of birds washed ashore rather than infer densities from observations on the weather. Although the effects of weather can be detected, and in some east coast regions are even quite good predictors of survey results, overall the effects are not particularly systematic. There is much unexplained variation in the results, and some, perhaps most, of this may be real variation in bird mortality - which is what the Beached Bird Survey is intended to detect. Further, the species composition of corpses found on the survey does appear to reflect well the known occurrence of birds offshore.

The higher densities and greater fluctuations in numbers of auk corpses recorded in the east than in the west are presumably a reflection of the larger numbers of birds wintering in the North Sea. As well as birds from east, north and north-west Britain (Cramp et al. 1974) numbers are boosted by auks from foreign colonies (Mead 1974).

Can the Beached Bird Survey be used to infer total mortality?

Several experiments have been undertaken by the RSPB and others to attempt to interpret the findings of beach counts, specifically with a view to inferring total mortality. In these experiments marked corpses were thrown into the sea to determine how many were subsequently found and reported. A summary of the experiments (with references) is given in Table 19. The recovery rates ranged from 100% (ringed gulls thrown into the sea from the beach) to 0.3% (ringed gulls dropped in the North Sea). The upper figure (100%) was derived from an experiment where there was no predation of corpses, sinking did not occur over the few yards the corpses drifted, and corpses were found immediately they came ashore. Since it is unlikely that many birds die and are beached and found under such circumstances a more realistic upper estimate from these experiments might be 59% determined from ringed gulls in the Irish Sea (there were no significant differences between recovery rates from points at different distances offshore in this experiment). The lower figure (0.3%) was derived for birds which were displaced at least 1000 km, and were recovered mainly on the highly indented coast of Norway where there was no Beached Bird Survey at the time. If it is assumed that under the prevailing SW wind conditions corpses arriving on the beaches in the British Isles are unlikely to have travelled as far as 1000 km, that corpses are in general easier to find on the British coasts and that once ashore their chances of recovery are higher, then this rate is too low for general application. A more reasonable lower estimate from these experiments might be 10%. Thus corpse counts under certain conditions may represent a kill of 1.7 to 10 times the observed number of corpses.

However, the reporting of recoveries from the corpse drift experiments has been largely from members of the public or specially requested surveys, and has often continued over several weeks, or even years (Bibby in press). Although birds were more likely to be reported at weekends

Table 19

Results of corpse drift experiments.

Location	Reference	Bird species	Number dropped	% reported	Number examined	% oiled	% of all recoveries oiled
Bristol Channel	Beer (1968)	Juvenile gulls		10			
Farne Islands	Coulson et al. (1968)	Shag		25			
Irish Sea	Hope Jones et al. (1970)	Guillemot	382	20			
		Razorbill	28				
Irish Sea	Bibby & Lloyd (1977) & RSPB unpublished data	Gulls	344	59	91	22.0	10.9
			309	11			
			302	44			
Brittany	Hope Jones et al. (1978)	Gulls	96	30	n/a		
N.North Sea	Bibby (in press)	Gulls	300	0.3			
		Gulls + tags	300	19	45	37.8	27.9
E.Norfolk	Appendix B7	Gulls	50	29	28	28.6	16.3
			50	20			
			20	100			
S.North Sea	Appendix B8	Gulls	150	11	22	52.3	38.6
		Gulls + tags	**98**	**41**			

(Bibby & Lloyd 1977), the corpses were marked and could therefore be reported at any time. On systematic surveys the minimum period between counts is one month, sufficiently long for many corpses to have beached and either been washed off again (Appendix B7) or to have disappeared for other reasons e.g. removal or destruction in situ by predators, or burial. It is not yet possible to differentiate between birds which were not found because they had sunk at sea, and those not found although they had beached. Experiments in Norfolk (Appendix B7) have shown that a quarter of corpses set out at or before the spring tides disappeared by the next spring tide series. In other areas the disappearance rate may be faster. In the Wash 50% of the corpses set out on the highest tideline had disappeared in 2 days in winter and 3 to 4 days in autumn and spring (Goss-Custard et al.1977).

The rate of disappearance varies with species as well as locality. Hope Jones (1980) found that corpses of Kittiwakes and gulls placed above the tideline broke up and would not be likely to be counted by survey participants, whilst diver corpses remained intact for several months.

In certain circumstances, perhaps especially during oil pollution incidents, the recovery rate from corpse drift experiments may underestimate the number actually reaching the shore. When birds become oiled a few may die shortly afterwards whilst some may sink immediately (Tanis & Morzer Bruyns 1968) but many probably attempt to swim ashore. Live oiled birds can reach the shore against the offshore wind (Standring & Stowe 1981). Hence, attempts to infer total mortality need to take into account at least species, location (the situation in estuaries is probably considerably different from other coasts), and time of year. Insufficient information is currently available to make a general estimate.

The influence of weather on the proportion of corpses oiled

Bourne & Bibby (1975) related the occurrence of oiled birds to cold temperatures. Kuyken (1978) showed positive correlations for density of oiled corpses with the ratio of onshore to offshore wind, and with air temperature, but for the proportion of birds oiled the correlation with temperature was not significant.

In the present study, the proportion of birds oiled was not systematically related positively or negatively to wind or sea temperature, although significant relationships were demonstrated in some regions. The results are slightly surprising since the occurrence of major pollution incidents affecting birds showed an increasing trend over the period 1971-79 which was also concurrent with an increasing trend in severity of winters. Most of the significant results required different regression lines for each month, indicating that within winters the proportion oiled was related to month, and perhaps therefore to temperature. The monthly pattern of occurrence of incidents showed a marked peak in mid-winter (Fig. 22). Standring & Stowe (1981) suggested that pollution incidents may be more common in winter as a direct consequence of the weather conditions. Ship operating practices may change under the stress of bad weather. More oil-contaminated ballast may be discharged because of weather conditions and perhaps in the knowledge that under the cover of the long hours of darkness detection by the authorities would be less likely.

Observed trends over time in the proportion of birds oiled suggest decreases in several regions. When the effects of weather are removed and the data examined in detail, there is little evidence of any trends. In general it appears that cold weather increases the density of unoiled birds reducing the proportion oiled, but the precise relationship between the proportion oiled and weather is poorly defined.

The increasing trend in the number of oil pollution incidents between 1971/2 and 78/9 is not due solely to the increasing severity of the winter weather. The 1977/8 total (8,112 birds affected) comprised one major kill of 5,044 birds, whilst in 1978/9 (11,847 birds affected) the opening of the Sullom Voe oil terminal in Shetland was responsible directly for one kill of 3,704 birds (Heubeck & Richardson 1980), and was probably the cause of several other incidents in Caithness, Orkney and Shetland, involving c.3,400 birds (Stowe 1979b).

Does the Beached Bird Survey monitor mortality due to oil pollution?

If the number of birds that clean their plumage of oil (Birkhead et al. 1973, Bourne 1974) but subsequently die because of oil ingested during preening is assumed to be small, the proportion of birds found oiled is probably an overestimate of the proportion actually dying of oil pollution

because some will have been oiled after death. Kuyken & Zegers (1968) calculated that about 5-7% of corpses found on Belgian beaches were oiled in this way. However, recoveries of corpses used in corpse drift experiments have indicated that between 10.9% and 52.3% of corpses may be oiled after death (Table 19), at times when no reported pollution incidents were taking place. These proportions are generally higher than the proportion of gulls oiled during the surveys, but lower than the proportion of auks. However, for a general relative measure of the amount of oil contaminating the sea, oiling after death may not be important and consequently counts of oiled birds may be the best measure currently available.

Occurrence and impact of oil pollution incidents affecting birds

In most cases first reports of the unusual occurrence of oiled birds have come from members of the public. In general the densities of corpses normally found on beaches are so low that most incidents manifest themselves readily. However, on occasions of prolonged onshore wind conditions, small numbers of live oiled birds may come ashore over several days, and it may prove difficult to determine reliably whether the beachings were the sole result of wind or were the effects of a specific isolated discharge. First reports often involve live oiled birds which are often caught and removed from the beach by the public. Systematic surveys are thus of little value in detecting specific pollution incidents.

Auks are the most frequent victims of oil pollution incidents, presumably because they spend much of their time on the sea surface at risk from floating oil and also because they are commonly found in the major shipping lanes where much of the pollution takes place. The shipping lanes along the coast of NE England were the scene of the largest kill in the period 1971-81, when 5,044 birds were washed ashore between Northumberland and Cleveland in February 1978. Only two previous oil pollution incidents in Britain or Ireland are known to have affected more birds - a spillage in north east England in spring 1970 when 12,400 birds were found oiled (Greenwood et al. 1970) and the wreck of the Torrey Canyon in March 1967 when 7,851 birds were found oiled in Cornwall and a further 2000 reported from France (Bourne et al. 1967). The wreck of seabirds in the Irish Sea in autumn 1969 involved at least 12,000 birds (NERC 1971).

In the majority of incidents, the birds affected, notably auks, do not breed near the scene of the spillage and the location of their breeding colonies (or natal colonies in the case of young birds) is seldom known. For auks morphometric and internal examination of the corpses, such as that carried out during the spillage from the Christos Bitas in October 1978 (Morgan 1980), can provide valuable information on the age, sex and general area of origin of the birds. These data can help interpret the likely impact of an incident on the populations.

The only reduction in the numbers of British or Irish seabirds that can reasonably be attributed to an oil pollution incident has occurred locally, in the Black Guillemot and Shag populations of Yell Sound, Shetland, following the spillage from the Esso Bernicia in December 1978 (McKay et al. 1981)

The future of Beached Bird Surveys.

Systematic counts have been carried out since 1971 and valuable results have been obtained, but the frequency of counts may now need reconsideration. For the species of most interest to nature conservationists because of their susceptibility to oil pollution, i.e. divers, grebes, seaduck and auks, the densities in the autumn months are low, and few birds are normally found oiled then. Also densities of both oiled and unoiled birds greater than those in autumn are likely to occur in other months which are not presently covered by the survey, eg. December and April. In Orkney high densities of auks occur between January and May with the highest densities in March (Hope Jones 1980), presumably in part due to the greater number of birds offshore then than in autumn and the early part of the winter. The September survey shows a peak in Gannet and gull densities but since information on age of the birds is not collected the proportion due to post-fledging mortality is not known. The survey is too late to monitor post-fledging mortality in some species, e.g. Kittiwake and auks. Winter surveys show higher densities with greater fluctuations. Presumably the winter period is a time of greater stress for most seabirds resulting in greater mortality. Less evidence of a relationship between densities and weather was found in autumn and some results were difficult to interpret. Hence priority should be given to maintaining or increasing cover in winter, and one or both of the September and November counts might be abandoned, especially if for economic reasons some reduction in the survey is desirable. If at a later

date it was thought necessary to monitor the beaches in autumn, those counts could be re-instated.

To improve further the interpretation of the winter counts, a computer-based model might usefully be developed to predict densities of corpses on beaches using wind data. Some preliminary work has already provided promising results (RSPB unpublished data). The model should be capable of predicting the time and place of beaching, if due solely to wind, for a corpse put in the sea at a given location. Tide/current displacement may subsequently be incorporated if sufficient data are available. A probability could be attached to the chances of sinking, beaching and loss of the corpse from the beach before it can be counted. Results of corpse drift experiments could be checked against predicted results. A further experiment, dropping batches of corpses over a time period at one place, may be worthwhile to test the predictions of the model.

Conclusions and Recommendations

The Beached Bird Survey has provided information on the regional, seasonal and annual patterns of occurrence of dead birds on beaches. This examination has demonstrated that the effects of weather, as described by the wind and sea temperature parameters, can be removed from observed densities of beached birds in most regions, enabling improved interpretation of the survey results, and enhancing the survey's capability to monitor seabird mortality.

Trends over time in the observed densities of gulls and auks indicated statistically significant linear increases in many regions, but once the effects of weather were removed there were no genuine trends. A further examination when a longer series of data is available would be advisable to confirm present findings.

Reliable assessment of total seabird mortality from the systematic survey cannot be achieved but some further investigation may be possible.

Although the proportion of birds found oiled may include those oiled after death, the Beached Bird Survey does provide a picture of the regional patterns of the occurrence of oiled birds. The proportion oiled was not systematically related to weather, but some relationship does appear to exist, since severe winter weather increases the numbers of unoiled birds.

Trends over time in the proportions of gulls and auks found oiled indicated statistically significant linear decreases in several regions but once the effects of weather were removed there were no genuine trends.

(1) **The systematic Beached Bird Survey should continue. However, interpretation of results should always take account of weather especially in assessing trends over time.**

It is important, in order to justify the use of c.800 volunteers who donate their time and effort to collect the data, that full use is made of the results. It is desirable that the distance covered per count is maintained or perhaps increased, since densities of many species are already rather low for a full analysis.

(2) **Distance covered per count should be maintained or improved.**

However, the frequency of the counts could be reduced. The September and November counts showed lower densities of the bird species of greatest interest and than in the winter months, and this and the poor relationship with weather made results less easy to interpret. The proportions of birds oiled were also lower in the autumn. Higher proportions are likely to occur in other months including those in which no systematic surveys currently take place, so for the purpose of monitoring oil pollution the autumn counts are not the most appropriate.

(3) **The September and/or November counts could be abandoned.**

Corpses of birds which die off the east coast of Britain may beach in Norway and auks from British colonies are washed ashore there, sometimes in large numbers. Surveys in Norway may thus provide useful information.

(4) **Encouragement should be given to the Norwegians to extend beach surveys on west-facing beaches.**

During bird mortality incidents, notably those caused by oil, surveys of beached birds are probably the best means of assessing the extent and relative seriousness of the kill in conjunction with an examination of the influence of weather. Corpse drift experiments during incidents can provide an estimate of total mortality, but are probably only justified where large numbers of birds are likely to be affected. Three areas where major oil pollution incidents have frequently occurred, or are likely to occur, and where there are large concentrations of birds, warrant particular attention for further experiments: Firth of Forth, north east England and the Moray Firth.

Corpse drift experiments have shown that corpses drift downwind, for gulls at 2.5%-4% of wind speed, and recovery rates have varied depending on geographical location. The fate of gull corpses in the open sea now appears relatively well understood and further experiments of this type are probably not profitable. It would be valuable to determine experimentally whether auk corpses drift at similar speeds to those of gulls. Such experiments might be carried out more conveniently at gravel pits.

(5) **Surveys during major mortality incidents should continue. Corpse drift experiments and an examination of the influence of weather should be undertaken in the largest incidents to attempt to estimate total mortality.**

(6) **The age and origin of birds, especially auks, affected in major incidents should be investigated to assist in the understanding of the impact of such incidents.**

(7) **Calibration of drift rates of auk corpses against those of gulls should be undertaken.**

Insufficient is known of the fate of corpses in inshore waters and the disappearance of corpses from beaches, in particular in relation to the currents and tidal cycle to make a general appraisal.

(8) **Experiments should be carried out in different areas to improve the understanding of the fate of birds in inshore waters and once they have been beached, and should be carried out on coasts where human disturbance is at a minimum.**

Corpses used in experimental work have been collected from the scene of culling operations and have been stored in a cold store until required. Hence they pose handling and storage problems. If an artificial corpse could be developed, this would have the advantages of being easily stored and readily accessible, especially for use at short notice in mortality incidents. The constraints are that it would have to drift at the same speed as an ordinary corpse and that it could not be predated, and over time it would not change density or sink. Further it would have to look like a bird to attempt not to bias finding rates, especially when covered in oil, but it may still attract more attention than a real corpse.

(9) **The possibility of developing an artificial corpse should be explored.**

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BEACHED BIRD SURVEY INSTRUCTIONS & RECORDING CARD

Observer	Distance (in kms.)	Day	Mon	Year	County	Office Use

Starting Place	Grid Ref	Ending Place	Grid Ref

Species	Number of dead				No. of sick			Oil on beach		
	State of oiling			Wings*	State of oiling			State of oiling		
	Clean	Slight	Heavy		Clean	Slight	Heavy	Clean	Slight	Heavy
Razorbill										
Guillemot								Other comments incl. healthy oiled birds		

*Min. number of birds involved

BEACHED BIRD SURVEY

This card has been jointly adopted by the Nature Conservancy Council, the Advisory Committee on Oil Pollution of the Sea, the Royal Society for the Protection of Birds, the British Trust for Ornithology, the Wildfowl Trust, the Seabird Group, the Society for the Promotion of Nature Conservation and the Royal Society for the Prevention of Cruelty to Animals, for use in the following circumstances.

A. Counts made on the special weekends in September, November, January, February and March. These counts should be made on **the same stretch of beach**, for comparative purposes. The dates are those weekends which include the last Saturday in the month. Counts made in the preceding or following weeks may be submitted as alternatives.

B. Emergency surveys of sites affected by major pollution or other bird mortality incidents when visits should be made as frequently as possible as long as the pollution continues. Such incidents should be reported **immediately** to the RSPB (telephone: Sandy (0767) 80551) who will ensure that other organisations are informed as appropriate.

Local organisers normally coordinate emergency surveys in liaison with the National Beached Bird Survey Organiser at The Lodge. Local organisers have home telephone numbers of appropriate RSPB HQ staff to enable contact outside normal working hours.

Any additional regular counts are welcomed (particularly in July, August and December). These should be entered on the pink form. If a pink form is used, all counts entered on the cards should be copied on the form as well, but clearly marked as "Priority Count". This makes the pink form more useful, as a complete record of findings in any one year, and also insures against possible loss of the cards in the post.

Please return cards to the **Local Organiser as soon as possible** after they have been used. Where there is no Local Organiser please return direct to The Lodge. Pink forms should be returned by July.

In cases of exceptional numbers of dead birds being found, or of severe oil pollution, please contact the RSPB, Sandy (0767) 80551 immediately. Outside normal working hours an Ansaphone is in operation. By telephoning the emergency number given by the Ansaphone appropriate staff can be contacted.

PTO for Instructions

PRIORITY COUNT CARD INSTRUCTIONS

1. Use one card for each count on a Priority Count weeken: or during an Emergency survey. If more than eleven species are found, please use a second card clipped on to the first. Please fill in a card even if no birds are found. The results for separate stretches of coast, even if covere: by the same counter, should be entered on a separate card.
2. Please give a name of the starting and finishing points and a six figure ordnance survey grid reference if possible. The same area should ideally be counted each time and the distance measured in KILOMETRES.
3. Walk along the high tideline (preferably the one related - the most recent spring tide) looking above and below it.
4. Indicate in appropriate columns the number of birds found dead, or sick — that is moribund or incapacitated but **not** those oiled and apparently healthy. Please recor: all corpses (including those apparently long dead), enter numbers not ticks in the boxes.
5. Please record any apparently healthy oiled birds seen, eg gulls with oil smears, in the other comments column.
6. Where a single wing, or two wings joined together are all that remain of a corpse, please record in the "wings" column the minimum number of birds thought to be involved, **not** the total number of wings found.
7. Record the amount of oiling on the corpses or the beach as follows:
   Clean = unoiled
   Slight oiling = less than half the surface of a corpse, including patches or smears on plumage. Patches on tideline.
   Heavy oiling = corpse or tideline extensively covered.
8. When a corpse has been examined please remove it from the beach so that it is not counted again.
9. Please examine birds' legs for rings. If found, these shou be sent to the BTO, Beech Grove, Tring, Hertfordshire, HP23 5NR, together with details of whether the bird was oiled, whether found in association with other bodies, and whether found during a survey. Please double check the ring number, and record on the card. If possible, please send us a wing or the body, as these are particularly useful when the origin and age of the bird is known.

Appendix B2

STORAGE AND RETRIEVAL OF BEACHED BIRD SURVEY DATA

All information contained on the survey card (Appendix B1) is stored on computer, except starting and finishing place names and entries under 'Comments'. Error-finding programs can be used to check the consistency between the stated distance and the grid references, the grid references and county, that the location given is on the coast, and identify any unusually large distance walked or total of species found.

Information may be extracted using the following parameters:

<u>Totals</u> dead : unoiled, slightly oiled, heavily oiled, slightly + heavily oiled, all.

wings : wings, wings + dead.

sick : as for dead.

density : any of the above can be expressed as a density. Length alone can also be requested.

Limit : 10 Totals parameters.

<u>Species</u> Any species or combination of species.

Limit : none.

<u>Place</u> Any county or region or combination of counties or regions, or any polygon defined by O.S. 8-character grid references.

Limit : none for counties

maximum of 10 grid references for the polygon.

<u>Date</u> Any date(s) or consecutive period(s).

Data may be sorted by day and/or month and/or year.

Limit : 10 dates or consecutive periods.

<u>Wind</u> Wind vectors (nautical miles/hour/day) resolved for any angle for any period can be requested with the Total parameters. Vectors for east and north displacements (units as above) may also be obtained independently.

Limit : Met. Office wind data only currently available 1971-79 inclusive.

<u>Other</u> Information on the number of cards and the state of oiling of beaches can also be requested. Data may also be selected by observer, length of beach walked, reference number or grid reference.

No statistical package is available but some statistics, e.g. regression, analysis of variance, are available.

Reasonable requests for information should be made in writing to Research Department, RSPB, Sandy, Beds. SG19 2DL.

Appendix B3

TOTAL DISTANCES (KM) OF BEACH SURVEYED IN EACH MONTH 1971 - 79

	9 counts 1971-79		8 counts 1972-79			
	Sep	Nov	Jan	Feb	Mar	Total
N Scotland	720.1	817.3	620.5	914.7	577.3	3649.9
E Scotland	470.4	721.7	597.2	850.1	458.8	3098.2
Firth of Forth	1074.5	1182.1	1141.6	1329.4	1043.2	5770.8
NE England	1571.4	1614.0	1389.9	1546.6*	1226.2	7348.1
SE England	2587.9	2529.0	2172.3	2684.8	1849.2	11824.2
S England	938.4	961.1	944.7	962.3	799.3	4605.8
Channel Islands	330.3	440.2	320.2	496.9	391.5	1979.1
SW England	1137.6	1223.8	1117.0	1234.2	917.9	5630.5
Wales	1548.2	1996.0	1645.5	1700.4	1313.8	8203.9
NW England	2736.1	2860.1	2663.7*	2680.6	2330.3	13270.8
Northern Ireland	1205.3	1354.7	992.1	870.0	734.7	5156.8
W Scotland	1901.5	2103.5	1776.0	2260.8	1433.9	9475.7
TOTAL	16221.7	17803.5	15381.7	17530.8	13076.1	80013.8

* lower distance totals apply for auks in these months since counts coinciding with major incidents were excluded.

Appendix B4

EXTENT OF COASTLINE IN REGIONS

(See Fig. 1)

N Scotland	Cape Wrath (NC 256 751) to Fraserburgh (NK 000 657), excluding Orkney and Shetland.
E Scotland	Fraserburgh to Tayside/Fife border (NO 212 183).
Firth of Forth	Tayside/Fife border to Borders/Northumberland border (NT 979 576).
NE England	Borders/Northumberland border to Humberside/ Lincolnshire border (TA 338 051).
SE England	Humberside/Lincolnshire border to Dungeness (TR 007 176).
S England*	Dungeness to Hampshire/Dorset border (SZ 218 931), including Isle of Wight.
Channel Islands	Alderney, Jersey, Guernsey, Herm.
SW England*	Hampshire/Dorset border to Avon/Gloucestershire border (ST 632 977), including Isles of Scilly.
Wales	Gwent/Gloucestershire border (ST 543 912) to Clwyd/ Cheshire border (SJ 266 750).
NW England	Clwyd/Cheshire border to Cumbria/Dumfries and Galloway border (NY 325 664).
W Scotland	Cumbria/Dumfries and Galloway border to Cape Wrath including Western Isles.
Northern Ireland	Ireland/Northern Ireland border (Lough Foyle; C 474 246) to Northern Ireland/Ireland border (Carlingford Lough; J 133 185).

* Different boundary divisions were used for S and SW England during the examination of the effects of wind and temperature. The S England region was enlarged westwards to Lands End (SW 342 250). The SW England region started at Lands End, extending to the Avon/Gloucestershire border as before. No counts were made in Gloucestershire.

Appendix B5

INTERNATIONAL BEACHED BIRD SURVEYS 1972-81

** denotes surveys coincided with specific oil pollution incidents affecting large numbers of birds. Density figures exclude counts of species involved.

1972	Norway	Denmark	West Germany	Netherlands	Belgium	E Britain	S Britain	W Britain	N Ireland	Ireland	Channel Islands	N France	Biscay	Spain
Distance(km)		80	377	314		912	197	772	16		23	396	35	
Divers			36	18		13	2		1			18		
Grebes			19	37		5	2	1				18		
Fulmar			1	2		25		1	1			2		
Gannet		2	5	6		36		6				8	1	
C/Shag			1			31	3	10				2		
Eider			113	17		11		5				1		
Scoter		1	70	57		9	1	17				25		
Other seaduck			1	13		21								
Other wildfowl		1	175	79		26	1	30				8	1	
Waders		1	62	63		44	1	18				31		
Larus gulls		4	272	160		302	15	95	7			128	8	
Kittiwake			24	14		46	2	4				16		
Razorbill		1	11	9		119	31	10	19			69	1	
Guillemot		3	28	54		198	42	39	15		2	29	1	
Puffin						15						2		
Other auks			1	1		7		1						
Others			1	2		2	1					6		
TOTAL		13	820	532		910	101	237	43		2	363	12	
Corpses/km		0.16	2.18	1.69		1.00	0.51	0.31	2.69		0.09	0.92	0.34	
% auks oiled		50.0	97.5	100.0		71.1	91.8	60.0	94.1		50.0	86.0	0	
% gulls oiled		0	69.6	50.0		18.4	41.2	30.3	42.9		0	35.4	0	

1973	Norway	Denmark	West Germany	Netherlands	Belgium	E Britain	S Britain	W Britain	N Ireland	Ireland	Channel Islands	N France	Biscay	Spain
Distancs (km)		708		314	63	870	202	871	173	10	52	202		
Divers		33		15	4	8		7	4			31		
Grebes				32	7	1		3				24		
Fulmar		59		8		2		19	1			2		
Gannet		17		16	4	2	1	11	1		2	39		
C/Shag		4				15	3	39	4		1	1		
Eider		574		12		18		10						
Scoter		354		198	19	6		9	1			46		
Other seaduck		9		2		2		9	1			11		
Other wildfowl		72		50	3	18		106	1					
Waders		32		21	2	30		96			1	8		
Larus gulls		340		246	35	147	10	327	4		5	186		
Kittiwake		50		26	7	8		13						
Razorbill		23		37	25	10	1	31	5		2	113		
Guillemot		77		33	12	77	13	88	3			131		
Puffin						1						1		
Other auks		4		3				1						
Others				3	1			1						
TOTAL		1648		702	119	345	28	770	25	0	11	593		
Corpses/km		2.33		2.24	1.89	0.40	0.14	0.88	0.15		0.21	2.94		
% auks oiled		83.7		78.1	100.0	76.1	85.7	51.7	87.5		100.0	100.0		
% gulls oiled		17.7		65.8	73.8	12.9	50.0	9.4	25.0		60.0	57.0		

1974	Norway	Denmark	West Germany	Netherlands	Belgium	E Britain	S Britain	W Britain	N Ireland	Ireland	Channel Islands	N France	Biscay	Spain
Distance (km)			152			896	173	711	30	26	69	505		
Divers						4	1	3			2			
Grebes								1			14	59		
Fulmar						5		8				3		
Gannet			1			12	4	4	1			16		
C/Shag						16	4	49	3	2	27	46		
Eider			5			8	2	4						
Scoter			3			2	2	18				5		
Other seaduck						6	1	10						
Other wildfowl			2			25		45	1		1			
Waders			1			24		40			1	4		
Larus gulls			5			171	5	132	4		5	179		
Kittiwake			7			15	2	23			4			
Razorbill			6			34	25	65	1		32	108		
Guillemot			6			78	31	148	1		1	23		
Puffin						2	1	1			3	11		
Other auks						4								
Others			1			2	2	2						
TOTAL			37			408	80	553	11	2	90	454		
Corpses/km			0.24			0.46	0.46	0.78	0.37	0.08	1.30	0.90		
% auks oiled			75.0			71.2	93.0	31.8	0	0	19.4			
% gulls oiled			75.0			13.4	71.4	5.2	0	0	22.2			

1975	Norway	Denmark	West Germany	Netherlands	Belgium	E Britain	S Britain	W Britain	N Ireland	Ireland	Channel Islands	N France	Biscay	Spain
Distance(km)			433	134	242	901	186	1241	79	31	60	471	250	
Divers			27			4		4				3	2	
Grebes			7	1	2	2						1	1	
Fulmar			19	3		16		12						
Gannet			21	6	6	14	5	10	1			11	8	
C/Shag						23	3	56	1	2	1	4		
Eider			**1181	15	1	8		4	2					
Scoter			84	10	23	2		13				26	2	
Other seaduck			6	1		3		1						
Other wildfowl			53	3	2	31		26						
Waderes			52	14	2	32		41	1		1			
Larus gulls			144	55	71	187	26	154	4		3	143	20	
Kittiwake			72	3	9	25		9						
Razorbill			13	12	33	32	4	40	16	2		45	3	
Guillemot			67	9	31	136	20	49	3	5	1	41	2	
Puffin						3	1	1						
Other auks			4	1	3	4	2	8	1					
Others						1		1						
TOTAL			1750	133	183	523	61	429	29	9	6	274	38	
Corpses/km			4.04	0.99	0.76	0.58	0.33	0.35	0.37			0.58	0.15	
% auks oiled			90.5	100.0	97.0	62.3	71.8	27.6	15.0					
% gulls oiled			52.3	75.9	58.8	17.0	57.7	3.7	0					

*Includes 164km of N France, 15km of SW Netherlands, 63km of Belgium

1976	Norway	Denmark	West Germany	Netherlands	Belgium	E Britain	S Britain	W Britain	N Ireland	Ireland	Channel Islands	N France	Biscay	Spain
Distance(km)		410	177	170	32	927	304	879	176	93	71	141		
Divers		9	7	9	3	7	5	4	1			8		
Grebes			1	23	2	6	1	2			1	12		
Fulmar		13	8	11	5	34		12	2			10		
Gannet		1	1	7	3	8	1	4		3	1	3		
C/Shag			1			66	6	34	9		4			
Eider		133	110	**774		37	1	2						
Scoter		56	16	28	5	17		10				26		
Other seaduck			1	23		16		5						
Other wildfowl		88	73	89	5	56	5	56			5			
Waders		14	19	582	102	144	7	51	1	1	2	36		
Larus gulls		111	82	127	23	301	51	170	20	4	12	204		
Kittiwake		13	8	21	5	48		13		3	1			
Razorbill		2	2	8	4	76	22	25	3	3	2	26		
Guillemot		3	10	21	3	324	30	59		2	2	19		
Puffin				3		3	1	2				7		
Other auks		4				15		7				2		
Others						4		2				2		
TOTAL		447	339	1726	160	1162	130	458	36	16	30	355		
Corpses/km		1.09	1.92	5.60	5.00	1.25	0.43	0.52	0.21	0.17	0.42	2.52		
% auks oiled		66.7	91.7	100.0	100.0	68.4	77.4	22.6	0	20.0	50.0	70.4		
% gulls oiled		2.4	43.3	93.9	53.6	15.8	29.4	6.0	0	0	23.1	11.3		

1977	Norway	Denmark	West Germany	Netherlands	Belgium	E Britain	S Britain	W Britain	N Ireland	Ireland	Channel Islands	N France	Biscay	Spain
Distance(km)		652	399	257	63	888	224	850	80	61	51	13		
Divers		44	10	13	2	10	1	6						
Grebes		5	1	7	1	1						2		
Fulmar		41	8	11	2	33	1	21		3		1		
Gannet		17	7	7	3	16	9	10	3	3	1	1		
C/Shag		6	1	2		81	2	35	5					
Eider		177	120	17		33		1						
Scoters		307	181	56	3	17	1	13				2		
Other seaduck		5	19	17	1	8								
Other wildfowl		171	112		1	41	1	66			1	1		
Waders		52	54	19	2	48	1	64			2	3		
Larus gulls		289	209	267	26	338	33	214	8	7	4	10		
Kittiwake		33	2		12	33	2	13	1	2		5		
Razorbill		27	9	18	1	95	7	15	4	4	1	1		
Guillemot		63	10	39	5	378	7	35	9	15		5		
Puffin			1	1		5	3							
Other auks		4				12				1				
Others		3	1			5	1	3						
TOTAL		1254	744	474	59	1154	69	496	30	35	9	31		
Corpses/km		1.92	1.87	1.84	0.94	1.30	0.31	0.58	0.38	0.57	0.18	2.39		
% auks oiled		28.9	40.0		66.7	75.7	82.4	22.0	69.2	90.0	100.0	100.0		
% gulls oiled		16.2	21.8		13.2	11.6	60.0	2.2	0	77.8	0	40.0		

1978	Norway	Denmark	West Germany	Netherlands	Belgium	E Britain	S Britain	W Britain	N Ireland	Ireland	Channel Islands	N France	Biscay	Spain
Distance (km)		280	373	[illegible]	67	897	261	788	109	288	91	679	302	
Divers		7	13	5	2	24		7			2	33		
Grebes			6	10	9	9	1	4			2	81		
Fulmar		31	5	5	4	70		14	1	4		4	1	
Gannet		16		5		24	2	9	1	2	2	8	5	
C/Shag		3		1		47	11	25	5	2	2	15	1	
Eider		112	28	7		51		6						
Scoters		163	34	5	3	15		6				21	6	
Other seaduck		3	3	7		9	2	1				2		
Other wildfowl		80	104	13		71		27				14		
Waders		20	25	50		170		58	1	2		8	3	
Larus gulls		232	122	81	31	570	42	223	114	30	10	285	15	
Kittiwake		31	3	18	2	172	1	12				38	2	
Razorbill		10	4	21	4	96	19	15	2	5	8	85	7	
Guillemot		42	15	54	7	361	31	44	4	6	1	98	8	
Puffin				1		12	1		1	4		1	202	
Other auks		11				10				1				
Others						4		2		1		1	2	
TOTAL		761	362	283	62	1715	110	453	129	57	27	694	252	
% Corpses/km		2.72	0.97	[illegible]	0.93	1.91	0.42	0.58	1.18	0.20	0.30	1.02	0.83	
% auks oiled		33.3	84.2	94.7	81.8	71.6	88.2	30.5	57.1	18.8	44.4			
% gulls oiled		31,2	26.4	41.4	24.2	24.8	16.3	7.2	0.9	10.0	0			

1979	Norway	Denmark	West Germany	Netherlands	Belgium	E Britain	S Britain	W Britain	N Ireland	Ireland	Channel Islands	N France	Biscay	Spain
Distance (km)		569	348	101	60	1036	270	911	207	99	81	c.550		
Divers		50	10	21	7	51	4	7				51		
Grebes		18	37	345	38	50		3		1	2	132		
Fulmar			4	11	1	130	1	7	6			17		
Gannet			1	3		17	1	11				10		
C/Shag		3	1	1		52	6	51	5	2	4	14		
Eiders		319	150	13		18	1	4				11		
Scoters		283	126	161	32	42	9	10	2	1		133		
Other seaduck		13	10	39	6	30		6	3			35		
Other wildfowl		107	145	133	86	134	3	56	1		1	330		
Waders		38	47	234	20	320		113	4		4	214		
Larus gulls		153	123	280	82	811	34	231	18	17	13	410		
Kittiwake		12	3	22	1	169	1	19	2	3	2	43		
Razorbill			5	13	2	273	9	30	8	9	11	156		
Guillemot		346	31	54	5	735	13	58	1	12	4	116		
Puffin				2		35						40		
Other auks		2		2		16			1			14		
Others			2	384	1	4		2	1			6		
TOTAL		1344	695	1718	281	2887	82	608	52	45	41	1689		
Corpses/km		2.36	2.00	17.0	4.68	2.79	0.30	0.67	0.25	0.45	0.51	c.3.07		
% auks oiled		7.5		100.	71.4	68.9	95.5	33.0	70.0	71.4	53.3			
% gulls oiled		0		17.5	31.3	11.7	17.1	4.4	0	35.0	13.3			

1980	Norway	Denmark	West Germany	Netherlands	Belgium	E Britain	S Britain	W Britain	N Ireland	Ireland	Channel Islands	N France	Biscay	Spain
Distance(km)	78	612	510	176	29	1015	294	801	1421	436	60	117		163
Divers		22	9	5		1		3		1		6		
Grebes		17	8	13		3		1				2		
Fulmar		6	6	9		36	1	15		1		1		1
Gannet		2	1	3	2	9	5	5			1	9		18
C/Shag	7	8	4	1		43	2	37	6	5	1	9		1
Eider	1	301	174	19		108		7	1					
Scoters		232	75	5	3	13	1			1		3		1
Other seaduck	1	14	19	4		8								
Other wildfowl		115	47	34	1	46	1	51		1	1	1		
Waders		19	68	30	1	59	1	40	1	1		5		2
Larus gulls	9	222	152	189	4	468	37	241	12	15	5	38		64
Kittiwake	2	15	9	53	3	52	1	13		1		14		
Razorbill			5	16	1	35	33	19	2	3	1	57		21
Guillemot	2	15	24	71		259	27	47	3	8	3	29		3
Puffin	1	2				7	3	3				39		37
Other auks	1		2	5		10		4		1		2		
Others						1	1	1				1		
TOTAL	24	990	603	457	15	1158	113	487	25	38	12	216		148
Corpses/km	0.31	1.62	1.18	2.60	0.52	1.14	0.38	0.61	0.18	0.09	0.2	1.85		0.91
% auks oiled	75.0	20.0		90.2	0	61.4	77.8	54.8	40.0		100.0	66.9		
% gulls oiled	18.2	1.7		70.3	28.6	12.7	50.0	5.5	8.3		80.0	19.2		

1981	Norway	Denmark	West Germany	Netherlands	Belgium	E Britain	S Britain	W Britain	N Ireland	Ireland	Channel Islands	N France	Biscay	Spain
Distance(km)			288	337		985	254	611	114	192	81	338		104
Divers			38	9		6					1	4		
Grebes			1	19				1	1		1	2		
Fulmar			35	89		10		10		6		1		
Gannet			1	9		4	1	8			4	10		3
C/Shag			1			10	2	50	2	4	2	19		2
Eider			70	65		24		6				1		
Scoters			127	55		1		2			1	11		
Other seaduck				13		3		4						
Other wildfowl			51	74		47	1	39	1		1	9		
Waders			32	82		43	7	20	1		1	21		
Larus gulls			533	497		207	30	161	10	20	10	140		28
Kittiwake			134	659		38	2	8	1	3		15		2
Razorbill			41	195		53	13	30		10	1	43		1
Guillemot			656	778		221	79	44	1	18	8	105		
Puffin			7	5		12		1		2		7		3
Other auks			7	33		5	2	1		1		12		10
Others						3		1						
TOTAL			1734	2582		687	137	386	17	64	30	400		49
Corpses/km			6.02	7.66		0.70	0.54	0.63	0.15	0.33	0.37	1.18		0.47
% auks oiled				96.3		56.0	91.5	51.3	0	71.0	100.0	72.5		100.0
% gulls oiled				93.4		9.8	43.8	2.4	9.1		66.7	5.2		30.0

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Birds Oiled during the *AMOCO CADIZ* Incident —an Interim Report

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Over 4500 oiled birds were collected from beaches in Northwest France and the Channel Islands following the oil spillage from the *AMOCO CADIZ* in March 1978. Auks were the most abundant casualties: 1391 puffins *Fratercula arctica*, 978 razorbills *Alca torda* and 731 guillemots *Uria aalge*, but there were also 126 divers *Gavia* spp. A total of 33 bird species were recorded oiled. A corpse drift experiment suggested that after 30 March at least 3450 seabirds died off north Finistère alone; the total mortality in the first fortnight of the incident was probably considerably larger.

The super-tanker *AMOCO CADIZ* was wrecked on rocks near Portsall, on the northwest coast of Brittany, on 16 March 1978, and she subsequently spilled her cargo of 220000 tons of light Iranian and Arabian crude oils. The incident occurred almost on the eleventh anniversary of the grounding of the infamous *TORREY CANYON*. Oil from that incident enveloped the seabird reserve of Les Sept Isles and apparently severely reduced the auk population (Monnat, 1969). In recent years these auks had begun to show a slight increase but the latest incident is likely to have reduced the numbers again. This report examines the situation concerning oiled seafowl; a detailed collation will be made at a later date.

In the first fortnight of the incident there were predominantly strong westerly winds, and later south-westerly winds. The sequence of events following the wreck has been described by O'Sullivan (1978) for the period up to 31 March. After that date, a change in wind direction to the northeast caused extensive secondary contamination of beaches. Oil also drifted around the western tip of the Brittany peninsula, and came ashore, under the influence of north- and south-westerly winds, on the coast as far as Pointe du Raz, about 66 km south of the wreck.

Emergency arrangements

With the previous experience of oil pollution in Brittany from the *TORREY CANYON* in 1967, and the wrecking of two other tankers, *OLYMPIC BRAVERY* and *BÖHLEN*, both in 1976, an operations centre was quickly established at Brest by the Société pour l'Etude et la Protection de la Nature en Bretagne (SEPNB). Members of this society, together with university